Novel ecosystems and social-ecological resilience

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Abstract

Context Novel ecosystems are anthropogenic landscapes that cannot be returned to their original ecological status. Little is known the social-ecological dynamics of these never-before-seen ecosystems. Less is known of their implications for society, sustainability and transitioning.

Objective and methods This literature review contends that novel ecosystems may be regarded as exemplars of social-ecological resilience and that the exploration of potential opportunities within novel ecosystem theory is being constrained by a lack of investigation.

Results Societal values in relation to novel ecosystems are unknown. Since societal values can influence conservation and restoration policies and practice, it is suggested that future policy prescriptions will need to explore the fundamentals this emerging relationship.

Conclusions It could be contended that such complex issues such as novel ecosystems will demand a *science of transition*, where the desire is to combine the science of discovery and science of engagement into a normative framework for societal change based on reality and realistic objectives and goals.

Keywords Novel ecosystems · Resilience · Social-ecological systems · Transitioning · Transitory landscapes

Introduction

Research and discussions on the subject of resilience have, over many years, progressed along intersecting lines of enquiry and have opened up many avenues in land use planning and management (Ahern 2013). Initially theorised as an engineered, bounce-back to a pre-existing equilibrium (Holling 1973), resilience can also be a measure of the ability of a system to self-organise (Gunderson and Folke 2005), essentially bouncing-forward to a new normal state. Such ecological resilience may be assessed by the level of disturbance a system can absorb and thereafter reorganise (Adger 2006). The engineered pathway of resilience thinking is often embedded in landscape planning and management practice (Folke et al. 2003), so that when increasingly *wicked* issues arise in the complex social-ecological arena, particularly when deciding when to intervene in restoring damaged systems, there is a lack of knowledge for how resilience may be realised. So, it is not known whether or how resilience theory deals with irreparably damaged ecosystems when it simultaneously seeks to resist and also adapt to change. This is exactly the case with the recently debated concept of novel ecosystems

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theory (Musacchio 2013). Novel ecosystems emerge as a direct result of land abandonment following human activities (Chapin III and Starfield 1997). They are ecologically distinct from historical analogues due to species distribution alteration, climate and land use change and an emerging acceptance of newer values and functions in habitats, ecosystems and landscapes. In essence they are no-analogue systems. More succinctly, a novel ecosystem is 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. 2013, p. 58). Morse et al. (2014) have sought to clarify this further, in order to stimulate more accurate/appropriate policy responses and to define timeframes. There is some urgency in this, because it is expected that novel ecosystems will become increasingly relevant in policy and practice (Bridgewater et al. 2011), as social and environmental stress changes over time (Lindenmayer et al. 2008), necessitating a new approach to landscape management (Seastedt et al. 2008) and a better understanding of ecological and cultural services in altered and/or abandoned places. With changes in land use due to human interventions, the policy and planning after-use prescriptions are often to seek to restore and rehabilitate; to strive to return the altered landscape to an earlier analogue (Aronson and Alexander 2013). When human impact has exceeded the tipping point where it is not possible to restore, we enter the realm of the novel ecosystem (Zedler et al. 2012). This paper examines novel ecosystem theory and its connectivity to evolved social-ecological resilience, with a view to contributing to current debates on future landscapes and new nature within land use management.

Up to 36 % of the Earth is considered to be so heavily altered by human activity that it may not be feasible to be restored to historical referents (Perring and Ellis 2013), and thus novel ecosystems are becoming increasingly prevalent in the landscape. They exist as urban brownfields and grasslands (Fischer et al. 2013; Klaus 2013), as abandoned agricultural landscapes (Cramer and Hobbs 2007), as cultural artefacts within these landscapes (Collier 2013), as afforested areas (Halme et al. 2013), and as maritime regions (Gomes 2013; Graham et al. 2014). Their pervasiveness derives from land use change,

none of the drivers of which are specifically new to this planet (Jackson 2013). Yet, these no-analogue systems have not been subjected to the same level of ecological scrutiny as other systems. Thus, the novel characteristics of these systems remain largely un-explored (Temperton 2007): characteristics such as novel ecological dynamics, invasiveness, multi-functionality, ecosystem services and the role of ecological design. Some evidence is emerging that novel ecosystems may support a biodiverse avian fauna in the US and South Africa (Lindenmayer et al. 2008; Rogers and Chown 2014), but little is known of the implications for biodiversity over time and in heterogeneous novel landscapes (Marris 2011). However, there is a growing awareness of values that can be derived from ecosystems and beyond their boundaries. In this way, novel ecosystems may have a potential for realising, for example, ecosystem services provision (Perring et al. 2012; Hulvey et al. 2013), perhaps new (cultural) services that were not present historically (Collier 2014). This provides an opportunity for developing innovative methods for research and exploration resulting in more targeted planning and management. One unifying element may be located in debates that surround resilience planning and management of novel ecosystems.

Resilience

Critiques of novel ecosystems advocate an adherence to the paradigm of a return or regression to historical analogues at all costs (Woodworth 2013; Blignaut et al. 2014), positing that a fully restored system may provide significant social and economic returns on such an investment. However, it could be argued that this approach views nature as somewhat static, predictable and fixed at specific points in time and negates the societal potentials that novel ecosystems may have (Hobbs et al. 2013). Ignoring the obvious issue of selecting a point in the past to restore to, and the incongruities this implies with respect to the unknown dynamics of such a past point, the argument is a similar argument to the bounce-back or equilibrium origins of resilience theory. This engineered resilience (Holling 1973) may be useful to those practitioners who deal with differing types and scales of damage such as economic collapse, earthquake recovery, pests and diseases and other shocks to

society. However, there is a danger that this kind of recovery may be viewed as part of a natural cycle; something that is normal and perhaps even necessary. However, as stated earlier, social-ecological theory also views resilience as a future-oriented approach (Choi 2007); that ecosystems follow dynamic, complex, non-linear and perhaps unpredictable trajectories, with the added unknown effects of the human elements, now part of all systems (Holling 1973; Palang et al. 2000; Holling 2001; Curtin and Parker 2014). Here, resilience is transformative and oriented towards an evolved paradigm, by seeing adaptivity as being a key driver and that crossing the threshold to a different state is not necessarily different in the long term (Sgrò et al. 2011).

Social-ecological resilience theory embraces this concept further, and explores those responses to change that maintain some but not all functions, whilst transitioning to a new system rather than maintaining a single equilibrium. Table 1 seeks to illustrate some aspects of this dichotomy, such as the paradigm differences and how this is manifested by the emergence of differing indicators and disciplinary approaches. Engineered resilience manifests the bounce-back towards stability and/or equilibrium approaches—striving for recovery and conservation (Lake 2013). This is manifested by localised, short-term indicators and is at the core of the restoration

ecology and ecological engineering arenas. Evolved resilience follows the unknown or emergence approach—striving for discovery and transformation or transitioning (Walker et al. 2004). This is manifested by a scalar, long-term approach as understood in the holistic arenas such as sustainability science and landscape ecology. Novel ecosystems, therefore, may be more accurately viewed as being *transitory landscapes*. Landscape ecologists understand such social-ecological landscapes, but quantifying them calls for more transdisciplinary and holistic research programmes (Musacchio 2013) which have been suggested as key to bridging the science-policy-community gap (Milcu et al. 2013) and are a step change in how we view land use change.

Novel ecosystems theory and evolved resilience theory share a commonality of being oriented towards an unknown, future paradigm. Novel ecosystems may be viewed as part of a transitioning and transformative process, rather than the end of a process. However, novel ecosystem theory offers little by way of practical guidance in a future-oriented testing of the theory, but the theory is now beginning to be subjected to in situ measurement and quantification (See, for example, Harris et al. 2013; Graham et al. 2014; Rogers and Chown 2014; Temperton et al. 2014; Trueman et al. 2014). Perhaps, more interestingly, the theory sets the agenda for discourse and iterative research. Co-

Table 1 An illustration of the social-ecological resilience spectrum (derived from: Adger 2000; Clark and Dickson 2003; Folke et al. 2005; Adger 2006; Birkmann et al. 2010; Folke 2010; Turner II 2010)

Tenets	Designing/engineering resilience	Ecological/evolved resilience
Paradigms	Nature exists in equilibrium and order Linear—cause and effect, response to external stressors Conservation/preservation	Nature is chaotic, dynamic, unsettled Lateral—internal and external stressors Transformation/transitioning
Facilitate	Bounce back—from disaster/change shock to stability	Bounce forward—to absorb shock/embrace emergence
Target	Return/fidelity to original steady state/equilibrium	Facilitating/accepting a new or novel states (ecosystems)
Societal view	Recovery	Discovery
Planning	Engineered and/or designed change Reactive	Evolved and/or facilitated change Proactive
Indicators	Designed recovery (short- to medium-term timeframe) Localised	Scalar/iterative response (longer-term timeframe) Holistic
Disciplines	Restoration ecology Conservation biology	Sustainability science Landscape ecology

This table is not intended to be a summarising of definitive, contrasting versions of resilience; rather it serves to capture aspects of the debate critical to land use planning and situates novel ecosystems within resilience theory

creation of research design and co-production of knowledge are challenging hallmarks of transdisciplinary research, but indicate the collaborative nature of land use planning and management currently being advocated and explored. However, exposing the novel ecosystem theory to academic scrutiny and quantification is hampered by the persistence in viewing landscape management and restoration as historically-oriented, though historical knowledge is lacking (Higgs et al. 2014), rather than exploring the multiple-gain complementarities the theory may offer. Furthermore, calling for a social-ecological re-orientation of landscape ecology, and simultaneously negating the opportunities that novel ecosystems offer by their very nature and origin, presents a dichotomous rather than unified approach to ecosystem repair and management (Hobbs et al. 2014), something with which policy-makers will be increasingly less enamoured with as more and more landscapes move towards becoming classed as potential novel ecosystems (Seastedt et al. 2013).

Opportunity

The theoretical underpinnings of novel ecosystems stem from the ecosystem approach and sustainability science, and bridge differing disciplines such as ecological design and restoration combined with collaborative governance in the landscape (Olsson et al. 2004; Folke et al. 2005; Biermann 2007; Sinclair et al. 2008; Kallis et al. 2009; Norgaard et al. 2009; Curtin 2014). This approach can support many research structures, which inform how novel ecosystems may be understood and quantified. Currently, the more prominent areas of exploration include ecosystem service provision (e.g. Aronson et al. 2010), biotic and abiotic change (e.g. Trueman et al. 2014), perception and well-being (e.g. Seastedt et al. 2013), socio-economic and socio-cultural change (e.g. Temperton 2007). The potential impacts of novel ecosystem exploration and understanding permeate everything from policy development through to land use management, from challenges to find new ecological monitoring and quantification mechanisms to the practices of ecological restoration and conservation.

As humans abandon an area, and cease to impart any energy into it, from a landscape level down to

individual species and communities, ecological processes will take over in their absence. However, humans do not necessarily just abandon damaged areas completely, so a new relationship emerges (Collier and Scott 2008). Ecosystems do not necessarily revert to historical analogues, so a new ecology emerges. Our understandings of this social-ecological interface (values, perceptions, services, etc.) coupled with this new ecology (species dynamics, functions, etc.) are poor. This deficit does not assist in predicting what ecosystem manipulations will result in, what management interventions may be most suited or desired, and what opportunities may be missed. Therefore, novel ecosystems may present society with opportunities to measure social-ecological resilience, and their paired transitioning could be illuminating on theoretical as well as practical levels.

Resilience can guide societal transitioning (Barr and Devine-Wright 2012), as well as build new ecosystem services (Plieninger et al. 2014), and the social-ecological literature contains many examples of resilience in planning and management, often using case studies as illustrators (e.g. Chapin III et al. 2013). Novel ecosystems have been identified as potential exemplars of cultural resilience in indigenous communities (e.g. Gomes 2013), but little is known about novel ecosystems in settings and landscapes with different challenges, nor what new cultural ecosystem services they may provide (Collier 2014) nor how to set about testing and quantifying the robustness of the framework theory and the policy challenges it provides. In the designation of *novel ecosystem* is there an implicit, if not explicit, call for a more fundamental exploration and exploration of the values and theories surrounding the emergence of social-ecological resilience? Therefore, could it be argued that the *journey* towards understanding and ecologically quantifying novel ecosystems may be equally or of greater social valuable? Throughout this journey there will be numerous actors and stakeholders drawn upon and therefore influenced; resulting is a wider appreciation of ecological processes and anthropogenic influences on nature. It is a journey of transition with the aim of making normative in the future what is theoretical today. Because the social implications of landscape ecology are challenging (Hobbs 2007), one of the areas where novel ecosystems may contribute to a wider societal appreciation is in the area of heuristic or social learning (e.g. Luks and Siebenhuner 2007; Pahl-

Wostl et al. 2008; Cumming et al. 2013), where feedback loops to the participant encourage normative, sustainable behavioural change (Higgs 2003).

Conclusion

It is perhaps an oversimplification to view novel ecosystem theory as a trend, revisionist, nor is it fraught with in passion or persuasion. Novel ecosystems theory is a conceptual lens for seeking to understand the complexities of the reality of our relationship with ecological processes and what society may view as degraded or damaged landscapes. It is an attempt to understand why restoration sometimes fails and what societal opportunities may be derived from those failures. Because of the continual impact of human progress on the Earth's landscapes, novel ecosystems contain never before seen combinations of disparate species, and little can be done to change this in the short to medium term given the growth and pace of human progress. Resilience is also an emergent concept; something that accommodates change or has the capacity to absorb without fundamental shifts in underlying structure and functions. If resilience is the ability to absorb disturbance without changing the fundamental regime to a new structure, then novel ecosystems are simultaneously an anathema to that idea (since they may be new regimes) as well as an example of resilience in practice (since they may not differ in structure and function). The difference is on the spatial and temporal levels, because over time all systems change as a response to impact. How society relates to novel ecosystems is unknown, and since this relationship governs values and attitudes, and therefore policies, it is likely that future policies will need to draw upon this relationship. What gets measured gets managed. So, because of the policy demand, there is a need to devise new methods for empirically understanding the social-ecological inter-relationship in novel ecosystems, to quantify the societal expectations and to explore novel ecosystems as locations for mainstreaming social-ecological policies. Meffe (2001) contended that conservation biology moved from a *science of discovery* to a *science of engagement*. Taking a longer term viewpoint, and looking at potential future directions in landscape ecology, it could be contended that such wicked issues such as novel ecosystems call for a *science of transition*,

where the desire is to combine discovery and engagement into a normative framework for actual societal change based on reality and realistic objectives and goals. This may lead to a mainstreaming of sustainability science and normative societal behaviour, and thus realise the desire for sustainable transitioning as a society. Social-ecological resilience thinking may contribute a structure for this, and novel ecosystems a global proving ground.

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