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Collaborative learning to unlock investments for functional ecological infrastructure: Bridging barriers in social-ecological systems in South Africa☆

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ABSTRACT

Maintenance of functional ecological (or green) infrastructure is threatened by habitat conversion, fragmentation and loss, water scarcity, invasive species, climate change, resource extraction, poor policy implementation and societal inequity. Using South Africa as a case study, our transdisciplinary team identified actions likely to be effective in scaling up research and development projects that support implementation of policy about ecological infrastructure by active adaptive management. Based on expert knowledge at three scales, we analysed South Africa's opportunity to active adaptive management and to unlock investments that enhance functional ecological infrastructure. Barriers included lack of trust among actors, limited collaborative governance and integrated planning, including local partnerships; as well as a poor inclusion of evidence-based knowledge based on monitoring of landscape restoration efforts and its social and ecological consequences. Bridges include practicing transdisciplinary knowledge production, enhancing social learning among actors and stakeholders, and advocacy based on improved understanding. We propose a portfolio of place-based actions that could help to facilitate unlocking investments for functional ecological infrastructure by prioritising conservation, management and restoration through integrated cross-scale, collaborative and multi-sector spatial planning. Understanding the structure and dynamics of social-ecological systems, identifying champions, framing key messages for different audiences, and sharing failures and success stories internationally, are crucial requirements to unlock investments.

1. Introduction

The natural capital provided by ecosystems is the ultimate foundation for human well-being. With its unique ability to modify its environment, *Homo sapiens* is a keystone species - a species that has disproportionately large effects on its environment relative to its abundance. This insight emerged long ago and has led to taboos and ancient norms, medieval legislations and scientific publications over more than three centuries to encourage conservation of natural capital (e.g., von Carlowitz, 1713; Marsh, 1864; Odum, 1959). Nevertheless, the human footprint on this natural capital is still heavy.

To describe the state and trends of ecosystems effectively, their composition, structure and function need to be understood. This complexity is captured by the biodiversity concept (e.g., Noss, 1990), which was originally proposed to highlight the intrinsic value of natural capital. In parallel, contemporary policies aimed at regulating anthro-

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pogenic pressures on ecosystems have adopted the concept of ecosystem services as a metaphor and means of advocacy (MEA (MEA (Millennium Ecosystem Assessment)) (2005)). The ecosystem services concept has launched a large and expanding field of research which seeks to measure and value human and societal dependence on ecosystems (e.g., Norgaard, 2010). Whereas the biodiversity concept captures the potential supply of ecosystem services in terms of what can be derived from species, structures and processes (e.g., Brumelis et al., 2011), the ecosystem services concept focuses on the benefits to human well-being in terms of provisioning, regulating, supporting/habitat and cultural dimensions (MEA (MEA (Millennium Ecosystem Assessment)), 2005). However, this link is not always straightforward as ecosystems may also incur dis-services; and there are trade-offs among services, stakeholders at different governance levels and spatial scales (Shackleton et al., 2016a; Vaz et al., 2017). Also, abiotic resources need to be considered and human investment is often required to realise the potential of biodiversity components to deliver human benefits (e.g., Lele et al., 2013).

Global or continental assessments of biodiversity and ecosystem services are crucial high-level advocacy tools (e.g., Costanza et al., 1997; Daily, 1997; Sutton and Costanza, 2002; de Groot et al., 2012). In tandem, however, local and regional level place-based approaches are also needed to facilitate appropriate landscape stewardship, strategic planning and land management to maintain functional networks of representative ecosystems that deliver ecosystem services at multiple levels (e.g., Mirtl et al., 2013, Angelstam and Elbakidze, 2017). This is explicitly captured by ecological (SANBI, 2014) and green infrastructure policy (European Commission, 2013), and implicitly by the United Nations sustainable development goals (Mbow et al., 2015). Implementation in places and regions require comprehensive understanding of coupled ecological and social systems (e.g., Angelstam et al., 2013b, 2013c). This process, termed landscape approach (Axelsson et al., 2011; Sayer et al., 2013; Sabogal et al., 2015), is a way of practicing sustainability science (Kates, 2011) in social-ecological systems that includes both evidence-based knowledge and engages multiple and diverse stakeholder groups.

Regarding the ecological system, the transformation of naturally dynamic or authentic cultural landscapes to intensively managed landscapes involves three different interacting factors that affect the functionality of ecological infrastructure: (1) habitat loss, i.e., the amount of land cover patches, which includes (a) the quality of patches, (b) the size of patches and (c) the number of patches (e.g., Fahrig, 2001); (2) fragmentation, i.e. the spatial configuration of patches, (e.g., Fahrig, 2002, 2003); and (3) connectivity, i.e. how the network of patches and the permeability of the matrix surrounding interact with and affect a particular species or process (e.g., Saura et al., 2011; Tischendorf and Fahrig, 2000). Integrated spatial planning to maintain functional ecological infrastructure of representative land covers (i.e. biophysical systems under different land uses) is the foundation for sustaining ecosystem services. This requires not only knowledge about desired benchmark conditions, land cover data and planning tools, but also engagement of stakeholders representing public, private and civil sectors at multiple levels (Elbakidze et al., 2010). Therefore, analysis of the social system is also needed. This include stakeholders' understanding of the issues, their ability and willingness to act (Lundquist, 1987), the establishment of trust and trustworthiness (Hardin, 2002), an understanding of different power relations at play, as well as managing expectations as to who benefits under different scenarios (e.g., Kosoy and Corbera, 2010). For example, operationalisation of strategic integrated spatial plans may be threatened by socio-ecological challenges such as rapidly growing human populations, non-sustainable exploitation of natural capital, and ecosystem degradation as a result of widespread plant invasions, climate change, water scarcity, social inequity, conflicts of interests among stakeholders, corruption and a narrow economic focus (e.g., de Groot et al., 2010; Hoffman and Todd, 2000).

The aim of this paper is to identify ways of bridging barriers in social-ecological systems towards collaborative learning, scaling up and unlocking investments for the maintenance of representative and functional ecological infrastructure at different spatial scales. Our team of sustainability scientists, practitioners and public sector experts at different levels of governance collaboratively went through three steps, which are reported in this paper. First, we present three case studies representing the need for investments in ecological infrastructure at national, regional and local levels in South Africa. Second, we identify barriers and potential solutions in the form of knowledge and collaborative learning at multiple levels as bridges within different parts of the social-ecological system. Third, we present a practical portfolio of steps to guide the development of a transdisciplinary culture of knowledge production based on collaborative learning and actions to scaling-up at multiple levels towards unlocking funding and managing investments. Finally, we discuss the need to encourage transdisciplinarity and international collaboration towards functional ecological infrastructure.

2. Methodology

2.1. South Africa as a case study

South Africa is a global biodiversity hotspot with a wide range of biomes that are subject to large-scale transformation via multiple anthropogenic agents and climate change (Olson and Dinerstein, 2002; Wynberg, 2002; Cowling et al., 2003; Gasparatos et al., 2016). The country also faces major developmental challenges to provide a 'safe and healthy environment' for its people (Shackleton et al., 2017a). The political history of South Africa, and in particular the huge disruptions to the social fabric of the nation caused by apartheid has left a polarised society – despite more than two decades of efforts towards poverty alleviation and other forms of social upliftment (e.g., Bond, 2000; Meredith, 2005). At the same time, South Africa has developed progressive and innovative environmental policies to maintain ecological infrastructure through participatory approaches to protection, management and restoration of ecosystems (Bennett and Kruger, 2015). Examples of this legislation are the invasive alien species regulations of the National Environmental Management: Biodiversity Act and the National Veld and Forest Fire Act. However, despite laudable environmental policies and investments into ecological infrastructure, South Africa is facing challenges with environmental degradation including loss of biodiversity and natural capital, while the government is simultaneously struggling to meet the rapidly increasing demand for ecosystem service delivery. The country is also struggling to turn legislation into effective practices but there is limited capacity to enforce laws (van Wilgen et al., 2016a). This calls for increased and improved relevance and coherence of investment portfolios to ensure the delivery of ecosystem services. Unlocking public and private sector funding for restoration of degraded ecosystems (Mills et al., 2015) is crucial as well as to ensure the sustainability of investments into functional ecological infrastructure through collaborative learning based on active adaptive management (e.g., Shea et al., 2002). South Africa is thus an excellent case study for elucidating the issues that confront actors at multiple levels involved with governance, management and assessment (Blignaut et al., 2013, 2014).

2.2. Atelier approach

This study emerged from an atelier workshop (Farley et al., 2005) held by the Ecosystem Services Partnership at St Helena Bay in South Africa during November of 2015. The aim of the workshop was to build the case for further investment in natural resource management (NRM) to develop a functional ecological infrastructure in South Africa. Specifically, the workshop aimed to: i) analyse barriers and bridges for improving investment in NRM; ii) analyse the need for integrative knowledge production and learning for optimising and unlocking investment in ecological infrastructure and; iii) understand