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POLICY PERSPECTIVE

Biodiversity Risks of Adopting Resilience as a Policy Goal

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Abstract

Resilience is increasingly being incorporated into environmental policy at national and global scales. Yet resilience is a contested concept, with a wide variety of definitions proposed in the scientific literature, and little consensus regarding how it should be measured. Consequently, adoption of resilience as a policy goal presents risks to biodiversity conservation, which are considered here in relation to three categories: (1) ambiguity, (2) measurement difficulty, and (3) misuse. While policy makers might welcome the ambiguity of resilience as a concept, as it provides flexibility and opportunities to build consensus, the lack of clear definitions hinders evaluation of policy effectiveness. Policy relating to resilience is unlikely to be evidence-based, as monitoring will be difficult to implement. Vague definitions also provide scope for misuse. This is illustrated by the case of European forests, where resilience is being used as a justification to promote management interventions that will negatively affect biodiversity. To address these risks, there is a need for standard definitions and measures of resilience to be developed for use in policy. Furthermore, there is a need for guidelines, standards, and identification of best practice in relation to resilience policy, to ensure that its implementation does not contribute to biodiversity loss.

Introduction

The term "resilience" is increasingly being included among environmental policy goals. At the international scale, resilience is referred to within global policy initiatives such as the Convention on Biological Diversity (CBD; Thompson *et al.* 2009) and the Intergovernmental Panel on Climate Change (IPCC). As illustration, Aichi Biodiversity Target 15 of the CBD commits signatory countries to take action so that by 2020 "ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration" (CBD COP 10 Decision X/2). In relation to climate change, adaptation is considered by the IPCC as a means to "build resilience" (IPCC 2014). At the national scale, guiding principles for climate change adaptation in the United States suggest that "adaptation should, where relevant, take into account strategies to increase ecosystem resilience" (EPA 2012). Australia's national biodiversity conservation strategy identifies building ecosystem resilience as one of three main priorities for action (Natural Resource Management Ministerial Council 2010), whereas in the United Kingdom, current environmental policy aims to create "a more resilient natural environment for the benefit of wildlife and ourselves" (HM Government 2011).

This rise in popularity of resilience in policy reflects a current trend in the discourse around responses to environmental change, with a shift from negative terms such as "impacts" and "vulnerability" to terms with more positive associations, such as resilience (McEvoy *et al.* 2013; Sudmeier-Rieux 2014). While the reasons for this shift are primarily political, the science underpinning resilience and its relationship with environmental change are the focus of significant debate (McEvoy *et al.* 2013). This is illustrated by a recent change in how resilience is being interpreted, developing from its origins within ecological science toward a vaguer and more flexible concept that is being applied within social and sustainability sciences (Brand & Jax 2007; Olsson *et al.*

Table 1 Selected definitions of resilience that have been proposed in the ecological literature

Definition	Source
The magnitude of disturbance that can be tolerated before a system moves into a different region of state space and a different set of controls	Carpenter *et al.* (2001)
The ability of the system to maintain its identity in the face of internal change and external shocks and disturbances	Cumming *et al.* (2005)
The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to change in order to maintain the same identity.	Folke *et al.* (2010)
Returning to the reference state (or dynamic) after a temporary disturbance	Grimm & Wissel (1997)
Resilience refers to the width or limit of a stability domain and is defined by the magnitude of disturbance that a system can absorb before it changes stable states	Gunderson (2000)
Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist	Holling (1973)
How fast the variables return toward their equilibrium following a perturbation.	Pimm (1984)
The ability of the system to return to the original state after a disturbance.	Scheffer *et al.* (2002)
Helpful resilience: Resilience that helps to maintain a predisturbance ecosystem state so that it does not cross a threshold.	Standish *et al.* (2014)
Unhelpful resilience: Resilience that helps to maintain an ecosystem in a degraded state following a disturbance.	
The capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity	Walker *et al.* (2006)
The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.	Walker *et al.* (2004)

2015). It has been suggested that this shift in meaning is undermining both the conceptual value of resilience and its practical application (Brand & Jax 2007).

As a result of these trends, there are biodiversity risks associated with including resilience among environmental policy goals. Here, I identify three types of risk: (1) ambiguity, (2) measurement difficulty, and (3) misuse. These are considered in relation to their potential impacts on biodiversity conservation.

Risk of ambiguity

In an ecological context, resilience was originally defined by Holling (1973) as a measure of the ability of ecosystems to absorb changes of state variables, driving variables and parameters, and still persist. A large number of alternative definitions of resilience have subsequently been proposed (Table 1). For example, Grimm & Wissel (1997) reported 17 different definitions of resilience in the scientific literature, whereas Brand & Jax (2007) identified 10 different definitions, grouped into three main categories. Key differences between definitions relate to whether a system is believed to return to an equilibrium point following a disturbance event (Pimm 1984), as in definitions of "engineering resilience" and "recovery" (Standish *et al.* 2014). Alternative definitions, often referred to as "ecological resilience" (Gunderson 2000), are based on a conception of ecosystems existing far from an equilibrium state, and the possibility of shifting to another stable state in response to a perturbation (Brand & Jax 2007). The idea that ecosystems exist in multiple stable states, with transitions from one state to another potentially occurring as a result of disturbance, is therefore fundamental to definitions of ecological resilience (Gunderson 2000). However, a variety of different definitions of ecological resilience have been proposed, focusing variously on the amount of disturbance an ecosystem can absorb before it changes state, the ability to return to an original state after disturbance, the degree to which the system is capable of self-organization, and the capacity for reorganization and adaptation (Brand & Jax 2007; Table 1).

Many authors have commented on the problems associated with this semantic uncertainty (Brand & Jax 2007; Standish *et al.* 2014). Notably, it creates confusion among researchers and undermines scientific quality. This is illustrated by Myers-Smith *et al.* (2012), who found in a review of 234 publications referring to resilience that 66% of studies did not identify which definition they applied. Given the large number of available definitions, this imprecision limits interpretation of research results and hinders cross-study comparisons (Myers-Smith *et al.* 2012). This review also highlighted a widespread mismatch between the definitions stated in scientific publications and those presented in supporting citations, together with frequent misapplication of resilience concepts. Specifically, while definitions of ecological resilience were most widely cited, most studies examined resilience in relation to continuous rather than discrete types of disturbance. Yet definitions of ecological resilience are not suitable for quantifying responses to ongoing ("press") disturbances such as climate change, which were the focus of 31% of studies in this review (Myers-Smith *et al.* 2012). Furthermore, the theory of multiple stable states that that underlies definitions of ecological resilience only relates to discrete ("pulse") disturbances, and is therefore not appropriate for quantifying responses to press disturbances (Connell & Sousa 1983; Petraitis 2013).

Ambiguity in the meaning of resilience as a scientific concept hinders its application both in policy and in management practice (Brand & Jax 2007). As use of the term resilience has extended from ecological science to other disciplines, such as economics, political science, and sustainability science, its meaning has broadened to represent a particular perspective or paradigm, incorporating elements such as social learning, leadership, and adaptive governance (Brand & Jax 2007; Olsson *et al.* 2015). According to Klein *et al.* (2003), the definition of resilience has now become so broad that it has been rendered "almost meaningless." This presents a challenge to policy implementation, as conceptual clarity is needed to operationalize any policy concept. Without a common frame of reference, different stakeholders will often talk at cross-purposes, perhaps without even realizing it (McEvoy *et al.* 2013). Despite the fact that resilience has become a goal of many development policies at both national and international scales, there is little guidance available regarding what resilience is or how to increase it (Sudmeier-Rieux 2014). It has consequently been labeled as a "fuzzword," meaning all things to all people (Tanner *et al.* 2015).

A further issue is whether resilience is always beneficial. In a development context, social scientists have criticized the adoption of resilience as a policy goal, as it focuses on supporting the process of recovery rather than addressing the root causes of the vulnerability of human communities to environmental change (Sudmeier-Rieux 2014). Similar criticisms can be raised in the context of environmental policy, with a focus on resilience potentially shifting attention away from the root causes of biodiversity loss. Furthermore, in a social context, increased resilience does not necessarily coincide with a decrease in vulnerability or risk (Sudmeier-Rieux 2014; Olsson *et al.* 2015). Similarly, in a biodiversity context, degraded ecosystems can have greater resilience to disturbance than those that have been less degraded (Standish *et al.* 2014), suggesting that increased resilience could actually be associated with biodiversity loss in some situations.

Risk of measurement difficulty

It is now widely recognized that conservation policy and management should be evidence-based, drawing upon the systematic compilation and analysis of available evidence. It is also recognized that effective conservation depends on integration of management with robust monitoring approaches, so that the effectiveness of interventions can be evaluated (Morecroft *et al.* 2012). A lack of consensus regarding how resilience should be defined hinders the application of such approaches, by creating uncertainty regarding how resilience might best be measured and evaluated.

In principle, engineering resilience can be measured as the inverse of the return time, or the time needed following disturbance to return to the original state of the system. Such analyses can be performed using modeling approaches such as individual-based models, cellular automata, and differential equation models (Grimm & Calabrese 2011). In contrast, ecological resilience is difficult to quantify or to formalize mathematically (Grimm & Calabrese 2011). As a result, it is unclear how to directly measure ecological resilience or to identify the underlying mechanisms. Holling (1973) proposed two resilience measures of an ecological system, namely the overall area of the domain of attraction and the height of the lowest point of the basin of attraction above equilibrium. In the context of social-ecological systems, a variety of approaches have been proposed, including the use of indirect proxies such as historical profiling, stakeholder assessments and scenarios (Carpenter *et al.* 2005; Cumming *et al.* 2005).

In a recent review, Standish *et al.* (2014) summarized available approaches for measuring ecological resilience in the context of biodiversity conservation, focusing on the location of thresholds of disturbance associated with switches between ecosystem states. Potentially, this can be achieved by experimentation or through the use of observational data. However, robust experimental evidence of multiple stable states is lacking, particularly in field situations (Petraitis 2013), and observational studies are limited by being correlative in nature (Standish *et al.* 2014). To demonstrate the existence of multiple stable states, studies must involve a pulse perturbation, be conducted at a single site, demonstrate that two or more different communities can occur in that same site, and demonstrate that the communities are stable (Petraitis 2013). These conditions are very difficult to meet in practice, particularly in relation to the demonstration of stability. The lack of robust supporting evidence undermines the value of ecological resilience as an operational scientific concept, a problem that is compounded by a lack of clarity about what the appropriate units are for measuring resilience (Petraitis 2013). Furthermore, the suggestion that resilience can be measured through analysis of thresholds (Standish *et al.* 2014) is based on a misconception that such thresholds are always a part of systems with multiple stable states (Petraitis 2013).

Risk of misuse

The lack of consensus regarding how resilience should be defined and measured creates a number of additional challenges to policy implementation. These can usefully be illustrated by reference to the concept of "sustainable development," which resilience is arguably replacing as a focus of policy dialogue (Sudmeier-Rieux 2014). Despite being the focus of international attention for more than three decades, sustainable development remains a highly contested concept, both in terms of its definition and how it should be implemented (Newton & Cantarello 2014). It provides an example of a "constructively ambiguous" term, a type that is often welcomed by politicians because such deliberate ambiguity can be used to build agreement on sensitive issues and achieve superficial consensus (Moore 2011; Robinson 2004). However, vague definitions also provide scope for misuse. This is illustrated by the widespread occurrence of "greenwash," whereby uncertainty surrounding the term "sustainable" is exploited by organizations seeking to mislead people regarding their environmental practices, or the environmental benefits of the products that they offer (Newton & Cantarello 2014). Other criticisms that have been levied at sustainable development associated with its ambiguity are that it encourages a focus on the wrong issues, deflecting attention away from key underlying factors such as power and exploitation (Robinson 2004); that it fosters illusions and obscures key trade-offs that need to be made (Moore 2011); and that it has been used to promote a development agenda that is demonstrably not sustainable (Sneddon *et al.* 2006).

Similar concerns can be levied at the concept of resilience. As the meaning of resilience has broadened with its incorporation into policy, it has become increasingly vague, while at the same time it is being used to provide justification for a variety of different policies, interventions, and practices (Olsson *et al.* 2015). It shares with sustainable development a tendency to ignore issues such as power and conflict, which are key factors shaping social interactions (Tanner *et al.* 2015); it is also being used to promote a particular political agenda, namely neoliberal economics (Olsson *et al.* 2015). The problems associated with incorporation of resilience into policy are illustrated by the fact that such use is almost always normative; in other words, in policy resilience is implicitly considered to be a "good thing" (Olsson *et al.* 2015; Tanner *et al.* 2015). Yet in the context of biodiversity conservation, resilience can also clearly be "unhelpful," for example, in situations where degraded or altered ecosystems do not readily return to a predisturbance state without some form of management intervention (Standish *et al.* 2014).

As a result, there is a risk that resilience could be used by political actors to justify or promote particular management plans or policies (Olsson *et al.* 2015), which could potentially result in deleterious impacts on biodiversity. I illustrate this risk with reference to the particular case of forest management in Europe, although similar issues might be anticipated in other ecosystem types and in other locations. In an article entitled "Five steps for managing Europe's forests," Fares *et al.* (2015) provide an overview of how they believe European forest managers should increase forest resilience in relation to threats including climate change, development of infrastructure, pollution, and the spread of pests and diseases. Specifically, they recommend planting "resilient tree species," namely those with wide climatic tolerance, and use of genetic material from more southern populations; use of silvicultural approaches to promote "the most resilient species," including thinning to encourage new growth and carbon storage capacity; the selection and deployment of clones that are resistant to pests and diseases; and the introduction of payments for ecosystem services.

As noted in subsequent responses to Fares *et al.* (Bruun *et al.* 2015; Jonsson *et al.* 2015), these recommendations represent a worldview in which the value of forests is primarily believed to reside in their economic value as a source of marketable goods and services, notably timber. This overlooks the high biodiversity value of many natural forest ecosystems (Lindenmayer 2009). These recommendations run counter to biodiversity conservation guidelines (e.g., Lindenmayer *et al.* 2006) and would undermine efforts to meet policy commitments such as the CBD Aichi Targets and the European Union's 2020 target for halting biodiversity loss. For example, establishment of productive, pest- and disease-tolerant tree species or genotypes would be at the expense of native woody species and the many species that depend on them (Bruun *et al.* 2015). Introduction of genetic material from more southern populations represents a form of genetic pollution, which could reduce the evolutionary fitness of locally adapted native tree populations (Koskela *et al.* 2014). Management interventions to promote carbon storage, such as thinning or shorter rotations, would endanger old-growth forests and veteran trees, and could destroy the habitat characteristics that underlie their exceptional importance for biodiversity conservation (Bruun *et al.* 2015; Jonsson *et al.* 2015). Such recommendations highlight the fact that forestry practices can represent a major threat to forest biodiversity (Lindenmayer *et al.* 2006; Lindenmayer 2009). Those management practices that preserve natural ecosystem processes are likely to be more effective in supporting forest biodiversity and resilience (Kuuluvainen & Grenfell 2012; Jonsson *et al.*

Table 2 Selected recommendations provided by the Forestry Commission, England, for "adapting England's woodlands to be more resilient" (Forestry Commission 2015)

Broadleaved woodland should be managed to maximize the crops' value by balancing quality and timber yield
Planting material should be sourced from improved stands, where available or appropriate.
It will be important to intervene frequently to promote adaptation through planting or to encourage natural regeneration and evolutionary adaptation.
New and regenerated woodlands' genetic variability should be enhanced by including local provenance and others from up to 5° south.
Opportunities should be taken to diversify the species mix within woodlands. This will include planting native species outside their natural range in the north and west.
Most of the species in England's native woodland occupy a wide climatic range across Europe, as these species distribution maps show. This makes it possible to use origins that are better adapted to England's future climate.
Broadleaved species new to forests in England should be considered as a component of the planting design, particularly in the south and east. For example, more sweet chestnut and other broadleaved species from the near continent can be used to take advantage of the changing climate.

These recommendations refer explicitly to native and ancient woodland.

2015). Yet such practices are not universally being advocated by policy makers aiming to deliver resilience.

Recommendations similar to those proposed by Fares *et al.* (2015) are already being applied in practice. For example, in England, official guidance that has been explicitly designed to strengthen the resilience of native and ancient woodland ecosystems similarly focuses primarily on management for timber. In a policy statement entitled "Adapting England's woodlands to be more resilient," Forestry Commission (2015) include the use of genetically improved planting stock; management interventions involving planting tree species outside their natural ranges; and the introduction of both non-native seed origins and non-native species to increase genetic variability and species richness (Table 2). This provides an example of how resilience to climate change is being used as a pretext to promote pro-timber forest management, typical of traditional forestry practice, rather than focusing on biodiversity conservation. Furthermore, resilience is being used to justify management interventions in forest ecosystems of high value for biodiversity conservation, such as ancient woodland, including their conversion to plantations of non-native species (Table 2). This runs the risk of returning to a situation that prevailed during much of the 20th century, when forestry practices prioritizing timber management were one of the main causes of biodiversity loss in UK woodlands (Rackham 2003). Such guidance also runs counter to the progress made over the past 40 years in recognizing the ecological history and exceptional biodiversity value of ancient native woodlands, which can be destroyed by planting exotic tree species within them (Rackham 2003).

Conclusions

Resilience has undoubted value as a scientific concept. The ability of ecosystems to tolerate and recover from disturbance represents a genuine phenomenon, which is vitally important to understand. Together with associated concepts such as stability, resilience has stimulated much valuable research that has provided new insights into the ecological processes influencing ecosystem persistence and recovery (Dornelas 2010). Furthermore, controversy and debate are elements of a healthy scientific discourse, and should therefore be welcomed. However, the example of resilience highlights the problems that can arise when a contested or ambiguous scientific concept is translated into policy.

The increasing popularity of resilience among policy makers is understandable, given that it offers a positive narrative around coping with future environmental change. At the same time, uncertainty regarding how resilience should be defined and assessed provides policy makers with room for maneuver. In relation to biodiversity conservation, however, a policy on resilience may be counterproductive, by encouraging a focus on adaptation to anthropogenic disturbance rather than addressing the root causes of biodiversity loss. Even proponents of resilience (Biggs *et al.* 2012) recognize that traditional, evidence-based approaches are difficult to apply to policy concepts that are so ambiguous. As a result of this semantic uncertainty, it will be difficult to evaluate the effectiveness of any policy designed to strengthen resilience. Furthermore, there is no consensus regarding how the concept of resilience should be translated into practice, which is creating confusion among practitioners (Biggs *et al.* 2012; Morecroft *et al.* 2012).

As a result of its ambiguity, resilience is a concept that is open to misuse (Olsson *et al.* 2015). The concept is currently being used to promote or justify interventions that will contribute to biodiversity loss. This is illustrated here by reference to the example of forest ecosystems. The establishment of plantations of non-native tree species and genotypes in native woodlands is being widely recommended as a way of increasing forest resilience (Thompson *et al.* 2009; Fares *et al.* 2015), even by conservation agencies (Morecroft *et al.* 2012). Given that higher numbers of species are associated with native tree species than exotics (Kennedy & Southwood 1984; Newton & Haigh 1998), such approaches will lead to a loss of biodiversity. The fact that such potential problems might not be limited to forest ecosystems is illustrated by the broader controversy surrounding assisted migration of species as an approach for addressing climate change (Hewitt *et al.* 2011).

The example of forest ecosystems presented here represents a form of policy conflict, arising when the value of an ecosystem service (such as timber) is accorded higher value than biodiversity. Risks of such conflicts have been highlighted previously for a range of ecosystem services, including carbon storage (Putz & Redford 2009) and food production (Ingram *et al.* 2012). Policy conflicts are not an inevitable result of adopting resilience as a policy goal, but are facilitated by the lack of consensus on how resilience should be defined and measured.

Part of the solution to the risks identified here is therefore for both researchers and policy makers to clearly communicate the definition of resilience that they are using (Myers-Smith *et al.* 2012). Ideally, a consensus would be reached regarding an appropriate definition of resilience. International processes such as the CBD and IPBES could usefully play a leading role in establishing an agreed definition of resilience for use in environmental policy. Agreement is also required on how resilience should be measured, which is currently an active area of research (e.g., Oliver *et al.* 2015; Seidl *et al.* 2015). Potential ways forward include a focus on different elements of resilience, such as "resistance" and "recovery," for which established measures exist (Hodgson *et al.* 2015; Newton & Cantarello 2015; Nimmo *et al.* 2015). Such measures should be embraced, standardized, measured, and compared across systems and fields of research (Hodgson *et al.* 2015).

Many researchers have suggested that policies aiming to deliver resilience should seek to enhance biodiversity conservation, and that maintenance of biodiversity should itself contribute to ecosystem resilience (Thomson *et al.* 2009; Standish *et al.* 2014; Nimmo *et al.* 2015). However, the risk of conflicts with conservation policies highlights the need to carefully scrutinize policies relating to resilience to ensure that they do not contribute to biodiversity loss. Adoption of resilience as a policy goal should not be allowed to justify interventions that will have a negative impact on biodiversity. This could be achieved through the development of guidelines, standards, or identification of best practice in relation to implementation of resilience policy, as exemplified by previous initiatives undertaken in relation to sustainable development. Again, international policy fora could usefully take a leading role in this area. In the absence of such guidance, there is a need for vigilance among the conservation community regarding how the concept of resilience is adopted and implemented by policy makers, to ensure that its use does not contribute to biodiversity loss.

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