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Response to Newman and Dale. 2005. "Network Structure, Diversity, and Proactive Resilience Building: a Response to Tompkins and Adger"

Social Networks in Natural Resource Management: What Is There to Learn from a Structural Perspective?

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ABSTRACT. Social networks among actors and stakeholders are gaining attention in studies of natural resource management, particularly those of adaptive management based on different forms of participation and co-management. In this sense, social networks have primarily been envisioned as enabling different actors to collaborate and coordinate management efforts. Here, we continue the discussion initiated by Newman and Dale (2005), which highlighted the fact that not all social networks are created equal. We discuss the relation between some structural characteristics and functions of social networks with respect to natural resource management, thus focusing on structural implications that are often overlooked when studying social networks within the context of natural resource management. We present several network measures used to quantify structural characteristics of social networks and link them to a number of features such as learning, leadership, and trust, which are identified as important in natural resource management. We show schematically that there may be inherent juxtapositions among different structural characteristics that need to be balanced in what we envision as social network structures conducive to adaptive co-management of natural resources. We argue that it is essential to develop an understanding of the effects that different structural characteristics of social networks have on natural resource management.

Key Words: *adaptive management; co-management; natural resource management; social networks; structure*

INTRODUCTION

Social networks are gaining attention in discussions of adaptive natural resource management based on different forms of participation and co-management (Holling 1978, Schneider et al. 2003, Anderies et al. 2004, Olsson et al. 2004, Ostrom 2005). This is a response to Tompkins and Adger (2004) and Newman and Dale (2005). Tompkins and Adger (2004) argued that social networks between stakeholders and actors can build community resilience and increase the adaptive capacity for environmental change. Newman and Dale (2005) extended this idea and noted that "not all social networks are created equal," and that a dynamic balance between bonding and bridging links is needed. Bridging links extend outside the community and provide access to a diverse set of resources, whereas bonding links within the community are necessary to absorb these benefits. Newan and Dale (2005) thus point out that social networks are more than just binary variables that either exist or do not exist. Here, we further unravel the social network variable to show its multidimensional nature when the structure of the social network is taken into account.

Thus, we address social networks as real observable phenomena that can be measured using quantitative techniques (Marsden 1990) and analyzed using social network analysis (Degenne and Forsé 1999, Scott 2000). The social networks primarily in focus are those that contain different stakeholders within a fairly well-defined management area and can be used to mobilize and maintain the co-management of common-pool resources.

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We begin by explicitly examining the relation between the structures and functions of social networks. We ask the question: How does the structure of a social network affect the ability to manage natural resources adaptively? We take our standpoint from a number of features identified in the literature as important for adaptive natural resource management and discuss how these are linked to network structure based on a review of social network literature. Secondly, we present some network measures that can be used to quantify network structure. Finally, we discuss how social roles and leadership in co-management can be understood based on their structural positions. Because most research on social roles in adaptive management lacks a structural perspective, we hereby hope to add to the understanding of these roles.

ROLE OF SOCIAL NETWORK STRUCTURE FOR NATURAL RESOURCE MANAGEMENT

Research has identified a number of features that are seemingly important for the adaptive management of ecosystems. We have chosen six of these as examples to be discussed further: social memory, heterogeneity, redundancy, learning, adaptive capacity, and trust (Table 1). In Table 1, we describe how each of the features is linked to social network structure and provide examples of measures (Table 2) that can be used to assess how each feature is affected by the network structure. Neither the list of features nor the linked structural characteristics should be viewed as exhaustive. They serve merely to illustrate the interaction between function and network structure within the framework of resource management.

It is evident that a network structure that enhances one feature may simultaneously inhibit another; an example is centrality (Table 1). A high degree of centrality may in some respects be very good for facilitating the process of solving simple tasks because relevant information can be relayed and synthesized to a few actors who can make a decision and take action (Leavitt 1951). For the same reason, high centrality might also be good in times of change when effective coordination of actors and resources may be needed. On the other hand, social networks in which a few individuals have a high degree of centrality may lead to increasingly centralized decision making, which in turn may have negative effects on, for instance, learning because it reduces the access of individual actors to multiple sources of information (Weimann 1982, Abrahamson and Rosenkopf 1997).

Density is another network measure that may have different effects depending on the feature in focus. For example, high density may contribute to the strengthening of trust between individuals and groups and thereby also increase the possibility for social control (Granovetter 1985, Coleman 1990, Pretty and Ward 2001). This is important in two ways; first, it decreases the risk and cost of collaborating with others, which is an essential prerequisite for collective action and collaboration (Ostrom 1990, Cohen et al. 2001, Burt 2003). Second, it promotes the development of and compliance with mutual norms in relation to what is considered acceptable with respect to resource use and extraction (Coleman 1990). High density may also benefit the spread of information through increased accessibility to information (Weimann 1982, Abrahamson and Rosenkopf 1997). However, very high density of relations among actors can result in homogenization of experiences and knowledge (Oh et al. 2004, Bodin and Norberg 2005, Crona and Bodin 2006). This occurs, for example, through a high density of interaction among individuals that leads to a situation in which all individuals tend to adopt similar perceptions of issues at hand.

A final example of a relevant network measurement is betweenness (Freeman 1979). This is a measure that can be used to describe the degree of modularity in a network. Modularity is the tendency to form multiple groups; a network with high modularity consists of several internally dense groups that are either isolated or relatively loosely connected to each other, i.e., clusters or cliques. High modularity increases the ability of the different groups to develop partly distinct knowledge systems such as local ecological knowledge (see Ghimire et al. 2004, Crona and Bodin 2006) about the same ecological system, which in turn bestows the ability to perceive different changes in the ecosystem that may be conveyed to others. High modularity thereby opens the network to a potentially large number of feedback possibilities from the ecosystem to the management system, i.e., it enhances monitoring, provided that the groups of actors in the network are not completely isolated. Because of high density within separate groups of actors, a very high degree of modularity can, however, foster a mind-set of “us

Table 1. Features identified as important for the adaptive management of natural resources and the ways in which they are linked to social network structure.

Feature	Link to social network structure
Social memory	
Collective memory/experiences to be used in times of change and uncertainty (e.g., McIntosh 2000, Folke et al. 2003).	Reachability: access to many individuals Density: many links to others in the network.
Heterogeneity	
A diversity of many types of actors or actors with differing knowledge will broaden the collective knowledge base and increase the capacity for innovation and maintenance of different knowledge systems and frameworks for interpretation (Folke et al. 2005).	Betweenness/modularity: A certain degree of separation of groups in the network is needed to maintain heterogeneity. Density: High density may have a negative effect on heterogeneity because it promotes homogeneity of experience and attitudes among actors and reduces the potential for innovation (e.g., Reagans and McEvily 2003, Oh et al. 2004).
Redundancy	
Provides buffering capacity in case of loss, i.e., if one or more actors are weakened or lost, others can fill the position and continue to perform the management function (Janssen et al. 2006).	Density: Many links makes the loss of single actors less disruptive, with a lesser effect on the average distance in the network. Betweenness/modularity: A high degree of betweenness of single actors makes the network vulnerable to fragmentation should these actors disappear (Borgatti 2003).
Learning	
Knowledge about ecosystems can be continuously increased and improved, and thereby governance and management can be updated and adapted to changing conditions (Holling 1978).	Betweenness/modularity: Maintenance of strong links within a group to some extent requires high modularity (Granovetter 1973), and strong links are needed to transfer tacit knowledge (e.g., Reagans and McEvily 2003 and references therein) and complex knowledge, i.e., knowledge that involves interpretation of a number of nonlinear and noncausal variables. Reachability: access to many actors from whom knowledge and information can be amassed or to whom it can be distributed (e.g., Oh et al. 2004). Centrality: A high degree of centrality may give rise to centralized management and thereby fewer experiments and experiential learning (Leavitt 1951, Shaw 1981).

(con'd)

Adaptive capacity	
New knowledge and/or changing conditions require adaptive capacity and innovation to meet new needs (e.g., Gunderson 1999, Walker et al. 2004 for a discussion on adaptive capacity, resilience, reorganization, and novelty).	Reachability: Collective action requires multiple actors to collaborate, but too much decentralization may have negative effects on the potential for collective action (Steel and Weber 2001). Centrality: Coordination ability, which is important in times of change and rapid response, increases with centrality (Leavitt 1951). Density: Too many links to others may lock an actor into a political position because of, e.g., peer-pressure, thereby limiting his/her ability to innovate and act (e.g., Frank and Yasumoto 1998).
Trust	
Co-management is facilitated by trust among actors (e.g., Olsson 2003).	Density: Many links foster feelings of belonging and group identity (Coleman 1990). Betweenness/modularity: A high degree of separation among groups can undermine the development of trust (Borgatti and Foster 2003).

vs. them," which consequently contributes to locking actors in fixed political positions and limiting their common ability to act and seek consensus (Borgatti and Foster 2003). The network measurement of betweenness can also be used to identify individual actors occupying bridging positions, that is, contributing to the linking of otherwise isolated groups (Freeman 1979, Gould and Fernandez 1989).

ROLES AND STRUCTURAL POSITIONS IN NATURAL RESOURCE MANAGEMENT

In addition to the abovementioned features, the importance of leadership and other social roles in adaptive natural resource management has been discussed (e.g., Folke et al. 2003). Many of these roles coincide with what Frances Westley describes as social entrepreneurship (F. R. Westley, *personal communication*; see also Westley and Vredenburg 1997). In social network theory, scholars have often sought to explain roles based on structural position (e.g., Scott 2000, Borgatti and Foster 2003). Here, we highlight the structural position that, in our view, seems to be one of the most important for social and institutional entrepreneurship: the broker.

Brokers are individual or organizational actors who carry many exclusive links, that is, links to groups that would otherwise not be in direct contact with each other (Burt 2003). In relation to Newman and Dale's (2005) discussion, we can view the broker as the actor who embodies the bridging links of the community. Consequently, and in relation to our discussion on different network measures, the broker acquires a high score of betweenness (Table 2) while also linking otherwise disconnected groups. Thus, a broker, merely by its structural position, gains access to many pieces of group-specific information captured inside the different groups, which allows the broker to synthesize a large knowledge pool. In addition, through its structural position, the broker learns about the inner life of many of the different groups and therefore achieves, through the position, an advantage in knowing which groups or individuals to connect and not to connect, how to connect them, and when (Burt 2003). In times of crisis, this is critical knowledge. Burt (2003) calls this capacity acquired by the broker adaptive implementation, i.e., the ability to navigate in a continuously changing social landscape and coordinate the actions of a network. The broker, which in a real setting could be an individual, a group of individuals, or an organization, can thus find new collaborative

Table 2. Examples of quantitative network measures and how they are related to different network characteristics.

Characteristic	Measure
Density	Number of links divided by the number of nodes in the network.
Reachability	Diameter, i.e., the number of steps maximally needed to reach from one node to any other node in the network.
	Number of components. A component is an independent network within the larger network in which all nodes are directly or indirectly in contact with each other. If a network consists of more than one component, it is considered fragmented; the degree of fragmentation is quantified by measuring the number of components.
Betweenness	A measure that quantifies the degree of betweenness (Freeman 1979), i.e., how much each node contributes to minimizing the distance between nodes in the network (compare with reachability above). This measure can be applied to individual nodes, and can then be used to identify the actors that contribute most to linking the network. The measure can also be applied to the network as a whole to quantify the degree of modularity, i.e., separation into smaller groups or modules.
Centrality	The degree of centrality indicates how many links a node has (Freeman 1979). This measure can be applied to individual nodes or the whole network. A high degree of centrality for an individual node indicates that it has many links compared to other nodes. Centrality for the whole network indicates the tendency in the network for a few actors to have many links, e.g., a wheel-star structure.

solutions for different situations at different points in time. It is also clear from this description that brokers are powerful actors in the sense that they can control the behavior of social groups and the information flow between groups in the network to a higher extent than can other actors. Burt (2003) further points out that brokers, with early access to critical information, often create new understandings and see new opportunities that other actors never recognize. The broker seems gifted with creativity and could be critical for the innovative and adaptive capacities of communities that Newman and Dale (2005) search for (see also Westley and Vredenburg 1997).

The broker is thus an important position and plays a critical social role in adaptive natural resource management. Other social roles important for such management have been identified (see, for example, Folke et al. 2003). Although a discussion of these roles lies outside the scope of this reply, we believe that an understanding of their importance can be further improved through discussions similar to the one presented here for brokers.

CONCLUDING REMARKS

We have discussed the relation between social network structure and function in natural resource management. We have furthermore highlighted network measures used to quantify structures in social networks and linked these to features identified as important in enhancing adaptive management of ecosystems. As in Janssen et al. (2006), our discussion deals with structural characteristics of networks, but with a stronger focus on the interplay between social structures and actors. We have shown, if only schematically, that there may be inherent juxtapositions between different structural characteristics that need to be balanced in what we envision as social network structures conducive for co-management of natural resources. One beneficial structure for this appears to be a network containing separate groups with internal trust and with some degree of trust among them, linked together by motivated brokers who are interested in using their structural positions to initiate and maintain adaptive co-management. This structure could be seen as supporting the dynamic balance between bonding and bridging links envisioned in the reply by Newman and Dale (2005), in which the broker embodies the critical bridging links. It also resembles the advantages of intermediate modularity as discussed by Webb and Levin (2005), who took a mainly ecological perspective. However, there are several issues we have not addressed. These issues relate to (1) problems of scale matching, i.e., how network structures match the different scales of ecosystem processes, both temporal and spatial; (2) temporal dynamics, i.e., how different structures can provide different benefits at given phases of the management process (compare with adaptive cycle phases as described by Gunderson and Holling 2002); (3) the role of leadership in organizational change (Danter et al. 2000); (4) the dynamics of structures, i.e., how and why network structures change and the effects on management; and (5) the social effects of structure on the distribution of power and influence. To increase our knowledge of the structures that serve adaptive natural resource management, we think that more emphasis should be placed on developing an understanding of the effect of different structures on co-management (compare Carlsson and Berkes 2005 and Crona and Bodin 2006). This line of research should be based on empirical studies of social networks in which we can use many of the methods and techniques already available and under constant development by a growing group of transdisciplinary-oriented researchers that has been partly assembled in the International Network of Social Network Analysis (see http://www.insna.org). In our current projects, we are generating empirical data on the networks of existing management structures, and we know that other researchers of natural resource management are using similar approaches. We look forward to the results of this ongoing effort and a continued discussion on the role played by social networks in the management of ecosystems.

Responses to this article can be read online at:
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Acknowledgments:

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