Scenario analysis for biodiversity conservation: a social–ecological system approach in the Australian Alps

Michael Mitchell [a]*, Michael Lockwood [a], Susan A. Moore [b], Sarah Clement [b]
(this is a pre-print version of paper published in *Journal of Environmental Management*, Vol. 150, pp. 69-80 http://dx.doi.org/10.1016/j.jenvman.2014.11.013 accepted Nov 2014 for publication Mar 2015)

[a] Geography and Spatial Studies, School of Land and Food, University of Tasmania, Private Bag 78, Hobart, TAS 7001, Australia
[b] School of Veterinary and Life Sciences, Murdoch University, South Street, Murdoch, WA 6150, Australia

* Corresponding author:
E-mail address: Michael.Mitchell@utas.edu.au

Abstract

Current policy interventions are having limited success in addressing the ongoing decline in global biodiversity. In part, this is attributable to insufficient attention being paid to the social and governance processes that drive decisions and can undermine their implementation. Scenario planning that draws on social–ecological systems (SES) analysis provides a useful means to systematically explore and anticipate future uncertainties regarding the interaction between humans and biodiversity outcomes. However, the effective application of SES models has been limited by the insufficient attention given to governance influences. Understanding the influence governance attributes have on the future trajectory of SES is likely to assist choice of effective interventions, as well as needs and opportunities for governance reform. In a case study in the Australian Alps, we explore the potential of joint SES and scenario analyses to identify how governance influences landscape-scale biodiversity outcomes. Novel aspects of our application of these methods were the specification of the focal system's governance attributes according to requirements for adaptive capacity, and constraining scenarios according to the current governance settings while varying key social and biophysical drivers. This approach allowed us to identify how current governance arrangements influence landscape-scale biodiversity outcomes, and establishes a baseline from which the potential benefits of governance reform can be assessed.

Key words

Social–ecological systems; Governance; Adaptive capacity; Biodiversity conservation

Highlights

- We undertake a futures analysis of threatened biodiversity in the Australian Alps
- The analysis uses plausible future scenarios based on critical uncertainties
- The critical uncertainties were identified using a social–ecological systems model
- This model included governance influences on landscape-scale biodiversity outcomes
- Our method provides a basis for identifying and assessing governance reform options

1. Introduction

The ongoing decline in global biodiversity is largely attributed to human-induced impacts (Millennium Ecosystem Assessment, 2005; Butchart et al., 2010), and current policy settings and interventions are having limited success (Fischer et al., 2007). This failure is, in part, attributable to a lack of assessments and interventions directed at a landscape-scale (Lefroy et al., 2012) and because most conservation plans pay insufficient attention to the social processes that drive decisions, which undermines their implementation (Ban et al., 2013). As institutions provide the mechanisms by which interventions are given effect, it is important that governance arrangements support the development of policies that address the multi-level dynamics of landscape-scale conservation and the effective implementation of these policies (Dietz et al., 2003; Cash et al., 2006). In this context, it is vital to understand the effects of interactions and interrelationships between humans and biodiversity over the long term and to develop governance processes that support strategic thinking, including anticipation of potential challenges and opportunities (Steinberg, 2009).

Scenario planning that draws on social–ecological systems (SES) analysis provides a useful means to systematically explore and anticipate future uncertainties regarding the interaction between humans and biodiversity outcomes, and to thus inform thinking about future interventions (Bohnet and Smith, 2007). Scenarios are organised accounts of plausible futures that create a 'possibility space' from which to explore the consequences of uncertainty (Peterson et al., 2003; Swart et al., 2004). By providing insight into drivers of change and the implications of current trajectories, and encouraging consideration of a variety of possible futures rather than attempting an accurate prediction of a single outcome, this approach can assist planners to explore potential consequences of current policies as well as develop more adaptive conservation interventions (Carpenter et al., 2006; Palacios-Agundez et al., 2013). Scenarios can accommodate diverse futures that range from the radical and visionary to minor variations from 'business-as-usual' (Swart et al., 2004).

Scenario analysis can incorporate quantitative and qualitative information (Peterson et al., 2003). Qualitative scenarios, such as those involving construction of narratives, are more suitable than primarily quantitative approaches for exploring social drivers and consequences, institutional influences, and system transformations (Swart et al., 2004; Garb et al., 2008). Both methods can benefit from a collaborative approach to which analysts, scientists, governance authorities, managers and other stakeholders contribute. Multiple sources of knowledge from a diversity of perspectives, including stakeholder and expert judgements and published science can be integrated into the process (O'Connor et al., 2005; Southern et al., 2011). Collaborative scenario development can be a powerful tool for increasing understanding, knowledge sharing, and communication among stakeholders (Biggs et al., 2007), and development of conceptual SES models is a useful strategy to this end (Reed et al., 2013).

SES models have been used to analyse a wide range of environmental issues, helping to demonstrate that an understanding of interactions between social and biophysical drivers can inform response strategies. Landscapes have been advocated as an appropriate scale for analysing relationships between people and place including through the use of SES models (Bohnet and Smith, 2007). Gallopín (2006, p. 294) defines a SES as 'a system that includes societal (human) and ecological (biophysical) subsystems in mutual interaction' that can be specified for any scale from the local to the global. SES models can enhance understanding of landscapes as complex adaptive systems, including how structural characteristics and dynamic feedbacks influence system behaviour, making them well suited to guide identification of management strategies (Schlüter et al., 2012). Linking conservation planning to a SES framework can lead to a more thorough understanding of human–environment interactions and more effective integration of governance and social considerations (Ban et al., 2013). However, the effective application of SES models has often been limited by the insufficient attention given to governance influences. Taking measures to foster SES resilience requires examination of the role of governance. As the link between social and ecological systems (Adger, 2000; Sikor, 2008), institutions and governance can both enable and constrain SES resilience. Understanding the influence governance attributes from multiple scales (international, national, local) have on the future trajectory of a SES is likely to assist choice of effective interventions, as well as needs and opportunities for governance reform.

In a case study in the Australian Alps, we explore the potential of joint SES and scenario analyses to identify how governance influences landscape-scale biodiversity outcomes. Novel aspects of our application of these methods were: (i) the specification of the focal system's governance attributes according to a set of requirements for adaptive capacity and their explicit inclusion in a SES model; and (ii) subsequent development of scenarios based on the key drivers, influences and interactions from this model, constraining scenarios by retaining the current governance settings while varying key social and biophysical drivers with the highest associated uncertainties.

We posit that this linked SES modelling and scenario analysis approach, where future scenarios are defined without changing current governance provides a robust platform for investigating the individualised effects of proposed governance reforms on a scenario-by-scenario basis. Such an investigation will allow the potential advantages of governance reform options to be explored in the different contexts created by the different scenarios. Investigation of the range of governance possibilities against a range of contexts (i.e. a number of different scenarios) is essential given the uncertainties regarding the future, and future biodiversity outcomes.

2. Methods

Our joint deployment of SES modelling and scenario analysis comprised five steps:

1. Identification of a focal system and associated biodiversity features.
2. Generation and refinement of biophysical and social drivers for the focal system.
3. Generation and refinement of a set of governance influences regarded as pivotal for adaptive capacity.
4. Development of a conceptual SES model indicating relationships between important drivers, governance and management influences, and biodiversity features. By 'governance' we mean the institutions, rules and processes, both formal and informal, by which powers and responsibilities are allocated, direction is established, decisions are made, and stakeholders are engaged. By 'management' we mean the actual decisions that are made, and the consequent deployment of policy instruments, implementation of interventions, delivery of outputs, and monitoring of outcomes. In this step, we observed Schlüter et al.'s (2012) caution against attempting to include too much detail and specified system complexity at a level sufficient to address our problem, but not more.
5. Development and validation of four scenarios (scenario spaces and narratives) derived from two critical uncertainties. In choosing to develop four scenarios, we were mindful of Schwartz's (1996) cautioning that the use of three scenarios usually leads to an inevitable focus on the middle, and Peterson et al.'s (2003) argument that more than four may confuse users and limit their ability to explore uncertainty.

In step 1, we ascertained an indication of (i) the biodiversity features that were of importance; and (ii) the broad concerns regarding these features by reviewing scientific, regulatory and planning documents. These choices were then verified by experts in alpine biodiversity and representatives of the Australian Alps Liaison Committee (AALC), a coordinating body of government agencies involved in Australian Alps management. Our interest was in the trajectory of these features under different scenarios, with declines in extent and/or condition being regarded as undesirable. Our purpose – to identify how current governance arrangements influence landscape-scale biodiversity outcomes, and establish a baseline from which the potential benefits of governance reform can be assessed – did not require the identification of more specific conservation objectives.

Initial generation of drivers and influences in steps 2 and 3 were also undertaken by the research team in consultation with nine key informants (two managers, six scientists and one knowledge broker). Steps 4 and 5, as well as further refinement of the outcomes from steps 2 and 3, were undertaken in collaboration with scientists and representatives from key organisations that were associated with biodiversity management in the focal landscape. The main vehicle for this collaboration was a 2-day workshop attended by 35 people: three from the research team, and 32 participants comprising: 10 parks agency staff from Victoria, two from New South Wales and one from the Australian Capital Territory; three from the Australian Government environmental agency; one from the Victorian state environmental agency, three from the two key local governments in the region; three alpine resort managers; one Australian Alps Traditional Owners representative; six scientists; and two knowledge brokers. These participants were purposively chosen to cover a diversity of relevant fields (biophysical, economic, social, cultural), governance levels (national, state, territory, local) and management expertise (resorts, tourism, biodiversity, fire, water).

As part of step 4, the relative importance of drivers and governance influences were assessed by workshop participants using aggregated data from an individual voting system against a five-point scale. In this paper we focus only on those drivers and influences judged by more than 20 participants as being of high or very high importance, and use a modified version of the SES model that matches this reduced set. A similar voting system was used to identify the critical uncertainties that formed the basis for the four scenario spaces in step 5. That is, participants were asked to judge the level of uncertainty about the future state of those drivers identified as being most important. The workshop process allowed for participants to discuss what 'high uncertainty' means in relation to each of the drivers before making their own subjective decision. The degree of spread in voting patterns was then discussed by participants, after which the participants, as a group, agreed on the two critical uncertainties. Participants then created an outline of the key points to include in the scenario narratives. These narratives were further developed after the workshop by the research team in consultation with a review panel comprising six biophysical scientists and an economist, who also

provided validation. Participants' views on the value or otherwise of the workshop process and outcomes associated with steps 2 to 5 were also obtained during the workshop.

This sequence of steps has similarities to procedures recommended for resilience assessments (Resilience Alliance, 2010) and undertaken by, for example, O'Connor et al. (2005) and Reed et al. (2013). However, our method differed from previous work in two respects, both related to our treatment of governance. First, in step 2, the identification of potentially important governance influences on biodiversity outcomes in the focal region concentrated on those attributes that have been identified in the literature as important in terms of adaptive capacity. Second, in step 5, we constrained our scenarios by assuming that, while management strategies may vary, the broad features of current governance arrangements (such as allocation of responsibilities and powers to organisations) remained unchanged out to 2030. This is in contrast to previous studies that, where governance arrangements were included, these were allowed to vary over time and across scenarios. The scenarios presented in this paper thus constitute a range of plausible outcomes as shaped by the current governance arrangements, with any policy changes congruent with the current governance structures, including legislation and the roles of the park agencies. This constraint was critical to our method, as it allowed us to test the implications of the current arrangements, and also establish a baseline against which variations to the current arrangements can be compared. This approach allows separate consideration of the impact of alternative governance arrangements on biodiversity outcomes for each scenario.

3. Results

3.1 Step 1. Identification of focal system and biodiversity features

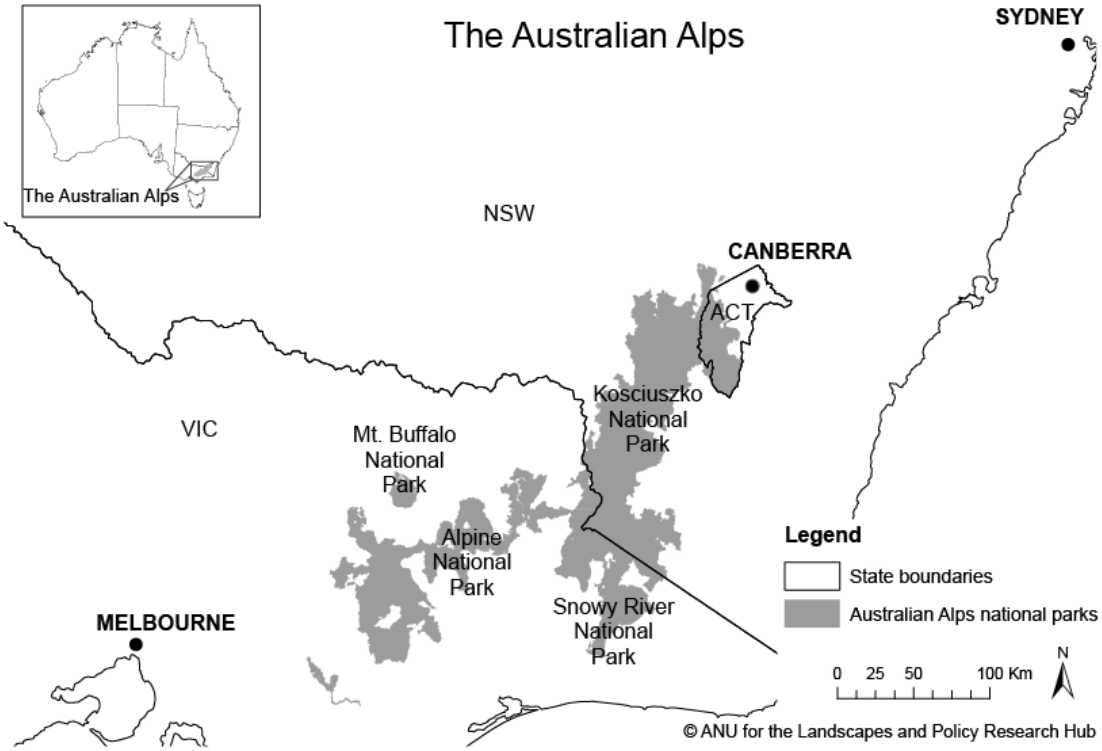
The Australian Alps is a region of low (by world standards) mountains stretching some 375 km from Mount Baw Baw north east of the Victorian state capital of Melbourne, into southern New South Wales (NSW) and the western margins of the Australian Capital Territory (ACT) (Figure 1). The focal system for the study reported in this paper is the treeless alpine and subalpine landscapes scattered throughout this region. There are approximately 160,000 ha of treeless vegetation in the Australian Alps – 70,000 ha in Victoria and 90,000 ha in NSW and the ACT. A total of 710 native plant species have been recorded across these areas, with 30% restricted to treeless vegetation in the Australia Alps and a further 14% restricted to treeless vegetation in general. The *Alpine Sphagnum Bogs and Associated Fens Ecological Community* and 14 plant species are listed under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and a further 17 species may be considered to be nationally threatened (McDougall and Walsh, 2007). The area also provides habitat for six fauna species listed under the Act.

The alpine zone (approximately 25,000 ha) comprises areas that are above the climatic treeline, which is generally located at the 10º C average summer temperature isotherm. At elevations above this isotherm, temperatures are too low to sustain tree growth (Costin et al., 2000). Alpine vegetation is a mosaic of grassland, heathland and wetland vegetation communities which supports many rare and endemic flora and fauna species. Exposed sites at high elevations support a feldmark community comprising prostrate windswept shrubs. On south easterly aspects where snow persists through spring and into summer, vegetation comprises a 'snowpatch' feldmark as well as low alpine herbfield. Elsewhere, extensive alpine grasslands have developed on deep humus soils, while heathlands occur on shallow soils and more rocky sites, and wetland communities are found in poorly drained areas (Wahren et al., 1999; McDougall and Walsh, 2007). Heath vegetation is variously dominated by species such as *Oxylobium ellipticum*, *Kunzea muelleri* and *Grevillea australis*. There are three broad types of alpine wetlands – peat bogs, fens and lakes. In Kosciuszko National Park, Blue Lake, together with the adjacent Hedley Tarn, is listed under the Ramsar Convention on Wetlands of International Importance.

Subalpine environments include woodlands with an overstorey dominated by *Eucalyptus pauciflora* (snow gum), and treeless landscapes comprising grasslands, heaths and wetlands (Williams and Ashton, 1987; McDougall, 2007). Although below the climatic treeline, diurnal temperature inversions produce extremely low temperatures in cold air drainage basins, preventing the establishment of trees in these subalpine areas (Williams and Ashton, 1987). Subalpine grasslands feature tussock grass species interspersed with herbaceous plants. Boulder heathlands feature *Podocarpus lawrencei* (mountain plum-pine) – this environment is critical habitat for the endemic and endangered mountain

pygmy-possum (*Burramys parvus*) (Mansergh and Broome, 1994). Subalpine wetlands provide critical habitat for the endangered southern and vulnerable northern corroboree frogs (*Pseudophryne corroboree* and *Pseudophryne pengillyi*), and broad-toothed rat (*Mastacomys fuscus*) (Hope et al., 2009; Hunter et al. 2009). The Ginini Flats subalpine bog complex in the Brindabella National Park in the ACT is on the Ramsar List of Wetlands of International Importance.

Figure 1. Location of the Australian Alps showing the major protected areas in the region



The subalpine and alpine areas of the Australian Alps were used by Aboriginal peoples at least since 4,500 BC, probably since the end of the last glacial period about 10,000 years prior to European invasion, and it is likely that they made occasional visits to all but the highest ice-covered elevations many thousands of years before that (Flood, 1992). Since European occupation, the alpine and subalpine landscapes of the Australian Alps have been used for stock grazing, hydroelectricity and water production, tourism and recreation, and scientific research. Protecting natural landscape features and associated ecosystems and species also has a long history in the region, There are now 11 major protected areas in the Australian Alps: Namadgi National Park and Tidbinbilla Nature Reserve in the ACT, reserved under the *Nature Conservation Act 1980 (ACT)*; Kosciuszko and Brindabella National Parks and Bimberi and Scabby Range Nature Reserves in NSW, reserved under the *National Parks and Wildlife Act 1974 (NSW)*; and Mt Buffalo, Alpine, Snowy River and Baw Baw National Parks and the Avon Wilderness Park in Victoria, reserved under the *National Parks Act 1975 (Vic)* (Figure 1). These acts and associated management plans are the key instruments that specify the objectives of these reserves, intended management actions, and permitted uses and activities. The management agencies for the reserves are the ACT Parks and City Services Division of Territory and Municipal Services, NSW National Parks and Wildlife Service and Parks Victoria. Cross border management and research activities are coordinated by the AALC. The associated Cooperative Management Program operates under a Memorandum of Understanding (MOU) signed by the Australian, NSW, Victorian and ACT Governments in 1986.

3.2 Step 2. Generation and refinement of biophysical and social drivers for the focal system

From an initial set of 17 biophysical and social drivers of change identified by the research team, and refined during the workshop, a smaller set were judged as being most important by workshop

participants. These most important drivers are summarised in Tables 1 and 2: climate change; invasive and predation processes; and fire regimes in Table 1, and community values and attitudes; social and human capital; and community understanding and learning in Table 2. The current status of each driver is presented in the left column, and their expected effects on system interactions and future biodiversity outcomes are presented in the right column. This information is drawn from the literature and supplemented with suggestions provided by workshop participants.

3.3 Step 3. Generation and refinement of a set of governance influences regarded as pivotal for adaptive capacity

A similar workshop process to step 2 was used to identify the most important governance influences. Out of an original 13 governance influences, nine were judged as having a strong or very strong influence by at least 20 workshop participants. The current status of these influences is indicated in Table 3. In the rest of this section, we elaborate on the general characteristics and importance of each governance influence.

Leadership, political will, supportive vision and strategic direction, priority setting and resources. The leadership of key persons has been shown to be a critical element for effective governance (Folke et al., 2005). Leadership is central to the collaboration among diverse individuals, organisations and government authorities required to address the complex problems of environmental protection. Effective environmental governance requires visionary leaders to drive a long-term agenda, entrepreneurial leaders to lead by example and stimulate action, and collaborative leaders to encourage linking of different actors (Olsson et al., 2006). Leadership is pivotal for managing conflict, connecting people, linking knowledge systems, developing and communicating a vision of ecosystem management, and building trust and broad support for change (Olsson et al., 2004). Leadership can have a major role through accessing the resources needed for policy implementation and change management (Black et al., 2011; Gupta et al. 2010). Leadership that inspires and enables others to transcend their own interests is crucial to innovation that maintains an appropriate fit between institutional and management arrangements and conservation needs. Such champions act as change agents who create environments for others to innovate, take risks and learn (Taylor et al., 2011). Political will, the extent of committed support among key decision makers for a particular policy solution to a particular problem (Post et al., 2010), is an important ingredient of government leadership. Political leaders need to work to secure wide political and community support for the objectives and actions of biodiversity conservation. Active political leadership is recognised as a key factor in influencing the success of adaptation to system drivers such as climate change (Smith et al., 2009).

Coordinated governance. Coordinating governance structures and management systems at a scale consistent with ecosystem characteristics is another key element in achieving biodiversity conservation objectives (Ruckelshaus et al., 2008). Coordinated governance refers to the extent of vertical and horizontal structures and processes that enable coordination and cooperation within and between authorities with responsibility for governing the focal system. Holman and Trawick (2011) found that horizontal integration across sectoral policies and practices, and vertical integration across the governance scales were important contributors to adaptive capacity. Establishing such connectivity may involve coordination of information and knowledge, joint mobilisation of resources, cooperative compliance and enforcement arrangements, and attempts to align multiple interests and priorities (Lowry et al., 2009). Governance connectivity is important in building shared recognition of interdependencies among issues, and in allowing actors to address problems in a concerted fashion. Linking different actors in networks to create opportunities for novel interactions is critical for learning and fostering integrated adaptive responses to change (Folke et al., 2009).

Effectiveness of engagement processes. The extent of public participation in decision-making and implementation is an element of adaptive capacity (Ivey et al., 2004). Participation can build trust and shared understanding, which in turn can mobilise coordinated action and encourage the emergence of self-organised governance structures (Lebel et al., 2006). Adaptive capacity is enhanced by democratic decentralisation that includes increased participation and representation with interactions and negotiations between governing agencies and stakeholders at multiple levels (Engle and Lemos, 2010).

Table 1. Biophysical drivers of 'High Importance'[a] for biodiversity outcomes

Driver	Current status and trends	System interactions
Climate change	Predicted climate change impacts for the focal region include increased average minimum and average maximum temperatures by about 0.2 °C from present; decreased average rainfall; increased extreme rainfall events; more frequent and severe droughts; shorter snow seasons; decrease in snow cover; and increased severity of unseasonable frosts due to reduced snow cover. By 2020 snow cover is predicted to decline by 60% compared to 1990 values. Sources: Hennessy et al. (2008), Pickering (2011), Pickering and Venn (2013).	Droughts mean increased susceptibility of vegetation to fires. More frequent fires are expected due to increased frequency of lightning strikes. Warmer temperatures will allow snow gum encroachment. Reduced rainfall and snow cover will lead to drying out of wetlands. Warmer conditions support invasive processes including predation and weeds. Herbs and grasses are already being replaced by more competitive shrubs. More frequent fire threatens rare and specialised plant communities such as snowpatch herbfield and feldmark. Sources: Pickering et al. (2004), McDougall and Walsh (2007), Pickering and Venn (2013).
Invasive and predation processes	Present pests include horses, deer, willow and hawkweed. Modelling based on aerial surveys indicate that feral horse populations in the Australian Alps increased at a rate of 21% per year since a low point following extensive fires across the region in 2003, Without active control measures, the current trend for all pests present in the system is for increased numbers and expansion until carrying capacity limits are reached. An increase in grazing animals such as rabbits and hares will lead to increase presence of cats and foxes, leading to increased collateral predation of native animals, including threatened species. Source: Dawson (2009).	Reduced snow cover, longer growing seasons and warmer conditions enables increased presence of invasive grazing animals such as horses, deer, rabbits and hares – as well as range shifting species such as wallabies. These conditions also enable increased numbers of predatory animals such as cats and foxes due to easier food access. Increased fire frequency allows invasion of wetlands by weed species. Additional concerns were raised by workshop participants about the possibility of increased number of range-shifting native predators such as kookaburras, as well as other as yet unknown invasive species that may become more prevalent under future climate scenarios. Sources: Pickering et al. (2004), McDougall and Walsh (2007).
Fire regimes	Pre-European fire frequency in the subalpine zone is thought to have been at intervals of approximately 50 years, with longer intervals between major fires in the alpine zone. These occasional extensive fires occurred when periods of extended regional drought coincided with extreme fire weather and multiple ignition points, often from lightning, in the surrounding montane forests. Fire frequency in many areas of the high country increased significantly following European occupation, in NSW first through the actions of graziers, but also through the increased incidence of major wildfires that have increasingly encroached into the high country. Over the past decade, the focal region has experienced an unprecedented sequence of fires with vast areas of the region impacts in 2003, 2006-07, followed by more localised events in 2013. Sources: Zylstra (2006), Williams et al. (2008).	Increased incidence of high intensity and widespread forest fires at lower altitudes, driven by increasingly frequent coincidences of high temperatures, strong winds and droughts, leads to increased frequency and extent of fire incidents in the focal area. Fires entering the focal area occur more frequently and burn more intensely due to the effect of drier conditions and higher evaporation on fuel loads and increased number of days with extreme fire danger conditions. There is increased fuel load due to an increase in area of heathland at the expense of grassland. Humus-rich peat soils in fire-damaged wetland areas are more susceptible to loss through erosion, and are unlikely to be replaced. Sources: Walsh and McDougall (2004), Williams et al. (2008).

[a] High Importance = at least 20 workshop participants judged the item to be of High or Very High Importance on a scale of 'No Importance'; 'Low Importance'; 'Moderate Importance'; 'High Importance'; 'Very High Importance'.

Table 2. Social drivers of 'High Importance'[a] for future biodiversity outcomes

Driver	Current status and trends	System interactions
Community values and attitudes	Community attitudes related to achievement of conservation outcomes range from strictly protectionist positions that support strongly managed national parks in which all uses are viewed with disfavour except for low-impact recreation, to more moderate stances that, while also supporting national parks, consider uses such as resort-based tourism and recreation. Others have opposed the establishment of protected areas, and advocate that cattle grazing, timber harvesting and four-wheel driving be permitted throughout the mountains. Strong views have been expressed about the cultural values of the Alps, particularly those associated with grazing and recreation activities. Representatives of these various positions have lobbied, and continue to lobby for public, political and management agency support for their views.	Community values and attitudes interact with vision/direction and influence political will and how stakeholders are engaged. These system interactions can have implications for priority setting and provision of public resourcing for protected area management agencies. Approaches to engaging stakeholders can also influence levels of social and human capital among stakeholders and parks managers, as well as the extent of community understanding and opportunities for learning about the system, and therefore strategies to enhance biodiversity outcomes. An agency's ability to implement adaptation strategies in response to challenges such as climate change is in part dependent on their social acceptability.
Social and human capital	The social and human capital among Australian Alps management authorities or of communities in and around the Australian Alps has not been formally documented. Nonetheless, there is evidence of well-developed networks, local leadership and a reasonably strong skills base through, for example, the on-going community participation and contributions to programs run by regional natural resource management bodies such as the North East Catchment Management Authority in Victoria and the Southern Rivers Catchment Management Authority in NSW. Partnerships between protected area management agencies and local organisations also exist and attest to the social and human capital in the region.	Well-developed social and human capital are fostered by effective communication and processes for social learning, and in turn provide conditions for social learning. Such learning can be supported by information provision and engagement in adaptive management processes. The levels of social and human capital in local communities influence the ability of management agencies to develop partnerships and the likelihood and quality of stakeholder participation in adaptive decision-making processes.
Community understanding and learning	Agency staff express frustration about reduced funding allocations for community education and the effect this can have on policy development, increasing pressure for reintroduction of cattle grazing into the alpine area to reduce fuel loads, even though scientific research provides contrary evidence. The NSW and Victorian parks agencies have also decided not to pursue aerial culling of feral horses due to fears of a community backlash provoked by pro-horse lobby groups, even though aerial culling is recognised as the most effective and humane solution to reduce feral numbers. However, a recent survey of public perceptions conducted in Victoria revealed that once respondents became aware of feral horse numbers and their impacts on the alpine environment, the level of acceptability of aerial culling as an option increases, especially among people who live close to the alpine area.	Engagement processes that build awareness of the need to act can support the development and implementation of adaptation responses. A systems understanding enhances acquisition of the necessary type and quality of information and effectiveness of knowledge deployment and the capacity for adaptive management. Community values and attitudes are in part shaped by processes of information sharing and social learning.

[a] High Importance = at least 20 workshop participants judged the item to be of High or Very High Importance on a scale of 'No Importance'; 'Low Importance'; 'Moderate Importance'; 'High Importance'; 'Very High Importance'.

Table 3. Governance influences of 'High importance'[a] for biodiversity outcomes

Influence	Status of current arrangements
Supportive political will	A critical impediment affecting biodiversity governance of the Australian Alps is the turmoil associated with changes in political direction and emphasis following changes in government, and how these align at state and federal levels in particular. Current political will is perceived as being antagonistic toward national parks in NSW and Victoria, with an increase in 'pro-use' policies and diversion of park agency resources to activities and priorities other than conservation (e.g. push for customer-focused agencies, introduction of hunting in NSW and grazing in Victoria, diversion of resources to feral dog control and prescribed burning to please the public). A lack of political support for adequately dealing with feral horses is a particular concern in the two states.
Strength of legislative protection	The 11 protected areas are reserved under the *Nature Conservation Act 1980* (ACT*); National Parks and Wildlife Act 1974* (NSW); and *National Parks Act 1975* (Vic). Specific ecosystems and species are given additional protection under other state and national legislation, including the *Flora and Fauna Guarantee Act 1988* (Vic), *Threatened Species Conservation Act 1995* (NSW) and the EPBC Act. As national heritage place, the parks and reserves of the Alps are a matter of national environmental significance under the EPBC Act.
Priority setting and resources	The Australian Alps is not currently a priority landscape for funding programmes at the state or national levels. Biodiversity conservation and protected area management have a lower profile on the political agenda than in previous decades, and thus fewer resources. For example, implementation of the AALC strategic plan receives a small budget ($310,000) from the state, territory and Australian governments to support its priorities. This budget has declined in real terms, as the quantum of funding has changed little in the past 20 years. Investments in Alps management by Parks Victoria and the NSW National Parks and Wildlife Service have similarly declined in real terms. Furthermore, biodiversity management in the Alps is primary enabled by short-term project-based funding and is not part of recurrent budget allocations.
Leadership	Senior managers in park agencies tend to have a managerial or economic background, consistent with broader trends in government agencies. This has led to a focus on efficiency and 'narrow' accountability that encourages a focus on short-term outputs and has encouraged a risk averse culture. The organisational environment is thus not conducive to innovation. Although there is evidence of entrepreneurial leaders in the park agencies, this capacity is underutilised. The AALC has had a long history of champions; however, there are concerns that the program is lacking energy and enthusiasm and would benefit from emergence of a new generation of leaders.
Effectiveness of plans and programs	Both NSW and Victoria conduct State of the Parks reporting every five years to monitor management effectiveness. State of the Parks results indicate that the condition of the alpine parks is generally good, and park agencies generally take a planned approach to management. Information is generally adequate, although there are knowledge and capacity gaps (e.g. trends and strategies for invasive species) that can be addressed to increase effectiveness. Current management plans across the Australian Alps are ambitious, and resourcing limits the scope of actions that can actually occur on the ground.
Supportive vision and strategic direction	A supportive vision at the managerial level is evident through strong support for the Cooperative Management Program. Supportive vision at the heads of agency and political level is more cyclical, with support varying depending on political agendas (e.g. reintroduction of grazing) and available resources. The AALC has a strategic plan that provides the framework for achieving its objectives over a 3-year period in the eleven parks and reserves in the ACT, NSW and Victoria covered by the MOU. Plans of management outline the strategic management direction for each of the parks in the two states and territory, although decisions are largely driven by the annual business and operational plans.
Effectiveness of engagement processes	Community engagement is standard in statutory management processes, and there are regular opportunities for stakeholders to provide input on other key decisions, though these processes vary across the Australian Alps. Parks Victoria has applied innovative engagement techniques in management planning for its alpine parks, using web-based tools like a 'wiki' that allows stakeholders to engage with and edit the draft plan, enabling early and proactive engagement. At an Alps-wide scale, the National Landscapes initiative has brought together tourism-resort interests and protected area managers – organisations and people with potentially very different values and aspirations – to work towards mutually beneficial outcomes. All of the park agencies have established processes for engaging Aboriginal stakeholders.

Coordinated governance and management	A significant advance towards cross-border governance and management of the Alps was made in 1986 with the signing of an MOU by the Australian, NSW and Victorian Governments. The MOU was re-signed in 1989 to enable the inclusion of the ACT into the agreement, with further modifications and re-signings in 1996, 1998 and 2003. Both Parks Victoria and the NSW National Parks and Wildlife Service have coordinated efforts within their own state boundaries, over the last decade, to collect information on how their park and reserve system is performing.
Quality and adequacy of information; its use in adaptive management	The AALC has been instrumental in fostering knowledge networks between parks agencies, universities, CSIRO and other research providers. Agencies also have well developed in-house capacity to identify strategic knowledge needs and work with partners to try and meet these needs. Parks Victoria's Research Partners Program is a prime example. This program is improving understanding of the natural values of the park system, building a body of knowledge to guide management, encouraging and supporting research, and enabling scientists and managers to work together to enhance protection outcomes. Three iterations of 'State or the Park' reporting have been undertaken in both NSW and Victoria, with such an approach aimed at adaptively improving management . Agencies are making ongoing efforts to institutionalise learning from protected area management effectiveness assessments and use of environmental management systems as a means to monitor and improve performance.

[a] High Importance = at least 20 workshop participants judged the item to be of Strong or Very Strong Influence on a scale of 'No Influence'; 'Weak Influence'; 'Moderate Influence'; 'Strong Influence'; and 'Very Strong Influence'. The table is organised in order of importance.

Effectiveness of plans and programs, strength of legislative protection. Governance bodies may earn legitimacy through demonstrating effectiveness at producing conservation outcomes (Newman et al., 2004). Brooks et al. (2005) also identified the effectiveness of governance and management authorities in delivering outcomes as an indicator of adaptive capacity. Legislative frameworks can provide the stability needed for leaders and collaborative processes to develop long-term strategies and for governance authorities and other actors to condition expectations and decision making (Pahl-Wostl et al., 2007).

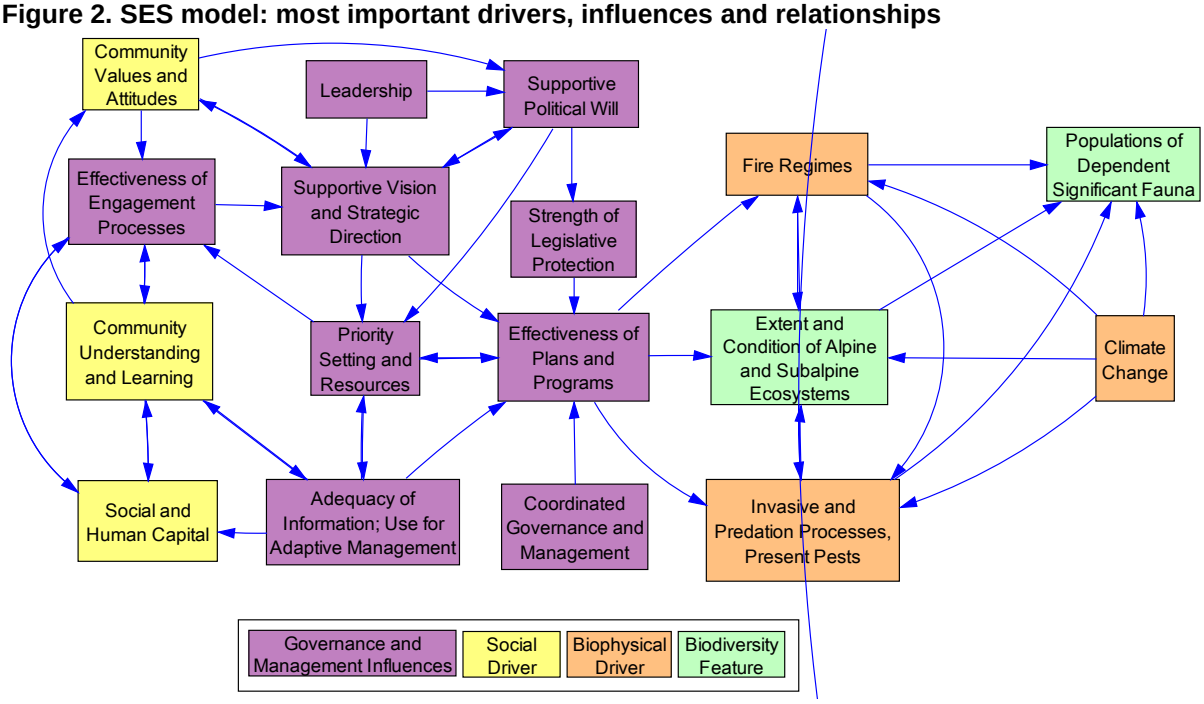
Adequacy of information and its use in adaptive management. The complexities of biodiversity management demand the integration of many types of knowledge including scientific, social, economic and cultural knowledge (Folke et al., 2003; Paterson et al. 2010). To ensure information quality, such information should not only be based on good science but measures should be taken to ensure the acceptance of the information and knowledge by multiple stakeholders such as by integrating scientific with local knowledge (Allen et al., 2001).The learning approach to management – adaptive management – is predicated on the fact that SES are managed with incomplete knowledge and that there is an imperative to monitor management outcomes and adjust management strategies, activities and practices based on the results of the assessment (McDonald-Madden et al., 2010). Experimentation, innovation and learning are the defining values of active adaptivity (Allan and Curtis, 2005). Such learning is supported by individuals' willingness to seeking out information and learn through iterative decision-making that constantly assesses outcomes from interventions and revises strategies accordingly (Tompkins and Adger, 2005). Access to current information of appropriate quality is essential for decision-making, planning, and implementation of adaptive measures (Ivey et al., 2004). The formation of networks to pool and share information is a necessary response for dealing with the complexities of biodiversity conservation (Armitage and Plummer, 2010).

3.4 Step 4. Development of a conceptual SES model indicating relationships between important drivers, governance influences, and biodiversity features

Using the literature as a starting point, the most important relationships between the drivers, governance influences and biodiversity features were identified by the research team and then refined by workshop participants. These relationships are depicted in the conceptual SES model given in Figure 2, which is a simpler version of a more detailed model used in the workshop that included 30 drivers and influences. The most important pathways affecting biodiversity outcomes, via the effectiveness of plans and programs, are four governance influences: (i) the extent to which vertical and horizontal structures and processes promote coordination and cooperation within and between authorities; (ii) the extent that diverse types of information are acquired and incorporated by managing agencies into a dynamic systems view of the alpine region, the accuracy and detail of this information, and the effectiveness with which it is deployed in policy, decision-making and adaptive management

processes; (iii) the processes through which those with responsibilities for governing the Australian Alps determine priorities and allocate resources; and (iv) the national and state legal provisions that influence protection of Australian Alps biodiversity. These primary governance influences are shaped by a complex of secondary governance influences (leadership, political will, vision and strategic direction, effectiveness of engagement processes); and social drivers (community values and attitudes, community understanding and learning, social and human capital). The system understanding afforded by this model and its components underpinned the development of the scenarios in Step 5.

Figure 2. SES model: most important drivers, influences and relationships



3.5 Step 5. Development and validation of four scenarios derived from two critical uncertainties

The development of a contrasting set of scenarios required the identification from among the most important drivers, those judged to have the greatest level of uncertainty regarding their future state in 2030. This enabled the positioning of scenarios against two axes representing these 'critical uncertainties'. To do this, workshop participants rated the drivers in Tables 1 and 2 using the following scale regarding their future state in 2030: no uncertainty; low uncertainty; medium uncertainty; high uncertainty; very high uncertainty. As our methodology involved fixing governance influences in their current configuration, these were not subject to this uncertainty assessment. The drivers judged by at least 70% of participants to have high or very high uncertainties were invasive processes, fire regimes, and community values and attitudes. These were discussed by workshop participants, who then selected invasive processes and community values and attitudes as the two critical uncertainties and set the extremes as 'Large Increase/No Increase' and 'Strongly Antagonistic/Strongly Supportive' respectively. The 'No increase' extreme was selected by workshop participants based on their view that any decrease in extent of invasive processes was implausible. Strongly antagonistic attitudes to matters that would drive negative conservation outcomes do not necessarily result from antagonism towards conservation per se, but may result from cultural or economic value orientations. Such orientations could, for example, lead to strong support for feral horses as part of the alpine landscape, or the desire to ensure conservation plans and programs do not get in the way of economic development. By contrast, attitudes strongly supportive of conservation are those that place a higher value on conservation than on economic development.

As is common practice, participants also created descriptive titles for each scenario. The resulting four scenario spaces for 2030 are indicated in Figure 3. One of the descriptive titles needs explanation – *R.I.P. - Take the Package Now* refers to a future where many of the current biodiversity features are substantially altered or lost (rest in peace), and the focus of governing and managing the

focal system has been redirected away from biodiversity conservation such that many of the current staff have taken an exit package and left the agencies.

Preliminary narratives for each scenario were then prepared and discussed by workshop participants. These narratives were further developed by the research team in consultation with the scientific review panel. Summaries of the four narratives follow. The associated implications for biodiversity outcomes are summarised in Table 4. These outcomes were initially generated by the research team based on understandings derived from the literature and the SES model and an assessment of the implications of each scenario, and then validated by the scientific review panel.

Figure 3. Scenario spaces

		Invasive Processes	
		Large Increase	No Increase
Community Attitudes	Strongly Antagonistic	R.I.P. - Take the Package Now	Multi Use Park
	Strongly Supportive	We Care But is it Too Late	Alpine Dreaming

The effects of climate change are consistent across all scenarios, and affect most of the key drivers of biodiversity change in the focal area. Based on the details in Table 1, the effects of climate change by 2030 have resulted in warmer, drier conditions and a reduction in snow cover. This has affected the quality and area of wetlands, and their replacement by grasslands or heathlands. Reduced snow cover and increased erosion have eliminated most feldmark and snowpatch herbfield ecological communities. Species restricted to high alpine environments are close to extinction because, under a warming climate, they lack any higher ground to move into and will be under pressure from species currently restricted to lower elevations. The most vulnerable alpine fauna are those dependent on wetlands and boulder heath ecological community types.

R.I.P. – Take the Package Now *(large increase in invasive processes; community attitudes strongly antagonistic to achievement of conservation outcomes)*. The landscape is drastically and irreversibly altered and the community is resigned to this outcome. Thousands more horses, deer, rabbits and other introduced herbivores now occupy the region, as do increased numbers of introduced predators, in particular foxes and cats. The community no longer focuses on the role that national parks play in biodiversity protection, but see them as places for recreational and other uses. There is little leadership or political will to protect environmental values, with no associated vision, strategic direction, or effective engagement processes. Stock grazing has been reintroduced into the focal area. Structure and function of ecosystems are severely undermined by increases in invertebrate pests, as well as woody and non-woody weeds. Native plants and animals have been outcompeted and have lost their habitat, and several species no longer exist in the wild due to increased predation. Ecological communities in the focal area are fragmented, and genetic diversity of most remaining endemic plant species is curtailed. Extensive fuel reduction burning is undertaken in lower elevation montane forests, which exacerbates the spread of invasive pests reaching higher elevations. This heavy focus on fuel reduction burning also diverts funding away from invasive species control, which is in decline and cannot address the magnitude of the problem. All wetlands in the focal area are irreversibly degraded, and many have dried out and are now weedy grasslands due to peat becoming exposed from trampling of horses and deer, and then lost through erosion following more frequent and severe fire events. The poor state of the parks and climate change impacts are continually reducing financial returns for businesses and reducing park revenue. Alpine resorts struggle to remain viable and have to be supplemented by summer-related recreation activities, such as golf courses.

Multi Use Park *(no change in invasive processes; community attitudes strongly antagonistic to achievement of conservation outcomes)*. While the landscape of the focal area is appreciated for its aesthetic appeal, the community places greater emphasis on its contribution to the promotion of tourism businesses, as a place to get away, to use as it sees fit for all sorts of pursuits, rather than as a place reserved for biodiversity conservation. Park users expect and are provided with increased paved access roads and tracks for bikes, horse riding and four wheel drive vehicles, viewing

platforms, chalet and cabin-style accommodation, and greater use of park resources for grazing, timber, hunting, fishing and water extraction. Tourism businesses and activities are flourishing due in part to increased private-funded development in national parks following reductions in 'green tape' environmental protection restrictions. Endangered iconic species such as the mountain pygmy possum are 'protected' through construction of open zoo type facilities financed through fee-paying tourists, while other less iconic species face extinction. Reduced funding for invasive species management has led to an increase in weeds and pests. Increased frequency and severity of fires entering the focal area from lower elevations has resulted in financial backing by resorts for increased fire breaks and fuel reduction burning to protect infrastructure assets such as alpine resorts. Fire affected wetland areas experience peat loss, undermining their tourism potential, and further accentuating community calls to protect the area from fire.

We Care But is it Too Late *(large increase in invasive processes; community attitudes strongly supportive to achievement of conservation outcomes).* Repeated intense fire events and growth and spread of invasive pests have significantly affected the landscape. The community is well-informed about the extent of the crisis facing the alpine ecosystem, which is seen as unacceptable. Feral horse and deer numbers are at record levels in the focal area, and cats, foxes, dogs, pigs, rabbits and hares are also prevalent. Public and philanthropic funding for invasive species control has increased, and volunteers contribute their time to invasive species control, especially for removal of weeds. There is considerable community energy and political support to stem the spread of invasive pests, with a strong focus on adaptive management. Parks agencies work closely with researchers, backed up by considerable and effective community monitoring. Flexible burning management practices with a biodiversity objective are undertaken, with a focus on managing spread of wildfires. Extensive post-fire intervention is undertaken to assist in recovery and rehabilitation of native ecological communities and species, but these efforts are undermined by ongoing spread of invasives. Community support has resulted in political will for strong legislation and pest eradication measures. Aerial culling is becoming a favoured way to reduce horse numbers, and dingoes are being introduced to reduce cat, fox and rabbit populations. Carefully managed hunting expeditions have also been introduced as another strategy to reduce numbers of feral horse, deer, pigs and wild dogs. Despite these measures, irreversible changes have already taken place, with several species facing extinction. 'Open' zoo protection zones financed through fee-paying tourists and/or philanthropic interests are used to save species such as mountain pygmy possum from predation. There is a concerted effort to save as many wetlands as possible from drying out, but it seems a losing battle. Climate change has forced a massive de-investment in resort infrastructure. The only infrastructure allowed in the parks has to meet strict environmentally-friendly guidelines, and only for companies providing eco-tourism services.

Alpine Dreaming *(no change in invasive processes; community attitudes strongly supportive to achievement of conservation outcomes)*. The Australian community is proud of the cultural and natural heritage that has been preserved in the alpine national parks, and actively support measures to constrain the spread of invasive species. Public and philanthropic funding for biodiversity conservation and invasive species control continues to meet the challenge, and volunteers increasingly contribute their time. There is strong community leadership, and increased partnership arrangements so parks agencies can benefit from community involvement and education. Dingoes have been introduced, and their function as predators in the alpine ecosystem is actively and adaptively monitored and managed to enhance biodiversity outcomes against other invading predators such as foxes, cats and wild dogs. The majority of the community approve of a full range of strategies to reduce populations of feral horses and deer, but appreciate that complete eradication is impossible. Zoned strategies of prevention, eradication, containment and asset protection are well instituted and working well, especially given the level of volunteer support that can be called upon at short notice. The protection of alpine and subalpine wetlands from the negative impact of horses, deer and pigs is a high priority. Most wetlands are degraded, and the loss of peat is a major concern. Government agencies respond with proactive adaptive management strategies, especially to explore human intervention to rehabilitate highly affected wetlands, supported by wetlands researchers. Government agencies with the support of volunteers manage lower elevation ecosystems to prevent wild fires moving upwards into the focal system, and manage fires in the focal system to enhance biodiversity outcomes. Adaptive management approaches are adopted to explore the best ways to support post-fire recovery of topsoils and native vegetation. Public access to the alpine areas is driven by a desire for sustainability, with increased nature-based tourism operating in the focal area. Because snow-related recreational activities are now greatly diminished, structural adjustment is

provided to ski resort businesses to transition towards provision of eco-tourism related activities. Camping is restricted to designated areas, where impact-minimising facilities are provided. Isolated chalet or cabin-style accommodation is seen as a rare privilege, and there is a waiting list for people wishing to experience nature in this way with park rangers as their guides.

Table 4. Summary of projected biodiversity outcomes under each scenario

		R.I.P. – Take the Package Now	Multi Use Park	We Care But is it Too Late	Alpine Dreaming
Community Attitudes		*Strongly antagonistic*	*Strongly antagonistic*	*Strongly supportive*	*Strongly supportive*
Invasive Processes		*Large increase*	*No increase*	*Large increase*	*No increase*
Wetlands	Drivers	Climate change, fire, invasive processes, community values and attitudes, community understanding			
	Extent	Large and continuing decline	Large but slowing decline	Large but slowing decline	Moderate but slowing decline
	Condition	Very poor and worsening	Poor and worsening	Poor and worsening	Poor to good depending on location
	Dependent fauna	Extinct	Threatened	Threatened	Surviving
Grasslands	Drivers	Climate change, invasive processes			
	Extent	Moderate decline	Small decline	Moderate decline	Small decline
	Condition	Degraded	Good	Degraded	Good
Heathlands	Drivers	Climate change, fire			
	Extent	Some expansion	Some expansion	Some expansion	Some expansion
	Condition	Moderate	Moderate	Moderate	Good
Boulder heath	Drivers	Climate change, fire, community values and attitudes			
	Extent	Moderate decline	Small decline	Moderate decline	Small decline
	Dependent fauna	Extinct	Threatened	Threatened	Surviving
Snowpatch and Feldmark	Drivers	Climate change, fire, invasive processes, community values and attitudes			
	Extent	Almost disappeared	Declining	Declining	Declining
	Condition	Very poor	Poor	Very poor	Moderate

3.6 Analysis of the workshop process as a means of developing scenarios with diverse biodiversity outcomes

Before concluding the workshop, participants completed a short survey regarding the efficacy and usefulness of the process. Key questions and responses are detailed in Table 5.

Table 5. Feedback from workshop respondents on the scenario process

Question	% agreed
The process of identifying and determining drivers and influences was effective	96
Having a draft list of key drivers and influences provided by the workshop organisers was better than starting with a blank page	75
The process of identifying and determining drivers and influences was of sufficient value that it would be worth trying for biodiversity conservation in other landscapes	82
The SES model was helpful to improve understanding of how the Australian Alps functions as a co-evolving social and ecological system	70
The SES model improved shared understanding of system dynamics	70
The SES model provided new ideas for how to influence biodiversity outcomes	41 (30% uncertain)
The process of developing and using the SES model was of sufficient value that it would be worth trying for biodiversity conservation in other landscapes	77
The approach to developing an array of plausible 2030 scenarios for biodiversity in the Australian Alps was effective	89
The process of developing and using scenarios was of sufficient value that it would be worth trying for biodiversity conservation in other landscapes	85
Participants were able to learn more about how to improve biodiversity outcomes through interaction with other participants at the workshop	96
The workshop provided participants with new skills to improve their work	78

Other comments:

- The conversation and debate was critical for shaping and improving a 'working' product.
- Having both scientists and managers present was a critical success factor.
- The SES model was a useful method to display a complex system and its interactions, and was particularly useful in articulating connections between social drivers and biodiversity outcomes.

4. Discussion and conclusion

From our data, the current governance arrangements are not well placed to deliver acceptable biodiversity outcomes. In particular, the political will and strategic direction for national parks is heavily influenced by community values and attitudes with insufficient priority and resourcing to enable effective action to address biodiversity conservation in the Australian Alps. The quality of information and its deployment concerning management strategies related to the Alps is also undermined for similar reasons, with pro-use lobby groups securing greater influence than those promoting conservation. These trends are confounded by a governance regime that is driven by short-term electoral cycles, and a failure to maintain a long-term agenda for biodiversity conservation unaffected by short-term political agendas. While there is a strong focus on monitoring and evaluation through State of the Parks reporting, significant improvements are needed to support effective adaptive management and learning (Growcock et al., 2009), and to prevent risk-averse constraints on the pursuit of innovation.

The workshop process of assigning importance ratings to drivers and influences helped reduce the complexity that can stymie the practical development and application of SES thinking in policy, planning and management. Researchers using participatory approaches to modelling have also found that stakeholders connected to policy processes judged models with fewer variables as most useful even though scientists felt inclined to develop highly complex models in an effort to represent system complexity (Sandker et al., 2010). Highly complex models either defy understanding and therefore implementation, or lack sufficient focus to make strategic action possible. The workshop process, with its conversations and debate, was noted as critical for shaping and improving a ‘working product’ (Reed et al. 2013). Having both scientists and managers present was identified by a number of workshop participants as a critical success factor.

Designing methodological processes that enhance connections between SES modelling and scenario generation is an important research agenda to improve the scientific basis underpinning practical applications of the concept and pursuit of resilience (Resilience Alliance, 2007). This paper has provided a case example of how such a linkage can be achieved, with the model informing and guiding scenario generation. The model’s focus on the most important biophysical and social drivers contributed to the plausibility of the scenarios and the reliability of the projected biodiversity outcomes accompanying each scenario (Table 4).

An important contribution of this paper has been to conceptualise governance attributes according to requirements for adaptive capacity. Planning for futures under uncertainty requires adaptability and governance arrangements that can facilitate adaptive management and planning (Allen et al., 2011; Folke et al., 2005). The workshop identified nine governance influences as being of high importance (Table 3) with the ‘effectiveness of plans and programs’ having pivotal interaction with key drivers of change affecting biodiversity outcomes (Figure 2). The majority of workshop participants identified the process of first determining drivers and influences and their relative importance, and then specifying their interrelationships and linkages with the focal features of interest, as a powerful approach that could be applied in other landscapes.

A significant contribution of the approach to SES modelling used here is to represent governance attributes as characteristics of adaptive governance (Folke et al, 2005; Lockwood et al., 2012; Olsson et al., 2006). Previous SES models that include governance influences have conceptualised them in terms of levels of government (Smajgl, 2010), policy instruments (Máñez Costa et al., 2011; Reed et al., 2013), or local institutional capacity (Ravera et al., 2011). Our approach can encompass multiple levels of government, policy instruments and local institutional capacity insofar as these contribute to or impede adaptive governance. In addition, specifying governance influences in terms of qualities rather than particular structural characteristics allows consideration of how multiple levels and centres of governance influence system dynamics and outcomes, while avoiding representations that involve intractably complex webs of governance actors and instruments. Our approach is therefore more inclusive of the range of possible governance configurations than has been evident in previous SES modelling, and allows the same set of influences to be deployed in a wide range of contexts.

A further innovation in our approach was to construct scenarios based on two critical uncertainties while constraining governance arrangements to remain in their current configuration. This allowed testing of the ability of the current governance regime to deliver acceptable biodiversity outcomes

across a range of plausible futures. A regime that passes this test can be considered to have the necessary adaptive governance capacity to deliver desired outcomes in a system subject to social and biophysical drivers of change. A failure in this test would point to the need to explore options for governance reform. Adaptive governance influences can be used to support development of reform options. They provide insight regarding potentially fruitful points of intervention in system dynamics that can shape outcomes for the focal features that motivate an SES model.

Acknowledgements

The report is an output from the Landscapes and Policy Research Hub. The hub is supported through funding from the Australian Government's National Environmental Research Program and involves researchers from the University of Tasmania, The Australian National University, Murdoch University, the Antarctic Climate and Ecosystems Cooperative Research Centre, Griffith University and Charles Sturt University. We thank the workshop participants who contributed their time and expertise to our research, and in particular Gillian Anderson for her contributions and support.

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