

**New wine and old wineskins? Novel ecosystems and conceptual change**

Brendon M. H. Larson

Department of Environment and Resource Studies

University of Waterloo

Waterloo, Ontario, Canada N2L3G1

Email: [blarson@uwaterloo.ca](mailto:blarson@uwaterloo.ca)

AND

Centre for Invasion Biology

Department of Botany and Zoology

Stellenbosch University

Matieland 7602

South Africa

**Abstract**

The concept of novel ecosystems (CNE) has been proposed as a way to recognize the extent and value of ecosystems that have been irreversibly transformed by human activity. In this sense, the CNE is realistic about ongoing changes that humans are causing and pragmatic about how to manage them now and in the future. It also provides a dramatic contrast with prevailing conceptions, particularly related to invasive species. Although the CNE has recently been subject to critique, existing critiques do not appear to seriously engage with the extent of anthropogenic change to the world's ecosystems. Here, I seek to provide a deeper, philosophical and constructive critique, specifically arguing that the usefulness of the CNE is limited in the following three ways: i) it is too static; ii) it is too vague; and iii) it is too dualistic. Although the CNE provides some conceptual advance ('new wine'), some of its

conceptualization and packaging weakly support this advance ('old wineskins'), so I consider some ways to further develop it, in part to encourage more widespread recognition and appreciation of novel ecosystems.

### **Keywords**

Anthropocene, nature-culture, rhetoric, social-ecological system, wilderness

## **Introduction**

Traditionally, conservation has focused on areas that are relatively free of human influence, in particular large wilderness areas. However, with increasing recognition of human effects on the planet, the adequacy of this approach is increasingly questioned in cases ranging from invasive species (Head 2012) to wilderness (Cronon 1995) to the planet as a whole (Steffen et al. 2011). There have been dramatic proposals to actively “introduce” human agency into natural areas, including Pleistocene rewilding (Donlan et al. 2006) and assisted colonization (McLachlan et al. 2007). But an emerging nexus for this shift is the concept of novel ecosystems (CNE, sensu Hobbs et al. 2006, 2009, 2013a), a novel ecosystem (NE) being defined as “a system of abiotic, biotic and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically, having a tendency to self-organize and manifest novel qualities without intensive human management (Hobbs et al. 2013b, p. 58; Figure 1).” The proposal to attend to these NE and to understand rather than denigrate them is based in part on the recognition that, by recent estimates, they cover on the order of 28-36% of the planet’s ice-free land (Perring and Ellis 2013).

--Insert Figure 1 about here--

Unsurprisingly, the CNE has been subject to recent critique. Murcia et al. (2014, in press), in particular, claim that NE are not as ubiquitous as claimed, mainly protesting that there is little evidence that irreversible thresholds to “novelty” have been crossed—not least because we have a growing capacity to restore disturbed ecosystems. In short, they conclude that the CNE sows confusion among governments that have already committed to restoration and that it “opens the door to impunity” by corporate interests wishing to devalue natural systems. In the words of Crist (2013, p. 129; and see Wuerthner et al. 2014), Anthropocene discourse—and by association, that about novel ecosystems—is “tenaciously anthropocentric,” it “refuses to challenge human dominion,” and it “blocks from consideration the possibility of abolishing a way of life founded on the domination of nature.”

These critiques raise several important points, yet they also highlight some unavoidable tensions for those wrestling with the meaning of contemporary conservation (e.g., see Houston 2013, Karlsson 2013, Ogden et al. 2013, Robbins and Moore 2013). The fundamental limitation of these critiques, in my view, is that they appear to misjudge the actual extent of humans' influence on the planet (cf. Hobbs et al. 2014, submitted). I see no evidence that the CNE endorses future development or human dominion; instead, it raises new possibilities for places that have already been affected by development or human dominion. A recent edited volume, for example, predicts that the impact of invasive species will continue to grow in coming decades in European protected areas, U.S. national parks, and the southern Ocean islands, among other places, despite the best efforts of conservationists (Foxcroft et al. 2013). As a specific and dramatic example, McNeely (2013, p. 64) reflects on the extent to which earthworms have transformed woodland ecosystems in northeastern North America, and concludes that "Eradicating these earthworms is impossible, so this ecosystem change is essentially permanent (p. 64)." Ecologist contributors Meiners and Pickett (2013, p. 56) are therefore being realistic and pragmatic when they recommend that "we should expect and plan for plant invasions within protected areas (p. 56)." The CNE does not endorse these changes, but simply seeks to acknowledge them and propose a role for NE in conservation.

In this context, there is much to be said for the CNE. It acknowledges humans as part of ecological systems, so it is realistic about the scale of change and encourages a pragmatic response. It does not focus on past reference states, for example, instead acknowledging the actual state of extant systems. Finally, it provides a positive alternative to the prevailing doomsday scenarios about the future of the planet. In what follows, I assume that the CNE is useful, but it is also in need of ongoing development. To facilitate this development, I wish to interrogate it with a deeper and perhaps more philosophical analysis than has occurred to date to uncover some of its underlying assumptions. We have arguably been hampered by the inadequate worldview of humans versus nature for a long time, seen most clearly in our perception and approach to invasive species, and now we have the opportunity

to fundamentally rethink conservation (e.g., Wapner 2010, Marris 2011, Sandler 2013). In this context, it is particularly important to carefully examine any remaining seeds of the former worldview. By analogy to the old conservationist worldview, one would not want to begin a restoration project without first seeking to eliminate the seed bank of potentially invasive species. If the vision for NE biology is to help humans to act more appropriately and fittingly in the Anthropocene, it must continuously further itself from some of the problematic assumptions of the past. I specifically consider three dimensions of the CNE that need further consideration: i) it is too static; ii) it is too vague; and iii) it is too dualistic.

### **1. Static**

Over the past several decades, there has been a growing emphasis on the prevalence of disturbance and change in ecological systems (e.g., Coates 1998). The CNE furthers this trend, thereby accentuating the dynamism of socio-ecological landscapes. At a basic level, novelty simply refers to change relative to a previous state, and by recognizing such change, the CNE helps to undo previous views of nature as stable and permanent. As Mascaro et al. (2013, p. 51) argue, “the novel ecosystems concept is grounded first in Gleason’s individualistic concept that species respond differently when faced with environmental change; ecosystems are therefore not the discrete units they may appear to be.” Neither are they static, which Lindenmayer et al. 2008 (p. 131) recognize in their description of novel bird communities in Australia: “Indeed, the novel ecosystem we have quantified is unlikely to be a static entity.” The CNE may provide a new meta-narrative for how to understand ongoing changes, and especially ones related to human action.

However, it could be argued that the prevailing meaning of “ecosystem” is too static to facilitate this shift. An ecosystem is commonly conceived as a thing on the landscape, part of the “compositionalist” approach to conservation, which emphasizes the species making up an ecosystem, in contrast to the “functionalist” approach, which emphasizes the functions that ecosystems perform (Callicott et al. 1999). By focusing on ecosystems, the CNE therefore runs the risk of management of

NE as objects and entities of conservation like other bounded ecosystems. Certainly, this may be true of much ecological thought, yet we now have an opportunity to reconsider and revise those fundamentals. The CNE brackets novel systems as if there is a discontinuity between something non-novel earlier and something novel now, perhaps suggesting that we can return to some “business as usual” of stable ecosystems (stable, novel ecosystems?) at some point in the future (cf. Marris et al. 2013). In this way, NE could eventually become reified as stabilized *things* too, just like the old ones. The introduction of “novelty” into ecological and conservation thinking alternatively points towards a more process-based view of reality, a view in which the foundations we take for granted or assume are less solid (e.g., Gare 1995). Instead, nature is more fluid, more Heraclitian; it is a world of becoming.

It is critical to maintain dynamism in our conceptions because these systems will keep changing, not only in response to global change as we currently understand it, but in ways we do not even foresee (e.g., Sutherland et al. 2013). Twenty-five years ago, invasive species had just become recognized as a significant biodiversity issue. What will be the new and critical issue in another 25 years? It may be nanoparticles. Or a cyborg future that some say is already here, given the presence of unmanned aerial vehicles (UAVs) the size of hummingbirds and “living moths [that have] been implanted with electrodes in their nervous systems to control their movements (Bowcott and Hopkins 2012).” It is worth keeping in mind that some scholars who question the nature-culture split (see below) have begun to extend a similar argument to the human-machine split, arguing that there is little basis for that dichotomy—especially given current developments in modern medicine (White and Wilbert 2009).

In this rapidly changing world, we need to revisit how we usually think of conservation and it is questionable in my view whether the CNE invites such exploration. Nature is now more relativistic and characterized by change, and scholars have been trying to make sense of this development for several decades (e.g., Lodge and Hamlin 2006). The anthropologist Tim Ingold (2008, p. 1802, 1808), for example, claims that

what is unthinkable is the idea that life is played out upon the inanimate surface of a ready-made world. Inhabitants, I contend, make their way *through* a world-in-formation rather than *across* its preformed surface ... Instead of saying that living beings exist in places, I would thus prefer to say that places occur along the life paths of beings. Life itself, far from being an interior property of animate objects, is an unfolding of the entire meshwork of paths in which beings are entangled.

This is not a static world of reserves, but a much more dynamic one where species move and relate for intermittent periods of time.

Part of the problem here lies in the nature of our language. A label such as “ecosystem” captures and reifies an object. The physicist David Bohm (1980) similarly noted that English is inadequate to communicating quantum realities, so he experimented with what he called the “rheomode” as a way to avoid our usual emphasis on nouns. His experiment was an invitation to his readers to more directly realize that nature is a world of becoming—that is, one of comings and goings, of verbs. However, we lack a way to write without nouns, so we have created solid external objects that the sciences may study, rather than engaging with the emerging process in which we are all involved. Ecosystems are no longer things, because we are embedded within them. They are becomings. Like the rheomode, we are seeking a new and more accurate way to portray them.

One simple option for reducing this tendency to reify is to follow Milton (2003, p. 404) and adopt the term “emerging” ecosystem, defined as “an ecosystem whose species composition and relative abundance have not previously occurred within a given biome.” In fact, this was an early choice of terminology, but “we couldn’t get that past the reviewers/editors (R. Hobbs, personal communication, July 9, 2013).” Yet this label would arguably better acknowledge the fundamental notion of becoming; emerging ecosystems are always-already emerging. They are emerging from what was before, and they will remain emerging. Emerging, as a verb, is an ongoing process that never ends,

whereas a “novel” ecosystem can, with time, become not-so-novel anymore. The CNE could recreate the illusion that these systems too can be captured at a point in time.

## **ii) Vague**

The CNE is vague in at least four ways that restrict its value for revising conservation in the Anthropocene. First, what precisely is novel about NE? Their novelty is ill-defined because even within the revised definition proposed in the new book by Hobbs et al. (2013a) there is a residual circularity, NE being defined in terms of their difference from historical ecosystems insofar as they “manifest novel qualities.” Furthermore, ecological systems have always been in flux, as discussed above, so one could argue that “there is nothing new about novel ecosystems (e.g., Jackson 2013, p. 64).” This is not an argument for crystal clarity in the formation of new concepts, when some ambiguity is often unavoidable if not productive, but the novelty of NE could be further specified. For example, the alternative of “functional” ecosystem would shift inquiry onto the question of “what function” rather than “what is new?” However, this shift undoubtedly moves the CNE in a managerial direction that is of concern within some critiques of related notions such as the Anthropocene (e.g., Crist 2013).

Second, the CNE applies at one scale only, which begs the question of application at other scales and the potential for greater generality. Ecology normally recognizes scales ranging from genes through species to communities and ecosystems. Why not specify novel genes, novel species, novel communities, and novel ecosystems? By restricting novelty to just the ecosystem scale, NE might be interpreted to mean that there are other scales where it is inapplicable. Clearly, there is value to specifying this one level of novelty, but the CNE may have been better packaged as part of a cross-scalar recognition of novelty. As just one example, Schwarz et al. (2005) demonstrate the origin of a new species of fly when its ancestor moved onto a new, non-native species of host plant in northeastern North America.



Third, it is unclear whether the CNE is meant to be used descriptively or prescriptively. One of its co-creators, for example, observes that “We didn’t intend ‘novel ecosystems’ to be a forward looking term, but a descriptive one (E. Higgs, personal communication, August 4, 2013).” I have already suggested that it may not be descriptive enough, but the greater challenge will be to restrict it to a descriptive meaning in this way. In particular, the terminology leaves open the potential for people to interpret this “novelty” as a good thing in itself, thus propounding novelty for novelty’s sake, even if that is not its intent (cf. Standish et al. 2013). It is worth keeping in mind that most people do not have enough connection with more “historical” systems to recognize novelty or to assess its significance. Thus, the question is whether the CNE puts appropriate limits on novelty, recognizing not only that there are different forms of change and novelty, but also that not all of them are desirable. It might not be clear enough that we may transgress significant ecological limits, assuming such limits are not—in the current era—anachronistic or mere natural history sentiment.

In short, the CNE is agnostic on the question of passive versus more active forms of novelty, which perhaps could have been disambiguated. One type of NE “just happens,” passively, perhaps what Marris et al. (2013, p. 347) refer to as “undirected succession.” This form of novelty may be somewhat contentious, but it would not rattle conservationists as much as alternatives: actively constructed, designer, and synthetic ecosystems (e.g., MacMahon and Holl 2002). These active ways of creating novelty suggest a hubris that we can create systems as we wish, which could engender the tendency to prefer what has been called “hyperreality,” a man-made reality that is better than the real thing—perhaps ecosystems without mosquitoes and poison ivy. As Borgmann (1995, p. 39) put it, “Today the critical and crucial distinction for nature and humans is not between the natural and artificial but between the real and hyperreal.” That is, some proponents may interpret NE as a means to a utilitarian end, to designing human playgrounds as they see fit. Yet I think the intention of those who introduced the CNE was to bring value to under-appreciated systems that already exist rather than to

endorse modifying systems that are currently less influenced by humans. It is unfortunate that the terminology is vague in this respect.

This third limitation points to a fourth and related form of vagueness. The purpose of the CNE, as a rhetorical invention, is to describe these systems and also to make a case that they exist and that they are pertinent to conservation thinking. The CNE also shifts perception of ecological change from a rather apocalyptic one, focused on destruction, to a more hopeful one (e.g., Yung et al. 2012). However, there is reason to question whether this terminology will galvanize the interest and imagination of everyday people. Traditionally, people's values towards nature, especially in North America, have derived from the notion of a balance of nature. This metaphor was a call to action to link what "is" with what "ought to be" (see Fleming 2006; Larson 2011); that is, humans ought to maintain the balance that existed since time immemorial. But what will accomplish this call to action now, if anything?

The problem is that in avoiding prescription, the CNE is too vague to motivate people to care for NE, to recognize their value. We need to more attentively consider which "propaganda tool" we will use (Marris et al. 2013, p. 346). In contrast to the descriptive intent of the CNE, mentioned above, Marris et al. (2013, p. 346) state that "Its purpose is not to describe certain places as they are, but to color our emotional reaction to certain places in order to make us see possibilities were [sic] we formerly only saw failure." NE are no longer "trash" or "degraded systems," but the CNE does not seem to communicate sufficient value. We require a term that is more catchy, more sticky, and NE does not quite succeed (e.g., Heath and Heath 2007). It is too jargony and the only alternatives to date are Emma Marris' (2009, 2011) valiant attempts elsewhere to frame it more broadly. However, I am skeptical that "ragamuffin earth" is quite right either (Marris 2009), given that ragamuffin is defined by my Webster's 3<sup>rd</sup> as "a ragged dirty man or boy, especially a disreputably tattered person" (or "a child in masquerade costume"). This does not fit with the more positive conceptions Marris espouses. As an alternative, her recent book is entitled *Rambunctious Garden* (Marris 2011). "Rambunctious" means

“1. outrageously flamboyant in behavior, excessively exuberant, wild, uncontrollable, unruly; 2. difficult to manage or bring under control, untamed.” Again, this option does not appear to be a truly inspiring and positive vision for conceptualizing these systems.

### **iii) Dualistic**

Finally, the CNE too easily reinforces a duality between humans and nature. This claim may seem counter-intuitive because CNE is often touted as a way to break down the traditional duality (cf. Yung et al. 2013). It recognizes that conservation has been ironically and profoundly anti-Darwinian; that is, Darwin helped us to recognize we are not the centre of the living world (like Copernicus before him), yet we have not fully understood this in an ecological context: viewing ourselves as outside of nature, managing it, we still sometimes neglect to see ourselves as part of ecosystems.

However, there are several indications of a residual duality in the CNE. Novelty has to be relevant to something, so it implies a black-white contrast, when in fact human effects on nature have been going on for a long time, not least since the agricultural revolution (but see Malm and Hornborg 2014). Yet the duality can be observed, in particular, in the standard mapping of the space in which NEs occur along a continuum from undisturbed to disturbed biotic and abiotic conditions (see Figure 1). In the middle of this mapping there are hybrid ecosystems: “Novel ecosystems are distinguished from hybrid ecosystems by practical limitations (a combination of ecological, environmental and social thresholds) on the recovery of historical qualities (Hobbs et al. 2013b, p. 58).” These hybrid ecosystems could still be returned to a former state because intransigent boundaries have not yet been transgressed. But the presence of this intermediate zone implies that there are areas not so hybridized, on the extremes: historical and novel systems.

Such dualities are at odds with arguments that hybridization is everywhere (e.g., Latour 1993, Arias-Maldonado 2013), which encourages us to move beyond such conceptions that reify pre-existing nature-society categories. There are no places where humans have not had at least some degree of

influence. This point is not meant to be a warrant for devaluing places that have been less affected, but it does draw into question the very idea of “historical” systems. In this regard, the CNE does not go far enough. Some social theoreticians in fact argue that nature is even more malleable than we think, even more interwoven with humans, that there is an “intra-action” (Barad 2007) rather than an “interaction” that posits two pre-existing entities (as “hybrid” does). While some scholars argue it is pointless to say that all ecosystems are novel (Mascaro et al. 2013), Marris et al. (2013) propose that eventually everything will more clearly be novel, so the term will no longer be needed—and perhaps soon if not already. This debate remains a critical and unresolved tension even among contributors to the recent edited volume about NE (Hobbs et al. 2013a).

There are deeper ways in which the CNE may hinder recognition of the embeddedness of humans in the natural world. Note that NEs are almost always discussed as a change in ecological systems in response to human agency and behavior. But partly what is remarkable is not so much the novelty of these ecosystems as the recognition that they are not over-and-against humans as we are often conceptualized, but always-already evolving and having human content. They have come into being to a greater or lesser extent under human influence; they should not be artifactualized/reified as separately existing objects. In other words, this is not a nature happening on its own without humans (“wilderness”), but one in which we are quite involved. As Proctor (2009, pp. 296-7) has observed of “environment,” “etymologically ... that which surrounds,” something has been lost over the past few decades: “the environment as connection. Now it is an object among other objects to be managed... Environment started as a relation, a sense of connection, then turned into a thing.” The question is whether the CNE assists the shift to reconceptualize nature in terms of relationship, the relationship of people and nature.

To give a specific example, consider that one of the defining characteristics of contemporary life is that human diaspora now move extensively around the globe. These new colonists are surrounded by NEs, which are novel from their *perspective* regardless of whether they are in fact novel

ecological systems (Pizarro et al., in preparation). It may be for this reason that these people may find a non-native species with which they are familiar, from their place of origin, to be non-novel and welcoming in their new place. Note that this form of ecological novelty has been going on for a long time (much as the ecological sense), yet it is not really considered in the literature to date. The point is that NEs have been conceptualized in terms of a fairly simplistic biological basis (e.g., with a static human baseline), when they are better understood as novel *social-ecological* systems.

The recognition that NE are novel social-ecological systems gives rise to a greater series of reflections on the way different cultures (and stakeholders) may relate to and interact with these changes. Just as there are diverse ways that people interact with invasive species—sometimes positive and sometimes negative (e.g., Pfeiffer and Voeks 2008), people will have similar and varied interactions with NEs. In particular, we need to address critical yet to date unconsidered questions about the environmental justice of NEs, in terms of who gains and who loses when they are acknowledged and recognized. In some respects, the marginality of many NE may open up conversations about conservation to a wider range of people than have hitherto been included.

### **Concluding thoughts**

Novel ecosystems are not just about novelty in ecological systems, but in our mindset and worldview as well. In particular, NE involve human society, so science will not hold a privileged position in decision making about them because they will be an emergent outcome of interactions among different stakeholders, values, and interests (cf. Hobbs et al. 2010, Lorimer 2012, Arias-Maldonado 2013, Seidl et al. 2013). Scientists will still be important knowledge brokers of what the trade-offs are and where they occur, for example in terms of the relation between species and function. Yet, overall, decisions about NE will require broader upstream engagement with a wide cross-section of society and varied stakeholders. Novel ecosystems are plural, rather than single, and at least in some instances they may

be outcomes in part of design—design that could help to bring local communities together (e.g., Higgs 2003).

Such shifts in values have happened before. Merchant (1980), for example, describes the “death of nature” that occurred when a living, feminine nature was “killed” by the rise of scientific approaches to the study of nature. More recently, there has been increasing account of the “end of nature” (McKibben 1989), which could be called the second death of nature. Here, we lose a further conception of nature, the idea that nature is separate from humans. Yet, at the same time, many critics have pointed out that that idea of separate nature or wilderness had been dead for a long time—if it ever existed (Cronon 1995). Perhaps we felt separate because of the prior “death of nature” through the scientific worldview that set us off from nature. At this time, we should recognize the current era as an opportunity to begin to rework an appropriate relation between humans and nature, given that the idea of a separate nature was never really appropriate. After the “end of nature” there is “ecological novelty”—it is the phoenix that rises from what is left after the end of nature; it is the new beginning.

This discussion may appear to rejoice in anthropocentric domination of the planet, but it instead acknowledges a continuum of human effects along with its rejection of the human-nature dichotomy. There are certainly ecosystems that are somewhat “intact” (*sensu* Caro et al. 2011)—and they should be treasured, just as there are ecosystems at the other, anthropogenic end of the spectrum. In between, there will be a range of options, including places where society should and will wish to expend the resources (time, money, patience) necessary for restoration. Yet in other places this will not occur, and a critical contribution of the CNE is that these places can still have value.

It is not necessarily inconsistent to talk of conserving nature after the end of nature (cf. Arias-Maldonado 2013). Proctor (2013), for example, reviews six recent books about the Anthropocene, half critical and half promotional, and he concludes that what they have in common is that they can only “count to one or two,” meaning the former can only count nature and culture as distinct, a dualism, and the latter can only lump them together monistically. In both cases, Proctor (2013, p. 91) notes that

“some version of nature is essentialized as a consistent moral rule.” This may have served us in the past, but it is inadequate to the world in which we now live. Accordingly, in the process of exploring the CNE and related concepts, we will necessarily encounter paradoxes and inconsistencies in the entangling of humanity with nature.

Some conservationists will even celebrate NE because through them we are bringing new forms of diversity and expression into the world. This is by no means to say that all will be well just with a diversity of built/urban environments. For it is still critical to maintain the tension in the conflicting values at play, in this case to retain value for what is other-than-human, what is wild, perhaps what was called “nature,” but not without learning and exploring what our entanglements are, which we wish to maintain and encourage, which we wish to reduce or even outlaw, and which changes are out of our hands entirely. We might still wish to recognize that “what is old among us is by that very fact worthy of respect and mimicry, [and] that what is *very* old is likely to be wise (Worster 1995, p. 81).”

The acceptance of NE, in this view, requires acceptance of change. It is difficult for us to accept that all things pass and change, yet important to recognize that this is not the same as “anything goes.” Buddhism, for example, teaches that wisdom is in part the experiential recognition that humans to a large degree suffer (*dukkha*) because we treat things as permanent when everything is impermanent (*anicca*). But they further state that enlightenment requires more than this wisdom; on an analogy with the two wings needed for a bird to fly, the other wing necessary for enlightenment is refined compassion for suffering—in this case, for species going extinct, for the angst many of us feel as favored places and species cease to exist.

### **Acknowledgements**

I appreciate comments on an earlier version of this manuscript from Eric Higgs, Richard Hobbs, Christoph Kueffer, and Libby Robin, and critical feedback from two anonymous reviewers and my students.

## References

Arias-Maldonado, Manuel. 2013. "Rethinking Sustainability in the Anthropocene." *Environmental Politics* 22: 428–446.

Barad, Karen. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.

Bohm, David. 1980. *Wholeness and the Implicate Order*. New York: Routledge.

Borgmann, Albert. 1995. "The Nature of Reality and the Reality of Nature" in *Reinventing Nature? Responses to Postmodern Deconstruction*, ed. Michael E. Soulé and Gary Lease, pp. 31-45. New York: Island Press.

Bowcott, Owen, and Nick Hopkins. 2012. "Future is Assured for Death-dealing, Life-saving Drones." *The Guardian*. 4 August. <http://www.theguardian.com/world/2012/aug/04/future-drones> (accessed 24 June 2014).

Callicott, J. Baird, Larry B. Crowder, and Karen Mumford. 1999. "Current Normative Concepts in Conservation." *Conservation Biology* 13: 22–35.

Caro, Tim, Jack Darwin, Tavis Forrester, Cynthia Ledoux-Bloom, and Caitlin Wells. 2011. "Conservation in the Anthropocene." *Conservation Biology* 26: 185–188.

Coates, Peter. 1998. *Nature: Western Attitudes Since Ancient Times*. Berkeley: University of California Press.



Crist, Eileen. 2013. "On the Poverty of Our Nomenclature." *Environmental Humanities* 3: 129–147.

Cronon, William. 1995. "The Trouble with Wilderness; or, Getting Back to the Wrong Nature" in *Uncommon Ground: Toward Reinventing Nature*, ed. William Cronon, pp. 69–90. New York: W. W. Norton.

Donlan, C. Josh, Joel Berger, Carl E. Bock, Jane H. Bock, David A. Burney, James A. Estes, Dave Foreman, Paul S. Martin, Gary W. Roemer, Felisa A. Smith, Michael E. Soule', and Harry W. Greene. 2006. "Pleistocene Rewilding: An Optimistic Agenda for Twenty-First Century Conservation." *American Naturalist* 168: 660–681.

Fleming, Patricia A. 2006. "Can Nature (Legitimately) Be Our Guide?" in *Religion and the New Ecology: Environmental Responsibility in a World in Flux*, ed. David M. Lodge and Christopher Hamlin, pp. 199–225. Notre Dame, IN: University of Notre Dame Press.

Foxcroft, Llewellyn C., Petr Pyšek, David M. Richardson, and Piero Genovesi, ed. 2013. *Plant Invasions in Protected Areas: Patterns, Problems and Challenges*. Springer.

Gare, Arran E. 1995. *Postmodernism and the Environmental Crisis*. New York: Routledge.

Head, Lesley. 2012. "Decentring 1788: Beyond Biotic Nativeness." *Geographical Research* 50: 166–178.

Heath, Chip, and Dan Heath. 2007. *Made to Stick: Why Some Ideas Survive and Others Die*. New York: Random House.

Higgs, Eric. 2003. *Nature by Design: People, Natural Process, and Ecological Restoration*. Cambridge, MA: MIT Press.

Hobbs, Richard J., Salvatore Arico, James Aronson, Jill S. Baron, Peter Bridgewater, Viki A. Cramer, Paul R. Epstein, John J. Ewel, Carlos A. Klink, Ariel E. Lugo, David Norton, Dennis Ojima, David M. Richardson, Eric W. Sanderson, Fernando Valladares, Montserrat Vilà, Regino Zamora, and Martin Zobel. 2006. “Novel Ecosystems: Theoretical and Management Aspects of the New Ecological World Order.” *Global Ecology and Biogeography* 15: 1–7.

Hobbs, Richard J., Eric S. Higgs, and James A. Harris. 2009. “Novel Ecosystems: Implications for Conservation and Restoration.” *Trends in Ecology and Evolution* 24: 599–605.

Hobbs, Richard J., David N. Cole, Laurie Yung, Erika S. Zavaleta, Gregory H. Aplet, F. Stuart Chapin III, Peter B. Landres, David J. Parsons, Nathan L. Stephenson, Peter S. White, David M. Graber, Eric S. Higgs, Constance I. Millar, John M. Randall, Kathy A. Tonnessen, and Stephen Woodley. 2010. “Guiding Concepts for Park and Wilderness Stewardship in an Era of Global Environmental Change.” *Frontiers in Ecology and Environment* 8: 483–490.

Hobbs, Richard J., Eric S. Higgs, and Carol M. Hall, ed. 2013a. *Novel Ecosystems: Intervening in the New Ecological World Order*. Oxford: Wiley-Blackwell.

Hobbs, Richard J., Eric S. Higgs, and Carol M. Hall. 2013b. “Defining Novel Ecosystems” in *Novel Ecosystems: Intervening in the New Ecological World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 58–60. Oxford: Wiley-Blackwell.

Hobbs, Richard J., Eric S. Higgs, and James A. Harris. 2014. “Novel Ecosystems—Concept or Inconvenient Reality?” *Trends in Ecology and Evolution* (submitted).

Houston, Donna. 2013. “Crisis Is Where We Live: Environmental Justice for the Anthropocene.” *Globalizations* 10: 439–450.

Ingold, Tim. 2008. “Bindings Against Boundaries: Entanglements of Life in an Open World.” *Environment and Planning A* 40: 1796–1810.

Jackson, Stephen T. 2013. “Perspective: Ecological Novelty is Not New” in *Novel Ecosystems: Intervening in the New Ecological World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 63–65. Oxford: Wiley-Blackwell.

Karlsson, Rasmus. 2013. “Ambivalence, Irony, and Democracy in the Anthropocene.” *Futures* 46: 1–9.

Larson, Brendon M. H. 2011. *Metaphors for Environmental Sustainability: Redefining Our Relationship with Nature*. New Haven and London: Yale University Press.

Latour, Bruno. 1993. *We Have Never Been Modern*. Cambridge, MA: Harvard University Press.

Lindenmayer, David B., Joern Fischer, Adam Felton, Mason Crane, Damian Michael, Christopher Macgregor, Rebecca Montague-Drake, Adrian Manning, and Richard J. Hobbs. 2008. "Novel Ecosystems Resulting from Landscape Transformation Create Dilemmas for Modern Conservation Practice." *Conservation Letters* 1: 129–135.

Lodge, David M. and Christopher Hamlin, ed. 2006. *Religion and the New Ecology: Environmental Responsibility in a World in Flux*. Notre Dame, IN: University of Notre Dame Press.

Lorimer, Jamie. 2012. "Multinatural Geographies for the Anthropocene." *Progress in Human Geography* 36: 593–612.

MacMahon, James A. and Karen D. Holl. 2002. "Designer Communities." *Conservation Biology in Practice* 3: 3–4.

Malm, Andreas and Alf Hornborg. 2014. "The Geology of Mankind? A Critique of the Anthropocene Narrative." *Anthropocene Review* 1: 62–69.

Marris, Emma. 2009. "Ragamuffin Earth." *Nature* 460: 450–453.

Marris, Emma. 2011. *Rambunctious Garden: Saving Nature in a Post-Wild World*. New York: Bloomsbury.

Marris, Emma, Joseph Mascaro, and Erle C. Ellis. 2013. "Perspective: Is Everything a Novel Ecosystem? If so, Do We Need the Concept?" in *Novel Ecosystems: Intervening in the New Ecological*

*World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 345–349. Oxford: Wiley-Blackwell.

Mascaro, Joseph, James A. Harris, Lori Lach, Allen Thompson, Michael P. Perring, David M. Richardson, and Erle C. Ellis. 2013. “Origins of the Novel Ecosystems Concept” in *Novel Ecosystems: Intervening in the New Ecological World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 45–57. Oxford: Wiley-Blackwell.

McKibben, Bruce. 1989. *The End of Nature*. Toronto: Doubleday.

McLachlan, Jason S., Jessica J. Hellmann, and Mark W. Schwartz. 2007. “A Framework for Debate of Assisted Migration in an Era of Climate Change.” *Conservation Biology* 21: 297–302.

McNeely, Jeffrey A. 2013. “Global Efforts to Address the Wicked Problem of Invasive Alien Species” in *Plant Invasions in Protected Areas: Patterns, Problems and Challenges*, ed. Llewellyn C. Foxcroft, Petr Pyšek, David M. Richardson, and Piero Genovesi, pp. 61-71. Springer.

Meiners, Scott J., and Steward T. A. Pickett. 2013. “Plant Invasions in Protected Landscapes: Exception or Expectation?” in *Plant Invasions in Protected Areas: Patterns, Problems and Challenges*, ed. Llewellyn C. Foxcroft, Petr Pyšek, David M. Richardson, and Piero Genovesi, pp. 43-60. Springer.

Merchant, Carolyn. 1980. *The Death of Nature: Women, Ecology, and the Scientific Revolution*. New York: Harper and Row.

Milton, Sue J. 2003. “‘Emerging Ecosystems’: A Washing-stone for Ecologists, Economists and Sociologists?” *South African Journal of Science* 99: 404–406.

Murcia, Carolina, James Aronson, Gustavo H. Kattan, David Moreno-Mateos, Kingsley Dixon, and Daniel ". 2014. “A Critique of the ‘Novel Ecosystem’ Concept.” *Trends in Ecology and Evolution* (in press).

Ogden, Laura, Nik Heynen, Ulrich Oslender, Paige West, Karim-Aly Kassam<sup>4</sup>, and Paul Robbins. 2013. “Global Assemblages, Resilience, and Earth Stewardship in the Anthropocene.” *Frontiers in Ecology and the Environment* 11: 341–347.

Perring, Michael P., and Erle C. Ellis. 2013. “The Extent of Novel Ecosystems: Long in Time and Broad in Space” in *Novel Ecosystems: Intervening in the New Ecological World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 66–80. Oxford: Wiley-Blackwell.

Pfeiffer, Jeanine M., and Rorbert A. Voeks. 2008. “Biological Invasions and Biocultural Diversity: Linking Ecological and Cultural Systems.” *Environmental Conservation* 35: 281–293.

Proctor, James D. 2009. “Environment After Nature: Time for a New Vision.” Pp. 293–311 In *Envisioning Nature, Science, and Religion*. West Conshohoken, PA: Templeton Press.

Proctor, James D. 2013. “Saving Nature in the Anthropocene.” *Journal of Environmental Studies and Sciences* 3: 83–92.

Robbins, Paul, and Moore, Sarah A. 2013. "Ecological Anxiety Disorder: Diagnosing the Politics of the Anthropocene." *Cultural Geographies* 20: 3–19.

Sandler, Ron. 2013. "Climate Change and Ecosystem Management." *Ethics, Policy & Environment*, 16: 1–15.

Schwarz, Dietmar, Benjamin M. Matta, Nicole L. Shakir-Botteri, and Bruce A. McPheron. 2005. "Host Shift to an Invasive Plant Triggers Rapid Animal Hybrid Speciation." *Nature* 436: 546–549.

Seidl, Roman, Fridolin Simon Brand, Michael Stauffacher, Pius Krütli, Quang Bao Le, Andy Spörri, Grégoire Meylan, Corinne Moser, Monica Berger González, Roland Werner Scholz. 2013. "Science with Society in the Anthropocene." *Ambio* 42: 5–12.

Standish, Rachel J., Allen Thompson, Eric S. Higgs, and Stephen D. Murphy. 2013. "Concerns about Novel Ecosystems" in *Novel Ecosystems: Intervening in the New Ecological World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 296–309. Oxford: Wiley-Blackwell.

Steffen, Will, Jacques Grinevald, Paul Crutzen, and John McNeill. 2011. "The Anthropocene: Conceptual and Historical Perspectives." *Philosophical Transactions of the Royal Society A* 369: 842–867.

Sutherland, William J., Sarah Bardsley, Mick Clout, Michael H. Depledge, Lynn V. Dicks, Liz Fellman, Erica Fleishman, David W. Gibbons, Brandon Keim, Fiona Lickorish, Ceri Margerison, Kathryn A. Monk, Kenneth Norris, Lloyd S. Peck, Stephanie V. Prior, Jorn P.W. Scharlemann, Mark

D. Spalding, and Andrew R. Watkinson. 2013. "A Horizon Scan of Global Conservation Issues for 2013." *Trends in Ecology & Evolution* 28: 16–22.

Wapner, Paul. 2010. *Living Through the End of Nature: The Future of American Environmentalism*. Cambridge, MA: MIT Press.

White, Damian F., and Chris Wilbert, ed. 2009. *Technonatures: Environments, Technologies, Spaces, and Places in the Twenty-first Century*. Waterloo, Ontario: Wilfrid Laurier University Press.

Worster, Donald. 1995. "Nature and the Disorder of History" in *Reinventing Nature? Responses to Postmodern Deconstruction*, ed. Michael E. Soulé and Gary Lease, pp. 65-85. New York: Island Press.

Wuerthner, George, Eileen Crist, and Tom Butler, eds. 2014. *Keeping the Wild: Against the Domestication of Earth*. Washington: Island Press.

Yung, Laurie, Steve Schwarze, Wylie Carr, F. Stuart Chapin III, and Emma Marris. 2013. "Engaging the Public in Novel Ecosystems" in *Novel Ecosystems: Intervening in the New Ecological World Order*, ed. Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, pp. 247–256. Oxford: Wiley-Blackwell.



**Figure 1.** Novel ecosystems are characterized by the degree to which their biotic and abiotic elements have been altered relative to historical conditions, with hybrid ecosystems considered intermediate (see text). [Source: Hobbs et al. 2009, though note that permission has not yet been obtained for use of this figure; if paper is accepted, I will provide a version for this paper.]