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The Fragile Menagerie: Biodiversity Loss, Climate Change, and the Law

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The Fragile Menagerie: Biodiversity Loss, Climate Change, and the Law*

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I. THE HIPPODROME OF THE GODS: RACING AGAINST ECOLOGICAL AND EVOLUTIONARY APOCALYPSE

Humanity, quite literally, is deep-sixing its planetary home. During the Phanerozoic eon, a span of 542 million years from the initial emergence of hard-shelled animals to the present,[1] the earth has experienced at least five catastrophic losses of biodiversity: the Ordovician-Silurian, the late Devonian, the Permian-Triassic, the Triassic-Jurassic, and the Cretaceous-Paleogene extinction events.[2] Humanity has pushed "the biological world" toward its "sixth major extinction event."[3] Severe enough to constitute "biological annihilation" on a global scale,[4] this death spasm

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1. *See, e.g.*, Kenneth G. Miller, Michelle A. Kominz, James V. Browning, James D. Wright, Gregory S. Mountain, Miriam E. Katz, Peter J. Sugarman, Benjamin S. Cramer, Nicholas Christie-Blick & Stephen F. Pekar, *The Phanerozoic Record of Global Sea-Level Change*, 310 SCIENCE 1293, 1293 (2005); *cf.* Alexander V. Markov & Andrey V. Korotayev, *Phanerozoic Marine Biodiversity Follows a Hyperbolic Trend*, 16 PALAEOWORLD 311 (2007) (extrapolating a hyperbolic model of marine biodiversity over the last 542 million years). The term *Phanerozoic* is derived from the ancient Greek words *φανερός* and *ζωή*, which together mean "visible life." *See* POCKET OXFORD CLASSICAL GREEK DICTIONARY 338, 150 (James Morwood & John Taylor eds., 2002) [hereinafter GREEK DICTIONARY]. I derived additional support for translations of ancient and modern Greek words and roots used throughout this Article from http://www.kypros.org/cgi-bin/lexicon [https://perma.cc/V5KV-6YLF] and http://www.etymonline.com [https://perma.cc/SR75-9NKB]. In addition, the authoritative dictionary, HENRY GEORGE LIDDELL & ROBERT SCOTT, A GREEK-ENGLISH LEXICON (1940), may be searched online at PERSEUS DIGITAL LIBRARY, http://www.perseus.tufts.edu/hopper [https://perma.cc/GB4L-9DEE].

2. *See* David M. Raup & J. John Sepkoski, Jr., *Mass Extinctions in the Marine Fossil Record*, 215 SCIENCE 1501, 1502 (1982). For an updated survey of mass extinction events throughout geologic history, see David P.G. Bond & Stephen E. Grasby, *On the Causes of Mass Extinctions*, 478 PALAEOGEOGRAPHY, PALAEOCLIMATOLOGY & PALAEOECOLOGY 3 (2017). Nearly everyone of a certain age knows the Cretaceous-Paleogene extinction by a different name, the *Cretaceous-Tertiary*. The International Commission on Stratigraphy has deprecated the term *Tertiary* and substituted the terms *Paleogene* and *Neogene* as designations for the periods of the Cenozoic Era. *See* Robert A. Rohde, *Whatever Happened to the Tertiary and Quaternary?*, GEOWHEN DATABASE, http://stratigraphy.org/bak/geowhen/TQ.html [https://perma.cc/47E4-FLR2] (last updated Jan. 18, 2005). But this decision trashes "terminology with nearly 250 years of history" and contradicts popular references to "the extinction of the dinosaurs at the Cretaceous-Tertiary (or K-T) boundary." *Id.*

3. J. A. Thomas, M. G. Telfer, D. B. Roy, C. D. Preston, J. J. D. Greenwood, J. Asher, R. Fox, R. T. Clarke & J. H. Lawton, *Comparative Losses of British Butterflies, Birds, and Plants and the Global Extinction Crisis*, 303 SCIENCE 1879, 1881 (2004); *see also*, *e.g.*, ELIZABETH KOLBERT, THE SIXTH EXTINCTION: AN UNNATURAL HISTORY (2014); RICHARD LEAKEY & ROGER LEWIN, THE SIXTH EXTINCTION: PATTERNS OF LIFE AND THE FUTURE OF MANKIND (1996).

4. Gerardo Ceballos, Paul R. Ehrlich & Rodolfo Dirzo, *Biological Annihilation via the*

deserves to be called the Anthropocene extinction.[5]

Life on Earth overcomes mass extinction events on a temporal scale spanning millions of years. Full restoration of biodiversity after mass extinction requires 10 million to 100 million years.[6] By this measure, "the loss of genetic and species diversity" is probably the contemporary crisis "our descendants [will] most regret" and "are least likely to forgive."[7] Because "time is the longest distance between two places,"[8] Edward Wilson has described biodiversity loss as the "scientific problem of great[est] immediate importance for humanity."[9]

To this concern we must add anthropogenic climate change. Scientific evidence attributing severe, even catastrophic, climate change to anthropogenic emissions of greenhouse gases has long passed the point of reasonable doubt.[10] "[W]e can no longer postpone serious consideration" of proper responses to climate change.[11] American debates over climate change, scientifically and politically wretched as they are,[12] have shifted from questions of causation to debates over the proper policy response.[13]

Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines, 114 PROC. NAT'L ACAD. SCI. E6089, E6089 (2017) (finding an "extremely high degree of population decay in vertebrates, even in common 'species of low concern,'" and decrying the resulting "massive anthropogenic erosion of biodiversity and of the ecosystem services essential to civilization").

5. *See, e.g.*, Will Steffen, Jacques Grinevald, Paul Crutzen & John McNeill, *The Anthropocene: Conceptual and Historical Perspectives*, 369 PHIL. TRANSACTIONS ROYAL SOC'Y A 842, 843 (2011); Jan Zalasiewicz, Mark Williams, Will Steffen & Paul Crutzen, *The New World of the Anthropocene*, 44 ENVTL. SCI. & TECH. 2228, 2228 (2010). The term *Anthropocene* is derived from *ἄνθρωπος* and *καινός*, the ancient Greek words for "human" and "new" (or "recent"). *See* GREEK DICTIONARY, *supra* note 1, at 30, 168. I have outlined an admittedly apocalyptic vision of agriculture and its regulation in the Anthropocene. *See* James Ming Chen, *Anthropocene Agricultural Law*, 3 TEX. A&M L. REV. 745 (2016).

6. *See* EDWARD O. WILSON, THE DIVERSITY OF LIFE 330 (2d ed. 1999).

7. *Endangered Species Act Oversight: Hearings Before the Subcomm. on Envtl. Pollution of the Comm. on Env't. and Pub. Works*, 97th Cong. 366 (1981) (statement of Edward O. Wilson, Baird Professor of Science, Harvard University).

8. TENNESSEE WILLIAMS, THE GLASS MENAGERIE 96 (New Directions Books 1999) (1945).

9. WILSON, *supra* note 6, at 254.

10. *See, e.g.*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS* (2014), http://www.ipcc.ch/report/ar5/wg1 [https://perma.cc/6T3S-8TNK]; James Hansen et al., *Ice Melt, Sea Level Rise and Superstorms: Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations That 2 °C Global Warming Could Be Dangerous*, 16 ATMOSPHERIC CHEMISTRY & PHYSICS 3761 (2016).

11. Daniel A. Farber, *Adapting to Climate Change: Who Should Pay*, 23 J. LAND USE & ENVTL. L. 1, 2 (2007); *cf.* Shi-Ling Hsu, *A Prediction Market for Climate Outcomes*, 83 U. COLO. L. REV. 179 (2011) (proposing a mechanism for adjusting carbon taxes and emission permits according to time-variant climate outcomes).

12. *See generally* Anthony Leiserowitz, *Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values*, 77 CLIMATIC CHANGE 45 (2006).

13. Jody Freeman & Andrew Guzman, *Climate Change and U.S. Interests*, 109 COLUM. L. REV. 1531, 1531 (2009); Carrie A. Scrufari, *Tackling the Tenure Problem: Promoting Land Access for New Farmers as Part of a Climate Change Solution*, 42 COLUM. J. ENVTL. L. 497, 499 (2017).

Biodiversity loss and climate change are closely related catastrophes.[14] Indeed, within the framework of biodiversity loss, climate change represents an extreme variation on the theme of habitat destruction. Large-scale habitat destruction through climate change threatens many plant and animal species with extinction. Although "organisms respond to climate and climatic change in a variety of ways, depending on the nature, rate and duration of the change, and the range of available biological responses,"[15] paleontology has connected "[t]he three best-studied mass extinction events" to "sharp changes in climate."[16] Humility about the human impact on natural history and the biosphere provides ample reason to presume "that rapid shifts in climate can reduce global diversity."[17]

If indeed biodiversity loss and climate change have reached apocalyptic proportions, it is fitting to describe the engines of extinction in equine terms. On the hippodrome of the gods, apocalyptic horsemen are riding roughshod over the face of the earth: "I looked, and there before me was a pale horse! Its rider was named Death, and Hades was following close behind him. They were given power over a fourth of the earth to kill by sword, famine, and plague, and by the wild beasts of the earth."[18]

Jared Diamond characterizes the deadly horsemen of the ecological apocalypse as an "Evil Quartet": habitat destruction, overkill, introduced species, and secondary extinctions.[19] Edward Wilson prefers an acronym derived from the ancient Greek

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14. *See* Céline Bellard, Cleo Bertelsmeier, Paul Leadley, Wilfried Thuiller & Franck Courchamp, *Impacts of Climate Change on the Future of Biodiversity*, 15 ECOLOGY LETTERS 365 (2012); Camille Parmesan & Gary Yohe, *A Globally Coherent Fingerprint of Climate Change Impacts Across Natural Systems*, 421 NATURE 37, 37 (2003); Robert L. Peters, *Conservation of Biological Diversity in the Face of Climate Change*, *in* GLOBAL WARMING AND BIOLOGICAL DIVERSITY 15, 21–22 (Robert L. Peters & Thomas E. Lovejoy eds., 1992); Stuart L. Pimm, *Climate Disruption and Biodiversity*, 19 CURRENT BIOL. R595 (2009); Terry L. Root, Jeff T. Price, Kimberly R. Hall, Stephen H. Schneider, Cynthia Rosenzweig & J. Alan Pounds, *Fingerprints of Global Warming on Wild Animals and Plants*, 421 NATURE 57, 57 (2003); *cf.* Herman E. Daly, *Ecological Economics*, 254 SCIENCE 358 (1991) (suggesting that global warming can threaten even *Homo sapiens* by destabilizing the human food supply). *See generally* Osvaldo E. Sala et al., *Global Biodiversity Scenarios for the Year 2100*, 287 SCIENCE 1770 (2000) (describing the potential ecological impact of land use, proliferation of exotic species, climate change, and the continued escalation of CO_2 and N_2 levels).

15. Douglas H. Erwin, *Climate as a Driver of Evolutionary Change*, 19 CURRENT BIOLOGY R575, R575 (2009). *See generally* Camille Parmesan, *Ecological and Evolutionary Responses to Recent Climate Change*, 37 ANN. REV. ECOLOGY EVOLUTION & SYSTEMATICS 637 (2006); Andreas Schmittner, Nathan M. Urban, Jeremy D. Shakun, Natalie M. Mahowald, Peter U. Clark, Patrick J. Bartlein, Alan C. Mix & Antoni Rosell-Melé, *Climate Sensitivity Estimated from Temperature Reconstructions of the Last Glacial Maximum*, 334 SCIENCE 1385 (2011).

16. Erwin, *supra* note 15, at R581.

17. *Id.*

18. *Revelation* 6:8 (New International Version).

19. *See* Jared Diamond, *Overview of Recent Extinctions*, *in* CONSERVATION FOR THE TWENTY-FIRST CENTURY 37, 39–41 (David Western & Mary C. Pearl eds., 1989); *see also* Jared M. Diamond, *"Normal" Extinctions of Isolated Populations*, *in* EXTINCTIONS 191 (Matthew H. Nitecki ed., 1984).

word for "horse."[20] HIPPO represents Habitat destruction, Invasive species, Pollution, Population, and Overharvesting.[21] Although conservation biologists have identified the leading causes of biodiversity loss, legal responses often fail to address distinct sources of human influence on evolutionary change. This Article takes a modest step toward remedying that shortcoming.

Such "environmental and land-use ethics" as are "codified in law" today stem from an "era when the human population, at one-tenth its present size, tamed wilderness with axe and ox."[22] Before the rise of Neolithic agriculture and the spread of sedentary human settlements across much of the globe's surface, Wilson's deadly HIPPO took the reverse sequence: OPPIH. The transmogrification of OPPIH to HIPPO over time frames the human impact on evolution in historical as well as biological terms.[23]

The transition from OPPIH to HIPPO can be seen at all geographical scales, from the continental to the insular. In Paleolithic times, the overharvesting of large mammals and flightless birds had a greater ecological impact than what was then "a still proportionately small amount of habitat destruction."[24] Whatever the precise mechanism elsewhere in the world,[25] a human invasion bears primary responsibility for biodiversity loss in the western hemisphere.[26] In North America, the sudden disappearance 11,000 to 12,000 years ago of large mammals such as mammoths and ground sloths, after the continent's megafauna had survived twenty-two glacial cycles, suggests that this mass extinction may have arisen from "blitzkrieg."[27] Changes

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20. *See* GREEK DICTIONARY, *supra* note 1, at 164 (*ἵππος*). Contemporary English words incorporating this root include "hippocampus" (seahorse), "hippopotamus" (river-horse), and "hippodrome" (racetrack, or literally "horse-road").

21. EDWARD O. WILSON, THE FUTURE OF LIFE 50–51 (2002).

22. David Tilman, *Causes, Consequences and Ethics of Biodiversity*, 405 NATURE 208, 210 (2000).

23. For evaluations of the human impact on biodiversity before the rise of sedentary civilizations, see Richard G. Klein, *The Impact of Early People on the Environment: The Case of Large Mammal Extinctions*, *in* HUMAN IMPACT ON THE ENVIRONMENT: ANCIENT ROOTS, CURRENT CHALLENGES 13 (Judith E. Jacobsen & John Firor eds., 1992); Paul S. Martin, *40,000 Years of Extinctions on the "Planet of Doom,"* 82 PALAEOGEOGRAPHY PALAEOCLIMATOLOGY PALAEOECOLOGY 187 (1990).

24. WILSON, *supra* note 21, at 50.

25. *See generally* Michael W. Beck, *On Discerning the Cause of Late Pleistocene Megafaunal Extinctions*, 22 PALEOBIOLOGY 91 (1996) (presenting different hypotheses for the extinctions of large mammals and birds during the late Pleistocene epoch).

26. *See generally* C Vance Haynes, Jr., *Contributions of Radiocarbon Dating to the Geochronology of the Peopling of the New World*, *in* RADIOCARBON AFTER FOUR DECADES: AN INTERDISCIPLINARY PERSPECTIVE 355 (R.E. Taylor, A. Long & R.S. Kra eds., 1992).

27. *Cf.* Jared M. Diamond, *Quaternary Megafaunal Extinctions: Variations on a Theme by Paganini*, 16 J. ARCHAEOLOGICAL SCI. 167, 169 (1989) (concluding ultimately that North American extinctions resulted not from blitzkrieg but from "sitzkrieg," or prolonged human occupation of theretofore human-free ecosystems); David. W. Steadman & Paul S. Martin, *Extinction of Birds in the Late Pleistocene of North America*, *in* QUATERNARY EXTINCTIONS: A PREHISTORIC REVOLUTION 466 (Paul S. Martin & Richard G. Klein eds., 1984) (estimating twenty to forty avian extinctions due to ecological dependencies on the more than forty extinctions of sloths, mammoths, mastodons, horses, tapirs, and other large North American mammals

in vegetation and climate stemming from the mass slaughter sealed North America's biological fate.[28]

The settlement of Polynesia, beginning 3500 to 3000 years before the present,[29] introduced three domesticated species of Eurasian provenance—pigs, dogs, and chickens—that simultaneously dictated the arc of economic development on each island and spelled doom for many of the islands' endemic species.[30] The enduring prominence of the words for pigs, dogs, and chickens in the Hawaiian language—*pua'a*, *'īlio*, *moa*[31]—pays linguistic homage to the centrality of animal husbandry in Polynesian culture before European contact.[32]

Today, relative to these episodes across what is now the territory of the United States, "the principal cause of biodiversity loss is the fragmentation, degradation, and destruction of ecosystems and habitats through conversion of land to economically productive uses, especially agriculture, forestry, mineral and fossil fuel extraction, and urban development."[33] Global climate change represents an even more potent driver of ecological ruin and evolutionary change.[34]

Prominent controversies over the constitutionality of endangered species protection[35] have established awareness in American law of the utilitarian rationales for protecting biodiversity. The red wolf, it is said, inspires tourism in the southeastern

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during the Pleistocene epoch). The extent to which human colonization affected the ecology of North America is fiercely debated. *See* TIM FLANNERY, THE ETERNAL FRONTIER: AN ECOLOGICAL HISTORY OF NORTH AMERICA AND ITS PEOPLES (2001); SHEPARD KRECH III, THE ECOLOGICAL INDIAN: MYTH AND HISTORY (1999); TED STEINBERG, DOWN TO EARTH: NATURE'S ROLE IN AMERICAN HISTORY (2002).

28. *See* M.-O. Brault, L. A. Mysak, H. D. Matthews & C. T. Simmons, *Assessing the Impact of Late Pleistocene Megafaunal Extinctions on Global Vegetation and Climate*, 9 CLIMATE PAST 1761, 1761–62 (2013); J. Tyler Faith, *Late Pleistocene Climate Change, Nutrient Cycling, and the Megafaunal Extinctions in North America*, 30 QUATERNARY SCI. REVIEWS 1675, 1676 (2011).

29. *See generally* GEOFFREY IRWIN, THE PREHISTORIC EXPLORATION AND COLONISATION OF THE PACIFIC 64–105 (1992).

30. *See* JARED DIAMOND, GUNS, GERMS, AND STEEL: THE FATES OF HUMAN SOCIETIES 60 (3d ed. 2005).

31. *See* MARY KAWENA PUKUI & SAMUEL H. ELBERT, NEW POCKET HAWAIIAN DICTIONARY 181, 38, 99 (1992).

32. *See* SALLY ENGLE MERRY, COLONIZING HAWAI'I: THE CULTURAL POWER OF LAW 221–42 (Sherry B. Ortner, Nicholas B. Dirks & Geoff Eley eds., 2000); PATRICK VINTON KIRCH, ON THE ROAD OF THE WINDS: AN ARCHAEOLOGICAL HISTORY OF THE PACIFIC ISLANDS BEFORE EUROPEAN CONQUEST (2000).

33. Bradley C. Karkkainen, *Biodiversity and Land*, 83 CORNELL L. REV. 1, 7 (1997) (footnotes omitted).

34. *See* sources cited *supra* note 14.

35. *See, e.g.*, Christine A. Klein, *The Environmental Commerce Clause*, 27 HARV. ENVTL. L. REV. 1 (2003); Bradford C. Mank, *Protecting Intrastate Threatened Species: Does the Endangered Species Act Encroach on Traditional State Authority and Exceed the Outer Limits of the Commerce Clause?*, 36 GA. L. REV. 723 (2002); John Copeland Nagle, *The Commerce Clause Meets the Delhi Sands Flower-Loving Fly*, 97 MICH. L. REV. 174 (1998); Omar N. White, *The Endangered Species Act's Precarious Perch: A Constitutional Analysis Under the Commerce Clause and the Treaty Power*, 27 ECOLOGY L.Q. 215 (2000).

United States.[36] The Delhi Sands flower-loving fly epitomizes those insects that might be conscripted as future pollinators[37] should honeybees ever fail[38]—a prospect that becomes likelier as colony collapse disorder spreads.[39] The dual myths of biopiracy and bioprospecting persist, even though economic gains from medicinal exploitation of endangered species are speculative at best.[40] Dreams of economic transformation through pharmacology must be tempered by realities such as the failure of the Pacific yew to spur a biotechnology boom through the oncological exploitation of Taxol.[41] Purely pecuniary interest in bioprospecting does tantalizingly promise the possibility of harnessing pharmaceutical companies into the business of biodiversity conservation by posing extinction as a bar to the patenting of drugs derived from species that have died out.[42]

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36. *See* Gibbs v. Babbitt, 214 F.3d 483 (4th Cir. 2000).

37. *See* Nat'l Ass'n of Home Builders v. Babbitt, 130 F.3d 1041, 1053 (D.C. Cir. 1997).

38. For discussions of the economic impact of insect pollinators, see GRETCHEN C. DAILY & KATHERINE ELLISON, THE NEW ECONOMY OF NATURE: THE QUEST TO MAKE CONSERVATION PROFITABLE (2002); John B. Loomis & Douglas S. White, *Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis*, 18 ECOLOGICAL ECON. 197 (1996); Leslie Richardson & John Loomis, *Total Economic Valuation of Endangered Species: A Summary and Comparison of the United States and the Rest of the World Estimates*, *in* CONSERVING AND VALUING ECOSYSTEM SERVICES AND BIODIVERSITY: ECONOMIC, INSTITUTIONAL AND SOCIAL CHALLENGES 25 (K.N. Ninan ed., 2009).

39. *See, e.g.*, Peter Neumann & Norman L. Carreck, *Honey Bee Colony Losses*, 49 J. APICULTURAL RES. 1 (2010); Benjamin P. Oldroyd, *What's Killing American Honey Bees?*, 5 PLoS BIOLOGY 1195 (2007); Kristine M. Smith, Elizabeth H. Loh, Melinda K. Rostal, Carlos M. Zambrana-Torrelio, Luciana Mendiola & Peter Daszak, *Pathogens, Pests, and Economics: Drivers of Honey Bee Colony Declines and Losses*, 10 ECOHEALTH 434 (2013); Andrea Tapparo, Daniele Marton, Chiara Giorio, Alessandro Zanella, Lidia Soldà, Matteo Marzaro, Linda Vivan & Vincenzo Girolami, *Assessment of the Environmental Exposure of Honeybees to Particulate Matter Containing Neonicotinoid Insecticides Coming from Corn Coated Seeds*, 46 ENVTL. SCI. & TECH. 2592 (2012); Geoffrey R. Williams, David R. Tarpy, Dennis vanEngelsdorp, Marie-Pierre Chauzat, Diana L. Cox-Foster, Keith S. Delaplane, Peter Neumann, Jeffrey S. Pettis, Richard E.L. Rogers & Dave Shutler, *Colony Collapse Disorder in Context*, 32 BIOESSAYS 845 (2010).

40. *See also* Mark Sagoff, *Muddle or Muddle Through? Takings Jurisprudence Meets the Endangered Species Act*, 38 WM. & MARY L. REV. 825, 844 (1997) ("Moral, aesthetic, and spiritual arguments amply may justify [biodiversity conservation], but an instrumental or economic rationale appears beyond reach."). *Compare* Jim Chen, *There's No Such Thing as Biopiracy . . . And It's a Good Thing Too*, 37 MCGEORGE L. REV. 1 (2006), *with* James Ming Chen, *Bioprospect Theory*, 7 AKRON INTELL. PROP. J. 19, 22 (2014) ("There simply is no defensible basis for treating ethnobiological knowledge as the foundation of a globally coherent approach to economic development."). On the apparent lack of connection between environmental quality and human well-being, see Ciara Raudsepp-Hearne, Garry D. Peterson, Maria Tengö, Elena M. Bennett, Tim Holland, Karina Benessaiah, Graham K. MacDonald & Laura Pfeifer, *Untangling the Environmentalist's Paradox: Why Is Human Well-Being Increasing as Ecosystem Services Degrade?*, 60 BIOSCIENCE 576 (2010).

41. *See generally* JORDAN GOODMAN & VIVIEN WALSH, THE STORY OF TAXOL: NATURE AND POLITICS IN THE PURSUIT OF AN ANTI-CANCER DRUG (2001).

42. *See* Andrew W. Torrance, *An Extinction Bar to Patentability*, 20 GEO. INT'L ENVTL. L. REV. 237 (2008); Andrew W. Torrance, *Patent Law, HIPPO, and the Biodiversity Crisis*, 9 J.

At the same time, however, the law fails to calibrate its remedies according to the severity of the biological threat. Perversely enough, the legal understanding of extinction mechanisms remains frozen in time, like an insect in amber or, more appropriately, a Chalcolithic (Copper Age) human in ice.[43] Legal responses to biodiversity loss take primary aim at overkill and the marketing of products derived from endangered species. These are biological concerns more closely linked to phases of human history before its great acceleration through agriculture, urbanization, and industrial production. The legal enterprise of preventing extinctions would seem likelier to succeed if it addressed the most powerful causes of biodiversity loss today. Climate change, habitat destruction, and alien invasive species should figure more prominently than overkill in the law of biodiversity protection.

Part II of this Article describes how the law seeks to preserve biodiversity by deterring overkill, habitat destruction, and the introduction of alien invasive species. The law imposes its clearest and harshest sanctions precisely where the drivers of extinction are weakest: when humans take conscious steps to capture or kill other living things for human gain.

Part III more closely examines the use of the Endangered Species Act of 1973 (ESA or "Act")[44] to address habitat destruction on private land and to mitigate climate change. Part IV concludes that the law's lack of congruence with conservation biology impedes efforts to preserve biodiversity and mitigate climate change. It accordingly prescribes a wide range of responses, pragmatic as well as aspirational, that better align the law with the most daunting environmental challenges of the Anthropocene epoch.

II. Across the Apocalypse on Horseback: Legal Responses to Biodiversity Loss

A. Overkill

In 1918, the fourth year of global warfare that would ultimately claim nine million military and seven million civilian casualties, a lethal influenza pandemic took hold. Between January 1918 and December 1920, the Spanish flu would kill between 50 and 100 million people worldwide—some three to five percent of the human population.[45]

Marshall Rev. Intell. Prop. L. 624, 637 (2010). *See generally* Analogue-Based Drug Discovery (János Fischer & C. Robin Ganellin eds. 2006).

43. *See generally, e.g.*, Brenda Fowler, Iceman: Uncovering the Life and Times of a Prehistoric Man Found in an Alpine Glacier (2000); The Iceman and His Natural Environment: Palaeobotanical Results (Sigmar Bortenschlager & Klaus Oeggl eds., 2000); Andreas Keller et al., *New Insights into the Tyrolean Iceman's Origin and Phenotype as Inferred by Whole-Genome Sequencing*, Nature Comm. (Feb. 28, 2012), https://www.nature.com/articles/ncomms1701.pdf [https://perma.cc/N5WR-TKUW]; William A. Murphy, Jr., Dieter zur Nedden, Paul Gostner, Rudolf Knapp, Wolfgang Recheis & Horst Seidler, *The Iceman: Discovery and Imaging*, 226 Radiology 614 (2003). All of these sources describe "Ötzi the Iceman," who lived around 3300 B.C.E. and was found in Tyrolean Alps in 1991.

44. 16 U.S.C. §§ 1531–1544 (2012).

45. *See, e.g.*, John M. Barry, The Great Influenza: The Epic Story of the Deadliest

At the front and at home, death came as a pale rider astride a pale horse.[46] Perhaps not coincidentally, two stories of biodiversity loss, evocative of the Edwardian excess of Joseph Conrad's *Heart of Darkness*,[47] bracketed the years of the Great War. Amid the human slaughter, two of America's iconic birds disappeared forever from the planet.

In a certain sense, we have never recovered from witnessing the extermination of the Carolina parakeet and the passenger pigeon. These birds, respectively "temperate North America's only native parrot"[48] and quite probably the continent's most abundant bird (if not also its most abundant terrestrial vertebrate),[49] became extinct at the Cincinnati Zoo four years apart. Martha, the last passenger pigeon, died on September 1, 1914; Incas, a male Carolina parakeet and the last of his kind, died on

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PLAGUE IN HISTORY (2004); ALFRED W. CROSBY, AMERICA'S FORGOTTEN PANDEMIC: THE INFLUENZA OF 1918 (2d ed. 2003); ALFRED W. CROSBY, JR., EPIDEMIC AND PEACE, 1918 (1976).

46. *See* KATHERINE ANNE PORTER, *Pale Horse, Pale Rider*, *in* PALE HORSE, PALE RIDER: SELECTED SHORT STORIES 314 (Penguin Classics 2011) (1939). On the connections between Porter's fiction, the apocalyptic vision of *Revelation* 6:1–8, and the influenza pandemic of 1918-20, see George Cheatham, *Death and Repetition in Porter's Miranda Stories*, 61 AM. LITERATURE 610 (1989); David A. Davis, *The Forgotten Apocalypse: Katherine Anne Porter's "Pale Horse, Pale Rider," Traumatic Memory, and the Influenza Pandemic of 1918*, S. LITERARY J., Spring 2011, at 55.

47. JOSEPH CONRAD, HEART OF DARKNESS (1902).

48. Timothy F. Wright, Book Review, 123 AUK 291, 291 (2006) (reviewing NOEL F.R. SNYDER, THE CAROLINA PARAKEET: GLIMPSES OF A VANISHED SPECIES (2004)). "Prior to its decline and extinction, the Carolina Parakeet . . . was distributed patchily throughout the eastern half of North America as far north as the southern shores of Lake Erie and Lake Ontario, making it by far the most northerly distributed parrot (Psittaciformes) in the Americas." Jeremy J. Kirchman, Erin E. Schirtzinger & Timothy F. Wright, *Phylogenetic Relationships of the Extinct Carolina Parakeet (*Conuropsis carolinensis*) Inferred from DNA Sequence Data*, 129 AUK 197, 198 (2012). "The USA was formerly home to 2 native parrot species—the Carolina parakeet . . . and the thick-billed parrot (*Rhynchopsitta pachyrhyncha*)—both of which disappeared from the USA during the 20th century." Christopher J. Butler, *Feral Parrots in the Continental United States and United Kingdom: Past, Present, and Future*, 19 J. AVIAN MED. & SURGERY 142, 142 (2005) (noting that the thick-billed parrot was "formerly present in southeastern Arizona and southwestern New Mexico"). *See generally* JOSEPH M. FORSHAW & FRANK KNIGHT, VANISHED AND VANISHING PARROTS: PROFILING EXTINCT AND ENDANGERED SPECIES (2017).

49. One credible estimate places the number of passenger pigeons in North America at the time of European arrival between three billion and five billion, A. W. SCHORGER, THE PASSENGER PIGEON: ITS NATURAL HISTORY AND EXTINCTION 204 (1955), or twenty-five to forty percent of the continent's avian population, *accord* JOEL GREENBERG, A FEATHERED RIVER ACROSS THE SKY: THE PASSENGER PIGEON'S FLIGHT TO EXTINCTION 1 (2014) ("At the time that Europeans first arrived in North America, passenger pigeons likely numbered anywhere from three to five billion. It was the most abundant bird on the continent, if not the planet, and may well have comprised 25 to 40 percent of North America's bird life."); *see also* Gemma G. R. Murray et al., *Natural Selection Shaped the Rise and Fall of Passenger Pigeon Genomic Diversity*, 358 SCIENCE 951, 951 (2017) ("The extinct passenger pigeon was once the most abundant bird in North America, and possibly the world."). "Whatever the number, this species enjoyed a population that may have exceeded that of every other bird on earth, and its aggregations surpassed in numbers those of every other terrestrial vertebrate on the continent." GREENBERG, *supra* at 7.

February 21, 1918.[50] The 1916 treaty at issue in *Missouri v. Holland*,[51] perhaps one of the first legal enactments in the United States (or anywhere else in the world) to treat biodiversity conservation as "a national interest of very nearly the first magnitude,"[52] focused exclusively on "the killing, capturing or selling . . . of . . . migratory birds."[53]

At least with respect to the passenger pigeon, humanity's failure to recover from the extinction of a species is true in a very tangible sense. By eliminating the principal predator of ticks in northern forests, the extermination of the passenger pigeon may be fairly blamed for the rise in the human incidence of Lyme disease.[54]

For their part, whether birds collectively exacted revenge on humanity through the Spanish flu remains a medical mystery.[55] Throughout the Great War, birds and humans had maintained a morbid symbiosis. While men fought in their trenches, "The larks, still bravely singing, fl[ew] / Scarce heard amid the guns below."[56] As the Armistice took hold on the eleventh hour of the eleventh day of the eleventh month in 1918:

> [W]ithin half an hour of the guns falling silent the birds began to sing again. . . .
> [K]aum eine halbe Stunde nach dem Schweigen der Waffen [begannen] die Vögel . . . , wieder zu singen. . . .
> [U]ne demi-heure après que le silence des armes se fit, les oiseaux chantèrent à nouveau.[57]

But not all the birds. Die Stimme mancher Vögel sind verloren worden. Pour toujours.

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50. *See* CHRISTOPHER COKINOS, HOPE IS THE THING WITH FEATHERS: A PERSONAL CHRONICLE OF VANISHED BIRDS 50–52 (2000) (Carolina parakeet); *id.* at 258–78 (passenger pigeon); SCOTT WEIDENSAUL, THE BIRDER'S MISCELLANY: A FASCINATING COLLECTION OF FACTS, FIGURES, AND FOLKLORE FROM THE WORLD OF BIRDS (1991). *See generally* ERROL FULLER, EXTINCT BIRDS (rev. ed. 2001). For a celebrated account of how Incas "died of grief" after the death of his mate, Lady Jane, see George Laycock, *The Last Parakeet*, AUDUBON, Mar. 1969, at 21; *see also* SCHORGER, *supra* note 49, at 28–30.

51. 252 U.S. 416 (1920).

52. *Id.* at 435.

53. *Id.* at 431.

54. *See* David E. Blockstein, Letter, *Lyme Disease and the Passenger Pigeon?*, 279 SCIENCE 1831 (1998); David E. Blockstein, *Passenger Pigeons, Lyme Disease, and Us: The Unintended Consequences of the Death of a Species*, BIRDING, Aug. 2001, at 302. *See generally* SCHORGER, *supra* note 49; Tim R. Hofmeester, Patrick A. Jansen, Hendrikus J. Wijnen, Elana C. Coipan, Manoj Fonville, Herbert H. T. Prins, Hein Sprong & Sipke E. van Wieren, *Cascading Effects of Predator Activity on Tick-Borne Disease Risk*, 284 ROYAL SOC'Y PROC. B, no. 1859, 2017.

55. *Compare* Jeffery K. Taubenberger, Ann H. Reid, Raina M. Lourens, Ruixue Wang, Guozhong Jin & Thomas G. Fanning, *Characterization of the 1918 Influenza Virus Polymerase Genes*, 437 NATURE 889 (2005) (describing the Spanish flu virus as avian in origin), *with* Janis Antonovics, Michael E. Hood & Christi Howell Baker, *Molecular Virology: Was the 1918 Flu Avian in Origin?*, 440 NATURE E9 (2006) (disputing the putatively avian origins of the Spanish flu virus).

56. JOHN MCCRAE, IN FLANDERS FIELDS AND OTHER POEMS 3 (1919).

57. NICK YAPP, 1910S: DECADES OF THE 20TH CENTURY 182–83 (2001).

"Because they are so conspicuous and appealing to the human senses of sight and sound, birds always have attracted more than their fair share of our zoological attention."[58] To love birds is to wade in Henry David Thoreau's "tonic of wildness," those "marshes where the bittern and the meadow-hen lurk, and [to] hear the booming of the snipe; to smell the whispering sedge where only some wilder and more solitary fowl builds her nest."[59] The sandhill crane moved Aldo Leopold to observe: "Our ability to perceive quality in nature begins, as in art, with the pretty. It expands through successive stages of the beautiful to values as yet uncaptured by language."[60] Environmental law hears clearly, if only belatedly, the melody that the "nightingales . . . sang within the bloody wood."[61]

No environmental sin is graver, and no biological loss more irreversible, than extinction.[62] Likewise, no vector of extinction is more emotionally gripping than direct, intentional killing. The paradigmatic act of converting wildlife to personal property through capture or slaughter[63] remains the central focus of laws designed to protect endangered species. In the United States, section 9 of the Endangered Species Act[64]

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58. David W. Steadman, *Human-Caused Extinction of Birds*, *in* BIODIVERSITY II: UNDERSTANDING AND PROTECTING OUR BIOLOGICAL RESOURCES 139, 139 (Marjorie L. Reaka-Kudla, Don E. Wilson & Edward O. Wilson eds., 1997). *See generally* C. J. BIBBY, N. J. COLLAR, M. J. CROSBY, M. F. HEATH, CH. IMBODEN, T. H. JOHNSON, A. J. LONG, A. J. STATTERSFIELD & S. J. THIRGOOD, PUTTING BIODIVERSITY ON THE MAP: PRIORITY AREAS FOR GLOBAL CONSERVATION (1992) (proposing the concept of an "endemic bird area"); ALISON J. STATTERSFIELD, MICHAEL J. CROSBY, ADRIAN J. LONG & DAVID C. WEGE, ENDEMIC BIRD AREAS OF THE WORLD: PRIORITIES FOR BIODIVERSITY CONSERVATION (1998).

59. HENRY DAVID THOREAU, WALDEN 242 (Empire Books 2017).

60. ALDO LEOPOLD, A SAND COUNTY ALMANAC, AND SKETCHES HERE AND THERE 96 (1st ed. 1949); *accord* COKINOS, *supra* note 50, at 13 ("[T]he Carolina Parakeet . . . was, by virtue of its beauty and its extinction, more than just a species.").

61. T.S. ELIOT, *Sweeney Among the Nightingales*, *in* COLLECTED POEMS 1909–1962, at 49, 50 (Harcourt Brace Jovanovich 1991); *see also* ELIOT, *The Waste Land*, *in* COLLECTED POEMS, *supra* at 51, 56 ("[Y]et there the nightingale / Filled all the desert with inviolable voice . . . .").

62. *See* Fred P. Bosselman, *Extinction and the Law: Protection of Religiously-Motivated Behavior*, 68 CHI.-KENT L. REV. 15, 15 (1992).

63. *See* Pierson v. Post, 3 Cai. 175 (N.Y. Sup. Ct. 1805) (awarding ownership upon actual capture of a fox, and not upon mere pursuit of it); Liesner v. Wanie, 145 N.W. 374 (Wis. 1914) (awarding ownership to the hunter who fires the shot that mortally wounds a hunted animal); Young v. Hichens, (1844) 115 Eng. Rep. 228, 230 (awarding ownership when a fisherman has attained "actual power over the fish"); *cf.* Geer v. Connecticut, 161 U.S. 519, 529–31 (1896) (recognizing the traditional police power of the states over hunting and fishing), *overruled by* Hughes v. Oklahoma, 441 U.S. 322 (1979). The Supreme Court has "expressly overrule[d] *Geer*," reasoning instead "that challenges under the Commerce Clause to state regulations of wild animals should be considered according to the same general rule applied to state regulations of other natural resources." *Hughes*, 441 U.S. at 335. *But cf.* Baldwin v. Fish & Game Comm'n, 436 U.S. 371, 388 (1978) (holding that a state may charge differential rates to residents and non-residents for recreational elk hunting permits without offending the privileges and immunities clause of U.S. CONST. art. IV, § 2, cl. 1). *See generally* 2 WILLIAM BLACKSTONE, COMMENTARIES *390 (describing common law precedent before the nineteenth century on the ownership of wild animals); Dhammika Dharmapala, *An Economic Analysis of "Riding to Hounds":* Pierson v. Post *Revisited*, 18 J.L. ECON. & ORG. 39 (2002).

64. 16 U.S.C. §§ 1531–1544 (2012).

flatly prohibits the "tak[ing]" of any protected species.[65] "The term 'take'" in turn "means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."[66] Section 9 so unequivocally condemns the killing or harassing of individual organisms that few litigated Endangered Species Act cases discuss this aspect of the statute. The killing of wolves, either with[67] or without[68] official sanction, dominates litigation over the deliberate targeting of individual members of protected species. One of the most prominent reported cases involving an attempt to "take" a member of a protected species[69] actually arose under the Marine Mammal Protection Act of 1972.[70]

The Endangered Species Act reveals an overt bias in favor of preventing direct takings of large, charismatic fauna over all other threats to biodiversity.[71] The Act excludes certain insects from its protective aegis,[72] even though insects are so essential to human welfare that if they "and other land-dwelling arthropods . . . were to disappear, humanity probably could not last more than a few months."[73] The reverse, assuredly, is not true: If humans should ever depart the planet, "among the immediate

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65. *Id.* § 1538(a)(1)(B)–(C).

66. *Id.* § 1532(19).

67. *See* Sierra Club v. Clark, 755 F.2d 608 (8th Cir. 1985) (invalidating Department of Interior regulations that would have permitted the sport trapping of eastern timber wolves).

68. *See* United States v. McKittrick, 142 F.3d 1170 (9th Cir. 1998) (upholding ESA penalties levied against a rancher who shot and decapitated a gray wolf).

69. *See* United States v. Hayashi, 22 F.3d 859, 863–66 (9th Cir. 1993) (holding that shooting at porpoises to discourage them from eating tuna did not fall within the Marine Mammal Protection Act's definition of "take" under 16 U.S.C. § 1362(13)).

70. 16 U.S.C.A. §§ 1361–1421 (West 2010 & West Supp. 2017).

71. *See generally* PAUL COLINVAUX, WHY BIG FIERCE ANIMALS ARE RARE: AN ECOLOGIST'S PERSPECTIVE 18, 31 (1978) (explaining the relative scarcity of large animals, especially predators, as a function of thermodynamics).

72. *See* 16 U.S.C. § 1532(6) (2012) (excluding from "[t]he term 'endangered species' . . . a species of the Class Insecta determined . . . to constitute a pest whose protection . . . would present an overwhelming and overriding risk to man").

73. WILSON, *supra* note 6, at 133. *See generally* THE NEW ENCYCLOPEDIA OF INSECTS AND THEIR ALLIES (Christopher O'Toole ed., 2002). On the concept of ecosystem services, see generally CONSERVING AND VALUING ECOSYSTEM SERVICES AND BIODIVERSITY, *supra* note 38; NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS (Gretchen C. Daily ed., 1997); PANEL ON BIODIVERSITY AND ECOSYSTEMS, PRESIDENT'S COMM. OF ADVISORS ON SCI. & TECH., TEAMING WITH LIFE: INVESTING IN SCIENCE TO UNDERSTAND AND USE AMERICA'S LIVING CAPITAL (1998); Graciela Chichilnisky & Geoffrey Heal, *Economic Returns from the Biosphere*, Commentary, 391 NATURE 629 (1998); Robert Costanza *et al.*, *The Value of Ecosystem Services: Putting the Issues in Perspective*, 25 ECOLOGICAL ECON. 67 (1998); Janet S. Herman, David C. Culver & James Salzman, *Groundwater Ecosystems and the Service of Water Purification*, 20 STAN. ENVTL. L.J. 479 (2001); H.A. Mooney, J. Lubchenco, R. Dirzo & O.E. Sala, *Biodiversity and Ecosystem Functioning: Basic Principles*, *in* GLOBAL BIODIVERSITY ASSESSMENT 275, 282 (Vernon H. Heywood ed., 1995); James Salzman, *Valuing Ecosystem Services*, 24 ECOLOGY L.Q. 887 (1997) (reviewing NATURE'S SERVICES, *supra*); Barton H. Thompson, Jr., *People or Prairie Chickens: The Uncertain Search for Optimal Biodiversity*, 51 STAN. L. REV. 1127, 1136–37 (1999).

beneficiaries of our absence will be mosquitoes."[74] An apocalyptic collapse in insect populations may have already begun: A 27-year study has revealed a decline of more than 75% in flying insect biomass throughout Germany.[75]

Moreover, even though "[t]he biological differences between animals and plants . . . offer no scientific reason for lesser protection of plants,"[76] the Act significantly undervalues plants.[77] Threatened and endangered plants are protected only insofar as they appear on federal land or are destroyed in knowing violation of state law.[78] Plants receive far fewer critical habitat designations than do threatened and endangered animals.[79] In so doing, the Act perpetuates, rather than corrects, the common law's baneful practice of treating plants as private property merely because they dwell on private land.[80] The law's failure to protect plants on equal footing with animals represents a form of official "plant blindness."[81]

Trafficking in goods derived from endangered species remains the single act of biodiversity destruction on which international law has reached a punitive consensus. The Convention on International Trade in Endangered Species (CITES),[82] now approaching half a century in age, would represent a major step toward conserving biodiversity, as long as one overlooks the fact that it does not work. The extension of CITES during the 1980s to "all aspects of trade and research" in orchids "immediately increased the desire for the plants, raised their market value dramatically, and led to even more collecting of rare orchid species from the wild."[83] Nothing in CITES stops developers and farmers who would "flood [critical] habitat with a hydroelectric dam, log it, level the hillsides for a road, build a golf course on the site, or burn the jungle to the ground for agricultural purposes."[84] Not surprisingly, "no reliable data" show "that CITES and similar efforts ha[ve] reduced smuggling, saved any orchid

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74. ALAN WEISMAN, THE WORLD WITHOUT US 129 (2007). "[A]mong the secondary beneficiaries will be many freshwater fish species, in whose food chains mosquito eggs and larvae form big links." *Id.*

75. *See* Caspar A. Hallmann et al., *More than 75 Percent Decline over 27 Years in Total Flying Insect Biomass in Protected Areas*, PLOS ONE (Oct. 18, 2017), http://doi.org/10.1371/journal.pone.0185809 [https://perma.cc/9M8A-BGKM].

76. COMM. ON SCI. ISSUES IN THE ENDANGERED SPECIES ACT, NAT'L RESEARCH COUNCIL, SCIENCE AND THE ENDANGERED SPECIES ACT 90 (1995).

77. *See* Sandra B. Zellmer & Scott A. Johnson, *Biodiversity in and Around McElligot's Pool*, 38 IDAHO L. REV. 473, 481–82 (2002).

78. *See* 16 U.S.C. § 1538(a)(2)(B) (2012).

79. *See* Conservation Council for Hawai'i v. Babbitt, 2 F. Supp. 2d 1280, 1281 (D. Haw. 1998) (noting that critical habitat designations covered only 24 of approximately 700 plant species listed in 1998).

80. *See* Holmes Rolston III, *Property Rights and Endangered Species*, 61 U. COLO. L. REV. 283, 293 (1990).

81. *See* William Allen, *Plant Blindness*, 53 BIOSCIENCE 926 (2003); James H. Wandersee & Elisabeth E. Schussler, *Preventing Plant Blindness*, 61 AM. BIOLOGY TEACHER 82 (1999).

82. Convention on International Trade in Endangered Species of Wild Fauna and Flora, Mar. 3, 1973, 27 U.S.T. 1087, 993 U.N.T.S. 243 (entered into force July 1, 1975).

83. ERIC HANSEN, ORCHID FEVER: A HORTICULTURAL TALE OF LOVE, LUST, AND LUNACY 67 (2000).

84. *Id.* at 17.

species from extinction, helped protect orchid habitats, or even salvaged orchid plants facing . . . certain destruction."[85]

The raw emotional power of overkill, especially when it involves charismatic animals such as elephants or tuna, subjects CITES and the Endangered Species Act to the cognitive biases that bedevil environmental decision making.[86] For some time, controlled harvests for profit appeared to outperform direct regulation under CITES in deterring the poaching of elephants.[87] Hopes that the elephant's salvation might lie in commercialization, as it did with the American alligator[88] or the Andean vicuña,[89] have evaporated in 2016 with the United States' imposition of a nearly total ban on the ivory trade.[90] Meanwhile, an effort to protect the Atlantic bluefin tuna under CITES collapsed in 2010 as the European nations most heavily involved in the bluefin harvest initially supported but eventually abstained from the listing decision.[91] On land and at sea, the focus on politically explosive but environmentally secondary acts of overkill and commercial exploitation has rendered CITES tragically impotent.

B. Alien Invasive Species

In an increasingly interconnected world, human ecological mismanagement often takes the form of introducing one or more invasive species.[92] "[M]ost invasions have

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85. *Id.* at 262.

86. *See, e.g.*, James Ming Chen, *Fables of the Reconstruction: Human Emotion and Behavioral Heuristics in Environmental Economics*, 63 STUDIA IURIDICA 77 (2016); Justin Pidot, *Deconstructing Disaster*, 2013 BYU L. REV. 213, 235–43 (2013).

87. *See* EDWARD B. BARBIER, JOANNE C. BURGESS, TIMOTHY M. SWANSON & DAVID W. PEARCE, ELEPHANTS, ECONOMICS AND IVORY 132–38 (1990); FRANCES CAIRNCROSS, COSTING THE EARTH: THE CHALLENGE FOR GOVERNMENTS, THE OPPORTUNITIES FOR BUSINESS 132–41 (Harvard Bus. Sch. Press 1992) (1991); Michael J. Glennon, *Has International Law Failed the Elephant?*, 84 AM. J. INT'L L. 1 (1990).

88. *Cf.* Gibbs v. Babbitt, 214 F.3d 483, 495 (4th Cir. 2000) (reporting the successful recovery of the American alligator from the United States' endangered species list in 1975 to a contemporary market for its hides); Catharine L. Krieps, Comment, *Sustainable Use of Endangered Species Under CITES: Is It a Sustainable Alternative?*, 17 U. PA. J. INT'L ECON. L. 461, 479–80 (1996) (describing the creation of a market in alligator products as a spur for the conservation of alligators and their habitats).

89. *See* Gabriela Lichtenstein, *Vicuña Conservation and Poverty Alleviation? Andean Communities and International Fibre Markets*, 4 INT'L J. COMMONS 100 (2010). *See generally* SARA J. SCHERR, ANDY WHITE & DAVID KAIMOWITZ, MAKING MARKETS WORK FOR FOREST COMMUNITIES (2002); *Pulp Friction*, ECONOMIST (Mar. 14, 2002), http://www.economist.com/node/1033859 [https://perma.cc/5UQZ-M3S6].

90. *See* Endangered and Threatened Wildlife and Plants; Revision of the Section 4(d) Rule for the African Elephant (*Loxodonta africana*), 81 Fed. Reg. 36,388 (June 6, 2016) (to be codified at 50 C.F.R. pt. 17); *see also* 16 U.S.C. §§ 4201–4245 (codifying the Endangered Species Act Amendments of 1988 and the African Elephant Conservation Act).

91. *See* D.G. Webster, *The Irony and the Exclusivity of Atlantic Bluefin Tuna Management*, 35 MARINE POL'Y 249 (2011); *see also* Carl Safina & Dane H. Klinger, *Collapse of Bluefin Tuna in the Western Atlantic*, 22 CONSERVATION BIOLOGY 243 (2008).

92. *See, e.g.*, David S. Wilcove, David Rothstein, Jason Dubow, Ali Phillips & Elizabeth Losos, *Quantifying Threats to Imperiled Species in the United States*, 48 BIOSCIENCE 607, 609

a weak impact," but on occasion "an invasive species [is] capable of precipitating monumental changes to an ecosystem."[93] For example, introducing the Nile perch into Lake Victoria devastated endemic cichlids.[94] Oceanic ecosystems fare no better. Barnacles, mollusks, worms, and hydroids leaving warmer seas on a flotilla of wooden fragments and buoyant pumice threaten the integrity of Arctic and Antarctic waters.[95]

North American birds face multiple threats from alien invasive species.[96] Feral cats, perhaps 100 million strong, constitute "a non-native predator that is creating havoc for certain native [bird] species" in the United States.[97] Starlings, a scourge to many native birds, entered North America by virtue of a single man's perverse obsession to import all birds mentioned by Shakespeare.[98] Efforts to reverse the damage by exterminating starlings have failed.[99] Exotics have suppressed or eliminated native,

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(1998) (ranking "[c]ompetition with or predation by alien species," which affects "49% of imperiled species," second among all threats, behind only "habitat destruction and degradation"). *See generally, e.g.*, GEORGE W. COX, ALIEN SPECIES IN NORTH AMERICA AND HAWAII: IMPACTS ON NATURAL ECOSYSTEMS (1999); CHARLES S. ELTON, THE ECOLOGY OF INVASIONS BY ANIMALS AND PLANTS (1958); MARK WILLIAMSON, BIOLOGICAL INVASIONS (1st ed. 1996); Andrew N. Cohen & James T. Carlton, *Accelerating Invasion Rate in a Highly Invaded Estuary*, 279 SCIENCE 555 (1998); David M. Lodge, *Biological Invasions: Lessons for Ecology*, 8 TRENDS ECOLOGY & EVOLUTION 133 (1993); M. Jake Vander Zanden, John M. Casselman & Joseph B. Rasmussen, *Stable Isotope Evidence for the Food Web Consequences of Species Invasions in Lakes*, 401 NATURE 464 (1999).

93. Kevin Shear McCann, *The Diversity-Stability Debate*, 405 NATURE 228, 232 (2000); *see* Dov S. Sax et al., *Ecological and Evolutionary Insights from Species Invasions*, 22 TRENDS ECOLOGY & EVOLUTION 465 (2007); Mark Williamson & Alastair Fitter, *The Varying Success of Invaders*, 77 ECOLOGY 1661 (1996).

94. *See* TIJS GOLDSCHMIDT, DARWIN'S DREAMPOND: DRAMA IN LAKE VICTORIA (Sherry Marx-Macdonald trans., 1996); Peter N. Reinthal & George W. Kling, *Exotic Species, Trophic Interactions, and Ecosystem Dynamics: A Case Study of Lake Victoria*, *in* THEORY AND APPLICATION IN FISH FEEDING ECOLOGY 295 (Deanna J. Stouder, Kurt L. Fresh & Robert J. Feller eds., 1994).

95. *See* David K. A. Barnes, *Invasions by Marine Life on Plastic Debris*, 416 NATURE 808 (2002).

96. *See generally* Steadman, *supra* note 58, at 144–46 (surveying past, present, and future threats to North American birds).

97. James Gorman, *Bird Lovers Hope To Keep Cats on a Very Short Leash*, N.Y. TIMES (Mar. 18, 2003), http://www.nytimes.com/2003/03/18/science/bird-lovers-hope-to-keep-cats-on-a-very-short-leash.html [https://perma.cc/F78L-92F8].

98. *See* ANNIE DILLARD, PILGRIM AT TINKER CREEK 40 (Olive Editions 2016) (1974) (recounting the story of Eugene Schiffelin); *cf.* WILLIAM SHAKESPEARE, THE FIRST PART OF KING HENRY IV, act 1, sc. 3, ll. 218–24, *reprinted in* THE OXFORD SHAKESPEARE: THE COMPLETE WORKS 453, 459 (Stanley Wells & Gary Taylor eds., 1988) ("[The king] Forbade my tongue to speak of Mortimer; / But I will find him when he lies asleep, / And in his ear I'll hollo 'Mortimer!' / Nay, I'll have a starling shall be taught to speak / Nothing but 'Mortimer', and give it him / To keep his anger still in motion.").

99. *See* DILLARD, *supra* note 98, at 41–42. *See generally* CHRISTOPHER FEARE, THE STARLING (1984); C. J. Feare, *The Changing Fortunes of an Agricultural Bird Pest: The European Starling*, 3 AGRIC. ZOOLOGICAL REVIEWS 317 (1989).

often endemic, species in the Everglades, the Great Lakes, the Hawaiian Islands, and Guam.[100]

Freed from competitive pressures in their native environment, invasive plants often thrive in particularly pernicious ways. Switching from sexual to asexual propagation has fueled the Japanese knotweed's conquest of new terrain as far away as the British Isles.[101] Dandelion, already asexually reproducing in North America upon being liberated from predators and competitors in its native Eurasia, would flourish in an atmosphere with higher levels of carbon dioxide.[102]

As overall biological diversity decreases, the environmental impact of invasive species will probably increase. If "simplified communities are more vulnerable to invasion," then "we should also expect an increase in frequency of successful invaders as well as an increase in their impact."[103] Repeated cycles of extirpation and invasion, whether intentional or inadvertent, "can, and eventually will, invoke major shifts in community structure and dynamics."[104] In this game of ecological roulette, the disturbances with the "greatest ecological impact frequently incur high societal costs."[105]

Existing law offers few if any answers to the problem of invasive species. The Plant Protection Act of 2000[106] does enable the Department of Agriculture to constrict the movement of organisms known or suspected to have an adverse effect on agriculture.[107] This law, however, serves more to regulate the proposed releases of

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100. *See, e.g.*, ROBERT DEVINE, ALIEN INVASION: AMERICA'S BATTLE WITH NON-NATIVE ANIMALS AND PLANTS (1998); WILLIAMSON, *supra* note 92, at 77, 139–49; Julie A. Savidge, *Extinction of an Island Forest Avifauna by an Introduced Snake*, 68 ECOLOGY 660 (1987); Don C. Schmitz & Daniel Simberloff, *Biological Invasions: A Growing Threat*, 13 ISSUES IN SCI. & TECH. 33 (1997); Eric Biber, Note, *Exploring Regulatory Options for Controlling the Introduction of Non-Indigenous Species to the United States*, 18 VA. ENVTL. L.J. 375, 380 (1999).

101. *See* John P. Bailey, *Reproductive Biology and Fertility of* Fallopia Japonica *(Japanese Knotweed) and Its Hybrids in the British Isles*, *in* ECOLOGY AND MANAGEMENT OF INVASIVE RIVERSIDE PLANTS 141 (Louise C. de Waal, Lois E. Child, P. Max Wade & John H. Brock eds., 1994); John P. Bailey, Kateřina Bímová & Bohumil Mandák, *Asexual Spread Versus Sexual Reproduction and Evolution in Japanese Knotweed* s.l. *Sets the Stage for the "Battle of the Clones,"* 11 BIOLOGICAL INVASIONS 1189 (2009).

102. *See* Tamara M. McPeek & Xianzhong Wang, *Reproduction of Dandelion (*Taraxacum officinale*) in a Higher CO_2 Environment*, 55 WEED SCI. 334 (2007).

103. McCann, *supra* note 93, at 233.

104. *Id.*

105. F. Stuart Chapin III et al., *Consequences of Changing Biodiversity*, 405 NATURE 234, 239 (2000). On the economic impact of alien invasive species, see U.S. OFFICE OF TECH. ASSESSMENT, HARMFUL NON-INDIGENOUS SPECIES IN THE UNITED STATES (1993); David Pimentel, Lori Lach, Rodolfo Zuniga & Doug Morrison, *Environmental and Economic Costs of Nonindigenous Species in the United States*, 50 BIOSCIENCE 53 (2000); David Pimentel, Rodolfo Zuniga & Doug Morrison, *Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States*, 52 ECOLOGICAL ECON. 273 (2005); Jamie K. Reaser et al., *Ecological and Socioeconomic Impacts of Invasive Alien Species in Island Ecosystems*, 34 ENVTL. CONSERVATION 98 (2007).

106. 7 U.S.C. §§ 7701–7786 (2012 & Supp. 2017).

107. *See* 7 C.F.R. pts. 319, 340 (2016).

genetically modified crops[108] than to provide broad-based authority to restrain the spread of invasive species.

The National Environmental Policy Act (NEPA)[109] provides a broader legal platform. Among other purposes, NEPA aspires "to promote efforts which will prevent or eliminate damage to the environment and biosphere" and "to enrich the understanding of the ecological systems and natural resources important to the Nation."[110] As a charter embodying the goals of sustainability, NEPA seeks "to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."[111] In particular, environmental impact statements issued under NEPA must address "any irreversible and irretrievable commitments of resources."[112] In economic theory as in legal doctrine, irreversibility warrants a precautionary exception to the otherwise risk-neutral weighing of costs and benefits.[113]

In principle, these statutory elements could infuse NEPA with some power to counter the spread of invasive species. One federal court of appeals has used NEPA to require a federal agency to address how dam construction could introduce zebra mussels into previously uninfested waters.[114] NEPA could—and should—be construed as embracing the Supreme Court's recognition that "nonnative species . . .

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108. *See, e.g.*, Availability of Determination of Nonregulated Status for Genetically Engineered Canola, 59 Fed. Reg. 55,250, 55,250–51 (Nov. 4, 1994) (declining to restrict genetically engineered laurate canola varieties containing "sequences . . . derived from the plant pathogens *A. tumefaciens* and cauliflower mosaic virus" once it had been determined that these plants were no likelier than comparable, traditionally bred varieties to become weeds, to confer weedy characteristics on canola's wild relatives, or to harm agriculturally beneficial organisms "such as bees or earthworms").

109. 42 U.S.C. §§ 4321–4370m-12 (2012).

110. *Id.* § 4321.

111. *Id.* § 4331(a).

112. *Id.* § 4332(C)(v).

113. *Compare* Kenneth J. Arrow & Anthony C. Fisher, *Environmental Preservation, Uncertainty, and Irreversibility*, 88 Q.J. ECON. 312 (1974) (urging precaution), *with* Kenneth J. Arrow & Robert C. Lind, *Uncertainty and the Evaluation of Public Investment Decisions*, 60 AM. ECON. REV. 364, 366 (1970) (urging risk-neutrality: "when the risks associated with a public investment are publicly borne, the total cost of risk-bearing is insignificant and, therefore, the government should ignore uncertainty in evaluating public investments"). The literature addressing this tension is voluminous. *See, e.g.*, RICHARD W. TRESCH, PUBLIC FINANCE: A NORMATIVE THEORY 759–771 (2d ed. 2002) (discussing uncertainty and the Arrow-Lind theorem); Ziemowit Bednarek & Marian Moszoro, *The Arrow-Lind Theorem Revisited: Ownership Concentration and Valuation*, 24 APPLIED FIN. ECON. 357 (2014); Eric Fesselmeyer, Leonard J. Mirman & Marc Santugini, *A Reconsideration of Arrow-Lind: Risk Aversion, Risk Sharing, and Agent Choice*, 6 J. NAT. RESOURCES POL'Y RES. 51 (2014); L. P. Foldes & R. Rees, *A Note on the Arrow-Lind Theorem*, 67 AM. ECON. REV. 188 (1977).

114. *See* Hughes River Watershed Conservancy v. Glickman, 81 F.3d 437, 445 (4th Cir. 1996). On the environmental merits of breaching dams, see PATRICK MCCULLY, SILENCED RIVERS: THE ECOLOGY AND POLITICS OF LARGE DAMS (enlarged and updated ed. 1996); Christine A. Klein, *Dam Policy: The Emerging Paradigm of Restoration*, 31 ENVTL. L. REP. 10,486 (2001); Christine A. Klein, *On Dams and Democracy*, 78 OR. L. REV. 641 (1999).

could disturb [local] aquatic ecology to an unpredictable extent by competing with native fish for food or habitat, by preying on native species, or by disrupting the environment in more subtle ways," such as the introduction of parasites.[115]

More typically, however, NEPA proves impotent to curb invasions. Rejecting arguments that airport expansion could dramatically increase the rate at which commercial flights (especially from Asia) would introduce alien species into Maui, the Ninth Circuit declined to find a NEPA violation.[116] That court took refuge in the vagaries of airport demand projections,[117] the multiplicity of invasion vectors,[118] and the impossibility of determining *ex ante* which species would become established and, among those, which would become "economic pests."[119]

The legal stance toward invasive species in other jurisdictions may be even more destructive. Even though there is no way to prevent farmed fish from escaping their pens,[120] Brazil has considered "naturalizing" non-native species by decree in an effort to promote freshwater aquaculture.[121] Legal and scientific safeguards against the catastrophic, irreversible effects of alien invasive species have fallen by the wayside in Brazil's rush to develop its biologically sensitive interior.[122] Such disregard for the western hemisphere's greatest storehouse of biological diversity "makes a mockery" of legal efforts to identify environmental impacts and soften their negative consequences.[123]

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115. Maine v. Taylor, 477 U.S. 131, 141 (1986).

116. Nat'l Parks & Conservation Ass'n v. U.S. Dep't of Transp., 222 F.3d 677 (9th Cir. 2000).

117. *See id.* at 680.

118. *See id.* at 681 n.3.

119. *Id.* at 681.

120. *See*, *e.g.*, Christine Marie V. Casal, *Global Documentation of Fish Introductions: The Growing Crisis and Recommendations for Action*, 8 BIOLOGICAL INVASIONS 3 (2006); Rodolphe Elie Gozlan, *Introduction of Non-Native Freshwater Fish: Is It All Bad?*, 9 FISH & FISHERIES 106 (2008) (yes); Rosamond L. Naylor, Susan L. Williams & Donald R. Strong, *Aquaculture—A Gateway for Exotic Species*, 294 SCIENCE 1655 (2001).

121. *See* Valter Monteiro de Azevedo-Santos, Odila Rigolin-Sá & Fernando Mayer Pelicice, *Growing, Losing or Introducing? Cage Aquaculture as a Vector for the Introduction of Non-Native Fish in Furnas Reservoir, Minas Gerais, Brazil*, 9 NEOTROPICAL ICHTHYOLOGY 915 (2011) (discussing proposed Federal Law 5.989-B, 2009); Fernando Mayer Pelicice, Jean Ricardo Simões Vitule, Dilermando Pereira Lima Junior, Mário Luís Orsi & Angelo Antonio Agostinho, *A Serious New Threat to Brazilian Freshwater Ecosystems: The Naturalization of Nonnative Fish by Decree*, 7 CONSERVATION LETTERS 55 (2014) (same).

122. *See* Valter M. Azevedo-Santos, Fernando Mayer Pelicice, Dilermando Pereira Lima-Junior, André Lincoln Barroso Magalhães, Mario Luis Orsi, Jean Ricardo Simões Vitule & Angel Antonio Agostinho, *How To Avoid Fish Introductions in Brazil: Education and Information as Alternatives*, 13 NATUREZA & CONSERVAÇÃO 123 (2015); Valter M. Azevedo-Santos et al., *Removing the Abyss Between Conservation Science and Policy Decisions in Brazil*, 26 BIODIVERSITY CONSERVATION 1745, 1747 (2017); J. Robert Britton & Mário Luís Orsi, *Non-native Fish in Aquaculture and Sport Fishing in Brazil: Economic Benefits Versus Risks to Fish Diversity in the Upper River Paraná Basin*, 22 REVIEWS FISH BIOLOGY & FISHERIES 555 (2012); Philip M. Fearnside, *Brazilian Politics Threaten Environmental Policies*, 353 SCIENCE 746 (2016).

123. Calvert Cliffs' Coordinating Comm., Inc. v. U.S. Atomic Energy Comm'n, 449 F.2d 1109, 1117 (D.C. Cir. 1971).

Even within the inherently global challenge of biodiversity conservation, invasive species pose a daunting obstacle for legal systems rooted in geographically defined notions of sovereignty. Biodiversity loss as a "diffuse, cross-jurisdictional" crisis defies "haphazard local encouragement" and requires cooperative solutions.[124] "[E]nvironmental interconnection has become too real to ignore"; the "existence of transboundary communities inevitably creates a drive away from localism in all spheres."[125] No country can seek refuge in localism, even at a continental scale, from its responsibility to engage "transboundary communities" in addressing environmental problems that ignore political borders.[126]

In short, no single country can contain the scourge posed by alien invasive species. Within the inherently global project of biodiversity conservation, any hope of addressing alien invasive species demands especially vigorous dedication to international cooperation.[127] The Convention on Biological Diversity exhorts its contracting parties, "as far as possible and as appropriate," to "[p]revent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species."[128] The United States' persistent refusal to sign the Convention,[129] however, effectively short-circuits international law's potential to spur domestic legal change. American withdrawal from the Paris Agreement on Climate Change, effective in 2020, further undermines constructive feedback between domestic and international environmental law.[130]

C. Habitat Destruction and Public Land Management

1. Island Biogeography

Habitat destruction threatens even deeper biodiversity loss.[131] Whereas foraging

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124. Stephen M. Nickelsburg, Note, *Mere Volunteers? The Promise and Limits of Community-Based Environmental Protection*, 84 VA. L. REV. 1371, 1409 (1998).

125. Daniel A. Farber, *Stretching the Margins: The Geographic Nexus in Environmental Law*, 48 STAN. L. REV. 1247, 1271 (1996).

126. *Id.*

127. *See* Lyle Glowka, *Bioprospecting, Alien Invasive Species, and Hydrothermal Vents: Three Emerging Legal Issues in the Conservation and Sustainable Use of Biodiversity*, 13 TUL. ENVTL. L.J. 329, 333–49 (2000); *cf.* Steven A. Wade, *Stemming the Tide: A Plea for New Exotic Species Legislation*, 10 J. LAND USE & ENVTL. L. 343 (1995) (urging similar efforts at the domestic level).

128. Convention on Biological Diversity, art. 8(h), June 5, 1992, 1760 U.N.T.S. 79 [hereinafter CBD].

129. *See* Robert F. Blomquist, *Ratification Resisted: Understanding America's Response to the Convention on Biological Diversity, 1989-2002*, 32 GOLDEN GATE U. L. REV. 493, 493 (2002).

130. *See generally* Shi-Ling Hsu, *A Game-Theoretic Model of International Climate Change Negotiations*, 19 N.Y.U. ENVTL. L.J. 14 (2011) (describing the logic underlying the assertion of domestic legal and political interest in the making of international agreements addressing climate change).

131. *See, e.g.*, Paul R. Ehrlich, *The Loss of Diversity: Causes and Consequences*, *in* BIODIVERSITY 21, 21 (E. O. Wilson & Frances M. Peter eds., 1988); P. A. Matson, W. J. Parton,

activities—hunting, fishing, gathering—often focus on particular species of utilitarian interest (or practical inconvenience) to humans,[132] comprehensive conversion of land for human use withdraws habitat indiscriminately from the full spectrum of fauna and flora. Contracting the physical range of endangered species spurs their extinction.[133] Island biogeography posits that a reduction in the area of a biological island—which may consist of an island in the geographic sense or merely an isolated patch of wildlife habitat—predicts a mathematically related reduction in that area's biological carrying capacity as measured by the number of distinct species that can be sustained.[134]

The most elementary mathematical formula expressing the species-area relationship is:

$$S = c \cdot A^z$$

where S represents the number of species, A represents the area, and c and z are empirically determined constants.[135] Taking the logarithm of both sides of that equation—by any base, including e (Euler's constant) or 10, as long as it is applied to

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A. G. Power & M. J. Swift, *Agricultural Intensification and Ecosystem Properties*, 277 SCIENCE 504, 504 (1997) (describing the conversion of land to agricultural use as "one of the most significant human alterations to the global environment"); *cf.* Larry E. Morse, John T. Kartesz & Lynn S. Kutner, *Native Vascular Plants*, *in* NAT'L BIOLOGICAL SERV., U.S. DEP'T OF THE INTERIOR, OUR LIVING RESOURCES: A REPORT TO THE NATION ON THE DISTRIBUTION, ABUNDANCE, AND HEALTH OF U.S. PLANTS, ANIMALS, AND ECOSYSTEMS 205, 208 (1995) (describing "[h]abitat alteration and incompatible land use" as larger threats than overcollecting, global climate change, and sea-level rise).

132. *See* Kent H. Redford, *The Empty Forest*, 42 BIOSCIENCE 412, 413–14 (1992).

133. *See, e.g.*, Rob Channell & Mark V. Lomolino, *Dynamic Biogeography and Conservation of Endangered Species*, 403 NATURE 84, 84 (2000); John H. Lawton, *Population Dynamics Principles*, *in* EXTINCTION RATES 147 (John H. Lawton & Robert M. May eds., 1995); Bruce A. Wilcox & Dennis D. Murphy, *Conservation Strategy: The Effects of Fragmentation on Extinction*, 125 AM. NATURALIST 879 (1985).

134. For further background on island biogeography, see LARRY D. HARRIS, THE FRAGMENTED FOREST: ISLAND BIOGEOGRAPHY THEORY AND THE PRESERVATION OF BIOTIC DIVERSITY (1984); ROBERT H. MAC ARTHUR & EDWARD O. WILSON, THE THEORY OF ISLAND BIOGEOGRAPHY (1967); DAVID QUAMMEN, THE SONG OF THE DODO: ISLAND BIOGEOGRAPHY IN AN AGE OF EXTINCTIONS (1996); THE THEORY OF ISLAND BIOGEOGRAPHY REVISITED (Jonathan B. Losos & Robert E. Ricklefs eds., 2010); Daniel Simberloff, *Experimental Zoogeography of Islands: Effects of Island Size*, 57 ECOLOGY 629, 629–30 (1976); Daniel S. Simberloff & Lawrence G. Abele, *Island Biogeography Theory and Conservation Practice*, 191 SCIENCE 285 (1976); Donald R. Whitehead & Claris E. Jones, *Small Islands and the Equilibrium Theory of Insular Biogeography*, 23 EVOLUTION 171 (1969). For a skeptical assessment of island biogeography's strongest claims, see Charles C. Mann, *Extinction: Are Ecologists Crying Wolf?*, 253 SCIENCE 736 (1991).

135. *See, e.g.*, Andrew Bially & Hugh J. MacIsaac, *Fouling Mussels (*Dreissena *spp.) Colonize Soft Sediments in Lake Erie and Facilitate Benthic Invertebrates*, 43 FRESHWATER BIOLOGY 85, 87 (2000); Jonathan Browne & Stewart B. Peck, *The Long-Horned Beetles of South Florida (*Cerambycidae: Coleoptera*): Biogeography and Relationships with the Bahama Islands and Cuba*, 74 CANADIAN J. ZOOLOGY 2154 (1996); M. J. Crawley & J. E. Harral, *Scale Dependence in Plant Biodiversity*, 291 SCIENCE 864 (2001).

each side—allows the presentation of the species-area relationship in linear form on a log-log plot:

$$\log S = \log c + z \cdot \log A$$

The related semilog model found favor in the early twentieth century antecedents of island biogeography, which consolidated the work of nineteenth century pioneers such as Charles Darwin, Joseph Hooker, and Alfred Russel Wallace:[136]

$$S = \log(c \cdot A^z)$$

The practical difference between the logarithmic and semilogarithmic models is that the semilog model depicts area, as the independent variable, on a linear rather than a logarithmic scale along the horizontal axis. Log-log plots of the basic species-area relationship originated with Philip Darlington's celebrated 1957 illustration of the number of amphibian and reptile species on islands of varying size in the West Indies.[137]

Despite considerable advances in island biogeography,[138] including the precise connection between species and area,[139] log-log plots continue to illustrate the species-area relationship. A more recent example illustrates the number of amphibian, avian, and mammalian species at the continental scale for the world's five largest land masses (Africa, Eurasia, North America, South America, Australia).[140]

Biologically catastrophic episodes of habitat destruction recur with alarming frequency. Large-scale damming, as typified by California's Hetch Hetchy

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136. *See, e.g.*, Olof Arrhenius, *Species and Area*, 9 J. ECOLOGY 95 (1921); Henry Allan Gleason, *On the Relation Between Species and Area*, 3 ECOLOGY 158 (1922).

137. *See* James Robertson, *Island Biogeography: Evaluating Correlational Data and Testing Alternative Hypotheses*, *in* AN INTRODUCTION TO METHODS AND MODELS IN ECOLOGY, EVOLUTION, AND CONSERVATION BIOLOGY 91, 94 (Stanton Braude & Bobbi S. Low eds., 2010) (citing PHILIP J. DARLINGTON, JR., ZOOGEOGRAPHY: THE GEOGRAPHIC DISTRIBUTION OF ANIMALS (1957)). For a more recent evaluation of amphibians and reptiles in the West Indies, see Robert W. Henderson & Robert Powell, *West Indian Herpetoecology*, *in* CARIBBEAN AMPHIBIANS AND REPTILES 223 (Brian I. Crother ed., 1999).

138. *See, e.g.*, Lawrence R. Heaney, *Dynamic Disequilibrium: A Long-Term, Large-Scale Perspective on the Equilibrium Model of Island Biogeography*, 9 GLOBAL ECOLOGY & BIOGEOGRAPHY 59 (2000); Matthew R. Helmus, D. Luke Mahler & Jonathan B. Losos, *Island Biogeography of the Anthropocene*, 513 NATURE 543 (2014); Mark V. Lomolino, *A Call for a New Paradigm of Island Biogeography*, 9 GLOBAL ECOLOGY & BIOGEOGRAPHY 1 (2000).

139. *See, e.g.*, MICHAEL L. ROSENZWEIG, SPECIES DIVERSITY IN SPACE AND TIME (1995); Stina Drakare, Jack J. Lennon & Helmut Hillebrand, *The Imprint of the Geographical, Evolutionary and Ecological Context on Species–Area Relationships*, 9 ECOLOGY LETTERS 215 (2006); Jonathan B. Losos & Dolph Schluter, *Analysis of an Evolutionary Species-Area Relationship*, 408 NATURE 847 (2000); Catherine E. Wagner, Luke J. Harmon & Ole Seehausen, *Cichlid Species-Area Relationships Are Shaped by Adaptive Radiations That Scale with Area*, 17 ECOLOGY LETTERS 583 (2014).

140. David Storch, Petr Keil & Walter Jetz, *Universal Species-Area and Endemics-Area Relationships at Continental Scales*, 488 NATURE 78, 79 (2012).

Reservoir,[141] Egypt's Aswan High Dam,[142] and China's Three Gorges Dam,[143] can likewise erase multiple ecological niches in a single blow. An area as large and diverse as Centinela, a diverse forest ridge in Ecuador, can fall to victim to cacao cultivation.[144] Destroying large chunks of the earth's physical infrastructure within a time frame that is effectively instantaneous by geological standards significantly accelerates the rate of evolutionary change attributable to human activity.

One study of regional extinctions of birds, butterflies, and vascular plants in Britain illustrates the effects of habitat destruction as an irreversible experiment in island biogeography.[145] Earlier studies of global biodiversity had exhaustively documented extinctions among plants, vertebrates, and certain mollusks.[146] These studies shed relatively little light on the global scope of biodiversity loss insofar as they did not cover organisms representing a sufficiently large sample of Earth's described species.

Insect species, however, represent a considerable portion of all fauna.[147] Decreases of 28% among native plant species, 54% of native bird species, and 71%

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141. *See generally, e.g.*, RICHARD WHITE, "IT'S YOUR MISFORTUNE AND NONE OF MY OWN": A HISTORY OF THE AMERICAN WEST 412–15 (1991).

142. *See generally, e.g.*, TOM LITTLE, HIGH DAM AT ASWAN: THE SUBJUGATION OF THE NILE (1965); Gilbert F. White, *Environmental Effects of the High Dam at Aswan*, ENV'T, Sept. 1988, at 5; Mahmoud Abu Zeid, *Environmental Impacts of the Aswan High Dam: A Case Study*, 5 INT'L J. WATER RESOURCES DEV. 147 (1989).

143. *See* Jianguo Wu, Jianhui Huang, Xingguo Han, Zongqiang Xie & Xianming Gao, *Three-Gorges Dam: Experiment in Habitat Fragmentation?*, 300 SCIENCE 1239 (2003). *See generally, e.g.*, VACLAV SMIL, CHINA'S ENVIRONMENTAL CRISIS: AN INQUIRY INTO THE LIMITS OF NATIONAL DEVELOPMENT (1993).

144. *See* C. H. Dodson and A. H. Gentry, *Biological Extinction in Western Ecuador*, 78 ANNALS MO. BOTANICAL GARDEN 273 (1991); *see also* WILSON, *supra* note 6, at 243 (arguing that the name Centinela "deserves to be synonymous with the silent hemorrhaging of biological diversity").

145. *See* Thomas et al., *supra* note 3.

146. *See* Robert M. May, John H. Lawton & Nigel E. Stork, *Assessing Extinction Rates*, *in* EXTINCTION RATES 1 (John H. Lawton & Robert M. May eds., 1995); Robert M. May & Kerry Tregonning, *Global Conservation and U.K. Government Policy*, *in* CONSERVATION IN A CHANGING WORLD 287 (Georgina M. Mace, Andrew Balmford & Joshua R. Ginsberg eds., 1998); Stuart L. Pimm, Gareth J. Russell, John L. Gittleman & Thomas M. Brooks, *The Future of Biodiversity*, 269 SCIENCE 347 (1995).

147. The precise share of insects among animal species, to say nothing of other proportional claims in global biodiversity, is highly contested. *See, e.g.*, Mark J. Costello, Simon Wilson & Brett Houlding, *Predicting Total Global Species Richness Using Rates of Species Description and Estimates of Taxonomic Effort*, 61 SYSTEMATIC BIOLOGY 871 (2012); Andrew J. Hamilton, Yves Basset, Kurt K. Benke, Peter S. Grimbacher, Scott E. Miller, Vojtech Novotny, G. Allan Samuelson, Nigel E. Stork, George D. Weiblen & Jian D. L. Yen, *Quantifying Uncertainty in Estimation of Tropical Arthropod Species Richness*, 176 AM. NATURALIST 90 (2010); Vojtech Novotny, Pavel Drozd, Scott E. Miller, Miroslav Kulfan, Milan Janda, Yves Basset & George D. Weiblen, *Why Are There So Many Species of Herbivorous Insects in Tropical Rainforests?*, 313 SCIENCE 1115 (2006); *cf.* Lucas N. Joppa, David L. Roberts & Stuart L. Pimm, *How Many Species of Flowering Plants Are There*, 278 PROC. ROYAL SOC'Y B 554 (2010); Stuart L. Pimm & Lucas N. Joppa, *How Many Plant Species Are There, Where Are They, and at What Rate Are They Going Extinct?*, 100 ANNALS MO. BOTANICAL GARDEN 170 (2015).

of butterfly species in Britain therefore raise more serious concerns.[148] "The greater loss among British butterfly species may foreshadow similar declines in birds and plants, because insect populations typically respond more rapidly to adverse environmental change than longer-lived organisms or those with dormant propagules."[149] Further confirmation of declines among insect populations akin to those already documented in taxa whose species abundance is better understood will clarify the precise extent to which habitat destruction, on scales as large as Great Britain or even larger, threatens the biosphere.[150]

2. Public Lands Management

Traditionally, much of the American legal apparatus for habitat conservation has focused on public lands. Although "[t]he Endangered Species Act of 1973 was motivated in part by the need to [regulate] beyond the limited confines of federal land,"[151] a significant degree of habitat conservation takes place under the aegis of public land management. Pending Part III's more comprehensive overview of the Endangered Species Act, we can profitably examine this aspect of biodiversity conservation policy in the United States as part of our broader overview of legal measures against habitat destruction.

Federal public lands law rests on the primary premise of "multiple use,"[152] defined as a range of uses "including, but not limited to, recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific and historical values."[153] Because "[m]ultiple use posits that all uses from commodity extraction and production to biodiversity conservation are equal," this principle "both supports and hinders biodiversity conservation."[154]

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148. *See* Thomas et al., *supra* note 3, at 1879–80.

149. *Id.* at 1880 (footnote omitted). *See generally* A. Erhardt & J. A. Thomas, *Lepidoptera as Indicators of Change in the Semi-Natural Grasslands of Lowland and Upland Europe*, *in* THE CONSERVATION OF INSECTS AND THEIR HABITATS 213 (N. M. Collins & J. A. Thomas eds., 1991); Amy E. M. Waltz & W. Wallace Covington, *Ecological Restoration Treatments Increase Butterfly Richness and Abundance: Mechanisms of Response*, 12 RESTORATION ECOLOGY 85 (2004).

150. *See* Hallmann et al., *supra* note 75; Michael L. McKinney, *High Rates of Extinction and Threat in Poorly Studied Taxa*, 13 CONSERVATION BIOLOGY 1273 (1999).

151. Gibbs v. Babbitt, 214 F.3d 483, 494 (4th Cir. 2000); *see also* Davina Kari Kaile, Note, *Evolution of Wildlife Legislation in the United States: An Analysis of the Legal Efforts To Protect Endangered Species and the Prospects for the Future*, 5 GEO. INT'L ENVTL. L. REV. 441, 456 (1993); *cf.* Conservation Council for Haw. v. Babbitt, 2 F. Supp. 2d 1280, 1281 (D. Haw. 1998) (invalidating a decision not to designate critical habitat insofar as that decision was based solely on a claim that some of the species at issue were located on private land, without determining whether a decision not to designate might be appropriate when a species exists solely on private land).

152. *See* 43 U.S.C. § 1701(a)(7) (2012) (directing that "management [of public land] be on the basis of multiple use and sustained yield unless otherwise specified by law").

153. *Id.* § 1702(c).

154. A. Dan Tarlock, *Biodiversity Conservation in the United States: A Case Study in Incompleteness and Indirection*, 32 ENVTL. L. REP. 10,529, 10,540–41 (2002).

When it first appeared, the concept of multiple use represented a substantial improvement in federal land management policy. "[I]ncreased competition for forage" among cattle and sheep ranchers during the nineteenth and early twentieth centuries "led . . . to overgrazing, diminished profits, and hostility among forage competitors."[155] The Federal Land Policy and Management Act of 1976 (FLPMA)[156] explicitly adopted two statutory principles: "multiple use" for recreation, range, timber, mineral extraction, wildlife and fish habitat, and natural, scenic, scientific, and historical uses;[157] and "sustained yield" of renewable resources.[158] At the same time, FLPMA retained "first priority" for existing grazing permit holders as long as federal land-use planning continued to leave land "available for domestic livestock grazing."[159]

Although a statutory commitment to multiple use may theoretically "provide[] the legal foundation for a management decision to preserve biodiversity,"[160] disputes over federal land management expose a bias favoring commercialization over conservation.[161] When the Department of the Interior tried in 1995 to "accelerat[e] restoration" of rangelands by making its managerial approach "more compatible with ecosystem management,"[162] incumbent ranchers argued in response that the Interior Department was legally obliged to "safeguard" livestock interests' reliance on the perpetuation of grazing privileges.[163] This argument ran squarely against an explicit statutory command that neither "the creation of a grazing district [n]or the issuance of a permit . . . shall . . . create any right, title, interest, or estate in or to the lands."[164]

Other decisions have demonstrated the willingness of federal land management agencies to favor grazing and other historically privileged land uses over conservation and other non-use values. A federal district court was forced to remind federal land managers in 1985 that grazing "[p]ermittees must be kept under a sufficiently real threat of cancellation or modification in order to adequately protect the public lands from overgrazing or other forms of mismanagement."[165] In spite of its statutory mandate to maintain "final control and decisionmaking authority over livestock grazing practices on the public lands," the federal government had all but ceded jurisdiction over grazing permits.[166]

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155. Pub. Lands Council v. Babbitt, 529 U.S. 728, 732 (2000). *See generally* DEBRA L. DONAHUE, THE WESTERN RANGE REVISITED: REMOVING LIVESTOCK FROM PUBLIC LANDS TO CONSERVE NATIVE BIODIVERSITY (1999).

156. Pub. L. No. 94-579, 90 Stat. 2743 (1976) (codified as amended at 43 U.S.C. §§ 1701–1785).

157. 43 U.S.C. § 1702(c) (2012).

158. *Id.* § 1702(h).

159. *Id.* § 1752(c).

160. Tarlock, *supra* note 154, at 10,541.

161. *See*, *e.g.*, United States v. State, 23 P.3d 117, 128 (Idaho 2001) (arguing that reservation of water for a wildlife refuge would unfairly subordinate rights to "water intended to be stored and regulated by colossal federal projects for the past 98 years" for the primary purpose of reclamation).

162. *See* Grazing Adm'n—Exclusive of Alaska, 60 Fed. Reg. 9894, 9901 (Feb. 22, 1995).

163. *See* Pub. Lands Council v. Babbitt, 529 U.S. 728, 741 (2000).

164. 43 U.S.C. § 315b (2012); *see Pub. Lands Council*, 529 U.S. at 741–42.

165. Nat. Resources Def. Council, Inc. v. Hodel, 618 F. Supp. 848, 871 (E.D. Cal. 1985).

166. *Id.* at 871; *see* 43 U.S.C. §§ 1901–1908 (2012).

The desire to protect grazing livestock from wolves has nullified other environmental gains from habitat conservation. Setting aside public land as a wildlife preserve, while conducting government-sponsored wolf shoots from helicopters, results in net negative effects on wolf populations.[167]

The priority accorded to grazing and other consumptive uses is especially galling on its own terms: economic valuation. Environmental economics has long recognized that non-use values can vastly exceed gains from the direct, immediate extraction of living things.[168] The Canadian polar bear population, for instance, might be worth $600,000 as bushmeat, versus $6 billion in "estimate[d] . . . value Canadians would have placed on the preservation of [this] iconic species"[169]—to say nothing of the bear's potential influence on climate change policy in the scientifically intransigent country neighboring Canada.[170]

On the whole, federal land management policy concentrates its habitat preservation efforts on tracts designated as "wilderness." "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is . . . an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."[171] Unlike other public lands, wilderness areas fulfill their function solely by virtue of remaining "in their natural condition."[172] Wilderness preservation helps ensure "that an increasing population, accompanied

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167. *See* Joshua H. Schmidt, John W. Burch & Margaret C. MacCluskie, *Effects of Control on the Dynamics of an Adjacent Protected Wolf Population in Interior Alaska*, 198 WILDLIFE MONOGRAPHS 1 (2017).

168. *See, e.g.*, John V. Krutilla, *Conservation Reconsidered*, 57 AM. ECON. REV. 777 (1967); John B. Loomis & Douglas S. White, *Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis*, 18 ECOLOGICAL ECON. 197 (1996).

169. ÉCORESSOURCES CONSULTANTS, EVIDENCE OF THE SOCIO-ECONOMIC IMPORTANCE OF POLAR BEARS FOR CANADA, at vi (2011); *see also id.* at 26 (using "the benefit-transfer method" to estimate that Canadian households "would pay approximately $508 per year" to preserve the polar bear, for an estimated total of "$6,320 million/year"); Richardson & Loomis, *supra* note 38. Any ambiguity in the ÉcoRessources analysis can be resolved by applying its one clear figure of $508 per household. According to the Canadian census, the population of Canada was 35,151,728 in 2016. *See Population and Dwelling Counts, for Canada, Provinces and Territories, 2016 and 2011 Censuses—100% Data*, STAT. CAN. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Table.cfm [https://perma.cc/K4X7-D7R9] (last updated Aug. 28, 2017). In 2011, the date of the ÉcoRessources report, the country's population was 33,476,688. *See id.* Dividing the population by 3 yields a reasonable estimate of 11 million to 12 million households. Multiplying that figure by $508 yields an approximate total of $6 billion—in Canadian dollars. As of November 2017, real-time currency exchange rates on http://www.xe.com [https://perma.cc/6RJZ-9BBM] report a rate of approximately 0.79 United States dollars for every 1.00 Canadian dollars. The figure in text may therefore be interpreted as $5 billion in American currency equivlent.

170. *See infra* Part III.C.

171. 16 U.S.C. § 1131(c) (2012); *cf., e.g.*, Or. Nat. Desert Ass'n v. Singleton, 47 F. Supp. 2d 1182, 1192 (D. Or. 1998) (holding that "the explicit 'protect and enhance' language of" the Wild and Scenic Rivers Act "requires that watersheds be maintained in a primitive condition and the waters kept unpolluted").

172. 16 U.S.C. § 1131(a) (2012).

by expanding settlement and growing mechanization, does not occupy and modify" the entire physical surface of the earth.[173]

"The global extent of the human footprint," made manifest by the sheer scarcity of truly wild places, makes humans the final "stewards of nature, whether we like it or not."[174] This responsibility includes "a commitment to conserving the last of the wild—those few places, in all the biomes around the globe, that are relatively less influenced by human beings—before they are gone."[175]

Cold and high-elevation wilderness areas, however, cannot anchor a comprehensive and effective biodiversity program.[176] Biodiverse "hot spots," rich in species, typically live up to their name: most such locales lie in the tropics.[177] Even a conservation strategy focused on hot spots, however, overlooks ecosystem services, phylogenetic diversity, and other forms of species richness.[178] Moreover, emphasizing hot spots may take little to no account of costs available for conservation and, as a result, may fail to achieve optimal resource allocation.[179]

Ultimately, neither the "wilderness" principle nor broader aspects of public lands management in the United States provide adequate protection for biodiversity. The National Park Service—which is directed to "conserve the scenery, natural and historic objects, and wild life" in the most spectacular federal lands and to "leave them unimpaired for the enjoyment of future generations"[180]—was designed to preserve

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173. *Id.*

174. Eric W. Sanderson, Malanding Jaiteh, Marc A. Levy, Kent H. Redford, Antoinette V. Wannebo & Gillian Woolmer, *The Human Footprint and the Last of the Wild*, 52 BIOSCIENCE 891, 902 (2002).

175. *Id.* at 903.

176. *See* Jonathan S. Adams, Bruce A. Stein & Lynn S. Kutner, *Biodiversity: Our Precious Heritage*, *in* PRECIOUS HERITAGE: THE STATUS OF BIODIVERSITY IN THE UNITED STATES 3, 17 (Bruce A. Stein, Lynn S. Kutner & Jonathan S. Adams eds., 2000); Tarlock, *supra* note 154, at 10,542.

177. *See* John Charles Kunich, *Preserving the Womb of the Unknown Species with Hotspots Legislation*, 52 HASTINGS L.J. 1149, 1157–58 (2001); Norman Myers, *The Biodiversity Challenge: Expanded Hot-Spots Analysis*, 10 ENVIRONMENTALIST 243 (1990); Norman Myers, *Threatened Biotas: "Hot Spots" in Tropical Forests*, 8 ENVIRONMENTALIST 187 (1988); Norman Myers, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A. B. da Fonseca & Jennifer Kent, *Biodiversity Hotspots for Conservation Priorities*, 403 NATURE 853 (2000).

178. *See* Peter Kareiva & Michelle Marvier, *Conserving Biodiversity Coldspots*, 91 AM. SCIENTIST 344 (2003).

179. *See* Hugh P. Possingham & Kerrie A. Wilson, *Turning Up the Heat on Hotspots*, 436 NATURE 919 (2005). For a proposed method for cost-effective ranking of priorities for biodiversity conservation and a critical application of that method, compare Martin L. Weitzman, *The Noah's Ark Problem*, 66 ECONOMETRICA 1279 (1998), with David W. Martin, *Noah Revisits Biodiversity Prioritization*, 7 MOD. ECON. 1272 (2016).

180. 54 U.S.C. § 100101(a) (Supp. 2016); *accord* Nat'l Park & Conservation Ass'n v. Stanton, 54 F. Supp. 2d 7, 17 (D.D.C. 1999). Before 2014, the National Park Service's iconic declaration of purpose boasted the commensurately iconic statutory citation of 16 U.S.C. § 1. *See* Pub. L. No. 113-287, § 7, 128 Stat. 3094, 3273 (2014) (repealing old 16 U.S.C. § 1); *id.* § 3, 128 Stat. at 3096 (recodifying 16 U.S.C. § 1 as 54 U.S.C. § 100101(a)); Sierra Club v. Salazar, 177 F. Supp. 3d 512, 516 n.2 (D.D.C. 2016) (acknowledging the statutory reorganization).

geological wonders, not to serve broader ecological purposes.[181] Wilderness policy, in microcosm, reveals the overall weakness of laws addressing biodiversity loss. Laws designed to prevent biodiversity loss behave like a twisted version of Wee Willie Keeler—aiming environmental law "where they ain't."[182]

III. THE ENDANGERED SPECIES ACT, FROM PRIVATE LANDS TO GLOBAL COMMONS

Having examined legal tools of varying effectiveness in addressing overkill, alien invasive species, and habitat destruction on public lands, I will now focus on the Endangered Species Act.[183] Whatever its shortcomings, the Act deserves credit for "preventing the ultimate extinction of the vast majority of protected species."[184] The Act represents "the most comprehensive legislation for the preservation of endangered species ever enacted by any nation."[185] American environmental law affords "endangered species . . . the highest of priorities."[186] The otherwise dismal record of biodiversity protection does reflect some progress in forestalling specific extinction[187] and in preserving particular swaths of critical habitat.[188]

Part III begins by outlining the mechanics of the Endangered Species Act. It then addresses two of the most important applications of this statute: preventing habitat destruction on private lands and protecting biodiversity from the effects of climate change.

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181. *See* RICHARD WEST SELLARS, PRESERVING NATURE IN THE NATIONAL PARKS: A HISTORY 2–3 (1997).

182. GEOFFREY C. WARD, BASEBALL: AN ILLUSTRATED HISTORY 52 (2010). Wee Willie Keeler amassed a career batting average of .341 from 1892 to 1910. *See* CHUCK KIMBERLY, THE DAYS OF WEE WILLIE, OLD CY AND BASEBALL WAR 35 (2014); *Willie Keeler*, BASEBALL REFERENCE, https://www.baseball-reference.com/players/k/keelewi01.shtml [https://perma.cc/3AWJ-9ZJJ]; *see also* WARD, *supra*, at 268 (reporting that Keeler achieved a 44-game hitting streak in 1897, which stood as the Major League record until Joe DiMaggio hit safely in 56 consecutive games in 1941).

183. 16 U.S.C. §§ 1531–1544 (2012).

184. J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1, 5 (2008).

185. TVA v. Hill, 437 U.S. 153, 180 (1978); *accord* Babbitt v. Sweet Home Chapter of Communities for a Great Or., 515 U.S. 687, 698 (1995); *see also* Theodore C. Foin, Seth P. D. Riley, Anitra L. Pawley, Debra R. Ayres, Tina M. Carlsen, Peter J. Hodum & Paul V. Switzer, *Improving Recovery Planning for Threatened and Endangered Species*, 48 BIOSCIENCE 177, 177 (1998) ("The Endangered Species Act . . . is arguably the most important legislation passed by the United States Congress to protect species and their habitats . . . .").

186. *Hill*, 437 U.S. at 174; *accord, e.g.*, Forest Conservation Council v. Rosboro Lumber Co., 50 F.3d 781, 787 (9th Cir. 1995); Pyramid Lake Paiute Tribe of Indians v. U.S. Dep't of the Navy, 898 F.2d 1410, 1417 (9th Cir. 1990).

187. *See* Taylor H. Ricketts et al., *Pinpointing and Preventing Imminent Extinctions*, 102 PROC. NAT'L ACAD. SCI. 18,497 (2005).

188. *See* Güven Eken et al., *Key Biodiversity Areas as Site Conservation Targets*, 54 BIOSCIENCE 1110 (2004).

A. Endangered Species Act Mechanics

1. Listing Endangered and Threatened Species

The Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (known together as the "Services") collectively enforce the Endangered Species Act. The FWS administers the Act for terrestrial and freshwater species, while the NMFS administers the Act for most marine species.[189] Maritime mammals straddle both sides of this jurisdictional divide. Polar bears, dugongs, manatees, walruses, and sea and marine otters fall on the FWS side.[190] The NMFS governs whales, dolphins, porpoises, sea lions, and seals.[191] A species is defined as "endangered" if it "is in danger of extinction throughout all or a significant portion of its range."[192] A

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189. *See* 50 C.F.R. § 402.01(b) (2016); Interagency Cooperation—Endangered Species Act of 1973, 51 Fed. Reg. 19,926, 19,926 (June 3, 1986) ("Generally, marine species are under the jurisdiction of the Secretary of Commerce and all other species are under the jurisdiction of the Secretary of the Interior.").

190. The Marine Mammal Protection Act of 1972, 16 U.S.C.A. §§ 1361–1421 (West 2010 & West Supp. 2017), defines a "marine mammal" as "any mammal which (A) is morphologically adapted to the marine environment (including sea otters and members of the orders Sirenia, Pinnipedia, and Cetacea), or (B) primarily inhabits the marine environment (such as the polar bear)." *Id.* § 1362(6); *accord* 50 C.F.R. § 14.102 (2016) (defining a "marine mammal" under standards for humane and healthful animal transport as "an individual of a species of the orders Cetacea, Pinnipedia, or Sirenia, or a polar bear (*Ursus maritimus*) or sea otter (*Enhydra lutris*)"); *see also In re* Polar Bear Endangered Species Listing & § 4(a) Rule Litig., 818 F. Supp. 2d 240, 246 (D.D.C. 2011) ("The Secretary of the Interior has jurisdiction over most marine mammals . . . including the polar bear."), *aff'd*, 709 F.3d 1 (D.C. Cir. 2013). The MMPA divides responsibility for marine mammals between the Secretary of Commerce, who is responsible for "members of the order Cetacea and members, other than walruses, of the order Pinnipedia," and the Secretary of the Interior, who is responsible for "all other marine mammals." 16 U.S.C.A. § 1362(12)(A)(i)–(ii) (West 2010). The Endangered Species Act likewise reflects this jurisdictional boundary between the Secretaries of Commerce and the Interior. *See* 16 U.S.C. § 1532(15) (2012) (defining "Secretary" as either the Secretary of Commerce or the Interior, according to Reorganization Plan No. 4 of 1970, 35 Fed. Reg. 15,627 (Oct. 6, 1970), 5 U.S.C. app. 1 (2012)).

191. In accord with statutory authorities cited *supra* note 190, regulations issued jointly by FWS and by NMFS assign jurisdiction to the Secretary of Commerce (who supervises NMFS) "over members of the order Cetacea and members, other than walruses, of the order Pinnipedia." 50 C.F.R. § 403.02(f). "[T]he Secretary of the Interior," who supervises FWS, "has jurisdiction over all other mammals." *Id.* Incidentally, this regulation mistakenly cites § 3(11) instead of § 3(12) of the MMPA, which is the true source of statutory authority. *See* MMPA, Pub. L. No. 92-522, § 3(12), 86 Stat. 1027, 1029 (1972). Consequently, NMFS regulations define marine mammals as "Cetacea (whales, dolphins, and porpoises) and Pinnipedia, other than walruses (seals and sea lions)," 50 C.F.R. § 216.3 (2016), while FWS regulations confine themselves to the polar bear, walrus, dugong, two species of otter, and three species of manatee, *see id.* § 18.3; *see also id.* § 18.2 (deferring all regulation of cetaceans, seals, and sea lions to 50 C.F.R. part 216).

192. ESA § 3(6), 16 U.S.C. § 1532(6) (2012).

"threatened species" is one "which is likely to become an endangered species within the foreseeable future."[193]

Of particular interest in the context of climate change is the time frame deemed "foreseeable." Because neither the Act nor its implementing regulations define the term "foreseeable future," the Services determine foreseeability on a case-by-case basis.[194] Definitions of foreseeability have varied considerably. One federal district court has declined to decide whether a risk that the coho salmon might become endangered within "30 or 100 years" satisfied the statutory definition of foreseeable future, because an administrative determination that this species "would not become endangered within the next two years" would "fall[] far short of any reasonable definition of the 'foreseeable future.'"[195]

Another court has noted—albeit without endorsement or rejection—the assumption that twenty-four years constitutes the foreseeable future for purposes of predicting the likelihood of endangerment.[196] Listing decisions involving salamanders have set foreseeability at forty years.[197] Amphibians such as salamanders have been on the forefront of biological assessments signaling catastrophic declines in diversity, since amphibians are "more threatened and are declining more rapidly than either birds or mammals."[198]

By contrast, one court has held that the same forty-year time horizon, from 2010 to 2050, as identified in projections of deleterious effects from climate change, was not sufficiently foreseeable to warrant the listing of the ribbon seal as a threatened species.[199] The FWS, of its own accord, has declined to list the American pika as threatened or endangered on the basis of climate change risks beyond 2050.[200]

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193. ESA § 3(20), 16 U.S.C. § 1532(20) (2012).

194. In re *Polar Bear Endangered Species Act Listing*, 709 F.3d at 15.

195. Or. Nat. Res. Council v. Daley, 6 F. Supp. 2d 1139, 1151 (D. Or. 1998).

196. *See* Trout Unlimited v. Lohn, 645 F. Supp. 2d 929, 954 n.18 (D. Or. 2007).

197. *See* 12-Month Finding on a Petition To List the Siskiyou Mountains Salamander (Plethodon Stormi) and Scott Bar Salamander (Plethodon Asupak) as Threatened or Endangered, 73 Fed. Reg. 4380, 4381 (Jan. 24, 2008).

198. Simon N. Stuart, Janice S. Chanson, Neil A. Cox, Bruce E. Young, Ana S. L. Rodrigues, Debra L. Fischman & Robert W. Waller, *Status and Trends of Amphibian Declines and Extinctions Worldwide*, 306 SCIENCE 1783, 1783 (2004). *See generally* Andrew R. Blaustein, Stephanie S. Gervasi, Pieter T. J. Johnson, Jason T. Hoverman, Lisa K. Belden, Paul W. Bradley & Gisselle Y. Xie, *Ecophysiology Meets Conservation: Understanding the Role of Disease in Amphibian Population Declines*, 367 PHIL. TRANSACTIONS ROYAL SOC'Y B 1688 (2012); Andrew R. Blaustein, Barbara A. Han, Rick A. Relyea, Pieter T.J. Johnson, Julia C. Buck, Stephanie S. Gervasi & Lee B. Kats, *The Complexity of Amphibian Population Declines: Understanding the Role of Cofactors in Driving Amphibian Losses*, 1223 ANNALS N.Y. ACAD. SCI. 108 (2011).

199. *See* Ctr. for Biological Diversity v. Lubchenco, 758 F. Supp. 2d 945 (N.D. Cal. 2010); *cf.* Rocky Mountain Wild v. Walsh, 216 F. Supp. 3d 1234, 1250–51 (D. Colo. 2016) (allowing FWS, in a decision not to list two species of beardtongue wildflowers as threatened or endangered, to consider both the probability and the improbability of future commercial development).

200. *See* 12-Month Finding on a Petition to List the American Pika as Threatened or Endangered, 75 Fed. Reg. 6438 (Feb. 9, 2010). *See generally* Erik A. Beever, Peter F. Brussard & Joel Berger, *Patterns of Apparent Extirpation Among Isolated Populations of Pikas*

Listing as an endangered or threatened species is a prerequisite to protection under the Act. "The ESA's protection of a species and its habitat is triggered only when FWS [or NMFS] 'lists' a species in danger of becoming extinct as either 'endangered' or 'threatened.'"[201] The Services' regulations explain why listing and its mirror image, delisting, have such overriding legal significance: "[t]he principal goal" of the Act "is to return listed species to a point at which protection . . . is no longer required."[202] If, and "only if the best scientific and commercial data available indicate that [a species] is no longer endangered or threatened," that "species may be delisted" and reassigned to the default state of nonprotection for species not listed as endangered or threatened.[203]

The Services must base their listing decisions on five factors:

> (A) the present or threatened destruction, modification, or curtailment of a species' habitat or range;
> (B) overutilization of a species for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) the inadequacy of existing regulatory mechanisms; or
> (E) other natural or manmade factors affecting a species' continued existence.[204]

The decision to list rests solely on biological grounds and must be made "without reference to possible economic or other impacts of [that] determination."[205] Moreover, listing decisions must be made "solely on the basis of the best scientific and commercial data available."[206] The requirement to use the best *available* data is not tantamount to a command to seek and apply "the best . . . *possible*" data.[207] Rather, this requirement prevents the Services from disregarding evidence that is better than the scientific basis on which the Services do base their listing decisions.[208]

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*(*Ochotona Princeps*) in the Great Basin*, 84 J. MAMMALOGY 37 (2003); Donald K. Grayson, *A Brief History of Great Basin Pikas*, 32 J. BIOGEOGRAPHY 2103 (2005); Philippe Henry, Alison Henry & Michael A. Russello, *Variation in Habitat Characteristics of American Pikas Along an Elevation Gradient at Their Northern Range Margin*, 86 NW. SCI. 346 (2012).

201. Defs. of Wildlife v. Norton, 239 F. Supp. 2d 9, 12 (D.D.C. 2002) (mem.), *vacated in part*, 89 Fed. App'x. 273 (D.C. Cir. 2004); *see also* Ctr. for Native Ecosystems v. U.S. Fish & Wildlife Serv., 795 F. Supp. 2d 1199, 1201 (D. Colo. 2011) ("Listed species are protected by the ESA . . . .").

202. 50 C.F.R. § 424.11(d)(2) (2016).

203. *Id.*

204. *See* ESA § 4(a)(1)(A)–(E), 16 U.S.C. § 1533(a)(1)(A)–(E); 50 C.F.R. § 424.11(c)(1)–(5).

205. 50 C.F.R. § 424.11(b) (2016).

206. ESA § 4(b)(1)(A), 16 U.S.C. § 1533(b)(1)(A); *accord* Ctr. for Native Ecosystems v. U.S. Fish & Wildlife Serv., 795 F. Supp. 2d 1199, 1202 (D. Colo. 2011).

207. Bldg. Indus. Ass'n v. Norton, 247 F.3d 1241, 1246 (D.C. Cir. 2001) (emphasis in original).

208. City of Las Vegas v. Lujan, 891 F.2d 927, 933 (D.C. Cir. 1989); *accord In re* Polar Bear Endangered Species Act Listing & § 4(d) Rule Litig., 794 F. Supp. 2d 65, 106 (D.D.C. 2011), *aff'd*, 709 F.3d 1 (D.C. Cir. 2013).

2. Critical Habitat

After listing a species as endangered or threatened, the Services must also designate critical habitat "to the maximum extent prudent and determinable."[209] Critical habitat includes areas containing "physical or biological features" that are "essential to the conservation of the species and [] which may require special management considerations or protection."[210]

Critical habitat may also include areas outside a species' current range if such habitat is essential to the conservation of that species.[211] Although the designation of critical habitat must "tak[e] into consideration the economic impact" of designating any particular area, the Services may not deny the critical habitat designation to any area where the "best scientific and commercial data available" indicate that "the failure to designate such area as critical habitat will result in the extinction of the species."[212]

Because the Act aspires not merely to "halt" but also to "reverse the trend towards" biodiversity loss,[213] the Act directs the Services to develop a recovery plan aimed at improving the status of each listed species so that listing is no longer necessary.[214] A recovery plan must identify "management actions necessary . . . for the conservation and survival of the species," to the point of either "recommend[ing] corrective action" or explaining why such action "is impracticable or unnecessary."[215] Although a recovery plan need not specify a precise timetable, it must include estimates for the time needed to perform recovery measures.[216] The ultimate factors for delisting a species are the same as those that inform the decision to list a species as endangered or threatened.[217]

3. Interagency Consultation

Section 7 of the Act requires each federal agency to ensure that its actions are "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."[218] The jeopardy prong of section 7 addresses the impact of agency action on the survival and recovery of a listed species.[219] By contrast, the adverse modification prong concerns critical habitat.[220] A determination that proposed agency action "may affect" a

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209. 16 U.S.C. § 1533(a)(3)(A).
210. *Id.* § 1532(5)(A)(i).
211. *Id.* § 1532(5)(A)(ii).
212. *Id.* § 1533(b)(2).
213. Tenn. Valley Auth. v. Hill, 437 U.S. 153, 184 (1978).
214. 16 U.S.C. § 1533(f); 50 C.F.R. § 424.11(d)(2) (2016).
215. Fund for Animals v. Babbitt, 903 F. Supp. 96, 108 (D.D.C. 1995).
216. *See* Defs. of Wildlife v. Babbitt, 130 F. Supp. 2d 121, 134 (D.D.C. 2001).
217. *See* 16 U.S.C. § 1533(b)(3)(A); Ctr. for Native Ecosystems v. U.S. Fish & Wildlife Serv., 795 F. Supp. 2d 1199, 1202 (D. Colo. 2011); *Fund for Animals*, 903 F. Supp. at 111.
218. 16 U.S.C. § 1536(a)(2); *accord Hill*, 437 U.S. at 183–84.
219. *See* Sierra Club v. U.S. Fish & Wildlife Serv., 245 F.3d 434, 441 (5th Cir. 2001).
220. *See id.*

listed species or its critical habitat triggers the obligation to formally consult the FWS or NMFS, as appropriate.[221]

Formal consultation under section 7 typically results in the issuance of a biological opinion evaluating jeopardy to a listed species' continued existence and adverse modification of its habitat.[222] At the very least, where a biological opinion has found that proposed federal action will directly affect a listed species for reasons independent of climate change, that biological opinion must also address the cumulative effects of climate change.[223]

The obligation to examine climate change in biological opinions that have already found direct, non-climate-related impacts on a listed species resembles an existing strategy for regulating greenhouse gas emissions under the Clean Air Act. The EPA has invoked its so-called "anyway" authority to require the installation of the best available control technology for greenhouse gases at facilities whose emissions of conventional pollutants would subject them to the EPA's permitting authority under Title V and/or the Prevention of Significant Deterioration provisions of the Clean Air Act.[224]

It is not statutory language, but administrative practice and judicial review, that have infused the Endangered Species Act with the power to address climate change. The text of the Act does not obligate the Services, in their discharge of their obligations under sections 4 and 7, to consider the impact of climate change.[225] Nor does the Act require that the Services account for climate change in their critical habitat designation decisions.[226] The proclamation that the Act contains "no statutory requirement" compelling the Services "to discuss climate change in [their] listing decisions"[227] echoes judicial sentiments expressed a generation earlier. In the 1990s, federal courts had opined that conservation biology—a diverse science whose concerns span "population dynamics, species turnover, patch size, recolonization problems, fragmentation problems, edge effects, and island biogeography"—need not guide federal administrative decision making.[228]

More recent judicial decisions have breathed new power into the Endangered Species Act as a legal tool for addressing the effects of climate change. In 2011, the

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221. *See* 50 C.F.R. § 402.14(a) (2016); Bennett v. Spear, 520 U.S. 154, 158 (1997).

222. *See* 16 U.S.C. § 1536(a)(2); 50 C.F.R. § 402.14.

223. *See* 50 C.F.R. § 402.14(g); Pac. Coast Fed'n of Fishermen's Ass'ns v. Gutierrez, 606 F. Supp. 2d 1122, 1184 (E.D. Cal. 2008); Nat. Res. Def. Council v. Kempthorne, 506 F. Supp. 2d 322, 374–76 (E.D. Cal. 2007).

224. *See* Util. Air Regulatory Grp. v. EPA, 134 S. Ct. 2427, 2447–49 (2014).

225. *See* Colo. River Cutthroat Trout v. Salazar, 898 F. Supp. 2d 191, 206–07 (D.D.C. 2012).

226. *See* All. for the Wild Rockies v. Lyder, 728 F. Supp. 2d 1126, 1140 (D. Mont. 2010).

227. *Colo. River Cutthroat Trout*, 898 F. Supp. 2d at 207; *see also* Interagency Cooperation Under the Endangered Species Act, 73 Fed. Reg. 47,868, 47,872 (Aug. 15, 2008) (opining that federal agencies face "no requirement to consult" the NMFS or FWS "on greenhouse gas (GHG) emissions' contribution to global warming and its associated impacts on listed species").

228. Sierra Club v. Marita, 46 F.3d 606, 618–20 (7th Cir. 1995); *see also id.* at 623 (declining to transform even valid "general theor[ies]" of science "into a management tool unless [an agency] can apply it to a concrete situation"); Fund for Animals v. Babbitt, 903 F. Supp. 96, 106 (D.D.C. 1995) (declining to endorse specific techniques for managing "distinct geographic ecosystems . . . inhabited by grizzly bears").

Ninth Circuit invalidated the Fish and Wildlife Service's attempt to delist Yellowstone grizzly bears as a threatened species, on the grounds that the Service had failed to properly account for the impact of climate change on the whitebark pine, a primary source of food for grizzlies.[229] The climate-driven loss of whitebark pine trees could foreseeably increase conflicts between bears and humans and thereby harm the bears' prospects for reproductive success and overall survival.[230]

Thanks to its breadth, section 7's requirement that federal agencies must consult the FWS or NMFS if proposed action "may affect" a listed species or its critical habitat has the potential to cover "any action that results in non-trivial net increases" in greenhouse gases.[231] As between administrative discretion and judicial review, more aggressive enforcement of the Endangered Species Act by the Services will have greater impact on efforts to mitigate climate change. Because reviewing courts are admonished "not to substitute [their] judgment for that of [an] agency,"[232] especially where disputed matters involve "a high level of technical expertise"[233] or lie near "the frontiers of science,"[234] courts will hesitate to reverse agency action on the basis of challenges "amount[ing] to nothing more than competing views about policy and science."[235]

B. Habitat Conservation on Private Lands

Section 9 of the Endangered Species Act provides: "it is unlawful for any person subject to the jurisdiction of the United States to . . . take any [endangered] species within the United States or the territorial sea of the United States [or] take any such species upon the high seas."[236] Section 9's prohibition against the taking of

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229. *See* Greater Yellowstone Coal., Inc. v. Servheen, 665 F.3d 1015, 1026 (9th Cir. 2011).

230. *See id. See generally* Jesse A. Logan, William W. Macfarlane & Louisa Willcox, *Whitebark Pine Vulnerability to Climate-Driven Mountain Pine Beetle Disturbance in the Greater Yellowstone Ecosystem*, 20 ECOLOGICAL APPLICATIONS 895 (2010).

231. John Kostyack & Dan Rohlf, *Conserving Endangered Species in an Era of Global Warming*, 38 ENVTL. L. REP. 10,203, 10,212 (2008); *see also* Nat. Res. Def. Council v. Kempthorne, 506 F. Supp. 2d 322, 331–32 (E.D. Cal. 2007) (ordering the Bureau of Reclamation, under authority of section 7 of the Endangered Species Act, to consult with FWS regarding the impact of climate change on the threatened Delta smelt (*Hypomesus transpacificus*)); Ruhl, *supra* note 184, at 45–46 (discussing *NRDC v. Kempthorne*).

232. Mt. Graham Red Squirrel v. Espy, 986 F.2d 1568, 1571 (9th Cir. 1993); *accord, e.g.*, Motor Vehicle Mfrs. Ass'n of the U.S., Inc. v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (1983); Aluminum Co. of Am. v. Adm'r, Bonneville Power Admin., 175 F.3d 1156, 1160–61 (9th Cir. 1999); Nat'l Wildlife Fed. v. Nat'l Marine Fisheries Serv., 839 F. Supp. 2d 1117, 1124 (D. Or. 2011).

233. Marsh v. Or. Nat. Res. Council, 490 U.S. 360, 377 (1989).

234. Balt. Gas & Elec. Co. v. Nat. Res. Def. Council, Inc., 462 U.S. 87, 103 (1983); Forest Guardians v. U.S. Forest Serv., 329 F.3d 1089, 1099 (9th Cir. 2003); *accord* Lands Council v. McNair, 537 F.3d 981, 993 (9th Cir. 2008).

235. *In re* Polar Bear Endangered Species Act Listing & Section 4(d) Rule Litig., 709 F.3d 1, 3 (D.C. Cir. 2013) (quoting *In re* Polar Bear Endangered Species Act Listing & Section 4(d) Rule Litig., 794 F. Supp. 2d. 65, 69 (D.D.C. 2011)).

236. *See* ESA § 9(a)(1), 16 U.S.C. § 1538(a)(1) (2012).

endangered species dramatically expands the scope of the Act from agencies of the federal government to all actors, including the entire private sector.

Notably, the Act does not directly prohibit the taking of a *threatened* species. Section 9, however, does punish the "violat[ion of] any regulation pertaining . . . to any threatened species of fish or wildlife listed pursuant to" section 4 of the Act.[237] By regulation, the Services have defined the taking of a threatened species as a violation of section 9.[238] Prophylactic protection of threatened species alongside more immediately endangered species supports "preventive measures before a species is 'conclusively' headed for extinction."[239]

The Act's definition of "take" and its administrative interpretation are the true source of legal power in section 9's prohibition against the taking of endangered species. The Act defines "take" to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" a member of an endangered species.[240] In turn, regulations issued by the Services have defined the term "harm" as including "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering."[241]

The celebrated 1995 Supreme Court case of *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*[242] upheld, as a "reasonable" exercise in statutory interpretation and implementation, the application of these expanded definitions of "take" and "harm" to the destruction or significant modification of critical habitat adversely affecting an endangered or threatened species, even without a demonstration of intent to injure any individual specimen.[243] If only incidentally, *Sweet Home* also left intact the Department of the Interior's application of its habitat destruction rule to threatened species.[244]

As a statutory and administrative law landmark, *Sweet Home* is regarded either as an intractably difficult battle over interpretive canons[245] or as a relatively easy case

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237. *Id.* § 1538(a)(1)(G); *see also id.* § 1533(d) ("The Secretary may by regulation prohibit with respect to any threatened species any act prohibited under section 1538(a)(1) of this title, in the case of fish or wildlife, or section 1538(a)(2) of this title, in the case of plants, with respect to endangered species . . . .").

238. 50 C.F.R. § 17.31 (2016).

239. Defs. of Wildlife v. Babbitt, 958 F. Supp. 670, 680 (D.D.C. 1997) (emphasis omitted); *accord* Ctr. for Native Ecosystems v. U.S. Fish & Wildlife Serv., 795 F. Supp. 2d 1199, 1202 (D. Colo. 2011); *see also* Humane Soc'y of the U.S. v. Jewell, 76 F. Supp. 3d 69, 79 (D.D.C. 2014) ("[T]he ESA was designed to prevent the extinction of species . . . before they reached the absolute brink of worldwide extinction . . . ."); Sw. Ctr. for Biological Diversity v. Babbitt, 926 F. Supp. 920, 924 (D. Ariz. 1996) (observing that "the United States should not wait until an entire species faces global extinction before [protecting] a domestic population segment").

240. 16 U.S.C. § 1532(19).

241. 50 C.F.R. § 17.3.

242. 515 U.S. 687 (1995).

243. *See id.* at 699–700; *see also* 16 U.S.C. § 1533(a)(3)(A) (authorizing the designation of "critical habitat" for endangered or threatened species).

244. *See Sweet Home*, 515 U.S. at 692 n.5 (observing how the parties challenging the habitat destruction rule had abandoned their attack on the threatened species variant of the rule, 50 C.F.R. § 17.31(a)).

245. *See* William N. Eskridge, Jr., *Nino's Nightmare: Legal Process Theory as a*

that the Supreme Court converted into a pitched ideological battle over environmental and regulatory values.[246] As a substantive exercise in environmental law, *Sweet Home* vindicated the promise that the Endangered Species Act had exhibited since the Supreme Court's first decision interpreting that statute. In 1973, shortly after the passage of the Act, the Justices immediately displayed their understanding of the potential of habitat destruction to disrupt breeding and eliminate indispensable food sources:

> [T]he snail darter occurs only in the swifter portions of shoals over clean gravel substrate in cool, low-turbidity water. Food of the snail darter is almost exclusively snails which require a clean gravel substrate for their survival. The proposed impoundment of water behind the proposed Tellico Dam would result in total destruction of the snail darter's habitat.[247]

The failure of CITES to protect orchids demonstrates that similar sophistication has not migrated from American law to the international sphere.[248]

The use of section 9 against habitat destruction triggers other provisions of the Endangered Species Act. Section 10 authorizes incidental take permits upon submission and approval of a habitat conservation plan (HCP).[249] In turn, approval of an HCP triggers the federal government's obligation under section 7 to "insure that any action" it undertakes "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.[250] Section 4(d) of the Act, which authorizes "necessary and advisable" protective regulations favoring threatened species,[251] may also be used

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Jurisprudence of Toggling Between Facts and Norms, 57 ST. LOUIS U. L.J. 865, 875–89 (2013).

246. *See* Victoria F. Nourse, *Decision Theory and* Babbitt v. Sweet Home*: Skepticism About Norms, Discretion, and the Virtues of Purposivism*, 57 ST. LOUIS. U. L.J. 909 (2013).

247. Tenn. Valley Auth. v. Hill, 437 U.S. 153, 162 (1978) (alteration in original) (emphasis omitted) (quoting 40 Fed. Reg. 47,505, 47,506 (Oct. 9, 1975)); *see also id.* at 165 n.16 (quoting Tenn. Valley Auth. v. Hill, 419 F. Supp. 753, 756 (E.D. Tenn. 1976)) ("[T]he snail darter requires for its survival a clear, gravel substrate, in a large-to-medium, flowing river. The snail darter has a fairly high requirement for oxygen and since it tends to exist in the bottom of the river, the flowing water provides the necessary oxygen at greater depths. Reservoirs, unlike flowing rivers, tend to have a low oxygen content at greater depths. Reservoirs also tend to have more silt on the bottom than flowing rivers, and this factor, combined with the lower oxygen content, would make it highly probable that snail darter eggs would smother in such an environment. Furthermore, the adult snail darters would probably find this type of reservoir environment unsuitable for spawning. Another factor that would tend to make a reservoir habitat unsuitable for snail darters is that their primary source of food, snails, probably would not survive in such an environment."). *See generally* Oliver Houck, *Unfinished Stories*, 73 U. COLO. L. REV. 867, 921—22 (2002).

248. *See supra* text accompanying notes 82–85.

249. *See* 16 U.S.C. § 1539(a) (2012).

250. *Id.* § 1536(a)(2); *see also* 50 C.F.R. § 402.01(b) (2016); Friends of Endangered Species, Inc. v. Jantzen, 760 F.2d 976, 984–85 (9th Cir. 1985); Nat'l Wildlife Fed'n v. Babbitt, 128 F. Supp. 2d 1274, 1286 (E.D. Cal. 2000).

251. 16 U.S.C. § 1533(d).

to establish the functional equivalent of HCPs for threatened species.[252] These provisions have been interpreted as imposing an affirmative obligation to pursue an active species conservation policy.[253]

Before HCPs became a familiar fixture of Endangered Species Act enforcement, developers and farmers facing section 9 liability often resorted to "the 'scorched earth' technique" of preemptively clearing wildlife habitat.[254] Debates over the supposed inflexibility of section 9 can be resolved, at least in part, by examining the actual record of responses to ESA enforcement.[255] The rates at which landowners "shoot, shovel, and shut up"[256] can be tracked, for instance, by measuring whether harvesting rates in southeastern pine forests vary according to the presence of the federally protected red-cockaded woodpecker.[257] In upholding the listing of the northern spotted owl as an endangered species and the designation of its critical habitat, the Ninth Circuit acknowledged the economic impact of these decisions and the potential for landowners to undermine the federal government's efforts to protect that species.[258]

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252. *See* Robert L. Fischman & Jaelith Hall-Rivera, *A Lesson for Conservation from Pollution Control Law: Cooperative Federalism for Recovery Under the Endangered Species Act*, 27 COLUM. J. ENVTL. L. 45, 94–109 (2002).

253. *See* Carson-Truckee Water Conservancy Dist. v. Clark, 741 F.2d 257, 262 (9th Cir. 1984); Fla. Key Deer v. Stickney, 864 F. Supp. 1222, 1237–38 (S.D. Fla. 1994); J.B. Ruhl, *Section 7(a)(1) of the "New" Endangered Species Act: Rediscovering and Redefining the Untapped Power of Federal Agencies' Duty to Conserve Species*, 25 ENVTL. L. 1107, 1137 (1995).

254. Michael J. Bean, *Overcoming Unintended Consequences of Endangered Species Regulation*, 38 IDAHO L. REV. 409, 415 (2002) (quoting NAT'L ASS'N OF HOMEBUILDERS, DEVELOPER'S GUIDE TO ENDANGERED SPECIES REGULATION 109 (1996)); *see also* George Cameron Coggins & Anne Fleishel Harris, *The Greening of American Law?: The Recent Evolution of Federal Law for Preserving Floral Diversity*, 27 NAT. RESOURCES J. 247, 297 (1987).

255. *Compare, e.g.*, Christopher A. Cole, Note, *Species Conservation in the United States: The Ultimate Failure of the Endangered Species Act and Other Land Use Laws*, 72 B.U. L. REV. 343, 350–54 (1992) (arguing that the Act, at least as enforced without resort to HCPs, is unduly harsh and ineffective), *with* Karin P. Sheldon, *Habitat Conservation Planning: Addressing the Achilles Heel of the Endangered Species Act*, 6 N.Y.U. ENVTL. L.J. 279 (1998) (arguing that landowners historically did not treat their chances of receiving incidental take permits under section 10 as sufficiently serious to warrant the making of HCP proposals). *See generally* Dean Lueck, *The Law and Politics of Federal Wildlife Preservation*, *in* POLITICAL ENVIRONMENTALISM: GOING BEHIND THE GREEN CURTAIN 61, 72–80 (Terry L. Anderson ed., 2000).

256. Shi-Ling Hsu, *A Game-Theoretic Approach to Regulatory Negotiation and a Framework for Empirical Analysis*, 26 HARV. ENVTL. L. REV. 33, 58 (2002) (quoting Mike Vivoli, *Shoot and Shovel, and Shut Up*, WASH. TIMES, Nov. 27, 1992, at F2); Sagoff, *supra* note 40, at 826 (quoting Martin van der Werf, *Endangered Species Act 'Gotta Be Fixed,' Foe Says*, ARIZ. REPUBLIC, July 1, 1995, at B1).

257. *See* Dean Lueck & Jeffrey A. Michael, *Preemptive Habitat Destruction Under the Endangered Species Act*, 46 J.L. & ECON. 27 (2003) (documenting higher harvest rates near woodpecker habitat and speculating that timber owners are harvesting before woodpeckers—and the land-use restrictions that follow them—move in).

258. *See* Seattle Audubon Soc'y v. Moseley, 80 F.3d 1401, 1403–04 (9th Cir. 1996).

Moreover, political pressure routinely pushes Congress to cripple the listing of endangered and threatened species under section 4.[259] The political economy of biodiversity conservation enables opponents of species protection to disrupt listing decisions.[260] Though extinctions proceed apace, Congress has been known to impose a moratorium on the expansion of the endangered species list,[261] only to suspend such moratoria when political winds shift.[262]

Beginning with efforts to reconcile preservation of the remaining habitat of the endangered Mission Blue butterfly with commercial development on San Bruno Mountain on the San Francisco peninsula,[263] ESA enforcement from the 1990s onward transformed "the previously obscure and rarely used permit provision" of section 10 into "the centerpiece of endangered species and ecosystem conservation policy."[264] Threatened section 9 liability became merely the "opening gambit[] in a prolonged bargaining process."[265] HCPs today represent "perhaps the most visible example of a consensus-based, multi-stakeholder approach to resource management."[266] Section 10 enforcement has transformed section 9's nominally invariant rule into a "penalty default," a legal baseline intentionally designed to be sufficiently unpleasant to spur affected parties into negotiating more favorable alternatives.[267]

The strategy has its limits. Like the Endangered Species Act as a whole, HCPs proceed species by species, and only after an individual species has begun to decline.

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259. *See generally* 16 U.S.C. § 1533(d) (2012) (authorizing the listing of endangered species).

260. *See* Amy Whritenour Ando, *Waiting To Be Protected Under the Endangered Species Act: The Political Economy of Regulatory Delay*, 42 J.L. & ECON. 29 (1999).

261. *See* Pub. L. No. 104-6, § 117, 109 Stat. 73, 86 (1995).

262. *See* Memorandum of April 26, 1996, 61 Fed. Reg. 24,667 (May 16, 1996); *see also* Holly Doremus, *Listing Decisions Under the Endangered Species Act: Why Better Science Isn't Always Better Policy*, 75 WASH. U. L.Q. 1029 (1997); Jason M. Patlis, *Riders on the Storm, or Navigating the Crosswinds of Appropriations and Administration of the Endangered Species Act: A Play in Five Acts*, 16 TUL. ENVTL. L.J. 257 (2003).

263. *See* Friends of Endangered Species, Inc. v. Jantzen, 760 F.2d 976, 982–83 (9th Cir. 1985).

264. Bradley C. Karkkainen, *Adaptive Ecosystem Management and Regulatory Penalty Defaults: Toward a Bounded Pragmatism*, 87 MINN. L. REV. 943, 970 (2003); *see also* S. REP. NO. 97-418, at 10 (1982); H.R. REP. NO. 97-835, at 31–32 (1982); MICHAEL J. BEAN, SARAH G. FITZGERALD & MICHAEL A. O'CONNELL, RECONCILING CONFLICTS UNDER THE ENDANGERED SPECIES ACT: THE HABITAT CONSERVATION PLANNING EXPERIENCE 52–55 (1991); Jamie A. Grodsky, *The Paradox of (Eco)Pragmatism*, 87 MINN. L. REV. 1037, 1058–59, 1058 n.81 (2003); Albert C. Lin, *Participants' Experiences with Habitat Conservation Plans and Suggestions for Streamlining the Process*, 23 ECOLOGY L.Q. 369, 375–76 (1996).

265. Daniel A. Farber, *Taking Slippage Seriously: Noncompliance and Creative Compliance in Environmental Law*, 23 HARV. ENVTL. L. REV. 297, 317 (1999). For further discussion of environmental law as a process of public-sector negotiation, see David A. Dana, *The New "Contractarian" Paradigm in Environmental Regulation*, 2000 U. ILL. L. REV. 35.

266. Jody Freeman, *The Contracting State*, 28 FLA. ST. U. L. REV. 155, 194 (2000).

267. *See* Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87, 94 (1989); Randy E. Barnett, *The Sound of Silence: Default Rules and Contractual Consent*, 78 VA. L. REV. 821, 825 (1992); Stephen J. Ware, *Default Rules from Mandatory Rules: Privatizing Law Through Arbitration*, 83 MINN. L. REV. 703, 706 (1999).

Despite well-founded doubts about the territorial and institutional suitability of states as participants in ecosystem management,[268] state-law restrictions on land use can enhance the effectiveness of federal HCPs.[269] California law facilitates natural community conservation plans that provide "large-scale, multi-species equivalents of HCPs."[270] That state's active intervention is crucial because it is home to the California floristic province, the hottest of biological "hotspots" in the continental United States.[271]

Ultimately, however, the Endangered Species Act only indirectly addresses habitat loss and altogether ignores "other causes" of biodiversity loss "such as the invasion of exotic species and air and water pollution."[272] The Act as a whole falls far short of "promot[ing] the conservation of ecosystems on the geographic scale necessary to promote biodiversity generally."[273]

C. Αρκτούρος: Climate Change in the "Last Great Wilderness"

Though the frigid polar regions may be poor in biodiversity, they exhibit some of the most dramatic effects of global warming. Climatic impacts on Arctic Ocean sea ice are among the most alarming harbingers of rising temperatures worldwide.[274] In the United States alone, many legal tools are emerging as instruments of climate change policymaking. For example, the Environmental Protection Agency (EPA) has

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268. *See* Bradley C. Karkkainen, *Collaborative Ecosystem Governance: Scale, Complexity, and Dynamism*, 21 VA. ENVTL. L.J. 189, 216 (2002).

269. *See* Marc J. Ebbin, *Is the Southern California Approach to Conservation Succeeding?*, 24 ECOLOLOGY L.Q. 695, 696–97, 697 n.7 (1997); *see also* 16 U.S.C. § 1535 (2012) (authorizing cooperative species conservation agreements between states and the federal government); *cf.* A. Dan Tarlock, *Biodiversity Federalism*, 54 MD. L. REV. 1315 (1995) (arguing that biodiversity conservation will not succeed absent state-federal cooperation).

270. Tarlock, *supra* note 154, at 10,539; *see* Natural Community Conservation Planning Act, CAL. FISH & GAME CODE §§ 2800–2835 (2013 & West Supp. 2017). *See generally* John M. Gaffin, *Can We Conserve California's Threatened Fisheries Through Natural Community Planning?*, 27 ENVTL. L. 791 (1997). For further discussion of the role of state tort law in biodiversity conservation, see A. Dan Tarlock, *Local Government Protection of Biodiversity: What Is Its Niche?*, 60 U. CHI. L. REV. 555 (1993).

271. *See generally, e.g.*, ROBERT ORNDUFF, PHYLLIS M. FABER & TODD KEELER-WOLF, INTRODUCTION TO CALIFORNIA PLANT LIFE (rev. ed. 2003); Bruce G. Baldwin, *Origins of Plant Diversity in the California Floristic Province*, 45 ANN. REV. ECOLOGY EVOLUTION & SYSTEMATICS 347 (2014); Ryan Calsbeek, John N. Thompson & James E. Richardson, *Patterns of Molecular Evolution and Diversification in a Biodiversity Hotspot: The California Floristic Province*, 12 MOLECULAR ECOLOGY 1021 (2003).

272. Tarlock, *supra* note 154, at 10,537. *See generally, e.g.*, Elaine K. Harding et al., *The Scientific Foundations of Habitat Conservation Plans: A Quantitative Assessment*, 15 CONSERVATION BIOLOGY 488 (2000) (evaluating the use of scientific data in HCPs).

273. Tarlock, *supra* note 154, at 10,540.

274. *See, e.g.*, Michael A. Alexander, K. Halimeda Kilbourne & Janet A. Nye, *Climate Variability During Warm and Cold Phases of the Atlantic Multidecadal Oscillation (AMO) 1871–2008*, 133 J. MARINE SYSTEMS 14 (2014); Elizabeth N. Cassano, John J. Cassano, Matthew E. Higgins & Mark C. Serreze, *Atmospheric Impacts of an Arctic Sea Ice Minimum As Seen in the Community Atmosphere Model*, 34 INT'L J. CLIMATOLOGY 766 (2014).

not only the authority but also the obligation under the Clean Air Act to regulate greenhouse gas emissions from new motor vehicles.[275] The Energy Policy and Conservation Act[276] and the National Environmental Policy Act[277] require the National Highway Transportation Safety Administration to address carbon emissions through corporate average fuel efficiency (CAFE) standards, or at least to explain why the agency has declined to adopt more stringent CAFE standards.[278]

For some time, the law has contemplated the possibility that human agents of climate change might bear tort liability.[279] Alaskan native villages have failed in their efforts to recover damages for climate change induced damage to human habitat. In rejecting the village of Kivalina's suit against ExxonMobil, a federal court described "the harm from global warming" as a causally remote "series of events disconnected from the discharge" of "greenhouse gases," which must then "combine with other gases in the atmosphere which in turn results in the planet retaining heat, which in turn causes the ice caps to melt and the oceans to rise, which in turn causes the Arctic sea ice to melt, which in turn allegedly renders Kivalina vulnerable to erosion and deterioration resulting from winter storms."[280]

Another court has rejected a native village's claim against the Bureau of Ocean Energy Management for alleged harm arising from an Arctic Ocean oil exploration plan.[281] Consistent with older precedent holding that the Federal Water Pollution Control Act Amendments of 1972 displaced federal common law claims arising from a sewage discharge,[282] the Supreme Court has invoked the Clean Air Act to repel federal common law claims against greenhouse gas emissions.[283]

Against this admittedly modest baseline, the Endangered Species Act has achieved remarkable success in addressing the seemingly relentless emission of greenhouse gases and the anthropogenic contribution to climate change. The application of the Act to species most immediately menaced by climate change offers a promising set of remedies. With a reach that exceeds that of sections 4 and 7, section

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275. *See* Massachusetts v. EPA, 549 U.S. 497, 532–33 (2007).

276. Pub. L. No. 94-163, 89 Stat. 871 (1975) (codified as amended in scattered titles throughout U.S.C.).

277. 42 U.S.C. §§ 4321–4370m-12 (2012).

278. *See* Ctr. for Biological Diversity v. Nat'l Highway Transp. Safety Admin., 538 F.3d 1172 (9th Cir. 2008); Ctr. for Biological Diversity v. Nat'l Highway Transp. Safety Admin., 508 F.3d 508 (9th Cir. 2007).

279. *See* Myles Allen, *Liability for Climate Change*, 421 NATURE 891 (2003).

280. Native Village of Kivalina v. ExxonMobil Corp., 663 F. Supp. 2d 863, 876 (N.D. Cal. 2009), *aff'd*, 696 F.3d 849 (9th Cir. 2012).

281. *See* Native Village of Point Hope v. Salazar, 680 F.3d 1123, 1135 (9th Cir. 2012) (concluding that the Bureau of Ocean Energy Management properly concluded that an Arctic oil exploration plan would not "probably cause serious harm or damage" to life, property or the human, marine, or coastal environment in violation of 43 U.S.C. §§ 1334(a)(2)(A)(i), 1340(c)(1), 30 C.F.R. §§ 550.202, 550.233). *See generally* Hari M. Osofsky, *The Inuit Petition as a Bridge? Beyond Dialectics of Climate Change and Indigenous Peoples' Rights*, 31 AM. INDIAN L. REV. 675 (2007).

282. *See* City of Milwaukee v. Illinois, 451 U.S. 304, 318–19 (1981).

283. *See* Am. Elec. Power Co. v. Connecticut, 564 U.S. 410, 424 (2011) (holding that "the Clean Air Act and the EPA actions it authorizes displace any federal common-law right to seek abatement of carbon-dioxide emissions from fossil-fuel fired power plants").

9 of the Act may yet be construed to treat greenhouse gas emissions as a legally critical link in a causal chain leading to the unlawful "taking" of an endangered species.[284]

The application of section 9 to climate change would represent a significant step beyond Justice O'Connor's concurrence in *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*.[285] Her opinion emphasized limitations imposed "by ordinary principles of proximate causation," including embedded "notions of foreseeability,"[286] in order to curb the perceived excesses of the Ninth Circuit's 1988 *Palila* decision.[287] In 1995 Justice O'Connor questioned whether section 9 could be lawfully construed to reach destruction of the palila bird's habitat in Hawaii through sheep-grazing.[288] The question today is whether section 9 may be applied to significant modification or degradation of habitat traceable to anthropogenic climate change.[289]

Climate change has figured prominently in both listing and critical habitat designation decisions for species ranging from subtropical elkhorn and staghorn coral[290] to sage grouse and wolverine on the North American mainland[291] and bearded and

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284. *See* Brendan R. Cummings & Kassie R. Siegel, Ursus Maritimus: *Polar Bears on Thin Ice*, NAT. RESOURCES & ENV'T, Fall 2007, at 3, 4, 7 (2007).

285. 515 U.S. 687 (1995).

286. *Id.* at 709 (O'Connor, J., concurring).

287. *See* Palila v. Hawaii Dep't of Land & Nat. Res., 852 F.2d 1106 (9th Cir. 1988).

288. *Sweet Home*, 515 U.S. at 709 (O'Connor, J., concurring).

289. *See generally* Matthew Gerhart, Comment, *Climate Change and the Endangered Species Act: The Difficulty of Proving Causation*, 36 ECOLOGY L.Q. 167 (2009).

290. *See* Ctr. for Biological Diversity v. Nat'l Marine Fisheries Serv., 191 F. Supp. 3d 157 (D.P.R. 2016); Ctr. for Biological Diversity v. Nat'l Marine Fisheries Serv., 977 F. Supp. 2d 55 (D.P.R. 2013); Ctr. for Biological Diversity v. Gutierrez, 451 F. Supp. 2d 57 (D.D.C. 2006); Final Listing Determinations for Elkhorn Coral and Staghorn Coral, 71 Fed. Reg. 26,852 (May 9, 2006) (codified at 50 C.F.R. § 223.208); Critical Habitat for Threatened Elkhorn and Staghorn Corals, 73 Fed. Reg. 72,210 (Nov. 26, 2008) (codified at 50 C.F.R. §§ 223.208, 226.216). *See generally* Blake Armstrong, Note, *Maintaining the World's Marine Biodiversity: Using the Endangered Species Act To Stop the Climate Change Induced Loss of Coral Reefs*, 18 HASTINGS W-NW. J. ENVTL. L. & POL'Y 429 (2012).

291. *See* Am. Lands All. v. Norton, 242 F. Supp. 2d 1, 6 (D.D.C. 2003) (identifying climate change as a factor favoring the listing of the Gunnison sage grouse as an endangered species), *vacated in part on reconsideration*, 360 F. Supp. 2d 1 (2003); Endangered Status for Gunnison Sage-Grouse, 78 Fed. Reg. 2486 (proposed Jan. 11, 2013) (codified at 50 C.F.R. § 17.95-b); Threatened Status for the Distinct Population Segment of the North American Wolverine Occurring in the Contiguous United States, 78 Fed. Reg. 7864 (proposed Feb. 4, 2013); *cf.* Defs. of Wildlife v. Jewell, 176 F. Supp. 3d 975, 1003–05 (D. Mont. 2016) (vacating the FWS's treatment of climate change data involving the North American wolverine's reproductive denning behavior, upon which the FWS had relied in refusing to list the wolverine as endangered); Friends of the Wild Swan, Inc. v. U.S. Fish & Wildlife Serv., 12 F. Supp. 2d 1121, 1127–28 (D. Or. 1997) (acknowledging the vulnerability of the bull trout to climate change). *See generally* Michael C. Blumm & Kya B. Marienfeld, *Endangered Species Act Listings and Climate Change: Avoiding the Elephant in the Room*, 20 ANIMAL L. 277, 294–305 (2014) (discussing the sage grouse and wolverine listing decisions); Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825,

ringed seals in northern seas.[292] The FWS has designated the Pacific walrus as a candidate for threatened status, but has not yet listed that species.[293] The record of Endangered Species Act cases addressing climate change upholds the longstanding legal preference for large, charismatic fauna over all other forms of biodiversity.[294]

The signature battle over the application of the Act to climate change has involved, quite unsurprisingly, the polar bear.[295] Litigation has swamped all aspects of the FWS's efforts to protect the polar bear, from its listing as a threatened species[296] to the designation of large portions of the Arctic as critical habitat[297] and the application of section 9's prohibition against takings of polar bears.[298]

The English word "Arctic," after all, stems from *ἄρκτος*, the ancient Greek word for "bear," in honor of the constellation that other ancient people called Ursa Major.[299] Arcturus (*Ἀρκτοῦρος*), the celebrated northern star, means the "guardian of

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879–80 (2008) (discussing *American Lands Alliance*, *Wild Swan*, and the *Acropora* coral listing decision).

292. *See* Threatened Status for the Beringia and Okhotsk Distinct Population Segments of the Erignathus Barbatus Nauticus Subspecies of the Bearded Seal, 77 Fed. Reg. 76,740 (Dec. 28, 2012) (codified at 50 C.F.R. pt. 223); Threatened Status for the Arctic, Okhotsk, and Baltic Subspecies of the Ringed Seal and Endangered Status for the Lagoda Subspecies of the Ringed Seal, 77 Fed. Reg. 76,706 (Dec. 28, 2012) (codified at 50 C.F.R. pts. 223–24)*; cf.* Greenpeace v. Nat'l Marine Fisheries Serv., 237 F. Supp. 2d 1181, 1188 (W.D. Wash. 2002) (recognizing the impact of climate change on reductions in the population of the Stellar sea lion).

293. *See* 12-Month Finding To List the Pacific Walrus as Threatened or Endangered, 76 Fed. Reg. 7634 (Feb. 10, 2011).

294. *See* Nigel Leader-Williams & Holly T. Dublin, *Charismatic Megafauna as 'Flagship Species,' in* PRIORITIES FOR THE CONSERVATION OF MAMMALIAN DIVERSITY: HAS THE PANDA HAD ITS DAY? 53 (Abigail Entwistle & Nigel Dunstone eds., 2000) (urging the deemphasis of large mammals in favor of more holistic conservation models that integrate social concerns with biological concerns encompassing multiple species and biodiversity at large); Diogo Verissimo, Douglas C. MacMillan & Robert J. Smith, *Toward a Systematic Approach for Identifying Conservation Flagships*, 4 CONSERVATION LETTERS 1 (2011) (proposing a new definition of flagship species that emphasizes the role of charismatic megafauna in promoting awareness of and support for biodiversity conservation).

295. *See generally* Louis A. Di Leo, *The Polar Bear Ethic: From the Reactionary Trend in Environmental Lawmaking to the Climate Change Imperative*, 28 J. ENVTL. L & LITIG. 347 (2013); Maggie Kuhn, Note, *Climate Change and the Polar Bear: Is the Endangered Species Act Up to the Task?* 27 ALASKA L. REV. 125 (2010).

296. *See In re* Polar Bear Endangered Species Act Listing & Section 4(d) Rule Litig., 709 F.3d 1 (D.C. Cir. 2013).

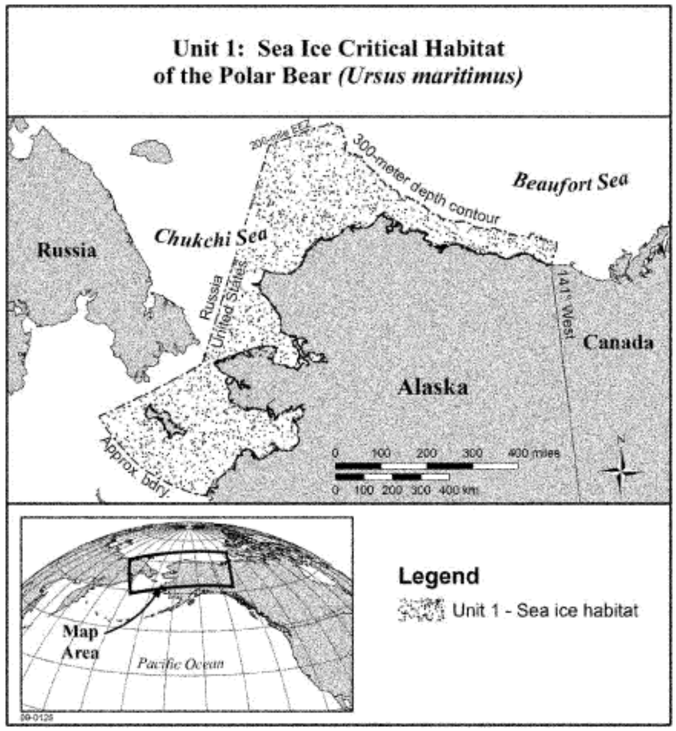
297. *See* Alaska Oil & Gas Ass'n v. Salazar, 916 F. Supp. 2d 974 (D. Alaska 2013).

298. *See In re* Polar Bear Endangered Species Act Listing & Section 4(d) Rule Litig., 818 F. Supp. 2d 214 (D.D.C. 2011), *aff'd*, 709 F.3d 1 (D.C. Cir. 2013).

299. *Arctic*, ONLINE ETYMOLOGY DICTIONARY, http://www.etymonline.com/index.php?term=arctic [https://perma.cc/M25C-Z5KX]; Henry George Liddell & Robert Scott, *Ἄρκτος*, GREEK-ENGLISH LEXICON, http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.04.0057%3Aentry%3D%2315199 [https://perma.cc/ZU5M-PADG] (*ἄρκτος*); Henry George Lidell & Robert Scott, *Ἀρκτικός*, GREEK-ENGLISH LEXICON, http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.04.0057%3Aentry%3D%2315193 [https://perma.cc/A2H6-YYFQ] (*ἀρκτικός*).

the bear."[300] Other ancient sources have drawn inspiration from these northern asterisms: "He is wise in heart, and mighty in strength," "[w]hich maketh Arcturus, Orion, and Pleiades, and the chambers of the south."[301] The existential threat to the polar bear has spurred legal action against the vectors of anthropogenically induced climate change.

In 2008 the FWS listed the polar bear as threatened by the effects of climate change on the bear's Arctic habitat.[302] Although the FWS initially declined to designate critical habitat for the polar bear, it dramatically reversed course in 2010 by designating 187,157 square miles in Alaska and adjacent waters of the United States and its territories[303]:



Unit 1: Sea Ice Critical Habitat of the Polar Bear *(Ursus maritimus)*

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300. *Arcturus*, ONLINE ETYMOLOGY DICTIONARY, http://www.etymonline.com/index.php?term=arcturus [https://perma.cc/7Y8A-25GX]. Both "Arctic" and "Arcturus" entered English through Latin, which imported even older Greek words as well as the northern connotations associated with these words. *See* CASSELL'S LATIN DICTIONARY 56 (D.P. Simpson ed., 1977) (describing the Latin word *arcticus* as derived from ancient Greek *ἀρκτικός* and *ἄρκτος*, and Latin *Arcturus* as derived from *Ἀρκτοῦρος*).

301. *Job* 9:4, 9:9 (King James Version). The New International Version and other contemporary translations of the Bible refer to "the Bear" instead of Arcturus, which would swap Ursa Major (the Great Bear) for Boötes (the Plowman), the constellation that includes Arcturus. *Cf.* CASSELL'S LATIN DICTIONARY, *supra* note 300, at 56 (recognizing that "Arcturus" in Latin could designate not only the star, but also the constellation Boötes).

302. Determination of Threatened Status for the Polar Bear (Ursus Maritimus) Throughout Its Range, 73 Fed. Reg. 28,212 (May 15, 2008) (codified at 50 C.F.R. pt. 17).

303. *See* Designation of Critical Habitat for the Polar Bear (Ursus Maritimus) in the United States, 75 Fed. Reg. 76,086, 76,088 (Dec. 7, 2010) (codified at 50 C.F.R. pt. 17).

Of central importance to the listing of the polar bear and to the designation of its habitat as critical is the existential threat that climate change poses to Arctic sea ice.[304] The D.C. Circuit quoted the portion of the listing decision which recognized that irreversible "changes to the polar bear's habitat will soon pose an existential threat to the species":[305]

> Productivity, abundance, and availability of ice seals, the polar bear's primary prey base, would be diminished by the projected loss of sea ice, and energetic requirements of polar bears for movement and obtaining food would increase. Access to traditional denning areas would be affected. In turn, these factors would cause declines in the condition of polar bears from nutritional stress and reduced productivity. As already evidenced in the Western Hudson Bay and Southern Beaufort Sea populations, polar bears would experience reductions in survival and recruitment rates. The eventual effect is that polar bear populations would decline. The rate and magnitude of decline would vary among populations, based on differences in the rate, timing, and magnitude of impacts. However, within the foreseeable future, all populations would be affected, and the species is likely to become in danger of extinction throughout all of its range due to declining sea ice habitat.[306]

The parallel with *TVA v. Hill*'s recognition of the Tellico Dam's existential threat to the snail darter is impossible to miss.[307]

The impact of climate change on the Arctic is hardly limited to polar bears. Even the color of ice itself contributes to a significant albedo effect:[308] as ice melts, the darkening of the sea or land surface absorbs more solar energy and accelerates global warming even more.[309] Albedo has sufficient climatic impact to warrant serious

304. *See* Determination of Threatened Status for the Polar Bear (Ursus Maritimus) Throughout Its Range, 73 Fed. Reg. at 28,212–13. *See generally* sources cited *supra* note 274.

305. *In re* Polar Bear Endangered Species Act Listing & Section 4(d) Rule Litig., 709 F.3d 1, 6 (D.C. Cir. 2013).

306. *Id.* (quoting Determination of Threatened Status for the Polar Bear (Ursus Maritimus) Throughout Its Range, 73 Fed. Reg. at 28,292–93).

307. *See* TVA v. Hill, 437 U.S. 153, 162, 165 n.16 (1978); *supra* note 247 and accompanying text.

308. *See generally* Robert J. Charlson, James E. Lovelock, Meinrat O. Andreae & Stephen G. Warren, *Oceanic Phytoplankton, Atmospheric Sulphur, Cloud Albedo and Climate*, 326 NATURE 655 (1987); Andrew J. Watson, & James E. Lovelock, *Biological Homeostasis of the Global Environment: The Parable of Daisyworld*, 35B TELLUS B 284 (1983).

309. *See* Determination of Threatened Status for the Polar Bear (Ursus Maritimus) Throughout Its Range, 73 Fed. Reg. at 28,225.

consideration of geoengineering projects designed to alter the color of the earth,[310] even to the point of turning the daytime sky from blue to white.[311]

Federal courts have upheld most aspects of the FWS's polar bear decisions.[312] The United States District Court for the District of Alaska did invalidate the FWS's designation of Unit 2, a stretch of northern Alaska spanning the Canadian border and the town of Barrow, because the FWS used its finding of a need to isolate polar bear dens from humans and human activities, an "essential feature" of Unit 2 that constituted only "approximately one percent of the entire area," as an improper basis for "designat[ing] a large swath of land . . . as 'critical habitat.'"[313]

For its part, the United States District Court for the District of Columbia has rejected a challenge to the FWS's decision to confine the protection of polar bears under section 9 of the Act according to exemptions granted by the Marine Mammal Protection Act[314] and the Convention on International Trade in Endangered Species of Wild Flora and Fauna[315] and to refrain from enforcing section 9 with respect to activities outside the polar bears' range, notwithstanding those activities' incidental impact on polar bears.[316] Using its authority under the Marine Mammal Protection Act,[317] the FWS has routinely authorized nonlethal, incidental takings of polar bears and Pacific walruses.[318] The authority to permit incidental takings requires the Service to determine that such takings will have no more than a "negligible impact" on the affected population.[319] In applying its incidental takings authority, the Service must analyze "reasonably expected" and "reasonably likely"

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310. *See, e.g.*, Peter J. Irvine, Andy Ridgwell & Daniel J. Lunt, *Climatic Effects of Surface Albedo Engineering*, 116 J. GEOPHYSICAL RES. D24112 (2011); Joy S. Singareyer, Andy Ridgwell & Peter Irvine, *Assessing the Benefits of Crop Albedo Bio-Geoengineering*, 4 ENVTL. RES. LETTERS 045110 (2009).

311. *See* Giovanni Pitari Valentina Aquila, Ben Kravitz, Alan Robock, Shingo Watanabe, Irene Cionni, Natalia De Luca, Glauco Di Genova, Eva Mancini & Simone Tilmes, *Stratospheric Ozone Response to Sulfate Geoengineering: Results from the Geoengineering Model Intercomparison Project (GeoMIP)*, 4 J. GEOPHYSICAL RES. ATMOSPHERES 2629 (2014).

312. *See, e.g.*, Alanna Kearney, Case Note, *The Battle May Be Over, but What About the War? Examining the ESA in the Crusade Against Global Warming After* In Re Polar Bear Endangered Species Act Listing and Section 4(d) Rule Litigation, 25 VILL. ENVTL. L.J. 529 (2014).

313. Alaska Oil & Gas Ass'n v. Salazar, 916 F. Supp. 2d 974, 1001–02 (D. Alaska 2013).

314. *See* 16 U.S.C. §§ 1373–74 (2012).

315. Convention on International Trade in Endangered Species of Wild Fauna and Flora art. VII, March 3, 1973, 27 U.S.T. 1087 ("Exemptions and Other Special Provisions Relating to Trade").

316. *See In re* Polar Bear Endangered Species Act Listing & Section 4(d) Rule Litig., 818 F. Supp. 2d 214, 222–24 (D.D.C. 2011), *aff'd*, 709 F.3d 1 (D.C. Cir. 2013).

317. 16 U.S.C. § 1371(a)(5)(A) (2012).

318. *See* Ctr. for Biological Diversity v. Salazar, 695 F.3d 893 (9th Cir. 2012); *see also* Ctr. for Biological Diversity v. Kempthorne, 588 F.3d 701 (9th Cir. 2009); Incidental Take During Specified Activities, 76 Fed. Reg. 47,010 (Aug. 3, 2011) (codified at 50 C.F.R. pt. 18).

319. 16 U.S.C. § 1371(a)(5)(A)(i)(I); *see Kempthorne*, 588 F.3d at 710.

effects leading to a "negligible impact," but bears no obligation to consider speculative or uncertain effects.[320]

The brief legal record of applying the Endangered Species Act to climate change has already shifted the policy-making terrain. Designation of the polar bear's critical habitat recognizes the ecological threat that climate change poses to the biosphere. The Arctic has been justifiably described as "the last great wilderness."[321] Wilderness areas have long offered the promise of providing refuges "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."[322]

Despite their low levels of biodiversity, the Arctic and other cold and/or high-elevation locales may yet prove to be pivotal legal battlegrounds in the last-ditch effort to save the earth and its diverse forms of life from anthropogenically induced climate change. Although the law offers no conclusive answer to the question of whether the Endangered Species Act "is an effective or appropriate tool to address the threat of climate change,"[323] climate change and biodiversity conservation remain the most important things that the law can address.

IV. THE LAW OF BIODIVERSITY CONSERVATION AND CLIMATE MITIGATION IN THE ANTHROPOCENE

A. A New Epoch

Remarkably, profound biodiversity loss and accelerating climate change represent "only the tip of the iceberg."[324] So deep is the human footprint on the global environment that some scientists have urged the redesignation of this moment in geological time as the Anthropocene epoch.[325] From the initial domestication of plants and animals 11,000 to 9000 years ago,[326] through the Industrial Revolution and the "Great Acceleration" of population, affluence, and technology since World War II,[327]

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320. 50 C.F.R. § 18.27(c) (2016); *accord Kempthorne*, 588 F.3d at 710–11.

321. *See* ROGER KAYE, LAST GREAT WILDERNESS: THE CAMPAIGN TO ESTABLISH THE ARCTIC NATIONAL WILDLIFE REFUGE (2006).

322. 16 U.S.C. § 1131(c).

323. *In re* Polar Bear Endangered Species Act Listing & 4(d) Rule Litig., 818 F. Supp. 2d 214, 234 (D.D.C. 2011), *aff'd*, 709 F.3d 1 (D.C. Cir. 2013).

324. Will Steffen, Jacques Grinevald, Paul Crutzen & John McNeill, *The Anthropocene: Conceptual and Historical Perspectives*, 369 PHIL. TRANSACTIONS ROYAL SOC'Y A 842, 843 (2011).

325. *See* Paul J. Crutzen, *Geology of Mankind*, 415 NATURE 23 (2002); Paul J. Crutzen & Eugene F. Stoermer, *The "Anthropocene*,*"* GLOBAL CHANGE NEWSL. (Stockholm), May 2000, at 17; Editorial, The Human Epoch, 473 NATURE 254 (2011).

326. Bruce D. Smith & Melinda A. Zeder, *The Onset of the Anthropocene*, 4 ANTHROPOCENE 8, 13 (2013).

327. *See* Kathy A. Hibbard, Paul J. Crutzan, Eric F. Lambin, Diana M. Liverman, Nathan J. Mantua, John R. McNeill, Bruno Messerli & Will Steffen, *Group Report: Decadal-Scale Interactions of Humans and the Environment*, *in* SUSTAINABILITY OR COLLAPSE? AN INTEGRATED HISTORY AND FUTURE OF PEOPLE ON EARTH 341 (Robert Costanza, Lisa J. Graumlich & Will Steffen eds., 2007).

human activity has had a profound impact on every physical and biological aspect of the planet.[328]

Strict notions of the human ecological footprint[329] define environmental sustainability according to the physical flows of energy and matter.[330] By these benchmarks, humanity is gobbling the planet. Humans now consume 20–40% of the solar energy captured by plants.[331] Humans co-opt approximately 40% of net primary production in terrestrial ecosystems and 25% of global net primary production, including photosynthesis in the oceans.[332] Humanity currently claims 54% of Earth's available fresh water, and that thirst is projected to increase to 70% by 2050.[333] "[T]he world's average human eco-footprint is about 2.3 [hectares, or 5.7 acres], even though there are only 1.9 [hectares, or 4.7 acres] of productive land and water per person on Earth."[334]

Even the mechanics of evolution have changed. Whereas island biogeography before humanity operated according to geographic area and isolation,[335] the island biogeography of the Anthropocene is dominated by the economic isolation of human populations.[336] Cuba, the largest land mass in the West Indies, has absorbed fewer losses of native anole lizards attributable to colonization by exotic anoles, almost entirely because trade sanctions have isolated the island's human population.[337] The

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328. *See* Elizabeth Kolbert, *Enter the Anthropocene: Age of Man*, NAT'L GEOGRAPHIC, Mar. 2011, at 60.

329. *See, e.g.*, JANE B. REECE, LISA A. URRY, MICHAEL L. CAIN, STEVEN A. WASSERMAN, PETER V. MINORSKY & ROBERT B. JACKSON, BIOLOGY 1204 (10th ed. 2014) (defining an ecological footprint as a method for estimating the aggregate land and water area appropriated for human consumption, including waste disposal); Jeroen C.J.M. van den Bergh & Harmen Verbruggen, *Spatial Sustainability, Trade and Indicators: An Evaluation of the 'Ecological Footprint*,*'* 29 ECOLOGICAL ECON. 61 (1999). *See generally* MATHIS WACKERNAGEL & WILLIAM E. REES, OUR ECOLOGICAL FOOTPRINT: REDUCING HUMAN IMPACT ON THE EARTH (1996).

330. *See generally* Geoffrey Heal, *Reflections—Defining and Measuring Sustainability*, 6 REV. ENVTL. ECON. & POL'Y 147 (2012). A competing (and notably weaker) sustainability criterion based on reinvestment of scarcity rents to maintain a perpetual level of consumption traces its origins to John M. Hartwick, *Intergenerational Equity and the Investing of Rents from Exhaustible Resources*, 67 AM. ECON. REV. 972 (1977).

331. WILSON, *supra* note 6, at 272.

332. *See* Peter M. Vitousek, Paul R, Ehrlich, Anne H. Ehrlich & Pamela A. Matson, *Human Appropriation of the Products of Photosynthesis*, 36 BIOSCIENCE 368, 372 (1986).

333. *See* Sandra L. Postel, Gretchen C. Daily & Paul R. Ehrlich, *Human Appropriation of Renewable Fresh Water*, 271 SCIENCE 785, 787 (1996).

334. William E. Rees, *A Blot on the Land*, 421 NATURE 898, 898 (2003) (summarizing WORLD WILDLIFE FUND, LIVING PLANET REPORT 2002, at 4 (Jonathan Loh ed., 2002)).

335. *See* sources cited *supra* note 134, 138, and 139.

336. *See* Helmus et al., *supra* note 138.

337. *See id. See generally* D. Luke Mahler, Liam J. Revell, Richard E. Glor & Jonathan B. Losos, *Ecological Opportunity and the Rate of Morphological Evolution in the Diversification of Greater Antillean Anoles*, 64 EVOLUTION 2731 (2010); Steven Poe, *Comparison of Natural and Nonnative Two-Species Communities of* Anolis *Lizards*, 184 AM. NATURALIST 132 (2014).

renormalization of economic relations between Cuba and the United States thus bodes ill for biodiversity in an ecologically sensitive region.[338] Peace among nations, alas, accelerates the anthropogenic vectors of biodiversity loss. In retrospect, Anthropocene revisions in island biogeography may explain weaknesses in the equilibrium theory underlying the traditional species-area relationship.[339]

Beyond the specific context of island biogeography, humanity's alteration of ecology to suit its own needs and tastes has triggered multiple *regime shifts* in terrestrial and aquatic environments.[340] If complex adaptive ecosystems are to regain their capacity to deliver services that humans prize, human institutions such as the law must work to sustain surviving ecosystems and to transform degraded ecosystems.[341] Community-level responses to radical changes such as global warming and ocean acidification may affect different trophic levels of the ecological pyramid, including simple organisms whose extinction could trigger the collapse of entire ecosystems.[342] Ecology, after all, involves the interaction of individuals, populations, and communities.[343] There is no time to waste. Especially as measured by sensitive measures such as vertebrates,[344] coral reefs,[345] and tropical forests,[346] the damage may be truly incommensurable.

In the sweep of geological time, humanity itself is the mass extinction event. Through natural history, most mass extinction events have been attributed to

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338. *See generally* Franz Essl, Marten Winter & Petr Pyšek, *Trade Threat Could Be Even More Dire*, 487 NATURE 39 (2012).

339. *See, e.g.*, F.S. Gilbert, *The Equilibrium Theory of Island Biogeography: Fact or Fiction?*, 7 J. BIOGEOGRAPHY 209 (1980); B.L. Zimmerman & R.O. Bierregaard, *Relevance of the Equilibrium Theory of Island Biogeography and Species-Area Relations to Conservation with a Case for Amazonia*, 13 J. BIOGEOGRAPHY 133 (1986).

340. *See* Carl Folke, Steve Carpenter, Brian Walker, Marten Scheffer, Thomas Elmqvist, Lance Gunderson & C.S. Holling, *Regime Shifts, Resilience, and Biodiversity in Ecosystem Management*, 35 ANN. REV. ECOLOGY EVOLUTION & SYSTEMATICS 557 (2004).

341. *See id.*

342. *See* Ivan Nagelkerken & Philip L. Munday, *Animal Behaviour Shapes the Ecological Effects of Ocean Acidification and Warming: Moving from Individual to Community-Level Responses*, 22 GLOBAL CHANGE BIOLOGY 974 (2016).

343. *See generally* MICHAEL BEGON, JOHN L. HARPER & COLIN R. TOWNSEND, ECOLOGY: INDIVIDUALS, POPULATIONS AND COMMUNITIES (3d ed. 1996).

344. *See* Ben Collen, Jonathan Loh, Sarah Whitmee, Louise McRae, Rajan Amin & Jonathan E. M. Baillie, *Monitoring Change in Vertebrate Abundance: The Living Planet Index*, 23 CONSERVATION BIOLOGY 317 (2009).

345. *See* Stéphanie D'agata, David Mouillot, Michel Kulbicki, Serge Andréfouët, David R. Bellwood, Joshua E. Cinner, Peter F. Cowman, Mecki Kronen, Silvia Pinca & Laurent Vigliola, *Human-Mediated Loss of Phylogenetic and Functional Diversity in Coral Reef Fishes*, 24 CURRENT BIOLOGY 555 (2014); Blake Armstrong, Note, *Maintaining the World's Marine Biodiversity: Using the Endangered Species Act To Stop the Climate Change Induced Loss of Coral Reefs*, 18 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 429 (2012).

346. *See* Matthew C. Hansen et al., *Humid Tropical Forest Clearing from 2000 to 2005 Quantified by Using Multitemporal and Multiresolution Remotely Sensed Data*, 105 PROC. NAT'L ACAD. SCI. 9439 (2008).

extraterrestrial causes,[347] or at least abiotic factors such as mass volcanism[348] or sea-level change.[349] Only twice before the present have life forms been blamed for inducing a mass extinction. First, cyanobacteria converted the anoxic pre-Cambrian atmosphere by producing so much oxygen that they irrevocably poisoned the atmosphere for obligate anaerobes.[350] Second, terrestrial plants may have triggered global cooling during the late Devonian period.[351] We may be witnessing the first geological episode in nearly 400 million years—or perhaps even 2.2 billion years—in which the rampant success of one form of life has doomed many unrelated species.

Geologic history offers humanity the thinnest glimmer of a future. Though "there is little positive to be said about extinction," modest hope lies in the realization that "present-day extinctions have not yet achieved the intensities seen in the Big Five mass extinctions of the geologic past, which each removed ≥50% of the subset of relatively abundant marine invertebrate genera."[352] On the other hand, most "[o]f the

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347. *See, e.g.*, L.W. Alvarez, Walter Alvarez, Frank Asaro & Helen V. Michel, *Extraterrestrial Cause for the Cretaceous-Tertiary Extinction*, 208 SCIENCE 1095 (1980); Asish R. Basu, Michail I. Petaev, Robert J. Poreda, Stein B. Jacobsen & Luann Becker, *Chondritic Meteorite Fragments Associated with the Permian-Triassic Boundary in Antarctica*, 302 SCIENCE 1388 (2003); Luann Becker, Robert J. Poreda, Andrew G. Hunt, Theodore E. Bunch & Michael Rampino, *Impact Event at the Permian-Triassic Boundary: Evidence from Extraterrestrial Noble Gases in Fullerenes*, 291 SCIENCE 1530 (2001); P.E. Olsen, D.V. Kent, H.-D. Sues, C. Koeberl, H. Huber, A. Montanari, E.C. Rainforth, S.J. Fowell, M.J. Szajna & B.W. Hartline, *Ascent of Dinosaurs Linked to an Iridium Anomaly at the Triassic-Jurassic Boundary*, 296 SCIENCE 1305 (2002); *cf.* A.L. Melott, B.S. Lieberman, C.M. Laird, L.D. Martin, M.V. Medvedev, B.C. Thomas, J.K. Cannizzo, N. Gehrels & C.H. Jackman, *Did a Gamma-Ray Burst Initiate the Late Ordovician Mass Extinction?*, 3 INT'L J. ASTROBIOLOGY 55 (2004).

348. *See, e.g.*, I.H. Campbell, G.K. Czamanske, V.A. Fedorenko, R.I. Hill & V. Stepanov, *Synchronism of Siberian Traps and the Permian-Triassic Boundary*, 258 SCIENCE 1760 (1992); Richard E. Ernst & Nasrrddine Youbi, *How Large Igneous Provinces Affect Global Climate, Sometimes Cause Mass Extinctions, and Represent Natural Markers in the Geological Record*, 478 PALAEOGEOGRAPHY PALAEOCLIMATOLOGY & PALAEOECOLOGY 30 (2017); Paul R. Renne, Zhang Zichao, Mark A. Richards, Michael T. Black & Asis R. Basu, *Synchrony and Causal Relations Between Permian-Triassic Boundary Crises and Siberian Flood Volcanism*, 269 SCIENCE 1413 (1995). *But cf.* P.B. Wignall, *Large Igneous Provinces and Mass Extinctions*, 53 EARTH-SCI. REVIEWS 1 (2001) (disputing the general correlation between volcanic activity and mass extinctions).

349. *See, e.g.*, Norman D. Newell, *Revolutions in the History of Life*, *in* UNIFORMITY AND SIMPLICITY: A SYMPOSIUM ON THE PRINCIPLE OF THE UNIFORMITY OF NATURE 63 (Claude C. Albritton, Jr., ed., 1967); J.W. Valentine & E.M. Moores, *Plate-Tectonic Regulation of Faunal Diversity and Sea Level: A Model*, 228 NATURE 657 (1970).

350. *See* James F. Kasting & Janet L. Siefert, *Life and the Evolution of Earth's Atmosphere*, 296 SCIENCE 1066 (2002).

351. *See, e.g.*, GEORGE R. MCGHEE, JR., THE LATE DEVONIAN MASS EXTINCTION: THE FRASNIAN/FAMENNIAN CRISIS (1996); Thomas J. Algeo & Stephen E. Scheckler, *Terrestrial-Marine Teleconnections in the Devonian: Links Between the Evolution of Land Plants, Weathering Processes, and Marine Anoxic Events*, 353 PHILOSOPHICAL TRANSACTIONS BIOLOGICAL SCI. 113 (1998).

352. David Jablonski, *Lessons from the Past: Evolutionary Impacts of Mass Extinctions*, 98 PROC. NAT'L ACAD. SCI. 5393, 5393 (2001).

major and minor extinctions" of the past half billion years "are associated with global warming" and its negative effects, such as marine anoxia and ocean acidification.[353] "The atmosphere is the obvious linkage between" the marine and terrestrial "biospheres, and . . . atmospheric drivers of extinction . . . may hold the key to catastrophes of global scale."[354] Whatever the proper antecedents in geological history, if any,[355] we are "in the midst of one of the largest experiments in the history of the Earth."[356]

At an absolute minimum, humanity should combat biodiversity loss and climate change out of crass self-interest. As biodiversity destruction, climate change, and other catastrophes "propagat[e] . . . perturbations through one or more trophic levels in an ecosystem," organisms seemingly remote from danger become, in fact, seriously imperiled.[357] In the killing fields of the Anthropocene, "[h]umans are among the most severely affected species."[358] Mortality is "the fatal flaw . . . which Nature, in one shape or another, stamps ineffaceably on all her productions, either to imply that they are temporary and finite, or that their [survival] must be wrought by toil and pain."[359]

Human domination of global ecosystems and their physical energy flows carries no inherent assurance that it will continue. Humanity's "transient domination" neither arises from "intrinsic superiority" nor guarantees "extended survival."[360] Panthalassa (*πανθάλασσα*—"universal sea"), which once designated the all-encom passing ocean that spanned the Permian extinction and the dawn of the Triassic,[361]

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353. David P.G. Bond & Stephen E. Grasby, *On the Causes of Mass Extinctions*, 478 PALAEOGEOGRAPHY PALAEOCLIMATOLOGY & PALAEOECOLOGY 3, 21 (2017). *See generally* Matthew E. Clapham & Jonathan L. Payne, *Acidification, Anoxia and Extinction: A Multiple Logistic Regression Analysis of Extinction Selectivity During the Middle and Late Permian*, 39 GEOLOGY 1059 (2011).

354. Bond & Grasby, *supra* note 353, at 4.

355. *Cf.* Douglas Fox, *Back to the No-Analog Future?*, 316 SCIENCE 823, 824 (2007) (recognizing that climate change and other ecological disruptions "are likely to resuhuffle[]" biological communities "into novel ecosystems unknown today").

356. Chapin et al., *supra* note 105, at 241.

357. John Terborgh, *The Big Things That Run the World—A Sequel to E.O. Wilson*, 2 CONSERVATION BIOLOGY 402, 402 (1988).

358. Redford, *supra* note 132, at 421.

359. NATHANIEL HAWTHORNE, *The Birthmark*, *in* THE COMPLETE SHORT STORIES OF NATHANIEL HAWTHORNE 227, 228 (1959).

360. STEPHEN JAY GOULD, FULL HOUSE: THE SPREAD OF EXCELLENCE FROM PLATO TO DARWIN 73 (1996); *see also id.* at 19–21 (arguing that diversity in life forms, not complexity as such, is the true hallmark of evolutionary success).

361. *See generally* JON ERICKSON, MARINE GEOLOGY: EXPLORING THE NEW FRONTIERS OF THE OCEAN 21–22 (rev. ed. 2003); Carmen Arias, *Palaeoceanography and Biogeography in the Early Jurassic Panthalassa and Tethys Oceans*, 14 GONDWANA RES. 306 (2008); Masaki Musashi, Yukio Isozaki, Toshio Koike & Rob Kreulen, *Stable Carbon Isotope Signature in Mid-Panthalassa Shallow-Water Carbonates Across the Permo-Triassic Boundary: Evidence for C-Depleted Superocean*, 191 EARTH & PLANETARY SCI. LETTERS 9 (2001); D.G. van der Meer, T.H. Torsvik, W. Spakman, D.J.J. Van Hinsbergen & M.L. Amaru, *Intra-Panthalassa Ocean Subduction Zones Revealed by Fossil Arcs and Mantle Structure*, 5 NATURE GEOSCIENCE 215 (2012). On the end-Permian event, the deadliest mass extinction in geological history, see Seth

may describe a future earth whose ice caps have melted.[362] "When the last of earth left to discover / Is that which was the beginning / . . . Not known, because not looked for / But heard, half-heard, in the stillness / Between two waves of the sea."[363]

On the geological time scales by which evolution and earth science operate, nearly all species become extinct. Of the "five to fifty billion species [that] have existed at one time or another," roughly "one in a thousand" still exists—"a truly lousy survival record" based upon "99.9 percent failure."[364] Indeed, careful evaluation of the Raup-Seposki "kill curve," a histogram of biological extinctions over the 600 million years of multicellular life,[365] "suggest[s] that there might be a maximum lifespan of about 350 million[] years" for any species.[366] In stark contrast with the vulgar and misleading depiction of evolution as "survival of the fittest,"[367] "extinction through bad luck" represents a crucial "element [of] the evolutionary process."[368] Biologically speaking, dominance today can dissolve into extinction tomorrow.[369] "[T]he race is not to the swift, nor the battle to the strong . . . but time and chance happeneth to them all."[370]

D. Burgess, Samuel Bowring & Shu-zhong Shen, *High-Precision Timeline for Earth's Most Severe Extinction*, 111 PROC. NAT'L ACAD. SCI. 3316 (2014).

362. *See* Aslak Grinsted, J.C. Moore & S. Jevrejeva, *Reconstructing Seal Level from Paleo and Projected Temperatures 200 to 2100 AD*, 34 CLIMATE DYNAMICS 461, 470 (2010) (projecting as much as a 2-meter rise in sea level by the end of the 21st century); W.T. Pfeffer, J.T. Harper & S. O'Neel, *Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise*, 321 SCIENCE 1340 (2008) (projecting 21st century sea-level rises from 0.8 to 2.0 meters).

363. T.S. ELIOT, *Four Quartets*, *in* COLLECTED POEMS 1909–1962, *supra* note 61, at 173, 208–09.

364. DAVID M. RAUP, EXTINCTION: BAD GENES OR BAD LUCK? 3–4 (1991) (emphasis omitted); *cf.* JOHN MAYNARD KEYNES, TRACT ON MONETARY REFORM 80 (1923) ("In the long run we are all dead.") (emphasis omitted).

365. *See* David M. Raup & J. John Sepkoski, Jr., *Periodic Extinction of Families and Genera*, 231 SCIENCE 833 (1986); David M. Raup & J. John Sepkoski, Jr., *Periodicity of Extinctions in the Geologic Past*, 81 PROC. NAT'L ACAD. SCI. 801 (1984).

366. J. Laherrère & D. Sornette, *Stretched Exponential Distributions in Nature and Economy: "Fat Tails" with Characteristic Scales*, 2 EUR. PHYSICAL J. B 525, 534 (1998).

367. *See, e.g.*, 1 HERBERT SPENCER, THE PRINCIPLES OF BIOLOGY 457 (1897); Herbert Spencer, *A Theory of Population, Deduced from the General Law of Animal Fertility*, 57 WESTMINSTER REV. 468, 499–500 (1852); *cf.* JULIAN HUXLEY, EVOLUTION: THE MODERN SYNTHESIS 564–65 (1942) (characterizing so-called "progress" in evolution as "increased control over and independence of the environment"). The literature on the misguided application of evolutionary principles in the social sciences is enormous. Two good starting points include STEPHEN JAY GOULD, THE MISMEASURE OF MAN (rev. ed. 1981) and RICHARD HOFSTADTER, SOCIAL DARWINISM IN AMERICAN THOUGHT (Beacon Press 1992) (1944).

368. RAUP, *supra* note 364, at 192.

369. *See* David Tilman, Robert M. May, Clarence L. Lehman & Martin A. Nowak, *Habitat Destruction and the Extinction Debt*, 371 NATURE 65 (1994) (describing how dominant species actually face a higher risk of extinction in the wake of habitat destruction because they have invested more in competition on a geographically circumscribed scale relative to colonization of a broader range).

370. *Ecclesiastes* 9:11 (King James).

B. An Environmental Ethos Intended To Endure for Ages To Come

Ecological and evolutionary science delivers a compelling case for legal intervention. What these environmental crises need from law is twofold—not only the mechanical tools for addressing specific vectors of biodiversity loss and anthropogenic drivers of climate change, but also abiding commitments to environmental preservation and sustainable development within fundamental law. If the law would fulfill its environmental schemes, it must first inspire environmental dreams. The environmental philosophies underlying law today are at once both obsolete and insufficiently respectful of natural history and human tradition. "A sustainable world will require an ethic that is ultimately as incorporated into culture and as long lasting as a constitutional bill of rights or as religious commandments."[371]

"For every constitution there is an epic, for each decalogue a scripture."[372] In contemporary secular society, fundamental legal charters represent "sacred symbol[s] of nationhood as well as . . . profane instrument[s] of government."[373] At the level of public international law, the Rio Declaration on Environment and Development has proclaimed that "[t]he right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations."[374] Many nations around the world enshrine a similar commitment to sustainability in their constitutions.[375]

Even more so than its constitutional counterpart, however, American environmental law prefers to play on its own turf.[376] The mere fact that occasional citations to foreign law divide the Supreme Court[377] suggests that the United States, at least in

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371. Tilman, *supra* note 22, at 211.

372. Robert M. Cover, *The Supreme Court, 1982 Term—Foreword:* Nomos *and Narrative*, 97 HARV. L. REV. 4, 4 (1983).

373. Thomas C. Grey, *The Constitution as Scripture*, 37 STAN. L. REV. 1, 17 (1984).

374. U.N. Conference on Environment and Development, *Rio Declaration on Environment and Development*, princ. 3, U.N. Doc. A/CONF.151/5/Rev.1 (June 13, 1992).

375. *See, e.g.*, § 41, CONSTITUTIÓN NACIONAL [CONST. NAC.] (Arg.) (granting "[a]ll inhabitants . . . the right to a healthful and balanced environment fit for human development in order that productive activities shall meet present needs without endangering those of future generations"); INDIA CONST. art. 48A (promising "to protect and improve the environment and to safeguard the forests and wild life of the country"); KONSTYTUCJA RZECZYPOSPOLITEJ POLSKIEJ [CONSTITUTION] art. 74(1)–(3), DZIENNIK USTAW [Journal of Laws], Item No. 483 (no. 78, 1997) (Pol.) (committing "[p]ublic authorities [to] pursue policies ensuring the ecological security of current and future generations" and granting citizens "the right to be informed of the quality of the environment and its protection").

376. *See generally, e.g.*, JAMES GUSTAVE SPETH, RED SKY AT MORNING: AMERICA AND THE CRISIS OF THE GLOBAL ENVIRONMENT (2004); Freeman & Guzman, *supra* note 13; Richard J. Lazarus, *A Different Kind of "Republican Moment" in Environmental Law*, 87 MINN. L. REV. 999 (2003).

377. *See, e.g.*, Roper v. Simmons, 543 U.S. 551, 575–78 (2005); Lawrence v. Texas, 539 U.S. 558, 573 (2003); Atkins v. Virginia, 536 U.S. 304, 316 n.21 (2002); Thompson v. Oklahoma, 487 U.S. 815, 830 (1988). *See generally, e.g.*, Daniel A. Farber, *The Supreme Court, the Law of Nations, and Citations of Foreign Law: The Lessons of History*, 95 CAL. L. REV. 1335 (2007); Vicki C. Jackson, *The Supreme Court, 2004 Term—Comment: Constitutional Comparisons: Convergence, Resistance, Engagement*, 119 HARV. L. REV. 109 (2005); Mark

the first instance, might draw environmental inspiration from its own laws. The Constitution "provide[s] the scripture of a national civil religion."[378] The preamble to the Constitution speaks of acts that are "sacred as well as secular in character and authority, for we know that ministers are 'ordained' and that churches as well as constitutions are 'established.'"[379] Constitutions, religious creeds, and rules of environmental engagement adhere to at least one shared creed: they are all "intended to endure for ages to come, and, consequently, to be adapted to the various crises of human affairs."[380]

Infusing American law with an environmental ethos is no trivial task. Despite its characterization as a "covenant running from" generation to generation,[381] the Constitution of the United States makes no explicit pledge to protect the environment. American law nevertheless enjoys other means to secure special legal status for environmental protection.[382] Enshrining a quasi-constitutional environmental ethos akin to Aldo Leopold's "land ethic"[383] or Arne Naess's "deep ecology"[384] requires the less direct, but more creative, use of tools at the law's disposal.

The balance of this Article addresses four possibilities. First, judges and other decision makers could take more direct account of advances in environmental science in wielding substantive tools directed at biodiversity loss and climate change. Second, NEPA may serve as a quasi-constitutional charter for environmental decision making. Third, even without concrete legal tools, policy makers may pursue more modest and pragmatic goals to protect biodiversity and mitigate climate change. Finally, failing all else, law should embrace appeals to the aesthetics and morality of environmental protection.

C. Environmental Protection on the Last Promontory of the Centuries

1. Revitalizing Environmental Law

Parts II and III of this Article have shown how the law has failed to keep pace with scientific understandings of biodiversity loss and climate change. Effective environmental protection demands "learning strategies" that not only withstand a "high degree of uncertainty" but also absorb "our rapidly evolving understanding" of the

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Tushnet, *When Is Knowing Less Better than Knowing More? Unpacking the Controversy over Supreme Court Reference to Non-U.S. Law*, 90 MINN. L. REV. 1275 (2006).

378. Grey, *supra* note 373, at 17.

379. JAMES BOYD WHITE, WHEN WORDS LOSE THEIR MEANING: CONSTITUTIONS AND RECONSTITUTIONS OF LANGUAGE, CHARACTER, AND COMMUNITY 240 (1984).

380. McCulloch v. Maryland, 17 U.S. (4 Wheat.) 316, 415 (1819) (Marshall, C.J.) (emphasis omitted).

381. Planned Parenthood of Se. Pa. v. Casey, 505 U.S. 833, 901 (1992).

382. *See generally* Holly Doremus, *Constitutive Law and Environmental Policy*, 22 STAN. ENVTL. L.J. 295 (2003) (describing the formation of law with ambitious future-regarding effects outside the drafting of constitutions and similar organic documents).

383. *See* LEOPOLD, *supra* note 60, at 201–26.

384. *See* ARNE NAESS, ECOLOGY, COMMUNITY AND LIFESTYLE: OUTLINE OF AN ECOSOPHY (David Rothenberg trans., 1989); Arne Naess, *The Shallow and the Deep, Long-Range Ecological Movement. A Summary*, 16 INQUIRY 95 (1973).

environmental sciences.[385] Advances in the field of conservation biology have had little or no legal impact. Federal courts routinely decline to treat innovations in conservation biology as "a necessary element of diversity analysis."[386]

Illustrations of judicial failure abound. In a case assaulting the government's failure to consider "population dynamics, species turnover, patch size, recolonization problems, fragmentation problems, edge effects, and island biogeography,"[387] the Seventh Circuit ultimately held that these concepts of conservation biology were "uncertain in application" and that the Forest Service could therefore ignore them in managing national forests.[388] Even a valid "general theory," the court held, "does not translate into a management tool unless one can apply it to a concrete situation."[389]

A federal district court similarly declined to endorse specific techniques for managing "distinct geographic ecosystems . . . inhabited by grizzly bears."[390] That court seemed to treat complexity as a legal excuse in its own right. The possibility that "science or circumstances could . . . change[]," the court reasoned, relieved the agency of any obligation to prepare an "exhaustively detailed recovery plan."[391] As a result, the court rejected a claim that the Endangered Species Act required "linkage zones" between ecosystems inhabited by grizzlies.[392]

Cases of this nature suggest that conservation biology, until further notice, will not govern American environmental law until federal land management agencies and the Services, charged with implementing the Endangered Species Act, decide that it does. In the meanwhile, federal judges take frequent refuge in the maxim that "a reviewing court must generally be at its most deferential" when an agency "is making predictions, within its area of special expertise, at the frontiers of science."[393] Administrative and judicial passivity bode ill for biodiversity conservation. The failure to coordinate the law with scientific knowledge threatens to consign yet another environmental crisis requiring transnational cooperation to the perdition of zero-sum politics.[394]

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385. Daniel A. Farber, *Environmental Protection as a Learning Experience*, 27 LOY. L.A. L. REV. 791, 806 (1994).

386. Sierra Club v. Marita, 46 F.3d 606, 620 (7th Cir. 1995).

387. *Id.* at 618.

388. *Id.* at 621.

389. *Id.* at 623.

390. Fund for Animals v. Babbitt, 903 F. Supp. 96, 106 (D.D.C. 1995).

391. *Id.* at 107.

392. *Id.* at 109–10.

393. Balt. Gas & Elec. Co. v. Nat. Res. Def. Council, Inc., 462 U.S. 87, 103 (1983); *see also, e.g.*, Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 656 (1980) (plurality opinion); *id.* at 705–06 (Marshall, J., dissenting); Int'l Fabricare Inst. v. U.S. EPA, 972 F.2d 384, 389 (D.C. Cir. 1992) ("The rationale for deference is particularly strong when the [agency] is evaluating scientific data within its technical expertise."); Envtl. Def. Fund, Inc. v. Costle, 578 F.2d 337, 339 (D.C. Cir. 1978) ("[I]n an area characterized by scientific and technological uncertainty[,] . . . this court must proceed with particular caution, avoiding all temptation to direct the agency in a choice between rational alternatives."); All. for Bio-Integrity v. Shalala, 116 F. Supp. 2d 166, 177 (D.D.C. 2000).

394. *See generally* NEIL CARTER, THE POLITICS OF THE ENVIRONMENT: IDEAS, ACTIVISM, POLICY 249–61 (2d ed. 2007); MATTHEW PATERSON, GLOBAL WARMING AND GLOBAL POLITICS (1996); Peter Newell, *Who 'CoPed' Out in Kyoto? An Assessment of the Third Conference of the*

At least in controversies involving climate change, federal courts have lost patience with expert agencies' pleas that scientific uncertainty warrants further study before concrete action. As the Supreme Court noted in *Massachusetts v. EPA*,[395] its landmark case on climate change, no agency can "avoid its statutory obligation" to enforce federal environmental law "by noting the uncertainty surrounding various features of climate change and concluding that it would therefore be better not to regulate at this time."[396] Because the relevant "statutory question is whether sufficient information exists to make an endangerment finding," and not whether the agency "would prefer not to regulate greenhouse gases because of some residual uncertainty," an agency wishing to defer "a reasoned judgment as to whether greenhouse gases contribute to global warming" must explicitly declare that "the scientific uncertainty is so profound" as to paralyze the agency as a matter of law.[397]

By the same token, an agency that does proceed despite uncertainty will find ample judicial deference, especially where its statutory authority "is 'precautionary in nature' and 'designed to protect the public health,' and the relevant evidence is 'difficult to come by, uncertain, or conflicting because it is on the frontiers of scientific knowledge.'"[398] Reviewing courts remain painfully aware that they lack the "training [and] experience" that a "chemist, biologist or statistician" might apply to a controversy involving biodiversity and climate change.[399] The law often hesitates to apply science even though law itself constitutes "a formalized system for gathering and evaluating information about the world" through "observation, communication, informed criticism, and response."[400]

Our legal culture, alas, remains a domain whose leaders shamelessly proclaim their ignorance of the "fine details of molecular biology."[401] Courts run a dire risk of falling behind "the extraordinary rate of scientific and other technological advances that figure increasingly in litigation" and, for that matter, in daily life.[402] American

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Parties to the Framework Convention on Climate Change, 7 ENVTL. POL., no. 2, 1998, at 153; Peter Newell & Matthew Paterson, *A Climate for Business: Global Warming, the State and Capital*, 5 REV. INT'L POL. ECON. 679 (1998).

395. 549 U.S. 497 (2007).

396. *Id.* at 534.

397. *Id.*

398. Coal. for Responsible Regulation, Inc. v. EPA, 684 F.3d 102, 121 (D.C. Cir. 2012) (quoting Ethyl Corp. v. EPA, 541 F.2d 1, 28 (D.C. Cir.) (en banc)), *aff'd in part, rev'd in part sub nom.* Util. Air Regulatory Grp. v. EPA, 134 S. Ct. 2427 (2014).

399. *Ethyl*, 541 F.2d at 36.

400. Doremus, *supra* note 262, at 1057; *see also id.* ("Substantively, science is the body of knowledge produced by this process.").

401. Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 133 S. Ct. 2107, 2120 (2013) (Scalia, J., concurring in part and concurring in the judgment) ("I join the judgment of the Court, and all of its opinion except Part I–A and some portions of the rest of the opinion going into fine details of molecular biology. I am unable to affirm those details on my own knowledge or even my own belief."); *cf.* Lisa Milot, *Illuminating Innumeracy*, 63 CASE W. RES. L. REV. 769, 769 (2013) (acknowledging the "open secret that lawyers" (stereo)typically "don't like math"). *See generally* James Ming Chen, *Legal Quanta: A Mathematical Romance of Many Dimensions*, 2016 MICH. ST. L. REV. 313 (2016).

402. Jackson v. Pollion, 733 F.3d 786, 788 (7th Cir. 2013) (Posner, J.).

law labors under an "extraordinary condition . . . which makes it possible for [someone] without any knowledge of even the rudiments of chemistry to pass upon" scientifically or technologically sophisticated questions.[403]

More than most other areas of legal endeavor, environmental law "involves policy determinations in which the agency is acknowledged to have expertise."[404] After all, the "principal purpose" of limitations of judicial review is "to avoid judicial entanglement in abstract policy disagreements which courts lack both expertise and information to resolve."[405] But review of administrative decisions routinely requires judges to "acquire the learning pertinent to complex technical questions in such fields as economics, science, technology and psychology."[406] Judges "should not automatically succumb" to the "acknowledged expertise" of the agencies they review, "overwhelmed as it were by the utter 'scientificity'" of the regulatory process.[407] "Restraint, yes, abdication, no."[408]

2. NEPA As an Environmental Charter

Alongside the Endangered Species Act,[409] the National Environmental Policy Act[410] heads the list of environmental "super-statutes" whose "normative [and] institutional" impact approaches that of the Constitution itself.[411] When passed, these statutes heralded a revolutionary cycle of federal environmental statutes.[412]

Despite their faults, NEPA and the Endangered Species Act outperform constitutional law in protecting the interests of future generations.[413] NEPA expressly declares the federal government's "continuing policy . . . [to] fulfill the social, economic, and other requirements of present and future generations."[414] Furthermore, it

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403. Parke-Davis & Co. v. H.K. Mulford Co., 189 F. 95, 115 (S.D.N.Y. 1911) (Hand, J.).

404. Time Warner Entm't Co. v. FCC, 56 F.3d 151, 163 (D.C. Cir. 1995) (per curiam) (quoting United States v. FCC, 707 F.2d 610, 618 (D.C. Cir. 1983)); *accord* WorldCom, Inc. v. FCC, 238 F.3d 449, 458 (D.C. Cir. 2001).

405. Norton v. S. Utah Wilderness All., 542 U.S. 55, 66 (2004).

406. Ethyl Corp. v. EPA, 541 F.2d 1, 69 (D.C. Cir.) (en banc) (Leventhal, J., concurring); *cf.* Kassel v. Consol. Freightways Corp., 450 U.S. 662, 670 (1981) (plurality opinion) (expressing a willingness to invalidate "marginally" effective and "substantially" obtrusive state laws despite state officials' claimed expertise over regulations designed "to promote the public health or safety").

407. Essex Chem. Corp. v. Ruckelshaus, 486 F.2d 427, 434 (D.C. Cir. 1973).

408. *Ethyl*, 541 F.2d at 69 (Leventhal, J., concurring).

409. 16 U.S.C. §§ 1531–1544 (2012).

410. 42 U.S.C. §§ 4321–4370m-12 (2012).

411. William N. Eskridge, Jr. & John Ferejohn, *Super-Statutes*, 50 DUKE L.J. 1215, 1216, 1242–46 (2001) (describing NEPA as a "super-statute").

412. *See generally, e.g.*, COUNCIL ON ENVTL. QUALITY, ENVIRONMENTAL QUALITY: 20TH ANNUAL REPORT (1990); Jerry L. Anderson, *The Environmental Revolution at Twenty-Five*, 26 RUTGERS L.J. 395 (1995).

413. *See generally* Daniel A. Farber, *Is the Supreme Court Irrelevant? Reflections on the Judicial Role in Environmental Law*, 81 MINN. L. REV. 547 (1997) (cataloguing the Supreme Court's failure to resolve critical questions under NEPA).

414. 42 U.S.C. § 4331(a).

describes "the responsibilities of each generation as trustee of the environment for succeeding generations."[415] NEPA thus represents the American expression of a principle that many other nations proclaim (and protect) through constitutional law.[416] No system of environmental ethics can command normative respect unless it preserves the interests of future generations.[417]

Severe limitations hamper NEPA's power as an environmental charter. The Supreme Court has barred the use of NEPA to review agency decisions on the merits. "NEPA itself does not mandate particular results, but simply prescribes the necessary process."[418] Indeed, a crippled NEPA has come to exemplify "soft look" review in administrative law.[419] The Court's admonitions that federal agencies should take a nominally "hard look" at the environmental consequences of their decisions[420] in practice "mandat[e]" little "more than the physical act of passing certain folders and papers [among] . . . reviewing officials" and thereby threaten to "make a mockery of the Act."[421]

Although NEPA is best known as a source of "procedural requirements . . . analogous" to those of the Endangered Species Act,[422] one of its critical provisions does establish an interpretive principle that could be treated as a substantive "green" canon. "Congress authorizes and directs that, to the fullest extent possible . . . the

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415. *Id.* § 4331(b)(1).

416. *See* sources cited *supra* note 375.

417. *See generally, e.g.*, DONALD EDWARD DAVIS, ECOPHILOSOPHY: A FIELD GUIDE TO THE LITERATURE (1989); RODERICK FRAZIER NASH, THE RIGHTS OF NATURE: A HISTORY OF ENVIRONMENTAL ETHICS (1989); EDITH BROWN WEISS, IN FAIRNESS TO FUTURE GENERATIONS: INTERNATIONAL LAW, COMMON PATRIMONY, AND INTERGENERATIONAL EQUITY (1989); Annette Baier, *For the Sake of Future Generations*, *in* EARTHBOUND: NEW INTRODUCTORY ESSAYS IN ENVIRONMENTAL ETHICS 214 (Tom Regan ed., 1984); Dan M. Berkovitz, *Pariahs and Prophets: Nuclear Energy, Global Warming, and Intergenerational Justice*, 17 COLUM. J. ENVTL. L. 245 (1992); Daniel A. Farber & Paul A. Hemmersbaugh, *The Shadow of the Future: Discount Rates, Later Generations, and the Environment*, 46 VAND. L. REV. 267 (1993); Lawrence B. Solum, *To Our Children's Children's Children: The Problems of Intergenerational Ethics*, 35 LOY. L.A. L. REV. 163 (2001); Edith Brown Weiss, *Agora: What Obligation Does Our Generation Owe to the Next? An Approach to Global Environmental Responsibility*, 84 AM. J. INT'L L. 190 (1990); Edith Brown Weiss, *The Planetary Trust: Conservation and Intergenerational Equity*, 11 ECOLOGY L.Q. 495 (1984).

418. Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 350 (1989); *accord* Morongo Band of Mission Indians v. Fed. Aviation Admin., 161 F.3d 569, 575 (9th Cir. 1998) ("NEPA exists to ensure a process, not a result."); *see also* Strycker's Bay Neighborhood Council, Inc. v. Karlen, 444 U.S. 223, 227–28 (1980) (per curiam); Vt. Yankee Nuclear Power Corp. v. Nat. Res. Def. Council, Inc., 435 U.S. 519, 558 (1978).

419. *See, e.g.*, Balt. Gas & Elec. Co. v. Nat. Res. Def. Council, Inc., 462 U.S. 87, 103 (1983). For a thoughtful look at NEPA's shortcomings and a proposal for improving its performance, see Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903 (2002).

420. *See, e.g.*, Marsh v. Or. Nat. Res. Council, 490 U.S. 360, 374, 376–77 (1989); Kleppe v. Sierra Club, 427 U.S. 390, 410 n.21 (1976).

421. Calvert Cliffs' Coordinating Comm., Inc. v. U.S. Atomic Energy Comm'n, 449 F.2d 1109, 1117 (D.C. Cir. 1971).

422. Thomas v. Peterson, 753 F.2d 754, 764 (9th Cir. 1985).

policies, regulations and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in" NEPA.[423] This language unambiguously requires the environmental laws of the United States to be interpreted and implemented so that they address all significant environmental risks, for the benefit of future generations as well as today's citizenry.[424]

If this provision of NEPA has any meaning, legal ambiguities should be resolved in favor of the environment, even when—and perhaps *especially* when—competing economic interests might support a different answer. This sort of substantive canon resembles the very familiar canon urging the interpretation of statutes so as not to raise doubts over the constitutionality of acts of Congress.[425] That interpretive canon in practice is a species of constitutional lawmaking.[426] NEPA's "green" canon has similar potential to serve as a significant source of substantive environmental principles.

Akin to section 7 of the Endangered Species Act,[427] NEPA frames the process by which the federal government considers the environmental impact of its major decisions. NEPA directs the federal government to consider not only the "relationship between local short-term uses of [the] environment and the maintenance and enhancement of long-term productivity," but also any "irreversible and irretrievable commitments of resources."[428] Environmental impact statements prepared under NEPA must consider "ecological" effects—namely, "effects on natural resources and

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423. 42 U.S.C. § 4332(1) (2012).

424. *See* DANIEL A. FARBER, ECO-PRAGMATISM: MAKING SENSIBLE ENVIRONMENTAL DECISIONS IN AN UNCERTAIN WORLD 126–27 (1999); Nicholas C. Yost, *NEPA's Promise—Partially Fulfilled*, 20 ENVTL. L. 533, 539–40 (1990).

425. *See, e.g.*, Edward J. DeBartolo Corp. v. Fla. Gulf Coast Bldg. & Constr. Trades Council, 485 U.S. 568, 575 (1988); NLRB v. Catholic Bishop of Chi., 440 U.S. 490, 499–501 (1979); Murray v. Schooner Charming Betsy, 6 U.S. (2 Cranch) 64, 118 (1804); *cf., e.g.*, Almendarez-Torres v. United States, 523 U.S. 224, 237–38 (1998) (asserting that courts ought to avoid interpreting the Constitution when some other basis for decision fairly presents itself); Spector Motor Serv., Inc. v. McLaughlin, 323 U.S. 101, 105 (1944) (same); Ashwander v. Tenn. Valley Auth., 297 U.S. 288, 347 (1936) (Brandeis, J., concurring) (same).

426. *See* William N. Eskridge, Jr. & Philip P. Frickey, *Quasi-Constitutional Law: Clear Statement Rules as Constitutional Lawmaking*, 45 VAND. L. REV. 593 (1992); William N. Eskridge, Jr. & Philip P. Frickey, *The Supreme Court, 1993 Term—Foreword: Law as Equilibrium*, 108 HARV. L. REV. 26, 81–87 (1994). For cases suggesting that the Supreme Court is aggressively transforming the constitutional avoidance canon into "a roving commission to construe all meaningful life out of regulatory statutes that offend a majority of Justices," Jim Chen, Filburn*'s Legacy*, 52 EMORY L.J. 1719, 1754 (2003), see Solid Waste Agency of N. Cook Cty. v. U.S. Army Corps of Eng'rs, 531 U.S. 159, 174 (2001) (invalidating the Corps's "Migratory Bird Rule" in order "to avoid the significant constitutional and federalism questions raised" by this interpretation of the term "navigable waters" within the Clean Water Act); Jones v. United States, 529 U.S. 848, 859 (2000) (holding that the federal arson statute "covers only property currently used in commerce or in an activity affecting commerce").

427. 16 U.S.C. § 1536 (2012).

428. 42 U.S.C. § 4332(2)(C)(iv), (v) (2012); *see also* 40 C.F.R. § 1502.16 (2016) (requiring consideration of the "irreversible and irretrievable commitments of resources" in an environmental impact statement's discussion of "environmental consequences").

on the components, structures, and functioning of . . . ecosystems" affected by major federal action.[429]

Perhaps NEPA's greatest accomplishment is its establishment of the principle that the federal government take no major action without first assessing the environmental impact of its decisions.[430] Today's international efforts to assess biodiversity, climate change, and other global environmental phenomena—perhaps the most vital scientific tools in humanity's struggle to forestall biological disaster[431]—have a predecessor in one of America's foundational environmental statutes.

3. Pragmatic Modesty

Even in the absence of aggressive legal intervention, "[t]hose of us who love nature, and who would like to ensure that nature persists for future generations to love, need to think about saving ordinary places and ordinary things."[432] Without abandoning the admittedly implausible prospect of comprehensively reconfiguring domestic and international environmental law to address climate change, habitat destruction, and alien invasive species, advocates of biodiversity conservation can pursue a more modest reform agenda.

First, international policymakers should develop a joint framework for the regulation of commercial bioprospecting. This idea may build upon two models in international environmental law. First, a bioprospecting annex to the existing Convention on Biological Diversity may aspire to the success of the Montreal Protocol on Substances That Deplete the Ozone Layer.[433] Routinely hailed as one of the most successful charters of international environmental law, the Montreal Protocol now contributes to the reduction of two greenhouse gases, hydrofluorocarbons and perfluorocarbons.[434] Second, given the general flow of commercially significant genotypes from the developing world to wealthier countries, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal[435] —which addresses traffic in hazardous wastes in the opposite direction, from rich

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429. 40 C.F.R. § 1508.8.

430. *See* 42 U.S.C. § 4332.

431. *See generally* Walter V. Reid, *Strategies for Conserving Biodiversity*, ENV'T, Sept. 1997, at 16 (assessing the impact of GLOBAL BIODIVERSITY ASSESSMENT, *supra* note 73, and the work of the Intergovernmental Panel on Climate Change).

432. Holly Doremus, *The Special Importance of Ordinary Places*, 23 ENVIRONS: ENVTL. L. & POL'Y J. 3, 4 (2000).

433. Montreal Protocol on Substances That Deplete the Ozone Layer, Sept. 16, 1987, 26 I.L.M. 1541.

434. *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE TECH. & ECONOMIC ASSESSMENT PANEL, SPECIAL REPORT: SAFEGUARDING THE OZONE LAYER AND THE GLOBAL CLIMATE SYSTEM: ISSUES RELATED TO HYDROFLUOROCARBONS AND PERFLUOROCARBONS (2005); Guus J.M. Velders, Stephen O. Anderson, John S. Daniel, David W. Fahey & Mark McFarland, *The Importance of the Montreal Protocol in Protecting Climate*, 104 PROC. NAT'L ACAD. SCI. 4814 (2007).

435. United Nations Environments Programme Conference of Plenipotentiaries on the Global Convention on the Control of Transboundary Movements of Hazardous Wastes: Final Act and Text of Basel Convention, Mar. 22, 1989, 28 I.L.M. 649.

countries to their developing counterparts—may provide useful guidance on the unavoidable, underlying questions of environmental justice.[436]

International coordination on commercial exploitation of biodiversity can improve the very process of collecting rare specimens. If even casual hiking affects the distribution and population of wildlife,[437] purposeful bioprospecting leaves a dramatically deeper footprint. Bioprospectors, anthropologists, or journalists may even engage in deliberate misconduct.[438] Even though the collapse of global fisheries has shaken public confidence in official efforts to achieve "sustainability,"[439] bitter experience teaches that the lack of coordination would be worse. The slash-and-collect approach of Victorian orchid harvesters would probably prevail.[440] Rationalized harvesting would limit instances of "the wonderfully unusual accomplishment of discovering and eradicating in the same instant a new species."[441]

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436. *See generally, e.g.*, Sejal Choksi, *The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal: 1999 Protocol on Liability and Compensation*, 28 ECOLOGY L.Q. 509 (2001); David P. Hackett, *An Assessment of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal*, 5 AM. U. J. INT'L L. & POL'Y 291 (1990); Katharina Kummer, *The International Regulation of Transboundary Traffic in Hazardous Wastes: The 1989 Basel Convention*, 41 INT'L & COMP. L.Q. 530 (1992).

437. *See* Francesca Ortiz, *Candidate Conservation Agreements as a Devolutionary Response to Extinction*, 33 GA. L. REV. 413, 508 (1999); *cf.* Mausolf v. Babbitt, 125 F.3d 661, 669–70 (8th Cir. 1997) (upholding snowmobiling restrictions in Voyageurs National Park on the basis of biological opinions that showed adverse impacts from snowmobiling on gray wolves). *See generally* David S. May, *Tourism and the Environment*, NAT. RES. & ENV'T, Summer 1999, at 57. Realizations of this sort have motivated the establishment of the National Wildlife Preservation System within the United States. *See* 16 U.S.C. § 1132 (2012).

438. *See* PATRICK TIERNEY, DARKNESS IN EL DORADO: HOW SCIENTISTS AND JOURNALISTS DEVASTATED THE AMAZON (2000).

439. *See, e.g.*, MICHAEL HARRIS, LAMENT FOR AN OCEAN: THE COLLAPSE OF THE ATLANTIC COD FISHERY (1998); CARL SAFINA, SONG FOR THE BLUE OCEAN: ENCOUNTERS ALONG THE WORLD'S COASTS AND BENEATH THE SEAS (1997); LISA SPEER, KAREN GARRISON, KYLE LONERGAN, ANN NOTTHOFF, WENDY PULLING, KERI POWELL, SARAH CHASIS & PAUL STOKSTAD, HOOK, LINE, AND SINKING: CRISIS IN MARINE FISHERIES (1997); Jonathan H. Adler & Nathaniel Stewart, *Learning How To Fish: Catch Shares and the Future of Fishery Conservation*, 31 UCLA J. ENVTL. L. & POL'Y 150 (2013); Scott Gordon, *Economics and the Conservation Question*, 1 J.L. & ECON. 110 (1958); H. Scott Gordon, *The Economic Theory of a Common Property Resource: The Fishery*, 62 J. POL. ECON. 124 (1954); Bob Holmes, *Biologists Sort the Lessons of the Fisheries Collapse*, 264 SCIENCE 1252 (1994); Donald Ludwig, Ray Hilborn & Carl Waters, *Uncertainty, Resource Exploitation, and Conservation: Lessons from History*, 260 SCIENCE 17 (1993); Alison Rieser, *Property Rights and Ecosystem Management in U.S. Fisheries: Contracting for the Commons?*, 24 ECOLOGY L.Q. 813 (1997); Anthony Scott, *The Fishery: The Objectives of Sole Ownership*, 63 J. POL. ECON. 116 (1955); Barton H. Thompson, Jr., *Tragically Difficult: The Obstacles to Governing the Commons*, 30 ENVTL. L. 241, 247–49 (2000).

440. *See* HAROLD KOOPOWITZ & HILARY KAYE, PLANT EXTINCTION: A GLOBAL CRISIS 199–205 (1983); SUSAN ORLEAN, THE ORCHID THIEF 62–67 (1998).

441. BILL BRYSON, A WALK IN THE WOODS: REDISCOVERING AMERICA ON THE APPALACHIAN TRAIL 92 (1998).

In addition, the international community should facilitate the professionalization of parataxonomy,[442] especially in the developing world. Millions of species await collection and classification by properly trained field biologists. Transnational cooperation can help translate ethnobiological knowledge into terms understood by the global scientific community. Translational science provides a social bridge between formally trained biologists and the populations closest to critically endangered, biodiverse habitats.[443]

Whatever the merits *vel non* of bioprospecting as a developmental strategy, the case for "codifying" traditional knowledge of all types is compelling.[444] No less than in the law of patents and other branches of intellectual property law, the ultimate legal goal with respect to traditional knowledge should be the preservation, transmission, and encouragement of human ingenuity.[445] Just as the enablement requirement ensures that a patent teaches practitioners of ordinary skill to duplicate an invention,[446] codification of traditional knowledge reflects the "ultimate goal" of patent law in more economically and legally complex societies: that of "bring[ing] new designs and technology into the public domain through disclosure."[447]

The economic impact of such scientific cooperation is simple, great, and immediate. "Scientific research," to put it bluntly, "generates jobs."[448] The science of systematics is so labor intensive that the task of classifying 10 million species would require 25,000 professional lifetimes.[449] Whether framed as cooperative bioprospecting or north-to-south technology transfer for the enrichment of parataxonomy, commercially oriented initiatives satisfy the Convention on Biological Diversity's exhortation that the international community should adopt "economically and socially sound measures . . . as incentives" to conserve biodiversity and to contribute to its sustainable development.[450] Integrating rural populations into scientific and commercial activities surrounding biodiversity conservation reflects the reality that "over a

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442. *See* CHRISTOPHER JOYCE, EARTHLY GOODS: MEDICINE-HUNTING IN THE RAINFOREST 118–21 (1994).

443. *See* David D. Briske, *Translational Science Partnerships: Key to Environmental Stewardship*, 62 BIOSCIENCE 449 (2012); Deborah M. Brosnan & Martha J. Groom, *The Integration of Conservation Science and Policy*, *in* PRINCIPLES OF CONSERVATION BIOLOGY 625 (Martha J Groom, Gary K. Meffe & C. Ronald Carroll eds., 3d ed. 2006).

444. *See* Aman K. Gebru, *International Intellectual Property Law and the Protection of Traditional Knowledge: From Cultural Conservation to Knowledge Codification*, 15 ASPER REV. INT'L BUS. & TRADE L. 293 (2015).

445. *See* Jim Chen, *The Parable of the Seeds: Interpreting the Plant Variety Protection Act in Furtherance of Innovation Policy*, 81 NOTRE DAME L. REV. 105, 112–21 (2005) (proposing to protect this interest, in American law, through a substantive canon of statutory interpretation drawn from U.S. CONST. art. I, § 8, cl. 8).

446. *See* 35 U.S.C. § 112(a) (2012); Minerals Separation, Ltd. v. Hyde, 242 U.S. 261, 270 (1916); Vas-Cath, Inc. v. Mahurkar, 935 F.2d 1555, 1563 (Fed. Cir. 1991); *In re* Wands, 858 F.2d 731, 737 (Fed. Cir. 1988); Hybritech, Inc. v. Monoclonal Antibodies, Inc., 802 F.2d 1367, 1384 (Fed. Cir. 1986).

447. Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 151 (1989).

448. Gibbs v. Babbitt, 214 F.3d 483, 494 (4th Cir. 2000).

449. *See* WILSON, *supra* note 6, at 317–19.

450. CBD, *supra* note 128, art. 11.

billion rural people," many of them abjectly poor, "are dependent for some part of their livelihood on the use and trade of wild resources."[451]

The willingness to pursue a more modest agenda, however, does not weaken the need for more aggressive conservation measures. *In situ* preservation remains the only effective way to save biodiversity. Consistent with the precepts of island biogeography, the larger the tract of land set aside for conservation, the better.[452] Zoos, gene banks, and other *ex situ* strategies fall far short of the mark.[453] Despite consuming a significant portion of the capital expended on conservation, *ex situ* efforts have protected a trivial amount of biodiversity.[454] *Ex situ* conservation cannot preserve the adaptive and evolutionary value of individual species, let alone entire ecosystems.[455]

Moreover, by introducing criteria designed to suit human tastes and preferences, *ex situ* preservation exerts selective pressure on those species that are targeted for protection.[456] Only *in situ* conservation can effectively preserve the "conditions where genetic resources exist with ecosystems and natural habitats," or at least the surroundings where "domesticated or cultivated species . . . have developed their distinctive properties."[457] Finding viable biomes, especially those that have no historical or current equivalent, for those imperiled species that might flourish in the ecosystems of the future will assume utmost urgency.[458]

Finally, the academic community bears a singularly immense responsibility to educate the public. America's wealth belies a crippling lack of political will and scientific sophistication. A country whose citizens lead the developed world in rejecting evolutionary biology[459] is ill equipped to reorient the primary focus of biodiversity

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451. Rosie Cooney & Max Abensperg-Traun, *Raising Local Community Voices: CITES, Livelihoods and Sustainable Use*, 22 REV. EUR. COMMUNITY & INT'L ENVTL. L. 301, 301 (2013).

452. *See* Karkkainen, *supra* note 33, at 10–12.

453. *See* Holly Doremus, *The Rhetoric and Reality of Nature Protection: Toward a New Discourse*, 57 WASH. & LEE L. REV. 11, 54–57 (2000).

454. *See* Roger A. Sedjo, *Property Rights, Genetic Resources, and Biotechnological Change*, 35 J.L. & ECON. 199, 203 (1992).

455. *See, e.g.*, EDWARD C. WOLF, ON THE BRINK OF EXTINCTION: CONSERVING THE DIVERSITY OF LIFE 44 (1987); Matthew B. Hamilton, *Ex Situ Conservation of Wild Plant Species: Time To Reassess the Genetic Assumptions and Implications of Seed Banks*, 8 CONSERVATION BIOLOGY 39 (1994); G. Ledyard Stebbins, *Why Should We Conserve Species and Wildlands?*, *in* CONSERVATION BIOLOGY: THE THEORY AND PRACTICE OF NATURE CONSERVATION PRESERVATION AND MANAGEMENT 453, 463 (Peggy L. Fiedler & Subodh K. Jain eds., 1992); Mark A. Urbanski, Note, *Chemical Prospecting, Biodiversity Conservation, and the Importance of International Protection of Intellectual Property Rights in Biological Materials*, 2 BUFF. J. INT'L L. 131, 181 (1995).

456. *See* Holly Doremus, Comment, *Patching the Ark: Improving Legal Protection of Biological Diversity*, 18 ECOLOGY L.Q. 265, 284 (1991).

457. CBD, *supra* note 128, at art. 2.

458. *Compare* Douglas Fox, *Back to the No-Analog Future?*, 316 SCIENCE 823 (2007) (describing the emergence of biomes that have no geologic precedent), *with* J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1 (2008) (proposing to set the highest conservation priorities among species imperiled by climate change for those organisms that can find niches in a no-analog future).

459. *See* Eugenie C. Scott, *Antievolution and Creationism in the United States*, 26 ANN. REV. ANTHROPOLOGY 263, 263–64 (1997) (reporting a 1996 survey conducted by the National Science

conservation from preventing overkill to preserving habitat and slowing the influx of alien species.

Law, along with economics and other social sciences within the "third culture" that bridges science and the humanities in modern society, has a unique opportunity (and obligation) to address and ameliorate the conditions under which "human beings are living or have lived."[460] American legal culture, after all, has made it possible for at least one member of the highest court in the land to condemn habitat preservation because it allegedly "imposes unfairness to the point of financial ruin—not just upon the rich, but upon the simplest farmer who finds his land conscripted to national zoological use."[461] That same jurist has even derived perverse pleasure from mocking "the much beloved secular legend of the Monkey Trial."[462] Rhetorical stunts of this sort deliver succor to the enemies of biological enlightenment.[463]

4. For Nowadays the World Is Lit by Lightning

In environmental protection as in "welfare economics," all "problems . . . must ultimately dissolve into a study of aesthetics and morals."[464] Human civilization has changed the world beyond recovery within any timeframe capable of being contemplated, let alone managed, by our species. The project of ameliorating humanity's environmental footprint demands humility, wonder, and above all a thorough scientific understanding of natural history and our species' contingent, evanescent, and fragile place in it. The law's approach to environmental ethics, as simple as it is obvious, should approach all efforts "to preserve an ecosystem and its component species . . . as if each species is sacred."[465]

Whether by design or by happenstance, however, civilization has trodden a different path. Much of environmental law's internal ethos of conservation and consumption reflects the aesthetic and political philosophy expressed by the early twentieth century's Futurist movement.[466] "[T]he world has been enriched with a new

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Board that found that forty-four percent of Americans do not believe in an evolutionary explanation of human origins); *see also* Nicholas D. Kristof, Opinion, *God, Satan and the Media*, N.Y. TIMES (Mar. 4, 2003), http://www.nytimes.com/2003/03/04/opinion/god-satan-and-the-media.html [https://perma.cc/TWX7-JDHN] (reporting that "Americans are more than twice as likely to believe in the devil (68 percent) as in evolution [(28 percent)]").

460. C.P. SNOW, THE TWO CULTURES: AND A SECOND LOOK 70 (1964).

461. Babbitt v. Sweet Home Chapter of Communities for a Great Or., 515 U.S. 687, 714 (1995) (Scalia, J., dissenting).

462. Tangipahoa Parish Bd. of Educ. v. Freiler, 530 U.S. 1251, 1255 (2000) (Scalia, J., dissenting from denial of cert.).

463. *See generally* Jim Chen, *Legal Mythmaking in a Time of Mass Extinctions: Reconciling Stories of Origins with Human Destiny*, 29 HARV. ENVTL. L. REV. 279, 303–15 (2005) (reviewing the legal and political damage arising from the late Justice Antonin Scalia's biologically illiterate pronouncements in *Sweet Home*, *Tangipahoa Parish*, and *Edwards v. Aguillard*, 482 U.S. 578 (1987)).

464. R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 43 (1960).

465. McCann, *supra* note 93, at 233. *See generally* URSULA GOODENOUGH, THE SACRED DEPTHS OF NATURE 153–66 (1998).

466. *See generally* CINZIA SARTINI BLUM, THE OTHER MODERNISM: F.T. MARINETTI'S FUTURIST FICTION OF POWER (1996); STEPHEN KERN, THE CULTURE OF TIME AND SPACE 1880–

beauty," proclaimed *The Futurist Manifesto* in 1909, "the beauty of speed."[467] Contemporary industrialized societies have affirmatively embraced "[s]peed [as] the form of ecstasy the technical revolution has bestowed on man."[468]

Having catapulted itself to global ecological dominance through its Great Acceleration,[469] human society must now pay a profound, perhaps unbearable, price. "A law of acceleration, definite and constant as any law of mechanics, cannot be supposed to relax its energy to suit the convenience of man."[470] Contemporary life having embraced the Futurists' "love of danger" and their "habit of energy and of temerity," we shall "like young lions . . . r[u]n after Death, its dark pelt blotched with pale crosses as it escape[s] down the vast violet living and throbbing sky."[471] Humanity's contribution to the acceleration of natural history has triggered a correlative, awful responsibility: that of managing "eternal, omnipresent speed" on "the last promontory of the centuries."[472]

Framing biodiversity loss and climate change as environmental issues operating on a geological clock reverses the preference for speed expressed in the accelerated timetables of politics and technology. "Ah, where have they gone, the amblers of yesteryear? Where have they gone, those loafing heroes of folk song, those vagabonds who roam from one mill to another and bed down under the stars?"[473] Only by tracing "feeling and myth . . . back through time past cultural history to the evolutionary origins of human nature"[474] can we recover the magic that bewitched humanity when first it beheld "[e]very contour of the terrain [and] every plant and animal living in it."[475] To aspire to anything less casts us on the inexorable and tragic path of "reject[ing] the best the earth could offer."[476]

In a "world . . . lit by lightning," humanity seems determined to extinguish the biosphere's sources of diversity, inspiration, and beauty as though there were mere "candles."[477] Perhaps we may find in evolutionary history and aesthetic "motion

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1918, at 119–23 (1983).

467. Filippo Tommaso Marinetti, *Futurist Manifesto*, LE FIGARO, Feb. 20, 1909, ¶ 4, *reprinted and translated in* ART OF OUR CENTURY: THE CHRONICLE OF WESTERN ART 1900 TO THE PRESENT 99 (Jean-Louis Ferrier & Yann le Pichon eds., Walter D. Glanze trans., 1988); *cf., e.g.*, MICHAEL L. DERTOUZOS, WHAT WILL BE: HOW THE NEW WORLD OF INFORMATION WILL CHANGE OUR LIVES 9 (1997) (predicting that the ongoing "Information Revolution will trigger a . . . sweeping transformation" of our lives, mostly for the better).

468. MILAN KUNDERA, SLOWNESS 2 (Linda Asher trans., 1st ed. 1996); *cf.* William E. Scheuerman, *Constitutionalism in an Age of Speed*, 19 CONST. COMMENT. 353 (2002).

469. *See generally* Hibbard et al., *supra* note 327.

470. 2 HENRY ADAMS, THE EDUCATION OF HENRY ADAMS: AN AUTOBIOGRAPHY 284, 289 (Time Reading Program spec. ed. 1964) (1918).

471. F. T. Marinetti, *The Founding and Manifesto of Futurism 1909*, LE FIGARO (Paris), Feb. 20, 1909, *reprinted in* FUTURIST MANIFESTOS 19, 20–21 (Umbro Apollonio ed., R. W. Flint trans., 1970).

472. *Id.* ¶ 8.

473. KUNDERA, *supra* note 468, at 3.

474. EDWARD O. WILSON, BIOPHILIA 55 (1984).

475. EDWARD O. WILSON, CONSILIENCE: THE UNITY OF KNOWLEDGE 237 (1998).

476. HAWTHORNE, *supra* note 359, at 237.

477. WILLIAMS, *supra* note 8, at 97.

what was lost in [legal] space,"[478] the better to present "truth in the pleasant disguise of illusion."[479] In an ironic twist on the more familiar political struggles over the teaching of evolution and biological literacy in the United States, "evolution has produced sentient species with a sense of purpose"—the very beings equipped *and* inclined to explore "the connections that might serve to reunify the scientific worldview with the religious instinct."[480] "[R]eligion and science," as "the two most powerful forces in the world today," have a unique opportunity—and responsibility—to become "united on the common ground of biological conservation" and agree "that we owe ourselves and future generations a beautiful, rich, and healthful environment."[481]

Among creation myths vying to satisfy the human need for a compelling story of origins, especially in an emotionally challenging "age of globalization," "none is more solid and unifying for the species than evolutionary history."[482] No other story of human beginnings boasts a more expansive narrative scope or enjoys greater scientific support.[483] "The Epic of Evolution . . . beautifully suited to anchor our search for planetary consensus," promises to unite not merely all branches of humanity, but own species with the entire tapestry of life itself.[484]

The tree of life, from a pivotal 1990 reorganization[485] to more recent debates over the precise relationship among Archaea, bacteria, and eukaryotes,[486] is now estimated to contain as many as a trillion (10^{12}) microbial species.[487] The horses of the

478. *Id.*

479. *Id.* at 4.

480. SIMON CONWAY MORRIS, LIFE'S SOLUTION: INEVITABLE HUMANS IN A LONELY UNIVERSE 328 (2003). "God does not play dice with the universe," a saying attributed to Albert Einstein, arises from a December 4, 1926, letter to Max Born: "Die Quantenmechanik ist sehr achtunggebietend. Aber eine innere Stimme sagt mir, daß das noch nicht der wahre Jakob ist. Die Theorie liefert viel, aber dem Geheimnis des Alten bringt sie uns kaum näher. Jedenfalls bin ich überzeugt, daß *der* nicht würfelt." MAX BORN, PHYSIK IM WANDEL MEINER ZEIT 244 (2d ed. 1957) (emphasis added). In my English translation: "Quantum mechanics is certainly impressive. But a voice inside me says that it's not yet the real McCoy. The theory says a lot, but it barely gets us closer to the secrets of God. Anyway, I am convinced that *He* does not play dice." *See generally* PAUL DAVIES, THE COSMIC BLUEPRINT: NEW DISCOVERIES IN NATURE'S CREATIVE ABILITY TO ORDER THE UNIVERSE 183–96 (1988) (pondering consciousness as evidence of broader self-organizing complexity in biology and physics).

481. EDWARD O. WILSON, THE CREATION: AN APPEAL TO SAVE LIFE ON EARTH 5 (2006).

482. WILSON, *supra* note 21, at 133.

483. *See* David Christian, *The Case for "Big History,"* 2 J. WORLD HIST. 223, 235 (1991) (describing history, at least if studied across the whole of time, "as a form of modern 'creation myth'" that "reflects the best attempts of our society to answer questions about origins").

484. GOODENOUGH, *supra* note 465, at 174.

485. *See* Carl R. Woese, Otto Kandler & Mark L. Wheelis, *Towards a Natural System of Organisms: Proposal for the Domains Archaea, Bacteria, and Eucarya*, 87 PROC. NAT'L ACAD. SCI. USA 4576 (1990).

486. *See, e.g.*, Richard Gouy, Denis Baurain & Hervé Philippe, *Rooting the Tree of Life: The Phylogenetic Jury Is Still Out*, 370 PHIL. TRANS. ROYAL SOC'Y LONDON, no. 1678, 2015; Cody E. Hinchliff et al., *Synthesis of Phylogeny and Taxonomy into a Comprehensive Tree of Life*, 112 PROC. NAT'L ACAD. SCI. 12,764 (2015); Laura A. Hug et al., *A New View of the Tree of Life*, NATURE MICROBIOLOGY, May 2016, at 1 (2016).

487. *See* Kenneth J. Locey & Jay T. Lennon, *Scaling Laws Predict Global Microbial*

Anthropocene need not fulfill their calamitous destiny. Even the spiritual tradition that ends in the Apocalypse contemplates "a vision" of "red, brown, and white horses," reporting "to the angel of the Lord . . . standing among the myrtle trees, 'We have gone through the earth and found the whole world at rest and in peace.'"[488]

Realigning environmental law with the scientific understanding of biodiversity loss produces its own epiphany, its own spiritually satisfying path toward detecting an "echo of the infinite, a glimpse of its unfathomable process, a hint of the universal law."[489] So that we might "explore and learn" all that the world would teach us, "all things [must] be mysterious and unexplorable, [and] land and sea [must] be infinitely wild, unsurveyed and unfathomed by us because unfathomable."[490]

The project of ameliorating humanity's environmental footprint demands humility, wonder, and above all a thorough understanding of humanity's place in natural history. "[I]ntense spiritual feelings" arise from the "unfathomable complexity and . . . sublime beauty" of the biosphere at its fullest and most diverse.[491] Only by recapturing the "beauty and mystery that seized us at the beginning" can the law hope to harness, perchance to halt, the horses of our ecological apocalypse.[492]

Diversity, 113 PROC. NAT'L ACAD. SCI. 5970 (2016).

488. *Zechariah* 1:8, 10–11 (New International Version).

489. Oliver Wendell Holmes, *The Path of the Law*, 10 HARV. L. REV. 457, 478 (1897).

490. THOREAU, *supra* note 59, at 242.

491. DAVID TAKACS, THE IDEA OF BIODIVERSITY: PHILOSOPHIES OF PARADISE 255 (1996).

492. WILSON, *supra* note 475, at 237.