Grappling with the social dimensions of novel ecosystems

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The novel ecosystem concept has emerged in response to the increasing prevalence of modified ecosystems. Traditional conservation and restoration strategies have been deemed inadequate to guide the management of ecosystems that are the product of anthropogenic environmental change and have no "natural" analogs. Opinions about novel ecosystems are currently divided between those who embrace the flexibility offered by the concept and those who see it as a shift toward the abandonment of traditional strategies. However, the debate is missing a key element: recognition that all conservation decisions are socially constructed and that the concept of novel ecosystems is most practicable within a decision or management context. Management of novel ecosystems should be framed in such a context, and the concept evaluated for its capacity to meet social, ecological, and economic objectives.

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As more of the Earth becomes modified by humans and as "natural" areas increasingly become unrecognizable in relation to the systems they replace (Radeloff *et al.* 2015), debate has emerged around the labeling of such systems as "novel ecosystems" (Murcia *et al.* 2014; Radeloff *et al.* 2015; Miller and Bestelmeyer 2016). Since the 1930s, several terms have been used to describe modified systems (Tansley 1935), including "anthropogenic ecosystems", "no-analog communities", "synthetic or emerging ecosystems", and "spontaneous vegetation" (Truitt *et al.* 2015). Regardless of terminology, highly modified ecosystems do exist (Chapin and Starfield 1997; Hobbs *et al.* 2006; Collier 2015) and when traditional conservation objectives can no longer be achieved, it is imperative to find an acceptable management framework within which conservation decision makers can communicate and develop new management strategies.

> **In a nutshell:**
>
> - The novel ecosystem concept describes modified natural systems that have crossed irreversible socioecological thresholds due to human-induced environmental change
> - Critics of this concept fear it will nullify efforts to conserve biodiversity, and consider it unnecessary because ecological restoration provides management options for modified ecosystems; in contrast, proponents contend that it broadens the possibilities for conservation (eg by valuing degraded ecosystems)
> - Because all approaches to conservation, including those that involve novel ecosystems, are values-based, decisions pertaining to the management of modified ecosystems are embedded in a social context
> - To help inform the management of novel ecosystems, we propose a values-based decision process, one that accounts for site-specific variation

A novel ecosystem is a "system of abiotic, biotic, and social components (and their interactions) that, by virtue of human influence, differs from those that prevailed historically" (Hobbs *et al.* 2013). Critics claim that this concept is ill-defined, may promote laissez-faire attitudes to conservation and restoration (Murcia *et al.* 2014; Higgs 2017), and is unnecessary, because ecological restoration already accounts for modified ecosystems (Egan 2006; Simberloff 2015). Conversely, proponents of the novel ecosystem concept maintain that it addresses a need to manage ecosystems that have irrevocably crossed social–ecological thresholds to the point where traditional ecological restoration frameworks can no longer accommodate them (Hobbs *et al.* 2013; Higgs 2017), and that it gives conservation value to anthropogenically modified systems that could otherwise be dismissed or overlooked (Marris *et al.* 2013). For example, Miller and Bestelmeyer (2016) saw the novel ecosystem concept as a way to name a class of ecosystem that has no historical analog but without the negative connotations of the term "degraded". For a critical discussion of the risks and benefits of the novel ecosystem concept, see Marris *et al.* (2013), Murcia *et al.* (2014), and Collier (2015).

In the debate on novel ecosystems, a crucial aspect is missing: that the concept is a social construct. As a social construct, like all conservation decisions, management decisions about novel ecosystems hinge on biodiversity conservation values held by individuals and society. These values

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are principles, preferences, and virtues associated with a quality of relationship with nature (Chan *et al.* 2016). Using science alone to understand complex ecological interactions and entities, by reducing them to the sum of their parts, cannot inform the acceptability of "novelty" within natural ecosystems to decision makers (Seastedt *et al.* 2008). Studying ecological components – such as novel species assemblages and interactions, along with ecological processes – improves understanding of them (Holling 1996), but how well ecological novelty is tolerated is based on individual and social values (Ives and Kendal 2014).

Here, we highlight the social context and processes that shape management decisions about novel ecosystems. Given the social dimensions of the novel ecosystem concept, we propose that it needs to be analyzed through a more inclusive lens – specifically, using a decision analysis perspective that accounts for human values and their social contexts. Phillips (1989) described decision analysis as a way of thinking that integrates different viewpoints on a problem, generating intuitions and an overview of perspectives. Decision analysis is not designed to replace the judgment upon which decisions depend; instead, it provides a framework that helps decision makers articulate and clarify their reasoning (Goodwin and Wright 2014). This decision analysis perspective builds on existing frameworks that contribute to guiding management options for modified landscapes (Hobbs *et al.* 2014; Morse *et al.* 2014; Truitt *et al.* 2015; Miller and Bestelmeyer 2016). We demonstrate how using decision analytics can advance the novel ecosystem debate by prompting consideration of a greater range of socioecological objectives and management alternatives for modified ecosystems.

The novel ecosystem concept

Similar to the concepts of biodiversity conservation (Morar *et al.* 2015), biodiversity offsetting (Coralie *et al.* 2015), ecosystem services (Barnaud and Antona 2014), and restoration ecology (Hobbs 2004), the "novel ecosystem" concept was coined and assigned collective attributes before empirical research defined it. Each of these concepts was borne from crisis-oriented disciplines (such as conservation biology in reaction to biodiversity loss) within which action needed to be taken before all the facts were known (Soule 1985). The collective decisions that were made during the development of these terms were fundamentally a manifestation of human values (Kareiva and Marvier 2012).

The concept of the novel ecosystem has been defined but is still a subject of contentious debate (Hobbs *et al.* 2014; Morse *et al.* 2014; Collier 2015). Because ecosystems are naturally in a constant state of flux, determining baselines against which to assess ecosystem states, and therefore the degree of novelty that will be allowed for in a management context, is not straightforward (Holling 1996; Rohwer and Marris 2016). Selecting a management target from a range of historical benchmarks or trajectories is a decision about what is technically feasible (in terms of a site's ecology) *and* what is culturally acceptable (Collier 2014). At the same time, it is difficult to identify whether and when a system has crossed a threshold to the point where it is no longer responsive to traditional restoration strategies (Harris *et al.* 2006; Balaguer *et al.* 2014). Miller and Bestelmeyer (2016) suggested that the reversibility of ecological thresholds may often depend on cost and public support, not just ecological knowledge. Another key aspect that defines novel ecosystems is the ability of a system to self-perpetuate without intensive human management (Hobbs *et al.* 2013). However, labeling a system as self-organizing is subjective (Morse *et al.* 2014). Lundholm (2016) contended that even human-engineered ecosystems, such as green roofs, show spontaneous dynamics, including uncontrolled or unexpected species colonizations and interactions. Resolution of these tensions cannot be achieved through science alone but will require consideration of their social context.

Current perceptions of novel ecosystems, and how they are valued by conservation decision makers, are reflected in a variety of cultural and social contexts that surround conservation movements in the US and Europe (Panel 1). The legacy of these divergent movements is evident in their different approaches to environmental management, as well as in their perceptions of both modified and novel ecosystems. Within the US model, where ecological restoration and conservation objectives aim to re-establish ecosystems that were present before European settlement, ecological novelty within highly modified ecosystems is commonly not embraced (Egan 2006). Under the European model, novel ecosystems are not explicitly considered. These landscapes have been subject to long-term agricultural and industrial change. A common aim is to return ecosystems to a pre-industrial state (mid-19th century), not pre-agricultural settlement (Whited *et al.* 2005). Here, biodiversity conservation includes protecting and actively managing system states that would be considered novel ecosystems under the US model, such as hedgerows and agricultural wildflower meadows (Halada *et al.* 2011). In the European landscape, recognizing modern novel species assemblages requires a nuanced ecological and social understanding with respect to what could be categorized as novel ecosystem baselines. This variation in approaches to how novel ecosystems are viewed highlights the social construction of the novel ecosystem concept. A belief (which "nature" should be conserved) is considered socially constructed if societies that hold the same knowledge (ecological facts and information) arrive at different and incompatible beliefs because of diverging social values (the preferred type of nature) (Boghossian 2001).

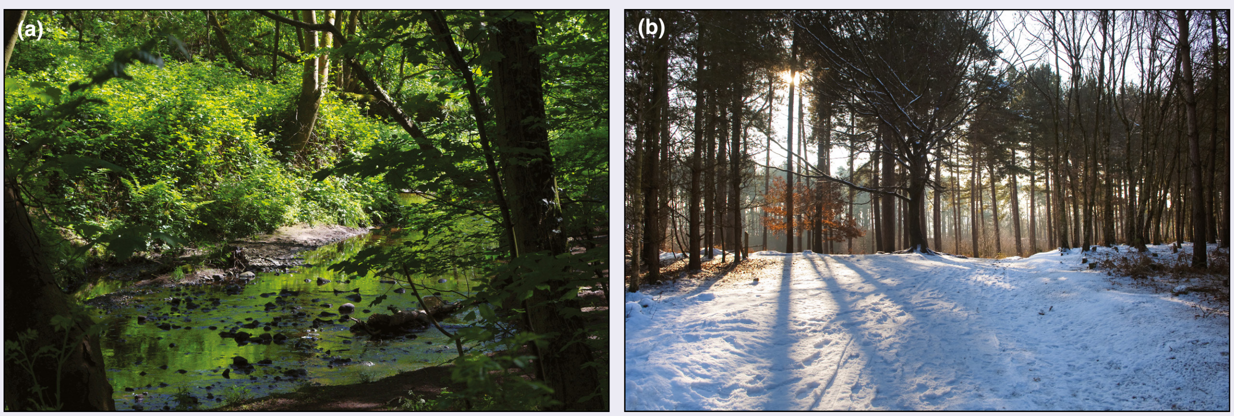
Critiques of the novel ecosystem concept echo the philosophical debate mounted against ecological restoration that began in the 1980s. Elliot's (1982) essay posited that ecological restoration could provide leverage for

Panel 1. Culturally divergent conservation models – examples from the US and Europe

Beginning in the mid-19th century, the US conservation model (commonly known as the Yellowstone model) set aside and protected "wilderness" areas (eg Figure 1), excluding people except in the context of, for example, recreational activities (Wuerthner *et al.* 2015). This is encapsulated in Thoreau's declaration that "in Wildness is the preservation of the World" (Thoreau 1851) and Aldo Leopold's demand "that representative portions of some forests be preserved as wilderness [because] it will be much easier to keep wilderness areas than create them" (Leopold 1921). This model sets the pre-European state of an ecosystem as the ideal goal for conservation because European colonization is perceived to be the point at which modern anthropogenic disturbance began to substantially affect natural landscapes. The Yellowstone model of creating reserves through park systems and attempting to restore ecosystems to pre-European states was adopted by several countries around the world, including Canada, New Zealand, and South Africa (Howkins *et al.* 2016). In contrast, in Europe – where the landscape has been subject to a longer period of anthropogenic modification (primarily through agriculture), a common ecological conservation model integrates people and nature (Whited *et al.* 2005). The focus of this alternative model is on promoting sustainable use by humans, avoiding species extinction, and maintaining (or replicating) agricultural practices that enhance biodiversity (eg Figure 2).

CE Watkins

Figure 1. *North Dome, Yosemite National Park (circa 1865). Yosemite was deeded by the US government to the state of California in 1864 as the nation's first wildland park.*



M Forest

W McCoy

Figure 2. *The Mersey Forest – a network of green spaces and woodlands stretching across Merseyside and North Cheshire, UK. Approximately 129,500 hectares of community forest grown from a novel assemblage of nine million trees supporting a diversity of wildlife and ecosystems while delivering social, economic, and environmental benefits. (a) Spring in Mersey Forest Rivacre Valley, Cheshire 14 May 2014; (b) Winter in Delamere section of Mersey Forest, 2 Feb 2009.*

developers to renege on commitments to preserve intact natural areas, leading to more environmental policy decisions that would negatively affect natural systems. For example, developers could be permitted to mine or log an area because the ecological impacts of the activity could be reversed by ecological restoration. Elliot further asserted that the outcome of ecological restoration is man-made, creating at best an inadequate replica of the original natural system, which has been irretrievably lost. Katz, a strong critic of ecological restoration, extended this argument by stating "the practice of ecological restoration can only represent a misguided faith in the hegemony and infallibility of human power to control the natural world" (Katz 1996). Similar claims have been made about the adoption of the novel ecosystem concept. Murcia *et al.* (2014) argued that, "What is at stake is whether we decide to protect, maintain, and restore ecosystems wherever possible or else adopt a different overall strategy, driven by a vision of a 'domesticated' Earth, and use a hubristic, managerial mindset". Underlying these perspectives are fundamental differences describing how people relate to nature. Katz (2012) believed that the value of natural places – wild spaces free from human control – is in their native autonomy, whereas a commonly held view in ecological restoration is that people are simultaneously part of, and apart from, nature (Jordan and Lubick 2011). The novel ecosystem concept encompasses both of these perspectives, reflects the anthropogenic origins of these systems (Hobbs *et al*. 2006), and describes them as new wildness or the wild lands of the Anthropocene (Marris *et al*. 2013; Lorimer 2015).

Novel ecosystems are socially defined

Acknowledging that novel ecosystems are conceptualized through a social process highlights the complex interactions between nature and culture (Collier 2014). This complexity is especially evident in the biotic component of novel ecosystems, which can be characterized by species assemblages that have no recognizable historical analog and that are partially or predominantly composed of exotic taxa (Hobbs *et al*. 2006). Exotic or non-native species are not inherently good or bad; judgment is predicated on the ecological context and human perspective (Morse *et al*. 2014) (Panel 2). To conservation decision makers, the acceptability of ecological novelty (eg interactions between native and non-native flora and fauna) is irrelevant outside of a decision or management context. If not explicitly recognized, the influence of decision makers' preferences and attitudes toward non-native species within novel species assemblages presents intractable challenges for resource managers and policy makers.

Whether invasive species are perceived as beneficial or detrimental depends on landscape context and site-specific attributes (Seastedt *et al*. 2008; Hobbs *et al*. 2014). For instance, bullrush (*Typha* spp) and common reed (*Phragmites australis*) are wetland flora species that are indigenous to Australia but have invasive tendencies (Zedler and Kercher 2004). Beneficial attributes of these species include providing habitat for secretive wetland birds – such as bitterns (Botaurinae spp) and curlews (*Numenius* spp) – in Australia and for the bullfrog (*Rana catesbeiana*) in North America (Rogalski and Skelly 2012). Although they can also contribute to stormwater filtration in wetland systems (Dhote and Dixit 2009), *Typha* spp and *Phragmites australis* are robust and highly competitive, often forming monospecific stands, reducing biodiversity, and potentially clogging waterways (Zedler and Kercher 2004). Management responses to these species assemblages will be driven by the site-specific context and by the decision-makers' perspectives and conservation priorities.

Panel 2. Management decision trade-offs between native and non-native species – the example of tamarisk and southwestern willow flycatcher

Tamarisk (*Tamarix* spp) (Figure 3) is considered by many to be one of the worst invasive weeds in the western riparian ecosystems of the US (DeLoach *et al*. 2000; Stromberg *et al*. 2009). A range of environmental impacts – including streamflow depletion from high evapotranspiration rates, increased soil salinization, increased frequency and intensity of riparian forest wildfires, and habitat depletion – have been attributed to this species (Shafroth *et al.* 2005). However, some research has questioned whether tamarisk is a driver of these changes or a consequence of landscape changes, such as agricultural conversion and altered hydrological regimes (Stromberg *et al*. 2009). While tamarisk has transformed over 400,000 hectares of riparian habitat (DeLoach *et al.* 2000) to monotypic stands that hold limited habitat value for small mammals, amphibians, and reptiles (Shafroth *et al.* 2005), tamarisk stands are used extensively for breeding and feeding by numerous bird species, including the nationally endangered southwestern willow flycatcher (*Empidonax traillii extimus*) (Figure 4) (Sogge *et al.* 2008). In some areas, tamarisk creates habitat for this endangered species, but negatively affects the riparian system. Decisions about whether this invasive plant should be eradicated, controlled, or protected are therefore contentious and will ultimately reveal contextual ecological and social values about the relative importance of the broader riparian system compared to the southwestern willow flycatcher.

C Shock

Figure 3. *Tamarisk (*Tamarix parviflora*), Lower Owyhee River, Oregon, 24 May 2007.*

S Howell

Figure 4. *The southwestern willow flycatcher (*Empidonax traillii extimus*).*

Biodiversity conservation, like all decisions to intervene in ecosystems, is an inherently subjective process.

Challenges for traditional ecological restoration and conservation management benchmarks

Biodiversity conservation and ecological restoration are prevailing scientific paradigms and social constructs. Similar to the social constructions of money and nation states (Harari 2014), conservation and restoration practices exist only because of people (Light *et al.* 2013; Rohwer and Marris 2016). While biophysical features and processes are separate from people, how biodiversity is valued is not (Morar *et al.* 2015). Biodiversity encompasses a vast array of flora, fauna, and biophysical interactions, but the aspects of biodiversity that are chosen for protection, conservation, and research are socially determined (Morar *et al.* 2015). Likewise, classifications of species assemblages, the development and implementation of environmental management strategies, and the delineation of national park/conservation reserve boundaries are not objectively determined; they are based on norms, laws, and values (Harari 2014).

In recent years, paleoecological studies, in conjunction with advances in modeling techniques and technology, have investigated historical environmental variation and ecosystem trajectories, providing an alternative to the traditional conservation strategy that relies on historical benchmarks (Seastedt *et al.* 2008). Despite improvements in understanding and projecting historical ranges of variation, potential environmental outcomes of ecological restoration and conservation are shrouded with uncertainty. Future scenarios are difficult to predict because the long-term impacts of management actions are uncertain in the face of climate and landscape change (Harris *et al.* 2006). Additionally, ongoing management is highly variable because management activities and the social context (political support, access to resources, community engagement) for a particular area may change in the future (Hobbs *et al.* 2014). Therefore, selecting management actions to facilitate a particular historical trajectory does not necessarily ensure the desired ecological outcome (Balaguer *et al.* 2014; Miller and Bestelmeyer 2016). Using historical trajectories to justify environmental management decisions is equivalent to deciding to manage an ecosystem for its novelty or adopting a conservative ecological restoration approach that targets pre-European colonization benchmarks. Each choice can equally be considered a subjective decision driven by bias for a particular management approach.

Novel ecosystems as legitimate management targets

Environmental, social, and economic values affect all steps of the conservation decision-making process, from prioritizing conservation objectives to determining resource allocations and triggers for management action (Ives and Kendal 2014). For example, differing conservation priorities can sway the decision either to conserve a highly modified site that supports threatened species or to protect an area of relatively intact remnant vegetation where no rare or threatened species have been recorded. Ecological preferences and economic priorities can dictate thresholds for taking action on a particular management objective, such as the decision to remove or manage invasive species once they have reached a prescribed distribution and/or abundance (Simberloff 2015). Benchmarks against which management actions are triggered and measured are human-driven, determined by land managers. Furthermore, assessing the success of ecological restoration and biodiversity conservation projects is challenging because there is no single recognized and validated approach (Kapos *et al.* 2009). Instead, methods to measure outcomes depend on site-specific conditions and individual project parameters (Wilson and Arvai 2006). The novel ecosystem concept expands the potential suite of management objectives for modified ecosystems by removing limitations of conservative conservation strategies and increasing flexibility to work with the extant system (Hobbs *et al.* 2013). Differing from ecological restoration that promotes the re-establishment of an historical range in variation or a fixed historical benchmark (Balaguer *et al.* 2014), a novel ecosystem framework works in concert with the uncertain future of highly modified systems that have no historical analog (Marris *et al.* 2013).

This raises important questions about when and how maintaining novel ecosystem dynamics might be an acceptable management target. A novel assemblage of species is generally considered a suitable goal for a rooftop or brownfield in an urban area (Lundholm 2016; Higgs 2017). Arguably, novel ecosystems contribute biodiversity and ecosystem services (including benefits to human well-being) in these environments (Light *et al.* 2013). Likewise, most natural resource managers would think it inappropriate to manage a remote, uninhabited area of the Amazon rainforest with a target of novel ecosystem characteristics. It is the transitional spaces – green spaces that have changed from natural to modified – where there are conflicting opinions about management goals (Higgs 2017). Deciding on management objectives for these no-analog systems is a value judgment, but it is unlikely that re-creating conditions that resemble those prior to human settlement is going to be the only appropriate objective. It is within this ecological decision-making context that there is a defined role for the novel ecosystem concept (Hobbs *et al.* 2014; Miller and Bestelmeyer 2016).

A way forward

We propose a values-based decision process that accounts for site-specific variation as a solution for

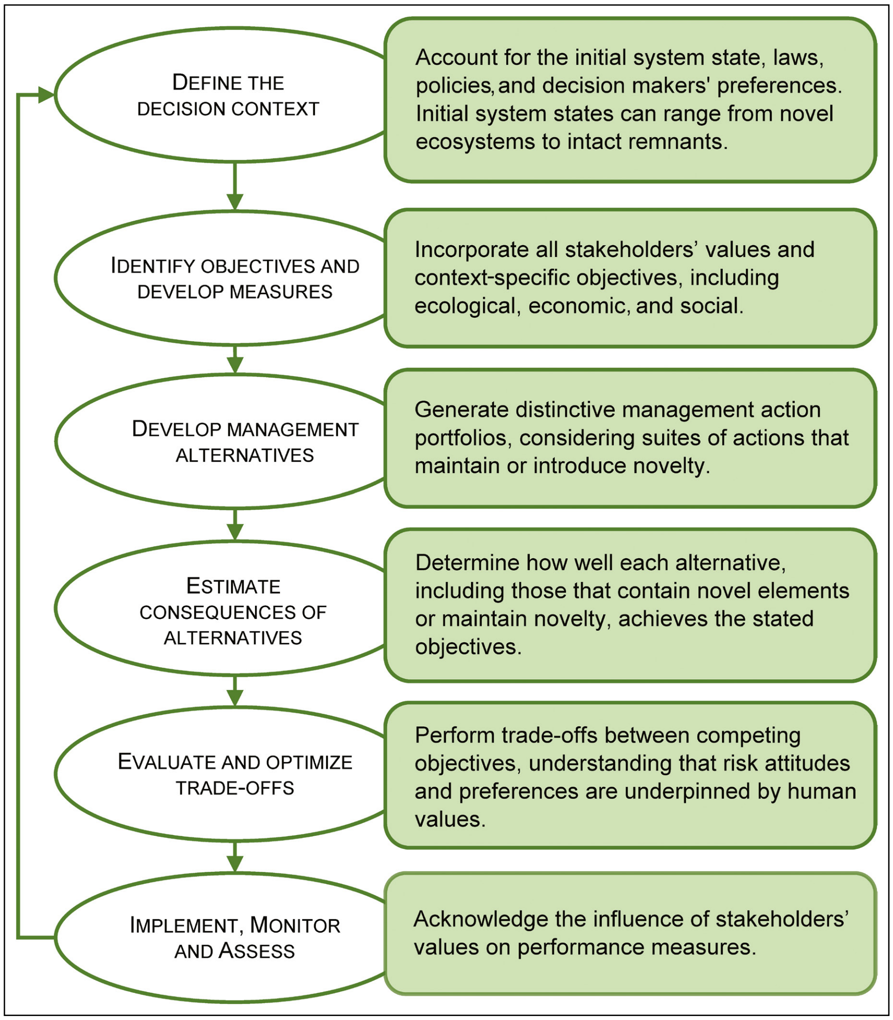


Figure 5. *A conceptual, values-based decision framework (adapted from Gregory* et al. *2012) for novel ecosystem management.*

determining management approaches for modified ecosystems. In order to understand and anticipate probable human reactions to ecological novelty, people who use this decision process must understand how concepts of biodiversity, conservation, and novelty are socially constructed (Gregory *et al.* 2012). There are fears that accepting the legitimacy of novel ecosystem management decisions will decrease investment (social and economic) in conservation (Seastedt *et al.* 2008; Murcia *et al.* 2014). But the opposite may be true – that the concept of novelty gives conservation value to systems that were previously disregarded or overlooked. Without the novel ecosystem concept, there is a risk of missing opportunities for biodiversity conservation in highly modified areas, such as conserving biodiversity in urbanized landscapes (Collier 2015). The novel ecosystem concept could also increase investment in conservation by forming the basis for pragmatic, cost-effective strategies with achievable objectives to manage novel systems that do not fit traditional conservation paradigms (Hobbs *et al.* 2014; Morse *et al.* 2014; Truitt *et al.* 2015).

Decisions about when and where novelty is an appropriate conservation objective cannot be resolved by ecological analyses alone. Social interpretations of ecological novelty, communication of conservation messages (Marris *et al.* 2013), objective setting, and the direct interventions that these objectives inform (Trueman *et al.* 2014), are each affected by decision makers' priorities and preferences. Management decisions for novel ecosystems typically involve working with knowledge gaps, uncertainty, and multiple objectives and stakeholders (Harris *et al.* 2006; Hobbs *et al.* 2014). High-quality decision making can make it possible to deconstruct a decision by revealing underlying individual and societal values that influence the decision and by teasing out the scientific, social, and economic aspects of the decision (Gregory *et al.* 2012). In contrast to intuitive decision making, where a range of alternative solutions are contemplated first, a structured approach in this context first identifies ecological, social, and economic objectives that are representations of ecological, social, and economic values relevant to the management decision (Gregory *et al.* 2012). Structured decision frameworks (eg Figure 5) are unique because they allow values inherent to the novel ecosystem concept to be explored and integrated into the decision process in a transparent manner.

We illustrate the application of structured decision making for novel ecosystem management, using a case study from the Highlands Estate's Conservation Areas (HECA), in Craigieburn, Australia (Figure 6). These conservation areas are novel ecosystems that display ecological landscape connectivity within an urbanizing landscape, and include a complex array of endangered species and communities, and exotic species assemblages that are habitat for indigenous species. Given this context, land managers need to decide how to manage these novel ecosystems by trading-off between environmental, social, and economic priorities.

A structured decision process begins with defining the decision context that accounts for the current system state, laws, policies, and decision makers' preferences (Figure 5). The HECA were protected in perpetuity as a condition of the planning approval for a masterplan housing development, fulfilling Commonwealth and State legislative and policy obligations. This network of novel ecosystems emerged through historical vegetation clearing and agricultural practices.

Next, stakeholders' preferences are identified and incorporated into context-specific objectives. For HECA managers, fundamental objectives include protecting ecological values, maintaining cultural heritage, ensuring community safety, and maximizing the economic benefits of the development. Three species of conservation concern on this site include: the endangered golden sun moth (*Synemon plana*) (Figure 7a) and matted flax-lily (*Dianella amoena*) (Figure 7b), and the vulnerable river swamp wallaby-grass (*Amphibromus fluitans*) (Figure 7c). The highly invasive Chilean needle-grass (*Nassella neesiana*) covers part of the reserve system and also provides habitat for the golden sun moth. Valued social goods range from indigenous cultural heritage to community safety and recreational activities. The primary economic objectives are maintaining site aesthetics to maximize house sales, and minimizing management costs, while ensuring that management actions achieve the site's ecological objectives.

Figure 6. *Mt Aitken Conservation Area, one of six conservation areas in Highlands Estate's reserve system, Victoria, Australia.*

Once objectives are identified, on-the-ground practitioners, in collaboration with HECA's land holders, generate management action plans that aim to achieve these objectives. Management actions include those that introduce, maintain, or enhance novelty. Management alternatives for HECA include a hierarchy of actions that conserve golden sun moth habitat; protect threatened plants; control, contain, or eliminate high-threat exotic species; and enhance site aesthetics. Concurrently, community safety is addressed by maintaining slashed firebreak zones at the perimeter of the conservation areas.

After assigning alternative management strategies to objectives, each alternative (including those that contain novel elements or support novelty) is assessed for its capacity to achieve stated objectives, and trade-offs between conflicting objectives are explored. Within HECA, competing objectives include the trade-off between controlling the invasive Chilean needle-grass and maintaining this species as habitat for the golden sun moth. The conservation benefit provided to the endangered species by this invasive grass must be weighed against any negative consequences for other ecological, economic, and social objectives.

In the implementation and monitoring phase, it is important to acknowledge the influence of human priorities on selected performance measures. For example, a value judgement precedes the selection of target ecological assemblages (eg determining a target percentage cover for a given flora species) and a monitoring methodology. Socioecological performance measures for HECA include persistence of endangered species populations, reduction in transformative woody weed species, abundance of other high-threat exotic species, and community perception of the conservation areas.

The benefits of explicitly considering novelty when determining management strategies for HECA include the potential to broaden site objectives and management alternatives. For instance, adopting a novel ecosystem approach to management can contribute to ecological niche filling, because it promotes a nuanced understanding of species interactions between native and non-native species, so biodiversity that is otherwise unlikely to thrive may instead flourish under this approach. Alternatively, entrenched exotic species can be managed to maintain ecological processes, irrespective of species origin. Using this approach, novel ecosystems are assessed not as "right" or "wrong", but by the extent to which they meet desired ecological, social, and economic objectives. Specific objectives drive the decision analysis, whether a system is novel or not, and the decision process aims to find the best way to achieve the stated objectives.

Conclusion

Determining conservation objectives and prioritizing management actions for novel ecosystems are often driven by values – priorities, principles, and preferences associated with a quality of relationship with nature (Hobbs 2004; Chan *et al.* 2016). The fundamental question of how novel ecosystems are perceived and consequently managed is essentially a philosophical one. The ways in which people interpret what "nature" is and what "natural" means has changed over time, from a philosophical position that "nature" exists objectively and has inherent value, to the idea that what is "natural" is socially constructed and therefore dependent on how

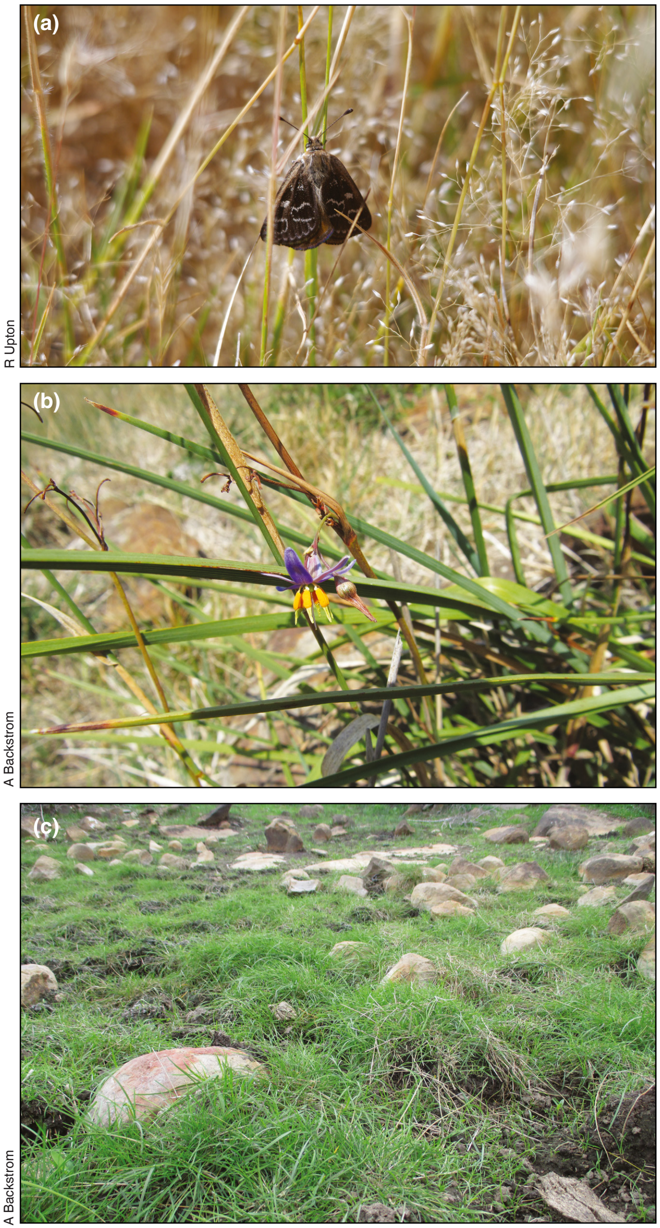


Figure 7. *Endangered species supported by the novel ecosystems of Highlands Estate Conservation Areas, Victoria, Australia. (a) The nationally endangered golden sun moth (*Synemon plana*) that uses a high-threat weed, Chilean needle-grass (*Nassella neesiana*), as habitat. (b) The nationally endangered matted flax-lily (*Dianella amoena*) growing at the base of an historical rock wall. (c) The nationally vulnerable river swamp wallaby-grass (*Amphibromus fluitans*) growing in a disused quarry.*

humans relate to and value the natural environment (Ridder 2007). Similarly, the interpretation of what constitutes a novel ecosystem may always be variable and context-dependent. Instead of trying to reach consensus about whether novel ecosystems are acceptable, an alternative is to acknowledge that different conservation priorities stem from different social and ecological preferences for novel ecosystem management outcomes. We propose that analyzing novelty within a decision context, against a range of ecological, social, and economic management objectives, will be an effective way to reconcile conflicting stances on novel ecosystems.

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