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Original Research Article

Not more, but strategic collaboration needed to conserve Borneo's orangutan

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ABSTRACT

In conservation, Collaboration is thought to improve returns from investment and is frequently encouraged, however not all collaborations are equal and may therefore lack characteristics important for addressing collective action problems. Furthermore, partnerships that are advantageous for a collective may not necessarily be advantageous for an individual. This study investigated collaboration within the Bornean orangutan (*Pongo pygmaeus*) conservation sector – a system with reported inefficiencies and for which there has been a renewed call for collaborative partnerships. Collaborative partnerships were conceptualised as a social network and analysed using exponential random graph modelling. The prevalence of structural attributes associated with social processes considered to be important for solving collective action problems such as trust and innovation were investigated. Qualitative surveying techniques were used to measure the perceptions of collaboration held by individual actors within the network and the impact of organizational attributes on network formation and perceptions was assessed. Collaboration was found to be occurring within the conservation network and was positively perceived at the individual organisational level. At the collective level, the current collaborative network contains some structural characteristics important for addressing the collective-action problem of orangutan conservation, particularly through innovation and knowledge sharing. However efforts to develop trust between organisations may be needed. To improve returns on investment, future collaborative partnerships must be strategically implemented with individual roles and desired overall outcomes explicitly articulated. Increased operational transparency and improved performance evaluation will be critical for achieving improved collaborative efficiency.

1. Introduction

Collaborative conservation projects can enhance the achievement of conservation goals. Theoretical models suggest benefits associated with the coordination of activities (Bode et al., 2011; Mazor et al., 2013), enhanced efficiency as a result of

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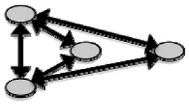
information and resource sharing (Gordon et al., 2013; Mills et al., 2014), and improved adaptive capacity and resilience (Dukes et al., 2011). In practice, some examples of effective collaborative conservation projects are the Yellowstone to Yukon initiative (Tabor et al., 2014), the greater Virunga transboundary initiative (Wambede, 2011), and the European Green Belt (Zmelik et al., 2011).

The presence of collaborative partnerships alone however, does not guarantee the achievement of desired outcomes. For collaboration to be worthwhile, the benefits must outweigh the costs (Gordon et al., 2013; Kark et al., 2015; McAllister and Taylor, 2015). Collaborative partnerships in conservation can entail high transaction costs, particularly when - institutional strength is lacking and decision-making forums are short lived or underfunded (Berardo and Lubell, 2016). Typically, the costs associated with collaboration are measured as the financial value of resources used to locate partners and execute an activity (Collins and Fabozzi, 1991). However, the establishment and maintenance of relationships can also entail an opportunity cost, as the allocation of resources to a collaborative relationship typically reduces the resources that are available for other potential activities (McLaren et al., 2002). There is also risk associated with conservation projects when individual interests conflict with collective interests, potentially detracting from the effectiveness of collaborative efforts. For example, organizations may share common goals but disagree on the best method to achieve them, resulting in the fragmentation of conservation efforts that might not address the needs of the collective whole (Berardo and Scholtz, 2010; Berardo and Lubell, 2016). Furthermore, direct conflicts between actors may result in additional adverse outcomes such as the failure to execute projects along with associated reputational impacts.

For collective-action problems where multiple stakeholders undertake the management of a common good, as is the case in conservation, social processes pertaining to both trust and innovation are needed (Berkes et al., 2003; Bodin et al., 2006; Foster and Meinheard, 2002; Guo and Acar, 2005; Newman and Dale, 2005). Trust is theorised to reduce risk and transaction costs associated with collaborating, and can be developed through repeated dealings with a small subset of actors (Chen and Graddy, 2010; McAllister et al., 2015). In contrast, innovation arises from the dispersal and acquisition of new types of knowledge from different sources and requires a diversity of ties between multiple actors (Burt, 2001; Inkpen and Tsang, 2005). The development and delivery of collaborative initiatives therefore necessitates emphasis on each of these social processes at different stages. Innovation and the dispersal of knowledge being important for stakeholder identification and problem definition during program development and trust important for program delivery (McAllister et al., 2015).

Patterns of collaborative partnerships between multiple stakeholders can be depicted as a social network. Social networks are an effective means of conceptualising and visualising interactions between different stakeholders (actors) and the application of social network analysis (SNA) methods can provide insight on who is interacting and how frequently (Bodin et al., 2006, Prell et al., 2009). Conventional forms of SNA are able to provide a descriptive insight into a system, and do so typically by analysing the structure of the entire network (Borgatti et al., 2009). Such analysis however is not able to conclude the nature of these collaborations, for example, the social processes underpinning the relationships and what the collaborations achieve. Employing a recent extension of a class of stochastic network models called Exponential Random Graph Models (ERGM; Snijders and Pattison, 2006), this paper investigates the overall structure of a conservation network along with the underlying social processes characterising collaborative partnerships (Table 1). Using the Bornean Orangutan Conservation Network as a case study, we empirically evaluate the extent of collaboration between actors, determine whether social processes of trust and innovation are prevalent in the observed network configuration, and ascertain the relationship between organisational attributes and perceptions of collaboration.

Table 1
Conceptual framework - configurations of interest within the observed social networks and their importance for explaining underlying social processes.

CONFIGURATION	NAME	MEANING	IMPORTANCE	REFERENCE
	Reciprocity	A bi-directional tie between actors.	Minimum requirement for collaboration to occur between organizations.	Henry et al. (2010), Lee et al. (2012)
	Open-out-star (AoutS)	A single central actor has ties to multiple actors, but those actors do not have ties to each other.	Coordination can allow for the exchange of resources and ideas and facilitates innovation. More ties prevent redundancy in information exchange	Robins et al. (2009)
	General Closure (AT-TDU)	Actors are well connected to one another.	Facilitates sanctions that make it less risky for organizations within the network to trust one another.	Snijders and Pattison (2006), Robins et al. (2009)

1.1. Case study

The conservation of Critically Endangered orangutans (*Pongo pygmaeus*) on Borneo (Ancrenaz et al., 2016), is an example of a large conservation initiative for which collaboration between numerous governmental and non-governmental actors is needed. Here we focus on the non-governmental components of conservation networks. Whilst not-for-profit, non-government conservation organizations share a common fundamental goal to 'save' the orangutan, a lack of collaboration and an incohesive approach to action implementation has previously been identified as a major weakness associated with the orangutan conservation sector (Fisher, 2010; Meijaard et al., 2012; Rijksen and Meijaard, 1999).

2. Methods

A five step process was undertaken to investigate the nature of collaborative partnerships in the orangutan conservation sector. Details pertaining to each of these five steps are elaborated upon in the following subsections of the methods (2.1–2.5). To summarise, actors and linkages between actors first were identified through a comprehensive internet search followed by qualitative surveys and semi structured interviews (2.1). In addition to ascertaining network ties (i.e connections between actors), surveys and interviews were also used to obtain actors perceptions of collaboration (2.2). Social networks were then constructed based on each of the data collection methodologies (Table A1) and a preliminary investigation of network structures and characteristics undertaken (2.3). Exponential Random Graph Modelling (ERGM) was then employed to analyse the structural attributes of the social network (2.4). Finally the relationship between organisation attributes and collaborative perceptions was investigated (2.5).

2.1. Case study system and associated actors

The protection of forest on the island of Borneo has been the central focus of numerous national and international conservation groups since the 1960's with the orangutan becoming an international symbol for conservation efforts in this region. Despite allocation of over US$20 million per annum in government and non-government conservation efforts (Meijaard, 2014), the average annual loss of orangutan habitat has been 3122 km^2 (Meijaard et al., 2012) and up to 2500 orangutans are lost annually in Indonesian Borneo alone (Davis et al., 2013). In the absence of a long lasting, centralised governance arrangement regarding roles and responsibilities of different actors, the orangutan conservation network is largely self-organized.

We identified the actors in this system and the presence of collaborative relationships between these actors through a comprehensive Internet search and hyperlink method of network construction, where we assumed that links from one organization's webpage in both the form of hyperlinks and in-text references to another organization were indicative of an organizational relationship (Kreakie et al., 2015). Organizations satisfying the following criteria were included:

a. The organization has an active project where conserving the Bornean Orangutan and its habitat were explicitly stated in their organization aims or mission statement.
b. The organization undertakes these activities as part of a research association, charitable foundation or as a not-for-profit organization according to relevant national criteria (i.e. registered as charity on state or national social organization registers).

For the identified organizations, characteristics such as core activities, goals, operational location, registration base and date of establishment was also recorded with data obtained from annual reports and financial statements. Network linkages were constructed based on an organization being explicitly named on a website of another organization (through text or hyper-links) as a partner, friend or collaborator. A total of 61 organizations were identified (Fig. 1).

2.2. Qualitative data collection

An online survey (Qualtrics, Provo UT) was distributed to all organizations identified through the web based analysis during April–May 2015 in English and Bahasa Indonesian. The survey was divided into three sections. The first section focused on identifying organizational characteristics and collaborative partners (i.e other organisations that were considered to be partner, friend or collaborator). The second described a specific collaborative endeavour, including the perceived costs and benefits. The third section focused on eliciting the perceptions of past collaborative activities. The survey was also used to refine and identify any additional organizations and relationships between organizations not previously identified through the hyperlink method (see Fig. 1b). Where organizations were unable to participate in the survey but expressed willingness to participate in the study, semi-structured interviews were undertaken during a regional stakeholder meeting coordinated by the United Nations Environment Program's (UNEP) Great Ape Survival Program (GRASP) in Kota Kinabalu, Malaysia in July 2015. 16 surveys were returned and three interviews with organisational representatives were undertaken following the same lines of questioning detailed in the survey (see online appendix A1). Interviews were recorded and later coded using

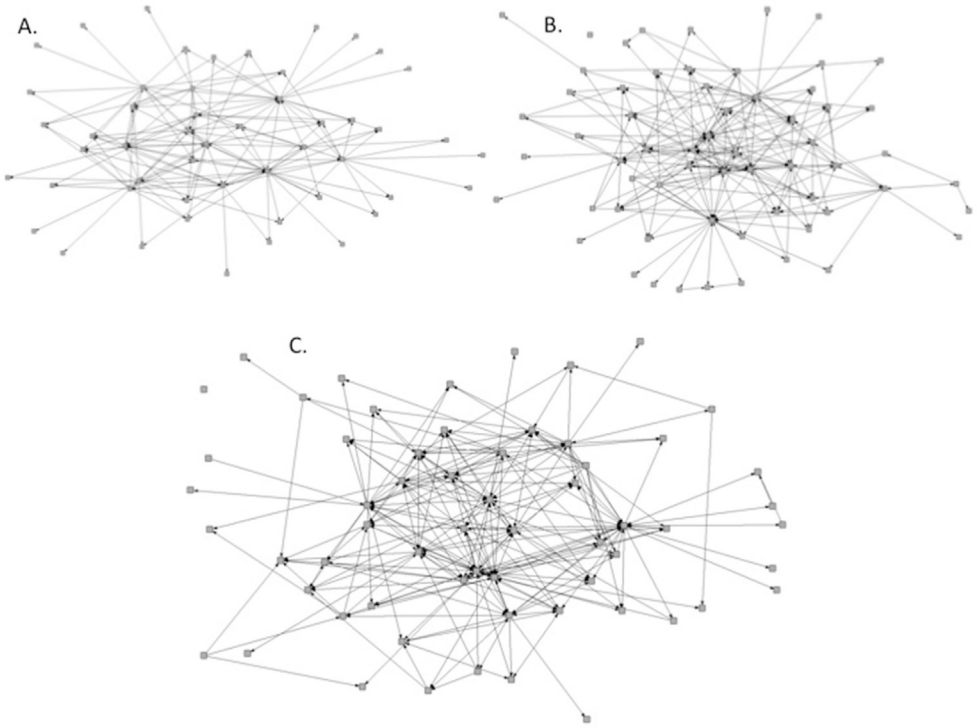


Fig. 1. Orangutan conservation network. (A) The whole network identified through the hyperlink method. Squares represent organizations and lines the collaborative ties reported to exist between organizations (n = 61). (B) The network identified through surveys and semi-structured interviews (n = 53). (C) The combined network, linkages identified through both the hyperlink method as well as through surveys and interviews.

Nvivo. Survey and interview procedures adhered to The University of Queensland ethics guidelines approval number 2005000940.

2.3. Network construction

Individual networks based upon each of the data collection methods (the website-based method and the combined survey/semi-structured interview approach) were constructed with linkages directed from focal organisations to reported partners and analyzed (see online appendix Table A2). Each of these methodologies are characterised by different strengths and limitations. For example, participation in the survey was low at just over 30% (n = 19/61). In contrast, the website-based methodology found ties between all but one organization, thus achieving a larger sample size. While we followed a clear protocol for determining linkages through the web-based method, these are only indicative of an organizational relationship, whereas survey responses provide greater certainty of relationship presence (Kreakie et al., 2015).

Despite these differences, both methods of network construction showed similar characteristics (i.e. density and centrality scores, see Table A2) suggesting that the two methods of data collection were not greatly influenced by the varying response biases. The matrices of both networks were also assessed and showed statistically similar reporting frequencies (survey network mean = 10.9, SE = 1.5. web based network mean = 10.3, SE = 1.7) and relationship patterns, whereby data obtained through the survey and interviews with participating organisations replicated 99.4% of the relationships identified through the hyperlink methodology. Subsequently, data derived from both the website-based methodology and the combined survey semi-structured interview approach were amalgamated to overcome the aforementioned limitations to form the focal network on which analysis was undertaken.

2.4. Analysis of the conservation collaboration network

We analyzed the structure of the network by employing Exponential Random Graph Modelling (ERGM) undertaken with p*net software (Wang et al., 2009). We used ERGM to statistically identify over or under-representation of patterns in the network (configurations) compared to what would be expected to occur through chance alone (Robins and Morris, 2007; Lusher et al., 2012) (Table 1). Network configurations found to be over or under-represented can then be used to infer the presence of social processes (e.g. innovation and trust) important for conservation and natural resource management (Bodin et al., 2006; Bodin and Tengo, 2012; Lubell et al., 2014; McAllister et al., 2015). The ERGM statistically infers the probability of

network configurations occurring relative to the presence of other network characteristics (Lusher et al., 2012). This is done by comparing observed frequencies of subnetwork configurations 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 (Snijders and Pattison, 2006). Importantly the model specifications used in ERMGs reproduce many of the structural features common in observed social networks and test for the prevalence of subnetwork configurations given the distribution of all other configurations included in the model (Snijders and Pattison, 2006).

We were primarily concerned with understanding the social processes of trust and innovation within the orangutan conservation community and subsequently, focused our attention on sub-network configurations related to network openness and closure (Table 1). Tendencies towards openness, where actors are connected to other actors who are in turn connected to different actors is thought to facilitate innovation through the uptake of novel information and techniques (Bodin and Crona, 2009, Lusher et al., 2012). Through such open bridging structures, actors are better able to access novel forms of information from distant parts of the network (Berardo and Lubell, 2016; Newman and Dale, 2005). Openness within the network is demonstrated through the presence of open 'star' configurations where a central actor is connected to multiple actors. Conversely, closure, where all actors are connected to one another is theorised to promote trust by lowering risk and transaction costs associated with establishing a new partner as well as imposing sanctions for selfish behaviour (Burt, 2001). Since trust and innovation are important for addressing complex problems such as conservation, a balance between openness and closure is therefore needed (McAllister et al., 2017).

The prominence and influence of several key attributes that could explain the social processes observed in the network configurations were also incorporated into the models. The parameterization of these individual level characteristics as binary, categorical or continuous variables facilitates examination of attribute-related processes on network ties. Attributes of interest in this analysis included the age of the organization, registration location, its area of operation, and primary activity. The method in which data was obtained (i.e. website-based or combined survey/interview approach) was also included as a binary attribute to control for potential reporting bias. The age of an organization is considered to be a likely predictor of network ties with older organizations positively correlated with number of ties (Armsworth et al., 2012; Guo and Acar, 2005). A close geographical proximity between actors is theorised to increase the likelihood of collaboration (Lomi and Pallotti, 2012; Whittington et al., 2009). For the Bornean Orangutan conservation network, geographical proximity can be considered as the area in which the organization is operating (e.g. undertaking conservation interventions in the same national park or region) or where the organization is registered (e.g. head offices located in the same country). Close geographical proximity can ease logistical constraints and represent similarities in the governance structures and policy environments in which organizations operate. For example, within this case study system, social organization policies (i.e. Indonesia Law 17 of 2003, Malaysia Societies Act 1966) restrict the activities of international non-governmental organizations. Consequently collaborations are established to channel resources from outside Borneo in support of on−ground activities. As orangutan conservation involves a series of complementary activities, (e.g. research is needed to identify priority areas for protection, habitats need to be protected for rescued individuals to be released into) it was expected that ties would exist between actors of different activity types. Alternatively it was also thought that within each of these specializations, hubs of expert knowledge may develop, thus reinforcing ties between actors undertaking the same activity (see online appendix able A2 and A3 for further detail).

2.5. Perceptions of trust, innovation and collaboration

Collaborative interactions can involve the exchange of similar resources (e.g. information) or dissimilar resources. The latter of these two exchanges present greater challenges to accurately measure and account for, particularly if the collaboration involves the exchange of tangible resources (such as money or equipment) for intangible benefits (such as knowledge, expertise or reputational benefits) (Kaplan and Norton, 2004). As such, calculating the perceptions of collaboration from the perspective of an individual organization is a useful mechanism to gauge interactions (Kaplan and Norton, 2004; Wagner et al., 2010).

To measure perceptions of trust, innovation and overall collaboration and to identify factors that influence these perceptions, survey participants were asked to score the frequency in which they experience knowledge gain through collaborative interactions as well as an increase/loss of trust. Trust can arise between actors for specific dealings and interactions (e.g when one actor trusts another actor in regards to particular issue), or can occur more generally where actors can base judgements of trustworthiness based on their own frame of reference (Baral, 2012). Our survey gauged the latter 'generalized' definition of trust (see online appendix A1 for further detail). Additional elements that characterize the advantages and disadvantages associated with collaboration were referred to in the survey to gauge an overall perception of collaboration (online appendix Table A4). Reported values for advantages and disadvantages were then averaged to calculate scores for positive and negative perceptions of collaboration.

The relationship between trust and innovation scores and the four organizational attributes (age of organization, registration location, area of operation and primary activity) was assessed using Welch's ANOVA. As with the ERGM analysis, age of organization was included as a continuous variable and registration location, area of operation and primary activity characterized as categorical variables (online appendix Tables A3 and A4). However, unlike in the ERGM, area of operation was reclassified as number of operational areas in order to ensure organization anonymity. In addition, attributes relating to financial capacity (primary source of funding (public donors/other) and annual gross income (whole organization $US p.a.)), were also included as a categorical and continuous variable respectively. Information on primary source of funding was

obtained through the survey and verified through content analysis from annual reports and financial statements. Organizations were considered to obtain the majority of funding from public sources if donations and contributions outweighed income obtained through grants and corporate sponsorship. Information on annual gross income was obtained from the latest published financial statement for each organization.

This same methodology was used to assess the relationship between overall positive and negative perception scores and organisational attributes. A polynomial regression was then fitted to explain the relationship between perception scores and number of actors with which an organization was reported to collaborate with (as recorded by other actors in order reduce biases associated with self-reporting). A polynomial regression was selected as it was hypothesized that collaborative frequency involved a cost benefit trade off, where few partners would yield few advantages or disadvantages and many partners would necessitate significant investment likely to outweigh advantages.

3. Results

3.1. Network analysis

The ERGM estimates presented in Table 2 indicate the network structures that are prevalent in the Bornean Orangutan conservation network. The significant and positive coefficient for reciprocity indicates a strong propensity for collaboration between stakeholders involved in this network. Furthermore, the significant and positive coefficient for the open-out-star configurations demonstrates a strong tendency of actors to collaborate and exchange resources with multiple other actors. ERGM analysis revealed a positive coefficient for closed triangles, however this result was not significant.

The estimates for the primary activity attribute parameters indicate the tendency for actors performing capacity building activities (i.e. fundraising and institutional support) to collaborate with actors performing direct action activities (i.e. rescue and rehabilitation of orangutan or habitat protection/restoration). None of the other ERGM estimates for activity attributes (age, registration location, and area of operation) were significant (Table A5). Method of data collection was not found to be significant.

3.2. Perception analysis

The reported perceptions of knowledge exchange were far higher than that of trust, reaffirming the tendency of the network to open structures that promote innovation revealed by the ERGM analysis (Fig. 2). Perception analysis of trust and innovation revealed no statistically significant relationship with any of the included organisational attributes.

Table 2
Exponential random graph model results for the Bornean Orangutan conservation network based on data accumulated from the hyperlink method along with qualitative surveys and semi-structured interviews [a]. Here we present key configurations of interest. Additional parameters were included in the model to improve convergence. Positive configuration estimates signify that the configuration appears in the network more than what would be expected from chance alone. ˙Depicts "activity type" sender effects from capacity building organisations to direct action organisations. Full results for all converged models (i.e *t* values smaller than 1 for all un-fitted effects) is presented in the online appendix (Table A5).

CONFIGURATION		MERGED NETWORK		
		ESTIMATE	SD	T-RATIO
Reciprocity		2.140*	0.426	-0.084
Open-out-star (Innovation)		0.747*	0.291	-0.075
Closure (Trust)		0.313	0.201	-0.066
Sender effect˙		0.234*	0.094	0.048

* shows 95% significance for the parameter. t-ratio = (observation − sample mean)/standard error, where values less that 0.1 for selected effects show goodness of model fit.

[a] Parameter estimations based on models with fixed density of 0.076. Table only includes key configurations of interest and of importance for interpreting results, the latter of which depicted by ˙.

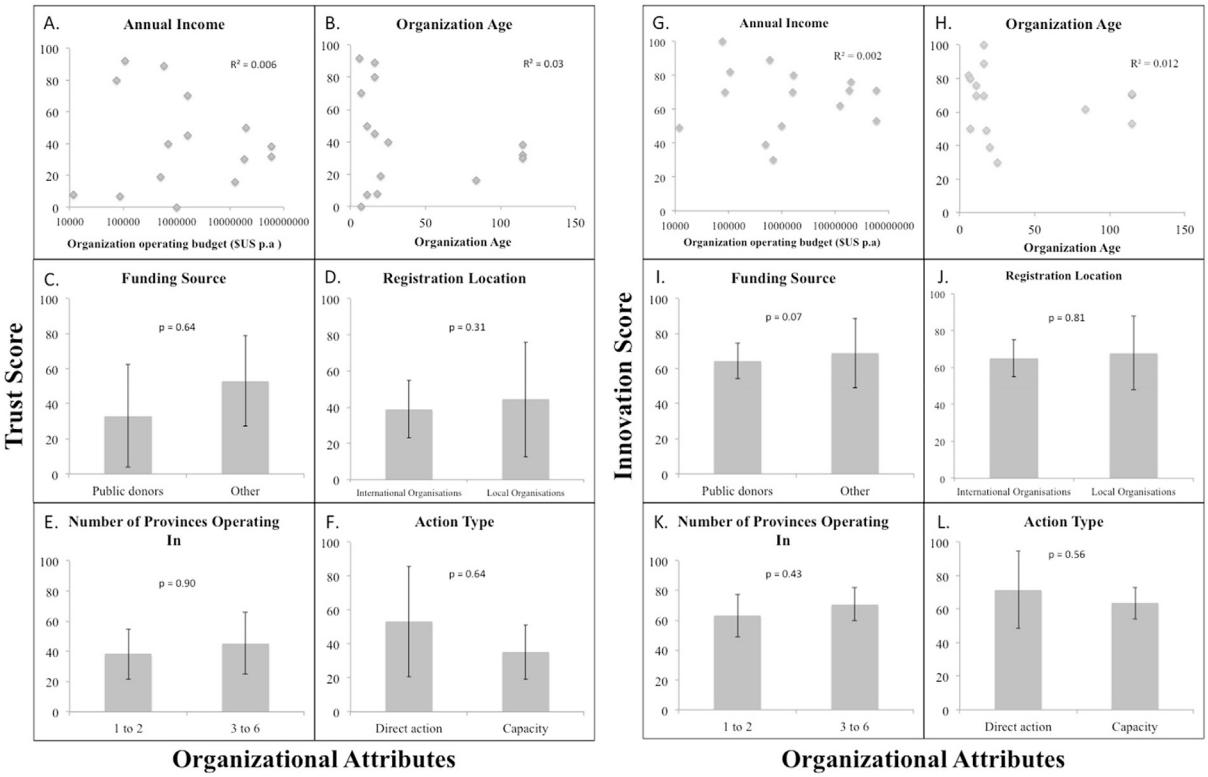


Fig. 2. Perceptions of trust, knowledge exchange and organizational attributes. Grey bars depict average score reported by organizations belonging to each of the attribute categories. Error bars show 95% confidence intervals. P values calculated using Welch's t-test.

No organizational attributes (age of the organization, registration location, its area of operation, primary activity, funding source or annual income (Fig. 3) had a statistically significant relationship with overall perceptions of collaboration. However, we observed a few general trends. Most notably, organizations funded primarily by donations from the public perceived lower benefits of collaboration than organizations funded by other NGOs and private donors such as business and philanthropic funds (Fig. 3b). Locally-registered organizations reported a higher positive perception of collaboration than internationally registered organizations. Similarly, organizations undertaking direct action activities, such as habitat restoration reported a more positive perception than capacity building organizations.

A positive and statistically significant relationship was found between overall positive perceptions and number of partners ($R^2 = 0.42$, $P = 0.03$). The relationship between the negative perception scores and number of partners was not significant ($R^2 = 0.07$, $P = 0.3$) (online appendix Fig. A1).

4. Discussion

The significant over-representation of open-out-star configurations suggests a strong innovative capacity within the Bornean Orangutan conservation sector as actors are frequently connected to multiple and otherwise disconnected actors. Responses to the qualitative survey reinforce this finding, as knowledge gain was the most frequently reported benefit obtained through collaboration. The significance of the activity type attribute parameter conveys a tendency for collaboration to occur between organizations performing capacity building roles and those undertaking direct action. Whilst this pattern is not surprising, it provides important insight into how resource exchange influences the self-organization of the Bornean orangutan conservation network.

The positive albeit non significant estimates for closed configurations could be indicative of stakeholders perceiving a low degree of risk associated with the partnership, and therefore not having the need to reduce risk through closed structures (Berardo and Scholtz, 2010). This is supported by the survey results showing that as the number of partners increases, the benefits perceived (and not the disadvantages) also increase. Closed configuration results also suggest that trust forming processes are taken place in some parts of the network, but not others. This is supported by the perception results that suggest that levels of trust are not equally distributed between stakeholder groups. Organisations reliant on public donations as a primary source of income reported lower, but non significant levels of trust than organisations that obtain funding through other means (Fig. 2C). Similarly, organisations performing capacity building activities reported a lower level of trust than

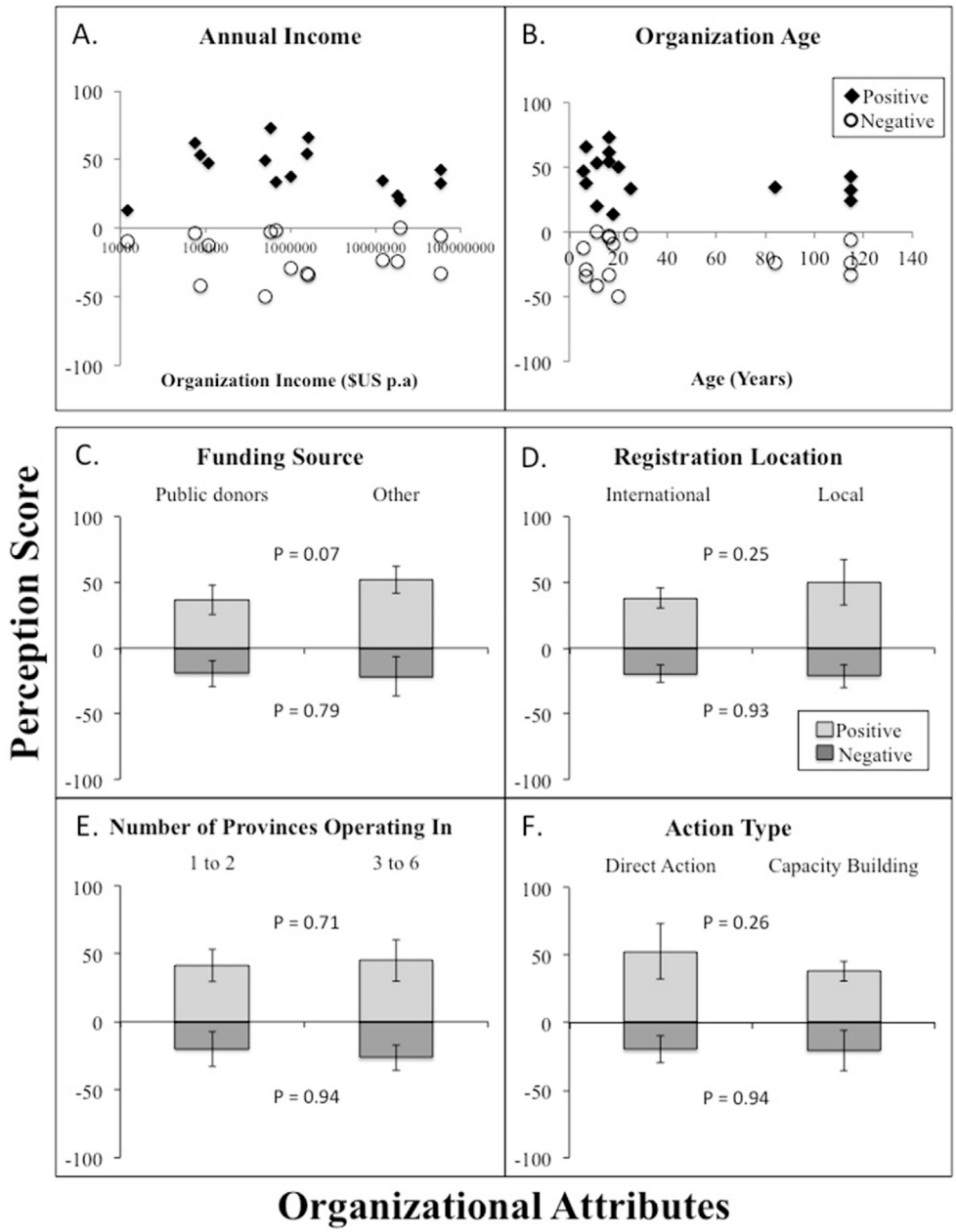


Fig. 3. Perception scores and organizational attributes. X axis depicts organizational attributes, Y axis shows positive and negative perception scores for organizations that participated in the survey. 3a; for each organizations negative and positive perceptions were correlated with reported annual income (top left) and organizational age (top right). Positive values as depicted as black diamonds and negative scores as circles. 3b; Organizations were placed in one of two categories for each of the attributes (Funding source, registration location, number of provinces operating in and action type). Positive and negative perception scores were averaged across organizations belonging each category for each attribute. Positive perceptions are depicted in light grey, negative perceptions shown in dark grey. Difference between each categories positive perceptions and negative perceptions was analysed using Welch's ANOVA, associated p values recorded for each analysis.

organisations involved in direct action (Fig. 2F). As the ERGM attribute analysis revealed "primary activity" as an important determinant of collaborative partnerships, the greatest opportunity to improve the distribution of trust across the network may exist between organizations that undertake direct action and organizations involved in capacity building.

"The tendency towards open configurations over closed configurations, combined with the variation in perceptions of trust suggests that in some parts of the current network stakeholder interactions are focused on addressing coordination problems, thought to arise when actors share a similar final goal, but that there is still a need to support the formation trust in

other parts of the network (Berardo and Lubell, 2016; McAllister et al., 2017). As initially articulated by Ostrom and Ostrom (1990) and summarised by Bodin et al. (2016), successful collaborative management of common resources requires actors to prioritise the long term greater good over individual short term benefits. However, accomplishing this in the context of orangutan conservation is difficult when shared vision of the greater good is non-existent or at best, poorly defined (Meijaard et al., 2012). Survey responses revealed organisations held differing opinions on the greatest threats to Orangutan ranging from habitat loss generally (n = 7) Oil Palm plantations specifically (n = 4) hunting and human/wildlife conflict (n = 3) issues with law enforcement and corruption (n = 2) and mining (n = 1). In addition, three interview respondents expressed that disagreements on the 'best outcomes' for a project have impacted their collaborative endeavours. Engaging with and receiving support from industry partners and representatives was seen as necessary means for achieving 'bigger picture' outcomes by some organisations, "Unless NGOs change their approaches and truly engage with everyone else, we won't be successful". Where as others felt engaging with bodies contributing to the problem was unethical and therefore "firmly reject any form of cooperation with the companies which we know to be causing the destruction of wildlife habitat". These findings suggest that the orangutan conservation network would likely benefit from trust building strategies that enable stakeholders to collectively prioritise and adequately respond to the multiple threats facing the species.

As there are costs associated with establishing and maintaining a single relationship, maintaining relationships with large number of actors is likely to be inefficient (Koskinen and Daraganova, 2012; Sayles and Baggio, 2017). Our perception results demonstrate that whilst there is not a significant increase in perceived disadvantage relative to number of partners, there is a trade-off in relation to the benefits. The number of collaborative partners was positively correlated with perceived benefits of collaboration to a point (16 partners), beyond which benefits begin to diminish. One explanation for the apparent lack of perceived disadvantage of collaboration within the orangutan conservation network might be that there is little pressure on individual organizations to be selective about collaborative partners. For example, the relatively consistent funding available to the sector even in the absence of reliable performance indicators may reduce the urgency of critically assessing conservation and collaboration strategies. Our partnership perception evaluation was based on interactions between non-profit, non-government conservation organizations and it is likely that these perceptions would change when interacting with organizations belonging to other sectors involved in conservation such as government and industry (Guerrero et al., 2014, Lubell et al., 2014). Further research is needed to understand how the non-governmental sector fits within the broader institutional environment responsible for the management of the species.

Previous evaluations of the effectiveness of the USAID funded Orangutan Conservation Services Program (OCSP) identified the need for a new collaborative management strategy to build upon the strengths of the already established network (Fisher, 2010). More recently, the United Nations Environment Program Great Ape Survival Partnership (UNEP GRASP) has emphasised the importance of collaboration to address the conservation crisis facing great apes (UNEP GRASP 2015). Our results reveal that the Bornean Orangutan conservation community has an overall positive perception of, and engages in collaborative partnerships. However, collaboration is not synonymous with effectiveness. Whilst ensuring favourable attitudes and relationships that arise from the collaborative process is an important first step, behaviour change and cooperation between stakeholders is needed to solve collective-action problems such as those associated with conservation of an endangered species (Bodin et al., 2016; Lubell, 2004, 2015). This study provides important insight on how reported weaknesses and inefficiencies of the orangutan conservation sector are not necessarily due to a lack of collaborative effort *per se*, but rather points to a limited capacity of these partnerships to achieve the desired outcome of conserving Borneo's Orangutan.

5. Conclusion

Conservation of individual species such as the orangutan, requires cooperation between a myriad of stakeholders from across the globe. Whilst securing populations of the critically endangered Great Ape depends on proper land use planning and management, which is currently absent, improving the efficacy of collaboration between conservation organizations is an essential precondition of success. To achieve this, social processes pertaining to both trust and innovation are needed. Our results show collaboration to be occurring between conservation organisations, particularly from those undertaking capacity building activities to those undertaking direct action. However, levels of trust are not equally distributed between stakeholder groups. While current stakeholder interactions are characterised by social processes pertaining to knowledge exchange, there are areas in the network where stakeholder interactions exhibit denser ties, and it is here were trust formation processes can be supported. Combined, these findings suggest that encouragement of generalised collaboration should be replaced with the development of strategic capacity development initiatives targeted to the specific needs of actors operating in different parts of the network.

More specifically, our study highlights that efforts to develop operational complementarities are needed. For example, organizations with strong fieldwork capabilities or strong connections with local communities may benefit from assistance with administrative and reporting requirements that have previously been identified as being beyond the operational capacity of some smaller organizations (Fisher, 2010). Both granting bodies and public donors have the potential to play an important role in encouraging the adoption of these practices. In addition, investigations should be made to identify and reduce duplication of effort in many projects as a means of reducing competition for donor resources and improving the efficiency of interventions (Mace et al., 2000). With regard to the latter, a better understanding of how different strategies contribute to the broader goals of the orangutan conservation community (e.g., maximizing the number of wild orangutans)

and at what costs, as well as how efficiently different organizations contribute to these goals, could facilitate strategic decision-making about optimal forms of collaboration.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.gecco.2017.07.004.

References

Ancrenaz, M., Gumal, M., Marshall, A.J., Meijaard, E., Wich, S.A., Husson, S., 2016. Pongo pygmaeus. The IUCN Red List of Threatened Species 2016. e. T17975A17966347.
Armsworth, P.R., Fishburn, I.S., Davies, Z.G., Gilbert, J., Leaver, N., Gaston, K.J., 2012. The size, concentration, and growth of biodiversity-conservation nonprofits. BioScience 62 (3), 271–281.
Baral, N., 2012. Empirical analysis of factors explaining local governing bodies' trust for administering agencies in community-based conservation. J. Environ. Manag. 103, 41–50.
Berardo, R., Scholtz, J.T., 2010. Policy networks: risk, partner in estuaries selection, and cooperation Ramiro Berardo University. Am. J. Polit. Sci. 54 (3), 632–649.
Berardo, R., Lubell, M., 2016. Understanding what shapes a polycentric governance system. Public Adm. Rev. 76 (5), 738–751.
Berkes, F., Colding, J., Folke, C., 2003. Navigating Social-ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge, U.K. ; New York.
Bode, M., Probert, W., Turner, W.R., Wilson, K.A., Venter, O., 2011. Conservation planning with multiple organizations and objectives. Conserv. Biol. 25 (2), 295–304.
Bodin, O., Crona, B.I., Ernstson, H., 2006. Social networks in natural resource management: what is there to learn from a structural perspective? Ecol. Soc. 11 (2), r2.
Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: what relational patterns make a difference? Global Environ. Change 19 (3), 366–374.
Bodin, Ö., Tengö, M., 2012. Disentangling intangible social–ecological systems. Glob. Environ. Change 22 (2), 430–439.
Bodin, Ö., Sandström, A., Crona, B., 2016. Collaborative networks for effective ecosystem-based management: a set of working hypotheses. Policy Stud. J. 45, 289–314 (online).
Borgatti, S.P., Mehra, A., Brass, D.J., Labianca, G., 2009. Network analysis in the social sciences. science 323 (5916), 892–895.
Burt, R., 2001. Structural holes versus network closure as social capital. In: Lin, N., Cook, K.S., Burt, R.S. (Eds.), Social Capital: Theory and Research. Aldine de Gruyter, New York, pp. 31–56.
Chen, B., Graddy, E.A., 2010. The effectiveness of nonprofit lead-organization networks for social service delivery. Nonprofit Manag. Leadersh. 20 (291), 405–422.
Collins, B.M., Fabozzi, F.J., 1991. A methodology for measuring transaction costs. Fin. Anal. J. 47 (2), 27–36.
Davis, J.T., Mengersen, K., Abram, N.K., Ancrenaz, M., Wells, J.A., Meijaard, E., 2013. It's not just conflict that motivates killing of orangutans. PloS One 8 (10), e75373.
Dukes, E.F., Firehock, K.E., Birkhoff, J.E., 2011. Community-based Collaboration: Bridging Socio-ecological Theory and Practice. University of Virginia Press, Charlottesville, Virginia.
Fisher, L., 2010. Lessons Learned Report - Orangutan Conservation Services Program (OSCP). United States Agency for International Development.
Foster, M.K., Meinhard, A.G., 2002. A regression model explaining predisposition to collaborate. Nonprofit Voluntary Sect. Q. 31 (4), 549–564.
Gordon, A., Bastin, L., Langford, W.T., Lechner, A.M., Bekessy, S.A., 2013. Simulating the value of collaboration in multi-actor conservation planning. Ecol. Model. 249, 19–25.
Guerrero, A.M., Mcallister, R.R., Wilson, K.A., 2014. Achieving cross-scale collaboration for large scale conservation initiatives. Conserv. Lett. 8 (2), 107–117.
Guo, C., Acar, M., 2005. Understanding collaboration among nonprofit organizations: combining resource dependency, institutional, and network perspectives. Nonprofit Voluntary Sect. Q. 34 (3), 340–361.
Henry, A.D., Lubell, M., McCoy, M., 2010. Belief systems and social capital as drivers of policy network structure: the case of California regional planning. J. Public Adm. Res. Theory 21 (3), 419–444.
Inkpen, A.C., Tsang, E.W.K., 2005. Social capital, networks, and knowledge transfer. Acad. Manag. Rev. 30 (1), 146–165.
Kaplan, R.S., Norton, D.P., 2004. Strategy Maps: Converting Intangible Assets into Tangible Outcomes. Harvard Business Press.
Kark, S., Tulloch, A., Gordon, A., Mazor, T., Bunnefeld, N., Levin, N., 2015. Cross-boundary collaboration: key to the conservation puzzle. Curr. Opin. Environ. Sustain. 12, 12–24.
Koskinen, J., Daraganova, G., 2012. Exponential random graph model fundamentals. In: Lusher, D., Koskinen, J., Robins, G. (Eds.), Exponential Random Graph Models for Social Networks: Theories, Models and Applications. Cambridge University Press, New York. NY, pp. 49–76. Structural Analysis in the Social Sciences Series (35).
Kreakie, B.J., Hychka, K.C., Belaire, J.A., Minor, E., Walker, H.A., 2015. Internet-based approaches to building stakeholder networks for conservation and natural resource management. Environ. Manag. 57 (2), 345–354.
Lee, Y., Lee, I.W., Feiock, R.C., 2012. Interorganizational collaboration networks in economic development policy: an exponential random graph model analysis. Policy Stud. J. 40 (3), 547–573.
Lomi, A., Pallotti, F., 2012. How to close a hole: exploring alternative closure mechanisms in inter-organizational networks. In: Lusher, D., Koskinen, J., Robins, G. (Eds.), Exponential Random Graph Models for Social Networks: Theories, Models and Applications. Cambridge University Press, New York. NY, pp. 202–213. Structural Analysis in the Social Sciences Series (35) (Chapter 14).
Lubell, M., 2004. Collaborative environmental institutions: all talk and no action? J. Policy Anal. Manag. 23 (3), 549–573.
Lubell, M., Robins, G., Wang, P., 2014. Network structure and institutional complexity in an ecology of water management games. Ecol. Soc. 19 (4), 23.
Lubell, M., 2015. Collaborative partnerships in complex institutional systems. Curr. Opin. Environ. Sustain. 12, 41–47.

Lusher, D., Koskinen, J., Robins, G., 2012. Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications. Cambridge University Press.
Mace, G.M., Balmford, A., Boitani, L., Cowlishaw, G., Dobson, A.P., Faith, D.P., Gaston, K.J., Humphries, C.J., Vane-Wright, R.I., Williams, P.H., Lawton, J.H., 2000. It's time to work together and stop duplicating conservation effort. Nature 405 (6785), 393.
Mazor, T., Possingham, H.P., Kark, S., 2013. Collaboration among countries in marine conservation can achieve substantial efficiencies. Divers. Distrib. 19 (11), 1380–1393.
McAllister, R.R.J., Taylor, B.M., Harman, B.P., 2015. Partnership networks for urban development: how structure is shaped by risk. Policy Stud. J. 43, 379–398.
McAllister, R.R., Taylor, B.M., 2015. Partnerships for sustainability governance: a synthesis of key themes. Curr. Opin. Environ. Sustain. 12, 86–90.
McAllister, R., Robinson, C., Brown, A., Maclean, K., Perry, S., Liu, S., 2017. Balancing collaboration with coordination: contesting eradication in the Australian plant pest and disease biosecurity system. Int. J. Commons 11 (1).
McLaren, T., Head, M., Yuan, Y., 2002. Supply chain collaboration alternatives: understanding the expected costs and benefits. Internet Res. 12 (4), 348–364.
Meijaard, E., 2014. Orangutan Conservation Management in Kalimantan. Recommendations for Improving Orangutan Conservation Strategy. Report for The Nature Conservancy. Page 65. People and Nature Consulting International, Jakarta, Indonesia.
Meijaard, E., Wich, S., Ancrenaz, M., Marshall, A.J., 2012. Not by science alone: why orangutan conservationists must think outside the box. Ann. N. Y. Acad. Sci. 1249, 29–44.
Mills, M., Álvarez-Romero, J.G., Vance-Borland, K., Cohen, P., Pressey, R.L., Guerrero, A.M., Ernstson, H., 2014. Linking regional planning and local action: towards using social network analysis in systematic conservation planning. Biol. Conserv. 169, 6–13.
Newman, L., Dale, A., 2005. Network structure, diversity, and proactive resilience building: a response to Tompkins and Adger. Ecol. Soc. 10, r2.
Ostrom, E., Ostrom, E., 1990. Governing the Commons: the Evolution of Institutions for Collective Action (No. 316.354). Cambridge University Press.
Prell, C., Hubacek, K., Reed, M., 2009. Stakeholder analysis and social network analysis in natural resource management. Soc. Nat. Resour. 22 (6), 501–518.
Rijksen, H.D., Meijaard, E., 1999. Our Vanishing Relative : the Status of Wild Orang-utans at the Close of the Twentieth Century. Kluwer Academic Publishers, Dordrecht ; Boston.
Robins, G., Morris, M., 2007. Advances in exponential random graph (p*) models. Soc. Netw. 29 (2), 169–172.
Robins, G., Pattison, P., WangP, 2009. Closure, connectivity and degrees: new specifications for exponential random graph (*P**) models for directed social networks. Soc. Netw. 31, 105–117.
Sayles, J.S., Baggio, J.A., 2017. Social–ecological network analysis of scale mismatches in estuary watershed restoration. Proc. Natl. Acad. Sci. 114 (10), E1776–E1785.
Snijders, T., Pattison, P., 2006. New specifications for exponential random graph models. Sociol. Methodol. 36 (1), 99–153.
Tabor, G., Carlson, A., Belote, T., 2014. Challenges and opportunities for large landscape-scale management in a shifting climate: the importance of nested adaptation responses across geospatial and temporal scales. In: Alaric, V., Bixler, Patrik, R. (Eds.), Forest conservation Management in the Anthropocene: Conference Proceedings. US department of Agriculture, Forest Service. Rocky Mountain Research Station, RMRS-P-71. Fort Collins, CO, pp. 205–227.
Wagner, S.M., Eggert, A., Lindemann, E., 2010. Creating and appropriating value in collaborative relationships. J. Bus. Res. 63 (8), 840–848.
Wambede, N., 2011. Effectiveness of transboundary collaborative conservation in Virunga National parks. Indonesian J. Geogr. 43 (2), 156–169.
Wang, P., Robins, G., Pattison, P., 2009. Pnet - Program for the Simulation and Estimation of Exponential Random Graph (P*) Models. Available from: http://sna.unimelb.edu.au/PNet. (Accessed 16 October 2013).
Whittington, K.B., Owen-smith, J., Powell, W.W., 2009. Networks, Propinquity and innovation in Knowledge intensive industries. Adm. Sci. Q. 54 (1), 90–122.
Zmelik, K., Schindler, S., Wrbka, T., 2011. The European Green Belt: international collaboration in biodiversity research and nature conservation along the former Iron Curtain. Innov. Eur. J. Soc. Sci. Res. 24 (3), 273–294.