Review Essay
Law and the New Ecology: Evolution, Categories, and Consequences

*Jonathan Baert Wiener**

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INTRODUCTION

In a fitting testament to sterling scientific journalism, the 1995 Pulitzer Prize for General Non-Fiction was awarded to a book about ecology. In *The Beak of the Finch: A Story of Evolution in Our Time*,[1]

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1. JONATHAN WEINER, THE BEAK OF THE FINCH: A STORY OF EVOLUTION IN OUR TIME (1994) [hereinafter BEAK OF THE FINCH].

Please note that I am not reviewing my own book (as nice as it would have been to have won the Pulitzer Prize). I feel compelled to say this because confusion on this point seems inescapable. In ecological terms, it is essential for us to distinguish similarities and differences in others; that is at the core of the finch's struggle to survive, *id.* at 85-88, and of the evolutionary biologist's craft in monitoring the effect of selection pressures on the attributes of organisms. It is equally at the core of the lawyer's method of reasoning by analogizing and distinguishing cases. *See* EDWARD H. LEVI, AN INTRODUCTION TO LEGAL REASONING (1949). As Weiner says, in the struggle for evolutionary success, every detail of variation can make the difference. BEAK OF THE FINCH, *supra*, at 171. Noticing similarities and differences is part of every organism's life. In my office, my copies of two books by Jonathan Weiner, *The Beak of the Finch* and *The Next One Hundred Years*, serve not only to enrich my collection, but to test my visitors' skills of taxonomic differentiation. Still, even the ecologically minded editors of this journal could not resist, on an earlier draft, deleting my name and attributing my biographical footnote to Mr. Weiner. This

Jonathan Weiner brings to light the wealth of current empirical research demonstrating Darwinian evolution in action. Weiner focuses on the work of Rosemary and Peter Grant, two Princeton biologists who have spent much of the last twenty-odd years in the Galápagos Islands, studying the same species of finches that Charles Darwin saw over a century ago. Through Weiner's reportage, we witness the meticulous work of the Grants' jovially named "International Finch Investigation Unit" to marshal the hard evidence that Darwinian evolution is not merely a speculative theory or an ancient artifact, but that it is real and occurring now, driven ceaselessly by environmental selection pressures, in ways we humans can observe.

Weiner's book is more than a biography of the Grants; it is also a tribute to Darwin, a survey of the cutting edge of ecological science today, and, most important, a bold call for a new metaphor for nature. Rejecting the conventional notion that life has settled into a stable equilibrium after millennia of evolution now long past, Weiner counters that, like Darwin's finches, all life on Earth is "in jittery motion. . . . [Life is] alert and nervous in every part, ready to dart off in an instant. Life is always poised for flight."[2]

To build his case that nature is relentlessly dynamic and that Darwin's hypothesized mechanism for evolution, natural selection, drives that dynamism, Weiner follows closely the marathon research program pursued by the Grants, as well as the research of numerous other evolutionary biologists who are documenting the impact of environmental selection pressures on species from elephants to *E. coli*. These new studies of evolution in action may not surprise those who have already accepted Darwin's theory. But Weiner points out that about half of the U.S. population does not believe in evolution at all,[3] and he argues that the new findings would have been cathartic even to Darwin. Darwin's theory of natural selection as the mechanism for evolution was a scientific revolution in its time.[4] Still, Darwin inferred from the present diversity of species only that evolution had occurred

review is, perhaps, in part a paltry effort to distinguish my plumage, even though being taken for another can be a flattering windfall.

2. BEAK OF THE FINCH, *supra* note 1, at 112.

3. *Id.* at 295.

4. *See* I. Bernard Cohen, *Scientific Revolutions, Revolutions in Science, and a Probabilistic Revolution 1800-1930*, *in* 1 THE PROBABILISTIC REVOLUTION 23, 35 (Lorenz Krüger et al. eds., 1987); THOMAS S. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS 171-72 (2d ed. 1970) [hereinafter KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS]. Kuhn says that: "When Darwin first published his theory of evolution by natural selection in 1859," what was revolutionary was "neither the notion of species change nor the possible descent of man from apes" but rather the replacement of a model of teleological evolution driven by a wise Creator to fashion perfection with a model of undirected natural selection driven by environmental pressures. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS, *supra*, at 171-72.

in the past. Darwin thought that evolution must be so gradual as to be visible to human observers only in distant retrospect: that current biological conditions change so slowly as to be effectively fixed on any human time scale. Weiner reflects that: "Darwin did not know the strength of his own theory. He vastly underestimated the power of natural selection. Its action is neither rare nor slow. It leads to evolution daily and hourly, all around us, and we can watch."[5]

The research that Weiner reports is part of a growing body of scientific evidence—the "new ecology"—that is changing not only our view of particular species and how they came to be, but our answers to ageless questions: What is nature, how does it work, and what is the human role? By both proving Darwin's theory of evolution by natural selection and also challenging Darwin's concession to a relatively static view of nature, the Grants and their colleagues are showing that evolution is both real and rapid, observable in as little as a few years, and driven by changes in environmental conditions. They are suggesting a new way to see nature: dynamic, in motion, tumultuous.[6]

This transformation of our vision of nature—from a vision of stable equilibrium to one of perpetual change driven by environmental pressures—is itself revolutionary, or at least a major aftershock of Darwin's original insight.[7] Certainly it challenges the social institutions through which we deal with nature—chief among them environmental law. For the last several hundred years our expert and lay imaginations have been fixated on a vision of a "balance of nature" in static equilibrium.[8] Through the growing body of research that Weiner examines, the new ecology is now subverting and replacing the

5. BEAK OF THE FINCH, *supra* note 1, at 9; *see* Richard A. Kerr, *Did Darwin Get It All Right?*, 267 SCIENCE 1421, 1421-22 (1995) (reporting evidence on rapid and abrupt evolutionary change).

6. BEAK OF THE FINCH, *supra* note 1, at 106-12, 148, 188. As Weiner notes, ancient philosophers like Heraclitus had made the same claim. *Id.* at 202 ("[A]ll is flux, everything flows."). Genetic change in species with rapid generational turnover, such as fish and fruit flies, had been observed on human time scales before, in laboratory studies. Weiner's thesis is that evolution-watchers like the Grants are the first to document rapid species evolution due to natural selection—to show that nature changes itself all the time.

7. *See* Thomas S. Kuhn, *What Are Scientific Revolutions?*, *in* 1 THE PROBABILISTIC REVOLUTION, *supra* note 4, at 7, 19-21 [hereinafter Kuhn, *What Are Scientific Revolutions?*]; A. Dan Tarlock, *The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law*, 27 LOY. L.A. L. REV. 1121, 1128 (1994) (positing that the shift from an equilibrium to a nonequilibrium paradigm in ecology is a "Kuhnian revolution").

8. BEAK OF THE FINCH, *supra* note 1, at 106, 148; *see* Fred P. Bosselman & A. Dan Tarlock, *The Influence of Ecological Science on American Law: An Introduction*, 69 CHI.-KENT L. REV. 847, 863-65, 869-71 (1994); DANIEL B. BOTKIN, DISCORDANT HARMONIES: A NEW ECOLOGY FOR THE TWENTY-FIRST CENTURY 12-13 (1990). The image of nature in stable equilibrium or balance has captivated ecology and conventional wisdom for much of the modern period. Giants of ecology have endorsed this paradigm: George Perkins Marsh wrote in 1864: " 'Nature, left undisturbed, so fashions her territory as to give it almost unchanging permanence of form, outline, and proportion, except when shattered by

vision of nature in stable equilibrium with a more realistic and sophisticated vision of nature in change, disturbance, and perpetual flux.[9] It is not that the evidence of rapid evolution by natural selection was not there before; it is that " '[p]eople never tried to look. They thought you would have to watch a population a thousand years. But that's changing now.' "[10] This revolutionary paradigm shift—seeing nature with new eyes that enable the same facts to describe a fundamentally different system[11]—is, Weiner argues, vindicating Darwin's theory even beyond Darwin's own expectations. Weiner summarizes:

> We have barely begun to digest the Darwinian implications of the present moment; we have barely begun to glimpse the degree to which we are all involved in the action and reaction of evolution right now. In this sense the revolution that Darwin began in 1859 is not yet completed.[12]

Widespread acceptance of a dynamic, nonequilibrium concept of nature, and the application of such a concept in environmental policy, will require not only a body of scientific evidence but also a new metaphor or intuition to replace the deeply ingrained concept of "the balance of nature." Reluctance to accept the dynamic implications of Darwinian evolution derives " 'not from what reason dictates but from the limits of what the imagination can accept.' "[13] Changing the metaphors we use to describe nature is itself a defining signal of a revolution in thought.[14] Not surprisingly, then, the imagery of a stable equilibrium balance of nature has played a key role in shaping our social institutions for dealing with nature, including our environmental laws. By bringing to imaginable life the new paradigm of dynamism in nature, evolutionary biologists like the Grants, and their storytellers like Weiner, are offering a new vision that will remake how we conceive of the world around us and how we design our environmental laws.

Weiner's ambition in *The Beak of the Finch* is thus to draw from the scientific findings of the new ecology a new metaphor for nature. As the ecologist Daniel Botkin sees it:

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geologic convulsions.' " GEORGE P. MARSH, MAN AND NATURE 29 (1864), *quoted in* BOTKIN, *supra*, at 54.

9. *See* BOTKIN, *supra* note 8, at 5-6; Eugene P. Odum, *Great Ideas in Ecology for the 1990s*, 42 BIOSCIENCE 542, 542-43 (1992); Judy L. Meyer, *The Dance of Nature: New Concepts in Ecology*, 69 CHI.-KENT L. REV. 875, 875-82 (1994).

10. BEAK OF THE FINCH, *supra* note 1, at 188 (quoting biologist Dolph Schluter).

11. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS, *supra* note 4, at 111-23.

12. BEAK OF THE FINCH, *supra* note 1, at 275.

13. *Id.* at 131 (quoting George Williams); *see also* LAWRENCE BUELL, THE ENVIRONMENTAL IMAGINATION: THOREAU, NATURE WRITING, AND THE FORMATION OF AMERICAN CULTURE (1995) (recounting the role of nature in the human imagination).

14. *See* Kuhn, *What Are Scientific Revolutions?*, *supra* note 7, at 20.

> The potential for us to make progress with environmental issues is limited by the basic assumptions that we make about nature, the unspoken, often unrecognized perspective from which we view our environment. This perspective, ironically in this scientific age, depends on myth and deeply buried beliefs. . . . We have tended to view nature as a Kodachrome still-life, . . . but nature is a moving picture show . . . continually changing and complex . . . .[15]

The ecologist Judy Meyer offers: "Unfortunately, we have not yet developed and popularized an image to replace that of the 'balance of nature.' I suggest 'the dance of nature' as an image that conveys a sense of change and movement in response to a myriad of influences."[16]

It is on the cusp of this transformation that Weiner writes. He offers his own metaphor for the new view of nature:

> If we look at the billowing smoke of a volcano from close up, we see intense and rapid motion, enormous and dangerous turbulence. If we look at the eruption from far, far away . . . , the smoke seems to hang in the air almost motionless . . . . The evolution of life turns out to be rather like the eruption of a volcano. The closer you look, the more turbulent and dangerous the action; the farther you remove, the more the living world seems fixed and stable, hardly moving at all.[17]

After briefly reviewing the evidence that Weiner presents for the new science of evolution in action, I consider how this new science and its metaphors will challenge and reshape humanity's chief institution for dealing with nature and our role in it: environmental law. Many of our environmental laws are rooted in a static and separatist conception of the way the world works that is rapidly becoming obsolete in the wake of the new ecology. But there are several signs on the horizon of a legal evolution to meet the challenge of the new ecology.

I
EVOLUTION IN ACTION

The heart of Weiner's book is his affectionate account of the Grants' research program on Daphne Major, a small volcanic island in the Galápagos archipelago. In 1973 the Grants came to Daphne Major to study Darwin's finches—the thirteen species of finches that

15. BOTKIN, *supra* note 8, at 5-6.

16. Meyer, *supra* note 9, at 877. Others offer the "flux of nature" or the "shifting mosaic." Steward T.A. Pickett et al., *The New Paradigm in Ecology*, *in* CONSERVATION BIOLOGY: THE THEORY AND PRACTICE OF NATURE CONSERVATION, PRESERVATION AND MANAGEMENT 60, 80 (Peggy L. Fiedler & Subdoh K. Jain eds., 1992).

17. BEAK OF THE FINCH, *supra* note 1, at 111. In another stab at coining a metaphor for this same insight, Weiner writes: "The Darwinian view of evolution shows that the unrolling scroll is always being written, inscribed as it unrolls. . . . We are not completed as we stand, this is not our final stage. There can be no finished form for us or for anything else alive." *Id.* at 299-300.

Darwin noticed when he visited the Galápagos in 1836.[18] The Grants' first visit ultimately grew into the most intensive and thorough study of natural selection yet conducted.[19] Darwin was not as thorough. Curiously, Weiner observes, his revolutionary thesis that evolution is driven by natural selection was backed by scant empirical research: Darwin never saw natural selection in action nor observed it creating a new species,[20] and even advocates of his theory found the lack of field evidence "pitiful."[21] From the early 1900's until even fairly recently, many biologists dismissed Darwin's theory, believing "[e]volution, yes; selection, no."[22] Weiner's "*Story of Evolution in Our Time*" is thus a report from the front lines of evolutionary biology, where painstaking field research is demonstrating that evolution by selection occurs. Moreover, Darwin evidently thought that natural selection, although "metaphorically" operating "daily and hourly," would take ages to effect speciation and would therefore be invisible to human eyes;[23] Weiner's report of work by the Grants and others shows that natural selection acts rapidly, persistently, and pervasively.

Through meticulous tracking of the finches and analysis of data on their eating habits, beak sizes, and other factors, the Grants have been able to document and rigorously demonstrate many of Darwin's essential theses. For example, they show that changes in local climate in a period of drought, followed by a period of flood, produced significant changes in the inherited attributes of three species of finches. The drought reduced the number of small seeds on the islands[24] and thus favored the survival of birds that could break into larger, heavier seeds. This pressure selected for larger finches with deeper, narrower beaks, who became much more prevalent within a few generations after the drought.[25] The subsequent flood reversed this selection pressure and favored smaller finches with longer beaks better adapted to eating smaller seeds.[26] Weiner also reports on other scientists' research demonstrating similar findings of rapid, observable evolution in

18. *Id.* at 3-5, 17. Darwin never visited Daphne Major itself, but he and his shipmates collected samples on other Galápagos islands, and Darwin inspected these in England. *Id.* at 13.

19. *See id.* at 19.

20. *See id.* at 6, 8. Darwin was familiar with "artificial selection" (breeding) as a source of new plant and animal varieties, but he only hypothesized the impact of natural selection on species. *Id.* at 31-35.

21. *Id.* at 8.

22. *Id.* at 129-30.

23. *Id.* at 6, 9.

24. Although most of the research was conducted on the island of Daphne Major, *see id.* at 10, Genovesa was the site for a large body of work, *id.* at 66. The research team also observed finches on the islands of Pinta, *id.* at 149, Gardener, Floreana, and Española, *id.* at 116, and the island group of Los Hermanos, *id.* at 46.

25. *Id.* at 59-64, 76-82.

26. *Id.* at 99-106.

organisms such as guppies,[27] sparrows,[28] fruit flies,[29] crossbills,[30] sticklebacks,[31] sport fish,[32] soapberry bugs,[33] elephants,[34] and microbes.[35]

Weiner devotes a considerable section of the book to the Grant team's findings on other ways in which selection pressures reshape species before our eyes. Sexual selection pressures—relative success in mating and reproducing—also turned out to favor birds with the most adaptable beaks,[36] demonstrating that the birds' beaks play the central role not only in each organism's survival but also in the genes' survival. In addition, Weiner explores the Grant team's more complex research on divergence, or "adaptive radiation," among species, as the species' inherited traits shift to fill available ecological niches.[37] For example, if two finch species inhabit the same island and compete for the same limited food source, the members with especially similar traits and hence overlapping feeding ranges may die out, while the members with more dissimilar traits and distinct feeding ranges may prosper. Thus one species may begin to specialize in the upper altitudes of the island while the other becomes more prevalent in the lower altitudes; each species adapts away from competition with the other and into its own niche.[38] In contrast, a new environmental pressure such as a drought or a flood may spur mixing of the two species (interbreeding or "hybridization") by changing the boundaries of niches and raising the nutritional and hence reproductive success rate of hybrid organisms that were previously outcompeted by more distinct species members occupying the former niches.[39]

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27. *Id.* at 89-96.
28. *Id.* at 106-07.
29. *Id.* at 178-79.
30. *Id.* at 182-84.
31. *Id.* at 185-89.
32. *Id.* at 263-64.
33. *Id.* at 228-30.
34. *Id.* at 263.
35. *Id.* at 258-65.
36. *Id.* at 159-70.
37. *Id.* at 141-56.
38. *Id.* at 144-46. Interestingly, in describing the "division of labor" and development of specialized skills to meet the challenges of selection pressures, Weiner cites Darwin, Emerson, Blake, and Aeschylus, but not the economist Adam Smith who devoted himself to this issue. *See id.* at 287-88. Meanwhile, Weiner's intriguing explanation of the environmental problems caused by finches who recklessly snip the cactus stigma in their search for food (rendering the cactus sterile and thus imperiling the finches' own future survival) is intellectually equivalent to the economist's explanation of externalities and the tragedy of the commons; but Weiner avoids citing Garrett Hardin or advocating the kinds of collective cost-internalizing regulation that economists urge could prevent environmental degradation. *See id.* at 289-92. Similarly, although Weiner devotes great attention to competition among species, *see id.* at 55-65, 142, 187, 289, he pays relatively little attention to another important factor in ecology (and in human society): mutualism or cooperation among species. *See id.* at 136, 201-02.
39. *Id.* at 196-201.

Weiner tells this "*Story of Evolution*" with evident alacrity. He takes joy in the zest of the evolutionary biologists, whom he offers as the heroic detectives of this scientific mystery story. While engaging the reader in lengthy discussions of scientific concepts and research methods, Weiner is sure to highlight the personal idiosyncracies of the researchers or the creatures they study. Most memorably, the book is almost as much a miniature intellectual biography of Charles Darwin as it is of the Grants. Weiner reports that initially Darwin did not think the finches in the Galápagos were important;[40] he paid more attention to other creatures he saw there and did not even label which finch specimens he took from which islands.[41] It was only nine months later, while sailing on the *Beagle* heading for England, that Darwin realized that varieties of a different bird, mockingbirds, on some of the Galápagos Islands might suggest species divergence.[42] It was even later, after Darwin had given his finch samples to ornithologists in England, that he began to realize that isolation on the islands could foster evolution by natural selection.[43]

Far from diminishing Darwin's legend, Weiner peppers every section of the book with some tidbit of Darwinian lore: the master's daily walks around his "Thinking Path";[44] his experiments growing seeds from mud, saltwater, and bird droppings;[45] his spelling errors corrected by his grandmother;[46] and his foibles in mathematics.[47] Particularly fascinating are Darwin's musings on how variations in species are modified under selection pressure and passed on to the next generation: Weiner reports that Darwin, knowing nothing of DNA, nonetheless predicted that: "[S]ecret writing would one day be detected and deciphered in the bodies of living things. . . . '[C]haracters, like those written on paper with invisible ink . . . lie ready to be evolved whenever the organisation is disturbed by certain known or unknown conditions.' "[48]

If Weiner's writing has a chief distinguishing feature—in a way, the writer's analog to the finches' beaks—it is his use of metaphor to capture complex scientific phenomena. This was the hallmark of his previous book on environmental science,[49] and in *The Beak of the*

40. *Id.* at 22.
41. *Id.*
42. *Id.* at 27.
43. *Id.* at 28-29.
44. *Id.* at 126.
45. *Id.* at 133-36.
46. *Id.* at 218-19.
47. *Id.* at 287.
48. *Id.* at 214.
49. JONATHAN WEINER, THE NEXT ONE HUNDRED YEARS: SHAPING THE FATE OF OUR LIVING EARTH (1990).

Finch the similes are equally lilting and enlightening. He explains reticulate evolution, the phenomenon of hybridization through interbreeding among species, in terms of the genealogical tree of life: "The finches' lines are not so much lines or branches at all. They are more like twiggy thickets, full of little networks and delicate webbings."[50] When the extended drought on Daphne Major gives way to an intense December rainfall predating the normal onset of the wet season, Weiner writes: "[I]t is as if the cup of the year to come was so overfull that it was spilling backward."[51] Weiner also enters his candidates for the metaphor to denote the new dynamic view of nature: the erupting volcano plume[52] or the unfolding scroll.[53]

Stimulating and delightful as Weiner's *The Beak of the Finch* can be, the book is sometimes frustrating as well. For the legal or policy scholar, the book lacks some key guideposts. There is an extensive bibliography, but there are no notes to the numerous quotations and citations in the text; scholars will find themselves searching the bibliography hoping to match a remark with a reference. Moreover, the book's organization is neither fully chronological nor fully topical, with metaphorical chapter titles, making it difficult for the reader to locate discussion of any particular matter. Scientists seeking an inspirational lift to their unsung labors in the service of greater knowledge may find the book short on detail and documentation, while nonscientists with a lighter interest in the story may find the middle section of the book too involved and perhaps over-long. Both scientists and lay readers may also wish for more detail on what life was like for researchers spending months at a time living on remote islands; Weiner may have chosen to downplay such material lest it cloud his main points about nonhuman life, but even an evolutionary biologist might enjoy a wider window into the challenges and rigors of the heroic field researcher's lot.

II
EVOLUTION IN ENVIRONMENTAL LAW

Weiner's book, by fundamentally reframing our conception of nature and of how the world works, challenges deeply held intuitions about social relationships and rules that undergird our environmental laws. Much of the environmental law adopted in the past has been based on an ideal of preserving nature in a stable balance, of preserving nature against change—an ideal that is increasingly out of step

50. BEAK OF THE FINCH, *supra* note 1, at 201.
51. *Id.* at 99.
52. *Id.* at 111; *see supra* text accompanying note 17.
53. BEAK OF THE FINCH, *supra* note 1, at 299-300.

with the new scientific understanding of ecosystems.[54] Today this anachronistic orthodoxy is being attacked by science from within[55] and by politics from without.[56]

But the new view of nature hardly calls for a rollback of environmental law; rather the progressive solution lies in a new environmental metaphor and a new kind of environmental law that accommodates flexibility, fluidity, and change instead of trying to hold it back. We need to move from an environmental law based on a paradigm of stable equilibrium—a policy mismatch[57] in light of the new ecology—to an environmental law that welcomes change and cares about consequences rather than categories.

Revolutions in scientific thought have repeatedly, though often belatedly, found their way into fundamental changes in legal rules. For example, the revolution in the understanding of causation precipitated by the developers of probabilistic theory from the eighteenth through the early twentieth centuries[58] is currently working its way into tort law through doctrinal innovations such as joint causation and market share liability, and may yet replace the preponderance rule with proportionate liability.[59] The more recent revolution in quantum

54. Bosselman & Tarlock, *supra* note 8, at 847; Tarlock, *supra* note 7, at 1122-23; BOTKIN, *supra* note 8, at 5-6.

55. In addition to the research on dynamism in nature that Weiner reports, the emerging science of comparative risk analysis has raised serious questions about whether our current environmental, health, and safety laws lead to overprotection against some risks and underprotection against others. *See, e.g.*, SCIENCE ADVISORY BD., U.S. ENVTL. PROTECTION AGENCY, SAB-EC-90-021, REDUCING RISK: SETTING PRIORITIES AND STRATEGIES FOR ENVIRONMENTAL PROTECTION (1990); STEPHEN BREYER, BREAKING THE VICIOUS CIRCLE: TOWARD EFFECTIVE RISK REGULATION 10-29 (1993).

56. *See Property Rights Measure Most Visible of Several Proposals To Curb Regulation*, 1995 Nat'l Env't Daily (BNA) at d6 (Apr. 14, 1995), *available in* LEXIS, BNA Library, BNANED File (discussing proposed legislation in the 104th Congress to curb environmental regulations, require agencies to pay landowners for decreases in fair market value, and limit unfunded mandates to the states).

57. *See* STEPHEN BREYER, REGULATION AND ITS REFORM 191-96 (1982) (discussing the concept of regulatory mismatch defeating well-intentioned policy).

58. *See generally* THE PROBABILISTIC REVOLUTION, *supra* note 4 (exploring the infusion of statistical thinking, to replace determinism, in diverse fields and cultures).

59. *See* David Rosenberg, *The Causal Connection in Mass Exposure Cases: A "Public Law" Vision of the Tort System*, 97 HARV. L. REV. 851, 866-68 (1984). Probabilistic causation has also influenced the standard of proof in criminal cases. *See* Barbara J. Shapiro, *Law and Science in Seventeenth Century England*, 21 STAN. L. REV. 727, 729-30 (1969) (discussing the effect of developments in probability theory on the shift in criminal law from absolute truth to proof beyond a reasonable doubt).

physics has changed doctrines of causation[60] and has begun to influence the law's treatment of uncertainty.[61]

The Darwinian revolution has also influenced law and legal thought in significant ways. The model of evolution via selection pressure was soon adapted by analysts of legal systems, and evolutionary models of the development of legal rules continue to be the subject of much study.[62] The assimilation of Darwinian evolution into the substance of law has been more uneven (much as the assimilation of probabilistic physics into the substantive tort law is still far from complete). For example, the teaching of Darwinian ideas in school biology courses has been the subject of a long-running conflict over the intersection of environmental science and religion. The courts have frequently been asked to decide whether either evolution or creation-

60. For example, the Oregon Supreme Court held that invisible air pollution may constitute a physical invasion and hence a trespass, because

> [i]t is quite possible that in an earlier day when science had not yet peered into the molecular and atomic world of small particles, the courts could not fit an invasion through unseen physical instrumentalities into the requirement that a trespass can only result from a *direct* invasion. But in this atomic age even the uneducated know the great and awful force contained in the atom .... In fact, the now famous equation $E=mc^2$ has taught us that mass and energy are equivalents and that our concept of "things" must be reframed.

Martin v. Reynolds Metals Co., 342 P.2d 790, 793 (Or. 1959), *cert. denied*, 362 U.S. 918 (1960).

61. *See* Laurence H. Tribe, *The Curvature of Constitutional Space: What Lawyers Can Learn from Modern Physics*, 103 HARV. L. REV. 1, 17-23 (1989). Heisenberg's uncertainty principle showed at the atomic level the field scientist's general difficulty in observing dynamic phenomena: the act of observing may itself influence the phenomena sought to be observed. Tribe extends this insight to legal doctrine. Weiner seems to skip too lightly over interesting questions about the influence that the finch researchers themselves might have had on the bird populations—a perturbation of which the Grants were plainly aware and concerned to avoid, BEAK OF THE FINCH, *supra* note 1, at 75, 247, but one that their mere presence and research methods might have insinuated (e.g., by erecting tents and red flagging tape), *id.* at 56.

62. *See generally* Oliver W. Holmes, *Law in Science and Science in Law*, 12 HARV. L. REV. 443 (1899) (describing examples of "morphology and transformation of human ideas in the law"); Robert C. Clark, *The Interdisciplinary Study of Legal Evolution*, 90 YALE L.J. 1238 (1981); E. Donald Elliott, *The Evolutionary Tradition in Jurisprudence*, 85 COLUM. L. REV. 38 (1985); Herbert Hovenkamp, *Evolutionary Models in Jurisprudence*, 64 TEX. L. REV. 645 (1985). This application of evolutionary theory to law seems not so distant from Darwin's application to ecology when one considers that both are addressing the adaptation of the rules of governance of complex living entities in the face of changing circumstances and needs. While Darwin studied the evolution of the rules (embodied in genes) that govern organisms, legal scholars are studying the evolution of the rules (embodied in laws) that govern society. In future decades, scholars may study human legal codes as a kind of social DNA, controlling the social organism's behavior, borrowing code sequences from other societies' legal systems, and adapting in the effort to improve the society's prospects for survival. One can imagine these evolutionary anthropologists assembling empirical evidence of systematic legal evolution in much the way that Weiner and the Grants have done for species evolution.

ism could be scientifically "proven,"[63] and many judges have cautiously avoided basing their decisions on a comparison of the empirical validity of creationism versus evolution.[64] Perhaps schools and courts will be emboldened by the body of research that Weiner marshals in *The Beak of the Finch*.[65] Meanwhile, the use of Darwinian evolution in public policy debates has been harshly criticized—especially by evolutionary biologists—as misunderstood and misapplied where it has been used to try to explain or justify class and racial differences among members of the human species.[66]

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63. *See* Lucien J. Dhooge, *From* Scopes *to* Edwards: *The Sixty-Year Evolution of Biblical Creationism in the Public School Classroom*, 22 U. RICH. L. REV. 187, 204-07, 224-45 (1988); Judith A. Villarreal, *God and Darwin in the Classroom: The Creation/Evolution Controversy*, 64 CHI.-KENT L. REV. 335, 335 (1988).

64. Thus, in *Edwards v. Aguillard*, the proponents of "creation science" urged that: "The evidence for evolution is far less compelling than we have been led to believe. Evolution is not a scientific 'fact,' since it cannot actually be observed in a laboratory. Rather, evolution is merely a scientific theory or 'guess.' . . . It is a very bad guess at that." 482 U.S. 578, 623 (1987) (Scalia, J., dissenting) (citing testimony from legislative hearings on the challenged statute). An amicus brief filed by scientists took issue with the characterization of evolution as a mere "theory" contrasted with "proven scientific facts." Amicus Curiae Brief of 72 Nobel Laureates, 17 State Academies of Science, and 7 Other Scientific Organizations, in Support of Appellees at 6, 14-15, 18, Edwards v. Aguillard, 482 U.S. 578 (1987) (No. 85-1513). Even while striking down the Louisiana law requiring teaching of creation science whenever evolution is taught, the majority continued to refer to the "theory of evolution." *Edwards*, 482 U.S. at 581, 592; *see also* Epperson v. Arkansas, 393 U.S. 97, 107 (1968) (describing evolution as a "scientific theory or doctrine" while striking down a state law prohibiting the teaching of evolution); *id.* at 114 (Black, J., concurring) (noting that "the Darwinian theory" is subject to criticism and doubt among scientists).

65. This is especially so where "[c]reation science posits that all life forms now on earth appeared suddenly and relatively recently and have changed little." *Edwards*, 482 U.S. at 622 (Scalia, J., dissenting). The research surveyed by Weiner indicates that life forms now on Earth can and have changed significantly over observable time periods and that they continue to undergo hybridization and speciation. BEAK OF THE FINCH, *supra* note 1, at 106-12, 148, 188, 202, 299.

66. *See* STEPHEN J. GOULD, THE MISMEASURE OF MAN 321-34 (1981). The controversy over Social Darwinism—the view that humans face natural selection and that, therefore, the most successful classes of humans must be the genetically fittest—was a major battleground early in this century, *see* Herbert Hovenkamp, *The Marginalist Revolution in Legal Thought*, 46 VAND. L. REV. 305, 328-29 (1993), and remains hotly controversial today, *see, e.g.*, RICHARD J. HERRNSTEIN & CHARLES MURRAY, THE BELL CURVE: INTELLIGENCE AND CLASS STRUCTURE IN AMERICAN LIFE (1994) (proposing that class divisions in society result from biological differences); THE BELL CURVE DEBATE: HISTORY, DOCUMENTS, OPINIONS (Russell Jacoby & Naomi Glauberman eds., 1995) (containing more than 80 responses to *The Bell Curve*). It is increasingly argued by both scientists and courts that racial groupings, whether or not they are an appropriate basis for public policy, are cultural rather than biological distinctions. *See* Donna Alvarado, *Geneticists Call "Race" Meaningless Term*, RALEIGH NEWS & OBSERVER, Feb. 21, 1995, at A4 ("Evidence . . . is mounting that what we think of as 'race' is only skin-deep—and beneath the surface lies a range of genetic variability that shows no link to skin color or other superficial physical traits."); Shaare Tefila Congregation v. Cobb, 481 U.S. 615, 617 (1987) (stating that notions of race groupings are cultural and change over time); United States v. Biaggi, 673 F. Supp. 96, 99-101 (E.D.N.Y. 1987) (holding that under Batson v. Kentucky, 476 U.S. 479 (1986), in the bar against racially discriminatory jury challenges, the term "cognizable racial group" in-

The most important substantive impact of the new evidence of Darwinian evolution will most likely be in the area of law directly concerned with the role of humans in nature: environmental law. Whereas most areas of law deal with interactions among humans (e.g., contracts, corporations, criminal law, free speech), environmental law deals with interactions not only among humans but also between humans and the several million other species sharing the Earth. It is a set of rules for managing the interface between humans and all other organisms—between humans and the larger ecological systems within which human social and economic systems are nested. Darwinian evolution constitutes the most powerful explanation we have for ecological change and so ought to play a major role in our legal institutions for managing ecology.

As with the law's halting adoption of the lessons of other scientific revolutions, the infusion of the new ecology into environmental law may also be gradual. Environmental law is often thought of as an area of law especially suited to rapid evolution in response to scientific change, and compared to other areas of law this may be so. Yet our environmental laws have displayed a striking insensitivity to the Darwinian revolution in science, and in particular to the new picture painted by Weiner and others of nature in motion. American environmental law has also been slow to adopt the key insights of social scientists.[67] This sluggishness suggests that the evolutionary pressures shaping the development of environmental law have not been wholly or largely scientific. To paraphrase Holmes, the life of environmental law has not been scientific logic, it has been political experience. Parochial rent-seeking by special interests has shaped significant contours of our current environmental law regime.[68] Adherence to

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cludes Italian-Americans because at the time of adoption of the 14th Amendment the term "race" was understood to mean ethnicity or nationality, classifying as different races Swedish-Americans, Polish-Americans, etc.). Moreover, in stark contrast to the Social Darwinists, modern advocates of rights for nonhuman organisms (e.g., animal rights) are increasingly arguing that the abolition of racial discrimination (extending rights to a group previously deemed unworthy) and the idea of Darwinian evolution (showing common origins of humans and other species) are mutually supportive intellectual forces for greater equality of treatment. *See* RODERICK F. NASH, THE RIGHTS OF NATURE 199-213 (1989).

67. Economists were recommending incentive-based pollution control policies at least as early as A.C. Pigou. *See* A.C. PIGOU, THE ECONOMICS OF WELFARE (1920). Today that advice is beginning to make a significant dent in the command and control edifice of environmental regulation. *See, e.g.*, Robert W. Hahn & Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea?*, 18 ECOLOGY L.Q. 1 (1991); Daniel J. Dudek, Richard B. Stewart & Jonathan B. Wiener, *Environmental Policy for Eastern Europe: Technology-Based and Market-Based Approaches*, 17 COLUM. J. ENVTL. L. 1 (1992).

68. *See, e.g.*, Richard B. Stewart, *Madison's Nightmare*, 57 U. CHI. L. REV. 335 (1990) (lamenting special interest politics that have engulfed environmental regulation). *See generally* B. Peter Pashigian, *Environmental Regulation: Whose Self-Interests Are Being Protected?*, 23 ECON. INQUIRY 551 (1985) (focusing upon the role of geographic self-interest,

scientifically inappropriate models for environmental law may also reflect the heuristic mental boxes with which humans of inevitably bounded rationality tend to make decisions.[69] Changes in the scientific understanding of nature will most likely influence the body of environmental law only gradually as they are mediated through the contending forces of human interests.

III
CHANGING THE METAPHOR FOR NATURE

A. *Stasis*

The new view of nature that Weiner offers could over time dramatically reshape our environmental law. Much of our current environmental law regime is organized around the balance of nature metaphor. This intuition of stability and equilibrium has generated a variety of legal rules aimed at ensuring the preservation of the "natural order." For example, in the noted case of *Just v. Marinette County*,[70] a takings claim against restrictions on filling private wetlands, the Supreme Court of Wisconsin ruled that no compensation is due to a property owner where environmental law exercises its essential purpose to preserve the land "in its natural state . . . by limiting the use of private property to its natural uses."[71] At times we have attempted to preserve the "natural order" against nature's own changes: witness the Army Corps of Engineers' attempts to keep the Mississippi River from changing its streambed,[72] the government's efforts to preserve forests against all fires,[73] and the Department of the

rather than the more commonly cited externalities hypothesis, to explain regulation of stationary sources); Cass R. Sunstein, AFTER THE RIGHTS REVOLUTION: RECONCEIVING THE REGULATORY STATE (1990).

69. *See* Roger G. Noll & James E. Krier, *Some Implications of Cognitive Psychology for Risk Regulation*, 19 J. LEGAL STUD. 747 (1990); John D. Graham & Jonathan B. Wiener, *Resolving Risk Tradeoffs*, *in* RISK VS. RISK: TRADEOFFS IN DECISIONS TO PROTECT HEALTH AND THE ENVIRONMENT (John D. Graham & Jonathan B. Wiener eds., forthcoming 1995).

70. 201 N.W.2d 761 (Wis. 1972).

71. *Id.* at 768.

72. The river periodically changes its path, connecting oxbows and meandering to one side or another. Human efforts to keep the river where it was have proved expensive and ultimately ineffectual. In addition to the direct expenses of maintaining levees and embankments, one of the greatest costs is the damage to houses and farms built on the assumption that the river would behave. *See generally* JOHN MCPHEE, THE CONTROL OF NATURE 3-92 (1989) (describing efforts to prevent the Mississippi River from changing course to empty through the Atchafalaya River). After the 1993 floods, the government began to change its relief and insurance policies to discourage rebuilding in the likely future domain of the dynamic river.

73. For much of this century, aggressive fire suppression was implemented in efforts to regrow and maintain forest lands. It gradually became apparent that suppressing fire did not preserve the forest unaltered, but by depriving the forest of nutrients led instead to new evolution in the mix of forest trees and plants. *See* BOTKIN, *supra* note 8, at 153-54.

Interior's insistence on protecting endangered species against the hybridization (interbreeding) that the Grants are showing can be essential to survival.[74] At other times we have acted on the apparent assumption that nature will not change in response to our actions: for example, the use of pesticides and antibiotics to kill pests that afflict our crops and our bodies, in the hope that the pests would not adapt and proliferate in new forms.[75]

From the perspective of the new ecology reflected in Weiner's book, the problem with such reasoning is not that wetlands protection should or should not be ruled a taking, or that wetlands or rivers or forests or endangered species should or should not be protected, but that the "natural state" of the environment is a moving target or a meaningless concept.[76] Neither private owners nor the government

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To nourish the forest and manage change rather than trying in vain to inhibit it, the National Park Service began to allow controlled burns. *Id.*; *see also* Meyer, *supra* note 9, at 878 (discussing effects of fire suppression strategies on the Hutcheson Memorial Forest in New Jersey).

74. For example, the Florida panther and the Dusky Seaside sparrow were both on the United States Department of the Interior's endangered species list in the early 1980's. The Florida panther numbered less than 50 and suffered from genetic defects due to inbreeding, but the Department of Interior ruled that allowing interbreeding of the Florida panther with a related subspecies of panther would create a hybrid that does not qualify as the same "species" under the Endangered Species Act (ESA), 16 U.S.C. §§ 1531-1544 (1988 & Supp. V 1993), and hence would not be subject to the Act's protection, *see* Stephen J. O'Brien & Ernst Mayr, *Bureaucratic Mischief: Recognizing Endangered Species and Subspecies*, 251 SCIENCE 1187, 1187-88 (1991). Similarly, the Interior Department opined that crosses between the Dusky Seaside sparrow and the related Scott's Seaside sparrow would create a hybrid not worthy of protection; the Dusky Seaside sparrow became extinct in 1987. *Id.* The Interior Department's interpretation of species to exclude hybrids may be consistent with or even dictated by the ESA, but it is no longer in synch with the evidence of hybridization in the wild. Hybridization used to be considered rare and a threat to species integrity, but the new ecology is demonstrating that it is fairly common (as the Grants showed for the finches on the Galápagos Islands, hybridization was substantial following environmental changes that rearranged feeding niches, *see supra* text accompanying note 39), and hybridization may be highly beneficial to a species that would otherwise face a restricted niche or an impoverished gene pool. *See* O'Brien & Mayr, *supra*, at 1187-88. The notion of permanently and stably distinct species embodied in the ESA and Interior Department policy now appears to be based on an unrealistic and obsolete static metaphor for nature. Weiner emphasizes that species change and evolve, including via hybridization that blurs the genetic lines between species. *See* BEAK OF THE FINCH, *supra* note 1, at 201.

75. BEAK OF THE FINCH, *supra* note 1, at 251-66. Weiner reports that the very segments of American society that reject the evolution paradigm include farming communities in the throes of a battle with evolving pesticide-resistant crop pests: " 'These people are trying to ban the teaching of evolution [in schools] while their own cotton crops are failing because of evolution.' " *Id.* at 255 (quoting biologist Martin Taylor).

76. *See* William K. Stevens, *Balance of Nature: What Balance Is That?*, N.Y. TIMES, Oct. 22, 1991, at C4. Daniel Botkin points out that there has been no stable natural balance of climate over any scale of Earth history, whether over 1500 years or one million years or more. BOTKIN, *supra* note 8, at 10-11 ("[T]here is no constancy or any simple pattern or regular cycle."). Furthermore, if one really tried to pick a "natural state" of the Earth's climate, one might have to choose an ice age, *id.* at 61; and the question is really

can define the "natural state" when ecological systems and species are ever in flux. The search for stasis is inevitably frustrated by nature's dynamic reality. As just noted, suppressing forest fires may not preserve the forest but rather impair its ability to regenerate. In the campaigns to save species, proscribing hybridization among them may be a recipe for their extinction; and in the campaigns to kill selected species—pests on the farm and diseases in the body—nature may rally as pests under selection pressure undergo evolutionary shifts to survive.[77] Even attempts to preserve nature by saving a species from extinction will inescapably change it, because as Weiner notes, the interventions to save the species must change its selection pressures and thus change the species.[78]

B. *Separatism*

In defense of the "natural order" intuition, some argue that the "natural" quality being preserved is not strict static constancy, but the absence of human-caused (anthropogenic) change. This view—that human action is separate from nature and that the balance of nature is disturbed by human intrusion—has long been intimately intertwined with the metaphor of preserving the balance of nature and might be called the separatist intuition.[79] Separatism admits of at least two normative presumptions: that human action represents undesirable ("unnatural") interference with nature, or by contrast, that human action represents desirable dominion over nature. These two presumptions, derived from the separatist intuition, have vied for public adherence over many centuries. Both versions erect a categorical presumption

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meaningless because there never has nor never will be a stable natural state but rather "[w]herever we seek to find constancy we discover change," *id.* at 62.

77. BEAK OF THE FINCH, *supra* note 1, at 251-66. *See generally* George M. Gray & John D. Graham, *Regulating Pesticides*, *in* RISK VS. RISK: TRADEOFFS IN DECISIONS TO PROTECT HEALTH AND THE ENVIRONMENT, *supra* note 69 (pesticide resistance); Jeffrey A. Fisher, THE PLAGUE MAKERS: HOW WE ARE CREATING CATASTROPHIC NEW EPIDEMICS—AND WHAT WE MUST DO TO AVERT THEM (antibiotic resistance in bacteria).

78. BEAK OF THE FINCH, *supra* note 1, at 249-50. In a replay of the debates over the Florida panther and the Dusky Seaside sparrow, *see supra* note 74, such a controversy is now swirling around efforts to save the Orangutan. With populations depleted on both Borneo and Sumatra, the proposal has been made to interbreed the two varieties and reintroduce the hybrid into the wild. Some scientists have opposed this hybridization on the grounds that it would change the species and introduce an unnatural kind of orangutan into the wild. Others have countered that the genetic differences between the two groups of orangutans are not so great, and that separating them smacks of racist hubris. Similar debates have arisen about several other species conservation strategies, such as for wolves and condors. *See* Natalie Angier, *Orangutan Hybrid, Bred To Save Species, Now Seen As Pollutant*, N.Y. TIMES, Feb. 28, 1995, at B5, B9.

79. Roderick Nash calls this artificial separatism the "human-nature boundary," and he regards it as the next major ethical divide to be crossed, after racism and sexism. NASH, *supra* note 66, at 212.

about human action: either that it is a taint on nature, or that it is taming nature.

Those in the separatist-dominion camp adopt the presumption that human intrusion on nature is presumptively appropriate because humans are normatively advised to tame and use nature for human ends. This view held sway for much of Western history, until the time of the Enlightenment and the industrial revolution;[80] it has obvious traces in religious writing[81] and was pointedly articulated by Francis Bacon in the 1500's.[82] It was the dominant view of nature in England at the time of the Renaissance, and though it changed significantly in England over the next few hundred years,[83] it has many vestigial remnants today—in some versions of creationism, in claims for open access to forests and other habitat, in property rules that require "undeveloped" land to be "improved" by human construction or conversion,[84] in the extreme versions of the property rights movement

80. *See generally* KEITH THOMAS, MAN AND THE NATURAL WORLD: A HISTORY OF THE MODERN SENSIBILITY (1983) (detailing the development of modern English sensibilities concerning human relationships with nature from early Tudor dominion-based views); BOTKIN, *supra* note 8 (describing the impact of industrialization on concepts of "organic" and "divinely ordered" nature).

81. "Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the birds of the air, and over the cattle, and over all the earth, and over every creeping thing that creeps upon the earth." *Genesis* 1:26; *see also* JOHN C. HENDEE ET AL., U.S. DEP'T OF AGRIC., MISCELLANEOUS PUB. NO. 1365, WILDERNESS MANAGEMENT 10 (1978) (indicating that under traditional Judeo-Christian ethics, "the greatest blessing to be bestowed was to transform the wilderness—to make it 'blossom like a rose' "). For the view that this imagery in Genesis has helped cause ecological damage at human hands, see Lynn White, Jr., *The Historical Roots of Ecologic Crisis*, 155 SCIENCE 1203, 1205-07 (1967); *see also* FRANK HERBERT, CHILDREN OF DUNE (1976) (describing how human efforts to transform the desert into irrigated cropland threaten to destroy the ecological basis of survival and spiritual growth). For the view that "dominion" in Genesis should be interpreted to mean benign stewardship and thus is consistent with harmonious relations between humans and ecosystems, see AL GORE, EARTH IN THE BALANCE 243-48 (1992).

82. *See* CAROLYN MERCHANT, THE DEATH OF NATURE: WOMEN, ECOLOGY, AND THE SCIENTIFIC REVOLUTION 164-72 (1980). Merchant quotes Bacon:

> Nature must be "bound into service" and made a "slave," put "in constraint" and "molded" by the mechanical arts.... [T]he most wholesome and noble [of human ambitions] was "to endeavor to establish and extend the power and dominion of the human race itself over the universe [so that] the human race [could] recover that right over nature which belongs to it by divine bequest."

Id. at 169-72.

83. *See* THOMAS, *supra* note 80; NASH, *supra* note 66, at 21-22 (quoting John Ray and Alexander Pope).

84. Land use laws that vest ownership only when the land is "improved" or "developed" (in turn interpreted to mean cleared and built upon) have included adverse possession rules in some American states, *see, e.g.*, Van Valkenburgh v. Lutz, 106 N.E.2d 28 (N.Y. 1952) (construing a New York statute—requiring an adverse possessor to demonstrate that (1) land has been enclosed, or (2) cultivated or improved—to require proof that a wooded lot has been entirely converted to farming or has been improved by erection of substantial buildings), as well as property rules in the Brazilian Amazon, *see* Susanna B. Hecht, *The Logic of Livestock and Deforestation in Amazonia*, 43 BIOSCIENCE 687, 691 (1993)

rhetoric, perhaps in advice to mothers to eschew breastfeeding for synthetic formula, and elsewhere.[85] Darwin evidently thought the view that humans were separate from and superior to other life was an indication of human arrogance.[86] The separatist-dominion view has gradually evolved a more textured and empathetic branch, one that continues to be premised on human separateness from nature, but that asks that nature be treated with stewardship instead of dominion.[87]

Those in the separatist-taint camp are far more prevalent today. They believe that natural systems ought to be protected from human intrusion; the goal is not necessarily to freeze nature in place, but to insulate the natural dynamic processes from human interference. George Perkins Marsh articulated this view in 1864: " 'Nature, *left undisturbed*, so fashions her territory as to give it almost unchanging permanence of form, outline, and proportion . . . . [I]n countries *untrodden by man*' all factors balance one another, so that 'the geographical conditions may be regarded as constant and immutable.' "[88] More recently Bill McKibben expressed this view, arguing that we

("[T]hose who clear land have a stronger legal claim to a parcel than those who do not . . . [and] land in effective use—that is to say cleared—cannot be expropriated under the terms of the new 1988 constitution."). These property rules fail to recognize the value of land in noncleared uses and thus encourage deforestation, filling of wetlands, and other land conversion practices that might be neither ecologically nor economically the highest and best use of the land. *See generally* THEODORE PANAYOTOU, GREEN MARKETS: THE ECONOMICS OF SUSTAINABLE DEVELOPMENT (1993) (advocating augmentation of market-based regulatory systems to more completely account for the costs of pollution and land use). The inability to "see" value, complexity, and change in a forest is intimately tied to the metaphor the observer uses to understand nature: the forest as wild nature to be tamed or subjugated (human dominion); the forest as sacred wilderness to be preserved (human taint); the forest as habitat and resource to be conserved or managed (human interaction).

85. For example, the debate over reintroducing the wolf to Yellowstone National Park has been fought in these terms. The wolf was ousted by human action; now ranchers oppose the reintroduction lest the wolf kill their livestock. As one wolf advocate describes the issue:

> The Yellowstone wolf-recovery debate is fundamentally an expression of a culture in transition; it is the struggle that accompanies old assumptions clashing against the new. The story of this conflict is the story of how we view ourselves in relation to animals, whether we can replace the assumption of 'dominion' that has been so destructive to us and the natural world with a worldview that recognizes that we live in a state of reciprocity with the birds and the beasts—that we are not only the product of nature but also part of it. Our attitudes toward wolves and our treatment of them cut to the very marrow of how we view our relationship to the natural world.

Releasing Wolves from Symbolism, HARPER'S, Apr. 1994, at 15, 17 (statement of Renee Askins, Executive Director, Wolf Fund, in Hearings Before the House Committee on Resources).

86. BEAK OF THE FINCH, *supra* note 1, at 281.

87. *See, e.g.*, JOHN PASSMORE, MAN'S RESPONSIBILITY FOR NATURE 28-40 (1974); GORE, *supra* note 81, at 55; NASH, *supra* note 66, at 22.

88. GEORGE P. MARSH, MAN AND NATURE 29 (1864), *quoted in* BOTKIN, *supra* note 8, at 54 (emphasis added).

must keep "pristine places, places substantially *unaltered* by man" else "[t]he idea [of] 'nature,' the separate and wild province, the world apart from man" will be destroyed.[89]

How the separatist-dominion presumption was replaced in popular consciousness by its opposite, the separatist-taint presumption, is not altogether clear. The idea that humans should not contaminate nature may arise from a deep-seated human fear of impurities—perhaps dating back to creation stories such as the fall from Eden after eating the apple furnished by the devil.[90] The notion of a Peaceable Kingdom, in which all creatures live in harmony (the lion does not eat the lamb), is at times linked to the eradication of human sin; nature is seen as divinely ordered, and any imbalance is attributed to human interference.[91] Or this intuition may be of more recent vintage: it may reflect a new appreciation of the impacts of the industrial revolution,[92] or a uniquely American yearning for nature in its state at the time of the arrival of the first pioneering European settlers.[93] A related American idea, reflected in the creation of our National Parks, is the view that humans should be able to use untouched lands for the spiritual virtues of contact with wilderness, "precisely because [experiencing untouched wilderness] provides a stimulus to engage the contemplative faculty."[94] Another rationale, more apt in the pollution control field than in the land management field, could be the fear that human synthetics and perturbations will injure complex natural systems (including our own bodies) that we do not fully understand, posing greater risk than natural substances and processes.[95]

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89. BILL MCKIBBEN, THE END OF NATURE 48, 55 (1989). McKibben may have shifted his views more recently to a more dynamic perspective (of the kind described *infra* part IV); on the jacket cover of Weiner's *The Beak of the Finch*, McKibben says: "This remarkable book will forever change your sense of the pace of nature—once you've read [*The Beak of the Finch*], the world will seem infinitely more fluid, shifting, *alive*."

90. *See* MARY DOUGLAS, PURITY AND DANGER: AN ANALYSIS OF THE CONCEPTS OF POLLUTION AND TABOO (1966).

91. BOTKIN, *supra* note 8, at 84-85.

92. Although the appreciation of these impacts may be new, the adverse impacts of humans on the Earth certainly long pre-dated industrialization. *See infra* text accompanying notes 111-14.

93. BOTKIN, *supra* note 8, at 59, 195. See also William Cronon, *The Trouble with Wilderness*, N.Y. TIMES, Aug. 13, 1995, § 6 (Magazine), at 42-43 ("For many Americans, wilderness stands as the last place where civilization, that all-too-human disease, has not fully infected the earth. . . . To protect wilderness was to protect the nation's most sacred myth of origin.").

94. JOSEPH L. SAX, MOUNTAINS WITHOUT HANDRAILS: REFLECTIONS ON THE NATIONAL PARKS 20, 27-46 (1980). The spiritual value of experiencing places untouched by humans was also emphasized by Aldo Leopold and John Muir. *See* HENDEE ET AL., *supra* note 81, at 11-12. Of course, keeping nature wild for human use must at some point conflict with the notion of keeping nature utterly untouched by humans.

95. *But see infra* text accompanying notes 105-10.

Whatever its origins, the separatist-taint presumption—the categorical intuition that we should seek to preserve some realm of "natural order" as against "artificial," "synthetic" human intrusions—has animated much of our modern environmental law, teaching the axiom "leave nature alone."[96] As the current environmental law regime was being launched in the 1960's and early 1970's, for example, the Wilderness Act of 1964 defined wilderness areas deserving of protection as those "where the earth and its community of life are untrammeled by man."[97] Soon after, in a landmark case the Supreme Court appeared to take for granted that a main goal of environmental protection is to "preserve [areas] uncluttered by the products of civilization."[98] Clearly the Wisconsin court in *Just v. Marinette County*[99] had this distinction in mind, else Just's filling of the wetlands could not have been called unnatural. Similarly, our pollution control laws have often taken this approach, requiring zero contamination regardless of risk.[100] Food safety laws typically provide more stringent restrictions on "unnatural" substances added by humans than on "natural" substances, even if the latter cause equally serious harm.[101] The next frontier of environmental law is the regulation of global threats and of genetic engineering; Bill McKibben says he deplores global warming and biotechnology not because of the adverse impacts they might have, but because they represent the intermingling of human action with untouched nature.[102] At least as to biotechnology, U.S.

96. *See* Bosselman & Tarlock, *supra* note 8, at 847.

97. 16 U.S.C. § 1131(c) (1988).

98. *See* Sierra Club v. Morton, 405 U.S. 727, 728 (1972).

99. 201 N.W.2d 761, 768 (Wis. 1972).

100. For example, the Delaney Clause of the Federal Food, Drug, and Cosmetic Act (FDCA), 21 U.S.C. § 348(c)(3) (1988), prohibits anthropogenic (but not natural) carcinogens in food, regardless of the degree of risk posed, Les v. Reilly, 968 F.2d 985, 986 (9th Cir. 1992). The Clean Water Act also contains a general zero discharge requirement, though subject to exceptions. 33 U.S.C. § 1311(a) (1988).

101. *See* LESTER B. LAVE, THE STRATEGY OF SOCIAL REGULATION 12 (1981). For example, under § 402(a)(1) of the FDCA, "added" substances causing harm may be condemned more readily than nonadded substances. 21 U.S.C. § 342(a)(1) (Supp. V 1993). Courts have interpreted the term "added" to mean added by human conduct. *See, e.g.*, United States v. An Article of Food Consisting of Cartons of Swordfish, 395 F. Supp. 1184, 1186 (S.D.N.Y. 1975) (holding that a substance is not "added" when it "occurs naturally in the food," and because the substance at issue was "not naturally produced by fish," the court deemed it "added"). Similarly, states have assigned heightened tort liability standards to "unnatural" substances in foods. *See, e.g.*, Title v. Pontchartrain Hotel, 449 So. 2d 677 (La. Ct. App. 1984) (stating that if a substance in food is unnatural, the defendant is strictly liable; if a substance is natural, the defendant is only liable for negligence); Evart v. Suli, 259 Cal. Rptr. 535, 541 (Ct. App. 1989) (holding that natural substances causing injury would be judged under a negligence standard unless reasonably anticipated by the plaintiff, in which case liability is precluded; but unnatural substances causing injury could not be shielded from liability based on the plaintiff's anticipation and may be negligent *per se*).

102. McKibben criticizes genetic engineering for its categorical change, not its consequences:

policy is already reflecting that presumption: under the Toxic Substances Control Act (TSCA), the Environmental Protection Agency (EPA) has been drafting rules for regulating as "new chemical substances" the DNA in microorganisms genetically engineered by humans, regulating only "new" microbes (those that depart from the "natural" baseline) even though natural microbes remain unregulated by EPA but may be more or less dangerous than newly engineered microbes.[103]

C. *The Challenge of the New Ecology*

In the world of the new ecology, the categorical separatist-taint intuition is a problematic basis for environmental law.[104] First, we know that nature is not safe: not for humans or for other organisms;

> [G]enetic engineering . . . represents the second end of nature. . . . [Unlike global warming,] this won't be by accident—this will be on purpose. I don't mean that we shall end nature if something goes wrong—if, say, a strain of bacteria programmed to eat cellulose gets loose and eats every tree and weed in sight. . . .
>
> It is the simple act of creating new forms of life that changes the world, that puts us forever in the deity business.

McKibben, *supra* note 89, at 166. One wonders whether moving genes across genera (e.g., from insects to plants or even to humans) would bolster human hubris at our god-like powers, or by contrast would engender a deeper empathy for our newly recognized nonhuman genetic "relatives."

103. Microbial Products of Biotechnology: Proposed Regulation Under the Toxic Substances Control Act, 59 Fed. Reg. 45,526 (1994) (to be codified at 40 C.F.R. §§ 700, 720, 721) (proposed Sept. 1, 1994). EPA's regulations would reach new microbes by determining that any new DNA is a "new chemical substance" for which EPA may require a premanufacturing notice under TSCA. EPA says it recognizes that: "Plants and animals could also be chemical substances under TSCA. Nevertheless, as a matter of policy, EPA has limited this rulemaking to microorganisms." *Id.* at 45,527. Clearly "new" breeds of animals and plants created by humans—such as dogs, cats, cows, and most crop plants—would also be subject to TSCA control under EPA's reasoning. Since, as Weiner points out, all sexual reproduction, whether among finches or humans, creates new DNA, EPA's authority under TSCA presumably covers all offspring of sexual reproduction (including human). *See* Beak of the Finch, *supra* note 1, at 126, 206-07. EPA is evidently asserting the legal authority under TSCA to require prior permission for all DNA-creating activities and then magnanimously forbearing from regulating plant and animal (including human?) DNA-creation "as a matter of policy."

104. Categorical classifications are always vulnerable to the claim that they obscure important overlaps and interdependencies. Certainly this has been true in the use of classifications in environmental law, such as the fragmentation of policy into separate laws for separate air, water, and land media, or for separate pollutants and separate species, as though they were unconnected. This approach has resulted in various perverse cross-category consequences. *See, e.g.*, Frances Irwin, *Introduction to Integrated Pollution Control*, *in* Integrated Pollution Control in Europe and North America 3, 5 (Nigel Haigh & Frances Irwin eds., 1990). Evolutionary biology itself must deal with problems of taxonomic classification. As Weiner puts it wryly: "Taxonomists can be classified into splitters and lumpers" (i.e., taxonomists who see differentiation among species, and taxonomists who see interrelationship among species). Beak of the Finch, *supra* note 1, at 41. Thus Darwin's finch samples from the Galápagos Islands were originally sorted by different taxonomists into larger and smaller numbers of distinct species. *Id.* at 41-42. Ultimately, the way we redefine our taxonomy of nature is pivotal to our acceptance of new scientific paradigms. Kuhn, *What Are Scientific Revolutions?*, *supra* note 7, at 20.

trying to sanitize nature from human taint does not necessarily make life safer or healthier. Darwin called natural selection a "war,"[105] and it is plain that natural systems are chaotic and full of hazards. Animals eat animals; animals eat plants; plants poison insects; insects eat plants; microbes eat everything. There is no Peaceable Kingdom; the lion and the lamb will not be allies, nor should we expect them to be. For humans, natural hazards include ferocious animals, natural plants like tobacco and belladonna, natural substances like arsenic and lead, natural insects like wasps and mosquitos, natural microbes like influenza and malaria,[106] and natural climate, weather, and geology.

From a safety or risk perspective, the presumption in favor of preserving nature untainted may even be counterproductive. It may have led our food safety laws to expose us to greater cancer risks from natural substances than from synthetic ones[107] and to discourage consumption of natural foods that provide great health benefits in order to avoid much smaller risks from chemical contaminants.[108] It may also have led our water safety laws to expose us to greater infection hazards than the hazards posed by chemicals added to kill the infectious microbes.[109] A categorical proscription against human involvement in nature could also prevent human efforts to save other species. If a "natural" asteroid were about to hit the Earth, as one probably did sixty-five million years ago in what is now Mexico, resulting in massive global extinctions and marking the boundary between the Cretaceous and Tertiary periods,[110] should humans intervene to stop it from causing an ice age—or would that violate the categorical rule against human interference with natural processes? If it were a scourge of microbes threatening to wipe out many species, should humans intervene? Should humans forswear genetic engineering,

105. BEAK OF THE FINCH, *supra* note 1, at 58.

106. The Endangered Species Act does not cover insect pests or microbes. 16 U.S.C. § 1532(6), (8), (14), (16) (1988).

107. Bruce N. Ames et al., *Ranking Possible Carcinogenic Hazards*, 236 SCIENCE 271, 271-80 (1987).

108. Paul D. Anderson & Jonathan B. Wiener, *Eating Fish*, *in* RISK VS. RISK: TRADEOFFS IN DECISIONS TO PROTECT HEALTH AND THE ENVIRONMENT, *supra* note 69 (noting that people who avoid fish because of chemical carcinogens, as many states advise consumers to do, may reduce their overall health because fish provides potent protection against heart disease).

109. *See* Susan W. Putnam & Jonathan B. Wiener, *Seeking Safe Drinking Water*, *in* RISK VS. RISK: TRADEOFFS IN DECISIONS TO PROTECT HEALTH AND THE ENVIRONMENT, *supra* note 69; Christopher Anderson, *Cholera Epidemic Traced to Risk Miscalculation*, 354 NATURE 255, 255 (1991) (suggesting that Peru's decision to stop chlorinating drinking water, because of carcinogenic risk of chlorinating compounds, helped unleash a cholera epidemic killing thousands).

110. *See* E.O. Wilson, *The Current State of Biological Diversity*, *in* BIODIVERSITY 11-12 (E.O. Wilson ed., 1988); Richard A. Kerr, *Huge Impact Tied to Mass Extinction*, 257 SCIENCE 878, 878 (1992).

even if biotechnology could save billions of human lives and millions of forest and wetland hectares through advanced agriculture? The categorical separatist-taint approach has difficulty with these questions—partly because it imagines a stable balance of nature that would not admit such crises, and partly because it has excluded humans from any role in these natural processes.

Second, the separatist-taint presumption may be irrelevant because humans may have already touched everything. Botkin states unequivocally: "Since there is no longer any part of the Earth that is untouched by our actions in some way, either directly or indirectly, there are no wildernesses in the sense of places completely unaffected by people."[111] Many places that we now regard as virgin wilderness turn out to have been markedly influenced by pre-industrial human actions, such as farming, burning, and siltation that occurred millennia ago.[112] Biotechnology is not new; humans have been engineering new forms of life for at least ten thousand years, since we began breeding plants and animals for agriculture.[113] The most serious threats to the global ecology today may be not industrial chemicals but low-tech activities like clearing biologically rich forests for timber, itinerant farming, and grazing.[114] But does the fact of human contact make nature any less worth protecting? If we learned that all the world's forests, even dense jungle, were merely regrowth after ancient human habitation, would that lead us to abandon them to deforestation? Faced with such facts, the categorical separatist-taint view would offer no reason for conserving forests or wilderness; and yet abdication cannot be the answer.

Third, the dividing line between "natural" and "unnatural" is as untenable as the action/omission distinction. If nature is always changing, the idea of unnatural changes becomes a nullity unless it is defined in terms of human intervention; and even then it is highly

111. BOTKIN, *supra* note 8, at 194.

112. *See* Carol K. Yoon, *Rain Forests Seen As Shaped by Human Hand*, N.Y. TIMES, July 27, 1993, at C1; David W. Steadman, *Prehistoric Extinctions of Pacific Island Birds: Biodiversity Meets Zooarchaeology*, 267 SCIENCE 1123, 1123 (1995) (showing that humans caused mass extinctions on tropical Pacific islands thousands of years ago).

113. Common products like food crops, beer, and yogurt are the products of classic biological engineering. Today's new biotechnology is different in that it manipulates specific genes at the molecular level rather than manipulating the entire genome through cross-breeding. But this is a difference of consequences, not of category. Precise manipulations may even be safer in many applications than were classic techniques; the ecological risk posed by the new organism depends not on the technique used to create it, but on the traits produced, the target environment into which it is introduced, and the use to which it is put. *See* Notice, Exercise of Federal Oversight Within Scope of Statutory Authority: Planned Introductions of Biotechnology Products into the Environment, 57 Fed. Reg. 6753 (1992).

114. *See* JAMES E. LOVELOCK, GAIA: A NEW LOOK AT LIFE ON EARTH 121 (1979); BOTKIN, *supra* note 8, at 154.

problematic. In EPA's effort to define "new" DNA for its regulation under TSCA,[115] for example, the distinction between "natural" and "new" swallows itself once the prospect of change in nature is admitted. EPA tries to say that genetic engineering creates "new" DNA. But all DNA produced by "natural" sexual reproduction is "new," so every new plant, animal, or human would be covered by EPA's asserted authority under TSCA to regulate new DNA.[116]

Fourth, the very concept of "nature" is not "natural" but is a human construct. We use terms like "nature" and "natural" not just to describe the environment but to signal what is "normal" or intended or morally accepted. The normative connotations of "nature" are plain in classifications such as "natural foods," "natural causes of death," "You Make Me Feel Like a Natural Woman,"[117] "It's only natural," and "human nature."[118] The confusion between nature-as-environment and natural-as-intended has no doubt clouded much of our environmental law. Natural-as-intended, moreover, is often wielded by enemies of progressives or innovators who threaten to change the status quo: "It's not natural for people to fly," "The natural roles of men and women." These uses likewise err in their static notion of what is natural.

The separatist-taint presumption tends to dole out so many exceptions that it loses its normative rigor. A proscription against human manipulation of nature would, after all, outlaw all sorts of things that most humans—one dares to suggest even the advocates of the proscription—hold dear: dogs and cats (domesticated),[119] crops, cows, lawns, gardens. Gardening is the epitome of subjecting the natural wild state of vegetation to human organization.[120] Now it turns out that we garden the planet—and the planet gardens us, through all manner of selection pressures. This does not make gardening good or bad, or breeding domesticated dogs or cats or crops good or bad, or global warming good or bad; but it suggests that a simple distinction between humans and nature offers unsatisfactory guidance on these issues.

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115. *See* discussion *supra* note 103.

116. EPA appears to admit as much. *See* Microbial Products of Biotechnology, 59 Fed. Reg. 45,526.

117. ARETHA FRANKLIN, *You Make Me Feel Like a Natural Woman*, *on* ARETHA: LADY SOUL (Atlantic Records 1968).

118. The ghost of Hamlet's father prefers "[i]f thou hast nature in thee." WILLIAM SHAKESPEARE, HAMLET act 1, sc. 3.

119. Indeed, affection for domesticated pets was a key force in the shift of attitudes from dominion to stewardship of animals. *See, e.g.*, THOMAS, *supra* note 80, at 101-08.

120. Dr. Pangloss advised Candide that even in the face of adversity, "Il faut cultiver notre jardin." ("We must cultivate our garden."). VOLTAIRE, *Candide*, *in* CANDIDE AND OTHER STORIES 111 (Roger Pearson trans., Oxford Univ. Press 1990) (1759).

Fifth and most fundamentally, from a Darwinian ecologist's point of view, the distinction between "nature" and "human" is untenable. Evolutionary biology holds that humans, just like any other species, have evolved from other organisms. Thus, as a categorical (not normative) matter, humans and human activities are *part* of nature.[121] The logic of this point is significant: human activities are thus the extension of human evolution from shared ancestry with other species. On this view, it is natural selection that steered the differentiation of humans from other primates, and with that speciation came human intelligence and human behavior, including human tools and technologies.[122] As Weiner indicates, humans use tools, but so do other organisms (like finches' use of their beaks or the sticks and rocks they sometimes use to open seeds or excavate cactus cavities);[123] humans have consciousness, but so may other organisms;[124] humans change nature, but so do other organisms in ways that may adversely (or beneficially) affect neighboring organisms.[125] Human systems, such as economies, cultures, and polities, are subsystems nested within larger ecological and biogeochemical systems—examples of human competition and mutualism.[126]

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121. As Nash summarizes, "Darwin killed dualism." NASH, *supra* note 66, at 70. This is a key tenet of the new ecology. *See* Meyer, *supra* note 9, at 875. The new science resonates with a parallel epiphany in environmental ethics. Thoreau hoped "to regard man as an inhabitant, or a part and parcel of Nature." HENRY D. THOREAU, *Walking*, *in* GREAT SHORT WORKS OF HENRY DAVID THOREAU 294, 294 (Wendell Glick ed., Harper & Row 1982) (1862). Leopold described his land ethic: "In short, a land ethic changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it." ALDO LEOPOLD, A SAND COUNTY ALMANAC 219-20 (enlarged ed. 1966). As a metaphor for the human role in nature, the adoption of this holistic concept may be "one of the most profound changes in human history." Tarlock, *supra* note 7, at 1137 n.67 (quoting Eric T. Freyfogle, *The Moral Psychology of the Environmental Age*, *in* ENVIRONMENTAL FEDERALISM IN THE EUROPEAN UNION AND THE UNITED STATES (John Braden et al. eds., forthcoming 1994)). Roderick Nash says that placing humans on the same plane as other life forms—in the same ethical boat—would be "arguably the most dramatic expansion of morality in the course of human thought." NASH, *supra* note 66, at 7; *see also* PAUL W. TAYLOR, RESPECT FOR NATURE: A THEORY OF ENVIRONMENTAL ETHICS 9-14 (1986); Bill Devall, *The Deep Ecology Movement*, 20 NAT. RESOURCES J. 299, 309-12 (1980).

122. Thoreau thought a good book was as "natural" as a wild flower. THOREAU, *supra* note 121, at 314.

123. BEAK OF THE FINCH, *supra* note 1, at 18, 50-51, 280-82.

124. *Id.* at 281.

125. *Id.* at 64-65; Meyer, *supra* note 9, at 885 ("Organisms not only [a]dapt to the [e]nvironment, [t]hey [m]odify it."). Meyer points out that nonhuman life has determined the planet's temperature as photosynthesis, respiration, and evapotranspiration affect the levels of trace gases in the atmosphere. Meyer, *supra* note 9, at 885-86. Microorganisms put oxygen into the Earth's atmosphere, making life possible for larger aerobic organisms. BOTKIN, *supra* note 8, at 138; *see also* LOVELOCK, *supra* note 114, at 64-83 (arguing that oceanic phytoplankton regulate the Earth's temperature through emissions of trace gases).

126. *See* discussion *supra* note 38. Aldo Leopold also saw human politics as mutualism within one species. LEOPOLD, *supra* note 121, at 218. One wonders whether human activity is symbiotic with any other species—do humans help support ecosystems?

If all nature is interconnected,[127] humans are part of that interconnected web of life as well. If all nature is changing, we are part of that change. The new metaphor of nature is recast: we are not outside Weiner's "volcano plume" of life,[128] looking at its immobile form from afar; we are inside, helping (along with all other organisms) to create the shape and rumble of life's exploding plume.

IV
ADAPTING ENVIRONMENTAL LAW TO THE NEW ECOLOGY

Edging away from the static equilibrium paradigm and its separatist presumptions leaves us bereft of simple categorical answers to our role on the planet and thereby creates new challenges for environmental law. The new ecology teaches that disturbance and change is a "natural" part of dynamic evolution.[129] If so, and if humans are a result of evolution, then (as a categorical matter) human-induced change is no less "natural" than disturbance induced by other organisms. This poses a crucial question: once we accept that change is natural and human-induced change is also part of nature, how can we distinguish which changes are good and which are bad?[130] If environmental law is to be about risk management, and risk is the chance of an adverse outcome, how can we tell which changes in nature are adverse and which are benign? Under the separatist-dominion presumption, all human interventions into nature were appropriate; under the separatist-taint presumption, the balance of nature was true and good, and human interference was *per se* improper. Truly Darwinian evolution—a vision of nature in motion, as Weiner demonstrates, and of a nature that encompasses humans as well—wipes away the concept of a stable balance of nature, and along with it the dividing line between what is human and what is nature, what is presumptively good and presumptively bad.[131]

127. The legendary ecologist John Muir put it: "When we try to pick out anything by itself, we find it hitched to everything else in the universe." JOHN MUIR, MY FIRST SUMMER IN THE SIERRA 110 (Sierra Club Books 1988) (1911) (diary entry for July 27, 1869).

128. BEAK OF THE FINCH, *supra* note 1, at 111.

129. *See* Meyer, *supra* note 9, at 875-83. *See generally* BOTKIN, *supra* note 8.

130. Botkin views this question as the central challenge for environmental management in light of the new ecology. *See* BOTKIN, *supra* note 8, at 190-91. It has also been a central issue for those concerned about the aesthetics of urban land use. Robert Smithson argued that a park like New York City's Central Park can be neither "beautiful" nor "wild," but must ever be subject to change, chance, and uncertainty, and must include human involvement. *See* Robert Smithson, *Frederick Law Olmstead and the Dialectical Landscape*, ARTFORUM, Feb. 1973, at 62, 62-68.

131. Mark Sagoff describes the dilemma posed by the two separatist presumptions: "The question, then, is not whether ecologists should seek knowledge of or try to understand how nature works; rather, the question is whether ecologists should seek that knowledge which will help society protect the environment *for* or *from* efficient use and exploitation." He replies that, "[p]lainly, we require both kinds of knowledge." Mark

Of course, human activity may cause great and rapid changes. Human dams may be larger than beaver dams; humans may clear habitat and thus accelerate extinctions; anthropogenic global warming may occur faster than prior climate changes. But nonhuman agents may also cause enormous disruption: infectious microbes kill millions of humans (and other organisms) every year; vegetation releases pollutants; and plankton, plants, and other organisms have shaped the composition of the atmosphere far more than have humans (so far), adding oxygen where there was little and thereby utterly transforming life on this planet.[132] The issues are rate, magnitude, and consequences, not categories. The impacts of human activity today may be approaching that of major extinction events of the past,[133] but even that grave threat does not translate automatically into a normative judgment: we must evaluate it in terms of ecological consequences. Could we say that the mass extinctions that occurred sixty-five million years ago at the Cretaceous/Tertiary (K/T) boundary were categorically "right" or "wrong"? They were disastrous for some species (such as dinosaurs) and their aftermath gave birth or advantages to others (including a major boost for mammals like us).[134] Are today's extinctions worse than the K/T event because the K/T event was "natural" but today's event is at the hands of humans? To say yes is to accept the separatist paradigm and its taint presumption, and to ignore the teaching of Darwinian evolution that humans are just as much a product of nature as any other organism. Are the present extinctions better than the K/T event because today's disruption is at the hands of terrestrial nature (humans) whereas the K/T event was a perturbation of terrestrial nature by an extraterrestrial force (the asteroid)? To say yes simply applies the separatist paradigm at a more global level, asking the unanswerable question whether the asteroid was natural or not. From a consequentialist point of view, neither question is meaningful; what matters are the relative consequences of the events in terms of rates, magnitudes, and outcomes. We need

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Sagoff, *Ethics, Ecology, and the Environment: Integrating Science and Law*, 56 TENN. L. REV. 77, 171 (1988). My reply is that we need to escape the separatist paradigm altogether and deal with the complexities posed by humanity's role within dynamic ecology.

132. *See supra* note 125.

133. Wilson, *supra* note 110, at 10-12 ("The current reduction of diversity seems destined to approach that of the great natural catastrophes at the end of the Paleozoic and Mesozoic eras—in other words, the most extreme in the past 65 million years.").

134. Richard A. Kerr, *Who Profits from Ecological Disaster?*, 266 SCIENCE 28, 28 (1994). The ecologist Daniel H. Janzen says bluntly: "The caprice of one large meteor hitting the earth 65 million years ago . . . is responsible for the existence of humanity. Had the dinosaurs survived, with all their capacity for carnivory, the large mammals, including primates, would never have evolved." Daniel H. Janzen, *Yucatan Meteor: The Real Impact*, 258 SCIENCE 1071, 1071 (1992) (Nov. 13 letter to the editor).

some way of assessing these events and our best responses, without the categorical baggage of "natural."

Accepting the new ecology, with its nonequilibrium paradigm and its holistic view of the human role in nature, by no means makes environmental law aimless, nor invites unbridled human mischief against ecosystems. On the contrary, human actions still need to be judged, but judged by their consequences rather than by their categorical attributes. New ecologists make a point to caution that calling human activity "natural" does not make it normatively advisable nor permissible;[135] to think so is to be trapped in the old metaphor, to forget that "natural" no longer equates with safe or divine or good. The question is not whether human-wrought changes in the environment are more or less "natural" than changes wrought by the sun or asteroids or other organisms, but whether changes susceptible to human influence are desirable. The question is not whose hand built the dam, beaver or human, but rather what impacts will the dam have on the river?

Weiner gives some nice examples of the use of this consequentialist view in ecology. Darwin, champion of "natural selection," did not abhor "artificial selection" (breeding conducted by humans—a practice that has been conducted for millennia and that has evolved through adaptations of human tools into today's molecular genetic engineering); indeed Weiner reports that Darwin cherished cross-breeding of plants and animals by human handlers as a source of insight into variation and evolution.[136] Similarly, Weiner argues that the problem with anthropogenic global warming is not its categorical human-in-

135. Dan Tarlock emphasizes: "The nonequilibrium paradigm does not undermine the case for biodiversity protection because it accepts the principal lesson of ecology: Unregulated, humans harm ecosystems and the magnitude of human intervention is often too great." Tarlock, *supra* note 7, at 1130. Daniel Botkin warns: "[T]o accept certain kinds of change is not to accept all kinds of change. . . . [W]e must focus our attention on the rates at which changes occur . . . ." BOTKIN, *supra* note 8, at 156-57. Judy Meyer says:

> Danger lurks in misinterpretation of the new paradigm: if change is a part of nature, then can we view anthropogenic change as just part of the natural way? Absolutely not; the new paradigm is not a license for environmental abuse. Anthropogenic change differs from natural change in both quality and rate.

Meyer, *supra* note 9, at 882. Botkin and Meyer are correct to focus on "quality and rate"—the consequences of change rather than its categorical features—but whether anthropogenic change is *always* different in rate and impact from nonanthropogenic change is an empirical matter that cannot be decided by flat statements; and what to make of such differences is a normative policy matter that does not follow automatically from observed differences in rate and impact. As Donald Worster observes, "[S]ometimes we get confused by talk about all change being 'natural.' In a loose, the statement is true, but it is also meaningless . . . . The challenge is to determine which changes are in our enlightened self-interest and are consistent with our most rigorous ethical reasoning, always remembering our inescapable dependency on other forms of life." DONALD WORSTER, NATURE'S ECONOMY: A HISTORY OF ECOLOGICAL IDEAS 432 (2d ed., Cambridge University Press 1994).

136. Darwin himself avidly took to breeding pigeons. BEAK OF THE FINCH, *supra* note 1, at 31-35. Artificial selection was the accepted practice; it was natural selection that seemed to Darwin and his contemporaries a strange and mysterious process.

duced character, but that it may cause ecological changes that outstrip the adaptive capacity of other species, causing harm to ecological viability.[137]

Consider again the hypothetical examples raised earlier. If an asteroid were careening toward the Earth,[138] would human intervention to avert this "natural" extinction event be warranted? Under the categorical separatist-taint presumption, one must say no—and let the asteroid hit—unless one makes a consequentialist exception. From a consequentialist viewpoint, the answer depends on the outcomes of acting and not acting, and the weights or values placed on those outcomes. Clearly humans and many other species would be devastated by an event comparable to the asteroid impact that occurred at the K/T boundary; but there might be risks to human intervention as well.[139] In which scenario would the world be better off?[140] If the K/T aster-

137. *Id.* at 274-75. Weiner puts faith in human learning—a tool he believes we have developed driven by selection pressures to specialize in skills, just as a bird's beak evolves to give it special skills—to solve our ecological difficulties. *Id.* at 283-93; *see also* BOTKIN, *supra* note 8, at 193-94 (urging greater use of intelligence and technology to solve rather than cause ecological problems); Daniel A. Farber, *Environmental Protection As a Learning Experience*, 27 LOY. L.A. L. REV. 791, 791-98 (1994) (advocating "learning" from available environmental information in order to improve environmental protection).

138. *See* William J. Broad, *Big Comet May Strike Earth in August 2126*, N.Y. TIMES, Oct. 27, 1992, at C7; Boyce Rensberger, *The End Is Not As Near As They'd Thought: Asteroid Misses Earth; Comet Likely Will Too*, WASH. POST, Dec. 8, 1992, at A3.

139. For example, attempting to destroy a large asteroid might break it into smaller pieces that continue to rain down on the Earth. Astronomer Carl Sagan fears that the technology to deflect an asteroid away from the Earth might be used by a maniac to deflect an asteroid toward the Earth. *See* Carl Sagan, *A Warning for Us? Comets on a Collision Course with Jupiter*, PARADE MAG., June 5, 1994, at 12, 14.

140. By "the world" I include not only human utility, but, at least on first principles, every living thing on the planet. This is not a departure from utilitarianism; Jeremy Bentham advocated maximizing the happiness of everything that suffers, human and otherwise.

> He reasoned that "the blackness of the skin is no reason why a human being should be abandoned without redress to the caprice of a tormentor. It may come one day to be recognized, that the number of the legs, the villosity of the skin, or the termination of the *os sacrum* [i.e., spinal base], are reasons equally insufficient for abandoning a sensitive being to the same fate. . . . The question is not, Can they *reason*? nor Can they *talk*?, but Can they *suffer*?"

NASH, *supra* note 66, at 23 (quoting JEREMY BENTHAM, AN INTRODUCTION TO THE PRINCIPLES OF MORALS AND LEGISLATION 311 (L. LaFleur ed., 1948) (emphasis in original)). Problems of measurement—how do we know what suffers, and how much? how do we weigh one being's suffering against another's? should species extinction weigh more heavily than suffering by members of a viable species?—have led consequentialists to emphasize human utility, but this may be an instrumental shortcut rather than a principled distinction. Moreover, giving consideration to the well-being of nonhuman organisms in policymaking is not the same as, and does not require, conferring litigable legal rights (or equal rights) on such organisms in the human judicial system. *See generally* Christopher D. Stone, *Should Trees Have Standing?—Toward Legal Rights for Natural Objects*, 45 S. CAL. L. REV. 450 (1972) (discussing general extension of "rights" to the natural environment); CHRISTOPHER D. STONE, EARTH AND OTHER ETHICS: THE CASE FOR MORAL PLURALISM 43-44 (1987) (distinguishing between actionable "rights" and conferring of legal status or "considerateness"—i.e., recognition of some level of legal protection).

oid replaced dinosaurs with mammals, might the world be better off with whatever would replace humans? Should we avert the asteroid for the sake of the other living things now on the planet? What would we have wished the dinosaurs to do, if they had had our technology? What if the hazard were not an extraterrestrial asteroid but a terrestrial ice age; or a very natural microbe that threatened to wipe out most life on Earth—should we extinguish it?[141] In our efforts to save an endangered species, may we cause harm to others?[142] Or may we try to save an endangered species by paradoxically allowing harm to individual members of that species?[143]

The new metaphor gives no easy answers; it requires judgment about risks, consequences, and tradeoffs. It makes us face all sorts of hard questions about our role on Earth. The new view of nature that Weiner presents—dynamic, ever changing, in which humans are a part—places humans neither above nor below nature; we are inside the volcano plume, part of interdependent evolution, both created by nature and creating nature—just as is every other species. Still we must judge our actions, and we are sentient beings capable of such evaluation.[144] This requires a legal regime meant to manage and accommodate change based on its consequences, rather than to preserve a rigid baseline status or simple normative distinctions based on what is "human" versus "natural." Environmental laws based on a distinction between the "natural order" and any change in that order are clearly in for a bout of selection pressure themselves as the new ecology sweeps through policy. Neither "leaving nature alone" nor "dominion" manages risk or conserves wilderness or makes sense when nature is changing and we are part of nature.[145]

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141. Consider the debate over whether to annihilate smallpox or to preserve a small sample for future study, tolerating a risk of its escape. *See* Charles Siebert, *Smallpox Is Dead: Long Live Smallpox*, N.Y. TIMES, Aug. 21, 1994, Magazine sec., at 30, 32-33, 52, 55.

142. *See, e.g.*, Sierra Club v. Lyng, 694 F. Supp. 1260, 1268 (E.D. Tex. 1988) (ordering "thinning cuts" and "aggressive prescribed burning" of forests to save habitat for the endangered Red-Cockaded woodpecker).

143. Some conservation strategies seek to save a species from extinction by allowing people to harvest or hunt a set fraction of the species population, so that the species is of value to local humans who will in turn protect the species' habitat. Such policy has been advocated for the African elephant. *See* Brian Child, *A Perspective from Zimbabwe: The Elephant As a Natural Resource*, WILDLIFE CONSERVATION, Mar.-Apr. 1993, at 60, 60-61. May we sacrifice some individuals to protect the species or community? This debate has divided ecological biocentrists from animal rights ethicists. *See* NASH, *supra* note 66, at 158-60.

144. If humans are distinguishable from other life on Earth (if at all) by our capacity for intelligent judgment, it would be odd to establish a legal regime based on categories that preclude judgment; yet this is what we have done, under both the separatist-taint and separatist-dominion approaches. The new paradigm, in this sense, may be more human (humane?) than its categorical predecessors.

145. According to Dr. William M. Schaeffer of the University of Arizona:

The new holistic-consequentialist approach to the environment is evident in several strands of our evolving environmental law. New approaches are seeking to protect species from extinction not by prohibiting human interference, but by developing "habitat conservation plans" that consider humans as one resident in the shared biotic community and plan mutually harmonious resource uses.[146] Pollution laws are moving from technology-based and zero-discharge controls to performance-based controls that set standards based on the risk of environmental damage.[147] Takings law is moving from a "natural state" baseline to a standard based on a calculus of harm and benefit.[148] Perhaps most dramatically, environmental law is rapidly beginning to charge "natural resource damages" for injury to natural resources, including the loss of value to those who do not even use the land.[149]

More generally, environmental policy is and ought to be moving away from categorical rules toward weighing harms and benefits in policy judgments.[150] Judgment in environmental policy is inescapable and highly desirable in the world of the new ecology. But such judgment is complicated by the inadequacy of rigid quantitative cost-benefit analysis, which omits many kinds of important values, not least the

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> "[Dynamic ecology] really cuts the legs out from underneath this position that all we really have to do is leave these systems alone and everything's going to be ducky. . . . What we have to do is understand how these systems behave and then we as people can decide what we want, how to manage them appropriately."

Stevens, *supra* note 76, at C4.

146. *See* Bruce Babbitt, *Science: Opening the Next Chapter of Conservation History*, 267 SCIENCE 1954, 1954-55 (1995) (asserting that the Pacific Forest Plan, created by federal land management agencies under judicial order, signals a shift towards an ecosystem-wide approach to protecting biodiversity and sustainable economic activity); Jon Welner, *Natural Communities Conservation Planning: An Ecosystem Approach To Protecting Endangered Species*, 47 STAN. L. REV. 319 (1995); Tarlock, *supra* note 7, at 1141; BOTKIN, *supra* note 8, at 162.

147. *See* Paul R. Portney, *Reforming Environmental Regulation: Three Modest Proposals*, ISSUES SCI. & TECH., Winter 1988, at 74, 77 [hereinafter Portney, *Reforming Environmental Regulation*]. *See generally* Dudek et al., *supra* note 67 (arguing for application of market-based environmental laws rather than command and control regulation in Eastern Europe).

148. *See* Lucas v. South Carolina Coastal Council, 112 S. Ct. 2886, 2892-95, 2900 & n.15 (1992) (prescribing a case-specific inquiry that balances hardship and benefit).

149. PETER S. MENELL & RICHARD B. STEWART, ENVIRONMENTAL LAW AND POLICY 1180-1213 (1994); Ohio v. Department of the Interior, 880 F.2d 432, 438 (D.C. Cir. 1989) (invalidating regulations limiting natural resources damages recoverable under the Comprehensive Environmental Response, Compensation and Liability Act § 107(a)(C)). Charging for nonuse damages to natural resources reflects a fundamental change in the law's appreciation of the environmental benefits and costs of human action, though it is still focused on anthropocentric valuations of these benefits and costs. *See* Paul R. Portney, *The Contingent Valuation Debate: Why Economists Should Care*, J. ECON. PERSP., Fall 1994, at 3, 3 [hereinafter Portney, *Contingent Valuation*].

150. *See* Richard H. Pildes & Cass R. Sunstein, *Reinventing the Regulatory State*, 62 U. CHI. L. REV. 1, 7-10 (1995); Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (1993).

value of difficult-to-quantify ecological processes.[151] A more complex and embracing form of benefit-cost judgment, which includes consideration of qualitative factors, ecological risks and values, and uncertainties, is therefore in need of development.[152] A theory of judgment in the world of the new ecology must at least encompass the value of ecological viability and the greater character of loss when a species goes extinct than when members of a viable species expire. These issues are at the heart of current debates over the valuation of natural resource damages and the Endangered Species Act. Ultimately, the theory of judgment may need to go further still, to develop a method of weighing consequences that measures our impact on the biosphere in global terms and therefore is not limited solely to human valuations.[153] Such a biocentric (as opposed to anthropocentric) calculus, despite its methodological challenges and measurement problems, probably cannot be avoided for long unless we view ourselves as blithely separate from nature.[154]

The question forced by Weiner and others documenting the new ecology is thus what paradigm, what metaphor, shall shape the future of environmental law. If environmental law is to be about risk management and accommodating nature, rather than about preserving some static conception of a "natural order," it cannot rest easily on a natural-unnatural or human-nature dichotomy. Yet in order to make intelligent risk-management policy, some means of valuing environmental outcomes must be employed, and here environmental policy is pressing the edges of its niche. Whether we are trying to value ecological change in terms of human utility (as through contingent valuation surveys)[155] or in terms of more biocentric ecological risk analysis that would somehow take into account the values of nonhuman species,

151. *See, e.g.*, Pildes & Sunstein, *supra* note 150, at 64-65, 86; Alyson C. Flournoy, *Coping with Complexity*, 27 LOY. L.A. L. REV. 809, 815-16 (1994).

152. *See, e.g.*, HARVARD GROUP ON RISK MANAGEMENT REFORM, HARVARD SCH. OF PUB. HEALTH, REFORM OF RISK REGULATION: ACHIEVING MORE PROTECTION AT LESS COST 30-37 (1995); Richard B. Stewart, *The Role of the Courts in Risk Management*, 16 Envtl. L. Rep. (Envtl. L. Inst.) 10,208, 10,208-09 (1986).

153. *See* Christopher D. Stone, *The Environment in Moral Thought*, 56 TENN. L. REV. 1, 2-4 (1988). For a brief discussion of nonhuman values in a utilitarian calculus, see *supra* note 140.

154. Of course, recognizing humanity's own evolution as part of nature does not by itself indicate whether the human species prospers most successfully in competition or mutualism with other species. Most likely we are largely interdependent with other life and therefore find it in our own interest to protect other life; but there is the lingering possibility that we are parasites on the planet, ready to move to another host if Earth becomes uninhabitable (perhaps by our own hand, or for other reasons).

155. The contingent valuation method uses surveys of people asking them to estimate their willingness to pay to save an environmental resource, or willingness to accept a payment in return for the loss of the resource. MENELL & STEWART, *supra* note 149, at 1192-97; Portney, *Contingent Valuation*, *supra* note 149, at 5-6.

these measurement methods are both technically and philosophically controversial. In addition, we will need far more information about environmental status and trends, and the dynamics of natural systems, in order to predict and evaluate the consequences of our actions.[156] Weiner's book raises a difficult question: if nature is perpetually changing and undergoing disturbance, how can we distinguish an adverse change from a benign disturbance? Darwin noted that "extinction and natural selection go hand in hand."[157] If human activity changes habitats, which impacts—reducing populations of some species but increasing populations of others—should be deemed adverse consequences and which benign? Ultimately, the new view of nature-in-motion that Weiner presents in *The Beak of the Finch* impels us to confront these valuation problems, because otherwise we cannot exercise good judgment amidst the turbulent plume of "natural" ecological changes of which we are a part.

156. *See* BOTKIN, *supra* note 8, at 192, 197-98; Portney, *Reforming Environmental Regulation*, *supra* note 147, at 75-77.

157. BEAK OF THE FINCH, *supra* note 1, at 40 (quoting Charles Darwin).