Achieving Cross-Scale Collaboration for Large Scale Conservation Initiatives

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Abstract
Large-scale conservation requires the involvement of numerous stakeholders to plan for and implement a range of activities across multiple scales. Establishing and sustaining the effective collaborations necessary to achieve this is a key challenge. Utilizing data from a large-scale conservation initiative in the south west of Australia we characterize the interactions between stakeholders as a social network. We employ a novel network theoretical approach to assess the different forms of collaboration, including cross-scale collaboration. We find that the social network predisposes cross-scale collaboration for invasive animal control, an action where coordination of activities is necessary. We find that for revegetation activities there is little evidence of collaboration across scales, but this could be fostered by a subset of stakeholders acting in a “scale-bridging” role. Addressing this will likely improve the effectiveness of revegetation efforts and the outcomes of the broader conservation initiative.

Introduction
Over the past two decades large-scale conservation initiatives have gained momentum as scientists and practitioners recognize the need to move beyond the identification and management of single protected areas to account for the management of surrounding landscapes (Lindenmayer & Burgman 2005). This new approach requires the consideration of ecological processes and threats that transcend protected area boundaries and determine the persistence of biodiversity in the wider landscape (Cowling et al. 1999; Rouget et al. 2006). Examples of large-scale conservation initiatives around the world, such as Yellowstone to Yukon (Y2Y) in North America and The Great Eastern Ranges in Australia, are characterized by multiple land tenures and jurisdictions, heterogeneous land uses and land covers, and numerous stakeholders with diverse, and potentially conflicting agendas (Worboys et al. 2010; Fitzsimons et al. 2013). Large-scale initiatives typically involve a diverse array of activities that span multiple ecological and management scales. Interpretations of the concept of “scale” vary and its definition is still contested across the social and natural sciences (Manson 2008; Higgins et al. 2012). We use the term “scale” to refer to the way the different interests of stakeholders participating in conservation initiatives fit along different spatial scales, from the property level to that of the supraregional (Saunders & Briggs 2002).

Large-scale conservation initiatives can benefit from an overarching plan (Pressey & Bottrill 2009; Fitzsimons et al. 2013) although this can hide local level variation in the values, interests and rights of local stakeholders (Cash et al. 2006; Pajaro et al. 2010). Overarching plans can be complemented by numerous smaller scale plans.
that are tailored to specific contexts and aligned to local realities (Marshall 2007; Lambert 2013). Still, integration across scales, is not automatically enabled by this approach (Carr 2013). Collaboration between the stakeholders of large-scale initiatives, including property owners, local communities, and government and nongovernment organizations, is required to enable adaptation of regional plans to local preferences, reconciliation of numerous plans, or scaling up of local actions (Henson et al. 2009; Lowry et al. 2009; Pajaro et al. 2010; Wyborn & Bixler 2013).

The establishment of relationships between individuals or organizations can lead to the coordination of activities, and can facilitate the formation of common goals and objectives (Jones et al. 1997; Snijders et al. 2006; Robins et al. 2011). Most large-scale conservation initiatives are underpinned by different collaborative arrangements, from short-term engagements, to long-term collaborative partnerships, to fully amalgamated institutions (Sabatier 2005; Wyborn 2013). These arrangements can entail formal agreements around a particular objective (e.g., Carlsson & Sandstrom 2008; Bode et al. 2010; Lauber et al. 2011), or develop informally around specific issues of conservation interest or establish over years of association, such as through the interactions between farmers when advice and information is shared (e.g., Isaac et al. 2007; Newman & Dale 2007; Vance-Borland & Holley 2011). We define these varied forms of relationships between the stakeholders of conservation initiatives as conservation social networks.

The level of collaboration between stakeholders in conservation social networks and the effective integration of planning and management across scales are key challenges for private land conservation (Kearney et al. 2012), marine resource management (Berkes 2006; Lowry et al. 2009; Pajaro et al. 2010), and landscape scale ecological restoration (Wyborn 2013). Initiating, and ensuring the longevity and sustainability of collaborative relationships, can be a lengthy process that can be impacted by budget limitations and funding cycles (Fitzsimons et al. 2013), dominance of individuals or organizations, obstructing disagreements between partners (Young 2006), or simply a lack of willingness to collaborate (Knight et al. 2010). Simply prescribing formal collaborative arrangements will not necessarily overcome these barriers and translate into greater capacity for or more effective collaboration (Lubell 2004; Carr 2013). Strategic approaches to the formation and support of effective collaborations for large scale conservation initiatives are needed.

The application of network theory to the study of collaborative processes and structures has been applied in diverse disciplines, including in natural resource management and conservation (Bodin & Crona 2009; Cumming et al. 2010). The goals of analyzing conservation social networks can range from understanding formal policy and institutional forms of governance (e.g., Sandstrom & Carlsson 2008) to more informal modes of governance that characterize many conservation endeavors, including community-centered governance and collaborative conservation initiatives (e.g., Lauber et al. 2008; Ernstson et al. 2010; Vance-Borland & Holley 2011). Typically, applications of social network theory in conservation link the structural characteristics of the whole network to theory about the social processes that underpin effective conservation governance (e.g., learning and innovation). Such characteristics can be explored using descriptive network statistics such as network centrality, cohesion, and density metrics (e.g., Isaac et al. 2007; Cohen et al. 2012). Fewer studies have analyzed whole networks by examining the subnetwork structures exhibited by stakeholders who interact within the network (but see Robins et al. 2011).

It is possible that comprehensive analysis of the relationships between stakeholders could reveal options to enhance collaboration within and across scales of planning and management. The analysis of these collaborative structural patterns would preface an understanding of the degree to which plans and activities are being, or can be, coordinated across scales (Guerrero et al. 2013; Bodin et al. 2014). This knowledge could then be utilized to inform a strategic approach for the formation or support of a conservation social network that enhances coordination of activities and higher forms of collaboration such as those leading to the formation of common goal and objectives. This could be facilitated by identifying key actors in the network or the connections between stakeholders that would be of most benefit.

We seek to better understand how stakeholders interact in a large-scale conservation initiative in Western Australia through analyzing the conservation social network. We statistically explore the different modes of interaction within and across scales for different types of activities (McAllister et al. 2014). We determine the propensity of the network to facilitate collaboration across scales to support multiscale conservation.

**Methods**

**Study region**

The Fitz-Stirling, our case study region, is situated in western Australia in one of the world’s 34 global biodiversity hotspots (Figure 1). This region is part of the Gondwana Link large-scale conservation initiative, which aims to restore ecological connectivity across over 1,000 km in southwestern Australia (Bradby 2013). The
Fitz-Stirling covers over 240,000 hectares, it is bounded by two of the largest areas of intact natural habitats that remain in the broader hotspot—the Fitzgerald River and the Stirling Range National Parks—and consists mostly of private farm land (cropping and sheep grazing) with scattered remnants of vegetation.

**Exploratory stage**

This stage informed the design of the network study and involved 25 semistructured interviews with stakeholders known to be involved in efforts to achieve conservation objectives for the Fitz-Stirling (see Supporting Information). We identified challenges to the implementation of conservation activities, including communication and coordination issues and the need for greater collaboration between different stakeholder groups. These findings were validated with quantitative methods (see Supporting Information) and pointed to the value of understanding how stakeholders interact to achieve conservation objectives for this region.

**Network definition and data**

The network was defined based on the collaborative interactions between stakeholders involved in conservation activities in the Fitz-Stirling region. An online survey was used to collect data on the people and organizations that each stakeholder collaborates with when performing different activities, including revegetation, protection of bushland, and invasive species management (Table 1). A stakeholder was deemed part of the network on the basis of their involvement with conservation activities in the Fitz-Stirling region. The data were collected between October 2011 and July 2012, at which time the Fitz-Stirling conservation social network included four state and three local government agencies, one regional natural resource management group, seven NGOs, ten community groups, five university and research organizations, over 20 private organizations and independent contractors, and around 120 property owners. We coded stakeholders by scale of interest, as: property; subregional; and supraregional level (Figures 2 and 4). We obtained 38 completed online questionnaires.
Cross-scale collaboration in conservation

Table 1 Main types of conservation activities in the Fitz-Stirling

| Types of conservation activity                  | Description                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| Revegetation/restoration                        | Over 1750 ha have been planted to date aided by the development and testing of large scale innovative restoration technologies, which include purpose built or modified machinery. |
| Livestock management                            | Activities such as fencing of bushland — to exclude cattle and sheep from sensitive areas are promoted by local community groups. |
| Weed management                                 | Activities to control damaging weeds such as the South African lovegrass are promoted by local community groups. |
| Invasive animal control                         | Invasive animal control activities include state-funded but community-run programs such as the Red Card for Rabbits and Foxes program plus more localized activities led by nongovernment organizations or landholders. |
| Fire management                                 | Landholders are required to ensure adequate firebreaks in their property to reduce the risk of wildfires. Bush fire brigades are coordinated by local government authorities and are comprised of hundreds of volunteer members (e.g., landowners). They assist in fire prevention and fire fighting. |
| Land use planning                               | Local government organizations interact with diverse stakeholders when undertaking planning activities that affect the Fitz-Stirling region. These include development approvals and local strategic plans that contain conservation objectives. |
| Purchasing or setting aside land for conservation | Around 10,900 ha of nongovernment conservation areas have been established in the Fitz-Stirling region since 2002 (Bradby 2013). |

Figure 2 Fitz-Stirling stakeholders’ scale of interest. At the property level a landowner decides whether they want to revegetate part of their land, protect remnants of bushland or manage threats such as invasive species. Community groups, local government and private organisations, make decisions at the sub-regional level, with an interest on particular areas (e.g. catchments). At the supra-regional level, state government and non-government organisations engage in state, national or international policy and projects, and provide funds or support for activities across the entire region. Universities and research organisations operate at a supra-regional level and also engage in projects which can influence and inform decisions across the entire region.

(19 organizations and 19 landowners). With this data we were able to identify the full set of collaborative interactions for the 38 respondents plus partial information on the collaborative interactions for an additional 47 organizations who did not respond to the survey. (See Supporting Information for a full description of data collection methods).

Conceptual framework

Our interest concerns the role of stakeholders that operate at multiple scales in a network. In particular we focus on how different types of interactions favored by individuals and organizations contribute to whole of network collaboration, and collaboration within and...
across scales. We use the term “collaboration” to refer to different types of interactions between stakeholders. Social processes such as the coordination of activities depend on such interactions being present (Granovetter 1973; Olsson et al. 2007). The different roles of stakeholders manifest as observed variances in the types of subnetwork interactions that they engage (McAllister et al. 2014). Such subnetwork interactions are referred to as configurations, and these can be mapped to theoretical ideas beyond the limited set provided by a more conventional social network analysis, which is typically based on describing the detailed structure of entire networks (Bodin & Tengo 2012; McAllister et al. 2014). To frame our analysis, we start by asking, what are the network configurations that we expect to see over- or underrepresented for stakeholders engaged in activities that require collaboration within and across scales.

Social conservation networks can be structured in very different ways. For example, multiple stakeholders can tend to cluster around a single stakeholder, forming a “star” (Figure 3). This network configuration connects stakeholders indirectly through a key stakeholder. In contrast, other configurations tend to be more tightly bonded or “closed,” connecting stakeholders directly to each other (Figure 3). Within these general network configurations there can be different modes of interactions such as collaboration between stakeholders within the same scale; and collaboration across scales. There can also be scale-bridging configurations, where a stakeholder connects stakeholders from different scales (Ernstson et al. 2010).

**Figure 3** Conceptual Framework. Different network configurations can be found within collaboration networks. These general structures e.g. more centralised or more closed and cohesive, can be studied to assess different modes of interaction e.g. within the same scale or across operational scales.

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**Exponential random graph models and configurations**

We utilize Exponential Random Graph Modeling (ERGMs) to identify the different modes of interaction that characterize the Fitz-Stirling network. ERGMs uses a statistical (regression) methodology to determine if certain configurations are more or less represented in an observed network than expected by chance alone (Wasserman & Pattison 1996; Snijders et al. 2006). In this manner, and like other inferential statistics, ERGM does not necessarily require that the whole network is measured (Robins et al. 2004). Observed frequencies of selected configuration are compared with frequencies derived from a large set of randomly generated networks to determine if these configurations are prevalent or rare in the network under study. In this way, statistical inferences can be drawn without the need for comparative networks. Importantly, ERGMs test for the prevalence of these configurations given the distribution of all other configurations included in the model. Some subnetwork configurations are nested within higher order configurations, so two configurations might compete to explain an interaction observed in a network. Making inferences about a social process, such as collaboration, therefore requires analysis of nested configurations, allowing interpretation of an observed configuration...
relative to observations about all other configurations. In this way, ERGMs permit an understanding of the complex combination of social processes by which network connections are formed. We used the computer package pNet (Wang et al. 2009) to analyze three networks based on (1) all-activities (see Table 1), (2) revegetation, and (3) invasive animal control.

Results

Exponential random graph model

We parameterize a model for the all-activities, the revegetation, and the invasive animal control networks that included the 11 configurations shown in Table 2 (see Supporting Information for further modeling detail). For the all-activities network, 9 of the 11 configurations are statistically significant, indicating over- or underrepresentation of these configurations in the network (depending of the sign – or +; Table 2). Our model contains parameters that account for the broad structural characteristics of the sampled network data (“star” and “closed” configurations). These configurations are critical for providing us a baseline that allows us to interpret the differences between the configurations of interest, namely within and cross-scale interactions.

Our key interest concerns the role played by stakeholders operating at different scales across the network. The all-activities model shows significantly greater representation of cross-scale interactions for stakeholders at the property and subregional scales, suggesting their inclination to collaborate across scales. Conversely, the model shows fewer representations of within-scale interactions for stakeholders at the subregional scale, whereas they are overrepresented for the supraregional stakeholders. Finally, there is evidence of scale-bridging roles suggested by the overrepresentation of scale-bridging interactions for all stakeholder categories.

For the revegetation activity network (Figure 4b), 7 of the 11 configurations are significantly over- or underrepresented (Table 2). There is evidence of underrepresentation of cross-scale interactions, although scale-bridging roles are apparent. For the invasive animal control activity network (Figure 4c) the results show that within-scale interactions are underrepresented for subregional

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**Figure 4** Conservation Social Network for the Fitz-Stirling. The all-activities (a), the revegetation (b), and the invasive animal control (c) networks. Nodes represent the different stakeholders and the links indicate collaborative interactions. The shapes of the nodes represent the scale of interest: property (diamond), sub-regional (triangle), and supra-regional (square).
Table 2  Exponential Random Graph Model (ERGM) model for the Fitz-Stirling conservation social network for the (A) all-activities, (B) revegetation, and (C) invasive animal control networks. Estimated parameters and observed configuration counts are based on a model with a fixed density of 0.0574, 0.0218, and 0.0176, respectively

| Baseline configurations | Configuration | (A) All-activities network | (B) Revegetation network | (C) Invasive animal control network |
|-------------------------|---------------|----------------------------|--------------------------|-----------------------------------|
|                         | Parameter estimates | Observed countsa | Parameter estimates | Observed countsa | Parameter estimates | Observed countsa |
| Star                    | 0.3965*         | 587              | 1.0822**           | 193              | 1.0958**           | 182              |
| Closed                  | −0.1876*        | 256              | −0.033            | 78               | −0.3337           | 46               |
| Mode of interaction     | Parameter estimates | Observed countsa | Parameter estimates | Observed countsa | Parameter estimates | Observed countsa |
| Within-scale (property) | −2.275           | 5               | N/Ab             | 0                | N/Ab              | 0                |
| Within-scale (subregional) | −1.8257**       | 13              | −0.9841          | 7                | −3.4069**         | 5                |
| Within-scale (supraregional) | 0.9977**        | 49              | 0.6255           | 17               | 2.1195*           | 11               |
| Cross-scale (property)  | 0.3267**        | 73              | −4.0711**        | 31               | 3.8099**          | 26               |
| Cross-scale (subregional) | 0.7976**        | 142             | −3.9261**        | 54               | 2.548**           | 33               |
| Cross-scale (supraregional) | −0.0104        | 195             | −4.1462**        | 71               | 0.8853*           | 47               |
| Scale-bridging (property) | 0.0411**        | 283             | 0.088           | 80               | −1.8949**         | 9                |
| Scale-bridging (subregional) | 0.0538**        | 514             | 0.1175**         | 175              | −0.0392           | 459              |
| Scale-bridging (supraregional) | 0.0453**        | 1845            | 0.084*           | 271              | −0.0454           | 180              |

*"** shows 90/95/99% significance for the parameters.

a T-tests show no statistical difference between the observed configuration counts and simulation means.

b One parameter could not converge as there are no instances of this configuration in the observed network.

stakeholders, whereas they are overrepresented for the supraregional stakeholders. Cross-scale interactions are represented greater than expected by chance for all stakeholder groups associated with invasive animal control activities.

**Discussion**

We have applied a novel method and developed an approach to analyze the ways in which stakeholders interact with one another to achieve conservation goals. We have applied this approach to a large-scale conservation initiative in Australia. The results suggest that in the Fitz-Stirling study region the coordination of plans and actions between stakeholders operating at a property or subregional scale is likely to present a challenge, given the underrepresentation of within-scale interactions at these levels. In particular, the coordination of invasive animal control activities in the Fitz-Stirling is less likely to occur at the subregional level, which is problematic given the prevalence of community-run programs for invasive animal control in the study region. The importance of coordinated efforts for the success of invasive animal control activities is well known (Coutts et al. 2013).

More central to our interest is the ability for collaborative conservation initiatives to enable the coordination of plans and actions across scales. Overall, cross-scale coordination in the Fitz-Stirling conservation social network can be facilitated by stakeholders at the property scale, and in particular, stakeholders at the subregional scale, who favor interactions across scales over within-scale interactions and show evidence of scale-bridging roles. Such roles have been observed in other studies. For example, a study on farmer adoption of conservation practices suggests that subregional natural resource management bodies in Australia are better positioned than
regional bodies to motivate cooperation from farmers (Marshal 2009). This finding is particularly important for activities and programs devised at higher levels, and that are expected to be cascaded down to the property level for implementation. An example is invasive animal control programs originating from government agencies, such as the Red Card for Rabbits and Foxes operating in Western Australia since 2004, which provides government funding to local groups for the purchase of baits, and is mostly driven by local coordinators.

For the Fitz-Stirling region our results suggest that while capacity for within-scale coordination could be strengthened for invasive animal control activities, capacity for cross-scale coordination of this activity is strong. This contrasts with our finding for revegetation activities where coordination across scales is likely to present a challenge given the underrepresentation of cross-scale interactions. However, the results show that some subregional stakeholders are well positioned to facilitate cross-scale collaboration for revegetation activities, given the overrepresentation of scale-bridging interactions. Making these stakeholders aware of their strategic position in the network, and supporting them in this role, may enhance coordination of revegetation activities across scales.

We demonstrate that network analysis can be used to determine the propensity for a network to support key social processes such as the coordination of key activities within and across scales. This information can then be used to identify ways that collaboration can be further promoted and inform future strategies and partnerships. We suggest that the Fitz-Stirling conservation social network should focus on developing new partnerships to strengthen relations within the subregional level, and provide further support to subregional stakeholders acting in a scale-bridging role.

Our dataset is a partial sample of the complete network, which means network links are only observed around the organizations and landowners who responded to the survey. This means that the network data cannot be used to derive descriptive statistics about the network or make interpretations about individuals in the network. We have not attempted to do either. Our analytical method treats network connections as a statistical sample, and hence robust conclusions can be drawn from partial networks. A complete dataset reduces the standard errors and there are emerging technical approaches for ERGMs to reduce standard errors in the context of missing data (Koskinen et al. 2013). However, in our analysis statistical patterns were observed which tells us that our dataset is a sufficient sample from which to analyze the patterns observed. While more data are certainly better, network data can be expensive and time consuming to collate, often with substantial logistical considerations. We demonstrate that even with incomplete data it is possible to undertake a practical analysis for a real conservation problem, and in doing so we have also contributed to the development of new, cutting edge approaches for analyzing social processes that are critical for the effectiveness of conservation actions.

The importance of collaboration for achieving conservation outcomes is well-known (Bode et al. 2010; Mazor et al. 2013), especially when multiple geographic scales are involved (Fitzsimons et al. 2013; Wyborn & Bixler 2013). We provide an approach for determining the potential for a network to support multiscale conservation and demonstrate its utility in a complex system that involves multiple stakeholders that undertake diverse activities across scales. Targeted approaches for the development and support of collaborative relationships can reduce the complexity that characterizes large-scale conservation initiatives. Specifically, it can avoid the inefficiencies that can result from comprehensive overarching approaches to specifying collaborative partnerships and governance arrangements. A targeted approach to understanding and enhancing collaborative relationships, such as the one we demonstrate, can improve the effectiveness of conservation initiatives by identifying, and nurturing key stakeholders and important relationships.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher’s web site:

Table S1: Semistructured interview guiding questions.
Table S2: Conservation activities in the Fitz-Stirling.
Table S3: Survey question: network boundary question.
Table S4: Survey question: collaboration network.
Table S5: Step 1 models for the all-activities (A), revegetation (B), and pest animal control networks (C) estimated as Exponential Random Graph Models using pNet.
with fixed Densities of 0.0574, 0.0218, and 0.0176, respectively. – ‘*’/*:* showing 90/95/99% significance for the parameters. T-tests compare observed configuration counts against simulation means.

Table S6: Step 2 models for all-activities (A), revegetation (B), and pest animal control networks (C) estimated as Exponential Random Graph Models using pNet, with fixed Densities of 0.0574, 0.0218, and 0.0176, respectively. – ‘*’/*:* showing 90/95/99% significance for the parameters. T-tests compare observed configuration counts against simulation means. * One parameter could not converge as there is no instances of this configuration in the observed network.

Table S7: Step 3 models for all-activities (A), revegetation (B), and pest animal control networks (C) estimated as Exponential Random Graph Models using pNet, with fixed Densities of 0.0574, 0.0218, and 0.0176, respectively. – ‘*’/*:* showing 90/95/99% significance for the parameters. T-tests compare observed configuration counts against simulation means. * One parameter could not converge as there is no instances of this configuration in the observed network.

Figure S1: Perceived usefulness of collaborating with others who have opposing values, interested or goals. Rating scale 1–5, n = 32.

Figure S2: Perceived barriers to conservation action implementation. Proportion of respondents who mentioned each barrier—unprompted (n = 33).

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