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Sustainability in forest management and a new role for resilience thinking

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ABSTRACT

Forest management faces a substantial challenge with ever-more-pervasive anthropogenic impacts and growing demands on forests coupled with the increasing certainty of global change. If the capacity of forests to provide valued ecological goods and services in the future is to be maintained, new tools and approaches will be needed. Several approaches have been influential in dealing with sustainability challenges in forest management and forestry to date, two of the most notable being the ecosystem approach and adaptive management. Resilience-based approaches have now emerged as a new paradigm to deal with these challenges. This paper considers how resilience thinking might inform forest management by exploring its conceptual basis in comparison with the ecosystem approach and adaptive management as two earlier influences. We identify three novel conceptual contributions and outline some of the key challenges encountered when applying resilience thinking to the management of forests.

Resilience thinking offers new conceptual contributions for dealing with large and uncertain changes, the relationships between social and ecological components of forest systems, and a new perspective on sustainability. However, there are several barriers to it informing forest management in a practical way, including means by which resilience can be measured and valued within a management context, and most importantly, how resilience can be maintained and enhanced within systems focused on resource production or service provision. Resilience thinking's contributions are largely conceptual at this stage and offer more in terms a problem-framing approach than analytical or practical tools. Decision-relevant, science-based, and solution-oriented approaches are required to tackle future forest management challenges. Resilience thinking, if developed to become more solution-orientated could offer a needed complement to current management paradigms.

1. Introduction

Forests represent a key provisioning ecosystem, and forestry a dominant human land use. The management of forests has intensified and global plantations have expanded in recent decades, accompanied by large increases in energy, water, and fertiliser consumption, and in some locations, considerable losses of biodiversity (Paquette and Messier, 2010; Hobbs et al., 2006; Hoekstra et al., 2005). While securing goods and services from forests is vital to human wellbeing, current intensive management may also potentially undermine the capacity of forests to sustain this production in the future (Bennett and Balvanera, 2007; Fischer et al., 2009), as well as to meet emerging demands for new goods and services (Canadell and Raupach, 2008).

These challenges must be dealt with in the face of existing and emerging drivers of change. Global phenomena, such as introduced species, climate change, and anthropogenic alterations of biogeochemical cycles are growing pressures (Newman, 1995; Vitousek et al., 1997; Simberloff, 2000; Dale et al., 2001; van Mantgem et al., 2009; Allen et al., 2010). In addition, regional and local forces such as changing demand for wood products and pest outbreaks are shaping forests (Burton, 2010; Meyfroidt et al., 2010). For example, in Canada, the area logged per year doubled between 1960 and 1995 (from ~500 000 ha/year^{-1} to ~1 Mha/year^{-1}) and, in many locations, harvesting has replaced fire as the dominant disturbance in productive forests (World Resources Institute, 2000). This combination of ever-more-pervasive anthropogenic impacts and demands on forests coupled with the increasing certainty of global change, suggests that compounded perturbations and ecological surprises will become more common (Paine et al., 1998). Thus forest management faces a substantial challenge if the capacity of forests to provide valued ecological goods and services in the future is to be maintained.

This challenge is failing to be adequately met in many locations currently. While in some locations a lack of an enabling market, policy and institutional environment represents significant obstacles; management itself also has major shortcomings. The current

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tendency to focus on a narrow set of management goals and methods fails to give adequate attention to the provisioning of a wide array of ecosystem services, including biodiversity (Spence, 2001; Puettmann et al., 2009; Kuuluvainen et al. 2012). Optimisation of a particular good, typically timber, commonly occurs at the expense of other forest goods and services (e.g. Gamfeldt et al., 2013), as well reducing options for the future (Fazey et al., 2010). A major shift in thinking about forest management is needed which will require challenging many of the fundamental goals and assumptions of conventional management methods and likely new approaches to silviculture (Puettmann et al., 2009; Puettmann, 2011; Messier et al., 2013).

In theory and application, natural resource management, including forestry, is routinely organised around a specific paradigm or approach; a particular set of principles, concepts, generalisations, or assumptions regarding how the system subject to management functions. These may include ideas about system dynamics or about what metrics indicate success. They guide what data are collected in assessment and monitoring activities, and how that information is later assembled so as to arrive at management decisions. They also have a more fundamental influence on management philosophy, including normative aspects of management, shaping perspectives on human-nature relationships, how trade-offs between competing objectives are reconciled, and how decisions over the targeting of interventions to meet particular aims or goals will be made. Thus, a particular paradigm or approach acts as a lens through which problems are viewed and can have a major influence on how these emerging challenges are conceptualised and confronted.

In the context of forestry, two of the most well-known and influential approaches to dealing with sustainability challenges are adaptive management (Holling, 1978; Walters, 1986) and the ecosystem approach (CBD, 1995, 2004). Both have been used in targeting the full range of forest management goals from timber production, forest restoration, and natural area management to those focused on water quality or carbon storage. More recently, 'resilience thinking' has emerged as a new paradigm in environmental and natural resource management (Gunderson, 2000; Folke, 2006; Walker and Salt, 2006). While there is increasing interest in resilience in the context of forest management and forestry (e.g. Chapin et al., 2007; Thompson et al. 2009), there has been little conceptual exploration of how these ideas might benefit forestry (except see Drever et al., 2006 and Messier et al., 2013). There is also a lack of empirical evidence to demonstrate how resilience may be operationalised in management. In this paper we investigate how resilience thinking may offer new contributions to forest management, in particular by identifying how it differs from earlier guiding paradigms.

We present a framework of characteristics to structure this comparison and identify similarities and differences among three paradigms (adaptive management (AM), the ecosystem approach (EA), and resilience thinking (RT)) with a view to assessing where RT is consistent, complementary, or even equivalent to the two earlier influences. Then, with current challenges in mind, we ask how new insights and perspectives from RT might be helpful or contradictory within an applied management context. In asking this question, we identify specific challenges that are encountered when applying RT in management practice.

2. Sustainability paradigms in forest management

Forest management has a long history, traditionally aiming for predictability and a continued supply of timber (Puettmann et al., 2009). Concepts, such as annual allowable cut, stand management and sustainable yield, predominated in early forestry, and the sustainability of forest use was equated solely with a sustained, and high, yield of timber. Subsequently, the need to accommodate changing perceptions and demands into forestry practice (including influences from the broader environmental movement and discussions of sustainable development), and to supply a more diverse collection of ecosystem goods and services, has lead to a strong focus on sustainable forest management (SFM) (Wilkie et al., 2003). The most widely used definition defines this as: "*The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems*".

While schemes of criteria and indicators for SFM describe the desired ends for management, they do not address the means of achieving those ends. As a result, SFM in particular has been operationalised through various management paradigms or approaches, two of the most well known are the EA and AM. The EA has had a particularly strong influence, largely a consequence of the CBD process (Ellenberg, 2003; FAO, 1993; Smith and Maltby, 2003; Hahn and Knoke, 2010), and in fact the EA has been the dominant framework for implementing SFM in many locations (Wilkie et al., 2003; CBD, 2007). The EA is an integrated management strategy that aims to promote both biodiversity conservation and sustainable use. It is based on 12 principles and additional operational guidance and has been incorporated into the design and implementation of forest policy as well as active management (FAO, 1993; Hartje et al., 2003; Wilkie et al., 2003; Sayer et al., 2004; Sayer and Maginnis, 2005; McAfee and de Camino, 2010).

Adaptive management developed by Holling (1978) and Walters (1986) first appeared in the natural resource management literature in the late-1970s. AM explicitly recognises uncertainty and the challenges it poses, with the aim to reduce uncertainty through an experimental, hypothesis-based process of management (Walters, 1986; Walters and Holling, 1990). It is a process that also places a significant emphasis on participation (Holling, 1978). Several elements of AM have been influential in forestry, particularly aspects of participation and structured decision-making (Provencher et al., 2001; Munks et al., 2009) as well as experimentation (Bormann et al., 1994, 2007). AM has been characterised as a method for gaining forests of high social value in the future (Puettmann et al., 2009) and remains prominent in many forest planning and policy documents, including in light of current global change discussions (Lawrence and Gillett, 2011; Skogsstyrelsen, 2013).

3. Resilience thinking

Managing *for* resilience is now a new focus in the literature (Folke et al., 2002; Walker et al., 2002; Folke 2006); with RT being suggested to provide a framework for achieving sustainability goals in the face of both established challenges as well as environmental change and uncertain future needs (Folke et al., 2010; Walker et al., 2010), including in the context of forests. (e.g. Hughes et al., 2005; British Columbia Forestry Roundtable, 2009; McAfee and de Camino, 2010). While there are several alternative 'usages' and numerous definitions of resilience ranging from the descriptive definition in ecological science (Holling, 1973; Pimm, 1984; Longstaff, 2005) – including both engineering (Holling, 1996) and ecological or ecosystem resilience (Gunderson and Holling, 2002) – through to increasingly more normative interpretations (Pickett et al., 2004). One of the dominant articulations of resilience, 'resilience thinking' has evolved to be a perspective for analysing interdependent ecological and human systems that allows for a more integrated consideration of dynamics and scale