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BIODIVERSITY VIEWPOINT

Engage the hodgepodge: management factors are essential when prioritizing areas for restoration and conservation action

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ABSTRACT

Restoration and conservation initiatives, such as the eradication of invasive alien plants, should be guided by scientific evidence. Typically, ecological data alone is used to inform the decision-making of these initiatives. Recent advances in the mapping of conservation opportunity include a diverse range of scientifically-identified factors that determine the feasibility and likely effectiveness of conservation initiatives, and include, for example, data on the willingness and capacity of land managers to be effectively involved. Social research techniques such as interview surveys, phenomenology, and social network analysis are important approaches for securing useful human and social data. These approaches are yet to be widely adopted in restoration initiatives, but could be usefully applied to improve the effective implementation of these initiatives. Restoration and conservation planners will deliver spatial prioritisations which provide more effective and cost-efficient decision-making if they include not simply ecological data, but also data on economic, human, management, social and vulnerability factors that determine implementation effectiveness.

Keywords

Conservation opportunity, conservation planning, inter-disciplinarity, multiple-criteria analysis, research–implementation gap, social research.

> One of the anomalies of modern ecology is that it is the creation of two groups, each of which seems barely aware of the existence of the other. The one studies the human community as if it were a separate entity, and calls its findings sociology, economics and history. The other studies the plant and animal community and comfortably relegates the hodge-podge of politics to the liberal arts. The inevitable fusion of the two lines of thought will, perhaps, constitute the outstanding advance of the present century.
> Aldo Leopold, 1935
> From: Meine & Knight (1999)

In recent research, Roura-Pascual *et al.* (2009, 2010) present a decision-support model and sensitivity analysis for managers to improve the robustness of their decision-making when clearing invasive alien plants in the Cape Floristic Region, a biodiversity hotspot in South Africa. The research offers an approach that managers will potentially find useful, as it integrates experiential and scientific knowledge (using the Analytical Hierarchy Process) and available spatial data, to set priorities for the restoration and management of invaded ecosystems. This research aims to provide spatially explicit information on which managers can base their management strategies so as to improve the effectiveness of restoration activities in a region over-run with invasive plants (Henderson, 2007).

Roura-Pascual *et al.* (2010) identify the potential importance of their research for the Working for Water programme (WfW), South Africa's government-lead initiative for managing invasive alien plants (van Wilgen *et al.*, 2011b). Invasive alien plants, particularly woody *Acacia* species, now cover some 20 million hectares of South Africa (Kotze *et al.*, 2010; Van Wilgen *et al.*, 2011a), causing significant negative

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impacts. Notably, invasive alien plants homogenize indigenous ecosystems, crowding-out lower biomass plant species and reducing species diversity (Le Maitre *et al.*, 2000). Hydrological flows are also significantly reduced (Cullis *et al.*, 2007). Established in 1995 to address these issues, the Working for Water programme aims not only to restore ecosystem function through the removal of invasive alien plants but also to improve the provision of ecosystem services, conserve species and their habitats and create jobs to alleviate poverty (van Wilgen *et al.*, 2011b). Estimates from WfW annual reports presented between October 1995 and March 2003 indicate that over 1,225,370 ha have been initially cleared, with 1,390,742 ha subjected to follow-up clearing (Marais *et al.*, 2004). Recently, WfW was estimated to have restored some 41,653 riparian condensed hectares of alien vegetation, leading to improved hydrological flows and grazing benefits (Marais & Wannenburgh, 2008). Clearly, given the vast areas covered by invasive alien plants, and the significant amounts of funding required to restore ecosystems, evidence-based decision-making is essential for ensuring the cost-efficiency and effectiveness of the WfW programme.

Roura-Pascual *et al.* (2009, 2010) demonstrate the significance of robust information for reducing uncertainty in spatially explicit decision-making. They highlight the importance of socio-economic factors in effective restoration and go to the trouble of consulting managers (and researchers) to identify factors that enhance or constrain management options for restoration. Unfortunately, their approach demonstrates the disciplinary divide highlighted by Leopold: whilst acknowledging the importance of socio-economic factors for the effectiveness of restoration programmes, they exclude from their decision-making framework the management factors identified by managers as essential for implementing effective restoration initiatives. Simply put, the management factor 'hodgepodge' highlighted by Leopold – that confusing mixture of political, human, institutional, organizational and social phenomena that ultimately blend and interact to define the feasibility and effectiveness of human land management interventions – is 'comfortably relegate[d]' to other fields of concern. The absence of these factors in Roura-Pascual *et al*'s. (2009, 2010) methodology, unfortunately, limits the significant utility of their approach and marginalizes the very managers they aim to support. A failure by restoration researchers to engage the hodgepodge identified by Leopold is a recognized short-coming of the discipline of restoration ecology (Aronson *et al.*, 2010; Christian-Smith & Merenlender, 2010).

Restoration and conservation share similarities and differences (Young, 2000) and can be considered essential, complementary activities for achieving effective environmental management (Hobbs & Harris, 2001). Whilst restoration ecologists have only recently began to systematically prioritize areas for restoration (e.g. Crossman & Bryan, 2006; Fuller *et al.*, 2006), conservation planners have been doing so since the 1980s (e.g. Kirkpatrick, 1983; Margules *et al.*, 1988). Recent research confirms, in agreement with Roura-Pascual *et al.* (2010), the importance of multi-criteria analysis for spatial prioritization (Moffett & Sarkar, 2006; Margules & Sarkar, 2007), but more specifically, also, for the inclusion of data on factors that define opportunity for effectively implementing action (Knight & Cowling, 2007; Knight *et al.*, 2010). Whilst the *goal* of conservation or restoration is biological, the *means* to achieving the goal are primarily social (Mascia *et al.*, 2003; Polasky, 2008). Best-practice spatially explicit conservation planning therefore incorporates the 'hodgepodge' of management factors that influence the effectiveness of on-ground conservation activities. Including management factors advances decision-making from simply addressing areas of ecological importance for restoration to areas that are not only important but also feasibly actioned (e.g. Knight & Cowling, 2007; Margules & Sarkar, 2007).

Factors defining opportunity vary from location to location, but are typically economic, human, institutional and/or social dimensions of our world (i.e. those influencing effective management; Knight *et al.*, 2010). When applied, these criteria should aim to actively embody the notion of feasibility (*sensu* Hobbs *et al.*, 2003) and the likelihood of implementation effectiveness (Knight *et al.*, 2010). Factors defining opportunity have been demonstrated to have significant influence upon spatial prioritizations. For example, including data on funding availability (e.g. costs of initial or follow-up clearing) affects the number and configuration of priority areas for implementation (Ando *et al.*, 1998). Human factors, such as land managers' willingness-to-sell land to conservation organizations, have also been demonstrated to influence the spatial configuration and cost of expanding protected area networks (Guerrero *et al.*, 2010). Restoration planners, specifically, have demonstrated how financial investments influence the location and optimal order of site restoration (Tucker *et al.*, 1998; Fullerton *et al.*, 2010). These factors of opportunity can only be effectively identified by researchers (who typically conduct spatial prioritizations) when they collaborate with managers (as recognized by Roura-Pascual *et al.*, 2009), because managers are most directly engaged with 'the hodgepodge' that embodies the systems we apply to conserve and/or restore ecosystems (Smith *et al.*, 2009).

Opportunity can be mapped and analysed with (e.g. Curran *et al.*, 2011) or without (e.g. Guerrero *et al.*, 2010; Knight *et al.*, 2010) ecological data, depending on the context. In specific regions, such as biodiversity hotspots, mapping and analysing human and social data alone is likely to be more effective, and time- and cost-efficient, than using ecological data for identifying areas of conservation or restoration importance (Cowling *et al.*, 2010). This results from (1) the impossibility of achieving comprehensive biological databases (Cowling *et al.*, 2010), (2) the rapidly diminishing returns on species inventory for improving the effectiveness of implementation (Grantham *et al.*, 2008) and (3) multi-criteria spatial prioritizations being most influenced by the datum with the highest heterogeneity (Perhans *et al.*, 2008). In cases such as that described by Roura-Pascual *et al.* (2010), where economic, human, institutional and social management factors vary greatly across whole ecosystems (e.g. Curran *et al.* 2011), management factors may have greater influence than ecological factors upon where, when and how we choose to conserve or restore. These influences further highlight the importance of understanding the benefits and limitations of applying not ecological data, but the range of data influencing effective management.

Intimately understanding not only ecosystems but also the social systems that provide the context for management is fundamental to effective conservation and restoration (Knight *et al.*, 2010). Absence of management data limits the ability of practitioners to usefully apply research on spatial priorities. Understanding what, how and where the opportunities and constraints influencing the effective implementation of conservation and restoration actions are distributed across a landscape is a prerequisite for being able to implement action effectively (Knight & Cowling, 2007) as this information identifies areas for practitioners that are not only a high priority (e.g. areas best cleared of invasive alien plants first) but where opportunities exist that can be feasibly implemented (e.g. because of willingness or capacity constraints). Importantly, mapping opportunity avoids the need to repeat analyses when it is found that areas of high priority do not coincide with areas of high opportunity (i.e. cannot be feasibly implemented; Hobbs *et al.*, 2003; Knight *et al.*, 2010).

Restoration opportunity has recently been mapped for a section of the Makana Municipality in the Maputaland–Pondoland–Albany hotspot in South Africa, with a view to identifying specific farms where carbon credit–funded restoration could be undertaken (Curran *et al.* 2011). Factors defining restoration opportunity that could be usefully integrated into future spatial prioritizations were included, such as Roura-Pascual *et al*'s. (2009, 2010) study regions, to better ensure that targeted areas for restoration are more likely to be effectively implemented. The mapping of restoration opportunity, as opposed to restoration priority, moves research from simply describing the biological dimension of a problem to provide a testable hypothesis for effective implementation. This is a prerequisite for adaptive management (Holling, 1978), a fundamental component of conservation and restoration programmes striving for long-term, effective action (Hobbs & Harris, 2001; Salafsky *et al.*, 2002; Teal & Weishar, 2005; Knight *et al.*, 2006; Klein *et al.*, 2007). It also promotes 'informed opportunism' (Noss *et al.*, 2002; Knight & Cowling, 2007), where unforeseen opportunities can be secured as they arise.

Leopold's (1935) (Meine & Knight, 1999) wisdom calls on conservation biogeographers not only to consider the physical geography of change and the biogeography of threat (Sexton *et al.*, 2010), as they most commonly do, but also to research the economic, human, institutional and social factors that define the effectiveness of our conservation and restoration initiatives. This requires that we grapple with, and intimately understand, the 'hodgepodge' of policy development, programme operations and land management. These spheres are defined by people's values, individual and institutional capacity, relationships and the vagaries of political process. It also challenges us individually and collectively to reflect upon the theories underpinning our practice and refine them to more accurately describe conservation and restoration problems. Innovative thinking, which pushes us beyond our disciplinary boundaries, is essential. This can be operationalized by integrating existing conceptual frameworks and methodologies, for example combining Roura-Pascual *et al*'s. (2009, 2010) technique for securing the best expert knowledge with the mapping of restoration opportunity. This will better ensure that we bridge the research–implementation gap (Knight *et al.*, 2008). We encourage conservation biogeographers to extend themselves beyond their disciplinary confines and engage with the messy hodgepodge of land management, so as to be better informed, and thereby more effectively support managers in restoring and conserving our precious species and ecosystems.

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BIOSKETCH

All authors are broadly interested in practical transdisciplinary conservation planning, inclusive of applied marine and terrestrial spatial prioritization, stakeholder collaboration and implementation strategy development. Much of our research straddles ecological and socio-economic spheres in the quest for approaches and techniques for improving decision-making to maximize conservation and restoration outcomes. Specifically, we collaborate with conservation organizations to develop operational models and decision-support tools for solving complex environmental problems, including multi-agent and multi-criteria analyses; understand factors defining risk, uncertainty and the effectiveness of conservation activities; develop optimal suites of instruments, including payments for ecosystem services, for ensuring the persistence of species and habitats; evaluate the effectiveness of conservation initiatives; and learning, individually and collectively, to adaptively improve conservation practice. We work widely throughout Australia, Europe, south and south-east Asia, southern Africa and Mesoamerica.

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