AUSTRIAN ECOLOGY: RECONCILING DYNAMIC ECONOMICS AND ECOLOGY

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Nature is not more complex than we think, but more complex than we can think.
—Frank Egler[1]

INTRODUCTION

The fields of economics and ecology largely developed independently of one another. Economic theories of human action seldom concern themselves with ecological theories of nonhuman interactions, nor do ecologists concern themselves with economic theories of human action. Each defines their field so as to exclude the other. For the ecologist, human action is considered a disrupter of natural ecosystem processes. For the economist, ecosystems are important only insofar as they affect the fundamental constraints of resource scarcity. Such a division has prevented ecologists and economists from integrating their understandings of the interrelationship between human action and the natural world.

Despite their different scopes of study, the development of mainstream ecological theory in many ways parallels the development of neoclassical economic theory. Both interpret the complex interactions of individuals through the lens of equilibrium analysis. The models used to understand ecosystems and economics are based on the assumption that each system achieves or exists in balance with itself. Ecologists, for instance, traditionally rely on models that assume an inherent balance of nature. Likewise, neoclassical economists study markets as if they exist in or rapidly attain a state of equilibrium. The assumptions of general equilibrium in economic theory are comparable to the balance-of-nature assumption that underlies most ecological theories. Over the last century, the standard practice of each field has been to formalize these equilibrium foundations into abstract mathematical theories. These equilibrium assumptions have had important implications for both economic and environmental policy.

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[1] FRANK EDWIN EGLER, THE NATURE OF VEGETATION, ITS MANAGEMENT AND MISMANAGEMENT: AN INTRODUCTION TO VEGETATION SCIENCE 2 (1977).

In addition to their parallel developments, modern ecological theory and neoclassical economic theory have received remarkably similar critiques from within of their assumptions and methodologies. Recent research in ecology has challenged traditional ecological theory in a manner similar to the Austrian critique of neoclassical economics. Ecologists are increasingly rejecting equilibrium analysis and adopting a view of ecosystem dynamics that is similar in many ways to the Austrian theory of the market process. According to each critique, a focus on points of equilibrium ignores the realities of human action and ecological interactions and distracts researchers from the dynamic forces that shape markets and ecosystems.

The purpose of this paper is to explore the linkages between ecology and economics through the lens of Austrian economics. Drawing upon recent theoretical advancements in ecological theory, I consider how these ideas relate to the insights of Austrian economists and discuss the implications of a more dynamic and integrated perspective of economics and ecology. By linking the two together, I aim to address the interconnectedness between human action and the natural world and attempt to reconcile dynamic economics and ecology through a new lens of what I will call "Austrian ecology."

Reconciling economics and ecology is important, if not essential, in light of the increasing recognition of the extent to which humans influence the environment. These effects go beyond anthropogenic global climate change. More than at any point in the history of ecology, scientists are concluding that human action cannot readily be separated from the natural world.[2] Research in paleoecology and other fields is revealing that landscapes once thought to be uninfluenced by humans were in fact dramatically affected by indigenous human action.[3] A new generation of conservationists is increasingly rejecting the idea of pristine nature as a worthy or practical conservation goal and adopting a more nuanced vision of the environment that includes human action.[4] Scientists have even proposed—and are in the process of considering—changing the current geologic era from the Holocene to the Anthropocene (the "age of man") to reflect the magnitude of human influences on the natural world.[5] The Anthropocene concept

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2 *See, e.g.*, Peter Kareiva & Michelle Marvier, *What is Conservation Science?*, 62 BIOSCIENCE 962, 962 (2012) ("Today, one of the most important intellectual developments is the recognition that ecological dynamics cannot be separated from human dynamics . . . .").

3 *See, e.g.*, CHARLES C. MANN, 1491: NEW REVELATIONS OF THE AMERICAS BEFORE COLUMBUS 319 (2005) (discussing the Amazon rainforest).

4 Peter Kareiva, Michelle Marvier & Robert Lalasz, *Conservation in the Anthropocene: Beyond Solitude and Fragility*, 2 BREAKTHROUGH J. 29 (2012) [hereinafter Kareiva et al., *Conservation in the Anthropocene*]. *See generally* EMMA MARRIS, RAMBUNCTIOUS GARDEN: SAVING NATURE IN A POST-WILD WORLD (2011).

5 *See* Paul J. Crutzen & Eugene F. Stoermer, *The "Anthropocene,"* IGBP NEWSL., May 2000, at 16; Will Steffen et al., *The Anthropocene: Are Humans Now Overwhelming the Great Forces of Na-*

makes linking economics and ecology a necessity, because virtually all ecological activity is influenced in some way by human action.

An Austrian ecological perspective implies a new framing for questions of environmental policy, one that should be considered by ecologists and economists alike. Once we accept that nature is dynamic and profoundly shaped by and connected to human action, we are compelled to see environmental problems through a different lens. In this view, environmental problems cannot be thought of as simply the consequence of human violations on the balance of nature. A new generation of ecologists has rejected the notion of a natural harmony in ecosystems. Nor can environmental problems be solved by simply separating the natural environment from human influences. The notion of the Anthropocene suggests that doing so is impractical or even impossible. Instead, environmental problems become questions of how to resolve competing human demands on an ever-changing natural world. The central environmental question, then, is how the institutions that govern these competing demands connect dynamic human action to dynamic nature.

The remainder of this paper proceeds as follows: Part I explores nature as a dynamic process and discusses how ecologists are rethinking the traditional equilibrium ecological framework. This new ecological perspective increasingly considers the impacts of human action as a part of or within the context of ever-changing ecological dynamics. Nevertheless, the traditional assumptions of equilibrium in nature still serve as the foundation of many environmental policies today. Part II traces the linkages between a dynamic view of ecology and Austrian economic theory. Indeed, the dynamic ecology perspective is challenging traditional ecological paradigms in much the same way that the Austrian school has challenged mainstream economic theory. Part III concludes by discussing the implications of these linkages and considers whether a more encompassing theory of dynamic economic and ecological processes, or "Austrian ecology," is a useful idea.

I. DYNAMIC ECOLOGY

Yosemite is best known for its scenic grandeur. Long before the region was set aside for protection, visitors marveled at its sheer granite walls, ancient trees, and towering waterfalls. Carleton Watkins' famous photograph of El Capitan, a 3,000-foot rock extending from the floor of

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ture?, 36 AMBIO 614-21 (2007). *See generally* Jan Zalasiewicz et al., *Are We Now Living in the Anthropocene?*, GSA TODAY, Feb. 2008, at 4 (making the case that sufficient evidence exists to recognize the Anthropocene as a new geological epoch); Paul Voosen, *Geologists Drive a Golden Spike Toward Anthropocene's Base*, GREENWIRE (Sept. 17, 2012), http://www.eenews.net/stories/1059970036 (describing how the International Commission on Stratigraphy is considering whether to formally propose the Anthropocene as a new epoch).

Yosemite Valley, was especially influential in attracting national attention to the area. The photograph, taken in 1868, reveals a valley sparsely populated with trees against the backdrop of El Capitan's granite face.[6]

Visitors to Watkins' spot today, however, no longer share his view. When the photograph was recreated in 1944, El Capitan was hardly visible through the encroaching forest.[7] Now the view is entirely obstructed by trees. Another photograph taken by Watkins in 1866 reveals a similar story. From Union Point, high above Yosemite Valley, Watkins' image shows the valley thinly scattered with trees. Later photographs from Union Point demonstrate just how much Yosemite Valley has changed.[8] The meadows that once offered stunning vistas have been almost completely swallowed by the forest.[9] The oak woodlands that dotted the landscape have been replaced by more aggressive, shade-tolerant conifer tree species.[10] The valley that Watkins captured with his camera more than a century ago had dramatically changed.[11]

In response to this enormous increase in forest growth, the National Park Service (NPS) initiated a plan in 2011 to cut thousands of trees in Yosemite National Park.[12] Currently underway, the plan attempts to restore the park's historic scenic vistas by clearing trees and other vegetation from nearly 100 viewsheds that have been obscured or completely hidden by the forest.[13] Arguably, the NPS's mandate "to conserve the scenery" and "to

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[6] Carleton E. Watkins, *Tutocanula, El Capitan, 3600 feet*, CARLETONWATKINS.ORG, http://www.carletonwatkins.org/getviewbyid.php?id=1001174.

[7] *See Scenic Vista Management Plan—Yosemite National Park*, NAT'L PARK SERV., http://www.nps.gov/yose/parkmgmt/vista.htm (last updated May 3, 2015).

[8] *See* Carleton E. Watkins, *View from Union Point, 1866*, SAN JOAQUIN VALLEY LIBRARY SYS. (1866), http://content.cdlib.org/ark:/13030/kt6d5nc840/?docId=kt6d5nc840&layout=printable-details; Robert P. Gibbens, *View from Union Point, 1961*, SAN JOAQUIN VALLEY LIBRARY SYS. (1961), http://content.cdlib.org/ark:/13030/kt2s201931/?docId=kt2s201931&layout=printable-details; *see also* NAT'L PARK SERV., SCENIC VISTA MANAGEMENT PLAN FOR YOSEMITE NATIONAL PARK: FINDING OF NO SIGNIFICANT IMPACT (2011), *available at* http://www.nps.gov/yose/parkmgmt/upload/Scenic-Vista-Mgt-Plan-FONSI.PDF.

[9] *See* NAT'L PARK SERV., SCENIC VISTA MANAGEMENT PLAN FOR YOSEMITE NATIONAL PARK: ENVIRONMENTAL ASSESSMENT I-3 (2010), *available at* http://www.nps.gov/yose/parkmgmt/upload/SVMP_YOSE_EA.pdf [hereinafter ENVIRONMENTAL ASSESSMENT] ("There are few places on the Valley floor from which upper and lower Yosemite Falls are visible. The 'Postage Stamp' vista of El Capitan, made famous in the 1934 one-cent postage stamp engraving from an 1868 Carleton Watkins photograph, is now obscured by conifers . . . .").

[10] *Id.*

[11] *See generally* ROBERT P. GIBBENS & HAROLD F. HEADY, THE INFLUENCE OF MODERN MAN ON THE VEGETATION OF YOSEMITE VALLEY 36 (1964) (demonstrating in photographs and text the dramatic changes in vegetation across Yosemite).

[12] ENVIRONMENTAL ASSESSMENT, *supra* note 9, at I-1–I-2.

[13] *See* NAT'L PARK SERV., SCENIC VISTA MANAGEMENT PROGRAM WORK PLAN 2014 (2014), *available at* http://www.nps.gov/yose/parkmgmt/upload/2014-Scenic-Vista-Work-Plan.pdf.

provide for the enjoyment of the same" compelled the agency to actively intervene to preserve Yosemite's scenic vistas.[14]

As Watkin's photographs suggest, throughout much of the Yosemite region, the landscape today is much different from the one seen by early preservationists. "The inviting openness of the Sierra woods is one of their most distinguishing characteristics," wrote John Muir in 1894.[15] Frederick Law Olmsted's report on Yosemite in 1865 described "miles of scenery" and "the most tranquil meadows," creating what he called "the greatest glory of nature."[16] Since then, the National Park Service estimates 75 to 90 percent of those meadows have been lost to the forest.[17]

The scenery that preservationists sought to protect was a landscape largely shaped by human influence.[18] Prior to the creation of the park, Native Americans regularly set fire to Yosemite Valley to clear forests, maintain open meadows, and grow food.[19] Frequent fires promoted the growth of scattered stands of black oaks, from which Indians gathered acorns.[20] The grassy meadows were seen by early white settlers, who brought with them livestock to graze in the open fields.[21] In an important sense, the tranquil meadows seen by Muir and Olmsted were as much the product of human action as they were the greatest glory of nature.

If the Yosemite depicted in early photographs was the product of human influence, then to what state should it be managed today? Should park managers maintain Yosemite in the state that existed when the park was first created? Or should the valley be managed to an even earlier era, one that existed before Indians began impacting the land? The *Leopold Report*, authored by a group of scientists in 1963 to guide wildlife management in national parks, stated that parks should be maintained "in the condition that

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14 The National Park Service Organic Act directs the National Park Service "to conserve the scenery, natural and historic objects, and wild life in the System units and to provide for the enjoyment of the scenery, natural and historic objects, and wild life in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." *See* 54 U.S.C. § 100101. The Statute also states that the director of the NPS "may . . . dispose of timber in cases where, in the judgment of the Secretary, the cutting of timber is required to control attacks of insects or diseases or otherwise conserve the scenery or the natural or historic objects in any System unit." 54 U.S.C. § 100753.

15 JOHN MUIR, THE MOUNTAINS OF CALIFORNIA 140 (2d ed. 1901) (1894), *available at* http://vault.sierraclub.org/john_muir_exhibit/writings/the_mountains_of_california/chapter_8.aspx.

16 Frederick Law Olmsted, *The Yosemite Valley and the Mariposa Big Tree Grove*, *in* AMERICA'S NATIONAL PARK SYSTEM: THE CRITICAL DOCUMENTS 12, 16 (Lary M. Dilsaver ed., 1994).

17 *Shifting Views on Fire—Yosemite National Park*, NAT'L PARK SERV., http://www.nps.gov/yose/parkmgmt/fire-history.htm (last updated May 3, 2015) (noting that "as much as 75 to 90 percent of meadows [in Yosemite Valley today] have been lost to tree encroachment").

18 *See generally* GIBBENS & HEADY, *supra* note 11.

19 ALFRED RUNTE, YOSEMITE: THE EMBATTLED WILDERNESS 38-39 (1993).

20 *Id.*

21 *Id.*

prevailed when the area was first visited by the white man."[22] Where this was not possible, the report concluded, a "reasonable illusion of primitive America could be recreated, using the utmost in skill, judgment, and ecologic sensitivity."[23] But is such a "reasonable illusion" even possible? What would such a landscape even look like?

The forests of Yosemite are just one illustration of how the idea of the balance of nature pervades the way we think about the environment. Indeed, for much of their history ecologists have tended to study ecological systems as if they achieved equilibria. Although equilibrium models are analytically appealing, they have proven to be inconsistent with the way ecosystems function in reality. By focusing on equilibrium conditions, ecologists have often overlooked the dynamic natural and human processes that shape ecosystems.

A. *Discordant Harmonies and the Balance of Nature*

The idea of stability and equilibrium in nature has deep historical roots, dating back at least to the ancient Greeks.[24] Writing in the nineteenth century, George Perkins Marsh, one of America's first environmentalists, expressed the prevailing view in this way: "Nature, left undisturbed, so fashions her territory as to give it almost unchanging permanence of form, outline, and proportion, except when shattered by geological convulsions . . . ."[25] Even in such rare events as geological convulsions, nature "sets herself at once to repair the superficial damage, and to restore, as nearly as practicable, the former aspect of her dominion."[26] Any changes that do occur are so slow that for all practical purposes nature "may be regarded as constant and immutable."[27] Were it not for man's influence, Marsh writes, nature "would have been constant in type, distribution, and proportion, and the physical geography of the earth would have remained undisturbed for indefinite periods."[28]

The emergence of the science of ecology in the early twentieth century rejected this pure expression of stable nature undisturbed by humans. Clearly, nature did not always remain the same. It often evolved, even without significant human influence. Internal forces other than "geological

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22 A. STARKER LEOPOLD, STANLEY A. CAIN, CLARENCE M. COTTAM, IRA N. GABRIELSON & THOMAS L. KIMBALL, NAT'L PARK SERV., WILDLIFE MANAGEMENT IN THE NATIONAL PARKS 3 (1963).

23 *Id.* at 4.

24 *See* Frank N. Egerton, *Changing Concepts of the Balance of Nature*, 48 Q. REV. OF BIOLOGY 322 (1973) (offering a detailed history of the balance of nature).

25 GEORGE PERKINS MARSH, MAN AND NATURE: OR, PHYSICAL GEOGRAPHY AS MODIFIED BY HUMAN ACTION 27 (Charles Scribner, 1864).

26 *Id.* at 27.

27 *Id.* at 34.

28 *Id.* at 38.

convulsion" exerted influence on natural communities. Beavers, for example, altered their landscapes. Temperatures fluctuated and droughts occasionally affected entire regions. Fires and floods at times dramatically changed the composition of species that could survive in certain areas. The vision of a completely static and balanced nature undisturbed by humans espoused by Marsh was certainly false.

In place of Marsh's simple vision of unchanging nature, however, the nascent field of ecology adopted the idea of ecological succession. Led by Eugenius Warming, a Danish plant geographer and author of *The Oecology of Plants: An Introduction to the Study of Plant Communities*, in 1909, scientists began to consider how plant communities transitioned from one community to another in a given area, ultimately arriving at a "climax" state or final community. In this view, nature was not necessarily unchanging, apart from human activity. It could be affected by drought, fires, and other natural forces, but it would progress through various stages of succession until it reached its final "climax" formation.[29]

Although Warming's idea of ecological succession implied at least some form of change, it was ultimately consistent with the notion of the balance of nature. The climax equilibrium was the ultimate equilibrium, perfectly balanced and self-perpetuating unless disturbed. As the science of ecology progressed, various ecologists extended Warming's ideas of succession further into the scientific parlance. Most notable was Frederic Clements of the University of Nebraska, whose influence on the emerging field of ecology in the early twentieth century is difficult to overstate. According to Oxford ecologist A.G. Tansley, Clements was "by far the greatest individual creator of the modern science of vegetation."[30]

Like Warming, Clements thought that ecosystems developed through a predictable succession of stages until they reached a climax state that persists indefinitely unless disturbed.[31] The exact outcome of this climax state was ultimately determined by the climate.[32] In every given climate, there existed a mature climax stage or equilibrium. This process of succession could be plotted by scientists for each climatic region, and once the climax stage was attained, it would remain in balance with itself, barring any external disturbance or major climatic shift.

The other influential facet of Clements work was his organismic view of plant formation. He considered the evolution of climax plant formations

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29 DONALD WORSTER, NATURE'S ECONOMY: A HISTORY OF ECOLOGICAL IDEAS, 198-202 (2d ed. 1994). *See generally* EUG. WARMING, OECOLOGY OF PLANTS: AN INTRODUCTION TO THE STUDY OF PLANT COMMUNITIES (1909).

30 WORSTER, *supra* note 29, at 209.

31 Frederic E. Clements, *Nature and Structure of the Climax*, 24 J. OF ECOLOGY 252, 256 (1936).

32 *Id.* at 253 (noting that "the climax constitutes the major unit of vegetation and as such forms the basis for the natural classification of plant communities").

as a kind of "complex organism" of its own.[33] Historian Donald Worster describes Clements' "underlying, almost metaphysical faith that the development of vegetation must resemble the growth process of an individual plant or animal organism."[34] This "superorganism" was "of a higher order than an individual geranium, robin or chimpanzee," according to Clements.[35] To Clements, a plant community was best understood as a collective organism rather than as an individual species. Entire communities evolved together through stages of succession into a mature adult form determined by conditions of a given climate.

The idea of Clementsian succession had a far-reaching impact on conservation and environmental values in the twentieth century. The idea of an equilibrium climax forest left little room for humans, other than as a disrupter of nature's final balance.[36] It implied that human action upset a predetermined balance that nature tended toward and a final state that would persist otherwise. "The notion of a superior climax state gave a scientific validation to the conservationist's case against the machine and the farmer," according to Worster, serving as "the yardstick by which man's intrusions into nature could be measured."[37]

Clements' ideas of a climax state and "superorganisms" were quickly challenged. In 1926, Henry Gleason of the University of Michigan published *The Individualistic Concept of the Plant Association,* a direct challenge to Clements' organismic notion of plant communities.[38] As the title implies, Gleason argued in favor of a more individualistic view of nature. In Gleason's view, plants formations "are mere accidental groupings, each the result of unique circumstances and too loosely related to be likened to an organized being," writes Worster.[39] Each species responds individually to its environmental conditions and the composition of species on a landscape changes continuously across time and space. The characterization by Clements of plant communities as collective superorganisms was thus a useless abstraction from the actual workings of ecosystems described in Gleason's "individualistic" conception of nature.

Like Gleason, A.G. Tansley refused to drink the "pure milk of the Clementsian word."[40] Tansley claimed that in any given region, there may be a variety of outcomes that could be considered climax states. Why should ecologists focus their attention on the equilibrium state of the climax

33 FREDERIC E. CLEMENTS, PLANT SUCCESSION: AN ANALYSIS OF THE DEVELOPMENT OF VEGETATION, 141 (1916).

34 WORSTER, *supra* note 29, at 211.

35 *Id.* (internal quotation marks omitted).

36 *Id.* at 240.

37 *Id.* at 234, 242.

38 Henry A. Gleason, *The Individualistic Concept of the Plant Association,* 53 BULL. OF THE TORREY BOTANICAL CLUB 7 (1926).

39 WORSTER, *supra* note 29, at 239.

40 *Id.*

forest, for example? But of more concern to Tansley was the separation of human activity from the ideas of plant succession and climax formation.[41] Did human actions not help create climax systems? Is there a meaningful difference between a balance achieved by nature alone and a balance determined by man? Tansley thought the idea of climax formation should consider both possibilities.

Despite the individualistic view of Gleason and the anthropogenic view of Tansley, the modern science of ecology developed in earnest with Eugene Odum and systems ecology. Considered a pioneer of modern ecosystem ecology, Odum used different language than Clements, but "he did not depart from Clements' notion that the law of organic nature was to bring order and harmony out of the chaotic materials of existence," according to Worster.[42] Succession, Odum wrote in 1969, is "an orderly process of community development that is reasonably directional and, therefore, predictable" and "culminates in a stabilized ecosystem."[43] In the 1960s and 1970s, systems ecology focused on the energy and nutrient flows through ecosystems, borrowing terms such as "producers" and "consumers" from economics to model inputs and outputs. The systems approach assumed a balancing out between various producers and consumers within ecosystems, adopting a similar equilibrium framework that had simultaneously emerged in the economics profession. Still, Odum's science of ecology largely ignored human actions as a relevant consideration other than as disrupters of nature's balance.[44]

In the latter part of the twentieth century, however, an internal critique of modern ecology began to emerge. Ecological research increasingly found that the equilibrium models theorized by early twentieth-century ecologists did not adequately explain the dynamic interactions that occur within ecosystems. Over the last several decades, some ecologists began to explicitly challenge the notion of a balance of nature that underlies most traditional ecological theories. "Another generation of ecologists began to

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41 *Id.* at 239-40.

42 *Id.* at 367.

43 DANIEL B. BOTKIN, THE MOON IN THE NAUTILUS SHELL: DISCORDANT HARMONIES RECONSIDERED 75 (2012) [hereinafter BOTKIN, THE MOON]; *see also* Robert V. O'Neill, *Is It Time to Bury the Ecosystem Concept? (With Full Military Honors, Of Course!)*, 82 ECOLOGY 3275, 3275-76 (2001). As O'Neill explains,

> Systems Analysis dealt with complex systems as interconnected components with feedback loops that stabilized the system at a relatively constant equilibrium point. Systems Analysis can be seen underlying E. P. Odum's . . . definition of the ecosystem as a ". . . natural unit that includes living and nonliving parts interacting to produce a stable system in which the exchange of materials between the living and nonliving parts follows circular paths . . . ."

O'Neill, *supra*, at 3275-76 (internal citation omitted).

44 Odum seemed to later contradict his earlier theory, writing in 1992 that "an ecosystem is a thermodynamically open, far from equilibrium, system," reflecting a broader paradigm shift among ecologists at the time. Eugene P. Odum, *Great Ideas in Ecology for the 1990s*, 40 BIOSCIENCE 542, 542 (1992).

question all the older ideas, theories, and metaphors, even to assert that nature is inherently unsettled," explains Worster.[45]

One question in particular was whether the outcome of ecological succession was a stable equilibrium or not. A study by William Drury and Ian Nisbet, published in 1973, revived Gleason's individualistic conception of nature.[46] The authors studied New England's temperate forests and concluded that the process of ecological succession did not lead anywhere in particular and never reached a point of equilibrium. None of Clements' or Odum's criteria for a mature "climax" ecosystem emerged. Instead a "shifting mosaic" was observed.[47] Increasingly, ecologists rejected assumptions of steady-state equilibria and instead began to focus on "disturbances," both natural and man-made, as part of an ever-changing mosaic of environmental conditions.[48]

The critique of equilibrium ecology is most forcefully made by ecologist Daniel Botkin. In his influential book, *Discordant Harmonies: A New Ecology for the Twenty-First Century,* Botkin documents how the conventional view of a balance of nature apart from human action is unsupported by the evidence. In reality, Botkin argues, "nature undisturbed is not constant in form, structure, or proportion, but changes at every scale of time and space."[49] According to Botkin,

> the true idea of a harmony of nature . . . is by its very essence discordant, created from the simultaneous movements of many tones, the combination of many processes flowing at the same time along various scales, leading not to a simple melody but to a symphony at some times harsh and at some times pleasing.[50]

This is in sharp contrast to the Clementsian faith in a predictable endpoint of succession, or what Botkins characterizes as the belief "that nature's melody leads to one final chord that sounds forever."[51]

Consider the wilderness of the Boundary Waters region, for example, located on the Canadian border of Minnesota. Using pollen records deposited in nearby lakes, scientists now know that since the end of the last ice age, the forest passed from tundra, to spruce, to pine, to birch and alder, and

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45 WORSTER, *supra* note 29, at 389.

46 William H. Drury & Ian C. T. Nisbet, *Succession,* 54 J. ARNOLD ARBOR 331 (1973).

47 WORSTER, *supra* note 29, at 391 ("The forest, they insisted, no matter what its age, was nothing but an erratic, shifting mosaic of trees and other plants.").

48 *See* MARRIS, *supra* note 4, at 26. In 2004, a group of scientists recommended ecologists reconsider the application of equilibrial perspectives to ecological systems, explaining, "this idea has been rejected on the basis of the weight of evidence." Gary E. Belovsky et al., *Ten Suggestions to Strengthen the Science of Ecology,* 54 BIOSCIENCE 345, 348 (2004).

49 DANIEL B. BOTKIN, DISCORDANT HARMONIES: A NEW ECOLOGY FOR THE TWENTY-FIRST CENTURY 62 (1990) [hereinafter BOTKIN, DISCORDANT HARMONIES].

50 *Id.* at 25.

51 *Id.* at 116.

then back to spruce and pine, changing composition every few thousand years. These changes occurred even though, for much of that time, the area had largely been spared from the impact of humans. Likewise, the traditional logistic growth curves and Lotka-Volterra models of oscillating predator-prey relationships have never been observed to fluctuate as classical equilibrium models would suggest.[52] In fact, as Botkin explains, the only instance in which such Lotka-Volterra stability has been observed is in a laboratory using single-celled microbes under extremely controlled conditions.[53]

In Botkin's view, these equilibrium constructs reduce the biological world to a mechanistic system:

> Strictly speaking, the logistic can accurately describe only a population to which all required resources are available at a constant rate, and whose members are exposed to all toxins (except those generated by themselves) at a constant rate. A logistic moose responds instantaneously to changes in the size of the population; there is no history, no time lags, no seasons; a logistic moose has no fat.[54]

As ecologist Frank Golley describes, "In the ecosystem model, species acted abstractly, like robots."[55] With such a mechanistic view of nature, it is difficult, if not impossible, not to ascribe a certain purposefulness to ecosystem processes.[56] Botkin criticizes this teleological element of ecology as a persistent and well-known flaw in ecological analysis as well as in non-scientific discussions of environmental problems.[57]

The changes that have occurred in Yosemite Valley since Carleton Watkins' photographs demonstrate, in part, the dynamic processes that are inherent within ecosystems. As Botkin argues, nature undisturbed by man is not a "Kodachrome still-life," but rather "a moving picture show," continually changing "at every scale of time and space."[58] Even in relatively wild places such as Yosemite and Yellowstone, ecosystems are constantly in flux.[59] Tree-ring studies suggest that Yellowstone's forest ecosystem

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52 *Id.* at 36. The Lotka-Volterra equations, named after two of the first scientists to apply this type of theory to population growth, describe the relationship between predator and prey.

53 *Id.* at 56-60.

54 *Id.* at 36-37.

55 FRANK B. GOLLEY, A HISTORY OF THE ECOSYSTEM CONCEPT IN ECOLOGY 106 (1993).

56 This is perhaps most evident in the metaphor of Gaia as Mother Earth, which is still common in modern discussion of global environmental problems. *E.g.*, JAMES E. LOVELOCK, GAIA: A NEW LOOK AT LIFE ON EARTH (1979).

57 BOTKIN, THE MOON, *supra* note 43, at 136-37.

58 BOTKIN, DISCORDANT HARMONIES, *supra* note 49, at 6.

59 J.A. Lutz, J.W. van Wagtendonk & J.F. Franklin, *Twentieth-Century Decline of Large-Diameter Trees in Yosemite National Park, California, USA*, 257 FOREST ECOLOGY AND MGMT. 2296-2307 (2009) (noting that "far from being the most unchanging component of Yosemite forests, large-diameter tree populations are undergoing directional change on multi-decadal timescales").

lacks a single steady state.[60] Wildlife populations, as well, have historically lacked stability.[61] Whether these dynamic forces are simply the result of ever-changing ecosystem processes or are driven primarily by human influence is often not clear. As scientists are discovering, the natural world cannot easily be separated from human action. The dynamic processes we see in nature are closely linked to ever-changing human actions, which make up another important piece of the shifting mosaic of human-nature interactions.

B. *Ecology in the Anthropocene*

When Maria Lebrado was a child, her Ahwahneechee tribe was driven out of Yosemite Valley by the Mariposa Battalion. Seventy-eight years later, in 1929, she returned for the first time. A guide later recalled her reaction: "Two young men drove us over the Valley she had not seen since her childhood. The wide open meadow of her day was covered with trees and shrubs. She shook her head, saying, 'Too dirty; too much bushy.'"[62]

The Yosemite scenery that early preservationists sought to protect was dramatically influenced by humans. "Much of the landscape in California that so impressed early writers, photographers, and landscape painters was in fact a cultural landscape, not the wilderness they imagined," writes ethnobiologist M. Kat Anderson.[63] "While they extolled the 'natural' qualities of the California landscape, they were really responding to its human influence."[64] Early preservationists such as John Muir objected to Indians' use of fire, a position that would later develop into federal policies of fire suppression and an emerging conservationist vision of nature apart from man.[65]

It was not until the 1970s that the National Park Service recognized the folly of its fire suppression policies. By then an enormous fuel load had accumulated in Yosemite. Forest growth transformed meadows into dense stands of trees. Giant sequoias were no longer regenerating, having evolved to rely on disturbances such as fire.[66] Many of the viewsheds that

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60 William H. Romme, *Fire and Landscape Diversity in Subalpine Forests of Yellowstone National Park*, 52 ECOLOGICAL MONOGRAPHS 199 (1982).

61 *See generally* BOTKIN, THE MOON, *supra* note 43, at 43-67; YELLOWSTONE'S WILDLIFE IN TRANSITION (P.J. White, Robert A. Garrott & Glenn E. Plumb eds., 2013).

62 *See* MRS. H.J. TAYLOR, THE LAST SURVIVOR (1932), *available at* http://www.yosemite.ca.us/library/the_last_survivor/.

63 M. KAT ANDERSON, TENDING THE WILD: NATIVE AMERICAN KNOWLEDGE AND THE MANAGEMENT OF CALIFORNIA'S NATURAL RESOURCES 158 (2005).

64 *Id.*

65 SHEPARD KRECH, THE ECOLOGICAL INDIAN: MYTH AND HISTORY 102 (1999) (noting that John Muir regarded fire as "the great master-scourge of the forest" and Indians as destructive in their use of it).

66 Sequoia seedlings were only sprouting where dirt roads had opened the canopy and allowed sunlight to reach the exposed soil. *See* THOMAS H. HARVEY, HOWARD S. SHELLHAMMER & RONALD E.

Muir and other early preservationists saw had vanished, and the region became prone to larger, more catastrophic wildfires. In response, the National Park Service initiated a prescribed fire program to replicate the fires of the past through controlled burning. During the last 40 years, controlled fires burned between 12,200 and 15,600 acres in Yosemite each decade.[67] But this was far less than the region's historic fire regime, in which 16,000 acres may have burned each year prior to the era of fire suppression.[68]

In addition to nature's ever-changing discordant harmonies, as Botkin described them, the notion of the Anthropocene is evident in the photographs of Yosemite Valley. There, the effects of natural ecosystem dynamics cannot be easily distinguished from those of human action. The two are intertwined closely together. What is the true character of Yosemite undisturbed by human action? Is it dense forests or open meadows? We cannot readily say. In many ways the only Yosemite we have ever known is one created by the actions—or deliberate inactions—of people.

Virtually all of the world's landscapes have been shaped in some way by human action. Just as Yosemite Valley was shaped by Indians, humans have been impacting their environment for millennia.[69] Long before the U.S. federal government recognized the advantages of letting some forest fires burn, Indians were burning the landscape to enhance wildlife habitat.[70] Recent evidence suggests that the American wilderness that Columbus, Lewis and Clark, and other early explorers witnessed was dramatically shaped by humans—both by native societies themselves and, later, by the impacts resulting from the spread of European diseases.[71] In the American West, as Charles Mann explains, it is likely that "a substantial portion of the giant grassland celebrated by cowboys was established and maintained by the people who arrived there first."[72] Ethnologist Dale Lott puts it more plainly. "When Lewis and Clark headed west from [St. Louis]," he writes,

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STECKER, GIANT SEQUOIA ECOLOGY: FIRE AND REPRODUCTION (1980), *available at* http://www.nps.gov/parkhistory/online_books/science/12/index.htm.

67 *See* Prescribed Fire History Map—Yosemite National Park, NAT'L PARK SERV., http://www.nps.gov/yose/parkmgmt/rx-fire-history.htm (last visited Sept. 29, 2014).

68 *Shifting Views on Fire—Yosemite National Park*, *supra* note 17.

69 Erle C. Ellis, et al., *Used Planet: A Global History*, 110 PROC. NAT'L ACAD. SCI. 7978, 7978 (2013) (explaining that "[human] land use has been extensive and sustained for millennia" and that "relatively small human populations likely caused widespread and profound ecological changes more than 3,000 [years] ago").

70 KRECH, *supra* note 65, at 112.

71 MANN, *supra* note 3, at 360-75, 348-59. The large bison populations and passenger pigeon populations seen by early explorers were likely the result of the recent decimation of Indians by European diseases. Many researchers also believe that large swaths of the Amazon rainforest are also the product of human action, created centuries ago as orchards.

72 *Id.* at 287.

"they were exploring not a wilderness but a vast pasture managed by and for Native Americans."[73]

While there is little debate that humans exert a large influence on the environment, there is debate as to how far back the notion of the Anthropocene extends.[74] Today, some archaeologists believe humans may be responsible for the extinction of large mammals across several continents during the late Pleistocene more than 10,000 years ago.[75] Anthropogenic forces may also have impacted the global climate for thousands of years. Carbon dioxide emissions increased significantly around 8,000 years ago as humans began clearing and burning large swaths of forests for agriculture, and methane emissions increased 5,000 years ago as humans began rice farming. William Ruddiman, a paleoclimatologist from the University of Virginia, estimates that these early anthropogenic impacts may have been large enough to prevent another ice age from occurring and, in effect, ensured the continued survival of humanity.[76]

Emma Marris describes the reach of human impact on ecosystems succinctly in her influential 2011 book, *Rambunctious Garden*: "Every ecosystem, from the deepest heart of the largest national park to the weeds growing behind the local big-box store, has been touched by humans."[77] Marris argues that conservationists should reject the idea of pristine wilderness and adopt a "more nuanced notion of a global, half-wild rambunctious garden, tended by us."[78] In 2012, a group of scientists led by Peter Kareiva, chief scientist for the Nature Conservancy, similarly criticized conservationists for viewing nature apart from people in a provocative essay, *Conservation in the Anthropocene*.[79] The scientists urged conservationists to embrace "a new vision of a planet in which nature—forests, wetlands, diverse species, and other ancient ecosystems—exists amid a wide variety of modern, human landscapes."[80]

The Anthropocene idea is challenging entire sub-disciplines of the ecological science. In a 2012 essay, Kareiva and Michelle Marvier revisit Michael Soulé's foundational 1985 article on conservation biology.[81] Referring to the emerging Anthropocene idea, the authors claim that "we live in a world dominated by humans, and therefore, the scientific underpin-

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73 *Id.* (quoting DALE F. LOTT, AMERICAN BISON: A NATURAL HISTORY 88 (2002)).

74 *See generally* William F. Ruddiman, *The Anthropocene*, 41 ANN. REV. EARTH & PLANETARY SCI. 45 (2013).

75 *See generally* PAUL S. MARTIN, TWILIGHT OF THE MAMMOTHS: ICE AGE EXTINCTIONS AND THE REWILDING OF AMERICA (2007). *See also* MANN, *supra* note 3, at 155-96.

76 *See generally* William F. Ruddiman, *The Anthropogenic Greenhouse Era Began Thousands of Years Ago*, 61 CLIMATIC CHANGE 261 (2003).

77 MARRIS, *supra* note 4, at 5.

78 *Id.* at 2.

79 Kareiva et al., *Conservation in the Anthropocene, supra* note 4.

80 *Id.* at 30.

81 Kareiva & Marvier, *supra* note 2, at 962 (2012).

nings of conservation must include a consideration of the role of humans."[82] Challenging the very foundation of conservation biology as "concerned solely with the welfare of nonhuman nature," they propose a new framework of *conservation science* as "a discipline that requires the application of both natural and social sciences to the dynamics of coupled human–natural systems."[83]

"In the traditional view of conservation," Karieva and Marvier write, "people play one of two roles: The vast majority of people are a threat to biodiversity, and a relatively small number—mostly Western biologists—act as biodiversity's protectors and, one hopes, saviors."[84] This is problematic because "conservation is fundamentally an expression of human values."[85] People's actions and values shape and reshape the natural world, just as they have in Yosemite Valley. Karieva and Marvier's conception of conservation science seeks "a more integrative approach in which the centrality of humans is recognized in the conservation agenda."[86]

The recognition that "ecological dynamics cannot be separated from human dynamics," as Karieva and Marvier suggest, harkens back to the critique of climax communities made by British ecologist A.G. Tansley.[87] In the 1930s, Tansley put forth the idea of an "anthropogenic" climax: "We cannot confine ourselves to the so-called 'natural' entities and ignore the processes and expressions of vegetation now so abundantly provided to us by the activities of man."[88] Today, the idea of "novel ecosystems" is gaining wider acceptance in ecology.[89] Such ecosystems are the product of human influence, often resulting in new combinations of species—both native and nonnative—that form anything but pristine, climax ecosystems. Yet novel ecosystems now dominate much of the world's surface, and although they were largely ignored by an earlier generation of ecologists, they are now a focus of ecological research.[90] Erle Ellis, an ecologist at the University of Maryland in Baltimore, has suggested the idea of "anthromes" or "human biomes" to better understand these anthropogenic landscapes and their dynamics at local and global scales.[91] In contrast to the conventional

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82 *Id.*

83 *Id.*

84 *Id.* at 963 (citation omitted).

85 *Id.*

86 *Id.*

87 Kareiva & Marvier, *supra* note 2, at 962.

88 WORSTER, *supra* note 29, at 240.

89 *E.g.*, MARRIS, *supra* note 4, at 111-22.

90 RICHARD J. HOBBS ET AL., NOVEL ECOSYSTEMS: INTERVENING IN THE NEW ECOLOGICAL WORLD ORDER 4 (2013) ("Until recently, the types of [novel] ecosystem resulting from these trends have largely been ignored both in ecological theory and in practical management, and yet they now loom large as a growing part of the world in which we live.").

91 Erle C. Ellis & Navin Ramankutty, *Putting People in the Map: Anthropogenic Biomes of the World*, 6 FRONTIERS ECOLOGY & ENV'T 439, 445 (2008).

view among ecologists of a world comprised of natural biomes with occasional human disturbances, anthromes "tell a completely different story, one of 'human systems, with natural ecosystems embedded within them.'"[92]

C. *Dynamic Ecology, Static Policy*

Ecologists are discovering that the natural world is characterized by perpetual change and dramatic human influence, yet our standard approaches to environmental problems remain based on assumptions of equilibrium and pristine nature. Historic baselines form the foundation for most of today's environmental statutes and regulations, which are often based on the goal of restoring the environment to an earlier set of desired conditions.[93] The Endangered Species Act, National Environmental Policy Act, and the Wilderness Act, as well as many of the statutes governing federal land management agencies such as the U.S. Forest Service, National Park Service, and Bureau of Land Management, are broadly based on the idea that an arbitrary baseline condition is the proper state to which the environment should be restored. Most of the large, centrally planned natural resource projects of the twentieth century were similarly based on the belief that environmental conditions at the time were relatively constant or that any dynamic forces inherent in nature could be effectively restrained or stabilized by planners.[94]

This tendency to address environmental problems from an equilibrium perspective has undermined our ability to integrate diverse human demands with an ever-changing environment. Consider the case of water allocation throughout much of the United States. Established in 1922, the Colorado River Compact allocates water from the Colorado River Basin to seven western states. The compact based water allocations on flow levels between the years 1899 to 1920. Years later, as researchers developed a better understanding of the hydrologic history of the basin, it became clear that the allocation decisions were based on a period of historically high river flows. Persistent droughts and changing human demands for water have

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92 *Id.*

93 J.B. Ruhl & James Salzman, *Gaming the Past: The Theory and Practice of Historic Baselines in the Administrative State*, 64 VANDERBILT L. REV. 1, 5 (2010).

94 As Bosselman and Tarlock note,

> Plans were not thought of as processes for adapting to change, but as visions of an ideal future that, once achieved, would avoid the need for additional change. Like the builders of suburban residential communities or the planners of national parks, scientists of the day tended to emphasize the objective of stability rather than the need for adaptability to ongoing change.

Fred P. Bosselman & A. Dan Tarlock, *The Influence of Ecological Science on American Law: An Introduction*, 69 CHI.-KENT L. REV. 847, 860 (1994) (footnotes omitted).

significantly reduced flows, causing concerns that Upper Basin states will not be able to comply with the compact.[95]

Studies of past environmental conditions in other regions reveal similar challenges. A reconstruction of the region's drought history from 1665 to 2010 suggests that the recent water shortages in Georgia, Florida, and Alabama are not unprecedented.[96] Severe droughts of even longer duration occurred more often between 1696 and 1820, and they are likely to occur in the future.[97] The drought record indicates that the region's state and local water allocation decisions were made during one of the wettest periods since 1665.[98] With continued growth in the region, along with an allocation system based on a static view of nature, the South's "water wars" are likely to intensify. Likewise, reconstructions of California's drought history reveal frequent "mega-droughts" throughout history that were more severe and longer lasting than droughts experienced by modern society.[99]

Reconciling the dynamic forces of nature with environmental policies based on equilibrium has proven difficult in other areas. Ecologists now recognize the important role that fire, both natural and man-made, has played in shaping many landscapes. By the twentieth century, however, a national policy of forest fire suppression imposed a static view of nature onto forest management. Fire suppression, along with other policies limiting timber harvests on national forests, caused significant increases in forest growth and density. In some areas of the southwestern United States, forest density has increased from less than 100 trees per acre to more than 1,000 trees per acre.[100] Today, this increase in forest density fuels larger and more damaging wildfires. Craig Allen, a research ecologist with the United States Geological Survey, estimates that today's megafires, which reach the trees' canopies rather than remaining on the ground, may threaten the very future of the forests.[101] Indeed, forests in some regions have not been regenerating after being scorched by massive fires fueled by decades of fire suppression.[102]

The Endangered Species Act (the Act), in particular, reflects an unrealistic and outdated view of nature that is both static and overly simplis-

95 *See* Ruhl & Salzman, *supra* note 93, at 26-27.

96 Pederson et al., *A Long-Term Perspective on a Modern Drought in the American Southeast*, 7 ENVTL. RES. LETTERS 1, 5-6 (2012).

97 *Id.*

98 *Id.*

99 Edward R. Cook, Richard Seager, Mark A. Cane & David W. Stahle, *North American Drought: Reconstructions, Causes, and Consequences*, 81 EARTH-SCIENCE REVS. 93, 93 (2007); Glen M. MacDonald, *Severe and Sustained Drought in Southern California and the West: Present Conditions and Insights from the Past on Causes and Impacts*, 173-74 QUATERNARY INT'L 87, 87 (2007).

100 *Hearing Before the S. Comm. on Energy and Natural Resources*, 112th Cong. 5 (2012) (statement of Dr. Craig D. Allen, U.S. Geological Survey, Dep't of Interior).

101 *Id.*

102 *Id.*

tic.[103] These static assumptions, when translated into law, have often complicated federal conservation efforts.[104] In its current form, the Act has experienced several problems squaring the reality of a complex and dynamic world with the static and orderly world envisioned in the Act. For one, the Act assumes that the boundaries between species are fixed and definable, yet there is no widely accepted definition among scientists of what species are and how they should be identified.[105] Translating the concept of species taxonomy into effective law has been difficult. The Act provides a broad definition of "species," but the definition has proven to be unclear or impractical in practice in many cases.[106] The Act has proven to be problematic in practice and resulted in considerable controversy because it is predicated on the notion of a static definable species, and attaches such significant regulatory and economic consequences to that underlying concept.

The distinction between species might seem clear enough in most cases, but when it comes to implementing the Act in practice, different interpretations of the species concept can have profound effects. As just one example, under some strict interpretations, polar bears may not be a distinct species from brown bears.[107] There is genetic evidence that some brown bears may be more closely related to polar bears than they are to other brown bears.[108] Such an interpretation would clearly have significant impacts on whether or not regulatory protections for polar bears are warranted. Moreover, the notion of a "subspecies" is even more fraught with disagreement.[109] There is debate among scientists over whether the Preble's meadow jumping mouse, a small rodent widely considered an endangered species, is a distinct subspecies from the common meadow jumping mouse.[110] Hybridization among species poses yet another problem for the Act. In some cases, hybrid species may not be considered "true" species and could outbreed other "pure" species.[111] However, in other cases, hybrids could also serve an important evolutionary role in preserving threatened species. In recent decades, the emergence of "coywolves" (coyote–wolf hybrids) and "pizzly bears" (polar bear–grizzly hybrids) have posed interesting problems for enforcement of the Act, and for conservationists in general.[112]

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103 Holly Doremus, *The Endangered Species Act: Static Law Meets Dynamic World*, 32 WASH. U. J.L. & POL'Y 175 (2010).

104 *Id.* at 215.

105 *Id.* at 184-88.

106 16 U.S.C. § 1532(16) (2006).

107 Emma Marris, *The Species and the Specious*, 446 NATURE 250, 250-51 (2007).

108 *Id.* at 250.

109 Doremus, *supra* note 103, at 186-88.

110 Marris, *supra* note 107, at 251.

111 Doremus, *supra* note 103, at 188-89.

112 Moises Velasquez-Manoff, *Should You Fear the Pizzly Bear?*, N.Y. TIMES MAGAZINE, Aug. 14, 2014, at 1.

The controversy over the northern spotted owl in the Pacific Northwest presents another example of the trouble with reconciling dynamic nature with static law. After the owl was listed as threatened under the Act in 1990, timber harvesting in Washington and Oregon came to a standstill in an effort to protect old-growth forests, the owl's preferred habitat. But more than two decades of federal protection have done little to help the spotted owl.[113] Its numbers continue to decline due to habitat encroachment by the barred owl, a slightly larger and more aggressive species.[114] Common in the eastern United States, barred owls are now displacing and interbreeding with spotted owls in the West. Over the last century, barred owls have gradually expanded from east to west, reaching Montana in 1909, Washington in 1965, and Oregon in 1972.[115] Within the context of the Act, the barred owl is considered nonnative to western forests. The federal government has responded to these changes with plans to shoot barred owls in order to protect the less aggressive spotted owls.[116] The plan is not without critics. Some biologists believe the owls were once the same species, split into eastern and western varieties during the last ice age. The natural expansion of the barred owl blurs the line between native and nonnative species. Moreover, such population movements are not unusual in a dynamic natural world. A recent study found that 111 North American bird species recently expanded their ranges into other states, calling into question the static view of the natural world that underlies endangered species policy.[117] In 2011, the U.S. Fish and Wildlife Service issued its final spotted owl recovery plan, which calls for $127 million and another thirty years of management.[118]

Daniel Botkin summed up the extent to which equilibrium views are entrenched in the way ecologists think about environmental policy in this way: "If you ask an ecologist if nature never changes, he will almost always say no. But if you ask that same ecologist to design a policy, it is almost always a balance of nature policy."[119] Botkin goes on to say:

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113 Eric Mortenson, *Make This Call in the Wild: Should Oregon Shoot Barred Owls to Save Spotted Owls?*, OREGONIAN, Feb. 5, 2011, at 3.

114 *Id.* at 1.

115 *Id.* at 3.

116 *Id.* at 1.

117 *See generally* Kent B. Livezey, *Killing Barred Owls to Help Spotted Owls II: Implications for Many Other Range-Expanding Species*, 91 NORTHWESTERN NATURALIST 251 (2010).

118 U.S. FISH & WILDLIFE SERV., REVISED RECOVERY PLAN FOR THE NORTHERN SPOTTED OWL *(STRIX OCCIDENTALIS CAURINA)* (2011), *available at* http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Documents/RevisedNSORecPlan2011.pdf.

119 MARRIS, *supra* note 4, at 30.

> Whatever the scientist's knowledge of the dynamic, changing properties of nature, the formal representations of these remove such considerations in most cases. . . . [W]hether or not environmental scientists know about geological time and evolutionary biology, their policies ignore them.
>
> It is strange, ironic and contradictory.[120]

Indeed, equilibrium policies, such as historic baseline management, are only feasible on a large scale if ecosystems remain relatively constant. While park managers in Yosemite may be able to restore some semblance of Yosemite Valley as it existed at the time of Carleton Watkins' Kodachrome still-life of El Capitan, water managers and wildlife officials are forced to deal with the reality of nature as a moving picture show.

II. DYNAMIC ECONOMICS

Economists have traditionally viewed markets the way we might view a still-life image of Yosemite Valley. Standard assumptions of perfect information, perfect competition, and zero transaction costs cause economists to focus their attention on hypothetical points of equilibrium in which the forces of supply and demand are in balance. As economists from the so-called Austrian school of economics have argued, this tendency to view markets as if they exist in equilibrium distracts economists from the market processes, entrepreneurial activities, and institutions that guide markets toward their prevailing conditions.[121] The extent of economists' fixation with equilibrium conditions, and the folly of the assumptions on which their models are based, is perhaps best demonstrated by one economist who went so far as to outline the equilibrium conditions in which society would achieve its "bliss point."[122]

But just as nature is never in equilibrium, neither are markets. Although equilibrium concepts are useful for developing hypotheses and gaining insights into basic market responses, they obscure the moving picture show of the market process. This dynamic process, found in both ecosystems and markets, suggests an important connection between ecology and economics. It is this connection that I am calling Austrian ecology.

Although markets may have a tendency toward order and even equilibrium, any equilibrium is a moving target and therefore is never reached. The features of this equilibrating process, however, are important for understanding how certain market outcomes are achieved. Much like the interac-

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120 BOTKIN, THE MOON, *supra* note 43, at xiii-xiv.

121 *See generally* PETER J. BOETTKE, HANDBOOK ON CONTEMPORARY AUSTRIAN ECONOMICS (2010).

122 *See generally* Francis Bator, *The Simple Analytics of Welfare Maximization*, 47 AM. ECON. REV. 22 (1957).

tion of organisms in nature, the Austrian view of the market process emphasizes the interaction of individuals based on factors that are time- and place-specific.[123] Just as individual species fill niches in ecosystems, entrepreneurship and specialization fill niches in markets that are constantly evolving in a Darwinian sense. Successful entrepreneurship depends on the entrepreneur using local knowledge and resources more efficiently than other individuals. As a result, inefficient resource use in markets and in ecosystems is crowded out through the process of entrepreneurship and evolution.

The critique that Austrian economists level against mainstream economics focuses on the inability of formal economic analysis to understand real-world market phenomena. In particular, Austrians criticize the equilibrium assumptions that underlie formal economic analysis as distracting economists from understanding the dynamics of the market process.[124] To Hayek, the central economic problem is one of coordination between individual human actors with dispersed knowledge.[125] Hayek sought to understand "how the spontaneous interaction of a number of people, each possessing only bits of knowledge, brings about a state of affairs . . . which could be brought about by deliberate direction only by somebody who possessed the combined knowledge of all those individuals."[126] Hayek later described this as the "problem of the utilization of knowledge which is not given to anyone in its totality."[127] To Austrian economists such as Hayek, it is only through a competitive market process that the relevant local and time-specific knowledge can be communicated in any intelligible and meaningful way.

At its core, this competitive market process depends on entrepreneurial discovery guided by prices. Hayek's critique of standard economics was that its focus on equilibrium conditions forced economists to assume that all market actors had complete knowledge. Economists had largely ignored the process by which the relevant "knowledge of the particular circumstances of time and place" were conveyed through the price system.[128] Moreover, they ignored the role of the entrepreneur in responding to changing market conditions. Acting on the disequilibrium inherent in the market process, entrepreneurs continually discover and convey new knowledge that

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[123] F. A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519, 522 (1945).

[124] *See* ISRAEL KIRZNER, COMPETITION AND ENTREPRENEURSHIP 1 (1973) (Kirzner's theory of the market is motivated by "a dissatisfaction with the usual emphasis on *equilibrium analysis*, and in an attempt to replace this emphasis by a fuller understanding of the operation of the market as a *process*").

[125] Hayek, *supra* note 123.

[126] F.A. Hayek, *Economics and Knowledge*, *in* INDIVIDUALISM AND ECONOMIC ORDER 33, 50-51 (1937).

[127] Hayek, *supra* note 123, at 520.

[128] Hayek, *supra* note 123, at 521.

is not reflective in market prices, promoting an ever-changing, occasionally discordant market process.[129]

This dynamism of the market process resists the sort of formal equilibrium analysis common in mainstream economics. As James Buchanan argued, theoretical economic models of perfectly competitive general equilibrium produce little more than "intellectual muddle."[130] "By imposing the condition that no participant in the economic process can independently influence the outcome of this process, all 'social' content is squeezed out of individual behavior in market organization."[131] In such models, "[t]he individual responds to a set of externally-determined, exogenous variables, and his choice problem again becomes purely mechanical," reducing "individual choice behavior from a social-institutional context to a physical-computational one."[132]

Buchanan's critique is not unlike Daniel Botkin's argument against equilibrium ecological models, which reduce the biological world to a simple, mechanistic system. Lotka-Volterra models in ecology assume, for instance, that moose and wolf interactions are purely mechanical, each species being equally identical in every way. "A wolf pack would not be divided into lead male and female; there would be no wolf pups playing at the adults' heels," writes Botkin.[133] "The populations are viewed as though from afar, through the wrong end of a telescope, reduced to their simplest single character, each animal indistinguishable from others of the same species."[134] Like the standard economic models described by Buchanan, the traditional ecological analysis of moose and wolf dynamics is merely a computational one.

In Buchanan's view, mainstream economists mistakenly characterize the economic problem as one of resource allocation.[135] Given the realities of scarcity, mainstream economists often frame their study as one concerned with the efficient allocation of scarce resources among competing ends. Along with other Austrian economists, Buchanan rejects this "theory of resource allocation" in favor of a more dynamic "theory of markets" that focuses on the process of exchange.[136] If the economic problem is simply one of resource allocation, then it is ultimately a problem best addressed by applied mathematicians using relatively simple computations to find the right allocation given certain market conditions. "If the utility function of the choosing agent is fully defined in advance, choice becomes purely me-

129 *See* KIRZNER, *supra* note 124.

130 James M. Buchanan, *What Should Economists Do?*, 30 S. ECON. J. 213, 218 (1964).

131 *Id.*

132 *Id.*

133 BOTKIN, THE MOON, *supra* note 43, at 56.

134 *Id.*

135 Buchanan, *supra* note 130.

136 *Id.* at 214.

chanical," Buchanan argues.[137] "No 'decision,' as such, is required; there is no weighing of alternatives."[138] Like the moose and wolves in Botkin's example, the real-world dynamism of the market process is overlooked in the equilibrium analysis.[139]

With its focus on resource allocation and its preoccupation with equilibrium models, standard economics is susceptible to the same teleological tendencies that Botkin describes in ecology. The Austrian framework, with its focus on market processes rather than end states, seeks to avoid such tendencies. Buchanan argues forcefully on this point:

> In economics . . . the "efficiency" that such market arrangements produce is independently conceptualized. Market arrangements then become "means," which may or may not be relatively best. Until and unless this teleological element is fully exorcised from basic economic theory, economists are likely to remain confused and their discourse confusing.[140]

In his earlier work, Buchanan argued a related point. "The 'market' or market organization is not a *means* toward the accomplishment of anything. It is, instead, the institutional embodiment of the voluntary exchange processes that are entered into by individuals in their several capacities. This is all that there is to it."[141]

Much like Gleason's individualistic view of nature, Austrian economists insist that individual human action should be the focal point of economic analysis. As Peter Boettke explains, Austrians emphasize that only individuals choose and, therefore, the individual human actor should be the starting point for understanding the market process. "Man, with his purposes and plans, is the beginning of all economic analysis. Only individuals make choices; collective entities do not choose."[142] When economists focus on collective units or statistical aggregates instead of individuals, they adopt what might be considered a Clementsian view of economics, not unlike Frederic Clements' view of nature as a "superorganism."

Nonetheless, despite the critiques of the Austrian school, equilibrium models are still pervasive in formal economic analysis.[143] And just as ecologists considered Clements' idealized "climax" communities as the "yard-

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137 *Id.* at 217.

138 *Id.*

139 Buchanan goes so far as to suggest the terms "catallactics" or "symbiotics" in place of "economics." He prefers symbiotics, which he defines as "the study of the association between dissimilar organisms, and the connotation of the term is that the association is mutually beneficial to all parties." *Id.* at 35; *see also* BOTKIN, THE MOON, *supra* note 43, at 56.

140 James M. Buchanan, *Order Defined in the Process of Its Emergence*, LITERATURE OF LIBERTY, Winter 1982, at 5, 5.

141 Buchanan, *supra* note 130, at 219.

142 BOETTKE, *supra* note 121, at xii.

143 *See generally* Peter J. Boettke & Kyle W. O'Donnell, *The Failed Appropriation of F.A. Hayek by Formalist Economics*, 25 CRITICAL REV. 305 (2013).

stick by which man's intrusions into nature could be measured,"[144] economists use equilibrium analysis as the yardstick by which to measure market failure. That is, markets are said to fail when they do not satisfy the assumptions and conditions of a perfectly balanced, competitive equilibrium. When certain blackboard assumptions fail to hold—when there are informational asymmetries, incomplete markets, external costs, or other unfortunate everyday realities of human existence—the outcome of the market process is considered second-best to some "ideal" outcome that properly accounts for the market's failures. These are often considered as justification for government actions such as taxes, subsidies, or regulations to adjust the market imperfections into a perfect equilibrium.

This preoccupation with formal equilibrium theory has led economists to neglect the importance of institutions in economic analysis. Instead of using equilibrium analysis as a benchmark for evaluating market outcomes, Hayek argues for comparative institutional analysis based on the real-world constraints of human interaction. Because knowledge in society is dispersed and "not given to anyone in totality," economists should focus attention on how different institutions solve the coordination problem identified by Hayek.[145] In the context of Austrian ecology, this analysis should consider how various institutions integrate the dynamic ecological process with the dynamic market process.

III. RECONCILING DYNAMIC ECOLOGY AND ECONOMICS

Understood as dynamic processes rather than static systems, markets and ecosystems have important similarities that are relevant for how we think about the interface between humans and nature. As we have seen, both are characterized by dynamic processes of constant change. The diverse interactions of organisms in nature and people in markets promote a spontaneous order that emerges through constant adaptation and continues to evolve. Ecosystem and market processes rely on local- and time-specific factors to adapt to changing circumstances. What is more, human action and human values exert a significant influence on natural systems. For millennia, human demands on nature's bounty have continually shaped and reshaped landscapes and contributed to the shifting mosaic of the natural world.

Once we accept that nature is profoundly shaped by and connected to human action, we begin to consider environmental problems through a different lens. In this view, environmental problems cannot be thought of as simply the consequence of human violations of the balance of nature. A new generation of ecologists has rejected the idea of a natural harmony in

144 WORSTER, *supra* note 29, at 234.

145 Hayek, *supra* note 123, at 520.

ecosystems undisturbed by people.[146] Moreover, environmental problems cannot be solved by simply separating natural systems from human influence. As the notion of the Anthropocene suggests, virtually all of earth's landscapes have been impacted in one way or another by human action.

Instead, environmental problems become questions of how to resolve competing human demands on an ever-changing natural world. Farmers in the American West want to use stream water for their crops, while anglers and rafters want to leave water in the stream for fish habitat and recreation. The Masai herders in Africa want to use the landscape to graze cattle as they have for centuries, while environmentalists and safari guides want to use it for wildlife habitat. Thought of in this way, the central problem then becomes a question of which institutions best allow humans to resolve those diverse and ever-changing human demands on an equally dynamic environment.

Contrary to the traditional equilibrium perspectives on economics and ecology, Austrian ecology suggests a more dynamic view of human's relationship with nature. Simply put, protecting the environment is not as simple as preventing human violations of nature's balance. It involves making tradeoffs—do we want scenic viewpoints or dense forests in Yosemite?—and doing so in a way that recognizes that nature is as ever-changing as the demands that humans place on it. How those tradeoffs are made in a world of diverse and conflicting human values ought to be the central environmental question of Austrian ecology.

CONCLUSION

Keynes wrote that "[t]he ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed the world is ruled by little else."[147] But perhaps he should have included ecologists as well. In much the same way, the ideas of ecologists, both right and wrong, are more powerful than is often appreciated. The idea of the balance of nature undisturbed by humans has persisted throughout the development of ecology and played an important motivating role in the creation of the conservation and environmental movements. It is also the view that underlies almost every modern environmental policy.

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146 Michael Shellenberger & Ted Norhaus, *Evolve*, ORION MAGAZINE, September–October 2011 ("Where ecotheology imagines that our ecological problems are the consequence of human violations of a separate 'nature,' modernization theology views environmental problems as an inevitable part of life on Earth. Where the last generation of ecologists saw a natural harmony in Creation, the new ecologists see constant change.").

147 WORSTER, *supra* note 29, at 294 (quoting JOHN MAYNARD KEYNES, GENERAL THEORY OF EMPLOYMENT, INTEREST AND MONEY 383 (1936)).

This paper has attempted to trace out an alternate vision, an Austrian ecology that links together the Austrian theory of the market process with a more dynamic view of ecological processes. In contrast to deeply held beliefs about the balance of nature, this dynamic view relies on two emerging critiques within the field of ecology. First, the traditional assumption of a steady-state balance of nature undisturbed by humans is unsupported by the evidence. Second, nature cannot be easily separated, if at all, from human action. The first idea is found in the work of a new generation of ecological theorists, most notably Daniel Botkin, and the second idea is embodied in the current proposal of the "Anthropocene" as the new geologic era to replace the Holocene. Although both ideas are still hotly debated in ecological circles, they are increasingly gaining acceptance.

This critique within ecology is then connected to the critique put forth by Hayek and other economists of the Austrian school. In particular, these Austrian theorists focused on the dynamic forces within the market process. As I have shown, a new generation of ecologists are critically reexamining the assumptions that underlie their theories and, unknowingly, mounting a remarkably similar critique to the one made by Austrian economists.

By integrating the two theories, I consider what this Austrian ecology vision implies for how humans interface with the environment. If there is no balance of nature and ecological dynamics cannot be separated from human dynamics, then environmental problems can no longer be viewed as simply violations of nature's balance. Nor can they be solved by separating humans from nature. Rather, environmental problems involve making tradeoffs between the competing and evolving values that humans place on their ever-changing environment. Thus, the central environmental question should be how human institutions resolve conflicting human demands on a dynamic natural world.