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Informing Implementation Strategies for Conservation Using a Social-ecological Systems Framework

Abstract

One of the key determinants of success in biodiversity conservation is how well conservation planning decisions account for the social system in which actions are to be implemented. Understanding elements of how the social and ecological systems interact can help identify opportunities for implementation. Utilizing data from a large-scale conservation initiative in the south west of Australia we explore how a social-ecological system framework can be applied to identify how social and ecological factors interact to influence the opportunities for conservation. We identified areas that could benefit from different implementation strategies, from those suitable for immediate engagement to areas requiring implementation over the longer term in order to increase on-the-ground capacity and identify mechanisms to incentivize implementation. The application of a social-ecological system framework can help conservation planners and practitioners facilitate the integration of ecological and social data to inform the translation of priorities for action into implementation strategies that account for the complexities of conservation problems in a focused way.

1. Introduction

The past two decades have seen an increase in the application of systematic techniques for informing decisions about better ways to reduce biodiversity declines and protect and conserve natural values. These techniques are applied within a conservation planning framework (Margules & Pressey 2000; Pressey & Bottrill 2009), to inform the selection of priority actions (associated with species and/or areas), or the allocation of resources (e.g. amongst multiple actions), to enhance objectivity, transparency, and scientific defensibility, and maximize the outcomes achieved with limited financial resources (e.g. Murdoch et al. 2007; Wilson et al. 2006). It is also increasingly recognized that to be effective, conservation decisions must be cognizant of the social and institutional context in which actions are to be implemented (Cowling & Wilhelm-Rechmann 2007; Robinson 2006). Factors such as competing social values and objectives, political agendas, social norms, organizational and governance processes and technological and financial constraints can all facilitate (or inhibit) the implementation of conservation programs but are not commonly considered in conservation plans (Mascia et al. 2003; Pannell et al. 2006).

The importance of the social and institutional context of conservation is acknowledged in the conservation planning literature, (Cowling & Wilhelm-Rechmann 2007; Knight et al. 2006b), but too often the mechanisms for accounting for this context reflect an *ad hoc* collection of technical solutions (Table 1). Many studies focus on the use of spatial data related to threats or costs for the identification of priorities (Armsworth 2014; Naidoo et al. 2006). An increasing number of studies investigate the social context to identify motivations and barriers for conservation (e.g. Januchowski-Hartley et al. 2012; Seabrook et al. 2008), but only a few studies have considered social characteristics to identify areas of conservation feasibility – areas where conservation actions are more likely to be successful – on the assumption that prioritizing these areas will increase the effectiveness of conservation investments (e.g. Adams et al. 2014; Guerrero et al. 2010; Knight et al. 2010; Sewall et al. 2011; Tulloch et al. 2014; Whitehead et al. 2014). Less attention has been given to utilizing social data to inform implementation strategies, which has been focused on identifying where the values of the community align (or otherwise) with scientifically defined ecological values (Bryan et al. 2011).

A systems approach can account for interactions between social and ecological factors. In a social-ecological system (Figure 1), elements of the social system, including actors (e.g. government and non-government organizations, resource users, civil society) and institutions (e.g. rules and regulations, formal and informal procedures, policy instruments) interact with one another and with elements of the ecological system to regulate a continual interchange of inputs (e.g. land/resource use, management actions) and outputs (e.g. harvest, cultural or biodiversity values and other ecosystem services; Berkes et al. 2003; Redman et al. 2004). While the integration of conservation planning with a social-ecological systems framework has been proposed (Ban et al. 2013; Palomo et al. 2014), practical examples of how this can be achieved are not available.

Ban et al. (2013) suggested different ways in which adoption of a social-ecological system framework can benefit conservation planning, and three dominant ways are outlined in Figure 2. First, both social and ecological data can be used to conceptualize the natural and human aspects of conservation problems (and conservation solutions) as a single complex system. Second, it can enhance prioritization analyses through the identification of key factors that influence conservation outcomes but are not commonly considered. Third, and the focus of this paper, is through the identification of areas that represent varying opportunity (Moon et al. 2014) for implementing conservation programs to inform the development of implementation strategies.

Implementation strategies are an essential, yet uncommon or under-reported, component of conservation plans (Knight et al. 2006a; Pressey & Bottrill 2009). While conservation prioritization analyses identify *what* we should conserve and the required conservation actions (e.g. land protection, revegetation, invasive species control), implementation strategies identify the particular approach that will determine *how* we will execute those actions (e.g. through direct engagement, political or financial support, collaboration strategies, education campaigns, marketing and communication strategies, financial and market-based incentives, or a combination of these). Implementation strategies reflect the available local resources and local modes of operation, are of direct relevance to stakeholders, and link directly to the activities of implementing organizations (Del Campo & Wali 2007; Pierce et al. 2005). For example they can inform the timing of actions, and target implementation efforts (Bryan et al. 2011). Implementation strategies can also target stakeholders that are well informed about, and aligned with, key aspects of the ecological system (Guerrero et al. 2015a; Guerrero et al. 2013; Vance-Borland & Holley 2011). They can involve communication strategies that emphasize the benefits for people's livelihoods rather than conservation benefits alone, such as financial benefits, for example through job creation and tourism activities (e.g. human-wildlife conflict mitigation programs; Henson et al. 2009). It is only through analyzing the connections between ecological and social factors, and not through analyzing individual subsystems (e.g. ecological or the social) that opportunities (and barriers) for implementation of conservation actions can be identified.

Utilizing a case study of large-scale conservation in the south west of Australia we demonstrate how a social-ecological systems framework can be applied to guide the identification of areas of varying conservation opportunity to inform the development of implementation strategies.

2. Methods

2.1. The Fitz-Stirling case study

The Fitz-Stirling region is situated in Western Australia in one of the world's 34 global biodiversity hotspots (Myers et al. 2000). It covers over 240,000 hectares and is part of an ongoing large-scale conservation initiative that aims to restore ecological connectivity along a 1,000 kilometer corridor in south-western Australia (Bradby 2013). Multiple stakeholders are involved in efforts to achieve conservation objectives for the Fitz-Stirling including property owners, state and local government agencies, regional natural resource management groups, non-government organizations, community groups, university and research organizations, private organizations and independent contractors (Guerrero et al. 2015b). These stakeholders engage in diverse activities, including revegetation, protection of bushland, invasive species management, livestock management, fire management and land use planning.

2.2. The Social-ecological Systems framework

There are a number of prominent frameworks used for conceptualizing social-ecological systems. These include the Social-Ecological Systems framework (SES), the Press–Pulse Dynamics framework (PPD), the Human Environment Systems framework (MEFA), the Drivers-Pressures-State-Impact-Response framework (DPSIR) and the Management strategy evaluation framework (MSE) (Bunnefeld et al. 2011; Ostrom 2007; Svarstad et al. 2008). These frameworks differ in terms of their disciplinary background and their applicability, but only a few explicitly account for social-ecological interactions and their dynamics (i.e. the SES, the MEFA and the MSE frameworks; Binder et al. 2013).

Here we apply the SES framework (McGinnis & Ostrom 2014; Ostrom 2007). The SES framework has been developed after decades of investigation on the key components of social-ecological systems, and the critical relationships amongst these, that are relevant to explaining outcomes in natural resource management. This has resulted in an extensive multi-tiered hierarchy of variables organized into four distinct internal sub-systems and two external ones (Figure 1). Interactions can occur between actors who jointly affect outcomes and between the social and the ecological system, which are specified by the range of activities in which actors are engaged (e.g. harvesting and monitoring activities; McGinnis & Ostrom 2014). We suggest this interdisciplinary framework can be useful for guiding the integration of social and ecological data to be included in conservation planning studies. Specifically, the framework can help organize the conservation planning task by directing attention to the variables affecting the relevant social-ecological interactions. These interactions are those that influence the effectiveness of conservation and management activities, and thus outcomes, in the social-ecological system of interest. The multi-tiered hierarchy of the SES framework permits different degrees of specificity in the analysis of social-ecological systems, and thus provides flexibility in relation to the types of data employed.

2.3. Analytical approach

We followed a staged approach to our data collection and analysis (Figure 3). We conducted semi-structured interviews, distributed an on-line survey and utilized publicly available data to derive measures for the variables identified. This included measures of ecological importance, stakeholder presence, collaboration between stakeholders and their scale of management.

Applying the SES framework to a particular case involves the identification of the variables in the SES framework (Actors, Governance System, Resource System and Resource Units; Figure 1) that interact in the Focal Action Situation, and that are the most relevant to the particular conservation problem and the objective of the analysis being undertaken (McGinnis & Ostrom 2014). To this end we sourced data from 25 semi-structured interviews with representatives of the key stakeholder groups, and reviewed internal documents and strategic plans. We analyzed this data to develop a conceptual model for the social-ecological system associated to the conservation of the Fitz-stirling region. This model was used to identify the variables in the SES framework relevant to our analysis.

We sourced publicly available data on the distribution and the functional connectivity of 80 vegetation patches in the study region (Guerrero et al. 2015a; Moilanen & Nieminen 2002). The functional connectivity metric was calculated based on the methods of Saura and Rubio (2010) and used a 1km threshold. The threshold is ultimately a species-specific measure. However, a 1 km threshold is able to describe the landscape's level of connectivity for a fairly broad range of species, relevant for many bird species, as well as for several mammal and amphibian species (Sutherland et al. 2000). It is likely that small mammal and insect species would require smaller thresholds that better reflect their dispersal across the landscape, and larger mammals would require greater thresholds (Sutherland et al. 2000). A *probability of connectivity* metric (PC) was calculated for each of the 80 vegetation clusters to quantify their relative importance to overall habitat connectivity.

The on-line survey asked respondents who they collaborate with for performing different conservation activities. Using the degree centrality metric (Borgatti et al. 2009) we measured the level of collaboration between stakeholders (Supporting information for further details). By coding stakeholders by their scale of interest (property, sub-regional and supra-regional levels; Figure S1) we were able to identify areas associated with multiple scales of management. We also used the on-line survey to capture the perceptions held by stakeholders on the challenges to conservation action implementation. This data was used to validate the SES model and the choice of variables. We collected survey data between October 2011 and July 2012 (see supporting information for further details).

In the last stages of our approach (Figure 3) we sought to identify areas of varying conservation opportunity by combining the different measures obtained to ascertain how areas associated to different levels of ecological importance coincide with areas associated to different levels of stakeholder presence, stakeholder collaboration and scales of management. This information can be used to inform the development of implementation strategies.

3. Results

3.1. The Fitz-stirling social-ecological system

The resulting conceptualization of the Fitz-Stirling region as a social-ecological system is presented in Figure 4. In the resulting SES model, the implementation of conservation activities such as revegetation, protection of bushland and invasive species management are the result of the interactions between the resource units system and units (remnants of native vegetation), and the stakeholders that influence conservation outcomes at different scales and their collaboration networks. This choice of variables is supported by the online survey. This data reveals the importance of collaboration to conservation action in this region. For example, data on the perceptions held by Fitz-Stirling stakeholders on the factors that influence on-the-ground activities points to insufficient communication and coordination as an important barrier to successfully carrying out conservation activities across the region (Figure S2). Importantly, of the collaborative relationships identified 83% were perceived to deliver results to the particular activity performed at particular locations (Figure S3). The data also suggests that accessibility to human resources (stakeholder presence) is a key aspect of implementation capacity in the Fitz-Stirling region (Figure S2). In addition, the perceived need for greater communication and coordination to support implementation appears to be particularly important across organizational scales (e.g. “between government agencies and NGOs and landholders”). This is further supported by perceptions of the value of collaboration with government agencies, with only 9% of non-government stakeholders identifying such collaborations to be of low or no value (Figure S4).

Results for the functional connectivity of the 80 vegetation patches in the Fitz-Stirling region and stakeholder presence and collaboration metrics are presented in Table S4 and S5 respectively. These results are integrated in Figure 5 to reveal areas of varying conservation opportunity. Areas of high ecological importance and high stakeholder presence (A in Figure 5) represent areas of existing opportunity, where conservation actions can be implemented in the near term. Areas of low ecological importance and high implementation capacity (B in Figure 5) are areas that could lead to inefficiencies in efforts to achieving outcomes. Areas of low ecological importance and low implementation capacity (C in Figure 5) are currently areas of low priority and unlikely to require immediate attention. Finally, areas of high ecological importance and low implementation capacity (D in Figure 5) represent areas of potential conservation opportunity, where conservation outcomes could be difficult to achieve in the near term.

4. Discussion

Implementation strategies are an essential, yet uncommon, component of conservation plans (Knight et al. 2006a; Reyers et al. 2010) . We show how ecological and social data can be integrated to identify priorities, opportunities, and potential challenges to conservation and how this information can inform the formulation of implementation strategies. We identified areas requiring different implementation strategies through integrating conservation planning with the knowledge and analyses from each component of a social-ecological systems framework. The result of this approach is the identification of areas of varying conservation opportunity that can be targeted in different ways to inform the development of implementation strategies.

The variables we identified through the use of interview and survey data and the application of the SES framework are supported by a wide literature on the factors that influence the capacity of an organization or group of individuals to put into practice an activity or program (i.e. the *implementation capacity*). These factors vary across different natural, social and health sciences disciplines, and are a combination of institutional, psychological, economic and organizational factors (Brown 2008; Katsuhama & Grigg 2010; Mountjoy et al. 2014).

For conservation programs, implementation capacity is often associated with a number of interacting factors including political and institutional support, access to financial and human resources, social norms, and the extent of collaboration amongst implementing organizations – particularly across sectors and scales (Crees et al. 2015; Fitzsimons et al. 2013; Guerrero et al. 2015b; Mastrangelo et al. 2014; Pasquini et al. 2011). Collaboration increases social capital and thus the ability to harness both resources and support, (Cramb 2006; Pretty & Ward 2001). Addressing complex problems – such as those associated with conservation programs – not only requires multiple stakeholders to contribute to implementation (i.e. contribute human resources) but it also requires coordinated action. Collaboration enables coordinated action to occur (Brondizio et al. 2009; Lubell et al. 2002). Importantly, for conservation problems transcending jurisdictional and ecological boundaries, successful programs require that such coordination happens across management scales (Dallimer & Strange 2015; Epstein et al. 2015; Ostrom 2010).

The consideration and integration of social and ecological data can enhance current approaches to conservation planning, by explicitly accounting for interactions between the social and ecological systems in the identification of conservation opportunities. In our study, areas of high opportunity (A in Figure 5) represent areas where conservation actions can be implemented in the near term and can thus benefit from immediate action, engaging with existing stakeholders to coordinate required conservation actions (e.g. revegetation, invasive species management). This might require the provision of financial, technological or knowledge to support current activities, or the development of partnerships and agreements to enable coordination of on-the-ground actions and support management of areas across multiple scales (red circles in A, Figure 5). Areas where potential inefficiencies could arise (B in Figure 5) would benefit from communication and education strategies, and the sharing of knowledge to increase stakeholder awareness of areas of higher ecological importance where they can redirect their efforts. Finally, areas of potential conservation opportunity (D in Figure 5) could benefit from a longer-term implementation strategy aimed at increasing on-the-ground capacity combined with incentives for conservation. This might entail diverse activities such as education campaigns to promote the ecological importance of the areas, forming or enhancing organizations capable of implementing actions, and the development of conservation incentive instruments (e.g. covenants). This might be achieved by harnessing the social capital of areas displaying high levels of social connectedness (larger circles in D, Figure 5). In addition, the success of conservation efforts could be maximized by focusing efforts on those areas associated to multiple scales of management (green circles in D, Figure 5).

For the Fitz-Stirling region, a standard approach may result in the prioritization of areas of high ecological importance but some of these areas may also have low capacity for implementation (D in Figure 5) – which could affect the effectiveness of conservation efforts. In addition, a poor understanding of the interactions between the social and ecological system would likely result in inadequate implementation strategies that fail to respond to the opportunities and challenges identified. For the Fitz-Stirling this could result in, for example, the provision of financial or other type of resources to implement activities in areas where the implementation capacity is currently limited. This could include areas where stakeholders are not ready or lack commitment to achieving conservation outcomes, which could in turn lead to failed implementation, delays and inefficient use of valuable resources.

For future studies utilizing our approach it would be feasible to incorporate other variables of the Resource Services and Units sub-system (Figure 1) such as more detailed biodiversity and ecosystem data than included in our example. Likewise, assessments of implementation capacity could include variables of the Actors and Governance Sub-systems not considered in our example if these were found to be relevant to the particular social-ecological system being studied (e.g. leadership, access to financial resources and technology). In addition, variables from the Related Ecosystems sub-system such as the impact of climate change on the components of the socio-ecological system could be captured if such dynamics were perceived to be important for designing implementation strategies (e.g. Faleiro et al. 2013).

Our study illustrates how the SES framework can be applied to conservation planning, specifically to extend the use of social and ecological data from identifying conservation priorities alone, to identifying conservation opportunities to inform the development of implementation strategies. Application of the SES framework, with a focus on socio-ecological interactions, enables the conservation researcher or practitioner to disentangle the complexity of conservation problems to focus on aspects that warrant closer investigation.

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Table 1. Social factors considered in systematic conservation planning.

Social factor	*Example*	*References*
Attitudinal and behavioral factors	Willingness to participate/to sell land	(Adams et al. 2014; Guerrero et al. 2010; Knight et al. 2011)
	Farmer uptake of conservation schemes	(Dutton et al. 2008)
	Landholder attitudes towards revegetation activities and remnant vegetation	(Jellinek et al. 2014)
	Public behavior affecting conservation outcomes	(Ng et al. 2014)
Social capital	Social relations and networks	(Mills et al. 2014) (Alexander & Armitage 2015)
Collaboration	Multiple stakeholders/ objectives	(Bode et al. 2010; Bryan et al. 2010a)
	Economic trade agreements	(Levin et al. 2013)
Social values	The social value assigned to ecosystems	(Bryan et al. 2011; Bryan et al. 2010b; Whitehead et al. 2014)
	Multiple stakeholder interests	(Klein et al. 2008)
	Community support	(Game et al. 2010)
	Social equity	(Halpern et al. 2013)

Financial	Cost of land	(Ando et al. 1998; Polasky et al. 2001)
	Management costs	(Balmford et al. 2000; Moore et al. 2004)
	Multiple conservation costs	(Naidoo et al. 2006)
	Return on Investment	(Murdoch et al. 2007; Tear et al. 2014; Wilson et al. 2007)
	Uncertainty of land availability / property costs /	(Carwardine et al. 2010; McBride et al. 2007; McDonald-Madden et al. 2008)
	Investment uncertainty Opportunity costs (socio-economic interests)	(Carwardine et al. 2008; Faith et al. 1996; Stewart & Possingham 2005; Venter et al. 2013; Williams et al. 2003)
Anthropogenic threats	Population & agriculture pressure	(Ceballos et al. 2005) (Wilson et al. 2005) (Wilson et al. 2006)
	Land conversion	(Wilson et al. 2010)
	Land use / degradation	(Wilson et al. 2007)
	Climate change	(Faleiro et al. 2013)
	Risk of habitat loss	(Wilson et al. 2011)
Governance factors	Corruption	(Eklund et al. 2011)

Legislative effectiveness	(Wilson et al. 2011)
Implementation feasibility	(Sewall et al. 2011)

Figures

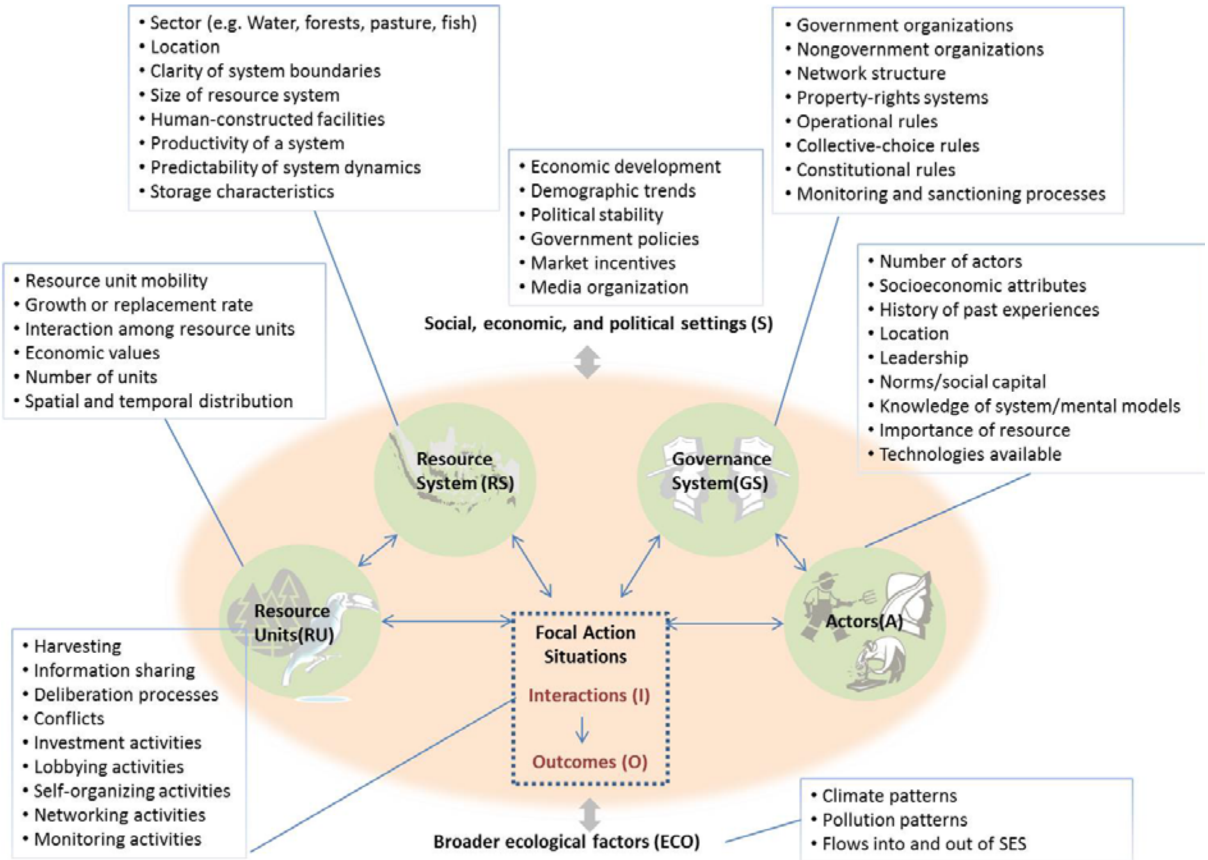

Figure 1. General framework for analyzing a social-ecological system. Boxes depict the social and ecological factors that can affect sustainability, livelihood and biodiversity outcomes, at multiple ecological scales (e.g. habitat, landscape) and socio-political scales (e.g. local, regional, national, global). Arrows depict how the different subsystems (RU, RS, GS and A) interact in a focal action situation. Interactions (I) influence different types of outcomes (O) - including biodiversity outcomes. Figure is based on Ostrom (2007, 2009) and McGinnis and Ostrom (2014).

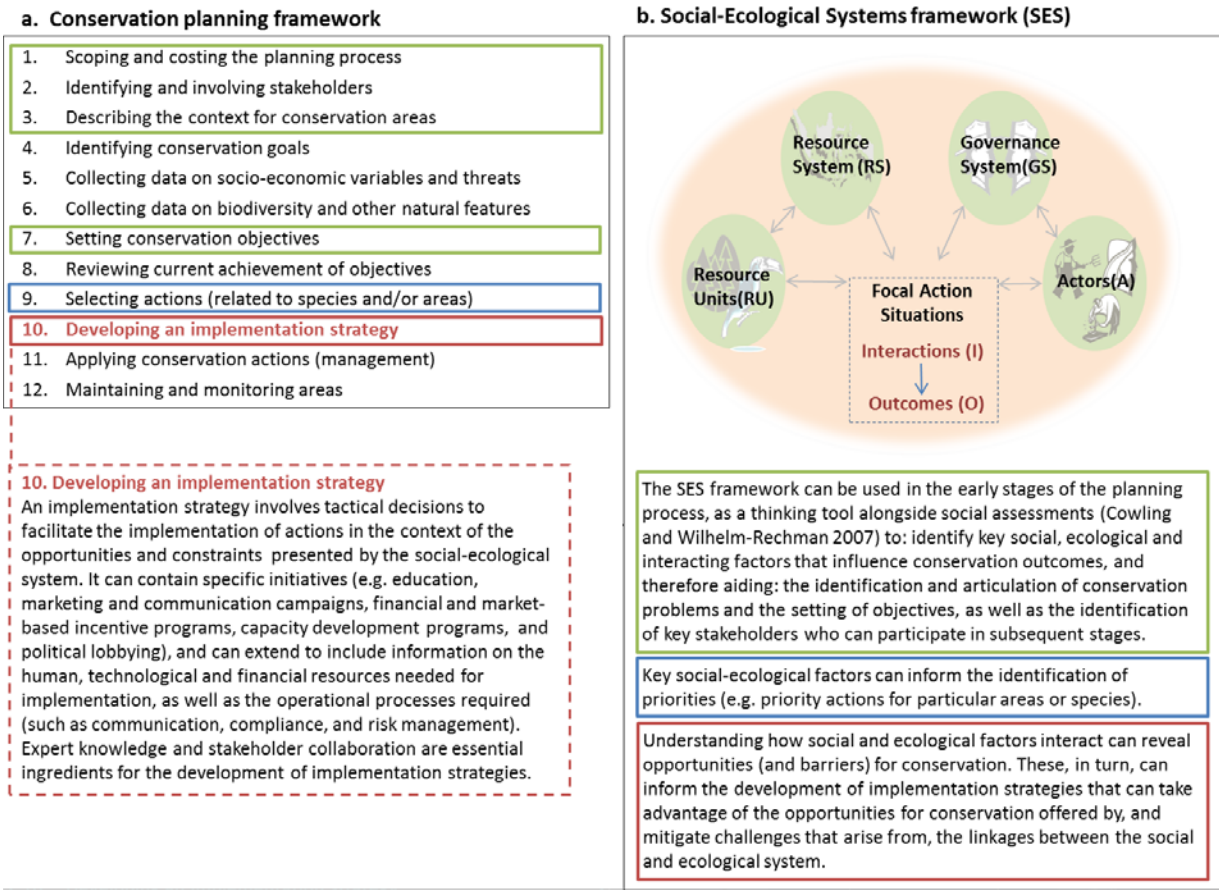

Figure 2. Three uses of a social-ecological systems framework in conservation planning (bottom right), using the systematic conservation planning framework (a) as an example. This framework has been adapted from of Pressey and Bottrill (2009) to include a new stage (stage 10), based on Driver (2003), Pierce et al (2005), Knight et al (2006a), Knight (2006b), and Cowling et al (2008). See Figure 1 for a detailed view of (b).

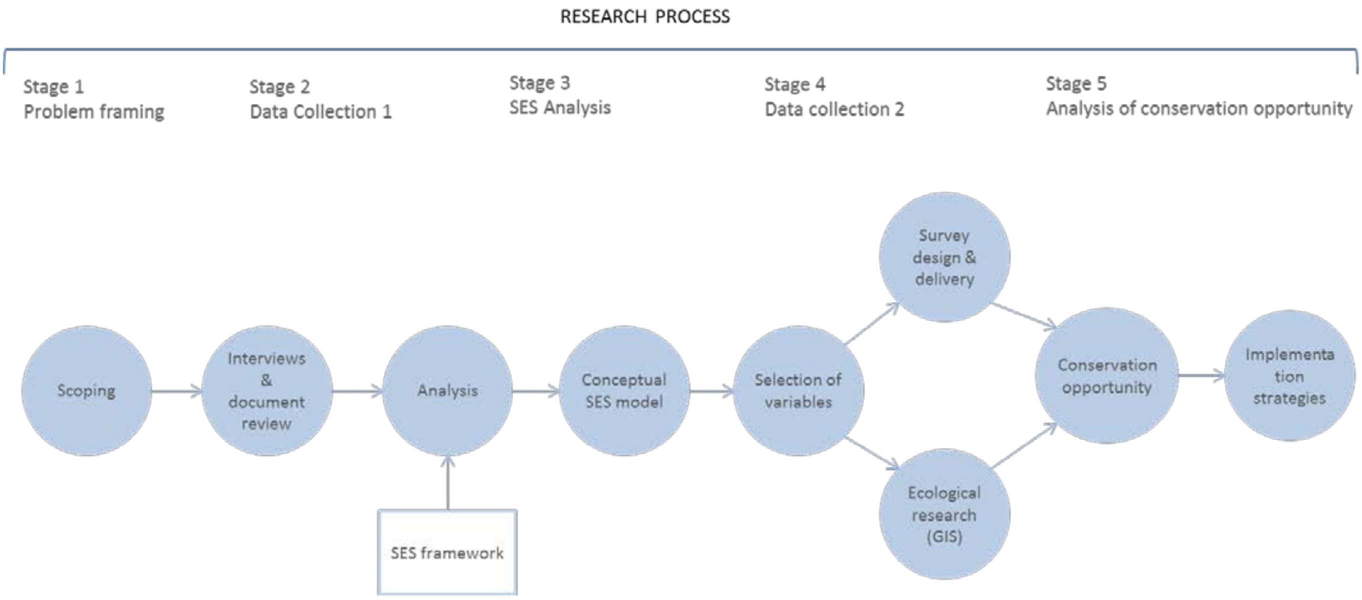

Figure 3. Research approach followed in this study.

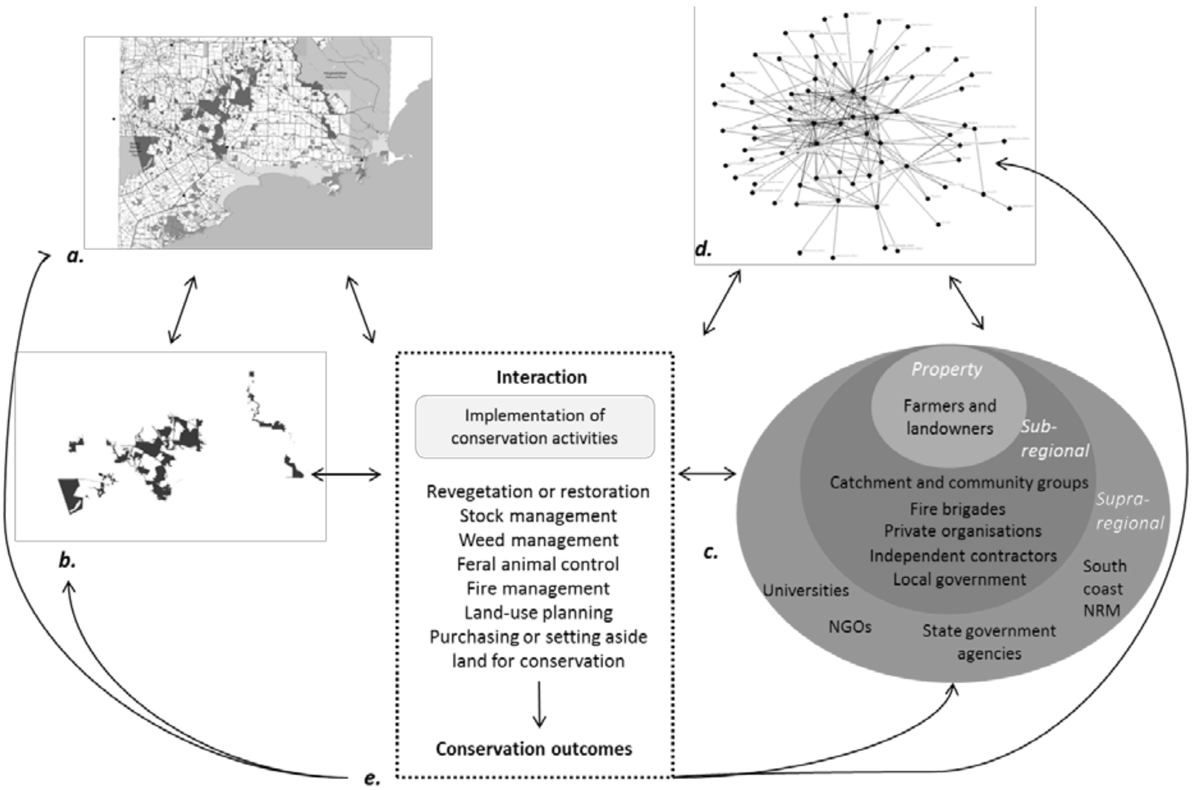

Figure 4. Conceptual model for the social-ecological system associated to the conservation of the Fitz-stirling region. Here the focal system of analysis is the broader landscape (i.e. matrix of remnant vegetation plus agricultural land). We identified the Resource System (a) as the entire Fitz-Stirling region, consisting of land used for agriculture and livestock production and land designated for conservation purposes. We identified the Resource Services and Units (b) as the remnants of native vegetation scattered through the landscape (totaling approximately 24,000 hectares). The Actors subsystem (c) is composed of the stakeholders that influence conservation outcomes at different scales, through land use and conservation activities in the Fitz-Stirling region, including landholders, government and non-government organizations and other stakeholder groups. The Governance System (d) includes the collaboration networks that relate to land-use management and conservation (specifically, organizational partnerships or community group collaborations). And our Focal Action Situation (e; where interactions between the social and the ecological system occur) is the implementation of conservation activities such as revegetation, protection of bushland and invasive species management.

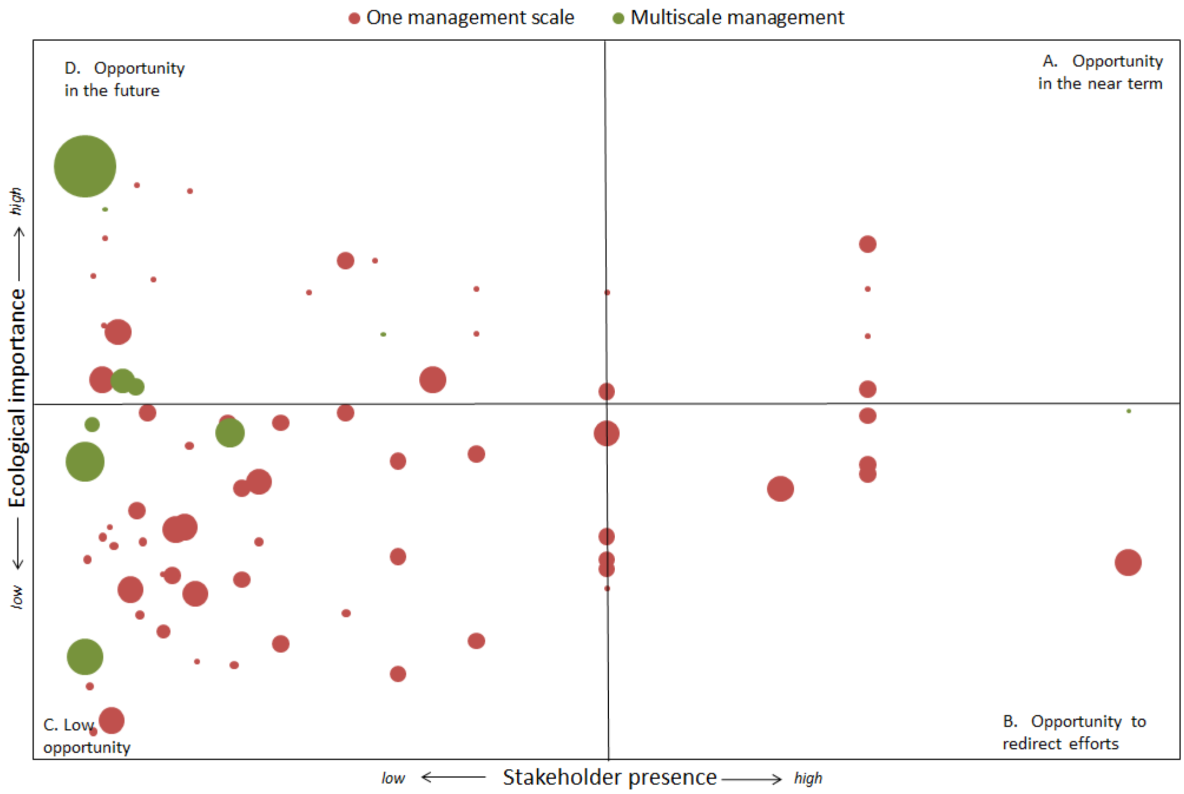

Figure 5. Vegetation clusters with different levels of ecological importance and implementation capacity. Implementation capacity metrics include stakeholder presence (proportion of stakeholders working in the area), stakeholder collaboration – measured by a degree centrality metric (i.e. total number of collaboration relations pertinent to each cluster), and the scale of management. Size of circles denotes the stakeholder collaboration associated to each area, from low collaboration (small circles) to high collaboration (big circles).