INSURING NATURE

CAROLYN KOUSKY† & SARAH E. LIGHT††

ABSTRACT

Scholars and policymakers have argued that insurance can shape behavior in ways that mitigate climate risks, such as by providing financial incentives to property owners to safeguard their property from increasingly intense hurricanes or from the risk of sea-level rise. But natural ecosystems like coral reefs, mangroves, and forest ecosystems can themselves protect property from these increased climate risks. This Article turns the climate governance literature on its head, examining the circumstances under which it is possible to insure nature itself in order to preserve these critical ecosystem services in the face of a changing climate.

TABLE OF CONTENTS

† Executive Director, Risk Management and Decision Processes Center, The Wharton School, University of Pennsylvania.

†† Associate Professor of Legal Studies and Business Ethics, The Wharton School, University of Pennsylvania. Thanks to J.B. Ruhl, participants in the Legal Studies and Business Ethics Workshop, and the Alliance for Research on Corporate Sustainability Annual Conference for comments and discussions on early drafts, to individuals working in the insurance industry for helpful background discussions, and to Tyler Knox and Jane Tomic for excellent research assistance.

INTRODUCTION

The natural world and its ecosystems are valuable both for intrinsic reasons and for their instrumental value to people.[1] These instrumental benefits that people derive from nature are often referred to as *ecosystem services*. However, these benefits are rapidly declining. For instance, a recent United Nations report compiled by 145 expert authors from 50 countries stresses that natural resources are declining globally at rates never before matched in human history and the rate of species extinction is increasing.[2] This degradation arises as a result

1. On the idea that nature has instrumental value for the services it provides to people, see generally NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS (Gretchen C. Daily ed., 1997) [hereinafter NATURE'S SERVICES] (discussing the value to humans of natural ecosystems in different contexts); GEORGE PERKINS MARSH, MAN AND NATURE 108 (David Lowenthal ed., 1864) ("Earth, water, the ducts and fluids of vegetable and of animal life, the very air we breathe, are peopled by minute organisms which perform most important functions in both the living and the inanimate kingdoms of nature."); Lawrence H. Goulder & Donald Kennedy, *Valuing Ecosystem Services: Philosophical Bases and Empirical Methods*, *in* NATURE'S SERVICES, *supra*, at 24–27 (discussing different ethical approaches to valuing ecosystem services grounded in utilitarianism and intrinsic rights). On the idea that nature has intrinsic value, see generally Gwendolyn J. Gordon, *Environmental Personhood*, 43 COLUM. J. ENVTL. L. 49 (2018) (discussing the view that the environment, or a feature of the environment like a river, can have legal status as a person). A recognition of the importance of ecosystem services dates back to Plato and possibly earlier. Harold A. Mooney & Paul R. Ehrlich, *Ecosystem Services: A Fragmentary History*, *in* NATURE'S SERVICES, *supra*, at 11.

2. SANDRA DIAZ ET AL., SUMMARY FOR POLICYMAKERS OF THE GLOBAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM SERVICES OF THE INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES 3 (advanced unedited ed. 2019).

of multiple causes, including pollution, land conversion for human use, and climate change.[3] This Article explores the circumstances under which insurance—a risk management tool not typically used in conservation—can actually help conserve and restore ecosystems and the ecosystem services on which society depends.

Ecosystems provide people with market goods, such as timber and food, as well as goods and services that do not have an easily ascertainable market value. These services include water and air purification, habitat provision for diverse species, crop pollination, climate regulation, shoreline protection, flood mitigation, pest control, renewal of soil fertility, and waste decomposition.[4] Ecosystems also provide space for activities like outdoor recreation, as well as supply other aesthetic or "non-use" values, such as the pleasure people derive from just knowing that certain species (such as polar bears) or ecosystems (such as the Grand Canyon or the Great Barrier Reef) exist.[5]

This Article focuses on an important class of ecosystem services that help minimize the risks of natural-disaster events to human populations[6]—services that are becoming even more important as the climate warms. For example, coastal mangroves and coral reefs act as natural barriers that can protect coastal properties from increasingly frequent storm surges.[7] Wetlands reduce growing flood risks to nearby property triggered by increasingly heavy precipitation events,[8] and

3. *Id.*

4. Gretchen C. Daily, *Introduction: What Are Ecosystem Services?*, *in* NATURE'S SERVICES, *supra* note 1, at 3–4; James Salzman, *Valuing Ecosystem Services*, 24 ECOLOGY L.Q. 887, 892 (1997) [hereinafter Salzman, *Valuing Ecosystem Services*] (discussing different types of ecosystem services).

5. *See* J.B. Ruhl, *Valuing Nature's Services: The Future of Environmental Law?*, 13 NAT. RESOURCES & ENV'T 359, 360 (1998) [hereinafter Ruhl, *Valuing Nature's Services*] ("The most difficult aspect of this problem . . . is that we can take ecosystem services for granted and still reap their benefits . . . ."); Salzman, *Valuing Ecosystem Services*, *supra* note 4, at 892–93. For further discussion of non-use value and other aspects of valuation, see *infra* Part I.B.

6. Carolyn Kousky, *Using Natural Capital to Reduce Disaster Risk*, 2 J. NAT. RESOURCES POL'Y RES. 343, 343 (2010) [hereinafter Kousky, *Using Natural Capital*]. On investing in natural resources as a tool of environmental governance, see generally MARK R. TERCEK & JONATHAN S. ADAMS, NATURE'S FORTUNE: HOW BUSINESS AND SOCIETY THRIVE BY INVESTING IN NATURE (2013).

7. *See* Katie K. Arkema et al., *Coastal Habitats Shield People and Property from Sea-Level Rise and Storms*, 3 NATURE CLIMATE CHANGE 913 (2013) (empirically demonstrating the role that natural coastal habitats—including mangroves, coral reefs, marsh, oyster reefs, dunes, seagrass beds, kelp forests, and other vegetation—play in protecting shorelines).

8. For two examples, see Iman Mallakpour & Gabriele Villarini, *The Changing Nature of Flooding Across the Central United States*, 5 NATURE CLIMATE CHANGE 250, 250–54 (2015) and

upland vegetation decreases the risk of landslides.[9] Wetlands can also store floodwaters and dunes can buffer storm surges.[10] More broadly, ecosystems can remove significant amounts of carbon from the atmosphere, lessening the impact of climate change on a global scale.[11]

Ecosystem services, while valuable, are what economists refer to as "public goods."[12] This means that it is not possible to exclude anyone from enjoying their benefits—they are provided to all—and one person enjoying them does not diminish their value for others. Because private entities cannot capture the full benefits of public goods, they tend to be underprovided in the market. This means there are fewer ecosystem services than would be economically optimal.[13] Indeed, one recent study concluded that global efforts to promote "natural climate solutions"—investment in the ecosystem services that benefit the climate—have received less than 1 percent of global public and private financing,[14] notwithstanding their potential to mitigate more than one-third of global greenhouse gas emissions through 2030.[15]

Andreas F. Prein et al., *Increased Rainfall Volume from Future Convective Storms in the US*, 7 NATURE CLIMATE CHANGE 880, 880–84 (2017).

9. THE ROLE OF ECOSYSTEMS IN DISASTER RISK REDUCTION 10 (Fabrice G. Renaud, Karen Sudmeier-Rieux & Marisol Estrella eds., United Nations University Press 2013); Robert Costanza et al., *The Value of Coastal Wetlands for Hurricane Protection*, 37 AMBIO 241, 241 (2008); Kousky, *Using Natural Capital*, *supra* note 6, at 343 (discussing examples of natural capital mitigating disaster risk, including wetlands mitigating flood risk in a watershed, revegetation reducing the risk of landslides, and mangrove forests protecting the coastline from storm surges).

10. *See generally* Kousky, *Using Natural Capital*, *supra* note 6, at 343 (discussing wetlands and dunes as critical ecosystem services).

11. Joseph E. Fargione et al., *Natural Climate Solutions for the United States*, 4 SCI. ADVANCES 1, 2 (2018) (concluding that improved land-management techniques such as reforestation, fire management, avoided grassland conversion, the use of cover crops, and tidal wetland restoration, among others, can remove carbon dioxide annually totaling approximately 21 percent of 2016 emissions).

12. On the idea that ecosystem services are "public goods," see Robert Costanza et al., *Changes in the Global Value of Ecosystem Services*, 26 GLOBAL ENVTL. CHANGE 152, 154 (2014) (noting that ecosystem services tend to be public goods); A. P. Kinzig et al., *Paying for Ecosystem Services—Promise and Peril*, 334 SCIENCE 603, 603–04 (2011) (discussing "mechanisms for motivating people to provide scarce [ecosystem services] that are public goods"); Christopher L. Lant, J.B. Ruhl & Steven E. Kraft, *The Tragedy of Ecosystem Services*, 58 BIOSCIENCE 969, 971 (2009); and James Salzman, *Creating Markets for Ecosystem Services: Notes from the Field*, 80 N.Y.U. L. REV. 870, 875–76, 876 n.17 (2005) [hereinafter Salzman, *Creating Markets*] (discussing literature on ecosystems as public goods).

13. Salzman, *Creating Markets*, *supra* note 12, at 875–76.

14. Fargione et al., *supra* note 11, at 4 (citing BARBARA K. BUCHNER ET AL., GLOBAL LANDSCAPE OF CLIMATE FINANCE 2015 (2015), http://climatepolicyinitiative.org/wp-content/uploads/2015/11/Global-Landscape-of-Climate-Finance-2015.pdf [https://perma.cc/6W6Z-3BSN]).

15. Bronson W. Griscom et al., *Natural Climate Solutions*, 114 PNAS 11645, 11645 (2017).

In addition to this public goods problem, the ecosystems that protect people from natural disasters, such as storms and wildfires, can themselves be damaged by these very same events,[16] decreasing the range of ecosystem services they can provide. Thus, there is the potential for a negative feedback loop. For instance, coral reefs and coastal mangroves protect coastlines against storm surges, which are becoming even more common as the oceans warm.[17] But these very same storms and hurricanes can damage coral reefs and coastal mangroves, thus lessening the protective services they provide to people and coastal properties.[18] This same cycle can play out in other ecosystems, as well.[19] Existing legal tools are typically inadequate to ensure that these ecosystems will be restored quickly if damaged. This inadequacy is magnified when such damage is caused by extreme weather events, rather than by persons (either natural persons or artificial persons like corporations) who can be sued as defendants ex post or who must obtain permits before causing harm ex ante.[20]

---

16. *See* Arkema et al., *supra* note 7, at 913 (noting projected increase in coastal flooding by mid-century); Thomas R. Knutson et al., *Tropical Cyclones and Climate Change*, 3 NATURE GEOSCIENCE 157, 160–61 (2010) (discussing projected increases in hurricane intensity); Loren McClenachan et al., *Ghost Reefs: Nautical Charts Document Large Spatial Scale of Coral Reef Loss over 240 Years*, 3 SCI. ADVANCES 1, 1 (2017) (noting that both human impact through agriculture and deforestation, as well as hurricanes and sea-level rise, have contributed to the loss of reef-building corals); Seung-Ki Min et al., *Human Contribution to More-Intense Precipitation Extremes*, 470 NATURE 378, 378–80 (2011) (discussing the increasing intensity of rainfall events). To call such disasters "natural" should not obscure the scientific consensus that human action is responsible for global climate change. *See, e.g.*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014 SYNTHESIS REPORT v, 2 (2014), https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf [https://perma.cc/S5JT-58HP] ("[H]uman influence on the climate system is clear and growing."). However, the role of humans in causing such disasters is more indirect than in other cases, such as through the flow of polluted runoff directly into a wetland.

17. McClenachan et al., *supra* note 16, at 1 (noting that loss of oysters, mangroves, and coral can reduce storm protection).

18. *See generally* T.P. Scoffin, *The Geological Effects of Hurricanes on Coral Reefs and the Interpretation of Storm Deposits*, 12 CORAL REEFS 203 (1993) (observing that the "violence of the storm relative to normal fair-weather conditions influences the extent of damage" and that other factors including the time before the next storm influence the chance of a reef's recovery or preservation).

19. For example, storms can erode beaches and dunes, making the land behind them more vulnerable to future storms. On the value of coastal habitats in providing storm protection, see Arkema et al., *supra* note 7, at 913–18.

20. *See infra* Part I.C. Existing legal tools that seek to prevent harm to ecosystem services include land acquisition and market-leveraging solutions like payments for ecosystem services, in addition to permit systems such as the Clean Water Act's § 404 wetlands program. *See* 33 U.S.C. § 1344 (2018) (describing the permitting process for dredged or fill material). Also illustrative are prescriptive rules like the Endangered Species Act's prohibition on the "take" of endangered

Practitioners and legislators are growing more interested, however, in whether insurance can help with both problems: increasing the provision of an underprovided public good and also restoring it quickly following a disaster. For example, in 2018, the governor of California signed Senate Bill 30 into law, which directs the state insurance commissioner to "identify, assess, and recommend risk transfer market mechanisms that promote investment in natural infrastructure."[21] This law followed quickly on the heels of the only current example of insuring nature itself: the creation in 2018 of a Coastal Zone Management Trust, funded in part through local tourism taxes, that partners a local hotel owners association with the Mexican state government of Quintana Roo, The Nature Conservancy, and a local marine park that manages the coral reef.[22] In mid-2019, the Trust purchased an insurance policy that will provide funds to quickly restore the coral reef if damaged in a hurricane.[23] The innovation is that the insurance covers damage to the *reef* rather than damage to the private *property* on the coastline. In other words, the policy insures nature itself.

Yet, despite the recent enthusiasm for broader use of insurance in conservation and restoration of ecosystems, very little academic work has been done to examine exactly how this would work, whether it would work, whether it could scale effectively around the world, and when it would be preferable to other approaches. This Article begins to address these questions.

---

species by any person, and the prohibition on adverse modification of critical habitat by federal agencies either through their direct actions or as a result of their licensing, permitting, or funding of private actions. *See* 16 U.S.C. § 1538 (2018) (prohibiting the "take" of endangered species by "any person"); *id.* § 1532(19) (defining "take"); *id.* § 1536(a)(2) (governing federal agencies). Governance tools that seek to restore damaged ecosystem services include natural resource damages provisions under the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA," also known as "Superfund"), 42 U.S.C. §§ 9601–9675 (2018), and the Oil Pollution Act, 33 U.S.C. §§ 2701–2761.

21. S.B 30, 2017–2018 Leg., Reg. Sess., § 2(a) (Cal. 2018) (codified at CAL. INS. CODE § 12922.5).

22. *See infra* Part III.C.1; *see also* Mark Tercek, *Business to the Rescue: Insurance for Reef Restoration*, FORBES (Mar. 8, 2018, 6:41 PM), https://www.forbes.com/sites/marktercek/2018/03/08/business-to-the-rescue-insurance-for-reef-restoration/#84c63a23e0c1 [https://perma.cc/H7BE-88DE]; *Insuring Nature To Ensure a Resilient Future*, NATURE CONSERVANCY (Mar. 8, 2018), https://www.nature.org/en-us/what-we-do/our-insights/perspectives/insuring-nature-to-ensure-a-resilient-future [https://perma.cc/YGD4-DLUK].

23. Gloria Gonzalez, *Parametric Insurance Policy to Cover Mexico Coral Reef*, BUS. INS. (June 7, 2019), https://www.businessinsurance.com/article/20190607/NEWS06/912328933/Parametric-insurance-policy-to-cover-Mexico-coral-reef [https://perma.cc/HR64-49KT].

This investigation begins in Part I with a brief primer on ecosystem services. This Part defines ecosystem services and highlights the challenges in valuation and in their status as public goods that can lead to an underinvestment in their protection. It discusses other governance tools used to protect ecosystem services and notes some drawbacks particular to these other methods, including their failure to focus on risk management.

Part II then turns to an overview of insurance and how it ordinarily operates, focusing specifically on property insurance and disasters. This Part explains the function of risk transfer, two types of insurance (indemnity and parametric), and when and why governments provide insurance. Much of the legal scholarship regarding the relationship between insurance and climate change has focused on the capacity of insurance to influence the behavior of private actors in ways that promote climate mitigation or adaptation on their private property.[24] This Article builds upon and extends beyond this existing literature.

The heart of the Article is presented in Parts III and IV. Part III takes a deep dive into the details of insurance at work in the context of ecosystems. After exploring how insurance can protect ecosystems in two primary ways, it offers several concrete examples of insurance products that are currently being applied (or considered) to protect and restore ecosystem services. These include the collaboration in

---

24. *See, e.g.*, Sean B. Hecht, *Climate Change and the Transformation of Risk: Insurance Matters*, 55 UCLA L. REV. 1559, 1585 (2008) (examining how the insurance industry's products can influence private actors' responses to climate change); Howard C. Kunreuther & Erwann O. Michel-Kerjan, *Climate Change, Insurability of Large-Scale Disasters, and the Emerging Liability Challenge*, 155 U. PA. L. REV. 1795, 1836–39 (2007) (offering suggestions to insurers to mitigate climate damages by providing rate credits and other incentives while focusing on insuring directors and officers); Benjamin J. Richardson, *Mandating Environmental Liability Insurance*, 12 DUKE ENVTL. L. & POL'Y F. 293, 293–94 (2002) (explaining that the article "aims to show how insurance can facilitate environmental care and compensation, and some advantages that may accrue from mandating insurance in relation to certain environmental risks"); Christina Ross, Evan Mills & Sean B. Hecht, *Limiting Liability in the Greenhouse: Insurance Risk-Management Strategies in the Context of Global Climate Change*, 26 STAN. ENVTL. L.J. 251, 252 (2007) ("The most widely discussed insurance-related consequences of climate change are the impacts of property damage from extreme weather events."); Christopher D. Stone, *Beyond Rio: "Insuring" Against Global Warming*, 86 AM. J. INT'L L. 445, 474 (1992) (discussing the role of insurance in the climate context). These articles focus on the financial incentives that insurance can have on private behavior of policyholders through rebates or premium reductions for climate-resilience or mitigation activities, how these incentives influence individuals and firms to purchase insurance products, and the incentives that insurance firms have to provide such products, in light of the fact that they are paying increasing amounts for insured losses. Hecht, *supra*, at 1594. They do not focus on insuring nature itself.

Mexico mentioned briefly above and a proposal to insure forests after wildfires, among a few others.

Part IV then shifts from the analytic and descriptive to the normative. It evaluates if and when insurance can be a valuable instrument to promote ecosystem restoration and conservation. To do so, this Part examines how different forms of insurance fare when evaluated along normative criteria including efficiency, environmental justice, accountability, and transparency, among others.[25] This Part concludes that insurance can be a uniquely effective tool for conserving or funding the restoration of ecosystems, at least in some instances. Insurance promotes certain normative values such as accountability, transparency, and expressive content. However, it is not without its drawbacks. We highlight the specific conditions under which insurance can be a useful conservation and restoration tool. The Article concludes by noting that insurance is an important policy tool in certain circumstances for protecting and restoring vital and increasingly threatened ecosystem services.

I. ECOSYSTEM SERVICES

This Part offers a basic primer on ecosystem services. It explains what ecosystem services are, the challenges in valuing them, and how they have been addressed in environmental governance to date. An understanding of these services is necessary to consider how insurance mechanisms may work to protect or restore their provision, which we take up in Parts II and III.

A. What are Ecosystem Services?

"An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit."[26] Ecosystem services are both the direct and indirect benefits that an ecosystem provides to human well-being.[27] These include crop pollination, habitat provision, air and water

25. Sarah E. Light & Eric W. Orts, *Parallels in Public and Private Environmental Governance*, 5 MICH. J. ENVTL. & ADMIN. L. 1, 53–71 (2015) (offering these normative values as benchmarks for evaluating public and private instruments to address environmental challenges).

26. MILLENNIUM ECOSYSTEM ASSESSMENT, ECOSYSTEMS AND HUMAN WELL-BEING (José Sarukhán et al. eds., 2005), https://www.millenniumassessment.org/documents/document.356.aspx.pdf [https://perma.cc/6XHR-4NQJ].

27. Gretchen C. Daily, *Introduction: What Are Ecosystem Services*, *in* NATURE'S SERVICES, *supra* note 1, at 3–4.

purification, pest control, renewal of soil fertility, climate regulation, shoreline protection, flood mitigation, and waste decomposition, among other services.[28]

The United Nations Millennium Ecosystem Assessment divides ecosystem services into four categories: *provisioning services* (providing goods for human consumption like fish or timber); *regulatory services* (regulating the environment for human benefit such as by generating oxygen in the atmosphere or fixing nitrogen in the soil); *cultural services* (providing recreational and aesthetic enjoyment); and *supporting services* (regulating the land for the benefit of nonhuman actors like bees or birds but also indirectly benefitting humans through crop pollination or seed dispersal).[29] Other than provisioning services, which encompass goods like timber or fish that can be bought and sold in markets, the remaining forms of ecosystem services are "indirect non-market uses, for while they provide clear benefits to humans they are neither directly 'consumed' nor exchanged in markets."[30]

In the climate context, certain ecosystem services are especially important. For example, coastal forests like mangroves, coral reefs, oyster reefs, dunes, and coastal vegetation like seagrass beds and kelp forests protect coastlines from storm surges and sea-level rise, reducing the impacts of such risks in the United States by as much as 50 percent.[31] The loss of such ecosystem services along the coastline would, therefore, have significant consequences, particularly for vulnerable populations:

---

28. *Id.*; Salzman, *Valuing Ecosystem Services*, *supra* note 4, at 892–93.

29. Barton H. Thompson, Jr., *Ecosystem Services & Natural Capital: Reconceiving Environmental Management*, 17 N.Y.U. ENVTL. L.J. 460, 465 (2008) (citing MILLENNIUM ECOSYSTEM ASSESSMENT, *supra* note 26). The U.N. Millennium Ecosystem Assessment was initiated in 2001 to "assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being." *Overview of the Millennium Ecosystem Assessment*, MILLENNIUM ECOSYSTEM ASSESSMENT (2005), https://www.millenniumassessment.org/en/About.html#1 [https://perma.cc/V8JZ-TRVK]. More than 1360 experts worldwide participated in the Assessment. *Id.*

30. Salzman, *Valuing Ecosystem Services*, *supra* note 4, at 893. Ecosystems and the services they provide can likewise exist at different scales. Some ecosystems such as wetlands may have local or regional impacts, while others, like the climate, are global in nature. The scale of the ecosystem of course has an impact not only on how it is valued, but also on how it might be governed.

31. Arkema et al., *supra* note 7, at 914 & fig. 1 ("Coastal habitats reduce by approximately 50% the proportion of people and property along the US coastline that are most exposed to storms and sea-level rise.").

> Habitat loss would double the extent of coastline highly exposed to storms and sea-level rise . . . making an additional 1.4 million people now living within 1 km of the coast vulnerable. The number of poor families, elderly people and total property value highly exposed to hazards would also double if protective habitats were lost.[32]

Some communities are beginning to actively try and preserve ecosystems that bring value to residents. In one of the best-known efforts to protect ecosystem services, beginning in the late 1990s, New York City chose to protect the quality of its drinking-water supply by purchasing conservation land in the Catskills River Basin.[33] The cost of protecting land, which was also done in conjunction with a number of programs to promote practices that improved water quality, was financed through the issuance of environmental bonds for approximately $600 million. This was far lower than the cost of using an engineered solution—the construction of a $4–6 billion water-filtration plant.[34] However, it is important to recognize that creating resilience through the protection and restoration of ecosystem services may go hand-in-hand with engineered solutions, also known as "grey" infrastructure, rather than replacing such engineered solutions entirely.[35]

B. How are Ecosystem Services Valued?

One of the biggest challenges for policymakers who seek to protect or restore ecosystem services is the fact that most of them are nonmarket goods and services. As such, there is no obvious price for them and thus no financial incentive to protect ecosystems from degradation in the first place, or restore them once they have been harmed.[36] If policymakers cannot value ecosystem services, they may not be able to make rational judgments about the appropriate amount of resources to devote to protecting them. Nor can they straightforwardly determine the best regulatory tool, method of

---

32. *Id.* at 914–15 (citation omitted) (noting variation in impacts to coastal ecosystems and habitat loss across the U.S. coastline, as well as valuation in coastal property values).

33. NAT'L RESEARCH COUNCIL, WATERSHED MANAGEMENT FOR POTABLE WATER SUPPLY: ASSESSING THE NEW YORK CITY STRATEGY 5 (2000).

34. Kousky, *Using Natural Capital*, *supra* note 6, at 351 (citing a $4–6 billion cost estimate).

35. Arkema et al., *supra* note 7, at 916 (noting that after hurricanes affected New York City and Louisiana, each jurisdiction sought to incorporate ecosystem-based strategies alongside engineering solutions to address sea-level rise and storm surges).

36. This difficulty in valuation compounds the problem of underinvestment as a result of the fact that many ecosystem services are public goods. *See supra* notes 12–13 and accompanying text.

private governance, or hybrid public–private approach to ensure their continued existence.

This problem has spurred the development of a host of methods for estimating the economic values of ecosystem services.[37] That said, to be done well, these methods are often time and resource intensive and require significant expertise. One benefit of using insurance as a tool for ecosystem-service provision is that it usually does not require economic estimates of the full "willingness-to-pay" of all beneficiaries. Instead, it can rely on much easier to obtain estimates: the costs of providing the service or restoring a damaged ecosystem.[38] Valuation studies can still play an important role, however, in identifying insurable value, quantifying stakeholder benefits from ecosystems, and generally stimulating the use of insurance.

Economists have developed a framework of the *total economic value* of ecosystem services to incorporate all of the benefits provided by a particular service. This divides total value into a *use value* component—which is the value derived from the direct use of the service by people—and a *non-use value* component—which is the value derived from the existence of the service without human consumption or use.[39] Use values are further broken down into *direct* values and *indirect* values.[40] Direct values are those derived from actual consumption or use of the ecosystem, such as clean water, food, or even recreation, and are typically more easily measured using market prices.[41] *Indirect* values are benefits that the ecosystem provides

37. *See* David Pearce, *An Intellectual History of Environmental Economics*, 27 ANN. REV. ENERGY & ENV'T 57, 57–61 (2002) (discussing the origins and development of environmental economics). *See generally* NAT'L RESEARCH COUNCIL, VALUING ECOSYSTEM SERVICES: TOWARD BETTER ENVIRONMENTAL DECISION-MAKING (2005) [hereinafter NAT'L RESEARCH COUNCIL, VALUING ECOSYSTEM SERVICES] (discussing methods for valuing the goods and services that ecosystems provide to human societies).

38. The relationship between insurance and valuation is more complex, as noted below. In the parametric insurance context, where recovery is tied to a specific triggering event, there is no need to engage in valuation of the actual damage. However, in creating such a policy, there is a need for the insurer to value the ecosystem services to the extent necessary to determine an appropriate payout in the event that the trigger requires payment under a policy. *See infra* Part III.

39. For a broad discussion of the total economic value framework, see generally STEFANO PAGIOLA, KONRAD VON RITTER & JOSHUA BISHOP, ASSESSING THE ECONOMIC VALUE OF ECOSYSTEM CONSERVATION (2004).

40. Edward B. Barbier et al., *The Value of Estuarine and Coastal Ecosystem Services*, 81 ECOLOGICAL MONOGRAPHS 169, 173 (2011).

41. *Id.*

beyond mere use of the ecosystem itself.[42] For example, while a mangrove forest *directly* contributes to fisheries or buffers against storm surge, it also *indirectly* benefits people by sequestering carbon, for example.[43] *Non-use values* are even more intangible and abstract, including, for example, the value of preserving an ecosystem as part of a community's cultural heritage, or the value that people derive simply from knowing that a particular species continues to exist.[44]

Various economic methods can be used to estimate the value of nonmarket goods and services like those described above.[45] These methods are based on the fundamental assumption that individual preferences define economic value.[46] These preferences are measured in terms of the beneficiaries' willingness-to-pay for the service, or the maximum dollar amount they would pay for a well-defined additional increment in the ecosystem service.[47] These calculations are thus inherently anthropocentric—that is, they are based exclusively on the benefits that people derive from ecosystems.[48]

Willingness-to-pay can be estimated in a number of ways, which are often grouped into two broad approaches: (1) revealed preference and (2) stated preference methods.[49] These are each discussed in turn.

---

42. *Id.*

43. *See, e.g.*, Taylor H. Ricketts, Gretchen C. Daily, Paul R. Ehrlich & Charles D. Michener, *Economic Value of Tropical Forest to Coffee Production*, 101 PNAS 12579, 12579–82 (2004) (estimating the value of tropical forests in supplying pollination services to agriculture).

44. *See generally* Raymond J. Kopp, *Why Existence Value* Should *Be Used in Cost–Benefit Analysis*, 11 J. POL'Y ANALYSIS & MGMT. 123 (1992).

45. *See* Gretchen C. Daily et al., *The Value of Nature and the Nature of Value*, 289 SCIENCE 395, 395–96 (2000).

46. For a discussion of the theory of revealed preference and its underlying assumptions, see generally Amartya Sen, *Behaviour and the Concept of Preference*, 40 ECONOMICA 241 (1973).

47. For a detailed treatment of willingness-to-pay, as well as its relationship to another metric, willingness-to-accept, see generally NAT'L RESEARCH COUNCIL, VALUING ECOSYSTEM SERVICES, *supra* note 37.

48. The anthropocentric nature of such valuation methods has therefore been the subject of criticism:

> [C]ost-benefit analysis is typically premised on a liberal conception in which only humans—and more specifically, only presently living individual humans—are capable of holding interests. For that reason, the value of nonhuman life-forms is acknowledged only to the extent that identifiable human individuals value those life-forms, generally through revealed preference or contingent valuation studies. . . . Neither the individuals who are subjected to preference-elicitation studies nor the economists who interpret the results are necessarily well versed in the underlying scientific questions regarding the role, resilience, and replaceability of natural resources and ecosystem services.

DOUGLAS A. KYSAR, REGULATING FROM NOWHERE: ENVIRONMENTAL LAW AND THE SEARCH FOR OBJECTIVITY 180–81 (2010).

49. For a detailed treatment, see generally A. MYRICK FREEMAN III, THE MEASUREMENT OF ENVIRONMENTAL AND RESOURCE VALUES: THEORY AND METHODS (2003).

We then discuss a method, called benefits transfer, which imports valuation estimates from other contexts when original valuation studies are infeasible.

Revealed Preference. Revealed preference approaches are based on observed decisions of individuals, often in other markets. From these decisions, one can estimate or infer the value of an ecosystem service.[50] One example is the hedonic method, which estimates how home buyers value different environmental attributes, such as a home's proximity to open space, flood risk levels, or local levels of air pollution, by comparing the prices of homes with variations in these attributes and controlling for all other aspects of a property that influence selling prices.[51] Using econometric approaches, this produces an estimate of the value of the attribute for an average homebuyer, often referred to as the "shadow price."[52] A similar approach, referred to as travel cost, can estimate the value of different aspects of recreation sites based on the cost spent to visit them.[53]

Another example of a revealed preference approach is referred to as replacement cost value. This method uses the cost to replace an ecosystem service with a built or engineered alternative as a rough estimate of economic value.[54] While this approach is convenient, it may not be a close approximation of willingness-to-pay.[55] For example, the value of cleaner drinking water could be estimated based on how much

---

50. Kevin J. Boyle, *Introduction to Revealed Preference Methods*, *in* A PRIMER ON NONMARKET VALUATION: THE ECONOMICS OF NON-MARKET GOODS AND RESOURCES 259 (Patricia A. Champ et al. eds., 2003).

51. *See, e.g.*, Patrick Bayer, Nathaniel Keohane & Christopher Timmins, *Migration and Hedonic Valuation: The Case of Air Quality*, 58 J. ENVTL. ECON. & MGMT. 1, 1 (2009) (discussing hedonic pricing techniques and accounting for migration costs); B. Bolitzer & N. R. Netusil, *The Impact of Open Spaces on Property Values in Portland, Oregon*, 59 J. ENVTL. MGMT. 185, 186 (2000) (discussing the hedonic pricing technique).

52. A shadow price is the estimated price for a good that is not traded in a market. *See* David A. Starrett, *Shadow Pricing in Economics*, 3 ECOSYSTEMS 1, 16 (2000) (recognizing "many goods and services for which there are no markets (such as clean air, wildlife habitat, and fishing stocks) as having value" and referring to this "'price-like' concept" as shadow price). On economic prices, see generally Geoffrey Heal, *Valuing Ecosystem Services*, 3 ECOSYSTEMS 24 (2000).

53. Gardner Brown, Jr. & Robert Mendelsohn, *The Hedonic Travel Cost Method*, 66 REV. ECON. & STATS. 427, 427 (1984).

54. For example:

> [T]he presence of a wetland may reduce the cost of municipal water treatment for drinking water because the wetland system filters and removes pollutants. It is therefore tempting to use the cost of an alternative treatment method, such as the building and operation of an industrial water treatment plant, to represent the value of the wetland's natural water treatment service.

NAT'L RESEARCH COUNCIL, VALUING ECOSYSTEM SERVICES, *supra* note 37, at 125.

55. *Id.*

a city pays to build a water filtration plant.[56] Yet this approach only provides reliable estimates of economic value when the human-engineered alternative provides a truly equivalent service, is the least-cost alternative to providing the service, and the population would pay these costs when faced with the absence of the ecosystem service.[57]

Valuation methods based on replacement cost are related to so-called averting expenditure approaches, which infer an economic value from the amount spent to avoid or reduce environmental risks.[58] For instance, if a household buys a water filter to reduce contaminants, this could be a lower-bound estimate for the value the household places on clean water. However, such estimates generally cannot be treated as exact because, for example, a household might purchase a filter for reasons other than (or in addition to) risk reduction, such as improving the water's look or taste. As a result, adjustments are often required to isolate the risk-reduction component of the expenditure.[59]

Revealed preference approaches such as these provide estimates of the value of an ecosystem service at or near its current level of provision and thus are useful for considering relatively small changes in the level of service.[60] However, revealed preference approaches may not be appropriate for estimating the value of very large changes in the level of service provided, as value may not scale linearly.[61] For example,

---

56. *See id.* at 156–57 (discussing New York City's choice to purchase lands within the watershed to ensure a clean water supply instead of constructing a filtration plant).

57. Nancy E. Bockstael et al., *On Measuring Economic Values for Nature*, 34 ENVTL. SCI. & TECH. 1384, 1388 (2000).

58. Paul N. Courant & Richard C. Porter, *Averting Expenditure and the Cost of Pollution*, 8 J. ENVTL. ECON. & MGMT. 321, 321 (1981); *see, e.g.*, Brian W. Bresnahan, Mark Dickie & Shelby Gerking, *Averting Behavior and Urban Air Pollution*, 73 LAND ECON. 340, 340 (1997) (explaining "defensive responses to air pollution using determinants predicted by an averting behavior model"). On the general method, see generally Mark Dickie, *Defensive Behavior and Damage Cost Methods*, *in* A PRIMER ON NONMARKET VALUATION, *supra* note 50, at 395.

59. Others have described this analysis:

> To estimate the overstatement of averting costs we need to determine the unadjusted aggregate averting costs as well as the adjusted aggregate averting costs. The unadjusted costs are the expenditures without adjusting for quality differences, while adjusted costs are the expenditures adjusted to reflect only risk averting behavior when there is no difference in taste, odor, or appearance . . . relative to tap water.

Nii Adote Abrahams, Bryan J. Hubbell & Jeffrey L. Jordan, *Joint Production and Averting Expenditure Measures of Willingness to Pay: Do Water Expenditures Really Measure Avoidance Costs?*, 82 AM. J. AGRIC. ECON. 427, 434 (2000) (citations omitted).

60. *See generally* ROBERT A. YOUNG, DETERMINING THE ECONOMIC VALUE OF WATER: CONCEPTS AND METHODS (2005) (laying out methods to determine the value of water through revealed preference approaches, among other methods).

61. *See* R. Kerry Turner, Sian Morse-Jones & Brendan Fisher, *Ecosystem Valuation*: *A Sequential Decision Support System and Quality Assessment Issues*, 1185 ANN. N. Y. ACAD. SCI.

the hedonic method may not accurately capture how much home values would change if a heavily polluted stream were restored to pristine quality or if a pristine stream suddenly became overwhelmingly polluted.

Stated Preferences. A second approach to valuation is based on stated preferences.[62] These methods use surveys that directly elicit willingness-to-pay from participants.[63] Researchers have used this method, for example, to estimate people's willingness-to-pay to avoid another oil spill similar to the infamous Exxon Valdez disaster.[64] However, these surveys are vulnerable to potential biases, such as the commonly observed difference between what survey participants state they would be willing to pay and what they may actually pay in practice.[65] The way researchers ask questions and the order in which they are asked can also influence responses. In addition, stated preference methods assume that participants are sufficiently informed to give meaningful answers.[66] In response to these challenges economists have identified sets of best practices to address these and

79, 82 (2010) ("The existence of nonlinearities in ecosystem services provision adds further complexity to their valuation and subsequent management. Because many ecosystems typically respond nonlinearly to disturbances, their supply may seem to be relatively unaffected by increasing perturbation, until they suddenly reach a point at which a dramatic system-changing response occurs . . . .").

62. *See* W. Michael Hanemann, *Valuing the Environment Through Contingent Valuation*, 8 J. ECON. PERSP. 19, 20 (1994) (discussing surveys as a valuation method); Paul R. Portney, *The Contingent Valuation Debate: Why Economists Should Care*, 8 J. ECON. PERSP. 3, 3 (1995) ("The contingent valuation method involves the use of sample surveys (questionnaires) to elicit the willingness of respondents to pay for (generally) hypothetical projects or programs.").

63. *See, e.g.*, John Loomis et al., *Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey*, 33 ECOLOGICAL ECON. 103, 103 (2000) ("Households were asked a dichotomous choice willingness to pay question regarding purchasing the increase in ecosystem services through a higher water bill.").

64. Richard T. Carson et al., *Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill*, 25 ENVTL. & RESOURCE ECON. 257, 257 (2003).

65. This is often referred to as hypothetical bias. *E.g.*, John Loomis, *What's To Know About Hypothetical Bias in Stated Preference Valuation Studies?*, 25 J. ECON. SURVS. 363, 363–64 (2011); James J. Murphy, P. Geoffrey Allen, Thomas H. Stevens & Darryl Weatherhead, *A Meta-Analysis of Hypothetical Bias in Stated Preference Valuation*, 30 ENVTL. & RESOURCE ECON. 313, 313 (2005).

66. *See* Salzman, *Valuing Ecosystem Services*, *supra* note 4, at 895 (offering critiques of contingent valuation methods based on surveys).

other issues,[67] yet criticisms remain.[68] Despite these criticisms, however, these types of studies are currently the only way to estimate certain values, such as non-use values.[69]

Benefits Transfer. Undertaking original valuation studies with either revealed or stated preference approaches can be expensive, time-consuming, and require substantial expertise. As a result, environmental economists have developed a method called "benefits transfer" to use valuation estimates from one study and apply them elsewhere.[70] The challenge with the benefits transfer approach is that service valuation is often context specific.[71] For example, the value of a coastal mangrove forest depends on its recreational access, the value of property behind it, the risk of storm surge, whether there are similar mangrove stands nearby, what species live in it, and so on. This means that an ecosystem in one region might be valued quite differently than

---

67. *See generally* Robert J. Johnston et al., *Contemporary Guidance for Stated Preference Studies*, 4 J. ASS'N ENVTL. & RESOURCE ECONOMISTS 319, 323 (2017) (proposing "contemporary best-practice recommendations for SP studies intended to inform decision making, grounded in the accumulated body of knowledge from the peer-reviewed literature"). For a discussion of the method and history of contingent valuation, see generally Richard T. Carson, *Contingent Valuation: A Practical Alternative when Prices Aren't Available*, 26 J. ECON. PERSP. 27 (2012). For the set of best practices inspired by the Exxon Valdez oil spill, see Report of the NOAA Panel on Contingent Valuation, 58 Fed. Reg. 4602, 4602–14 (Jan. 15, 1993).

68. *See* Richard T. Carson, *Contingent Valuation: A User's Guide*, 34 ENVTL. SCI. & TECH. 1413, 1415 (2000) ("There are several other issues surrounding the use of [contingent valuation]. These include the related issues of yea-saying, protest zeros, nay-saying, and calibration."); Hanemann, *supra* note 62, at 26 ("Small changes in question wording or order sometimes cause significant changes in survey responses." (citation omitted)).

69. *See* Richard T. Carson, Nicholas E. Flores & Norman F. Meade, *Contingent Valuation: Controversies and Evidence*, 19 ENVTL. & RESOURCE ECON. 173, 197 (2001) ("Without stated preference survey methods, though, economists have to admit that they are not measuring the passive use aspects of environmental and other non-market goods, and that these are the aspects about which people may care about most.").

70. Randall S. Rosenberger & John B. Loomis, *Benefit Transfer*, *in* A PRIMER ON NONMARKET VALUATION, *supra* note 50; *see also* Robert J. Johnston & Randall S. Rosenberger, *Methods, Trends and Controversies in Contemporary Benefit Transfer*, 24 J. ECON. SURVS. 479, 479 (2010).

71. Others have expanded on this point:

> Compensation measures cannot be defined in isolation. They are entirely dependent on the context and may change as there is a change in one or more elements of that context. This feature of economic values requires analysts to be specific about what is obtained with the change as well as the default situation that exists without it.

Bockstael et al., *supra* note 57, at 1385; *see also* James Salzman & J.B. Ruhl, *Currencies and the Commodification of Environmental Law*, 53 STAN. L. REV. 607, 607 (2000) (arguing that environmental goods and services like wetlands are context-dependent and therefore nonfungible, a fact that complicates the creation of environmental trading mechanisms).

the same type of ecosystem located elsewhere.[72] Economic valuation is also dependent on the surrounding population, its preferences, and its income.[73] Therefore, not only may the actual ecosystem's physical characteristics be different across locations, but the people benefiting from those systems may vary as well—both of which will impact valuation estimates.

The inherent difficulties in valuation make more appealing policy approaches that can help ensure economically efficient levels of ecosystem services without original and ongoing valuation studies.[74] Of course, valuation may sometimes be necessary for government cost-benefit analyses and making truly informed trade-offs, and hard numbers can influence policy development.[75] Stakeholders may also benefit from a clear identification of the value provided by ecosystems. Still, conservation and restoration tools that do not require detailed or precise economic valuation estimates ex ante—including several of the insurance mechanisms discussed in Part III—are important and worthwhile. The next Section examines the current law and governance continuum to help situate the role of insurance within more standard policy approaches.

C. A Law and Governance Continuum for Ecosystems

A continuum of legal and private governance mechanisms exists to ensure the protection and, if necessary, restoration of ecosystem services. These include direct public law regulation that bans certain types of actions, regulatory permit-based systems, market-leveraging approaches like payments for ecosystem services that combine public law and private market activity, and acquisition of land by public or

72. *See* Salzman & Ruhl, *supra* note 71, at 622–30 (identifying nonfungibilities of space, time, and type); *see also* Mark L. Plummer, *Assessing Benefit Transfer for the Valuation of Ecosystem Services*, 7 FRONTIERS ECOLOGY & ENV'T 38, 38 (2009) ("[B]enefit transfer should not be pursued blindly. Not all ecological systems are pearls of great price.").

73. Economists have conducted research on income effects for certain nonmarket goods and services and broadly investigated how environmental protection in communities and countries varies with income levels. More problematic, however, is the concern that reported willingness-to-pay will be constrained by ability-to-pay and that the values of more affluent individuals could dictate policy. This raises serious environmental justice concerns that must enter any policy decision. *See infra* Part IV.

74. *See* Salzman, *Valuing Ecosystem Services*, *supra* note 4, at 894 (noting that estimating the future value of ecosystem services raises additional challenges).

75. *Id.* at 896–97.

private actors.[76] In addition, certain statutes provide for natural resource damages to restore impaired ecosystems. Who bears the cost of ensuring that the ecosystem services are provided or restored depends on the statute. Some laws place the costs on beneficiaries of the services, while others impose costs on taxpayers broadly. Still others charge landowners seeking to alter land use in ways that reduce the amount of services provided by their land.

While these methods may be effective in some contexts, they fall short in others. This is not simply a question of how the existing statutes are drafted—although modifying existing legal rules could improve their effectiveness at the margins. Rather, this Article's analysis demonstrates that there are some significant gaps in the operation of existing ex ante approaches to preventing harm to ecosystems regardless of whether they employ prescriptive rules, permit systems, market-leveraging approaches, or land acquisition programs. Ex post statutory schemes that seek to restore ecosystems—like statutes providing natural resource damages—also have significant weaknesses. At the most basic level, none of these regimes can easily account for the risk to ecosystems arising from catastrophic weather events. Rather, their aim is either (a) to direct how "persons"—be they natural persons or firms—manage ecosystems on privately owned land to prevent harm, or (b) to make responsible parties (which must also be "persons") pay for harm to ecosystems that they have caused. A catastrophic weather event, however, will not seek a permit from regulators before destroying a coral reef as a private land developer must. Nor will such a catastrophic weather event follow prescriptive regulations detailing how a wetland can be damaged. And market-leveraging approaches like payments for ecosystem services, which are based on a beneficiary pays principle, require the identification not only of beneficiaries but also of those who own the resources. Thus, traditional ecosystem services governance regimes falter when the ecosystem is unowned.

76. *See* J.B. Ruhl, *In Defense of Ecosystem Services*, 32 PACE ENVTL. L. REV. 306, 312–14 (2015) (discussing the rise of the ecosystem framework in environmental law and policy scholarship since its initial conceptualization in the 1990s); Lynn Scarlett & James Boyd, *Ecosystem Services and Resource Management: Institutional Issues, Challenges, and Opportunities in the Public Sector*, 115 ECOLOGICAL ECON. 3, 4–5 (2015) (discussing both specific statutory programs and broad policy statements permitting or requiring the preservation of ecosystems and noting challenges when addressing large spatial areas). On private environmental governance, see generally Light & Orts, *supra* note 25.

In addition to these overarching weaknesses, each governance regime comes with its own set of specific limitations. This final subsection of Part I briefly describes some of these existing methods of governance, as well as their shortcomings, with the aim of giving context to the Article's later discussion of insurance. Although insurance is not a panacea, it can fill some of the governance gaps that we identify here which traditional methods fail to address.[77]

1. *Prescriptive Rules*. Prescriptive rules are one mechanism to prevent harm to ecosystems. One of the strongest examples on the governance continuum for ecosystem services is the prescriptive Endangered Species Act ("ESA"). Section 9 of the ESA prohibits the "take" of any listed species.[78] The statute itself defines the term "take" to encompass "harm."[79] The Department of the Interior ("DOI")[80] has interpreted "harm" to include "an[y] act which actually kills or injures wildlife" which may include "significant habitat modification or degradation . . . by significantly impairing essential behavioral patterns,

77. *See* Light & Orts *supra* note 25, at 50–53 (noting that while insurance should be considered a primary tool of environmental governance, it is not always included in the environmental law "toolkit"). It is worth noting that these different forms of governance may fulfill different goals. For example, in some cases the goal is to prevent destruction of ecosystem services. In other cases, the goal is to repair damaged ecosystem services. In many cases, the existence of a governance regime provides secondary information about ecosystem services that can then be used to improve governance both through public law and private methods. Salzman, *Valuing Ecosystem Services*, *supra* note 4, at 898–99 (noting the importance of the creation of secondary information markets through existing regulations under the Oil Pollution Act, the Clean Water Act, and the National Environmental Policy Act, among others); *see also infra* Part IV.

78. Endangered Species Act of 1973, 16 U.S.C. § 1538(a)(1)(B) (2018) (providing that, absent an exception, it is unlawful for any person to "take any [endangered] species within the United States or the territorial sea of the United States").

79. *Id.* § 1532(19) (defining "take" to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct").

80. The Department of the Interior, acting through the Fish and Wildlife Service ("FWS"), is one of two agencies authorized to interpret this statute. *See Endangered Species: ESA Implementation Overview*, U.S. FISH & WILDLIFE SERV. (June 6, 2018), https://www.fws.gov/endangered/improving_esa/index.html [https://perma.cc/3EXE-XNPN] ("The U.S. Fish and Wildlife Service collaborates . . . to achieve on-the-ground conservation for species and habitats around the country."). The other is the Department of Commerce, acting through the National Marine Fisheries Service. *Endangered Species Conservation*, NOAA FISHERIES, https://www.fisheries.noaa.gov/topic/endangered-species-conservation [https://perma.cc/7W9V-CVST] ("NOAA Fisheries is responsible for the protection, conservation, and recovery of endangered and threatened marine and anadromous species under the Endangered Species Act.").

including breeding, feeding, or sheltering."[81] In *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*,[82] the Supreme Court upheld the DOI's definition of the term "harm," making clear that habitat cannot be significantly modified or destroyed if such modification actually kills or injures protected wildlife, even when that habitat exists on privately owned land.[83] In essence, the regulation (and decision) codified protections for habitat provision, a supporting ecosystem service that allows the continued delivery of a range of other services that depend on healthy animal and plant communities.[84]

In addition, § 7 of the ESA, which applies to federal agencies, more directly regulates actions that could jeopardize endangered or threatened species or harm their "critical habitat."[85] Specifically, that section provides that federal agencies must consult with the Secretary of the Interior or Commerce to ensure that "any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [critical] habitat of such species," absent an exemption.[86] While this section might appear to have a narrower scope, both because it only applies to a subset of habitat—critical habitat—and because it only applies to federal agencies, the section actually sweeps quite broadly. Because federal permitting, licensing, and funding decisions are covered under this provision, § 7's direction that critical habitat should not be adversely modified operates comprehensively.[87] And by virtue of this

81. 50 C.F.R. § 17.3 (2019) ("*Harm* in the definition of 'take' in the Act means an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.").

82. Babbitt v. Sweet Home Chapter of Cmtys. for a Great Or., 515 U.S. 687 (1995).

83. *Id.* at 697–703.

84. *Ecosystem Services & Biodiversity (ESB)*, FOOD & AGRIC. ORG. OF THE UNITED NATIONS, http://www.fao.org/ecosystem-services-biodiversity/background/supporting-services/en [https://perma.cc/W8XX-TFNQ]; *see supra* note 29 and accompanying text.

85. 16 U.S.C. § 1536 (2018). Critical habitat is a subset of "habitat," which is not defined under the ESA. *See* Weyerhaeuser Co. v. U.S. Fish & Wildlife Serv., 139 S. Ct. 361, 369 (2018) (holding that "critical habitat" must also be "habitat"). The Act defines "critical habitat" as "specific areas" within and outside "the geographical area occupied by the species" at the time of listing on which physical or biological features that are "essential to the conservation of the species" and "which may require special management considerations or protection" are found. 16 U.S.C. § 1532(5)(A)(i).

86. 16 U.S.C. § 1536(a)(2).

87. The *Weyerhaeuser* Court noted that "[a] critical-habitat designation does not directly limit the rights of private landowners" but rather operates indirectly such that if the Secretary of the Interior determines that a federal agency permitting decision would adversely affect critical

broad mandate, § 7 also applies to a large swath of private actions, including many commercial, residential, or industrial efforts to develop land.[88]

However, the ESA's prohibitions are not absolute. While the ESA is on the strong end of the governance continuum for ecosystems, it is not without exception. For example, federal agencies whose actions may jeopardize listed species or adversely modify critical habitat can seek an exemption from the Endangered Species Committee, a cabinet-level body specifically empowered to authorize such actions.[89] In addition, the Committee may grant an exemption if the Secretary of Defense finds such an exemption is necessary for national security reasons.[90] And the Secretary of the Interior or Commerce may likewise permit "any taking" otherwise prohibited by § 9 "if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."[91] Such an "incidental take" permit under § 10 must be accompanied by a habitat conservation plan that spells out the steps an applicant will take to mitigate harm to endangered species. However, these plans have been criticized for failing to adequately protect listed species and their habitats.[92]

The ESA also has other limitations. First, while the determination of whether a species should be *listed* as endangered or threatened is to be made solely on the basis of "the best scientific and commercial data available," a determination of *critical habitat*—the ecosystem-services determination—permits the consideration of both the best scientific data and the "economic impact, the impact on national security, and

habitat, "the agency must terminate the action, implement an alternative proposed by the Secretary, or seek an exemption from the Cabinet-level Endangered Species Committee." 139 S. Ct. at 365–66.

88. Jessica Owley, *Keeping Track of Conservation*, 42 ECOLOGY L.Q. 79, 86–87 (2015).

89. 16 U.S.C. § 1536(e)–(h) (defining the composition of the Committee, procedures for seeking an exemption, and the basis on which exemptions may be granted). Because this Committee essentially has the power to permit an endangered species to become extinct, it has been dubbed the "God Squad." ROCKY BARKER, SAVING ALL THE PARTS: RECONCILING ECONOMICS AND THE ENDANGERED SPECIES ACT 20, 155 (1993) (explaining the history of the "God Squad" nickname).

90. 16 U.S.C. § 1536(j).

91. *Id.* § 1539(a)(1)(B).

92. Owley, *supra* note 88, at 89–93 (critiquing the lack of sufficient public participation in habitat conservation plans, their lack of funding, and the lack of follow up to determine their effectiveness); J.B. Ruhl, *How To Kill Endangered Species, Legally: The Nuts and Bolts of Endangered Species Act "HCP" Permits for Real Estate Development*, 5 ENVTL. L. 345, 352–53 (1999). As of 2015, nearly seven hundred habitat conservation plans had been issued. Owley, *supra* note 88, at 89.

any other relevant impact, of specifying any particular area as critical habitat."[93] Second, while ecosystems provide numerous services, the ESA only protects an ecosystem when a single one of those services—habitat provision—is in jeopardy. As a result, other modifications to an ecosystem that negatively affect ecosystem services, but that do not affect endangered or threatened species, cannot trigger the ESA's prescriptions.[94] Third, the ESA does not cover a situation in which the habitat is destroyed or degraded as a result of an action not undertaken by a "person," such as that resulting from an extreme weather event. Fourth, the ESA does not provide any compensation or funding to restore ecosystem services that have been degraded or destroyed. Finally, the costs of preserving the ecosystem services are primarily borne by the private landowner seeking to develop the property. Thus, while the ESA's prescriptive rules provide some strong protections, they are limited, and its approach is of little help in restoring ecosystem services once they are degraded.

2. *Regulatory Permits*. A second, related approach to protecting ecosystem services requires private actors to obtain a permit before undertaking land use changes or other actions that could degrade those services.[95] This approach is perhaps best exemplified by the Clean Water Act's ("CWA") § 404 permit regime.[96] Section 301 of the CWA generally prohibits the discharge of any "pollutant" into the waters of the United States by any person.[97] "Pollutant" is defined

93. 16 U.S.C. § 1533(b)(2). On August 27, 2019, the Departments of the Interior and Commerce published a final rule interpreting this section that recognizes that the listing decision is to be made "*solely* on the basis of the best available scientific and commercial information regarding a species' status," 50 C.F.R. § 424.11(b) (emphasis in original), but deletes the words "without reference to possible economic or other impacts of such determination" on the basis that the Act "does not prohibit the Services from compiling economic information or presenting that information to the public, as long as such information does not influence the listing determination." Dep't of the Interior (FWS), Dep't of Commerce (NOAA), Endangered and Threatened Wildlife and Plants; Regulations for Listing Species and Designating Critical Habitat, 84 Fed. Reg. 45020, 45024 (Aug. 27, 2019). On September 25, 2019, seventeen states, the City of New York, and the District of Columbia sued these Departments to challenge this and other changes to the regulations under the ESA. Complaint, California v. Bernhardt, No. 3:19-cv-06013 (N.D. Cal. Sept. 25, 2019).

94. Of course, if the habitat of an endangered or threatened species must be protected, then protection of the habitat will protect other ecosystem services provided by that habitat.

95. In practice, the Clean Water Act permit program is ultimately not so different from the approach under the ESA, which contains a prohibition, but allows applications for exemptions.

96. Clean Water Act, 33 U.S.C. § 1344(a) (2018).

97. *Id.* § 1311(a) (explaining that except in compliance with the CWA permit systems, "the discharge of any pollutant by any person shall be unlawful").

broadly and is not limited to toxic pollutants, but includes such ordinary materials as sand.[98] However, § 404 of the Act allows discharges of "dredged or fill material" into such waters, if the person first obtains a permit from the Army Corps of Engineers.[99] The Army Corps and the EPA, which has regulatory authority under other sections of the Act, have jointly issued regulations over the years that interpret the term "waters of the United States" to include some wetlands.[100] Unlike the ESA, which only protects one type of ecosystem service—habitat provision—the § 404 permit program, which is triggered by the placement of dredged or fill material into a wetland, applies regardless of what ecosystem services the discharge of dredged or fill material might endanger.

The § 404 permit regime is limited in four ways, however. First, like the ESA, the CWA's protections are not absolute, because numerous § 404 permits are granted each year—indeed, that is the very

---

98. *Id.* § 1362(6); Eric Biber & J.B. Ruhl, *The Permit Power Revisited: The Theory and Practice of Regulatory Permits in the Administrative State*, 64 DUKE L.J. 133, 160 (2014) (discussing the § 404 permit program and noting the broad definition of pollutant to include sand).

99. 33 U.S.C. § 1344. In reviewing these permits, the Army Corps follows guidelines adopted jointly with the EPA. *See generally* Memorandum Between The Department of the Army and The Environmental Protection Agency (Jan. 1989) (allocating enforcement authority between the Army and the EPA and noting that both agencies share this authority under the CWA). For a look at these guidelines see U.S. ARMY CORPS OF ENG'RS, U.S. ARMY CORPS OF ENGINEERS PERMITTING PROCESS INFORMATION, https://www.lrl.usace.army.mil/Portals/64/docs/regulatory/Permitting/PermittingProcessInformation.pdf [https://perma.cc/Z9HH-2P9K]. In some cases, when a permit is granted, the harm to the wetland requires the purchase of offsets through wetlands mitigation banking. Because one acre of wetland in one location is not necessarily equivalent to one acre of wetland elsewhere in terms of the services provided, wetland mitigation banking has been criticized. Salzman & Ruhl, *supra* note 71, at 607 (calling into question the rationale for using environmental trading markets).

100. 33 U.S.C. § 1344(b) (noting that the Army Corps's permit decisions must be made through the application of guidelines developed by the EPA administrator "in conjunction with" the Secretary of the Army); Rapanos v. United States, 547 U.S. 715, 732–39 (2006) (holding that the regulatory definition of "waters of the United States" adopted by the Army Corps and the EPA was too broad, but offering competing definitions of the test for whether wetlands qualify for federal protection); 33 C.F.R. § 328.3(a)(1) (2018) (defining traditionally navigable waters and adjacent wetlands to include those that have a "significant nexus" to traditionally navigable waters); *id.* § 328.3(c) (defining "adjacent wetlands" to include wetlands bordering traditionally navigable waters even if "separated from [such] waters . . . by constructed dikes . . . and the like"). Most recently, on September 12, 2019, the EPA and Army Corps jointly published a final rule to repeal the more expansive 2015 definition of "Waters of the United States" and to "restore the regulatory text that existed prior to the 2015 Rule." *See* U.S. DEP'T OF DEFENSE & U.S. ENVTL. PROT. AGENCY, EPA-HQ-OW-2017-0203, PRE-PUBLICATION NOTICE: DEFINITION OF "WATERS OF THE UNITED STATES"—RECODIFICATION OF PRE-EXISTING RULES (Signed Sept. 12, 2019), https://www.epa.gov/sites/production/files/2019-09/documents/wotus_rin-2040-af74_final_frn_prepub2.pdf [https://perma.cc/ES9L-DXSW].

purpose of a permit program.[101] Second, like the ESA, the CWA only prohibits "persons" from engaging in a specific action—placing dredged or fill material into waters of the United States from a point source.[102] It does not contemplate or address harm to wetland ecosystems that result from natural disasters or extreme weather events.

Third, uncertainty about what qualifies as a wetland for purposes of the Act has limited the protective capacity of this statute over time. The shifting definition of "waters of the United States" has been controversial for many years because it implicates whether the federal government has control over what some consider to be "local" land use decisions.[103] In 2015, the Obama administration adopted the Clean Water Rule, with a relatively broad definition of the term.[104] That rule was immediately subject to litigation.[105] On December 11, 2018, the Trump administration issued a proposed rule narrowing the scope of the wetlands covered under this provision to those with a surface connection to traditionally navigable waters.[106] And on September 12, 2019, the EPA and Army Corps of Engineers issued a final rule

101. For a permit to be granted, an applicant must make efforts to avoid and minimize the most harmful effects on the resource and may be required to engage in "compensatory mitigation" such as the preservation of other ecosystems or wetlands through mitigation banking. 40 C.F.R. § 230 (2019). However, scholars have criticized some of these measures as inadequate, because offsets that preserve wetlands in other locations are generally not comparable. Salzman & Ruhl, *supra* note 71, at 607.

102. 33 U.S.C. § 1311(a) (stating that except in compliance with the CWA permit systems, "the discharge of any pollutant by any person shall be unlawful").

103. Biber & Ruhl, *supra* note 98, at 161–62 (describing the "long and often tortuous history" of the evolving geographic reach of the § 404 permit program); *Rapanos*, 547 U.S. at 737–38 (expressing the concern that the expansive definition of the term would intrude on the states' "traditional and primary power over land and water use" (quoting Solid Waste Agency of N. Cook Cty. v. U.S. Army Corps of Eng'rs, 531 U.S. 159, 174 (2001))). It is worth noting that in *Weyerhaeuser Co. v. U.S. Fish & Wildlife Service*, 139 S. Ct. 361 (2018), the Supreme Court indicated that while the ESA defines the term "critical habitat," it does not define the term "habitat." *Id.* at 369. Thus, the definition of the term "habitat" may, like the definition of the term "waters of the United States," be a basis for future battles over the scope of federal protection of endangered and threatened species. *See supra* note 85 and accompanying text. Thanks also to J.B. Ruhl for discussions on this point.

104. Clean Water Rule: Definition of "Waters of the United States," 80 Fed. Reg. 37,104 (June 29, 2015); 33 C.F.R. § 328.3(a) (2018) (using the "significant nexus" standard for wetlands adjacent to traditionally navigable waters).

105. Nat'l Ass'n of Mfrs. v. Dep't of Def., 138 S. Ct. 617, 635–27 (2018) (noting that multiple parties had challenged the Clean Water Rule in both district courts and courts of appeals and discussing the history of the shifting definitions).

106. Revised Definition of "Waters of the United States," 83 Fed. Reg. 67174 (Dec. 28, 2018) (to be codified at 33 C.F.R. pt. 328, 40 C.F.R. pts. 110, 112, 116, 117, 122, 232, 300, 302, and 401).

formally revoking the 2015 Clean Water Rule and reinstating the regulatory definition that existed prior to 2015.[107] The agencies indicated that they would issue the final substantive rule in the future.[108] This significant uncertainty leaves open to question the extent to which wetlands and the ecosystem services they provide will be protected from development. Some significant ecosystem services could remain unprotected by this federal permit program.[109]

Finally, § 404 does not address the restoration of damaged wetlands. Rather, the general aim of the permit system is mitigation or prevention of harm ex ante. And as in the ESA, all of these costs are borne by the entity seeking to develop the property. Accordingly, while the § 404 permit system serves important goals by helping to prevent the destruction of some wetlands and their ecosystem services, it does not adequately address concerns about scope and restoration raised here. As noted above, absolute protection of an ecosystem is simply incompatible with the notion of a permit system that allows some destruction under some circumstances.

3. *Market-Leveraging Approaches: Payments for Ecosystem Services*. A third approach to ecosystem-service protection relies on market-based or incentive-based mechanisms.[110] These cost-effective policy approaches harness the market to achieve beneficial environmental outcomes. Examples include taxes, subsidies, and tradable permit systems.

Payments for ecosystem services ("PES") are yet another market-based approach to providing ecosystem services that have risen to prominence in the last several decades.[111] Dr. Sven Wunder has defined

---

107. *See supra* note 100.

108. EPA, *U.S. Army Repeal 2015 Rule Defining "Waters of the United States" Ending Regulatory Patchwork* (Sept. 12, 2019), https://www.epa.gov/newsreleases/epa-us-army-repeal-2015-rule-defining-waters-united-states-ending-regulatory-patchwork [https://perma.cc/HY33-Z9BV].

109. Indeed, while federal regulation might not protect a wetland, the CWA permit program provides that the states have a role to play and could nonetheless protect ecosystem services provided by wetlands more stringently. *See* Sarah E. Light, *Regulatory Horcruxes*, 67 DUKE L.J. 1647, 1666–67 (2018) (observing that states play a backstop role under the CWA, even in the face of narrowing federal protections).

110. *See generally* Robert W. Hahn & Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea?*, 18 ECOLOGY L.Q. 1 (1991) (addressing and investigating issues regarding market-based approaches).

111. James Salzman et al., *The Global Status and Trends of Payments for Ecosystem Services*, 1 NATURE SUSTAINABILITY 136, 137–40 (2018) [hereinafter Salzman et al., *Global Status and Trends*] (surveying and evaluating the effectiveness of extant global examples of PES, including

"[a] PES scheme . . . [a]s a voluntary, conditional agreement between at least one 'seller' and one 'buyer' over a well-defined environmental service—or a land use presumed to produce that service."[112] The mechanism of PES relies upon a simple premise: the services that ecosystems can provide to consumers are not so different from the valuable goods they provide for sale in the marketplace.[113] Indeed, many scholars have recognized that markets can provide financial incentives to protect ecosystem services on private lands.[114] Ultimately, the PES approach suggests that the beneficiary of the service should pay, or bear the costs, of ecosystem-service provision.[115]

PES schemes can take a number of different forms depending on who is "buying" and who is "selling" the services. Because ecosystem services are public goods, the government (which is ultimately funded by society through taxes or other government revenue) often fills the role of the buyer, using its payments to ensure private actors provide the service.[116] Who bears the costs of these services can be more dynamic, however, so one group of scholars has recently classified PES schemes into three broad types: voluntary PES, subsidy PES, and compliance PES.[117] In a voluntary PES program, private parties benefit from the ecosystem services and voluntarily enter into some kind of contractual agreement to compensate the landowners.[118] In a subsidy PES program, the government or some other public entity pays the landowners whether or not the government is a "direct beneficiary" of the services.[119] Finally, in compliance PES programs, parties acting

watershed PES, forest and land use carbon sequestration, biodiversity, and habitat protection); *cf.* S. Naeem et al., *Get the Science Right When Paying for Nature's Services*, 347 SCIENCE 1206, 1207 (2015) (proposing guidelines and principles to govern the use of natural science in research and analysis of PES mechanisms).

112. Sven Wunder, *The Efficiency of Payments for Environmental Services in Tropical Conservation*, 21 CONSERVATION BIOLOGY 48, 48 (2007).

113. *Id.* at 49.

114. Thompson, *supra* note 29, at 462 ("Rather than being viewed as a 'public good' that governments provide because it is the 'right thing to do,' ecosystems could become valuable economic assets that people privately pay to conserve for the valuable services that the ecosystems provide.").

115. Stefanie Engel, Stefano Pagiola & Sven Wunder, *Designing Payments for Environmental Services in Theory and Practice: An Overview of the Issues*, 65 ECOLOGICAL ECON. 663, 663–64 (2008).

116. *Id.* at 663.

117. Salzman et al., *Global Status and Trends*, *supra* note 111, at 136 (offering these three categories).

118. *Id.* (explaining the three categories of PES programs).

119. *Id.*

pursuant to some regulatory obligation like the CWA § 404 permit program purchase "offsets" of comparable ecosystems services to mitigate any harms they may cause if their development project moves forward.[120]

There are many examples of PES programs globally. For instance, in the United States, the Conservation Reserve Program ("CRP") pays farmers to promote land-conservation practices on their farms, including the preservation of topsoil and wildlife-habitat conservation.[121] In Australia, the State of Victoria's Department of Natural Resources and Environment adopted a PES program to promote the conservation of native vegetation on privately owned land.[122] In 1997, Costa Rica adopted a PES program called Pagos por Servicios Ambientales.[123] This program authorizes the government to enter into contracts with private landowners to pay them for providing carbon sequestration, biodiversity conservation, aesthetic services that promote tourism, and water-quality protection.[124] China also has extensive PES programs under the Sloping Lands Conversion Program, which pays farmers not to cultivate steep slopes to protect water quality and flood-control services.[125]

In some respects, PES programs are a superior approach to prescriptive regimes like the ESA (especially from the perspective of the landholder). Namely, under a PES scheme, the landholder actually derives some financial value from the payments. In contrast, regulatory schemes like § 9 of the ESA arguably burden landowners with the cost of compliance without providing additional financial benefits. However, PES programs have been the subject of criticism as well.[126]

---

120. *Id.*

121. 16 U.S.C. §§ 3801–3836 (2018); 7 C.F.R. pt. 1410 (2018); Salzman, *Creating Markets*, *supra* note 12, at 892; Farm Serv. Agency, *Conservation Reserve Program*, U.S. DEP'T OF AGRIC., https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program [https://perma.cc/QK6A-RKCU]. The program was signed into law in 1985 by President Reagan and provides that farmers enter into long-term contracts with the U.S. Farm Service Agency lasting between ten and fifteen years, on average. *Id.*

122. Salzman, *Creating Markets*, *supra* note 12, at 892–97.

123. *Id.* at 898. For an analysis of the Costa Rica program, see generally Kenneth M. Chomitz, Esteban Brenes & Luis Constantino, *Financing Environmental Services: The Costa Rican Experience and Its Implications*, 240 SCI. TOTAL ENV'T 157 (1999).

124. Chomitz, Brenes & Constantino, *supra* note 123, at 158.

125. Salzman et al., *Global Status and Trends*, *supra* note 111, at 137.

126. *See, e.g.*, Kai M.A. Chan et al., *Payments for Ecosystem Services: Rife with Problems and Potential—For Transformation Towards Sustainability*, 140 ECOLOGICAL ECON. 110, 110–22 (2017); Nicolás Kosoy & Esteve Corbera, *Payments for Ecosystem Services as Commodity Fetishism*, 69 ECOLOGICAL ECON. 1228, 1228–36 (2010); R. Muradian et al., *Payments for*

Notably, while PES programs can lead to greater conservation on certain parcels of land, destructive environmental practices can just shift elsewhere—a process known as "leakage" or "slippage."[127] In other words, a PES program does not guarantee a minimum total level of service is provided. And while PES might be effective when ecosystems are located on private land, it is not clear how they would fare on public lands and waters or ecosystems like the ocean that are not "owned" by private landowners.

4. *Land Acquisition*. Public and private actors can wield property law to protect ecosystem services, primarily through land acquisition. In the purely public context, for example, governments can use the power of eminent domain to preserve ecosystem services.[128] To illustrate, when New York City chose to use natural capital to protect its drinking water supply rather than construct a water filtration plant, it used the power and threat of eminent domain to acquire land for a system of reservoirs and surrounding properties to ensure the purity of its water.[129] Alternatively, governments can designate areas as national, state, or local public lands.[130] In the private realm, nongovernmental or

Ecosystem Services and the Fatal Attraction of Win Win Solutions, 6:4 CONSERVATION LETTERS 274, 274–79 (2013); Mike Gaworecki, *Cash for Conservation: Do Payments for Ecosystem Services Work?*, MONGABAY (Oct. 12, 2017), https://news.mongabay.com/2017/10/cash-for-conservation-do-payments-for-ecosystem-services-work [https://perma.cc/3U2E-F2JE].

127. *See* Engel, Pagiola & Wunder, *supra* note 115, at 670–71 (defining leakage and slippage). For one study that measured slippage impacts for the case of a PES program in Mexico, see generally Jennifer M. Alix-Garcia, Elizabeth N. Shapiro, & Katharine R. E. Sims, *Forest Conservation and Slippage: Evidence from Mexico's National Payments for Ecosystem Services Program*, 88 LAND ECON. 613 (2012).

128. Kalyani Robbins, *Allocating Property Interests in Ecosystem Services: From Chaos to Flowing Rivers*, 42 HARV. ENVTL. L. REV. 197, 207–10 (2018) (discussing the power of eminent domain to protect ecosystem services but observing that property rights in the services themselves are unclear and conflicting in different contexts).

129. *Id.* at 207.

130. J.B. Ruhl, *Ecosystem Services and Federal Public Lands: Start-Up Policy Questions and Research Needs*, 20 DUKE ENVTL. L. & POL'Y F. 275, 276 (2010) (observing that as the "largest landowner in the nation," the federal government and its land management agencies should naturally be concerned with how to "manage the flow of ecosystem services on and off of its landholdings"). These four land management agencies are the Forest Service, the Bureau of Land Management, the Fish and Wildlife Service, and the National Parks Service. *Id.* at 278. Ruhl contends that these agencies' missions are not styled in relation to the provisioning of ecosystem services, and indeed, that federal lands are not solely concerned with those services that have economic value. *Id.* at 279. Rather, the protection of ecosystem services is "only . . . an incidental effect of implementing the conservation goal." *Id.* at 279.

conservation organizations like The Nature Conservancy can purchase and set aside land for conservation purposes.[131]

Although land acquisition can further the conservation of ecosystem services, it also has flaws. On the one hand, land ownership can be overprotective of ecosystem services. It may not always necessary to protect *all* of the services on a parcel at any cost—perhaps only the vegetation must be preserved, for example. At the same time, ownership can also underprotect ecosystem services because merely holding title to land does not guarantee that government appropriations (in the case of public lands) or private funds (in the case of private conservation land) will be available to finance ecosystem restoration. Finally, even powerful tools like eminent domain have transaction costs—such as legal fees arising from challenges to condemnation proceedings—and might require paying a stiff political price, as well.[132]

5. *Natural Resource Damages and Liability Rules*. Each of the tools addressed up to this point has largely focused on preventing harm to ecosystem services rather than restoration after damage. However, certain statutory mechanisms can be employed both to prevent damage in the first place and restore ecosystems if they are degraded. For example, when companies or individuals damage an ecosystem, tort law and statutory liability rules can provide funds for restoration while simultaneously acting to deter such behavior in the future.[133]

There are two well-established programs under U.S. law that address liability for restoration: provisions for natural resource damages under the Comprehensive Environmental Response,

131. Thomas C. Brown, John C. Bergstrom & John B. Loomis, *Defining, Valuing, and Providing Ecosystem Goods and Services*, 47 NAT. RESOURCES J. 329, 361 (2007) (noting that property ownership, either by public or private entities, is the "most obvious way to constrain the practices permitted on a plot of land"). There are lesser methods of limiting use of land than outright ownership, including through regulatory means such as a Wild and Scenic River or wilderness designation. *Id.*

132. R. H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386, 390 (1937) (discussing legal or regulatory costs as transaction costs). Such costs may include attorneys' fees, expert-witness fees, and other litigation costs. *See* Douglas Ayer, *Allocating the Costs of Determining "Just Compensation*,*"* 21 STAN. L. REV. 693, 698–99 (1969) (discussing costs in eminent domain litigation).

133. The term "liability rule" refers to an entitlement that may be destroyed if someone is "willing to pay an objectively determined value for it" such as a value determined by a court. Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1092 (1972).

Compensation, and Liability Act ("CERCLA"),[134] also known as Superfund, and similar provisions under the Oil Pollution Act ("OPA").[135] Under these statutes, "natural resources" are defined as "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by" the United States, or a state, local, tribal, or foreign government.[136] Natural resource "damages" are the result of the "injury or loss of natural resources," and include the cost of restoring the resource to its baseline condition, compensation for the interim loss of injured resources pending recovery, and the reasonable cost of a damage assessment.[137]

While these programs directly address the restoration of damaged natural resources—a tool exactly on point with the problems raised here—they also have their flaws. The first limitation is their timing. The assessment and restoration of natural resource damages generally "takes place *following* cleanup."[138] This is so because some cleanups also "effectively restore habitat."[139] However, not all cleanups restore all of the relevant damaged ecosystems, and thus restoration must sometimes wait. Cleanups under CERCLA and the OPA can take years or even decades.[140] And many cases settle with long time horizons for payment and restoration. For example, after the 2010 explosion at British Petroleum's ("BP") Deepwater Horizon oil rig caused the most severe oil spill in U.S. history, BP settled and agreed to pay up to $8.8 billion for the restoration of natural resources including wildlife

---

134. Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), Pub. L. No. 96-510, §§ 101(6), 107(a)(4)(C), 94 Stat. 2767, 2767, 2781 (codified as amended in scattered sections of the U.S. Code).

135. Oil Pollution Act of 1990 ("OPA"), Pub. L. No. 101-380, §§ 1001(5), 1002(b)(2), 104 Stat. 484, 486, 489–90 (codified as amended at 33 U.S.C. §§ 2701(5), 2702(b)(2) (2018)); Natural Resource Damage Assessments, 43 C.F.R. pt. 11 (2018); Natural Resource Damage Assessments, 15 C.F.R. pt. 990 (2018).

136. CERCLA § 101(16) (codified as amended at 42 U.S.C. § 9601(16) (2018)); OPA § 1001(20) (codified as amended at 33 U.S.C. § 2701(20)).

137. CERCLA §§ 101(6), 107(a)(4)(C) (codified as amended at 42 U.S.C. § 9601(6), 9607(a)(4)(c)); OPA §§ 1001(5), 102(b)(2) (codified as amended at 33 U.S.C. §§ 2701(5), 2702(b)(2)); 43 C.F.R. § 11.14(l); 15 C.F.R. § 990.30.

138. *Natural Resource Damages: A Primer*, U.S. ENVTL. PROT. AGENCY (emphasis added), https://www.epa.gov/superfund/natural-resource-damages-primer [https://perma.cc/PK5X-DUZX].

139. *Id.*

140. *Superfund: National Priorities List (NPL)*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/superfund/national-priorities-list-npl-sites-state [https://perma.cc/T6HA-P66G] (listing some sites on the National Priorities List for remediation since the 1980s).

refuges, habitats, water quality, migratory birds, threatened and endangered species, and federal lands.[141] But the payment schedule under the settlement lasts fifteen years.[142] Thus, it can be years or even decades before damaged resources are restored and returned to baseline conditions. Second, liability regimes require the identification of the person or entity responsible for the damages. As a result, these regimes cannot easily account for damages from severe weather events that arguably have no identifiable responsible party or parties causing them. To be sure, while sometimes there is a responsible party and sometimes there are such significant damages to natural resources that they will necessarily take time to restore, in other cases the damage is caused by extreme weather events and restoration can and must proceed quickly.

To summarize, there are many different public policy and private governance instruments that promote the conservation of ecosystem services, though some have limited scope. While there is at least one policy instrument (natural resource damages) that broadly promotes their restoration once damaged, CERCLA and the OPA have a narrow focus on certain types of pollution that requires identifying a defendant. And neither regime provides restoration funds quickly. As such, none of these instruments promotes the speedy restoration of ecosystem services that lack an owner or that are injured by an event rather than by the actions of a "person." Therefore, it is worth looking to innovative tools—like insurance—to determine whether it is possible to fill these gaps.

II. THE ROLE OF INSURANCE

This Part identifies and explains the basics of insurance as a form of governance that transfers risk and provides incentives for risk-reducing activities. It then discusses the conditions of insurability and explains the differences between two primary forms of insurance: indemnity-based insurance and parametric insurance. This discussion includes an evaluation of the circumstances under which insurance is and ought to be private or public. The next Part then builds on this basic primer to explore how insurance can be used in innovative ways

141. Nanciann Regalado, *Historic NRDAR Settlement Reached for Deepwater Horizon Spill*, U.S. DEP'T OF THE INTERIOR (June 21, 2016), https://www.doi.gov/restoration/historic-nrdar-settlement-reached-deepwater-horizon-spill [https://perma.cc/TBX9-EDYL].

142. *Id.*

to protect and restore ecosystems, particularly in the context of climate change.

A. Transferring Risk

Insurance is a tool to smooth income. Insureds pay a set amount—the premium—to guarantee access to funds should they suffer specified damages. Risk averse individuals are willing to pay more than their expected loss in order to transfer risk to another entity with more ability to pool the risk.[143] This is because, for a risk averse individual, it is welfare enhancing to transfer funds from a state of the world with no loss to the state of the world in which a loss occurs.[144] Insurance is thus an important part of risk management. It provides protection against a financial loss that the insured could not otherwise fund on his or her own or that would otherwise require diverting current income, taking on additional debt, or using savings in order to pay.

Insurance's risk-transferring ability can also promote beneficial economic activities which might not otherwise be undertaken, especially when the potential losses associated with the activities are devastating.[145] Consider, for example: medical liability insurance, which allows physicians to work without worry of being bankrupted by a lawsuit; mortgage insurance, which protects lenders who may not otherwise write certain loans; auto insurance, which empowers people to drive without having to set aside a large fund to cover possible accident damages; or the financial protection against accidents provided to those constructing high-rises or infrastructure.[146]

Insurance is, therefore, a tool that provides access to substantial capital in disaster situations—when such capital is most needed. However, if money cannot replace what was lost, insuring the object

---

143. For a broader discussion of insurance, see generally Howard Kunreuther & Mark Pauly, *Insurance Decision-Making and Market Behavior*, 1 FOUND. & TRENDS IN MICROECON. 63 (2006).

144. Insurance thus transfers income from states where the marginal utility of income is low to those where the marginal utility of income is high. *See* David M. Cutler & Richard Zeckhauser, *Extending the Theory to Meet the Practice of Insurance*, *in* BROOKINGS-WHARTON PAPERS ON FINANCIAL SERVICES 5 (Robert Litan & Richard Herring eds., 2004).

145. On the broad contributions of insurance to the economy, see generally STEVEN WEISBART, HOW INSURANCE DRIVES ECONOMIC GROWTH (2018), https://www.iii.org/sites/default/files/docs/pdf/insurance-driver-econ-growth-053018.pdf [https://perma.cc/9FUN-ERDY].

146. One example is the "Big Dig" project in Boston, undertaken to improve congestion, reclaim greenspace, and reduce greenhouse gas emissions. It would not have been initiated had it not been possible for all the contractors and construction companies involved to have purchased insurance. *See id.* at 12–13.

does not make sense. For instance, family photographs that hold sentimental value but little financial value cannot be insured. Being paid some amount of money if they are damaged will not make it possible to replace them. Some natural resources and ecosystem services are similarly uninsurable. For example, no amount of money could replace the loss of Methuselah, the oldest living tree. On the other hand, many ecosystems can be repaired or restored with proper post-disaster funding. This could include capital to repair damaged coral, to replant a burnt forest, or to stabilize slopes with new plantings.

There are other times insurance may not be an appropriate tool. For example, insurance is not necessary for inconsequential risks, such as the risk of breaking a chair or a plate. Administrative costs would make it uneconomic to transfer these risks to others, as they can easily be handled directly by the insured. At the other end of the spectrum, systemic and catastrophic risks—risks that impact a large population with catastrophic losses (such as an asteroid strike or nuclear war)—will also not be cost-effective to transfer. They are simply too expensive for even a globally diversified insurance company to insure.[147]

With these limits in mind, economists have developed a framework of ideal insurability conditions.[148] Namely, to be insurable, risks must be random, well-enough understood to make pricing and underwriting possible, diversifiable, and exist in markets with low levels of moral hazard and adverse selection. Each of these conditions is discussed in turn.

First, losses must be due to random chance. There must be a *risk*, rather than a *certainty*.[149] No insurer would write a policy for a known adverse event at a price less than the full cost because risk transfer in that situation produces no gain. Therefore, long-term, inevitable threats such as sea-level rise cannot typically be insured against. The risk in any given year of tidal flooding, however, may be insurable.

Second, the risk must be well-enough understood to allow for pricing and underwriting. If the risk is not well understood, insurers

---

147. *See* Christian Gollier, *About the Insurability of Catastrophic Risks*, 22 GENEVA PAPERS ON RISK & INS. 177, 179 (1997). For a broader discussion of catastrophic risks and how to manage them, see generally RICHARD A. POSNER, CATASTROPHE: RISK AND RESPONSE (2004).

148. *See, e.g.*, Cutler & Zeckhauser, *supra* note 144, at 3–5 (discussing insurability conditions for health, life, personal property, business liability, and terrorism insurance); Joan T. Schmit, *A New View of the Requisites of Insurability*, 53 J. RISK & INS. 320, 320–21 (2004) (listing the seven requisites of ideally insurable risk).

149. FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT 197–232 (1921) (distinguishing risk from uncertainty).

cannot determine how much premium to charge or whether a risk is worth adding to their portfolio. For instance, the insurer may worry about the potential for catastrophic losses if they price premiums too low or accept too many high risks. Often pricing is done using historic data, but also—especially for rare, changing, or uncertain risks—with modeling.[150] Risks do not have to be perfectly estimated, however, since insurers can and do charge higher prices for risks that are ambiguous or difficult to model.[151] But if insurers are too uncertain about a risk, they may shy away from the market completely.

Third, risk pooling must be possible. This requires a substantial number of insureds whose risks are independent of each other and for which catastrophic losses are not possible. These are the conditions under which the average claim approaches the expected value (thanks to the Law of Large Numbers) and the policyholder's expected loss will be approximated by the population's expected loss (thanks to the Central Limit Theorem).[152] In this case, the premium charged can be closer to the expected loss, plus any administrative loadings. As a result, an insurance firm can be more confident that its revenues will be sufficient to cover losses in any given year and prevent bankruptcy.[153]

Disaster risks, however, can be both dependent and catastrophic, making them more difficult to insure. For instance, when one person gets into an automobile accident, it does not make it more likely that all of her neighbors will as well. But when a hurricane or flood occurs, entire communities all sustain damage at the same time, meaning the insurer must pay them all at the same time. Disasters can also be extreme in magnitude. Many natural disasters have fat-tailed distributions, meaning there is a higher-than-normal probability of a very severe event. As such, insurers need to have access to very large amounts of capital in a given year to cover disaster losses without going

150. On catastrophe risk modeling, see generally CATASTROPHE MODELING: A NEW APPROACH TO MANAGING RISK (Patricia Grossi & Howard Kunreuther eds., 2005).

151. Robin M. Hogarth & Howard Kunreuther, *Ambiguity and Insurance Decisions*, 75 AM. ECON. REV. 386, 387–89 (1985).

152. These two related mathematical theorems are the basis for risk pooling. As more risks are added to the pool, the variation is reduced, and it is less likely that funding will be insufficient. For a discussion of these theorems and their application to insurance, see generally Michael L. Smith & Stephen A. Kane, *The Law of Large Numbers and the Strength of Insurance*, *in* INSURANCE, RISK MANAGEMENT, AND PUBLIC POLICY: ESSAYS IN MEMORY OF ROBERT I. MEHR (Sandra G. Gustavson & Scott E. Harrington eds., 1994).

153. For a deeper treatment, see generally Ray Rees & Achim Wambach, *The Microeconomics of Insurance*, 4 FOUND. & TRENDS IN MICROECON. 1 (2008).

bankrupt—more than they take in from annual premiums.[154] This can make disaster insurance prohibitively expensive.

Finally, the market must also be subject to minimal levels of moral hazard and adverse selection. Moral hazard occurs when insureds engage in excessively risky activities knowing that they are insured and the risks are not appropriately priced.[155] An example of moral hazard would be homeowners failing to adopt flood risk reduction measures, such as moving heating and cooling systems to higher levels of a home, because they know that they will receive a payout after the next storm to replace their damaged systems. With adverse selection, the insured knows more about their risk than the insurer, leading only high-risk individuals to insure, thus "unraveling" the market.[156] For instance, adverse selection has been invoked to support the Affordable Care Act's "individual mandate," which requires all people, not merely those who know they are sick and need medical care, to purchase insurance on health insurance markets.[157]

Insurance premiums in a well-functioning private market are directly tied to the risk. Although regulators may suppress prices, in most private insurance markets, insurers still charge higher prices for higher risks. This means insurance markets may be able to create incentives to reduce risk by rewarding insureds' investments in risk reduction with lower premiums.[158] To date, research on this topic has

---

154. Dwight M. Jaffee & Thomas Russell, *Catastrophe Insurance, Capital Markets, and Uninsurable Risks*, 64 J. RISK & INS. 205, 208 (1997).

155. Seminal early work on moral hazard includes: Kenneth J. Arrow, *Uncertainty and the Welfare Economics of Medical Care*, 53 AM. ECON. REV. 941 (1963); Isaac Ehrlich & Gary S. Becker, *Market Insurance, Self-Insurance, and Self-Protection*, 80 J. POL. ECON. 623 (1972); and Mark V. Pauly, *The Economics of Moral Hazard: Comment*, 58 AM. ECON. REV. 531 (1968). For an overview, see generally David Rowell & Luke B. Connelly, *A History of the Term "Moral Hazard*,*"* 79 J. RISK & INS. 1051 (2012).

156. Economic work on adverse selection begins with these seminal papers: George A. Akerlof, *The Market for "Lemons": Quality Uncertainty and the Market Mechanism*, 84 Q.J. ECON. 488 (1970) and Michael Rothschild & Joseph Stiglitz, *Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information*, 90 Q.J. ECON. 629 (1976).

157. *See* Nat'l Fed'n of Indep. Bus. v. Sebelius, 567 U.S. 519, 547–49 (2012) (discussing the purpose of the individual mandate in the Affordable Care Act to ensure that healthy individuals do not delay purchasing insurance until they are ill, and to force healthy individuals into the risk pool to subsidize the cost of covering those who are ill without drastically increasing premiums).

158. Multiple states—including Alabama, California, Florida, Louisiana, Maryland, Mississippi, New York, South Carolina, and Texas—require insurance companies to offer premium discounts for certain wind-hazard mitigation investments, or they have state insurance programs that offer such discounts. For instance, insurers may be required to charge a lower premium if homeowners install hurricane shutters or storm-resistant roofs, doors, and garages,

tended to focus on using premium reductions on standard property insurance to provide incentives for individual action, such as roof retrofits. Very little work has been done on the ability of insurance to both incentivize ecosystem protection and provide risk-reduction benefits. To the extent that it has been discussed, most treatments have emphasized the potential perverse incentives involved. For example, scholars and policymakers have expressed concern that discounted or subsidized insurance can "have a negative impact" on ecosystem services by distorting the true cost of planning or development in certain areas.[159]

B. Types of Insurance

There are two dominant types of insurance contracts: indemnity based and parametric.[160] Indemnity-based policies guarantee payment in an amount equal to the actual losses sustained.[161] This requires a loss adjuster to visit the property following a damaging event to confirm the loss and the amount that is covered under the policy. Indemnity insurance requires some understanding and modeling of the exact exposure and risk management actions of the insured to establish accurate pricing, since any payout is based on the actual losses sustained.

---

among other possible measures. However, there has been no evaluation of their efficacy in providing incentives for new mitigation investments. *See* OFFICE OF MGMT. & BUDGET, STANDARDS AND FINANCE TO SUPPORT COMMUNITY RESILIENCE 8–10 (2016) (surveying incentives given by different states to encourage citizens to install environmental safety measures on their homes).

159. *See, e.g.*, Chad J. McGuire, *Valuing Ecosystem Services in Coastal Management Policy: Looking Beyond the Here and Now*, 30 NAT. RESOURCES & ENV'T 42, 45 (2015) ("[S]ubsidies can often lead to price distortions that influence valuations.").

160. Since the late 1990s, a market for insurance-linked securities, which transfer risk to the financial markets, has developed. These are risk-transfer tools that can be used by companies and governments as a substitute or complement to standard insurance. Catastrophe bonds are a common example. They have not yet been used in the context of insuring ecosystems, although they could be used in a similar fashion to the insurance policies discussed in this Part. For general discussions about how catastrophe bonds work, see generally Todd V. McMillan, *Securitization and the Catastrophe Bond: A Transactional Integration of Industries Through a Capacity-Enhancing Product of Risk Management*, 8 CONN. INS. L.J. 131 (2002) (discussing how catastrophe bonds integrate the insurance and financial industries) and Daniel Schwarcz & Steven L. Schwarcz, *Regulating Systemic Risk in Insurance*, 81 U. CHI. L. REV. 1569, 1606–08 (2014) (discussing insurance-linked securities including catastrophe bonds).

161. *See* ROBERT W. KLEIN, A REGULATOR'S INTRODUCTION TO THE INSURANCE INDUSTRY 13 (2d ed. 2005) ("Under the principle of indemnity, insureds should not profit from a covered loss but should be restored to no better than their financial position prior to the loss.").

In contrast, parametric policies pay the insured when a certain predefined "triggering event" occurs, regardless of the insured's level of loss.[162] Triggers tend to be objective measures of disaster occurrence, such as wind speed in a particular location or water height on a flood gauge. To avoid possible manipulation of the trigger, most parametric policies are triggered by data sourced from independent third parties, such as governmental agencies.[163] The benefit of a parametric policy over an indemnity-based policy is that payout can be extremely rapid since there is no need for adjusters to validate a specific level of loss. The absence of adjusters can also make parametric policies less expensive.

The primary downside of parametric insurance is what is known as "basis risk." This is simply the risk that the payout will not match actual damages sustained. Basis risk can be minimized, however, through careful attention to trigger design—that is, by choosing a trigger that is highly correlated with the insured's potential losses.[164]

C. Private and Public Insurance

Thus far, this Article has largely focused on the private insurance market. But private insurance has its limits. For example, there are some risks—namely those that violate some of the criteria for insurability[165]—that private commercial insurance firms find challenging to take on, making it less likely that private markets will supply coverage for these risks at all. In particular, natural disasters and other catastrophes can have very extreme loss years as discussed

162. For a broader discussion of parametric insurance, see generally CLYDE & CO, PARAMETRIC INSURANCE: CLOSING THE PROTECTION GAP (2018), https://www.clydeco.com/resilience/download [https://perma.cc/XNG5-BSGA].

163. Neil A. Doherty & Andreas Richter, *Moral Hazard, Basis Risk, and Gap Insurance*, 69 J. RISK & INS. 9, 13 (2002). On moral hazards associated with trigger-type policies, see generally Tobias Götze & Marc Gürtler, *Risk Transfer and Moral Hazard: An Examination on the Market for Insurance-Linked Securities* (Working Paper, 2018), https://ssrn.com/abstract=3262669 [https://perma.cc/D6QF-ZTDN].

164. *See* J. David Cummins, David Lalonde & Richard D. Phillips, *The Basis Risk of Catastrophic-Loss Index Securities*, 71 J. FIN. ECON. 77, 80–81 (2004) (studying the hedging efficacy of insurance contracts for Florida insurers). There is also increasing interest in minimizing basis risk for microinsurance—which tends to be parametric—in a developing world context. *See, e.g.*, Ghada Elabed, Marc F. Bellemare, Michael R. Carter & Catherine Guirkinger, *Managing Basis Risk with Multiscale Index Insurance*, 44 AGRIC. ECON. 419, 428–29 (2013) (describing the findings of an index insurance pilot project launched in Mali that was designed to pay out for particular triggers and concluding that "to be effective, index insurance contracts must be found that reduce levels of basis risk").

165. *See supra* Part II.A.

above. When a severe loss year occurs, it can threaten private insurer solvency. This makes risk transfer more challenging, because insurers must have access to sufficient capital to remain solvent after an event in order to meet regulatory and rating-agency requirements.[166] Holding or renting such capital can be expensive.[167] The premiums associated with catastrophic risk insurance, therefore, can exceed the consumer's ability or willingness to pay.[168] Further, disasters can create a negative capital shock to the insurance industry, leading to hard markets where supply is scarce and coverage costly.[169]

Such challenges have led to myriad government interventions in disaster insurance markets across the globe.[170] Many of these interventions established insurance programs after disaster events exposed either a lack of available private insurance or raised concerns about its cost. But while their origins may be similar, the forms these programs have taken are not. At times the government acts as the insurer and at other times as a reinsurer. Some programs are purely public, while others are quasi-public or designed as a public-private partnership. Examples in the United States include the National Flood Insurance Program ("NFIP"),[171] the California Earthquake

---

166. John Patrick Hunt, *Rating Dependent Regulation of Insurance*, 17 CONN. INS. L.J. 101, 110–27 (2010) (discussing the role of credit rating agencies in shaping state insurance regulation); Daniel Schwarcz, *The Risks of Shadow Insurance*, 50 GA. L. REV. 163, 168–69 (2015) (discussing regulatory capital requirements for insurers as protecting policyholders).

167. *See* Jaffee & Russell, *supra* note 154, at 208 (discussing the financial difficulties with capital in catastrophe insurance).

168. Carolyn Kousky & Roger Cooke, *Explaining the Failure to Insure Catastrophic Risks*, 37 GENEVA PAPERS 206, 207 (2012).

169. Carolyn Kousky, *Revised Risk Assessments and the Insurance Industry*, *in* POLICY SHOCK: RECALIBRATING RISK AND REGULATION AFTER OIL SPILLS, NUCLEAR ACCIDENTS AND FINANCIAL CRISES 58, 62–64 (Edward J. Balleisen et al. eds., 2017).

170. Several reports have surveyed these interventions around the world. *See, e.g.*, PAULA JARZABKOWSKI, KONSTANTINOS CHALKIAS, EUGENIA CACCIATORI & REBECCA BEDNAREK, BETWEEN STATE AND MARKET: PROTECTION GAP ENTITIES AND CATASTROPHIC RISK 3 (2018); Youbaraj Paudel, *A Comparative Study of Public–Private Catastrophe Insurance Systems: Lessons from Current Practices*, 37 GENEVA PAPERS 257, 262–78 (2012).

171. Carolyn Kousky, *Financing Flood Losses: A Discussion of the National Flood Insurance Program*, 21 RISK MGMT. & INS. REV. 11, 11 (2018).

Authority,[172] state wind pools such as Florida Citizens,[173] and the Terrorism Risk Insurance Program.[174]

These quasi- to fully governmental insurance programs differ in some fundamental respects from their private counterparts. First, many can combine risk transfer with other regulations or incentives for risk reduction. For example, to participate in the NFIP, communities must first adopt minimum floodplain-management regulations.[175] A private insurer could not require such regulations as a precondition, although they could use risk reduction in their underwriting, and choose not to offer policies in areas that do not meet certain criteria. Second, pricing and underwriting in the programs are often driven by broader political concerns, rather than just profitability.[176] For example, the NFIP must offer a policy to anyone in a participating community and Congress has repeatedly intervened in pricing for political purposes.[177] Finally, public insurance programs often have different financial structures than a private program or policy. For example, many state wind pools rely on bond issuances and ex post assessments on policyholders and insurers to finance losses—something a private insurer cannot do.[178]

III. INSURING ECOSYSTEMS

This Part identifies and describes the two primary ways that insurance could contribute to ecosystem conservation and restoration: (1) insuring ecosystems directly and (2) providing incentives through insurance for the provision of certain ecosystem services. While these approaches are not a silver bullet, they may be an effective

172. Daniel Marshall, *An Overview of the California Earthquake Authority*, 21 RISK MGMT. & INS. REV. 73, 74–75 (2018).

173. Lorilee A. Medders & Jack E. Nicholson, *Evaluating the Public Financing for Florida's Wind Risk*, 21 RISK MGMT. & INS. REV. 117, 117–18 (2018).

174. Erwann Michel-Kerjan & Howard Kunreuther, *A Successful (Yet Somewhat Untested) Case of Disaster Financing: Terrorism Insurance Under TRIA, 2002–2020*, 21 RISK MGMT. & INS. REV. 157, 158 (2018).

175. *See Floodplain Management Ordinances*, FEMA (Mar. 27, 2018, 9:47 AM), https://www.fema.gov/floodplain-management-ordinances [https://perma.cc/B84F-TZJR].

176. Lorilee A. Medders, Charles M. Nyce & J. Bradley Karl, *Market Implications of Public Policy Interventions: The Case of Florida's Property Insurance Market*, 21 RISK MGMT. & INS. REV. 183, 186 (2013).

177. Carolyn Kousky, Brett Lingle & Leonard Shabman, *The Pricing of Flood Insurance*, 4 J. EXTREME EVENTS 1750001-1, 1750001-4 (2017).

178. ROBERT P. HARTWIG & CLAIRE WILKINSON, RESIDUAL MARKET PROPERTY PLANS: FROM MARKETS OF LAST RESORT TO MARKETS OF FIRST CHOICE 21 (2014).

complement to existing forms of governance. This Part then delves into the specifics of the extant attempts—in practice and in theory—to use insurance to help protect or restore ecosystem services. Although interest in insurance-based approaches is growing, the number of on-the-ground examples is quite limited.

A. *Insuring Nature Itself*

A novel approach to insurance comes from recognizing that ecosystems could be protected and restored by insuring the ecosystems themselves. In essence, spatially delineated natural areas could be insured against possible damage or degradation just like real property.

The first challenge with this approach is finding an entity with an insurable interest that is willing and able to pay the premium. An insurable interest is simply a stake in the value of the insured item. If an entity would not suffer a financial loss, there is no insurable interest, and the entity cannot legally purchase an insurance policy.[179] This suggests it may not be possible for an environmental nongovernmental organization to insure damage to Yellowstone National Park, for example, assuming that it would not suffer a financial loss if the park was damaged. The National Park Service, on the other hand, would have an insurable interest and could purchase such a policy.

If an entity with an insurable interest is identified, this entity then must also be willing and able to pay the necessary insurance premiums.[180] For many ecosystems, their benefits are public goods, which might provide disincentives to those with an insurable interest to pay. Even those entities that would be financially affected by ecosystem degradation might be unwilling to shoulder the cost of the premium alone, when benefits accrue to many others. That is, as with the property insurance incentives discussed in Part III.B, ecosystem insurance could suffer the same free-riding problems afflicting attempts at providing many public goods. Fortunately, there are multiple examples of coordinating mechanisms and institutions that can help overcome this free-rider problem that could be used in this context as well. The Mexican Coastal Zone Management Trust we discuss below is an example of such an institution that can collect

179. *See, e.g.*, CAL. INS. CODE art. 4, § 281 (2018) (defining "insurable interest" as "[e]very interest in property, or any relation thereto, or liability in respect thereof, of such a nature that a contemplated peril might directly damnify the insured" (emphasis omitted)).

180. *Id.*

contributions from multiple beneficiaries and coordinate a collective response.[181]

Even if an entity has an insurable interest and available funds, it still must believe that an insurance product is preferable to other approaches and worth the cost. This first requires that there are indeed restoration efforts that can be undertaken post-disaster to help the system recover. Further, to justify paying insurance premiums, this restoration should require large sums of money, unlikely to be immediately available without claims payouts. For instance, reforestation after a wildfire requires many person-hours of growing and planting seedlings, making it expensive. But planting native grasses and shrubs post-fire can help stabilize the soil and prevent further damage from mudslides and erosion,[182] if undertaken quickly. If no other funding for this restoration is otherwise available, a wildfire insurance policy may be an attractive option.

The type of insurance contract will also determine the feasibility of this approach. Indemnity-based policies may likely be difficult for insuring nature directly. As discussed above, an indemnity policy would compensate for the actual damage to an ecosystem or to natural capital. Estimating this damage could require costly and time-consuming nonmarket valuation studies post-disaster. This would drive up the transaction costs of the insurance and slow payouts considerably. As such, a parametric insurance policy, in which the payout is based on objective measures of the disaster, is likely preferable.

Finally, the insurance policy must be cost-effective and add value beyond what the entity with an insured interest could do on its own. Instead of purchasing insurance from a third party, entities could choose to self-insure by setting aside their own funds to use post-disaster, or they could use debt to finance any needed restoration. It may not always be financially optimal to purchase insurance for restoration; financial analyses would need to be undertaken on a case-by-case basis.

---

181. *See infra* Part III.C.

182. On the effectiveness of measures to reduce erosion after wildfire, see Peter R. Robichaud & William J. Elliot, Protection from Erosion Following Wildfire 2–6 (July 9–12, 2006) (unpublished manuscript), https://www.fs.usda.gov/treesearch/pubs/24606 [https://perma.cc/VWZ4-Z7QX]; *see also* J. W. Wagenbrenner, L. H. MacDonald & D. Rough, *Effectiveness of Three Post-Fire Rehabilitation Treatments in the Colorado Front Range*, 20 HYDROLOGICAL PROCESSES 2989, 3002–04 (2006) (discussing the efficacy of methods to decrease erosion in Colorado).

B. Financial Incentives for Ecosystem Protection or Restoration

Standard property insurance policies paired with financial incentives through premiums are a second avenue to address risks to ecosystem services. If natural ecosystems provide protection to insured property—such as green infrastructure mitigating stormwater flooding, for instance—insurers could charge property owners a lower premium than would be feasible in the absence of that protection. The insurer USAA, for example, provides discounts to policyholders residing in communities that participate in the Firewise program.[183] Firewise is a community-level program run by the National Fire Protection Association, a nonprofit focused on reducing fire losses. Participants undertake a range of preparedness activities, including landscaping, to reduce fire risk on their properties. At least theoretically, such an approach is not limited to just property insurance. Liability insurance policies could also be priced to reflect more careful ecosystem management, although no specific examples of this practice are known.

While it is appealing to lower the cost of property insurance to reflect protection from natural capital, there are two substantial challenges with this practice. The first is that insurers must be very confident about the risk-reduction benefits before they can offer a premium reduction. Quantifying an ecosystem's protective benefits is still a relatively new endeavor; while protection may be established at broad levels, it may be difficult to reach a level of precision that could inform actual pricing.[184]

To be clear, confidence in risk-reduction benefits is not the same thing as economic valuation. Insurers do not need exact estimates of the ecosystem service's total monetary value but rather require an assessment of the service's impact on risk levels. That is, they need to know how changes in the extent of natural infrastructure impact expected losses for an insured property for various magnitude events.[185] For example, while an insurer might know that coastal mangroves generally act as a storm surge buffer,[186] they may find it

183. *See Insurance Discounts for USAA Members in Seven States*, NAT'L FIRE PROT. ASS'N, https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA/Become-a-Firewise-USA-site/Program-benefits/Insurance-discounts-for-USAA-members-in-seven-states [https://perma.cc/L45S-2CF9].

184. This conclusion is based on informal interviews with multiple representatives of global reinsurance and brokerage firms.

185. *See supra* Part I.B.

186. *See supra* note 31 and accompanying text.

difficult to assess how planting a new acre of mangroves alters the price of hurricane insurance for specific insured properties behind those mangroves.

The second challenge is a mismatch in scale. While ecosystems are often local or even regional public goods that provide risk-reduction services to many properties simultaneously, property insurance is typically purchased at the level of the individual household or firm. The premium reduction for any one property may not be sufficient to cover the costs of providing the ecosystem service as a whole. As a result, some type of institutional arrangement is necessary to overcome free riding and encourage all insured property owners to participate in funding the conservation or restoration of their shared service, such as a trust.[187] In other words, insurance still must overcome the public goods provision problem.

As with some other public goods, governments could choose to pay for the provision of the ecosystem service. Governmental entities may be motivated to invest more in conservation and restoration when their residents see premium reductions in response to risk-reducing investments. An example comes from the NFIP's Community Rating System,[188] a program that rewards communities that adopt flood risk reduction measures with reductions on flood insurance premiums for residents. These reductions, however, do not necessarily reflect lower overall payments. Instead, premiums are lowered by cross-subsidizing other policyholders in a public effort to promote better flood risk management.[189] They may, however, partially contribute to increased local government interest in adopting such measures.[190] The extent to which residents benefiting from lower premiums encourages local governments to invest in risk reduction, however, is unknown. For example, it is unclear whether the premium reductions homeowners receive on their policies in Firewise communities provide incentives for local governments to invest further in wildfire mitigation.

---

187. *See infra* Part III.C.

188. For more on the program see FED. EMERGENCY MGMT. AGENCY, FACT SHEET: COMMUNITY RATING SYSTEM (June 2017), https://www.fema.gov/media-library-data/1507029324530-082938e6607d4d9eba4004890dbad39c/NFIP_CRS_Fact_Sheet_2017_508OK.pdf [https://perma.cc/7MQA-B272].

189. *See supra* note 177.

190. A case study of Avalon, New Jersey, notes lower flood insurance premiums as being at least a part of the discussions over investments in dune protection. *See* Karl F. Nordstrom, Nancy L. Jackson, Michael Bruno & Harry A. de Butts, *Municipal Initiatives for Managing Dunes in Coastal Residential Areas: A Case Study of Avalon, New Jersey, USA*, 47 GEOMORPHOLOGY 137, 143 (2002).

C. Innovations in Insuring Ecosystems Globally

Having offered some general lessons about the types of insurance that may help guarantee provision of ecosystem services, this Section describes the few examples of such policies in practice or in development. These examples are worth understanding because they are the first attempts to innovate in insurance markets for ecosystem services and, as such, the lessons gleaned from these examples will be critical in helping other communities and governments follow in their footsteps.

1. *Mexican Coastal Zone Management Trust*. In 2018, The Nature Conservancy ("TNC") signed an agreement with the Quintana Roo State Government in Mexico and the Cancún and Puerto Morelos Hotel Owners Association to develop a Coastal Zone Management Trust to build resilience along the coastline of the Yucatan peninsula.[191] The project was initiated following two hurricanes that caused approximately $8 billion in damages and shuttered many local hotels and businesses.[192] Research revealed that the hotels and beaches near Puerto Morelos—which is protected by a coral reef system—sustained less harm than neighboring, unprotected areas.[193] Thus, the stated goal of the project is for the Trust to "finance ongoing maintenance of reefs and beaches and purchase insurance to ensure these vital ecosystems are restored after extreme storms hit."[194] To that end, the tourism industry will collect and provide taxes to fund "maintenance and restoration efforts for 60 kilometers of reef and beaches" and will fund the purchase of a parametric insurance policy.[195]

The concept for the parametric policy was developed in partnership with Swiss Re, a global reinsurance firm,[196] and is a form of parametric insurance. As noted above, parametric insurance pays out when a specified, verifiable event occurs. In this case, when wind speeds exceed certain thresholds, policy payouts are triggered—at higher wind speeds, a larger payment is given.[197] Parametric insurance

191. *Insuring Nature to Ensure a Resilient Future*, *supra* note 22; Tercek, *supra* note 22.

192. *Insuring Nature to Ensure a Resilient Future*, *supra* note 22.

193. *Id.* ("[A] healthy coral reef can reduce up to 97 percent of a wave's energy before it hits the shore . . . .").

194. *Id.*

195. *Id.*

196. Gonzalez, *supra* note 23.

197. *Id.*; Tercek, *supra* note 22 (noting that 110 knots represents the wind speed of a Category 4 hurricane).

obviates the need for assessors to come out to assess damage, does not require economic valuation of the damage, and eliminates any ensuing disputes that might occur over the extent of the damage. Instead, the aim is to provide funds to restore the reef and beaches quickly.[198] The Trust purchased the insurance policy in June 2019 from a Mexico-based insurer, Afirme Seguros Grupo Financiero SA de CV, with a coverage limit of $3.8 million.[199] If a storm occurs that damages the reef but the policy-triggering wind speed is not reached, the Trust can operate as a form of self-insurance.[200]

Although parametric insurance has been used for many years, this policy is innovative in that a group of beneficiaries of a public good collaborated to insure an ecosystem that they do not own. The policy should be scalable to other locations, as researchers have determined that coral reefs generate $36 billion globally in tourism.[201] Indeed, in September 2019, TNC indicated that it is actively working to expand this concept to Florida and Hawaii, and that the organization received a $1 million grant from Bank of America to fund research to locate areas in these two states where such programs could be effectively implemented.[202]

2. *Global Ecosystem Resilience Facility*. In March 2018, at the Economist's World Ocean Summit, Willis Towers Watson, a London-based risk-management, insurance, and reinsurance brokerage firm, announced the creation of its Global Ecosystem Resilience Facility ("GERF"). The GERF aims to build management frameworks and use innovative financing to increase the resilience of both ecosystems and the communities that depend on them.[203] In its initial phase, the GERF

---

198. *Insuring Nature to Ensure a Resilient Future*, *supra* note 22.

199. Gonzalez, *supra* note 23.

200. *Insuring Nature to Ensure a Resilient Future*, *supra* note 22.

201. Mark Spalding et al., *Mapping the Global Value and Distribution of Coral Reef Tourism*, 82 MARINE POL'Y 104, 109 (2017) (including both on-reef activities like snorkeling and off-reef activities like beach enjoyment that is enhanced by the presence of coral reefs).

202. *$1 Million Grant from Bank of America Helps The Nature Conservancy Explore Scaling a Coral Reef Insurance Product in Florida and Hawaii*, BANK OF AMERICA (Sept. 24, 2019, 11:00 AM), https://newsroom.bankofamerica.com/print/pdf/node/9579 [https://perma.cc/TAW6-5ABF]; Claire Wilkinson, *The Nature Conservancy Looks to Reef Policy for US Coastal Areas*, BUS. INS. (Sept. 25, 2019), https://www.businessinsurance.com/article/20190925/NEWS06/912330842/The-Nature-Conservancy-looks-to-reef-policy-for-US-coastal-areas [https://perma.cc/2QZT-FF4N].

203. *Services*, WILLIS TOWERS WATSON, https://www.willistowerswatson.com/en/services [https://perma.cc/L69Y-CT69]; *Willis Towers Watson Launches the Global Ecosystem Resilience Facility*, GLOBE NEWSWIRE (Mar. 9, 2018, 4:00 AM) [hereinafter *Willis Towers Watson*

focuses on "the protection of ecosystems such as coral reefs, mangroves and seagrasses . . . to support resilience of fishing communities at threat from hurricanes and coral decline."[204] The goal is to provide incentives for better ecosystem stewardship through risk finance tools. In particular, by assisting with project finance, the GERF can "help regions bridge the post-disaster funding gap" if natural disasters affect these ecosystem services.[205] In addition, the GERF aims to provide programs that enable the "coordination and pre-planning of swift post-event recovery"[206] and supply analytical and technical support. Although the facility is brand new, Willis Towers Watson sees the potential for risk-transfer approaches and analytics to support ecosystem protection and restoration.

3. *Other Potential Uses of Insurance*. Outside the ocean ecosystem context, other policymakers are exploring the ways in which innovative insurance tools could address ecosystems threatened by wildfire or earthquake risks. With wildfire, insurance has traditionally been used to cover the value of timber lost during disaster events.[207] However, policies that cover the costs of replanting these forests are feasible, but less common. One study has estimated that only slightly more than 1 percent of forests in Spain, for example, are insured for replanting costs after a wildfire, despite high wildfire risk in many places throughout the country.[208] At least some theoretical policy design research has explored the benefits of an insurance-funded replanting scheme from the timber manager's perspective, but it is not common on the ground.[209]

Launches], https://www.globenewswire.com/news-release/2018/03/09/1419744/0/en/Willis-Towers-Watson-launches-the-Global-Ecosystem-Resilience-Facility.html [https://perma.cc/FVM9-PDET].

204. *Willis Towers Watson Launches*, *supra* note 203.

205. *Id.*

206. *Id.*

207. While available, many landowners may not purchase this insurance, perhaps because they do not believe the value to be worth the expense. *See generally* Yiling Deng, Ian A. Munn, Keith Coble & Haibo Yao, *Willingness to Pay for Potential Standing Timber Insurance*, 47 J. AGRIC. & APPLIED ECON. 510 (2015).

208. ROMAN MARCO HOHL, AGRICULTURAL RISK TRANSFER: FROM INSURANCE TO REINSURANCE TO CAPITAL MARKETS 341 (2019).

209. *See* Jesús Barreal, Maria L. Loureiro & Juan Picos, *On Insurance as a Tool for Securing Forest Restoration After Wildfires*, 42 FOREST POL'Y & ECON. 15, 16–18 (2014). Also, for a broader discussion of forestry insurance and the possibility of insuring carbon sequestration credits, see generally BRUCE MANLEY & RICHARD WATT, FORESTRY INSURANCE, RISK POOLING, AND RISK MINIMISATION OPTIONS (2009).

Similar policies could also be taken out for publicly managed forests that are not harvested for timber, but protected for the other ecosystem services they provide. In the United States, such insurance is not common, but there are public programs to assist with replanting. For example, the national Tree Assistance Program provides payouts to qualifying orchardists or nursery tree growers to replant or rehabilitate trees damaged by natural disasters.[210] These programs may crowd out private insurance. In other words, if robust free or low-cost public insurance programs exist, there would be no need to purchase an insurance policy on private markets.

A similar approach might be possible to provide funding to fill in land that has rifts, breaks, or other damage after an earthquake. Currently, the California Earthquake Authority's insurance policies do not cover landscaping or land damage, such as from sinkholes, land fissures, or erosion.[211] Such coverage may be privately available for a high premium from select private firms. In contrast, New Zealand provides a public earthquake insurance program with more coverage for land, although it primarily supports land restoration near homes or accessways.[212] New Zealand's program did not explicitly cover restoration of damage from liquefaction and soil thinning—as occurred in the 2010 Canterbury earthquakes—leading to ongoing policy discussions about whether to redefine the scope of the program.[213]

Finally, some scholars have recently called for more research to examine how insurance could be used to shield municipalities from liability if green infrastructure investments fail to perform as designed.[214] This would be a slightly different approach than the two

210. For more information, see Farm Serv. Agency, *Tree Assistance Program (TAP)*, U.S. DEP'T OF AGRIC., https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/tree-assistance-program/index [https://perma.cc/Q3XD-2K3A].

211. The policy terms are available at *Earthquake Insurance*, CAL. DEP'T INS., http://www.insurance.ca.gov/01-consumers/105-type/95-guides/03-res/eq-ins.cfm [https://perma.cc/9ZLH-28XJ].

212. More information is available at *What We Do: Land*, EQC EARTHQUAKE COMMISSION NEW ZEALAND (May 20, 2019), https://www.eqc.govt.nz/what-we-do/land [https://perma.cc/LJ2H-BF3C].

213. Hugh Cowan, Bryan Dunne & Anna Griffiths, *Planning for Loss or Complexity? New Zealand's Earthquake Commission: The Story So Far*, 5 CONSORSEGUROS 1, 13–15 (Oct. 2016) (describing the lessons learned in the wake of the Canterbury earthquake disaster).

214. *See, e.g.*, James Salzman et al., *The Most Important Current Research Questions in Urban Ecosystem Services*, 25 DUKE ENVTL. L. & POL'Y F. 1, 38 (2014) ("[C]an insurance protect against the risk of failure or noncompliance of a green-infrastructure project that depends on coordinated activities by multiple public and private parties to maintain their components of the ecosystem services project?").

methods discussed above, where the focus is on how insurance can help incentivize the protection or restoration of natural systems.

D. The Necessary Conditions for Insurance

The above analysis demonstrates that, under certain conditions, pairing incentives for ecosystem protection with property insurance or insuring nature itself can both be effective tools for conserving and restoring ecosystems. This final Section summarizes the necessary conditions for these approaches.

In sum, because both methods require that some very specific conditions be met, it is unlikely that insurance will become a panacea for ecosystem service provision. Yet when those conditions are met, insurance can be a powerful governance tool, because it fills a niche that other approaches cannot. Thus, to return to the primary question motivating this Article, we contend that insurance can play an important role in ecosystem management but that this role is narrow.

We begin with the conditions for the more innovative approach of insuring nature itself and then discuss using property insurance to provide incentives for ecosystem protection. To insure nature itself, there must first be a party or parties with an interest in purchasing insurance. This could be a private landholder, a set of private landholders, a government entity or entities, or some combination of the three. Stimulating these parties' interest, however, may require studies demonstrating the economic value of ecosystem services provided directly to certain stakeholders by natural systems.

Second, and relatedly, these interested parties must be willing and able to pay the premium associated with an insurance policy. In some cases, private property owners may be incentivized to pay such premiums on their own; for example, landowners living in a fire-prone area might pay insurance premiums so that they can restore their forest after a wildfire. However, many ecosystems are not privately owned, and in those that are, private owners usually derive only a small portion of the benefits from an ecosystem on their property. Therefore, some form of government or multistakeholder participation may be required to drive the creation of collaborative institutional mechanisms.

Third, the target ecosystem must be threatened with damage or degradation by a random peril, such as a hurricane, storm surge, wildfire, or high winds. If instead the ecosystem is threatened by a known, certain peril, such as a slow rise in temperature or an increase in ocean acidification, the ecosystem likely does not meet basic criteria for insurability.[215] Insurers will only insure against random risks, not certainties. Therefore, while insurance may not be an appropriate mechanism for protecting ecosystems from the *gradual* effects of climate change, it can be employed to combat its more *stochastic* effects, such as hurricanes, flooding, or storm surge.

Fourth, the ecosystem must be able to be restored by actions that can be funded by an immediate infusion of post-disaster cash. If an ecosystem is incapable of being repaired once damaged, then insuring the ecosystem provides no benefit. But if an ecosystem is capable of being restored, such as a forest after a wildfire, or a coral reef after a hurricane, or a beach after an oil spill, then ecosystem insurance has a role to play that goes beyond existing governance tools. Timing is also critical for determining whether insurance is the right tool. If a slower time frame for restoration is acceptable, then it may be possible for an ex post financing scheme—even if significantly delayed—to fill this gap. For instance, if a local government could issue bonds to pay for restoration, it may not need to purchase insurance. In such a situation, the extra transaction costs associated with an insurance policy make it less appealing. When time is of the essence, however, insurance is often preferable.

Finally, insurance must be cost-effective as compared to other mechanisms. For example, if the cost of restoration is very low, it may be more financially sound simply to self-insure. The Mexican Coastal Zone Management Trust provides a fine illustration: in that case, when wind speeds do not exceed the insurance policy's pay-out threshold, the Trust itself acts as a self-insurance mechanism. Self-insurance aside, insuring nature must also be cheaper than other available financial mechanisms, such as bonding. But when post-disaster funds are not likely to come cheaply, readily, or quickly using such mechanisms, insurance becomes more attractive.

We turn now to the approach of using standard property insurance to create incentives for protecting natural systems. Some of these necessary conditions overlap with the approach of insuring nature directly, while others differ. First, there must be insured property benefiting from or having the potential to benefit from an ecosystem service. Second, there must be some institutional mechanism to aggregate contributions from many property owners and prevent free

215. One caveat is that if the timing of impacts was indeed random, the losses may still be insurable. For instance, if ocean acidification could occur at any random time over the next several decades, there may be a private entity willing to insure the risk.

riding, because the financial incentive provided by one insurance policy alone is unlikely to be sufficient to cover the costs of conservation or restoration. Finally, insurer understanding of ecosystem service modeling must be advanced enough to inform pricing or underwriting decisions by an insurance company. This modeling can be challenging, and often our understanding of the protective services from ecosystems is not yet sufficiently advanced to offer such premium reductions.

IV. THE VALUE AND VALUES OF INSURANCE

At a basic level, any selected tool of environmental governance must be able to achieve its goals and be cost-effective.[216] If the government must play a role, the tool must also be politically feasible.[217] Part III analyzes the conditions under which ecosystem-based insurance policies can achieve their goals and describes when this approach is preferable to or complementary to other forms of environmental governance.

But once we know that insurance can "do the job," a second question arises: Is insurance worthwhile? In other words, what value or values does insurance promote that other governance tools do not? Specifically, how does insurance further or hinder important values like legitimacy, accountability and transparency, potential for transnational impacts, environmental or distributive justice, and expressive content, compared to other approaches?[218] This final Part of the Article takes up these normative questions.

With respect to accountability and transparency, insuring ecosystems fares exceptionally well. In contrast to other governance options such as self-insurance or relying on the government to provide ex post disaster relief and restoration funds, insurance is far more transparent and provides greater accountability. Because a policy can be purchased in advance for a known payout when a determinate triggering event occurs, all parties know the stakes ahead of time. Further, because a third-party insurance firm guarantees the payments, delivery of what was bargained for is assured. This avoids the pitfalls of an all-too-familiar scenario in which a government promises disaster relief or restoration funds in the abstract but does not deliver, or provides funds only according to some unknown, ex post criteria. It

216. Light & Orts, *supra* note 25, at 56 (listing multiple criteria, including efficiency and effectiveness, against which to weigh public or private environmental governance tools).

217. *Id.* (discussing political feasibility).

218. *Id.* (listing multiple normative criteria beyond effectiveness and efficiency).

also avoids the possibility that loans or other forms of bonding or debt are not forthcoming.

Insurance also has significant potential for positive transnational impacts[219] that certain domestic governance regimes like the ESA or the CWA § 404 permit program cannot reach.[220] If, for example, a coral reef straddled a geographic or national boundary, an insurance policy could be developed on a global or multinational scale to include private parties and government actors on both sides of the boundary. There is no clear geographic limit to who can participate in the creation of a multiparty trust fund to purchase insurance, or who could be insured under a single parametric policy. This is a significant advantage over certain other forms of ecosystem governance.

With respect to distributive justice, the impact of ecosystem insurance is more of a mixed bag. On the one hand, insurance that promotes ecosystem restoration can have positive impacts on distributive or environmental justice. Unlike the situation in which a private landowner chooses to insure her forest against the risk of fire solely for the value of the timber which benefits her alone, ecosystem insurance can accommodate broader goals to restore those services that may benefit the public at large. As noted above, ecosystems tend to be public goods and no one can easily be excluded from the benefits of their conservation and restoration. And studies have therefore shown that ecosystems protect vulnerable populations along the coastline, including both impoverished communities and the elderly, as well as the more affluent.[221]

On the other hand, however, the necessary conditions for the creation and purchase of ecosystem insurance may only exist when the ecosystem protects a valuable asset that someone with means wants to safeguard. If the asset being protected is not sufficiently valuable (for example, an impoverished community rather than upscale tourist hotels), there may be less impetus for the relevant stakeholders to create a mechanism to pay insurance premiums. Focusing solely on the property values that would be protected by such ecosystem services could lead to concerns about environmental justice—namely, that

219. *Id.* (discussing transnational impacts).

220. In contrast to these wholly domestic programs, PES programs can have significant transnational impacts. For example, the Costa Rican PES program designed to encourage private landowners to conserve ecosystems that sequester carbon and protect biodiversity has a global impact. *See* sources cited *supra* notes 126–28.

221. *See supra* note 7 and accompanying text.

policymakers ignore the importance of ecosystem services to populations with low property values.[222] In such cases, ecosystem insurance might still be useful; however, it may be more important to involve governments in such cases to ensure that such communities have access to the immediate restoration funds they need.

The expressive content of ecosystem insurance is also complex and multifaceted. On the one hand, the idea of insuring nature itself appears to express respect for nature in a way that standard private-property indemnity insurance does not.[223] Indeed, rather than a private entity purchasing insurance for the loss or damage to private property, nature itself is the focus of the policy. At the very least, this expresses that nature is of value, just as private property is. However, although nature may be the subject of the insurance policy, such policies are ultimately designed to protect ecosystem services that themselves protect people and benefit society. In fact, the very notion of ecosystem *services* or natural *capital*—rather than "nature"—is consistent with the underlying anthropocentrism of other forms of environmental governance in this context.[224]

This need not be so, however. Although initial efforts to insure nature in the ways described here focus on the services that ecosystems provide to society, it is possible to take a more expansive view and enshrine a more nature-centered view of governance.[225] While a full treatment of such efforts is beyond the scope of this Article, it is worth pausing to suggest that insuring *nature itself*—not just ecosystems and the services they provide—deserves a closer look in the environmental law and policy literature.

---

222. Arkema et al., *supra* note 7, at 916 (noting this concern and providing evidence that coastal ecosystems "protect more poor families relative to the total population in Texas and more elderly and total property value in Florida" (citations omitted)).

223. *Cf.* Sierra Club v. Morton, 405 U.S. 427, 741–42 (Douglas, J., dissenting) ("Contemporary public concern for protecting nature's ecological equilibrium should lead to the conferral of standing upon environmental objects to sue for their own preservation."); Gordon, *supra* note 1, at 87 (arguing that the issue of environmental personhood is not a binary question, but rather one that has different shades of meaning because it is "real, constructed, and lodged in discursive space"); Christopher D. Stone, *Should Trees Have Standing?—Toward Legal Rights for Natural Objects*, 45 S. CAL. L. REV. 450, 452 (1972) (arguing that natural objects should have standing to sue on their own behalf).

224. Gordon, *supra* note 1, at 74 (surveying literature on whether the environment has standing, and concluding that a "human-centered way of approaching environmental problems distorts even the best-intentioned environmentalism").

225. It is likely that government entities and nonprofit organizations would need to play a larger role in the creation of such instruments than private parties.

Insurance can also create positive spillover effects for other tools of governance. For example, insurers must perform sophisticated modeling and risk quantification before issuing policies. These models and risk quantifications, if shared with the public or other groups working on ecosystem services, could guide investments in conservation even in the absence of ecosystem insurance. Similarly, just as advocates of PES contend that market-based approaches generate valuations that can, in turn, inform other governance approaches to ecosystem services, so, too, can insurance generate such information.

Although ecosystem insurance fares well along these different normative criteria, it is not without its flaws. As an initial matter, any regime employing a parametric policy introduces basis risk—the risk that the payout does not match the extent of damage or the cost of restoration.[226] Thus, there is a risk that a disaster is so extreme and catastrophic that the insurance payout does not provide sufficient funds to restore the ecosystem. Indeed, basis risk is one reason why individual homeowners are unlikely to opt for parametric insurance over indemnity insurance, as any discrepancy between the funds needed to repair one's home and the actual loss or damage can be devastating. Of course, sophisticated buyers can work to design a policy trigger that is highly correlated with needed funds and thus minimize concerns about basis risk in the ecosystem-insurance context. But the risk remains, nonetheless.

Finally, it is important to remember that, at base, insurance is just a mechanism to transfer risk; it is not a source of funding. As such, it is not a silver bullet for generating more funds for ecosystem conservation and restoration than might otherwise be available. In other words, someone must pay annual premiums in order to have post-disaster payouts. And in order to provide incentives and coordination mechanisms for parties with insurable interests to be willing to pay and participate in such mechanisms, government participation may well be required.

CONCLUSION

Insurance offers unique attributes that other forms of environmental governance do not, namely its ability to disperse funds immediately and to restore ecosystems quickly after a damaging event.

226. *See* Elabed et al., *supra* note 164 and accompanying text.

Although parametric insurance is not a panacea for all forms of damage to ecosystem services, it can play a potentially significant role in the appropriate circumstances. Insurance is thus an important complement to existing mechanisms that protect, restore, and make essential ecosystems more resilient. To the extent ecosystems are public goods and society is underinvesting in their provision, insurance alone will not solve that problem. However, wisely designed insurance programs can mitigate risk and ensure that conservation or restoration efforts will be implemented quickly in the face of catastrophic or harmful severe weather events.