

A critique of the ‘novel ecosystem’ concept

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The ‘novel ecosystem’ concept has captured the attention of scientists, managers, and science journalists, and more recently of policymakers, before it has been subjected to the scrutiny and empirical validation inherent to science. Lack of rigorous scrutiny can lead to undesirable outcomes in ecosystem management, environmental law, and policy. Contrary to the contentions of its proponents, no explicit, irreversible ecological thresholds allow distinctions between ‘novel ecosystems’ and ‘hybrid’ or ‘historic’ ones. Further, there is no clear message as to what practitioners should do with a ‘novel ecosystem’. In addition, ecosystems of many types are being conserved, or restored to trajectories within historical ranges of variation, despite severe degradation that could have led to their being pronounced ‘novel’.

Challenging current conservation and restoration practices

New concepts that challenge existing paradigms drive science and innovation. However, presumably revolutionary concepts must be based on solid arguments and evidence, in particular when they affect how we manage the ecosystems on which all life depends. Doak *et al.* [1] analyzed the implications of uncritically adopting a new human-centered conservation approach based on opinions, untested assumptions, and unwarranted conclusions. Here we discuss a similar case in which a new ecological world order [2] is proposed without the necessary substance and supporting evidence, but with potentially disturbing policy implications. The concept of ‘novel ecosystems’ [2–4] advocates embracing novelty as a way to move forward and away from ‘traditional’ conservation and restoration approaches. Our goal is to analyze the concept, its foundations, and its policy implications objectively.

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A ‘novel ecosystem’ refers to a new species combination that arises spontaneously and irreversibly in response to anthropogenic land-use changes, species introductions, and climate change, without correspondence to any historic ecosystem. The ‘novel ecosystem’ concept, first introduced by Chapin and Starfield [5], was brought to the attention of the restoration and conservation communities in 2006 [3]. Presented as a new paradigm [2] aligned with the proposed synthetic fields of ‘Intervention Ecology’ [6] and ‘New Conservation Science’ [7], the concept of ‘novel ecosystems’ and its definition have mutated continuously (Table S1 in the supplementary material online) sometimes to address criticism [2,3,8–11] and sometimes with unresolved conflicts [12,13]. In its latest definition, a ‘novel ecosystem’ is ‘a physical system of abiotic and biotic components (and their interactions) that, by virtue of human influence, differs from those that prevailed historically, having a tendency to self-organize and retain its novelty without future human involvement’ [12]. This definition is

Glossary

Ecological rehabilitation: in the broad sense, the improvement of ecosystem functions without necessarily achieving a return to ‘pre-disturbance’ conditions. Emphasis is generally on restoring ecosystem processes and functions to increase the flow of services and benefits to people [51,52].

Ecological restoration (ER): ‘The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed’ [52]. The term is often used broadly to mean returning a site or system to ‘pre-disturbance conditions’. It implies connecting an ecosystem, as it occurred and developed in the historical past, to its future potential to evolve and adapt. The notion of ‘historical continuity’ is relevant and useful [51].

Ecological threshold: a ‘tipping point’ at which an ecosystem, under pressure from environmental drivers of change, shifts to an alternative stable state (sometimes referred to as state-change).

Ecosystem resilience: the capacity of an ecosystem to tolerate disturbance and recover autonomously by natural regeneration without collapsing or shifting into a qualitatively different state controlled by a different set of processes [53].

Evolutionary rescue: the possibility that rapid evolutionary processes may allow a population to adapt even to abrupt environmental changes.

Reference ecosystem (or reference model): one or more natural or semi-natural ecosystems, ecological descriptions, or carefully selected attributes of corresponding ecosystems that are assembled to serve as models, benchmarks, and rallying points for planning, executing, and monitoring ecological restoration projects.

still impaired by logical contradictions and ecological imprecisions. We propose that the overall foundations and implications of this concept are as troublesome as the semantic details.

'Novel ecosystems' constitute a special case of ecosystem transformation resulting from species invasions and environmental change [2]. Some proponents of the concept assert that because of the global nature of climate change, all ecosystems are at risk of transformation by extinctions and invasions. Moreover, the pervasiveness of the human footprint suggests to some that no corner of the earth can escape transformation [14]. Consequently, all systems previously considered 'wild' or 'natural', and the abandoned remnants of previously managed systems (particularly agricultural lands), are likely to become so profoundly transformed that no effort will suffice to return them to their historic state [2]. In this scenario, conserving and restoring ecosystems is a futile endeavor [15], driven by sentimentality (R.J. Hobbs, cited in [16]) and psychological impairment [8]. Instead, efforts should focus on steering ecosystems towards a desirable state or away from an undesirable state [6], none of which involves an historical pre-disturbance condition (hence its difference from restoration). This line of thought, however, contains ambiguous statements and can lead to misconceptions and poor policy, especially when ecological thresholds are confused with socioeconomic and political ones, as discussed below.

Faulty assumptions and oversights of the 'novel ecosystem' concept

'Novel ecosystems' are ubiquitous [2] and constitute a 'new normal' [17]

The above-cited oversimplification is based partly on inferences drawn at an inappropriate scale. The argument that most of the world's ecosystems are moving into 'novel' condition [2,17] is based on the global human footprint map [18], which shows potential human disturbance at a coarse scale based on proxy variables such as roads or human settlements. However, a closer look at the ecosystem scale shows that many ecosystems are well preserved, well managed, or only mildly degraded [19,20] with sound prospects for restoration.

An analysis of forest cover trends over a 10 year period in 16 050 municipalities in Latin America and the Caribbean indicated that, although some areas are affected by deforestation, in many others the extent of natural forest is stable or increasing [19]. Specifically for Colombia, a country-wide net gain of forest cover of almost 17 000 Km² has occurred between 2000 and 2010 [21]. Furthermore, in the megadiverse 'Eje Cafetero' region of the central-western Andes of Colombia, 208 000 hectares of cloud forest are being conserved and restored in what appears as a thoroughly transformed region in human footprint models. Geographical analysis at a finer scale shows that much native forest is intact and supports a complete biota, including large mammals such as mountain tapir (*Tapirus pinchaque*). Ecological restoration of degraded pastures based on an historical reference (see [Glossary](#)) has aided recovery of the cloud forest biota and ecosystem functioning [22,23].

Similar trends are observed on other continents. For example, in western Africa the Transfrontier Reserve of

Benin, Burkina Faso, and Niger (<http://www.parks.it/world/NE/parc.w/Epar.html>), assisted natural regeneration is facilitating dramatic comeback of savanna vegetation in large areas without major cost and with few invasive organisms (J.A., unpublished data, February 2014). These examples, and many others, show that blanket statements about the relentless global spread of 'novel ecosystems' or the irreversibility of ecosystem change are unsubstantiated. Similarly, assisted regeneration coupled with sound management practices in many forest systems is currently observed in eastern North America and southern Europe [24].

'Novel ecosystems' result from predictable and unavoidable responses in species distributions caused by climate change or other global changes

The 'novel ecosystem' concept is based on the premise that we should be 'pragmatic' and accept unavoidable, widespread, and irreversible changes in ecosystems caused by climate change, biological invasions, and other altered global processes (e.g., nitrogen deposition) [6]. This premise presents an inaccurate forecast for the planet. Although evidence accumulates that many species are responding to global change by migrating and invading other ecosystems, our ability to predict climate change is still limited, especially at local and regional scales that are relevant to conservation and restoration projects. Hence, abandoning attempts to restore damaged ecosystems over an uncertain future might not be wise. A study modeling potential biome responses to climate change in the tropical Andes found that, depending on greenhouse gas emission scenarios and time horizons, 75–83% of the biomes in the region will not change [25]. Importantly, many species have pre-adaptations to climate change, as shown by their recent evolutionary history [26].

The growing literature on evolutionary rescue suggests that we should not automatically assume that species or assemblages cannot adapt to rapid changes [27]. Although populations shift their distributions in response to climate change, entire ecosystems and natural species assemblages may be remarkably resilient. For example, although birds in Peru are shifting their distribution upwards as a result of climate change [28], the shift is much smaller than expected. In addition, there is great uncertainty about which species combinations, based on species functional traits, will match new biophysical conditions, exhibit resilience, maintain biodiversity, and provide ecosystem services to people [29].

These facts argue for a precautionary principle of conservation and restoration. Rather than embracing invasion-driven 'novel ecosystems' as a 'new normal' [17], we should seek to reestablish – or emulate, insofar as possible – the historical trajectory of ecosystems, before they were deflected by human activity, and to allow the restored system to continue responding to various environmental changes [30,31].

'Novel ecosystems' tend to self-organize and retain their novelty

This premise (see [4,12]) is based on untested assumptions that current ecosystems are not resilient, whereas 'novel

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