Journal of Environmental Management 159 (2015) 235–244

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Private land manager capacity to conserve threatened communities under climate change

C.M. Raymond [a, b, *], A.M. Lechner [c, d], M. Lockwood [e], O. Carter [f], R.M.B. Harris [g], L. Gilfedder [f]

[a] Geosciences and Natural Resource Management, University of Copenhagen, Rolighedsvej 23, Frederiksberg, Denmark
[b] Enviroconnect, PO Box 190, Stirling, South Australia 5152, Australia
[c] Centre for Environment, University of Tasmania, Private Bag 141, Hobart, Tasmania 7001, Australia
[d] Centre for Social Responsibility in Mining, Sustainable Minerals Institute, Sir James Foots Building (47A), Staff House Road, The University of Queensland, Brisbane, Queensland 4072, Australia
[e] Geography and Spatial Sciences, School of Land and Food, University of Tasmania, Private Bag 78, Hobart, Tasmania 7001, Australia
[f] Natural and Cultural Heritage Division, Department of Primary Industries, Parks, Water and Environment, PO Box 44, Hobart, Tasmania 7001, Australia
[g] Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC), University of Tasmania, Private Bag 80, Hobart, Tasmania 7000, Australia

ARTICLE INFO

Article history:
Received 16 January 2015
Received in revised form
26 April 2015
Accepted 29 April 2015
Available online 9 June 2015

Keywords:
Adaptive capacity
Pro-environmental behaviour
Environmental change
Threatened communities
Novel ecosystems

ABSTRACT

Major global changes in vegetation community distributions and ecosystem processes are expected as a result of climate change. In agricultural regions with a predominance of private land, biodiversity outcomes will depend on the adaptive capacity of individual land managers, as well as their willingness to engage with conservation programs and actions. Understanding adaptive capacity of landholders is critical for assessing future prospects for biodiversity conservation in privately owned agricultural landscapes globally, given projected climate change. This paper is the first to develop and apply a set of statistical methods (correlation and bionomial regression analyses) for combining social data on land manager adaptive capacity and factors associated with conservation program participation with biophysical data describing the current and projected-future distribution of climate suitable for vegetation communities. We apply these methods to the Tasmanian Midlands region of Tasmania, Australia and discuss the implications of the modelled results on conservation program strategy design in other contexts. We find that the integrated results can be used by environmental management organisations to design community engagement programs, and to tailor their messages to land managers with different capacity types and information behaviours. We encourage environmental agencies to target high capacity land managers by diffusing climate change and grassland management information through well respected conservation NGOs and farm system groups, and engage low capacity land managers via formalized mentoring programs.

1. Introduction

Climate change is projected to be a dominant driver of species extinctions and distribution shifts over the 21st century, exacerbated by land-use change (Pereira et al., 2010). As climate conditions diverge from those under which current ecosystems adapted, the composition and structure of ecological communities are also expected to change, potentially leading to establishment of degraded, or even novel ecosystems for which there are no current analogues (Folke et al., 2010; Starzomski, 2013). In North America, vegetation composition and dynamics have been strongly influenced by combinations of human land management and altered disturbance regimes such as fire (Nowacki and Abrams, 2014; Thébault et al., 2014). However, climatic change may affect the dynamics and balance of different vegetation communities, including the potential for range contraction of native grasslands and expansion of invasive species (Polley et al., 2013; Prevéy and Seastedt, 2014). The influence of climate change on grassland community dynamics in Europe is less clear. Recent modelling of twelve grassland sites in France suggests a move towards more arid climates by the end of the century, and new opportunities for

* Corresponding author. PO Box 190, Stirling, South Australia 5152, Australia.
E-mail address: chris.raymond@enviroconnect.com.au (C.M. Raymond).

http://dx.doi.org/10.1016/j.jenvman.2015.04.048
0301-4797/

annual and seasonal herbage production in spring and winter (Graux et al., 2013).

Temperate grassy eucalypt woodlands and grasslands in south-eastern Australia are likely to be particularly affected by changing climatic conditions (Prober et al., 2012). In their study of the projected effects of climate change on these grasslands and closely related vegetation communities, Harris et al. (2015) concluded that attempting to maintain the status quo by conserving the current structure and composition is unlikely to be a viable management option in the future. They pointed out that measures such as long-term conservation covenants with fixed boundaries, and protection under environmental legislation that sets thresholds based on historical floristic composition, have not accounted for the potential development of novel grassy vegetation communities under climate change.

Given the prospect of major global changes in the vegetation community distributions and in ecosystem processes, it is desirable that land managers have the capacity and resources to minimise degrading impacts. In this paper, we focus on the contribution that private land managers, by which we mean the managers of lands under private tenure, can make to achieving biodiversity outcomes on their properties. In agricultural regions, a significant proportion of threatened communities tend to be located on land managed by individual private land owners. In North America, Europe and Australasia, private land tenure constrains the regulatory power of governments so that unilateral acquisition of private land for conservation purposes is either unlawful or highly unlikely. In Australia, governments and conservation non-government organisations (NGOs) have applied multiple policy instruments and nature conservation strategies to augment regulatory responses, including capacity building, education, management agreements, conservation covenants and economic incentives to improve nature conservation on private land (Stoneham et al., 2000; Curtis et al., 2014; Fitzsimons and Carr, 2014).

The effectiveness of conservation policy instruments and mechanisms can be enhanced if their selection and design is informed by an understanding of land manager adaptive capacity (Moon and Cocklin, 2011; Sorice et al., 2011). Adaptive capacity is the ability for individuals, communities or institutions to respond to change (Folke et al., 2005). Under climate change, the adaptive capacity of land managers is expected to be of particular importance (Smit and Wandel, 2006). Understanding the influence of adaptive capacity on uptake of conservation actions or instruments will be useful in future engagement of private land managers by governments and NGOs working to secure conservation outcomes under a changing climate. Adaptive capacity may be expressed through actions that maintain a desired state, or lead to a favourable transformation when the current state is untenable or undesirable (Folke et al., 2005; Gupta et al., 2010; Engle, 2011). The adaptive capacity of private land managers is comprised of their social capital, human, financial and physical capital, and management approaches (Lockwood et al., 2015).

In the context of land management, social capital refers to managers' social networks (both local and non-local), partnership agreements with environmental agencies and conservation non-government organisations, and flows of information (Adger et al., 2005). Aspects of social capital that are particularly implicated in adaptive capacity are trust, reciprocity and networks (Adger, 2003; Armitage, 2005; Folke et al., 2005; Pelling and High, 2005). Land managers with high trust in government and NGOs, who reciprocate knowledge and skills with neighbours, and have strong social networks are likely to have stronger capacity to adapt to a changing climate than those without these characteristics (Lockwood et al., 2015). Social capital infers collaboration and cooperation between land managers and conservation-relevant stakeholders in times of stress, and implies the effective delivery of management effort to cope with threats to resources and resource users (Adger, 2003; Adger and Vincent, 2005).

The adaptive capacity of land managers is informed by their human capital in terms of knowledge and access to information, access to labour, and willingness and capacity to devote time to thinking through and acting on change management strategies (Gupta et al., 2010; Nelson et al., 2010). Availability of supporting financial capital to enable access to learning opportunities and to support implementation of conservation actions, as well as physical capital including management-related infrastructure, are also important (Yohe and Tol, 2002; Pahl-Wostl, 2009; Engle and Lemos, 2010; Nelson et al., 2010). In addition, adaptive capacity depends on the land manager's approach to management, which is influenced by attitudes to risk, uncertainty and innovation, as well as willingness to seek out information and embrace an adaptive management approach (Ivey et al., 2004; Tompkins and Adger, 2005). Adaptive management recognises that uncertainty and incomplete knowledge are inevitable, and that there are benefits to embracing experimentation, innovation and learning (Allan and Curtis, 2005).

In addition to adaptive capacity, it is useful to consider land managers' receptiveness to involvement in long-term conservation management when designing future engagement strategies and programs. Land managers with a long duration of property ownership, large property size, extensive area of native vegetation, and past program participation are more likely to become engaged in both formal and informal forms of conservation management (Crase and Maybery, 2004; Bohnet, 2008; Seabrook et al., 2008; Morrison et al., 2011). However, the relationships between grassland distribution, adaptive capacity and conservation program participation remain largely unknown globally. Examining the relationships between the distributions of native vegetation communities, adaptive capacity and conservation program participation will improve understanding of the capacity of land managers (of all types) to anticipate and cope with change, given their existing resources and approaches. With such knowledge, governments and conservation NGOs can devise conservation instruments, strategies and programs that are more likely to produce good conservation outcomes from the perspective of environmental agencies.

A growing conservation opportunity literature indicates that environmental management policies and plans are more likely to be implemented if they consider dimensions of conservation priority, including conservation value, alongside aspects of feasibility of policy or plan implementation, including economic cost of conservation efforts, adaptive capacity, land manager willingness to engage in conservation programs, and land manager socio-demographic and farm characteristics (Knight et al., 2006; Naidoo et al., 2006; Raymond and Brown, 2011; Ban et al., 2013; Mills et al., 2013; Pressey et al., 2013). While a recent special section of *Conservation Biology* sheds light on theories, methods and processes for integrating spatially referenced biological and social data to inform community engagement programs (see Raymond, 2014 for an overview), we are not aware of any works which have systematically integrated measures of the distribution of threatened communities (an indicator of conservation priority) with aspects of management feasibility to inform the selection and design of community engagement programs. Such a line of questioning should help tailor engagement approaches to increase the range of land managers and conservation science organisations involved in conservation planning in the 21st century (Foster et al., 2014).

The aim of this paper is to demonstrate how integration of data on (i) land manager adaptive capacities and factors associated with conservation program participation; (ii) vegetation communities;