Building systems-based scenario narratives for novel biodiversity futures in an agricultural landscape

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Abstract

Improving biodiversity futures requires a systems-based appreciation of the dynamic human and biophysical interactions shaping landscapes. By combining a structured approach to identifying key drivers of change on biodiversity with a collaborative approach to scenario planning, biodiversity planners and managers can work with stakeholders to identify a range of possible futures and explore their implications. This paper presents an approach to developing scenario narratives constructed against key drivers of change identified through a social-ecological systems analysis. The approach facilitated the integration of stakeholder and expert input to inform system dynamics affecting biodiversity outcomes, helping to direct and discipline the collective imagination, and to challenge assumptions and reveal new opportunities and strategies. Examples are provided to show how conventional notions about preserving biodiversity remnants “as is” were not a good fit for the diverse range of futures imagined, and that restoration ecology would have to expand to incorporate ideas of landscape fluidity and novel ecosystems. Aspects of the scenario narratives highlighted the need for new conservation strategies for the endangered native grassland ecological community within the Tasmanian Midlands case study, and a re-focusing on new locations across that landscape.

Keywords: scenario planning; land use change; private land conservation; biodiversity futures; novel ecosystems

Highlights

- Systems-based scenario planning helps stakeholders rethink biodiversity futures.
- Building scenario narratives using a systems structure enabled expert input.
- The scenarios helped challenge assumptions and reveal new opportunities.
- Future conservation will need to prioritise new locations and strategies.
- Novel ecosystems are a key biodiversity conservation strategy under climate change.

1. Introduction

Creating scenarios to explore and imagine the future is a widely used tool in landscape planning (Xiang & Clarke, 2003). The use of scenarios in planning processes is recommended for contexts of high uncertainty and low controllability (Peterson, Cumming, & Carpenter, 2003), and to open up constrained thinking to new possibilities (Chermack, 2004). In this journal alone, there are accounts of scenarios being used to initiate discussion about future constraints and opportunities for rural development (Van Berkel, Carvalho-Ribeiro, Verburg, & Lovett, 2011), to develop visual aids that enhance learning about climate change impacts and/or development trajectories (Albert, Zimmermann, Knieling, & von Haaren, 2012; Lamarque et al., 2013; Norman, Feller, & Villarreal, 2012), and to explore policy options for alternative futures (Pearson, Park, Harman, & Heyenga, 2010; Southern, Lovett, O'Riordan, & Watkinson, 2011).

Landscapes are social constructs that evolve out of the systemic interactions between humans and their environment (Greider & Garkovich, 1994; Tress & Tress, 2001). Participatory tools that help stakeholders analyse complex social-ecological system (SES) interactions in a holistic way are therefore required (Hanspach et al., 2014), especially when planning for future landscapes under climate change (Bohnet & Smith, 2007). While it is a characteristic of both social and ecological systems to self-organise as they adapt to change, a particular feature of social systems is human agency associated with an ability to anticipate, imagine, and potentially influence the future (Davidson, 2010). Scenarios can help capture that imagination, and direct it for the benefit of planning and decision-making (Chermack, 2007).

The future for biodiversity in landscapes predominantly used for agriculture is a case in point. In landscapes with a long history of agriculture, biodiversity has become entwined with traditional land management practices, and reviving this traditional ecological knowledge has been posited as one strategy for conserving future biodiversity (Barthel, Crumley, & Svedin, 2013). For landscapes with a more recent history of agriculture, such as in Australia, the discourse underpinning conservation strategies is more often directed at protecting individual species and preserving the few remaining remnants of native vegetation. Yet preserving biodiversity “as is” will no longer be feasible under climate change (Dunlop, Parris, Ryan, & Kroon, 2013). As a result, biodiversity planners are facing high uncertainty and low controllability, while also needing to change their way of thinking. The use of scenarios is therefore apt.

In particular, scenario planning could assist restoration ecologists identify and plan for the management of novel ecosystems (Hobbs et al., 2014; Hobbs, Higgs, & Harris, 2009; Seabrook, McAlpine, & Brook, 2011). This may involve biodiversity managers exploring how to provide valued ecosystem attributes in alternative places or under alternative configurations, and managing for (novel) species composition and function (Hobbs et al., 2014). A systems-based approach to scenario planning can assist in matching that need for imaginative reconceptualisation with the expertise of climate change modelled projections, and an appreciation of the dynamics of landscapes (Manning et al., 2009) and their connectivity (Worboys, Francis, & Lockwood, 2010).

Scenarios are developed for predictive (What will happen?), normative (What should happen?) and/or exploratory purposes (What could happen?), representing probable, preferred or possible futures (Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006; Rickards, Wiseman, Edwards, & Biggs, 2014; Rounsevell & Metzger, 2010). While species distribution modelling can offer an element of future prediction for biodiversity, a key challenge for biodiversity planning is to explore potential futures and new possibilities. The range of possible futures can be restricted to those deemed more plausible or opened up depending on the extent that scenarios are being used for decision support or for stimulating wider debate about possible futures (Volkery & Ribeiro, 2009). While restricting the range of scenarios helps reduce complexity overload, it can also undermine the potential of opening up the minds of those involved to new possibilities (van Drunen, van’t Klooster, & Berkhout, 2011). Indeed, credentials for a good set of scenarios include that they are both plausible and surprising, are provoking as well as proximate, and that they enable mind stretching without overload (Xiang & Clarke, 2003).

A commonly-used systems-based strategy for developing diverse plausible future scenarios involves identifying two critical uncertainties from among key drivers of change on system dynamics, and then creating a quadrant matrix of scenarios comprising the four possible combinations at the end points of these critical uncertainties (Rickards et al., 2014). This matrix approach was used by the UK Climate Impacts Programme, adopting characteristics associated with governance and social and political values as the two axes forming the matrix (Berkhout, Hertin, & Jordan, 2002). In the context of marine biodiversity, best case and worst case trends for climate change have been adopted as the critically uncertain extremes by Evans, Hicks, Fidelman, Tobin, and Perry (2013), who intersected these end points with limited versus ideal adaptation pathways to create four scenarios, and by Haward et al. (2013), who intersected these with high versus low level of development affecting marine areas. In an agricultural landscape facing rural decline, community stakeholders developed a matrix of scenarios representing combinations of a declining versus an improving environment intersecting with the possibility of new markets versus a continuation of rural economic decline (O'Connor, McFarlane, Fisher, MacRae, & Lefroy, 2005). In terms of governance characteristics, other studies have characterised scenarios in terms of extremes of autonomy and interdependence (Dockerty, Lovett, Appleton, Bone, & Sünnenberg, 2006); level of centralisation and autonomy (Daconto & Sherpa, 2010); and laissez-faire and proactive approaches (Carter & White, 2012).

Construction of scenario narratives as descriptive storyline texts are often adopted as part of participatory approaches to scenario planning (e.g. Foran, Ward, Kemp-Benedict, & Smajgl, 2013; Kok, van Vliet, Bärlund, Dubel, & Sendzimir, 2011). In such cases, participants are usually given control over the production of the narrative texts, which requires a considerable time commitment. For example, Kok et al. (2011) describe a writing process involving two consecutive 3-day workshops followed by a 30 day period to finalise the narrative texts online. These narrative techniques are often combined with simulations to assist in evaluating the implications of the scenarios for policy and planning (e.g. Kok et al., 2011; Volkery, Ribeiro, Henrichs, & Hoogeveen, 2008). However, in most cases, the scenario logic is pre-determined, often as a matrix combining a global-local axis with an axis ranging from economic self-interest to an environmental and equity orientated approach (Kok et al., 2011; Rounsevell, Berry, & Harrison, 2006). The challenge, as highlighted by Rounsevell and Metzger (2010), is to enhance the saliency and legitimacy provided through these participatory methods with approaches that also enhance their credibility. Credibility can be undermined by "a potential lack of diversity" among participants, and because participants may not always have "a complete mental model of the system" being analysed (Rounsevell & Metzger, 2010, p. 610). Vervoort, Kok, Beers, Van Lammeren, & Janssen (2012) explored an approach that combined a systems-based analytic approach with an experiential technique, but this involved a series of individual participant narratives rather than a group-level narrative.

This paper reports on a systems-based exploratory scenario development exercise to support landscape-scale biodiversity planning in the Tasmanian Midlands, an agricultural landscape identified by the Australian government as a biodiversity hotspot. Scenarios were developed by stakeholders using the above quadrant matrix process, building on a prior SES analysis of dynamics affecting native grasslands which are the key biodiversity feature of this landscape. This ensured that stakeholders were given greater control over the initial design of the scenarios, leaving the more time-consuming process of refining scenario narratives to the research team. These scenario narratives were developed in consultation with relevant scientific experts from initial dot point prompts provided by stakeholders. The process used mirrors that adopted for a parallel case study involving the Australian Alps (Mitchell, Lockwood, Moore, & Clement, 2015b).

The paper's first aim is to present the approach used to develop scenario narratives that enabled expert input into how the key drivers of change might affect system dynamics under each of the future scenarios. A detailed examination of the key drivers of change is vital for complex issues such as biodiversity conservation on predominantly privately managed agricultural land. As Spangenberg (2007, p. 348) has noted: "Only if the driving forces are adequately reflected in the scenario dynamics, allowing projections into the future and the analysis of unsustainable trends, is it possible to compare different scenarios regarding their expected impacts on biodiversity, and to derive suitable priorities for strategic policy action."

Our second aim is to explore the extent that the resulting scenario narratives when presented back to stakeholders contributed to a re-evaluation of assumptions concerning biodiversity management strategies, and the revelation of new opportunities and strategies that could be pursued by planners, policy makers and managers. For this reason, all four scenario narratives were based on a consistent set of climate projections. This ensured the scenarios would offer diverse consideration of future possibilities in addition to climate change impacts, including a contrasting range of levels of adaptive capacity, and the possibility of new opportunities and novel ecosystems emerging in the future (Seabrook et al., 2011; Starzomski, 2013), while also challenging strategies to preserve biodiversity in its historical condition given projected climate change.

This paper continues with a description of the case study context and an explanation of the methods used to create and elaborate the scenarios, followed by a presentation of the results and a discussion of their implications for biodiversity conservation planning, and concluding with a summary of the benefits of the approach used and how it could be improved.

2. Trajectories for native grassland biodiversity in the Tasmanian Midlands

To explore possible future trajectories for a landscape based on SES analysis, it is first necessary to define the system and determine the focal issue of concern for the analysis (Resilience Alliance, 2010). The landscape selected for this study was the 415,445 ha Tasmanian Northern Midlands Bioregion (Department of the Environment, 2013) (Figure 1). The Midlands is a highly modified, predominantly privately managed agricultural landscape with scattered remnants of native grassland on public and private land. The focal issue of concern in this case is the endangered lowland native grassland ecological community, identified as a Matter of National Environmental Significance (MNES) under the Australian Government's *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) (DEWHA, 2010). This ecological community comprises Silver Tussock Grass (*Poa labillardierei*) and/or Kangaroo Grass (*Themeda triandra*) with a rich diversity of herbaceous species in the inter-tussock spaces (DEWHA, 2010). Sixty-five per cent of this community is located in the Tasmanian Midlands area (DSEWPAC, 2012).

Tracking the historical trajectory for a focal issue of concern can help set the context for possible future trajectories by identifying key historical and contemporary drivers of change affecting SES dynamics (Ravera, Tarrasón, & Simelton, 2011; Resilience Alliance, 2010). Our analysis of past disturbances affecting the region's native grasslands (see Figure 2) was derived through interviews focused on establishing a historical timeline with three local experts identified by our knowledge broker as having a wealth of knowledge about the history of grasslands in the Tasmanian Midlands, and revealed a series of states and transitions. Each transition is represented in Figure 2 as a break between adjoining blocks representing the states, with one complete break to suggest a transformation between states. One interviewee described this history as a series of shocks, and the analysis suggested that each shock was associated with a key driver of change resulting in a change in state for the native grasslands. The main drivers of change have included the initial land use change following European settlement, then the spread of invasive species, and more recently the effect of fertilisers, market forces and irrigation development on land use. Given that for much of this history the grasslands were used as native pastures, the widespread post-war use of fertilisers and associated introduction of improved pastures represents a major transformation for the state of native grasslands, as indicated by the gap between the states shown in Figure 2 (i.e. post-1950).

These historical impacts mean that this lowland native grassland ecological community of interest, now listed as a MNES, has been reduced to small, fragmented pockets across the landscape. However, other grassland community types comprising the two dominant species exist in a degraded state across other parts of the landscape, and these two species are also a component of other vegetation communities, such as grassy woodlands existing along the foothill fringes of the Midlands study area. These other grassland types are not protected under federal legislation, and

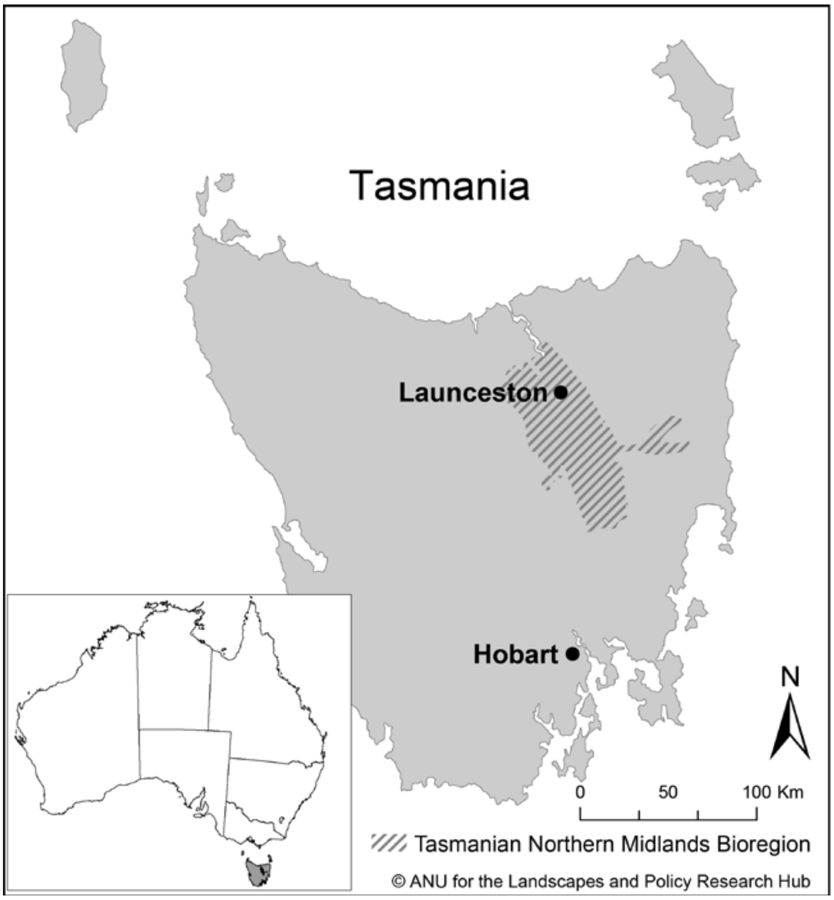

Figure 1. Tasmanian Northern Midlands Bioregion - based on the Interim Biogeographic Regionalisation for Australia developed by the Australian Government (Department of the Environment, 2013)

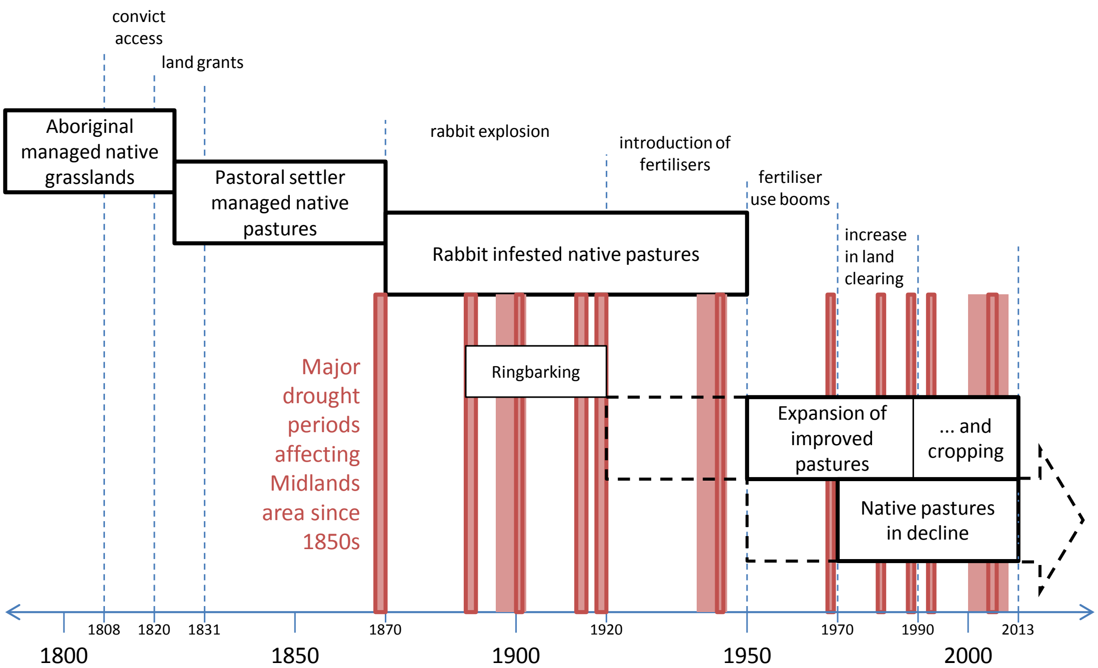

Figure 2. Historical timeline of key events influencing biodiversity of native grasslands in the Tasmanian Midlands; additional information sourced from Kirkpatrick and Bridle (2007), Boyce (2008), and Evans (2012)

predominantly exist on privately owned land. Such areas provide potential and actual use as native pastures, especially for high quality wool production. However, the use of native grassland as pasture has been in decline, initially as a result of increased use of fertiliser-fed introduced pastures, followed by the declining significance of wool production to the regional economy (Kirkpatrick & Bridle, 2007). Remaining native pastures also encapsulate some but not all of the conservation values held by the listed MNES lowland native grassland ecological community.

Engaging private landholders in conservation programs is therefore key to future protection of Midlands' biodiversity. The Tasmanian Northern Midlands Bioregion is one of Australia's most under-reserved bioregions (<4%) (Cowell, Cameron, Sprod, & Appleby, 2013), leading to significant interest in establishing private land conservancies. This interest has been supported through the Tasmanian government's Protected Areas on Private Land program, as well as through the innovative "Midlandscapes" program established by non-governmental organisations including Bush Heritage and the Tasmanian Land Conservancy. Recent trends to reduce government spending in general, and for biodiversity conservation in particular, have seen an increased reliance on non-governmental organisations to facilitate delivery of conservation programs. Strong interest in non-regulatory mechanisms involving incentives for voluntary uptake of covenants and management agreements also reflect a worldwide trend (Doremus, 2003). In the Midlands, conservancy arrangements are supported by philanthropic donations facilitated by the Midlands Conservation Fund, a perpetual fund providing stewardship payments to farmers who enter an outcome-based agreement (Males, 2013).

The dashed arrow in Figure 2 represents the uncertainty surrounding the future state for native grasslands in the region. Government investment in the recently established Midlands Water Scheme will further entrench the development of intensified irrigated agriculture, which currently offers much better financial returns for landholders than livestock grazing. Continued conversion of land use from grazing to irrigation is expected to increase pressure on all remaining native grassland areas, especially those areas not protected by legislation. An intriguing speculation is that the state of native grasslands in the Midlands might be heading for another transformation, especially given recent modelling that projects a trend towards climatic conditions becoming unsuitable by 2050 for the grassland community in those areas where fragments of that grassland type currently remain (Harris et al., 2015).

3. Scenario method

The method used to develop scenarios for the Tasmanian Midlands is the same as that used for a parallel case study involving the Australian Alps (Mitchell et al., 2015b). In both case studies, SES analysis provided the basis for developing the scenario narratives, and we were able to connect with and build on emerging efforts among key stakeholders to develop alternative, more collaborative planning and governance arrangements. The year 2030 was chosen to ensure the scenarios were within a reasonable planning timeframe. Key stakeholders responsible for biodiversity outcomes were engaged through workshop activities, providing initial input into the design of the scenario narratives. The narratives were then further developed by the research team (the authors of this paper) in consultation with scientists that had expertise related to key drivers of change. This approach has its origins in scenario planning guidelines provided by Schwartz (1996, pp. 241-246), where the following steps are suggested:

1. Identify the issue (as identified above, a focus on native grassland conservation).
2. Identify key factors affecting the issue (as above, through historical analysis and other scoping activities, which included a field trip, small survey and associated workshop, literature review and a socio-economic profile of the region – see Lefroy, 2011; Gadsby, 2012; Gadsby, Lockwood, Moore, & Curtis, 2013).

3. Identify the driving forces behind these factors (as described below, including use of mind-mapping influence diagram exercises together with stakeholders, the output of which is presented below as a systems conceptual model).
4. Rank driver importance and uncertainty (as described below, undertaken with stakeholders as a workshop activity).
5. Develop scenario logics (i.e. identify the critical uncertainties that shape scenario characteristics, also described below).
6. Flesh out the scenarios (the focus and contribution of this paper).
7. Consider implications (the process presented in this paper reveals implications for biodiversity conservation objectives; implications for the governance of biodiversity from both the Tasmanian Midlands and Australian Alps case studies are presented in a separate paper).

Stakeholder input into the design of the scenario narratives (Steps 3 to 5 above) was secured through a one-day workshop in March 2013, attended by 27 participants, comprising government officials at national (1), state (6), regional (2) and local (2) government levels, people involved in non-government conservation (3) and other rural organisations (4) active in the area, rural landholders (2) and scientists (7). These participants were purposively selected for their local expertise. Many have been actively involved in efforts to improve land management practices and associated biodiversity outcomes in the region.

SES analysis was used to identify key drivers of change (Step 3). The factors identified at Step 2 were classified into drivers and influences, with drivers being those social and biophysical factors that operate exogenously to the governance regime, while influences are those factors associated with the governance regime that modify the action of social and biophysical drivers on native grassland conservation outcomes. An initial list of these drivers of change and governance influences was compiled by the research team drawing on the historical analysis described above (Figure 2), stakeholder input through a separately conducted survey and workshop, literature review, and iterative development of a conceptual model (Mitchell, Lockwood, Moore, & Clement, 2015a). Participants at the March 2013 workshop then discussed and modified this list, suggested other drivers, and, as a small group activity, made revisions to the conceptual model. To produce a final version of the model, the five outputs from the small group activity were synthesised post-workshop by the research team to identify commonalities and underpinning logic (see Mitchell et al., 2015a).

Each of the drivers and influences in the modified list were then assessed in terms of their importance or strength of influence on native grassland conservation outcomes, and the extent of uncertainty surrounding their future states by 2030 (Step 4). This was achieved through two separate workshop activities where participants ranked importance and uncertainty by placing dots on a 5-point scale against each driver in the modified list. A 5-point scale from "no importance" to "very high importance" was used for the social and biophysical drivers, and a separate 5-point scale was used for governance influences in terms of strength (from "none" to "very strong"). The second activity focused only on the most important drivers so identified, where stakeholders rated the level of uncertainty regarding the future state of each driver in 2030 against another 5-point scale from "no uncertainty" to "very high uncertainty". These two activities enabled workshop participants to collectively determine the two critical uncertainties, thus providing the characteristics of the four scenarios narratives situated at the intersecting end points of the two critical uncertainties (Step 5).

This paper focuses on the process used for the subsequent step of fleshing out the scenarios (Step 6). At the March 2013 workshop, four small groups of 5-6 participants had about an hour to craft initial dot-point descriptions to direct the scenario narratives that would be further developed after the workshop by the research team. Each group focused on one scenario, and were instructed to identify a label for their scenario. The dot-point notes provided by the participants included notes on the anticipated outcomes of each scenario for biodiversity in terms of condition and extent of the native grassland community.

To further elaborate the scenarios post-workshop, the research team again drew on Schwartz's (1996) recommendation that the scenario narratives be developed by paying attention to each of the key drivers identified in the earlier stages of scenario construction. The research team typed up the hand-written notes provided by workshop participants and organised them into a tabular structure to facilitate systematic development and additions to the narratives. The structure included rows for each of the social and biophysical drivers identified at Step 3, and columns for the four scenarios. As common elements of each scenario narrative began to emerge in different rows, we were able to iteratively combine rows and reduce their number and minimise duplication. That is, the resulting rows represented distinct themes ensuring repetition was avoided, with all key drivers being considered. Systematically constructing narratives about the state of each driver for each scenario facilitated comparisons between the contrasting scenarios. That is, points of commonality and difference between scenarios could be identified by reading the different narrative texts for each row. Climate change projections were judged to have a consistent effect across all scenarios on water availability, land use constraints and opportunities, and invasive species distribution potential. These aspects therefore had common text across all scenario columns.

A panel of relevant scientific experts was then engaged to review drafts of the narratives and associated biodiversity outcomes for their technical accuracy and plausibility, and to suggest further elaborations to the narratives. These experts were sourced from the interdisciplinary research hub within which this research project was undertaken (three of whom also participated at the workshop), and included experts in the economics of water management and conservation, climate science, the implications of climate change on threatened vegetation species, vegetation ecology, wildlife ecology, freshwater ecology, and conservation management. The process of review included two rounds of interviews conducted by the research team with each of the experts in July 2013. The experts were asked to suggest additions and revisions to the scenario narratives and to revise the anticipated biodiversity outcomes as part of the first interview, and then to validate the resulting narratives and anticipated biodiversity outcomes at the second interview.

4. Results

4.1 Key drivers of change

Drivers that most workshop participants (i.e. >70%) considered as "important" or "very important" are shown in Table 1, together with governance influences considered "strong" or "very strong". Following clarification of the term "Land Use Mix", participants asked that it be included as one of the most important drivers. The comparatively low vote (50%) was attributed to insufficient recognition of the intended meaning of "Land Use Mix" as being changes in the land use mix, especially those changes resulting from irrigation-driven agricultural intensification (i.e. as determined by the influence of irrigation development on water availability and enterprise profitability – see Figure 3). Figure 3 is the final post-workshop version of the conceptual model that had been used by workshop participants to explore SES dynamics. This version shows only the most important drivers of change as identified by workshop participants, except for two additional climate change affected biophysical drivers judged by the research team as crucial to understanding the overall context of SES dynamics – i.e. "Water Availability" (68%) and "Increased Average Temperatures and Temperature Extremes" (65%).

Table 1. Top 16 drivers and influences as identified by workshop participants

(in order of importance by category, as identified by workshop participants –percentages corresponds to the proportion of participants considering each driver as being of high or very high importance, and each influence as being strong or very strong)	**Biophysical Drivers:** – Invasive Species (83%) – Irrigation Development (72%) – Land Use Mix (50%)
Social and Economic Drivers: – Level of Trust Between Actors (92%) – Enterprise Profitability (88%) – Landholder Engagement in Conservation Practices (87%) – Landholders' Terms of Trade (84%) – Landholder Economic Motivation (80%) – Time Constraints and Prioritisation (77%) – Landholder Values and Attitudes (76%)	**Governance and Management Influences:** – Supportive Political Will (95%) – Effectiveness of Engagement Processes (92%) – Longevity of Programs (87%) – Grazing Management Practices (83%) – Level of Financial Incentive (77%) – Quality and Adequacy of Information, and its Deployment (75%)

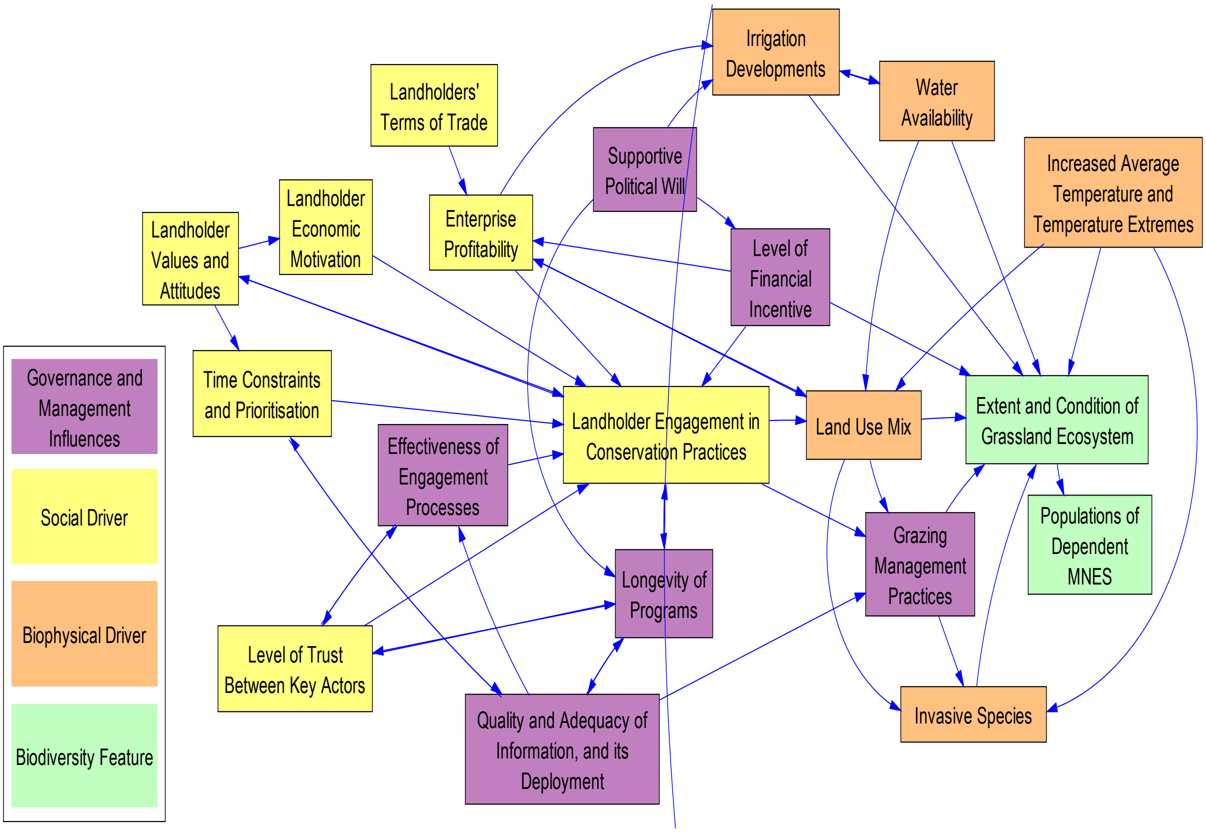

Figure 3. Tasmanian Midlands SES conceptual model (MNES stands for Matter of National Environmental Significance)(modified from Mitchell et al., 2015a)

4.2 Scenario spaces

To construct a matrix of four scenario spaces, two critical uncertainties were identified by workshop participants. Greatest levels of uncertainty associated with the 2030 state of the most important social and biophysical drivers listed above were identified by participants as being "landholders' terms of trade" and associated "enterprise profitability". "Enterprise profitability" had been a term preferred by participants for the driver because landholders' profitability is secured through a range of pursuits, including those not related to agriculture. However, when it came to the critical uncertainty, they preferred "farmer profitability" given that the extremes of uncertainty primarily related to agricultural activities and associated future terms of trade. Such a focus allowed exploration of different responses by landholders to the scenarios. For example, in the case of low farmer profitability, the result could be rural decline or reinvigoration through alternative non-agricultural rural enterprises. "Level of trust between actors" was another driver whose future state was deemed as being most uncertain. The term "human and social capital" was chosen for this critical uncertainty, as it was a broader term than trust covering a range of related drivers. Extremes of low versus high social and human capital provided an appropriate match to explore different responses to farmer profitability extremes. For example, "Cha Ching" represented a highly profit-driven scenario where low levels of social and human capital accompanied the evolution of large, corporate-driven farming enterprises reliant on a transient workforce. The scenario spaces were thus constructed according to the quadrant matrix shown in Figure 4. The labels for each scenario were selected by workshop participants working in small groups.

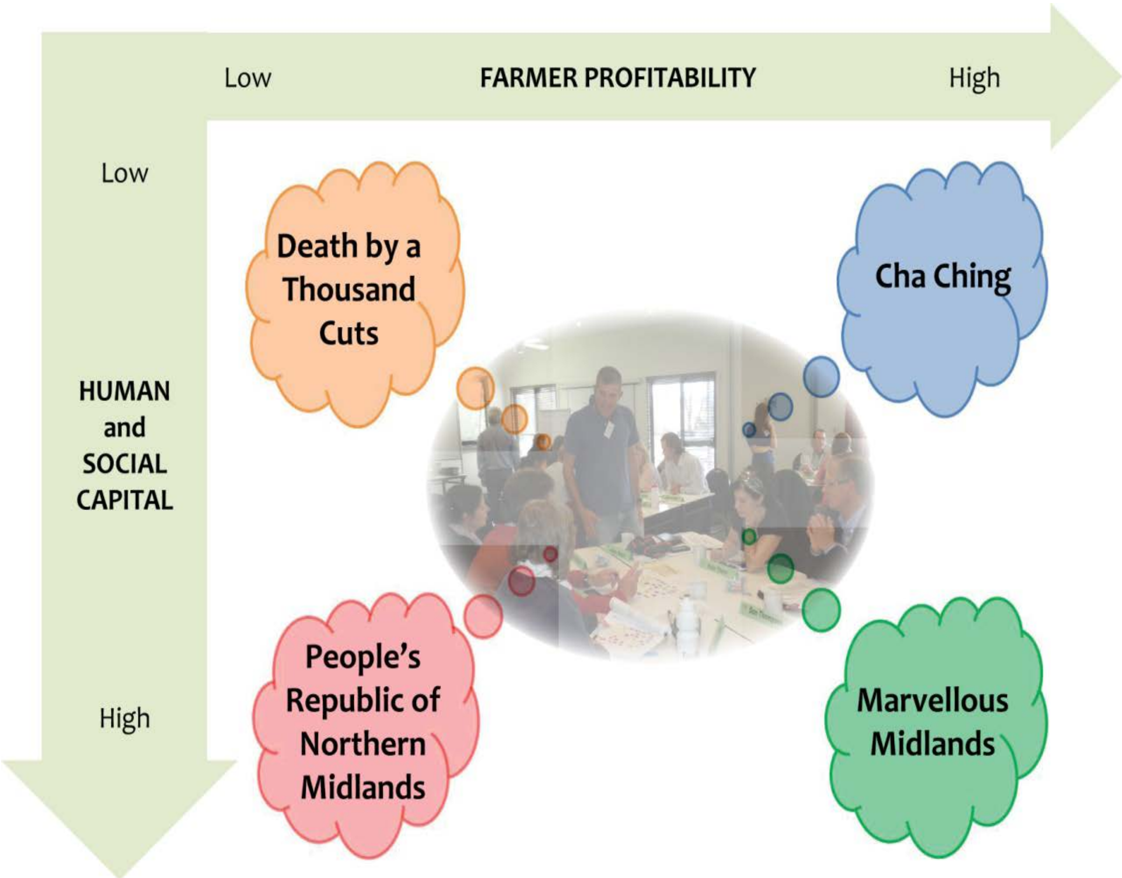

Figure 4. 2030 scenario spaces developed for the Tasmanian Midlands

4.3 Development of scenario narratives

The overall structure we used to develop the scenario narrative prompts provided by the workshop participants is summarised in Table 2. As noted above, this structure evolved iteratively and includes some narrative text that is consistent across all scenarios related to climate change effects, and other text appearing in rows where there are differences for each scenario. The final text of the narratives is available as supplementary online material. All excerpts from the narratives are represented as italicised text within quotation marks.

4.3.1 Development of narratives consistent across all scenarios

The narratives benefited from detailed analysis of climate change projections for Tasmania (Grose et al., 2010), and their implications for water availability (Bennett et al., 2010) and agriculture (Holz et al., 2010). These projections helped frame the narratives and associated contributions from experts. For example, the narrative on water availability included the following text for all scenarios:

> *"Rainfall patterns have changed. The previously reliable winter rainfall has become less reliable, with fewer days in which there are extended periods of light, soaking rain. More rain now falls in shorter heavier bursts, involving much greater levels of runoff. This has placed pressure on landholders to capture the runoff for future use, and to prevent erosion. Occasional extended dry periods have also put pressure on landholders to find alternative means to access and store water."*

With these climate change effects as a framing, it was possible to explore differences in how landholders might respond. Such responses depend on their levels of social and human capital, and the degree to which profitability is sourced through agriculture.

Table 2. Structure of matrix used to develop scenario narratives

	Scenarios			
	1*	**2***	**3***	**4***
State of key drivers in 2030 with consistent effects across all scenarios				
Narrative related to state of climate change in 2030 (1) increased average temperature and temperature extremes (2) increased variability of rainfall Implications of these climate change effects for native grasslands biodiversity outcomes				
Narrative related to the consistent effects from climate change trends across all scenarios on: (a) water availability (b) land use mix (c) invasive species				
State of key drivers in 2030 that differ between scenarios				
Narrative related to differing landholder responses to irrigation developments and associated water availability in 2030				
Narrative related to different states of farmer profitability between scenarios in 2030, and associated landholder choices regarding land use mix				
Narrative related to varying landholder responses to invasive species in 2030				
Narrative related to different states of landholder values, attitudes and behaviour in 2030 (incorporating landholder sense of place, lifestyle motivations, economic motivations, time constraints and prioritisations, extent of networks, information seeking behaviour, extent of entrepreneurship and innovation, all influencing engagement in conservation practices, ability for adaptive management, and other management practices)				
Narrative related to different states of trust between key actors in 2030				
Narrative related to different states of community values and attitudes in 2030				
Narrative related to different states of technological innovation in 2030				
Implications of these effects for native grassland biodiversity outcomes				

* numbers refer to the four different scenarios
(Death by a Thousand Cuts, Cha Ching, People's Republic of Northern Midlands, and Marvellous Midlands)

Landholders would also respond differently to the changing opportunities for land use mix options as driven by climate change. The narrative on this for all scenarios included the following:

> *"An increase in average temperatures and in growing degree days has opened up possibilities for new agricultural options such as horticulture and viticulture... However, more frequent heat waves constrain certain crops and grape varieties, and are beginning to reduce yields of some pastures. An increase in growing degree days has brought forward harvest times and has started to increase the number of life cycles for some invertebrate pests."*

Because these parts of the narratives were based on an analysis of the implications of climate change projections, they represent the “probable” predictive approach to frame narrative generation. More explorative and imaginative “possibilities” were then developed when fleshing out narratives differing across the range of scenarios.

4.3.2 Development of narratives that differed across scenarios

Land managers are likely to respond differently to the “probable” future changes in the pattern of natural water availability and agricultural options becoming available. Such responses are part of an inter-connected set of dynamics that will change the SES as a whole. In the Tasmanian Midlands case study, the breadth of scenarios was achieved by constructing responses in terms of high versus low levels of farmer profitability, and high versus low levels of social and human capital. This required imagining system dynamics for the four scenarios, as determined by the key drivers of change on those dynamics.

To exemplify the resulting contrasting scenarios, Box 1 provides excerpts from the scenario narratives relating to water availability and land use mix as drivers of change on system dynamics. The effect of low social and human capital reduces the capacity for landholders to respond effectively to reduced profitability from agriculture in the “Death by a Thousand Cuts” narrative, creating an image of rural decline, and *“an increase in land no longer used for agriculture”*. In contrast, the effect of low social and human capital on “Cha Ching” system dynamics accentuates a focus on maximising short-term profits over social cohesion and environmental sustainability, and intensive irrigated agriculture is pursued ruthlessly at the expense of native grassland biodiversity conservation.

The effect of high social and human capital on system dynamics would be markedly different. For example, as a response to increased variability in water availability, the narratives explored possibilities of increased collaboration among landholders to manage runoff, irrigation and retention of water in the landscape. These ideas had their origins in the initial prompts provided by stakeholders, with the idea of landholders co-investing in infrastructure suggested by workshop participants discussing the “People’s Republic of Northern Midlands” scenario, and a shared vision and strong sense of place and community characterising both scenarios involving high human and social capital. However, the ideas were further embellished through consultation with water management experts who highlighted that such small-scale collaboration was already burgeoning. One of these experts had already been approached by a local group of landholders seeking a better understanding of local hydrology, and how that hydrology was changing. With this as a basis, it was easy to imagine and draw upon innovative landscape-scale water management techniques, including some landscape water retention techniques inspired by Natural Sequence Farming (Andrews, 2008).

High levels of human and social capital would also have positive effects on regional community and enterprise viability. For the scenario involving low levels of farmer profitability, the *“strong commitment to stay on the land”* means that *“landholders have energetically taken up the challenge to work together to find alternative sources of income.”* The “Marvellous Midlands” scenario takes that a step further where the strong sense of community and shared vision combines with high farmer profitability to make the Tasmanian Midlands *“the place to combine the good life with excellent profits”*, especially for skilled agriculturalists escaping negative effects of climate change in other parts of Australia.

Input from experts also helped increase scenario possibilities beyond conventional assumptions. For example, a dominant stakeholder view of irrigation as a panacea to help landholders manage increased variability in water availability was challenged by consideration of the effect of competing hydropower needs for the same stored water sources. Experts were able to imagine a scenario where pressure for increased carbon neutral sources of renewable energy from the Australian mainland could potentially compete with the timing of the release of water needed for irrigation, creating frustration for landholders. Such scenarios might be exacerbated if landholders had reduced capacity to bargain with hydropower managers due to low levels of financial and/or social capital.

Box 1. Excerpts from narratives relating to different responses to changes in water availability and land use mix options

Excerpts from Death by a Thousand Cuts narrative
(***low*** farmer profitability and ***low*** social and human capital)

There is less capacity among landholders to adjust to one extreme climate event after another, and all are struggling to cope with increased natural variability in water availability… Many landholders tend to respond in an ad hoc reactive way to on-property impacts from run-off and erosion, capturing whatever runoff they can in existing on-property dams.

The region has experienced a slow death of farming enterprises leading to an increase in land no longer used for agriculture. Most young people have chosen to leave... Crippling debt and a continuous run of bad seasons has resulted in crashing property prices in the worst affected areas… The main positive outcome from a conservation point of view is that plunging property prices have resulted in the purchase of portions of the area by philanthropists and the government to form a set of native grassland conservation reserves.

Excerpts from Cha Ching narrative
(***high*** farmer profitability and ***low*** social and human capital)

Using irrigation to compensate for increased natural variability in water availability is the norm, and pursued ruthlessly… The high profitability of irrigated crops has resulted in an over allocation of water for irrigation at the expense of that needed to maintain hydrological ecosystem function and for biodiversity conservation.

Improved profitability has attracted more corporate players into the region, resulting in a fewer number of larger farming businesses that are increasingly corporate and/or foreign-owned… The emphasis for these businesses is to maximise short-term financial outcomes, as they know they can easily disinvest and move elsewhere if profits were to dive… Irrigation and warmer temperatures have opened up a whole suite of new agricultural ventures that can be pursued… Grassland conservation has become a small part of the land use mix, no longer existing on productive land.

Excerpts from People's Republic of Northern Midlands narrative
(***low*** farmer profitability and ***high*** social and human capital)

Midlands landholders with potential to benefit from irrigation developments have formed a cooperative to ensure fair water allocation among irrigation users without jeopardising the sustainability of irrigated agriculture in the region. This cooperative is organised into smaller sub-units to enhance collaboration around a shared source… [and they] pool their resources and ideas to improve the functioning of the irrigation system… Landholders individually and collectively have become increasingly resourceful in managing to capture runoff on properties and manage natural water variability through coordinated on-property water storage and retention works.

Declining terms of trade and competition from overseas producers have made almost all farming activities unprofitable, but landholders have energetically taken up the challenge to work together to find alternative sources of income... There is a strong commitment by most to stay on the land, supporting each other as a community through difficult times. This includes family members choosing to financially support other members of the family to stay on the land… The overall result is an increase in land used for conservation purposes.

Excerpts from Marvellous Midlands narrative
(***high*** farmer profitability and ***high*** social and human capital)

Landholders have found effective ways to balance water availability through irrigation with innovative practices to manage increased natural variability in water availability... There is strong smaller-scale collaboration among landholders who draw irrigation water from the same local pipe, canal or river system... These efforts have helped avoid over-allocation of water for irrigation, and to ensure adequate provision of water for the environment and the maintenance of an environmentally appropriate water flow regime.

The Midlands area has become the place to combine the good life with excellent profits. No matter what size property, landholders seem to make good returns, and there is a low level of property turn-over. The land has become hotly sought after, and some landholders have started to sub-divide their properties... Vignerons from other parts of Australia have set up small boutique organic and biodynamic wineries in the area, greatly increasing the profit potential for the area… Grassland conservation is a key part of the land use mix, and there is well-developed capacity and interest for good practice conservation management amongst Midlands landholders.

4.4 Biodiversity outcomes for each scenario

The underlying purpose behind construction of these scenario narratives was to inform biodiversity planning strategies at a landscape scale. In particular, the aim was to imagine a contrasting range of scenarios that would help determine biodiversity outcomes for such a diverse range of futures. The anticipated biodiversity outcomes, as initially proposed by workshop participants, and then revised and validated by the expert panel, are shown in Figure 5.

The broad finding was that biodiversity outcomes would generally worsen for all scenarios, with the possible exception of Marvellous Midlands. However, the exploratory process of opening up the possibilities for future scenarios also enabled opportunities for biodiversity conservation to be identified. For example, the workshop group discussing the “Death by a Thousand Cuts” scenario identified the decline in land used for agriculture as an opportunity. The associated drop in price for some of this underused land could eventuate in its purchase by philanthropists or the government as native grassland conservation reserves. This explains the assessment that there may be a small increase in grassland extent for both of the low farmer profitability scenarios.

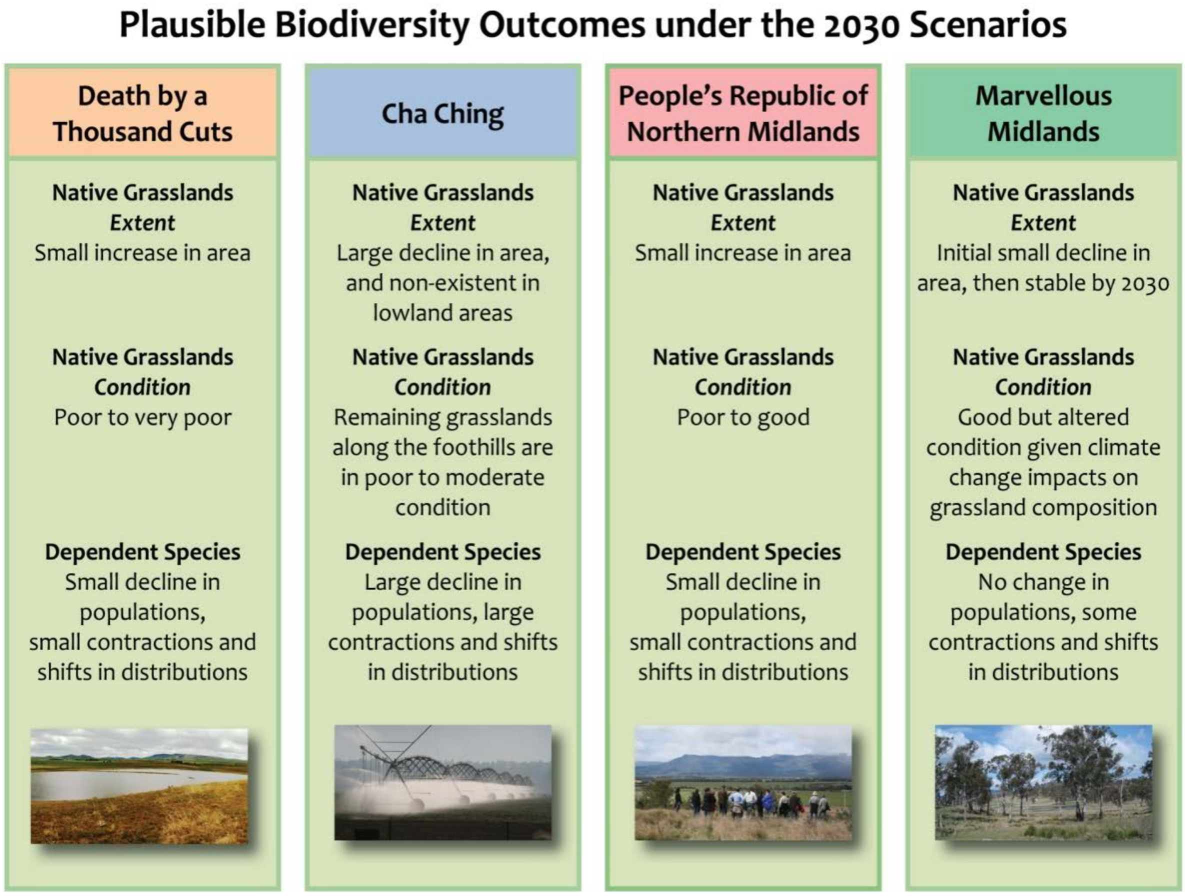

Figure 5. Expert assessment of biodiversity outcomes for 2030 Tasmanian Midlands scenarios

5. Implications of scenario narratives for biodiversity conservation

This paper has presented an approach to enhancing scenario narratives to enable detailed consideration of key drivers of change and to engage experts to provide further detail in ways that stretch conventional thinking. The approach builds on stakeholder engagement in SES analysis to frame and direct this input. A strength of the approach was to separate out the common effects across scenarios arising from climate change to focus on aspects more likely to lead to diversity in future conditions. While expert input greatly benefited the post-workshop development of scenario narratives, a weakness of the approach is the insufficient interaction with workshop participants as part of that process. This undermined the sense of ownership participants had for the scenario narratives.

A summary of the scenario narratives was provided to participants prior to a subsequent workshop held in March 2014, with many of the same participants who had attended the 2013 workshop. Participants were given an opportunity to discuss the finalised scenario narratives, and the interventions that could improve biodiversity outcomes, with a focus on governance arrangements. Some of the additions to the narratives sparked debate among participants, and the key learnings arising from post-workshop reflections by the research team are summarised below. Benefits of the approach include identification of biodiversity conservation strategies that may no longer be tenable, an essential aid for decision support and policy prioritisation (Spangenberg, 2007), and identification of new opportunities for conservation by opening up the minds of those involved to unexpected future possibilities.

Given the consistent effect of climate change across the scenarios, combined with other inter-related drivers of change, a shift in management strategies away from preservation of biodiversity "as is" is imperative (Dunlop et al., 2013). All four scenarios support this imperative and acceptance that many landscape systems supporting biodiversity conservation are undergoing rapid change and even transformation (Lockwood, Mitchell, Moore, & Clement, 2014). The four scenarios imagined through this exercise all strongly suggest the need to reconsider current biodiversity planning strategies and a readiness to adopt new approaches. These new strategies include redefining what is being protected, reimagining opportunities for protection that align with landholder needs, and a focus on the functions ecosystems can provide to support biodiversity under a changing climate.

The recent increased focus on novel ecosystems is highly relevant (Hobbs et al., 2014 Hobbs et al., 2009;). The exploration of novel ecosystems in restoration ecology is based on a realisation that under changing biophysical, social and/or economic circumstances, it is likely to be impossible to retain ecosystems such as these Tasmanian native grasslands in their current state and/or location. Managers may therefore need to consider how to provide at least some of these threatened ecosystem attributes in new ways. Identification of "suitable" places and spaces requires attention to the goals of protecting species of interest, maintaining ecosystem function, and managing for (novel) species composition and function (Hobbs et al., 2014). These actions are only part of the solution. The scenario planning detailed in this paper helps to meet the additional and critical need for testing the approach identified by Hulvey et al. (2013) and Hobbs et al. (2014) using real-world examples, in this case using scenarios.

The analyses presented in this paper enable planners and policy makers to move beyond the "constraints" of real-world examples to more broadly imagine the future. Three examples are illustrative. The first draws on the narratives' descriptions of landholder efforts to enhance water retention in the landscape as a response to climate change projections of increased runoff events across the Tasmanian Midlands (see for example the Box 1 narrative related to People's Republic of Northern Midlands scenario). A reasonable expectation, as highlighted by the freshwater ecology and water management experts consulted, is that landholders might identify these naturally occurring ephemeral wetland areas as suitable for rehabilitation to assist in water retention following high runoff events (also see Seabrook et al., 2011). Some of the dependent and endangered fauna and flora species associated with the native grassland ecosystem (e.g. the Southern Bell Frog *Litoria raniformis* and the regionally endemic Tunbridge Buttercup *Ranunculus prasinus*) are dependent on ephemeral wetland conditions that have become extremely rare in the region (Gouldthorpe & Gilfedder, 2002). In other words, the landholder management strategy here involves a reconsideration of ecosystem function offered by the landscape. Landholders can choose to allow inundation of such wetland areas, and the timing of such inundation could be managed to also confer biodiversity enhancements.

The second example draws from consideration of invasive species as a driver of change. The wildlife ecology expert we consulted prompted consideration of an increased prevalence of deer along the woodland-grassland interface on the margins of the Tasmanian Midlands, and their likely effects on the grassy woodland ecosystems. While the prospect of deer affecting condition and extent of grasslands had been raised during workshop discussions, the issue had not been highlighted in the scenarios. Subsequent consultation with the wildlife ecologist provided additional more detailed information that was not available during the workshop. In particular, advice was provided that new tree growth in deer-affected areas is likely to be impacted by their physical presence and grazing, which could lead to reduced tree coverage, and an associated expansion of grassland extent. When combined with the enterprising nature of landholders with high levels of social and human capital, it is possible to envisage human intervention to adaptively manage the deer invasion using landholders' expertise in managing native grassland grazing regimes and innovative development of local value-added meat produce. This combination could have a net benefit for the lowland native grasslands.

The third example builds on the preceding consideration of the expansion of native grassland areas along the foothill fringes of the Midlands. While interest in using some of these areas for biodiversity conservation would vary across scenarios (from a low likelihood under "Cha Ching" to a much higher likelihood under "Marvellous Midlands"), recent species distribution modelling suggest these areas may provide suitable conditions for the threatened native grassland ecosystem, currently located elsewhere in the landscape, under projected future climate change conditions (Harris et al., 2015). The inclusion of this suggestion as part of the discourse framing the scenario narratives reinforces a change in thinking. The future requires a focus on new areas for biodiversity conservation rather than merely preserving the few remaining fragmented pockets of native grassland biodiversity "as is" (Hobbs et al., 2014).

Two important considerations for biodiversity conservation were brought to attention through the scenario planning process, both related to proactively addressing a changing climate. Consideration of the high profitability scenarios by experts, with a concomitant focus on areas not suitable for irrigated agriculture but potentially suitable for biodiversity conservation, suggested the foothills on the edge of the Midlands region. The protection of such places as highly valued for grassland biodiversity requires modification to the current demarcation and classification of the lowland grassland community in Tasmania to protect a more diverse range of grassland communities and their associated dependent species. This finding also suggests the necessity of broadening statutory definitions of endangerment and its application to ensure management and policy flexibility.

The assessment of the impact of these changes on the lowland grasslands, especially by the vegetation ecologists we consulted who were working with climate scientists, also reinforces the need to reconsider how we demarcate and delineate areas for biodiversity conservation in fluid landscapes under an uncertain, changing climate (Manning et al., 2009). The projected shift in distribution of individual species will vary according to the particular needs of each species, and it is likely that the projected shifts will head in different directions. Current legislation focuses on the protection of particular threatened species, whereas these findings suggest a need to focus more on ecosystem function (Harris et al., 2015). Functional concerns require attention to connectivity and more flexible boundaries to reserved/protected patches as habitat across landscapes becomes more or less suitable over time. Issues of connectivity and landscape fluidity are issues globally, especially in agricultural landscapes such as the Tasmanian Midlands, where biodiverse patches may be widely separated. A focus on ecosystem function can allow novel choices regarding species that may enhance connectivity but may not necessarily reflect species historically known from the region.

6. Conclusions

Constructing and embellishing scenario narratives provides an opportunity to iteratively direct the collective imagination and challenge constrained thinking. In the Tasmanian Midlands case study presented in this paper, the disciplined approach combined local stakeholder input with that of key experts resulting in illustrations of future possibilities that underpinned a reconsideration of biodiversity conservation strategies. It also provides current efforts to understand and develop novel ecosystems with a means to imagine the future and test management goals and aspirations against these futures. Such testing is a critical next step if we are to deal with the complexities and uncertainties facing biodiversity conservation today (Hobbs et al., 2014).

Increasing the opportunities for iterative interaction as part of scenario construction is pivotal to future success. Ongoing engagement of a core group of local stakeholders and external experts to help direct and validate scenario construction and then testing governance options against these scenarios will help us plan ahead. Visualisation tools such as maps that spatially represent the land uses and land cover for each scenario could improve and facilitate this interaction. In addition, through ongoing engagement with and direction provided by local stakeholders, ongoing reconsideration of approaches is possible and can take into account plausible system trajectories rather than being anchored on historical baselines. The great benefit of scenario narratives is assisting us to better plan for biodiversity in the face of great uncertainty, and in ways that open up possibilities for the future rather than becoming mired in the litany of constraints that often characterise biodiversity considerations.

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