

weighed against less costly interventions in other systems that have greater chances of success [10].

The significant ramifications of engaging with novel ecosystems – as fact and concept – have been clearly articulated elsewhere. Has identification and discussion of novel ecosystems inadvertently opened the floodgates to heedless human meddling, as Murcia *et al.* imply? We think not. Those who would transform ecosystems for human benefit have not been shy about doing so and certainly do not need a concept such as novel ecosystems to justify their actions. Indeed, continued retention of unrealistic restoration goals may feed into the ongoing destruction of good-condition ecosystems by allowing unachievable offset and mitigation targets to be traded for development [11].

Recalling earlier fears that restoration would dilute preservation and conservation efforts, history, it would seem, is repeating itself. Careful management of hybrid and novel ecosystems can add capacity and innovation to environmental management in the same way that restoration has. It can also open up a wider range of ecosystems for consideration, providing many opportunities for both ecological and social gains in urban and other developed areas where novel ecosystems are perhaps most prominent [12].

The question is thus not whether we should continue to discuss and research novel ecosystems, but whether the developing concepts and frameworks can assist with the process of better understanding, managing, and restoring ecosystems in a rapidly changing world. Murcia *et al.* highlight ([1], see Box 2) the ongoing empirical research needed on nonlinear dynamics and thresholds, resilience, and new paradigms to manage highly disturbed ecosystems – all features of the emerging body of work on novel ecosystems. While this research is continuing, the need for difficult management decisions remains. Embracing the increasing prevalence of altered ecosystems (whether

these are called hybrid, novel, emerging, or something else) does not involve throwing away all current efforts in conservation and restoration. Rather, it should allow more reasonable discussion of the options available, the likelihood of success of different degrees of intervention, and the priorities for action.

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References

- Murcia, C. *et al.* (2014) A critique of the 'novel ecosystem' concept. *Trends Ecol. Evol.* 29, 548–553
- Graham, N.A.J. *et al.* (2014) Coral reefs as novel ecosystems: embracing new futures. *Curr. Opin. Environ. Sustain.* 7, 9–14
- Harborne, A.R. and Mumby, P.J. (2011) Novel ecosystems: altering fish assemblages in warming waters. *Curr. Biol.* 21, R822–R824
- Hobbs, R.J. *et al.*, eds (2013) *Novel Ecosystems: Intervening in the New Ecological World Order*, Wiley–Blackwell
- Martin, L.J. *et al.* (2014) Conservation opportunities across the world's anthromes. *Divers. Distrib.* 20, 745–755
- Venton, D. (2013) Forest management plans in a tangle: conservation fight flares over invasive California eucalyptus. *Nature* 501, 15–16
- Hagerman, S.M. and Satterfield, T. (2014) Agreed but not preferred: expert views on taboo options for biodiversity conservation, given climate change. *Ecol. Appl.* 24, 548–559
- Robbins, P. and Moore, S.A. (2013) Ecological anxiety disorder: diagnosing the politics of the Anthropocene. *Cult. Geogr.* 20, 3–19
- McCarthy, D.P. *et al.* (2012) Financial costs of meeting global biodiversity conservation targets: current spending and unmet needs. *Science* 338, 946–949
- Hobbs, R.J. *et al.* (2014) Managing the whole landscape: historical, hybrid and novel ecosystems. *Front. Ecol. Environ.* (in press)
- Maron, M. *et al.* (2012) Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biol. Conserv.* 155, 141–148
- Kowarik, I. (2011) Novel urban ecosystems, biodiversity, and conservation. *Environ. Pollut.* 159, 1974–1983

The road to confusion is paved with novel ecosystem labels: a reply to Hobbs *et al.*

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Responding to our critique of the novel ecosystem concept [1], Hobbs *et al.* [2] misrepresent our points of view, so we

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begin by clarifying our position. First, we do not deny the existence of anthropogenically transformed ecosystems; cities, pastures, agricultural fields, or open-pit mines are real and have accompanied humans for millennia. We agree: society must deal with these ecosystems in sensible and effective ways, as part of the much larger effort to transition toward sustainability, maintain biodiversity,

and provide ecosystem services to humans and habitat to other species. Neither point is under discussion. However, we propose that there is no need to develop a new label for transformed ecosystems, especially any label that might restrict management options by potentially excluding restoration. Restoration includes a wide range of practical possibilities for dealing with transformed ecosystems, including rehabilitation, reclamation, and remediation. Some will bring the ecosystem back to its historical trajectory, some will bring back only some attributes, but the intention is that the end product is better than the degraded ecosystem. Importantly, a label such as novel ecosystem implies no need for further intellectual exertion – and ignores the growing science of the young discipline of ecological restoration.

The proliferation of new labels for anthropogenic ecosystems ('the various formulations – of the concept of novel ecosystems – and allied terminology' [2]) only generates confusion and may predispose people to abandon attempting restoration simply because it may be difficult and appears costly, especially since categories like 'hybrid' and 'novel' are not well defined and no quantitative criteria to characterize them have been developed. Applying the novel label to an ecosystem adds an unnecessary layer of complexity to an already complicated process of conservation, management, and restoration planning. In particular, we see the use of the term novel as potentially damaging. Words matter and language can greatly affect people's view of the world [3]. We live in an age in which novelty and innovation are prized in endeavors such as product development and the arts. The novel ecosystem concept thus sends a message of scientific endorsement of improvement over the 'old' nature and breaking with the old ways. Embracing anthropogenic ecosystems as the 'new normal' or 'new ecological world order' opens the floodgates to the intellectual hubris of redesigning nature that assumes a complete knowledge of the ecological and biological outcomes and consequences.

We do not deny the existence of nonlinear dynamics that shift ecosystems into different regime states. What we dispute is assuming that any profoundly transformed ecosystem has crossed an irreversible threshold that automatically makes ecological restoration impossible (understanding ecological restoration as the wide set of goals and end points that we seek to achieve in a restoration program, wherever possible using a historical reference for orientation and metrics). In addition, the fact that socioeconomic issues play a central role in discussion of ecosystem management projects does not mean they are so inextricably linked that they cannot be differentiated and analyzed separately. At least in theory, any conservation and restoration project begins with a definition of goals and objectives, and courses of action are defined within a framework of cost-effectiveness and adaptive management. In this context, multiple options can be explored

Box 1. Reiterating our still unchallenged points

- The concept of novel ecosystems is ill defined and can lead to undesirable practical and policy outcomes.
- Successful restoration projects abound in areas that could have been considered novel.
- Socioeconomic and political limitations to ecological restoration should not be confused with ecological thresholds.
- Hobbs *et al.* [2] agree that 'novel ecosystems' is a term that has morphed many times in its short lifetime. They argue that this is normal; we suggest that this level of morphing and re-morphing indicates only that it has not hit a true target and should be handled much more cautiously.

that may include the question of whether to attempt to restore.

It is customary that any critique will be followed by responses and counter-arguments. That is the beginning of a dialog and we expected a sound rebuttal. However, we found that Hobbs *et al.*'s response [2] recycles ideas from previous papers with vague statements of unsubstantiated criticism and claims and, more importantly, does not address our concerns (Box 1). No matter what counter-arguments are presented, there is not a single paper that defines the thresholds for applying the novel ecosystem label or one that shows how the novel ecosystem label has changed practitioners' management approach to yield results that exceed what a good restoration (or rehabilitation) program would have achieved. Thus, we await the experimental evidence to support these theoretical musings.

Finally, '...negative policy impacts are feared rather than observed' [2]. We believe that it is legitimate to anticipate possible negative impacts and wise to take measures to avoid or deal with them. In the social sciences, the law of unintended consequences warns us to beware of 'advances' that may create more problems than they solve. Based on our considerable and direct collective experience in working with policy makers and managers, and the many (and often unsubstantiated) interpretations that novel ecosystems now have in those two guilds, we feel that our concerns are justified. Scientists play an important role as trusted advisors to policy makers. We are recognized as custodians of the 'truth industry', especially in instances where there is uncertainty, and it is then that an open dialog with a great deal of humility, rather than offers of 'unequivocal advice', is necessary to help policy makers cope with complex issues and unforeseen consequences [4].

References

- 1 Murcia, C. *et al.* (2014) A critique of the 'novel ecosystem' concept. *Trends Ecol. Evol.* 29, 548–553
- 2 Hobbs, R.J. *et al.* (2014) Novel ecosystems: concept or inconvenient reality? A response to Murcia *et al.* *Trends Ecol. Evol.* 29, 645–646
- 3 Hajer, M.A. (2006) Doing discourse analysis: coalitions, practices, meaning. Words matter in policy and planning discourse. *Theory Method Soc. Sci.* 344, 65–74
- 4 Spruijt, P. *et al.* (2014) Roles of scientists as policy advisers on complex issues: a literature review. *Environ. Sci. Policy* 40, 16–25