Incorporating governance influences into social-ecological system models: a case study involving biodiversity conservation

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Abstract

Addressing environmental problems requires sophisticated approaches to complexity and uncertainty. Conceptual models are increasingly used to improve understanding of complex system interactions. However, cursory treatment of governance limits their analytical potential. This study included governance considerations in a social-ecological system model of biodiversity conservation in the Tasmanian Midlands (Australia). Effectiveness of engagement processes and conservation program longevity were identified as critical governance influences. The conceptual representation of this system enabled exploration of how governance influences interact with social drivers (e.g. landholder engagement in conservation practices) to modify the effect of biophysical drivers (e.g. land use) on biodiversity outcomes. Such a methodology provides essential information for identifying and guiding governance-related points of intervention.

Keywords: resilience assessment; adaptive governance; conservation program design; landholder engagement; Tasmanian Midlands

1. Introduction

Frameworks and methods inspired by resilience thinking are increasingly used to address the complexities and uncertainties inherent in environmental management (Walker and Salt 2012). The concept of a social-ecological system (SES) underpins much of the resilience discourse, where the hyphen is used to emphasise that social and ecological dimensions are equivalently important aspects of the one system, and that integrative analysis is more useful than their delineation (Folke *et al.* 2005). SESs can be analysed as multiple inter-connected sub-systems related to natural resources, resource users, nested scales and governance systems (Ostrom 2009). These sub-systems encompass cultural, political, social, economic, ecological and technological components that interact in complex ways (Resilience Alliance 2010). Complexity can be conceptualised in terms of the multiple interactions that can occur within and between different system components, at different scales, and the different responses and feedbacks that occur as the social and ecological system components co-evolve over time (Rammel *et al*. 2007; Cox 2011).

This SES discourse, associated with the Resilience Alliance and its journal *Ecology and Society*, has also been the subject of criticism. Its practical application to effect change within social systems is sparse, and there have been calls for more substantive consideration of human agency (Davidson 2010) and the influence of governance, institutions and power (Hornborg 2009; Hatt 2013). Efforts among SES resilience scholars to learn from and make connections with other related discourses are increasing, including community resilience (Berkes and Ross 2013), disaster resilience (Walker and Westley 2011), vulnerability (Miller *et al.* 2010), institutional analysis (Ostrom and Cox 2010) and multi-level governance (Duit *et al.* 2010). Attention is also focussed on deploying such theoretical insights and frameworks in case study applications (e.g. Haider *et al.* 2012; Mitchell *et al.* 2014). This paper seeks to further these contributions through the practical application of an approach to conceptual SES modelling that pays serious attention to governance influences on system dynamics.

Developing conceptual and computational models of SESs is a technique applied in a diverse array of environmental management contexts (Schlüter *et al*. 2012), and promoted as a practical means to improve resilience assessments (Resilience Alliance 2010). SES modelling draws on complex adaptive systems analysis and emphasises interactions between social and ecological domains to improve system understanding related to feedbacks and uncertainty, and thus provide enhanced policy and management advice. Its increasing popularity is in part a response to the limitations of optimisation models that ignore system uncertainties and feedbacks, particularly from the variable influences of human decision-making (Schlüter *et al*. 2012).

Resilience scholars appreciate the role that governance plays in system dynamics, and have begun identifying key attributes that can enhance adaptive capacity (e.g. Lebel *et al.* 2006). Use of the term 'governance' in this paper continues a shift away from traditional ideas about governance as the formalised exercise of authority towards new approaches where decision-making processes and power are decentralised and increasingly exercised beyond or in association with government authority (Stoker 1998). As a result, new approaches to analysing governance are required to shift away from linear logic towards an appreciation of how governance operates as an inter-connected, poly-centric system (Dale *et al.* 2013).

Governance encapsulates the processes through which institutions and policies are formed, applied, interpreted and reformed (Paavola 2007), and the methods used to secure stakeholder input, especially in terms of how power and responsibilities are exercised (Lockwood *et al*. 2010). It shapes the social institutions that continually modify how social and ecological systems co-evolve in ways that can both enable and constrain SES resilience (Adger 2000; Dietz *et al*. 2003; Hatt 2013). Detailed understanding of how governance influences a system can enhance intervention strategies to achieve desired outcomes (Armitage *et al*. 2012).

While those promoting resilience assessments appreciate that governance arrangements shape and embed environmental decision-making processes, the governance dimension has received limited attention in SES modelling. Existing examples include the use of influence diagrams depicting system interactions by Bisaro *et al*. (2010) to elicit stakeholder views about governance structures and influences affecting environmental outcomes, and by Metcalf *et al*. (2014) to analyse the interactions between key actors in order to improve environmental outcomes. Smajgl (2010) used a similar systems analysis to explore decision-making at different levels of government in Indonesia, and this approach helped challenge beliefs encumbered by the scale at which those participating in the systems analysis exercise were operating. Other SES models have included one or two specific governance-related attributes identified as critical influences in the particular SES of interest, such as policy reforms (Reed *et al*. 2013), government subsidies (Máñez Costa *et al*. 2011), and governance influences on local institutional capacity such as multi-level institutional coordination, efficacy of local rules and state commitment (Ravera *et al*. 2011).

However, a key limitation of this and related work is that there has been no systematic attempt to investigate the influence of governance on SES dynamics by drawing on those attributes of governance identified as critical to enhancing adaptive capacity. This limitation means that existing models do not provide a structure for analysing the governance capacity to address complexity and uncertainty. Rigid governance, planning and management approaches can erode system resilience and hasten the deterioration in desirable SES functions (Berkes *et al*. 2003). It is therefore vital to identify the kinds of governance arrangements conducive to strategic thinking that is adaptive to change and anticipatory of future challenges and opportunities. In particular, adaptive governance offers a framework to better align governance dynamics to those of complex SESs, by embedding dynamic learning processes and adaptive experimentation into the design and redesign of actions and institutions associated with building adaptive and/or transformative capacity (Folke *et al*. 2005).

In this paper, we explore the influence of governance on system dynamics by using attributes identified as critical for adaptive governance. Our aim is to explicitly include adaptive governance considerations in a conceptual SES model, thereby providing a structure for designing interventions by analysing the direct and indirect influences of these governance attributes on system dynamics. We demonstrate the application of our approach in the context of biodiversity conservation, using a case study involving the Tasmanian Midlands, a largely cleared agricultural landscape with small, highly-valued areas of remnant biodiversity.

The paper continues with an explanation of the methods used to develop the conceptual SES model, and how this relates to resilience assessment. The case study focal system is then described followed by a detailed presentation of the system model, including the key biophysical and social drivers and governance influences. Given the focus of this paper, governance influences on SES dynamics are addressed in some detail. The paper concludes with a discussion of the implications arising from representing the case study system in this way, and suggestions are made on how our approach can contribute to further research and planning.

2. Methods

The Resilience Alliance (2010) workbook for practitioners provides practical advice on using SES analyses as a core component of resilience assessments. Once a focal system of interest and key issues of concern have been identified, a resilience assessment can proceed by identifying the key drivers of change for the focal feature or features of interest. Relationships and interactions between drivers and features are often represented in a conceptual model or influence diagram (e.g. H. Biggs *et al*. 2011). Such conceptual models can support communication and co-learning between stakeholders, especially where multiple sources of knowledge are involved (D. Biggs *et al.* 2011). As conceptual tools, they can inspire discussion among stakeholders to identify adaptive management intervention strategies related to regime shifts. They have also been used to identify indicators that allow monitoring of approaching thresholds of concern (Béné *et al*. 2011).

The steps used to develop the conceptual SES model for this case study broadly corresponded to the early stages of a resilience assessment as specified in Resilience Alliance (2010). The study began with a scoping step to identify and define the focal system and the focal issues of concern related to biodiversity conservation in that system, being the native grassland ecosystem remnants (i.e. resilience *of* what?). The next step involved an iterative identification, analysis and conceptual mapping of factors affecting these focal biodiversity features (i.e. resilience *to* what?). These factors were classified into social and biophysical drivers, and government and management influences. Drivers operate exogenously to the governance regime, but can be influenced by it. That is, governance and management influences modify the action of social and biophysical drivers on the focal features of interest. Governance sets the vision and direction (e.g. through policy), and management operationalises the vision (Folke *et al.* 2005). Because of the close relationship between management and governance, they are considered together in this model.

An initial set of biophysical and social drivers of change on biodiversity were identified from a review of Midlands-specific literature, including the 'grey' literature, discussions with key stakeholders, and a survey and associated workshop with landholders, government and non-government officials involved in Midlands conservation programs (Gadsby 2012). Potential governance influences on grassland conservation were sourced from the academic literature, including attributes identified as critical for adaptive governance (Dietz *et al.* 2003; Folke *et al.* 2005; Olsson *et al.* 2006; Lockwood *et al*. 2012) and factors that have been found to enhance landholder engagement in conservation programs and practices (Pannell *et al.* 2006; Ruto and Garrod 2009; Morrison *et al.* 2011; Baumgart-Getz *et al.* 2012; Ingram *et al.* 2013). Management influences were sourced from the research team's working knowledge of the management issues associated with the lowland native grasslands in the Midlands. To help manage and verify the iterative identification of drivers and influences, a comprehensive database was established that compiled evidence from the literature detailing the importance of each driver and influence and their relationships with each other.

The drivers and influences were compiled into a draft conceptual SES model showing the relationships between social and biophysical drivers, governance and management influences, and aspects of the focal biodiversity features (i.e. condition and extent of the grasslands ecosystem and its dependent endangered species of national significance). The draft model was then considered and refined at a one-day workshop in March 2013, which included 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.

Workshop participants were shown a list of drivers and influences and asked to add missing drivers and influences, cross out unimportant ones, and make any adjustments needed to the terms used to describe specific drivers and influences. They were then asked to allocate a level of importance to each driver (on a 5-point scale from no importance to very high importance) and level of strength to each influence (on a 5-point scale from none to very strong). At this stage, participants added another social driver of very high importance, ‘landholders’ time constraints and task prioritisation’, and one new very strong governance influence, ‘longevity of programs’. This step was designed to eliminate any unimportant drivers or influences from the model, thereby ensuring subsequent analyses focussed on the key system dynamics. Results from this prioritisation exercise are provided for the governance influences as part of Table 1 in Section 4.2.

Small groups of 4-6 people then worked with a draft conceptual model, pre-printed but then modified by-hand by the research team to take into account the preceding activities in the workshop, to identify important relationships between the drivers, influences and the focal biodiversity features. Participants validated some of the illustrated relationships and removed others they considered unimportant. Some groups also contributed additional drivers to the SES model that were not part of earlier considerations, and two of these (‘technological innovation’ and ‘land capability’) were later incorporated into the version of the model presented here. Workshop participants were asked to evaluate the usefulness of the process and their responses form part of the results.

The research team then analysed and further processed the outputs from the workshop. While the small groups at the workshop identified somewhat different sets of key relationships, the research team was able to synthesise these into a single model by concentrating on commonalities, as well as the logic underpinning relationships. The synthesised model was then further validated and adjusted with reference to supporting literature. With respect to governance, the multi-stage process we adopted ensured that each of the influences ending up in the model, while initially drawn from the literature, has real importance for our case study landscape. Importantly, the selected influences represent Midlands’ governance in a way that is appropriate for an SES approach. Specifying governance influences in terms of qualitative attributes of adaptive governance capacity is more suitable for analysing system dynamics than, for example, organisation or instrument-based representations.

3. Description of the focal system

The first scoping step of this study involved defining the focal system and its features (i.e. resilience *of* what?). The landscape selected for this study is the 415,445 ha Tasmanian Northern Midlands bioregion (Department of the Environment 2013) (Figure 1), a highly modified, predominantly privately managed agricultural landscape with scattered remnants of native grassland on public and private land. The region-wide landscape scale was chosen in response to an expressed need for alternative approaches to biodiversity conservation, and because landscape-scale planning and decision-making have been posited as part of the solution to the persistent and intractable problems involved (Hawke 2009; Curtis and Lefroy 2010). Developing policies to address the multi-level dynamics associated with landscape-scale conservation planning requires an understanding of the interactions between human decision-making and biodiversity outcomes over the long-term (Steinberg 2009; Duit *et al.* 2010), and necessitates appreciation of the importance of social, economic and institutional dimensions of environmental management (Wyborn 2011; Ban *et al.* 2013).

The Tasmanian Midlands landscape is a mosaic of mostly cleared farmland containing small remnants of native vegetation conservation assets, primarily grasslands, dry eucalypt forest, and grassy woodlands, and a small proportion of riparian and alluvial areas and valley floor wetlands (DSEWPAC 2012). Native vegetation extent is less than 30 per cent of its original range (Sattler and Creighton 2002). The land is mostly privately owned, thus private landholders manage most of the remnant vegetation. Land use is predominantly cropping and grazing, with irrigation development currently being pursued. Less than 4 per cent of the Northern Midlands bioregion is protected making it one of Australia's most under-reserved bioregions (Cowell *et al.* 2013). Conservation in this landscape thus requires the collective action of individual landholders.

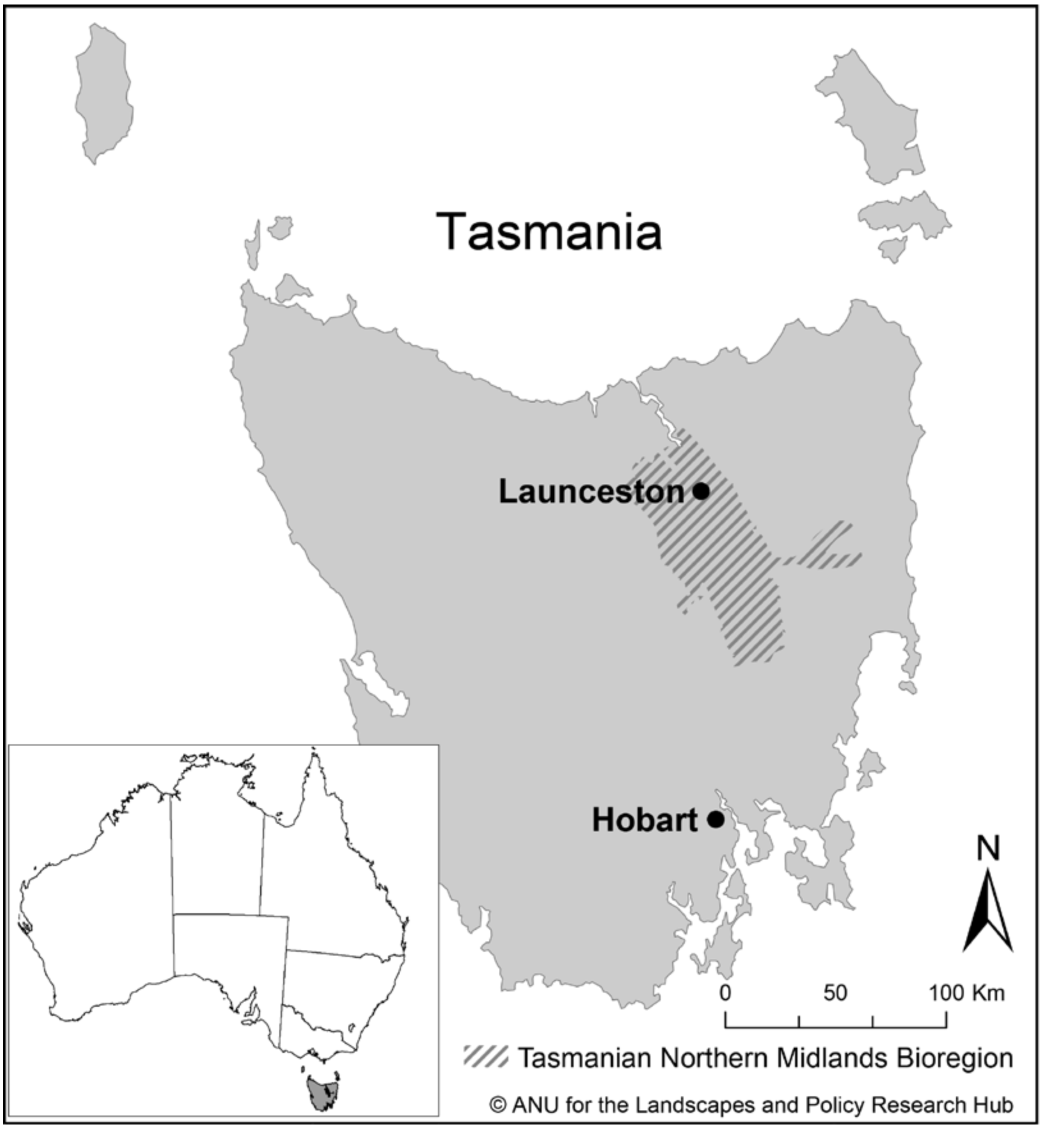

Figure 1. Tasmanian Northern Midlands Bioregion - based on the Interim Biogeographic Regionalisation for Australia developed by the Australian Government (Department of the Environment 2013)

The region is one of 15 national biodiversity hot spots identified by the Australian government due to systemic challenges involved in protecting the endangered endemic species therein. Pivotal to this status is the lowland native grassland ecological community, identified as a Matter of National Environmental Significance (MNES) listed under the *Environmental Protection and Biodiversity Conservation Act 1999*

(Cth) (EPBC Act), and characterised as comprising 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).

Governance arrangements for the protection and management of these valued grasslands are framed by national and state (Tasmanian) legislation. In Australia, responsibility for environmental management largely rests with the states, with the Australian Government having legislative powers over matters of national environmental significance, as well as key roles in setting agendas, developing guiding strategies and frameworks, and providing finance. The Tasmanian Government's Department of Primary Industries, Parks Water and Environment (DPIPWE) is responsible for administering the *Threatened Species Protection* Act 1995 (Tas) and also has an important role in supporting conservation on private lands through capacity development, incentives and private reserve programs. The Australian Government administers the EPBC Act, which as noted above, includes measures to assess developments that might have a significant impact on Matters of National Environmental Significance, including listed endangered species and communities such as the lowland native grasslands. The Australian Government has also administered the *Caring for our Country* program, which has been the source of significant resources in support of conservation activities in the Tasmanian Midlands.

Non-government organisations such as Bush Heritage and the Tasmanian Land Conservancy have leadership roles in biodiversity conservation, particularly through the innovative 'Midlandscapes' project and its associated conservation fund (Cowell *et al.* 2013; Males 2013). Regional natural resource management bodies, Landcare and Greening Australia also play important roles in working with landholders on land management and conservation issues. Socially, the region of around 4,700 people is experiencing population decline, especially in rural districts, and there is a decreasing number of people employed as farmers or farm managers. A higher proportion of people in the area is employed in the agricultural, fisheries and forestry sector than for Tasmania as a whole, but their number is declining (Gadsby *et al.* 2013).

The complexity of land tenures and regulatory arrangements immediately suggests the value of explicitly considering governance, especially in terms of authority, responsibility, power and how stakeholder input to decision making is secured (Lockwood *et al.* 2010). In addition to land ownership and associated responsibilities, a number of government and non-government organisations promote private landholder conservation programs in the region. Farmers and farmer groups, irrigation management groups and environmental non-government organisations are also part of this complex governance mix.

4. Drivers, influences and relationships in the Tasmanian Midlands social-ecological system

The next step in model development involved identifying and assigning importance to the biophysical and social drivers and governance and management influences, and specification of the key relationships between these drivers, influences and biodiversity outcomes. The elements and relationships that comprise the resulting SES are indicated in Figure 2, and elaborated in this section.

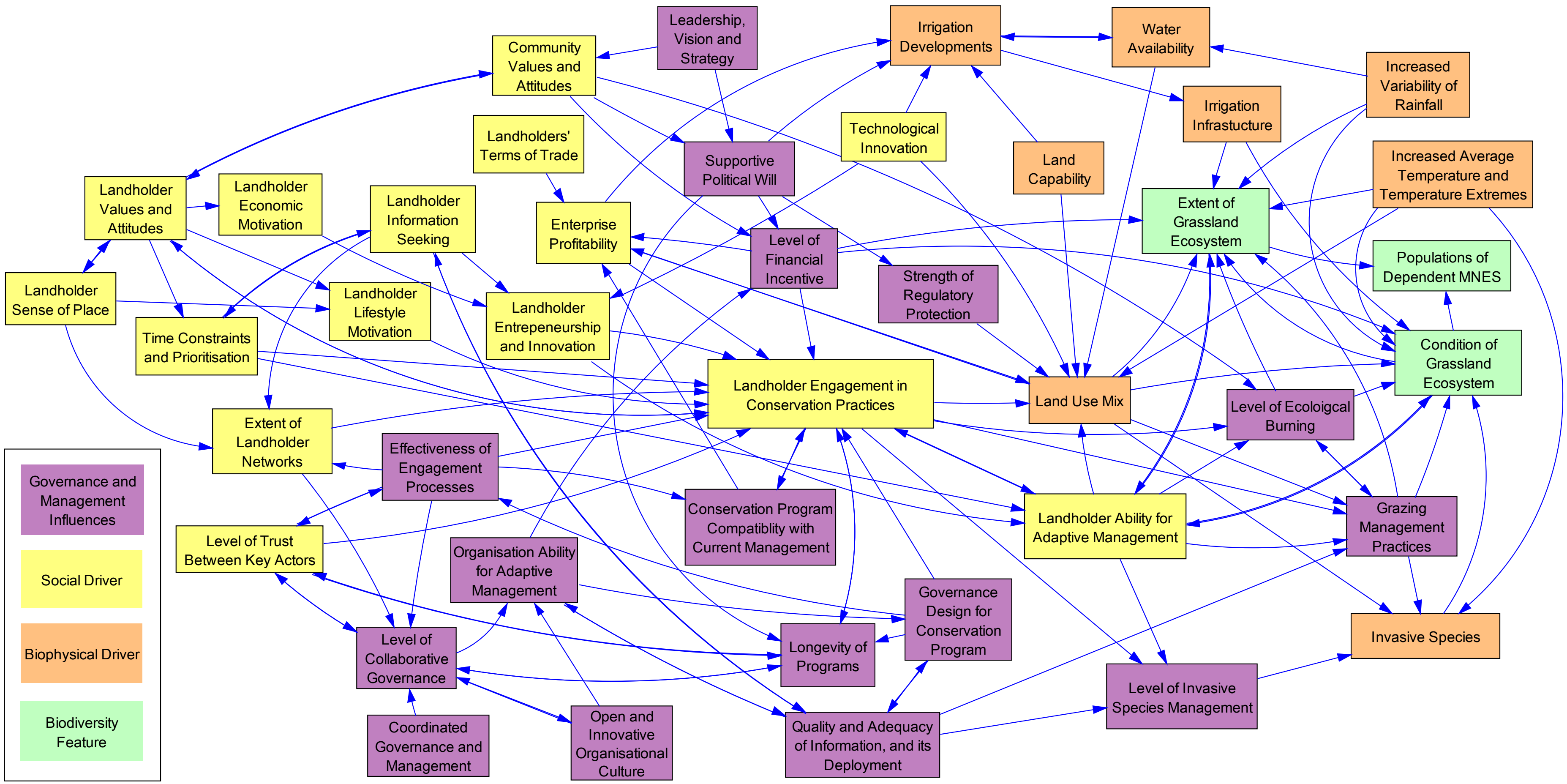

Figure 2. Tasmanian Midlands social-ecological system (SES) model

4.1 Biophysical and social drivers

The biophysical drivers identified as having ‘very high importance’ in the workshop were land use mix, climate change effects on temperature and water availability, invasive species and irrigation developments (5 of the 8 orange-coloured boxes in Figure 2). Over half of workshop participants identified these drivers as being of high or very high importance. Social drivers were generally ranked more highly in importance. Those identified as being of high or very high importance by over 75% of participants were enterprise profitability and landholders’ terms of trade; landholder values and attitudes; landholder engagement in conservation practices; landholder economic motivations; time constraints and prioritisation; and level of trust between key actors (7 of the 15 yellow-coloured boxes in Figure 2). In this analysis the term ‘social’ also includes economic drivers.

Land use mix is a pivotal biophysical driver of change, and has been over the history of European settlement of the Tasmanian Midlands. Most of the lowland native grasslands have already been replaced by improved pastures used for sheep grazing, with more grasslands likely to disappear with the projected increases in irrigated crop cultivation. As the arrow sequencing in Figure 2 shows, a major factor affecting land use decisions is profitability and the associated effects of external markets on landholders’ terms of trade.

Impacts from climate change (increased variability of rainfall and increased average temperature and temperature extremes) add another layer of uncertainty concerning future land use mix. The Midlands region will be increasingly affected by a rise in average temperatures (Grose *et al.* 2010), and an increase in heat wave events and in number of days with maximums over 25^{o}C (White *et al.* 2010). Heat wave events and increased average temperatures have already affected horticulture and viticulture in other parts of Australia (Webb *et al.* 2010), making the Tasmanian Midlands a possible alternative location for these land uses. The predicted reduction in the number of days with frosts (White *et al.* 2010) could also provide farmers with opportunities to expand into new cropping ventures. Forecasts suggest increased annual rainfall and associated runoff for the Northern Midlands bioregion, while overall average rainfall is expected to decrease in the catchments of key water storages servicing Midland’s irrigation schemes (Grose *et al.* 2010).

Increased invasion of weed species into native grasslands is also a predicted outcome of climate change (Gilfedder *et al.* 2012). The impact of invasive grazing animals such as deer and rabbits is also of concern, and further research is required to explore population projections of these species and their likely impact on ecosystem dynamics. Irrigation developments are evident both at a property scale and through major infrastructure projects such as the Midlands Water Scheme. These developments are reinforcing a trend towards farm diversification that is already in place, driven by the need to ensure farm viability and profitability (Mooney *et al.* 2010). Irrigation is likely to enable farmers to increase areas devoted to dairy production, crop cultivation, horticulture and viticulture, thereby reducing the area of native grasslands.

Enterprise profitability is a critical social driver and is strongly influenced by landholders’ terms of trade, the latter being the ‘prices received by landholders for their agricultural products divided by the prices they pay for inputs’ (Productivity Commission 2005, 66). Enterprise profitability is determined by external market forces including international currency exchange rates affecting agricultural commodity prices; changes in international and domestic demand for agricultural products that imposes constraints and creates opportunities; and competition from other suppliers for agricultural goods. Landholders manage the uncertainties associated with enterprise profitability by varying their land use mix to remain financially viable.

The remaining social drivers (i.e. landholder values and attitudes, landholder engagement in conservation practices, landholder economic motivations, time constraints and prioritisation, and level of trust between key actors) all indirectly influence biodiversity outcomes through their effect on pro-environmental behaviours. In this research these are behaviours associated with protecting and managing the lowland native grasslands. These drivers, in addition to enterprise profitability and other financial considerations, influence landholder engagement in pro-conservation practices (shown by the network of arrows pointing to this driver in Figure 2), and pro-environmental behaviour more broadly (Gärling *et al.* 2003; Pannell *et al.* 2006). Emtage and Herbohn (2012) and Morrison *et al.* (2011) detail the following landholder attributes as drivers of pro-environmental behaviours, which are similar to those identified in this study: the presence and extent of landholder networks (both formal and informal); approaches to seeking information; economic and lifestyle motivations; level of entrepreneurship and innovation; time constraints and prioritisation; and the levels of trust between landholders and agencies providing conservation programs.

4.2. Governance and management influences

As noted above, we made a conceptual distinction between the above set of biophysical and social drivers that operate exogenously to the governance regime, and the set of management and governance influences detailed in this section, which modify the action of social and biophysical drivers on the focal features of interest. This distinction is important when considering system interventions. The SES model is designed to assist in identifying these direct and indirect influences on biodiversity outcomes in terms of pathways from proposed governance intervention to biodiversity outcomes via social and biophysical drivers of change.

The governance influences identified as being ‘very strong’ in the workshop were: effectiveness of engagement processes; longevity of programs; supportive political will; leadership, vision and strategy; and quality and adequacy of information and its deployment (5 of the 16 purple-coloured boxes in Figure 2). Given the lack of attention to governance influences in previous SES analyses, a review of the full suite of governance influences included in the SES model is detailed below and in Table 1.

Regarding effectiveness of engagement processes, an ongoing challenge is how to engage landholders who are not already involved in current stewardship and incentivising schemes and may have high biodiversity values on their land. Governance approaches that effectively link with existing landholder networks, especially as these networks are often a vital source of information for time-starved landholders, is an important consideration (Baumgart-Getz *et al.* 2012). The Midlandscapes program has a particular focus on these networks and is pursuing innovative approaches to engagement.

Table 1. Governance influences and characteristics

Governance influence*	Characteristics
Effectiveness of Engagement Processes (3.4)	Effective engagement in conservation programs relies on trust and landholder networks. In the Midlands, programs such as Midlandscapes place as a high priority on seeking new participants in conserving native grasslands.
Longevity of Programs (3.4)	Programs with longevity have a positive influence on landholder engagement in conservation practices. The short electoral cycles in Australia make longevity of programs problematic.
Supportive Political Will (3.3)	Supportive political will contributes to the provision of the financial resources desired by private landholders to ensure their engagement in biodiversity conservation activities on their land.
Leadership Vision and Strategy (3.1)	Visionary, entrepreneurial and collaborative leadership can provide direction, stimulate action, and build trust and collaborative capacity. Local community, non-government organisation and government agency leaders are critical for successful native grasslands conservation in the Midlands.
Quality and Adequacy of Information, and its Deployment (3.0)	Improving information quality and deployment can bolster the capacity for adaptive management and enhance land management practices. Protection of grasslands ecosystems in the Midlands suffers from information gaps concerning their location, condition and extent.
Level of Collaborative Governance (2.9)	Collaborative governance rests on effective partnerships between government and non-government authorities, and at local, state and national levels. Improved collaborative governance can enhance landholder engagement in conservation practices.
Organisation Ability for Adaptive Management (2.9)	Rigidities in accountability, compliance and resource allocation processes within government departments can prevent adaptive management. Capacity for adaptive management is a key influence on whether landholders are able to implement effective conservation-oriented land management practices (e.g. ecologically-oriented prescribed burning of native grasslands).
Coordinated Governance and Management (2.8)	Coordination within and between organisations offering conservation programs and incentives is essential in the Midlands if confusion among landholders regarding overlapping roles and responsibilities is to be avoided.
Level of Financial Incentive (2.8)	For Midlands landholders, engagement in conservation programs should not adversely affect their financial viability. Landholders who go beyond a duty of care for biodiversity also see financial reward for their efforts as an issue of fairness.
Conservation Program Compatibility with Current Management (2.5)	Conservation programs need to become part of a coherent set of farm practices if they are to be successful.
Open and Innovative Organisational Culture (2.4)	Non-government organisations in the Midlands offer flexibility and innovation in pursuing biodiversity objectives together with landholders. Constraints associated with political imperatives and organisational cultures mean that government agencies face greater challenges in offering innovative and flexible policy support.
Governance Design for Conservation Program (2.3)	Governance design includes the extent to which programs enable landholders to determine how outcomes are to be achieved, efficiency and utility of monitoring and compliance provisions, and accountability mechanisms for financial support.

Strength of Regulatory Protection (1.9)	Strength of regulatory protection can influence the land use mix. Listing of grasslands (as protected under national or state legislation) may prevent their clearing for other land uses. Scepticism was expressed by Midlands respondents regarding the efficacy of listing grasslands under the *EPBC Act*.

*Average level of strength of influence as judged by workshop participants on a scale of 0 = 'None'; 1 = 'Weak'; 2 = 'Moderate'; 3 = 'Strong'; 4 = 'Very Strong'.

Achieving biodiversity outcomes relies on commitment over time as it can take many years for the condition of vegetation to improve or endangered species to breed successfully and their population size increase. The short electoral cycles in Australia and many other countries make long-term policy commitments by elected officials and governments problematic. The high importance placed by workshop participants on longevity of programs is reflective of this concern. Government departments and larger environmental non-government organisations, such as the Tasmanian Land Conservancy (which promotes and co-administers several conservation initiatives in the Midlands), were identified by workshop participants as having governance arrangements enabling program longevity.

As the arrow sequencing in Figure 2 shows, leadership, vision and strategic direction and supportive political will both affect the financial resources available to support landholders' conservation actions. The financial resources available to support landholders undertaking biodiversity conservation activities on their lands were a central concern of workshop participants. Workshop participants flagged the importance and need for leadership and vision to support the grasslands and their future. Regarding the quality and adequacy of information, gaps in knowledge regarding the location, condition and extent of the native lowland grasslands were identified as adversely affecting the ability to govern and manage this ecological community and its dependent species.

A plethora of other governance influences were considered and validated as important by workshop participants and through a review of the literature that details influences enabling flexible and adaptive governance. Table 1 includes the scores of strength workshop participants determined for all these influences, plus a brief review of the nature of the influence in the Midlands and its current conceptualisation in the natural resource management literature. The level of collaborative governance, the ability of an organisation to be adaptive, and the extent of coordination and collaboration (which facilitates flexibility) were all identified as having very strong influence by workshop participants. Research into adaptive governance has reached a similar conclusion (Folke *et al*. 2005; Lockwood *et al.* 2012).

The effect of governance influences on biodiversity outcomes is also exerted through management practices. Such practices relevant to grassland conservation in the Tasmanian Midlands are grazing, fire and invasive species management (Mokany *et al*. 2006). Grazing is an important management tool to maintain the inter-tussock spaces required by herbaceous species, without being so intensive as to eliminate them. Overgrazing, especially where there is no rest, is highly detrimental. The arrow sequencing in Figure 2 indicates how approaches to grazing management and stocking rates are influenced by land use mix decisions associated with commodity markets and the relativity of wool and meat prices, and landholders' experience, knowledge and ability for adaptive management in relation to use of native grasslands for pasture (Kirkpatrick and Bridle 2007).

Fire management in the Midlands, as in many other landscapes, is influenced by landholder values, past experiences and access to relevant information. Some native plant species in this landscape rely on fire to germinate, and fire can also be a useful approach to maintain inter-tussock spaces in the absence of grazing (Mokany *et al*. 2006). Lowland grassland ecosystems and associated species are well adapted to frequent low level burning events, but are likely to be adversely affected by frequent high intensity fires (Lunt *et al*. 2012). A study of the nearby Eastern Tiers showed that fire events have become less frequent in recent decades, and this has been driven in part by changing community attitudes to fires and the need to ensure protection of assets, including forest plantations (von Platen *et al*. 2011).

4.3. Model relationships

The final product of the Midlands workshop and subsequent analyses by the research team was a conceptual SES model of the Midlands with the lowland native grasslands as the focal feature (Figure 2). This model incorporates biophysical drivers and social drivers, governance and management influences and the focal feature of interest. Also shown are the various relationships between these elements, indicated by connecting arrows.

The biodiversity features at the ‘centre’ of this system are defined as: (1) the extent of the native grassland ecosystem; (2) the condition of the grassland ecosystem, and (3) the status of populations of endangered species dependent on these grasslands (shown as green-coloured boxes in Figure 2; the box for the third aspect is titled ‘Populations of Dependent MNES’ – i.e. Matters of National Environmental Significance). The web of relationships affecting condition and extent is particularly dense as evidenced by the large number of arrows connecting with these two boxes.

Land use mix is a dominant biophysical driver directly influencing the focal biodiversity features. It also mediates a number of social drivers and in particular the landholder engagement in conservation practices driver, which dominates the Midlands SES both in its centrality and extent of links and interconnections. Climate is also an important direct driver of change for the focal biodiversity features. Land use mix, as well as being affected by landholder engagement in conservation practices, is also determined by irrigation development.

Governance influences are most evident in their relationships with social rather than biophysical drivers. Governance influences on the social drivers of landholder engagement in conservation practices, level of trust and enterprise profitability were most evident. On the flip side, community values and attitudes was the social driver with the clearest effect on governance influences. Almost all of the social drivers and governance influences had a direct relationship with landholder engagement.

Feedback by workshop participants noted the benefits of this exercise, with 72% of respondents agreeing that ‘the process of developing and using the SES model was of sufficient value to be worth trying for biodiversity conservation in other landscapes’. A similar number of participants (76%) provided the same endorsement for the process identifying and prioritising key drivers and governance influences.

5. Discussion

This study has provided a methodology for explicitly describing and including governance influences in a conceptual SES model using a case study involving biodiversity conservation. Given that issues related to biodiversity conservation parallel those of general relevance to environmental management, the approach used for this case study has broader relevance and applicability. In particular, incorporation of governance influences as part of a conceptual SES model provides pointers for how governance arrangements could be improved, and these pointers have broad relevance.

The first implication arising from examining SES dynamics as represented in our conceptual model relates to the potentially positive effect of governance arrangements on social drivers for change. The model highlights the centrality and importance of landholder engagement in conservation practices as a driver in the Midlands SES, and its direct effect on the land use mix and thus the condition and extent of lowland native grasslands as the focal biodiversity feature. The model then indicates the network of governance influences acting on this driver. Key governance influences on landholder engagement include the effectiveness of engagement programs and the design of conservation programs, especially their longevity. Such a depiction visually reinforces similar conclusions made by others researching influences on landholder adoption of conservation behaviour (e.g. Ruto and Garrod 2009; Ingram *et al.* 2013) but, unlike this previous work, identifies these as issues to be considered as part of governance reform. More broadly, the model also helps demonstrate how governance influences interact with social drivers to modify the effect of biophysical drivers on biodiversity outcomes. Workshop participants expressed appreciation for the resulting improved ability to understand and take better advantage of social drivers, including that landholder values can play a crucial role in conservation efforts, and that such efforts are not just about offering financial incentives.

A second implication for governance intervention relates to building collaboration and adaptive capacity. The model demonstrates how governance influences that enhance levels of trust are of pivotal importance. For organisations involved in supporting biodiversity programs in the Midlands, the implication is the high value that needs to be placed on collaboration strategies that enhance levels of trust. For example, more effective coordination between organisations when engaging landholders can ease the current duplication of interactions and an associated perception of competition between organisations that can undermine trust. A high level of collaborative governance can also positively influence the ability for organisations to practise and facilitate adaptive management, which has also been shown to assist in the kind of social learning needed to effectively navigate profound change (van Herk *et al.* in press). In the Midlands, the nurturing of collaborative governance is exemplified by a high level of information sharing between organisations, and active engagement with landholders in understanding how conservation practices can co-exist with agricultural development. For landscape-scale biodiversity conservation planning processes to be both adaptive and collaborative, changes to traditional command and control forms of governance are required so that they are fit for the purpose of adaptively managing complex systems (Rijke *et al.* 2012).

A pathway towards governance arrangements that build collaboration and adaptive capacity in the Midlands is already in development. The Midlandscapes program (Cowell *et al.* 2013) offers great governance possibilities for the future as it seems to enable a number of the desirable governance influences on social drivers identified in this study to come into play. The program promotes devolution of decision-making to landholders regarding strategies to achieve biodiversity outcomes, and this is a key aspect of its governance design. Such devolution of responsibility for biodiversity management strategies is illustrative of a high level of trust in landholders by the conservation agencies involved. Midlandscapes has also demonstrated the benefits of engaging landholders' ability for adaptive management to advance achievement of biodiversity outcomes in novel ways. These strengths of the Midlandscapes program provide directions for governance reforms that can be applied to environmental management strategies more broadly.

A final implication arising from developing a conceptual SES model for the Midlands context relates to the kind of governance arrangements needed to facilitate biodiversity conservation strategies at a landscape scale. To extend the benefits of a devolved, adaptive and collaborative governance design for conservation programs to a landscape scale is a significant challenge. In addition to enhancing collaboration among organisations, multi-property collaboration among landholders is required. The Tasmanian Midlands landscape is characterised by highly fragmented property ownership and an equally as fragmented distribution of the lowland native grassland biodiversity feature itself. For such a diverse landscape, the model reinforces the findings of Emery and Franks (2012) and Wyborn and Bixler (2013), which suggest a governance regime is required that can enhance collaboration with and between landholders; extend beyond those areas where listed species and ecosystems are located; and traverse property boundaries and categories of land tenure. The SES model also demonstrates that such a regime must also acknowledge and integrate landholders' lifestyle and economic motivations with the protection and enhancement of values associated with biodiversity conservation.

These implications of the SES model for reforming governance arrangements parallel similar calls for alternative governance arrangements that can foster greater regional-scale landholder self-organisation and devolution of responsibility (Garmestani *et al.* 2009). Our findings also connect with the growing body of literature from Europe on multifunctional landscapes, and the related interest in nurturing new approaches to public-private partnerships that support multifunctional rural development (Penker 2009).

However, the notion of applying greater regional-scale devolution of responsibility as an alternative governance arrangement to improve biodiversity management on private land is new and controversial. Ideas of community self-governance for natural resource management are well developed in fishery and forestry contexts where there is a degree of community self-interest and benefit from enhancing the sustainable use of common pool resources, and such efforts can have some associated benefits for biodiversity (Basurto *et al.* 2013; Bixler 2014). In terms of biodiversity conservation on private land, a policy approach of giving landholders responsibility for determining and delivering biodiversity conservation program outcomes is recent and rare (e.g. de Sainte Marie 2014; Vella & Dale 2014). Scenario planning could be an effective means to further explore the design of alternative governance arrangements, and their implications for SES dynamics. Indeed, the methods adopted in this case study are well suited to a scenario planning approach. The exercise of prioritising drivers in terms of their importance provides a basis for the determination of critical uncertainties, an approach forming the basis for many scenario planning approaches (e.g. O'Connor *et al.* 2005).

Future work could also involve a combination of this scenario planning approach with that involving an operationalisation of the SES model using indicators. This combined approach could provide a more formal analysis to compare scenarios under current governance arrangements with those under alternative arrangements.

6. Conclusion

The conceptual SES model presented in this paper provides contextually relevant guidance for the design of alternative governance arrangements to improve biodiversity outcomes. A point of intervention clearly evident from this study relates to the governance influences on landholder engagement and especially governance design of conservation programs, their longevity, engagement strategies, and compatibility with current landholder management practices. Level of trust, as a social driver, is a critical part of this mix.

More broadly, the uncertainties and complexities associated with managing natural resources require systems-based approaches and systems thinking. A significant contribution of the approach used in this paper is the inclusion of governance attributes when conceptualising a SES, and the articulation of these governance influences as characteristics of adaptive governance. Compared with other efforts to incorporate governance attributes into SES models, our approach is better aligned with a research agenda that seeks to understand SES dynamics in determining points of intervention. Because the governance influences are derived from the literature detailing attributes of adaptive governance, the approach to SES model development can be applied to a variety of contexts and potential governance configurations and designs.

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