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Stakeholder Analysis and Social Network Analysis in Natural Resource Management

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The increasing use of stakeholder analysis in natural resource management reflects a growing recognition that stakeholders can and should influence environmental decision making. Stakeholder analysis can be used to avoid inflaming conflicts, ensure that the marginalization of certain groups is not reinforced, and fairly represent diverse interests. We present a case study from the Peak District National Park in the United Kingdom, where we used social network analysis to inform stakeholder analysis. This information helped us identify which individuals and categories of stakeholder played more central roles in the network and which were more peripheral. This information guided our next steps for stakeholder selection. The article ends with a discussion on the strengths and limitations of combining social network analysis with stakeholder analysis.

Keywords participatory resource management, social network analysis, stakeholder analysis

Many conservation initiatives fail because they pay inadequate attention to the interests and characteristics of stakeholders[1] (Grimble and Wellard 1997). As a consequence, stakeholder analysis has gained increasing attention and is now integral to many participatory natural resource management initiatives (Mushove and Vogel 2005). However, there are a number of important limitations to current methods for stakeholder analysis. For example, stakeholders are usually identified and categorized through a subjective assessment of their relative power, influence, and

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legitimacy (Mitchell et al. 1997; Frooman 1999). Although widely varied categorization schemes have emerged from the literature, such as primary and secondary (Clarkson 1995), actors and those acted upon (Mitchell et al. 1997), strategic and moral (Goodpaster 1991), and generic and specific (Carroll 1989), methods have often overlooked the role communication networks can play in categorizing and understanding stakeholder relationships. Social network analysis (SNA) offers one solution to these limitations.

Environmental applications of SNA are just beginning to emerge, and so far have focused on understanding characteristics of social networks that increase the likelihood of collective action and successful natural resource management (Schneider et al. 2003; Tomkins and Adger 2004; Newman and Dale 2004; Bodin et al. 2006; Crona and Bodin 2006). In this article, we harness and expand upon this knowledge to inform stakeholder analysis for participatory natural resource management. By participatory natural resource management we mean a process that engages stakeholders on multiple levels of decision making and facilitates the formation and strengthening of relationships among stakeholders for mutual learning (Grimble and Wellard 1997; Dougill et al. 2006; Stringer et al. 2006). To enhance stakeholder analysis, we use SNA to identify the role and influence of different stakeholders and categories of stakeholder according to their positions within the network. We do this using case study material from the Peak District National Park, United Kingdom.

Stakeholder Analysis

Selecting relevant stakeholders for participatory processes is challenging. For example: certain categories of stakeholder may be historically marginalized from management decisions, and may therefore be difficult to identify or involve; pre-existing conflicts between different groups may preclude a willingness to join a deliberative process; and participatory processes tend to focus on small groups for in-depth deliberation and mutual learning which can lead to a lack of representativeness (Daniels and Walker 2001; Grimble and Wellard 1997; Stringer et al. 2006).

The growing popularity of stakeholder analysis in natural resource management partly reflects an increasing recognition of the extent to which stakeholders can and/or should influence environmental decision-making processes (Burroughs 1999; Varvasovszky and Brugha 2000; Duram and Brown 1999; Selin et al. 2000). Stakeholder analysis can be used to understanding environmental systems by defining the aspects of the system under study; identifying who has a stake in those aspects of the system; and prioritizing stakeholders for involvement in decisions about those aspects of the system (Grimble and Wellard 1997; Mushove and Vogel 2005).

In order to identify stakeholders, it is first necessary to define the aspect(s) of the system, problem(s), or issue(s) under study. This is an important initial step, but one that is rarely considered explicitly in stakeholder analyses. This may partly be due to the difficult dialectic between issue definition and stakeholder identification. Without knowing the issues, it is difficult to know which stakeholders should be involved in identifying relevant issues (Dougill et al. 2006). As a consequence, issues are typically identified in a top-down manner by the team leading the stakeholder analysis and may therefore reflect their interests and biases (Clarkson 1995; Varvasovszky and Brugha 2000).

As relevant issues start to emerge, one can then start identifying, characterizing, and prioritizing stakeholders for future involvement in the project. One of the most common approaches is to assess the urgency, legitimacy, and power of potential stakeholders in relation to the issues under question (Mitchell et al. 1997). This may involve evaluating and ranking the type, source and level of power that different stakeholders possess. Such a process has been criticized for prioritizing top-ranked (often more powerful) stakeholders, leading to underrepresentation of lower ranked groups (Grimble and Chan 1995; Calton and Kurland 1996; MacArthur 1997). An alternative approach is to explicitly include those who are remote, weak, disinterested, or considered "nonlegitimate."

Social Network Analysis (SNA)

Social networks are comprised of actors who are tied to one another through socially meaningful relations. These relations can then be analyzed for structural patterns that emerge among these actors. Thus, an analyst of social networks looks beyond attributes of individuals to also examine the relations among actors, how actors are positioned within a network, and how relations are structured into overall network patterns (Scott 2000; Wasserman and Faust 1994; Wellman and Gulia 1999).

Both the social network and resource management literature discuss ways in which networks influence individual actors and groups. For example, research on the strength of ties between actors shows how strong versus weak ties relate to different kinds of outcomes. As Granovetter (1973) notes: "The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, and intimacy (mutual confiding), and the reciprocal services which characterize the tie" (1361). Thus, the higher a tie scores on each of these attributes, the stronger the tie is. Actors sharing a strong tie tend to: (i) influence one another more than those sharing a weak tie; (ii) share similar views; (iii) offer one another emotional support and help in times of emergency; (iv) communicate effectively regarding complex information and tasks; and (v) be more likely to trust one another (e.g., Coleman 1990; Crona and Bodin 2006; Cross and Parker 2004; Friedkin 1998; Kadushin 1966; Newman and Dale 2004; Wellman and Frank 2001). The advantages of strong ties for resource management are obvious: Stakeholders with strong ties are more likely to influence one another, and thus, creating strong ties among diverse stakeholders can enhance mutual learning and the sharing of resources and advice (Crona and Bodin 2006; Newman and Dale 2004, 2007). Benefits of strong ties may be countered, however, by the redundancy of information that typically runs through such ties, as stakeholders who have shared a strong tie for a long period of time tend to have the same information and knowledge regarding resource management. In contrast, diverse information and new ideas have been shown to travel best through weak ties. A weak tie is often characterized by less frequent communication. Research has shown that weak ties tend to exist between dissimilar others, and as such, they offer individuals and the network as a whole access to diverse pools of information and resources. They do so primarily through performing bridging roles between otherwise disconnected segments of a network (Burt 2001; Granovetter 1973). Within the context of resource management, weak ties can make a network more resilient and adaptive to environmental change. A potential drawback to weak ties, however, is that they may be easy to break. In addition, actors sharing weak ties may lack the trust and understanding needed for in-depth dialogue over environmental issues; (Burt 1992, 1997, 2000; Newman and Dale, 2004; Volker and Flap, 1999).[2]

Closely related to this discussion regarding strong and weak ties are the ways stakeholders' attributes can influence which ties get established within a network. Homophily, a situation where similar actors are attracted to one another and thus choose to interact with each other, is a well-documented occurrence in social networks (Friedkin 1998; Skvoretz et al. 2004). Stakeholders who are similar to one another are better able to communicate tacit, complex information, as there tends to be higher mutual understanding between such actors. Conversely, such homogeneity can be problematic, as successful natural resource management projects require different views and opinions to be recognized and brought into the discussion (Crona and Bodin 2006; Newman and Dale 2007). In such situations, it may be beneficial to increase the diversity of stakeholders engaged in the project.

Centralization is another network concept discussed in the resource management literature. A highly centralized network is one characterized by one or a few individuals holding the majority of ties with others in the network. Centralized networks are helpful for the initial phase of forming groups and building support for collective action (Crona and Bodin 2006; Olsson et al. 2004). However, research suggests that such centralized networks are disadvantageous for long-term planning and problem solution. These more long-term goals require a more decentralized structure: one holding more ties, both weak and strong, among more actors and stakeholder categories (Crona and Bodin 2006).

Just as strength of ties and network centralization can affect resource management practices, so the position of individuals within a network can affect how information and resources circulate and get exchanged in the network. The concept of centrality has recently received attention in the resource management literature (Bodin et al. 2006: Crona and Bodin 2006), but the distinction between the different kinds of centrality and their potential impacts on resource management has been largely ignored. We distinguish between two types of centrality: degree centrality and betweenness centrality. Degree centrality refers to how many others a stakeholder is directly connected to; stakeholders with a high degree centrality can be seen as important players for mobilizing the network and bringing other stakeholders together. However, because such stakeholders must exert a lot of energy to maintain a large number of ties, these ties are often weak. Thus, highly (degree) central stakeholders can be trusted to use their links to diffuse information and potentially mobilize the group to action, but there is no guarantee that they can significantly influence those to whom they are tied. On the other hand, betweenness centrality refers to how many times an actor rests between two others who are themselves disconnected (Freeman 1979; Wasserman and Faust 1994). Stakeholders holding high betweeness centrality are important for long-term resource management planning; as such, actors perform a broker role of bringing together disconnected segments of the network, thus bringing diversity and new ideas to the network (Bodin et al. 2006; Brass 1992; Prell 2003). However, it should be noted that such "brokers" may feel torn between the different elements of the network and feel forced to take sides (Krackhardt 1992), particularly in situations of resource or land use conflicts.

Thus, the resource management community is beginning to realize that social networks matter, and that such networks can be studied with a great deal of analytical precision, given the tools and concepts afforded by social network analysis (Ramírez 1999; Dougill et al. 2006; Lockie 2006). Table 1 summarizes these social network concepts in relation to resource management.

Table 1. Network concepts relevant for natural resource management

Network concept		Effect on resource management
Strong ties	+	Good for communicating about and working with complex information
	+	Hold and maintain trust between actors
	+	Actors more likely to influence one another's thoughts, views, and behaviors
	+	Encourage creation and maintenance of norms of trust and reciprocity
	–	Encourage the likelihood that actors sharing strong tie hold redundant information
	–	Actors less likely to be exposed to new ideas and thus may be less innovative
	–	Can constrain actors
Weak ties	+	Tend to bridge across diverse actors and groups
	+	Connect otherwise disconnected segments of the network together
	+	Good for communicating about and working with simple tasks
	+	New information tends to flow through these ties
	–	Not ideal for complex tasks/information
	–	Actors sharing weak ties are less likely to trust one another
	–	Can break more easily
Homophily	+	Shared attributes among social actors reduces conflict, and provide the basis for the transference of tacit, complex information
	–	Can also result in redundant information, i.e., actors have similar backgrounds and therefore similar sources of knowledge
Centrality		*Degree centrality:*
	+	Actors with contacts to many others can be targeted for motivating the network and diffusing information fast through the network, i.e., these are the focal actors in a centralized network
	–	These actors do not necessarily bring together diverse segments of the network
	–	Because of their many ties to others, these ties are often weak ones, thus decreasing influence over others
		Betweenness centrality:
	+	Actors that link across disconnected segments of the network have the most holistic view of the problem
	+	As with degree centrality, they can mobilize and diffuse information to the larger network
	–	They can feel constrained or torn between two (or more) positions
Centralization	+	As only a few actors hold the majority of ties linking the network together, only need reach these well-connected few to reach entire network
	–	Reliance on only a few is not the optimal structure for purposes of resilience and long-term problem-solving

As Table 1 shows, there are trade-offs between the different network properties we have discussed. However, by understanding these properties in any given network, it is possible for those working and engaging with stakeholder networks to make better informed decisions about how to engage with and involve stakeholders in meaningful deliberation. The next section of this article shows how we have applied SNA as part of a stakeholder analysis in the Peak District National Park.

The Peak District National Park (PDNP): A Case Study

We are involved in ongoing research that aims to combine knowledge from local stakeholders, policymakers, and social and natural scientists to anticipate, monitor, and sustainably manage rural change in UK uplands (Dougill et al. 2006; Prell et al. 2007). This region is typical of the UK uplands and many marginal mountain areas of Europe that are facing pressures resulting from demographic change, policy reform, and environmental problems, such as soil erosion, biodiversity loss, and climate change.

To enhance the sustainability of upland management in this region, we have been engaging with groups of stakeholders to identify sustainability goals, strategies that could be used to reach these goals, and indicators to measure progress toward these goals. In addition, we are developing tools to evaluate the management options that emerge from this process in a multistakeholder, participatory framework. In this article, we report on the early stages of this process. In particular, we discuss:

- How to identify stakeholders: representing diverse stakeholder communities, accounting for divergent stakeholder opinions about who should be considered, and addressing the dialectic between stakeholder and issue identification.
- How social network analysis (SNA) can supplement qualitative information with more in-depth and quantitative data about stakeholder relationships.

Context

The Dark Peak area of the Peak District National Park (PDNP) was chosen for its diversity of land use activities (for conservation, farming, tourism, water supply, and game/fishing), and the range of social, economic, political, and environmental pressures it faces. It is situated at the southern end of the Pennine upland range, between three large cities (Figure 1). With an estimated 22 million recreational visitor days annually, the PDNP is Britain's most visited National Park (Peak District National Park 2004). The PDNP contains a number of villages and towns, but only 17.2% of its 38,000 population live in the Dark Peak area (Office for National Statistics 2003). PDNP residents are more reliant on agriculture, game birds, and tourism than the national average (Office for National Statistics 2003). Most moorland is privately owned and managed for a combination of grouse and sheep production.

The Dark Peak contains a number of internationally important habitats (UK Biodiversity Steering Group 1995; English Nature 2003) that add to the list of competing demands of conservation, water supply, recreation and tourism, agriculture, and game management that have led to a conflict of interests between many upland stakeholders. English Nature (2003) attributed the high proportion of Peak District Sites of Special Scientific Interest in unfavorable condition predominantly to a combination of overgrazing and "inappropriate" burning. Such burning is carried out to create a mosaic of heather stands to maximize grouse populations (Holden et al. 2007). These factors (compounded by historic atmospheric pollutant deposition)

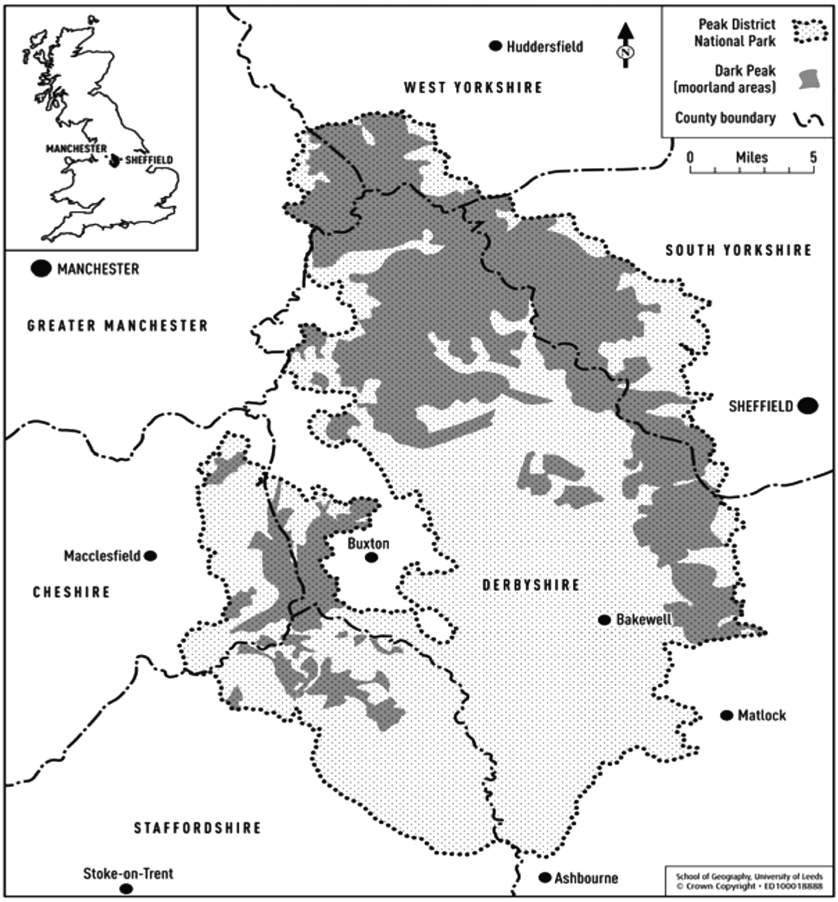

Figure 1. Map of Peak District National Park showing the Dark Peak area (shaded) (from Dougill et al. 2006).

have also been blamed for increased erosion, with consequent effects on water quality (Tucker 2003). Grazing levels have declined significantly (mainly as a result of Environmentally Sensitive Area agreements), but rotational burning continues to be practiced widely (Dougill et al. 2006).

Methods

Identifying Stakeholders and Issues

We started by conducting a focus group with members of Moors for the Future (MFF), which is a partnership of organizations in the PDNP. Representatives from the Moors for the Future partnership were chosen to take part in this initial focus group because it had already brought together many of the key stakeholder organizations as part of their partnership, including the Peak District National Park Authority, two water companies, Natural England, National Trust, Sheffield City Council, Moorland Association, Derbyshire County Council, and the Environment Agency. In addition, two individuals whom MFF had identified as relevant stakeholders were also invited to the focus group. To avoid bias arising from initial group composition, focus-group data were triangulated through semistructured interviews with eight stakeholders identified during the focus group to represent different land management perspectives. The aim of the focus group and subsequent interviews was to evaluate and adapt the proposed aims of the project in order to ensure it was focusing on relevant issues and identify and categorize stakeholders.

The focus group and interviews identified over 200 relevant organizations and groups of individuals. These organizations and individuals were initially categorized during the focus group into stakeholder categories based on the perceived role of these individuals and organizations in the PDNP. In addition, information was elicited about the most effective way to gain the support and involvement of these individuals and organizations. Successive interviews resulted in the addition and subdivision of stakeholder categories. The final categorization was then checked with participants from the initial focus group and those who had been interviewed at the beginning of the interview process.

These categories were then used to guide our snowball sample: One to two individuals from each stakeholder category were interviewed, and these interviews led to further nominations and interviews until both names and land management issues began to repeat. In total, 22 interviews representing all categories were thus conducted. These interviews were used to deepen our knowledge of the current needs and aspirations of those who work, live, and play in the park.

Social Network Analysis

After we had identified and categorized relevant stakeholders, we conducted structured telephone interviews with these individuals to gather network data that would indicate how stakeholders were socially related to one another (88% response rate). To start identifying this social network, we asked the following "name generator" question[3]:

> "Do you communicate with anyone from [stakeholder category named here] on upland management issues in the Peak District National Park? Please list up to five names."

We asked our respondents this question for each of the eight main stakeholder categories. Respondents nominated individuals in each stakeholder category, resulting in a total number of 147 nominations. A follow-up question was then asked, based on this name-generator question, to elicit tie strength among these stakeholders[4]:

> "How often do you communicate with this person?" (Daily, Weekly, Monthly, 1–2 times/year)

This question was repeated for each name generated in each of the eight stakeholder categories. The resulting data were then analyzed in UCINET.[5] The analyses chosen were the following:

Density: This is the proportion of possible ties in a network that are actually present, and a network's density is commonly used to measure the extent to which all actors in a network are tied to one another (Wasserman and Faust

1994). A density score of 1 indicates that all actors in the network are directly tied to one another, and a density score of 0 indicates the network is fully disconnected.

Centralization: A centralization score of 1 indicates that the maximum number of ties concentrated around one actor is present, and a score of 0 indicates a fully connected network, where all actors are directly connected to each other.

Degree centrality: Refers to how many others an actor is directly connected to.

Betweenness centrality: Refers to how many times an actor rests on a short path connecting two others who are themselves disconnected.

Results

The eight stakeholder categories that emerged from our stakeholder analysis were water companies; recreational groups; agriculture; conservationists; grouse moor interests (consisting of owners/managers and game keepers); tourism-related enterprises; foresters; and statutory bodies. In the 22 interviews, the issue of heather burning continued to emerge as the most pressing issue pertaining land management issue due to the government's ongoing and highly contentious review of the Heather and Grass Burning Code.

The social network analysis, which followed from the stakeholder analysis, resulted in a network composed of 147 stakeholders from eight different stakeholder categories, linked together through differing strengths of ties. This network is shown below in graph A in Figure 2.

In graph A, the thicknesses of the lines depict the varying frequencies of communication, where thicker lines represent more communication between two stakeholders. The varying shapes of nodes represent the various stakeholder categories. The size of the nodes represents the relative betweenness centrality of the actors, a point we discuss in detail shortly. From these data, we were able to collapse ties occurring on a monthly or more frequent basis to provide a network composed of "strong ties." This strong ties network appears in graph B.

As noted in Table 1, uncovering the strength of tie can suggest which stakeholders are more likely to influence one another, which ones are more likely to hold similar views, which ones are marginalized, and which play a brokering role. An initial comparison between graphs A and B shows that once we concentrate on the stronger ties (graph B), the network breaks apart into several components, as well as a large number of isolated individuals who appear on the left side of the graph. This suggests that this stakeholder network is dependent on its weak ties for remaining fully connected, a situation that reflects the "strength of weak ties" argument (Granovetter 1973). Although the weak ties are performing the bridging roles one would expect in holding otherwise disconnected segments of the network together, this reliance on weak ties also suggests potentially vulnerable areas in this network (please refer to Table 1).

The importance of weak ties in the network is further illustrated by comparing the overall structure of graph A with graph B. Two network analyses were chosen for this purpose: density and centralization. The results, which appear to the right of each graph, show that graph A has a higher density score and higher centralization score than graph B. This again shows that weak ties are leading toward more connectivity in this network. In addition, the higher centralization score indicates that certain actors, through their numerous weak ties to others, are emerging as key

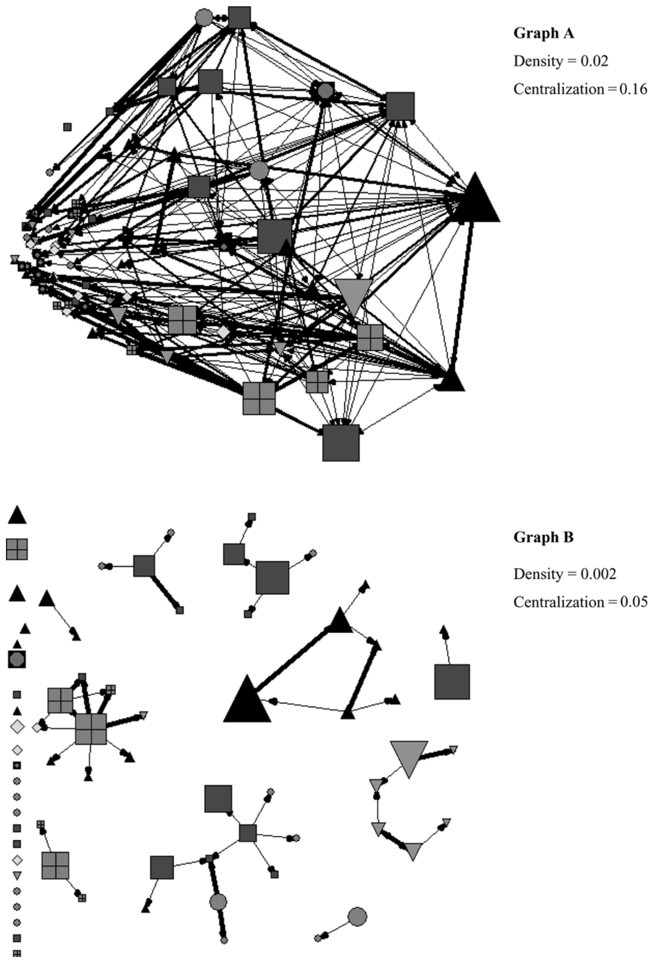

Figure 2. Two graphs showing social network of stakeholders.

figures in holding this network together. This is a point we take up again in our discussion on centrality. Thus, we know that weak ties are important for this network, and as such, they are also important for our natural resource management project. However, there are a plethora of stakeholders who are linked to the network via weak ties, and we cannot possibly invite all of these stakeholders into our future deliberations. Further, although weak ties are important, we also recognize the importance of strong ties, and we therefore wish to identify stakeholders who are also prominent in the network by virtue of their strong ties with others.

In addition to the preceding considerations, we were also aware of the role of centrality in identifying stakeholders, and also the role of homophily. Centrality would help us locate which stakeholders generated more ties in the network as well as brokered across disconnected segments of the network. In addition, the stakeholder categories unearthed in our stakeholder analysis would help us identify stakeholders according to issues of homophily. Thus, analyzing the centrality of stakeholders according to strength of tie and stakeholder category would help us narrow down our selection of stakeholders to a list of individuals that played important communication and brokering roles in the network. In doing so, these individuals would be more likely to bring holistic views to the discussions and diffuse information outward to the wider social network.

Locating Central Actors: Degree, Betweenness, Tie Strength, and Stakeholder Category

As summarized in Table 1, two forms of centrality can play important roles in resource management. Degree centrality refers to how many others an actor is directly connected to, and betweenness centrality refers to how many times an actor rests between, two others who are themselves disconnected. Table 2 below shows those stakeholders holding the top 10 degree and betweenness values.

These scores were calculated based on the network found in graph A, where we then dichotomized the data, and in the case of betweenness centrality, also converted all directional ties to nondirectional ties.[6] In addition, Table 2 shows the category each stakeholder belongs to, and a breakdown of that stakeholder's immediate neighbors in the network according to stakeholder category. This breakdown also took into consideration whether a stakeholder was strongly or weakly tied to their neighbor.

Linear regression shows that stakeholders with high betweenness scores (Table 2) tend to also have high degree scores ($p < .01$; $r^2 = .57$). So those stakeholders who are investing time in a great many ties also tend to form these ties across disconnected others. However, a closer look at these stakeholders' neighbors reveals a slightly different story. Recall from Table 1 the role of strong ties and homophily: Stakeholders sharing a strong tie are more likely to influence one another, yet they are also more likely to share many similarities. Table 2 shows that, by and large, these stakeholders' strong ties are with ones largely from their own stakeholder category. As such, these highly central individuals tend to be embedded within and more influenced by members of their own category, which reflects much of the literature discussed earlier on homophily and strong ties (Friedkin 1998; Newman and Dale 2004, 2007; Skvoretz et al. 2004). For example, actor 8 has a high betweenness centrality, yet the immediate neighbors to whom he is strongly tied consists mostly of actors within his own stakeholder category (i.e., Grouse Moor Managers). Thus, while actor 8 does connect many different areas of the network together and is reinforced by the diversity of his weakly tied neighbors, his immediate strong connections tend to be with people similar to himself. In contrast, actor 21, from the water stakeholder category, does not have as high a betweenness score as actor 8, yet his immediate strongly linked neighbors comprise a more diverse mix.

Taken together, Table 2 helps us understand which kinds of actors might be important to involve in our resource management dialogues. Actors with high centrality scores are important for the bridging roles that they play (e.g., Granovetter 1973; Burt 2001). In addition, however, we suggest also considering the issues of (i) strength of tie and (ii) homophily, thus also looking at the stakeholder categories from which actors and their immediate neighbors come from, and how strongly tied central stakeholders are to these others. This additional information can help one distinguish whether an actor is linking across similar or dissimilar others, an important distinction to be made for natural resource management purposes.

Table 2. Centrality scores for stakeholders and stakeholders' network breakdown[1]

ID	Group	Degree	Between	Strong Ties	Weak Ties
2	Grouse	14	752	Ag (2), Gro (1)	Gro (2), SB (2), Rec (2), Ag (1), H_2O (1), For (1), Con (1)
14	H_2O	14	1180	H_2O (3), SB (1), Con (1)	Con (3), H_2O (1), Rec (1), For (1), SB (1), Gro (1), Ag (1)
1	Ag	15	702	Ag (2), SB (1)	Con (5), Gro (3), Rec (2), H_2O (1), SB (1)
8	Grouse	15	760	Gro (5), Con (1), Ag (1)	Con (3), H_2O (2), Ag (2), SB (1)
5	Grouse	16	921	Gro (2), Ag (2), Con (1), For (1)	Con (4), SB (1), Rec (1), For (1), H_2O (1), Ag (1)
12	H_2O	17	749	Con (2), SB (1)	Con (4), H_2O (3), Gro (2), Rec (2), For (2), Ag (1)
7	Grouse	19	1190	Gro (4), Con (1)	Gro (3), Con (5), Ag (4), SB (3), Rec (1)
17	Rec	20	1718	Rec (3)	Con (5), Gro (4), H_2O (3), For (2), Rec (1), SB (1), Ag (1)
6	Grouse	20	1494	Gro (4), Ag (3)	Con (6), H_2O (3), Rec (2), For (1), SB (1)
21	H_2O	21	1390	Con (5), H_2O (2), For (1), Gro (1), SB (1), Ag (3), Rec (3)	Gro (2), For (2), Con (1)
13	H_2O	21	1004	H_2O (2), Con (3), For (2), Gro (1)	SB (3), H_2O (2), Con (2), Gro (2), For (1), Ag (2), Rec (2)
9	Grouse	21	1658	Con (1), Gro (1)	H_2O (5), Gro (2), Rec (4), Ag (3), Con (3), For (1), SB (1)
11	Con	24	1070	Con (4), H_2O (1), For (1), SB (1)	Con (3), Gro (4), Ag (3), For (3), Rec (2) H_2O (2), SB (1)
18	Con	27	2299	Con (4), Rec (1), For (1), H_2O (1)	Gro (6), Ag (4), Rec (3), For (3), Con (1), H_2O (2), SB (1)

[1]Analyses for this table were based on Graph A, where all ties where then dichotomized and (for betweenness) they were also made undirectional.

Note. Gro = Grouse; Con = Conservation; Ag = Agriculture; H_2O = Water; Rec = Recreation; For = Forestry; SB = Statutory Body.

Table 2 also shows individuals and stakeholder categories that are not playing central roles: for example, no foresters or statutory body representatives appear as "highly central," suggesting that these categories of stakeholders could be brought more actively into dialogue about resource management.

Refining and Verifying Our Selection

We conducted a number of analyses on our social network data, and each analysis has informed decisions about whom to involve in future resource management dialogues:

1. Separating weak from strong ties: This gave us an initial view as to which stakeholders were more heavily involved in the network than others. Such stakeholders are important to identify and involve, as these stakeholders have a more durable presence in the network and their ties with others in the network hold more trust. Thus, these stakeholders' presence will most likely be felt for quite some time in the future, and the influence they have on others will be more than for those who are connected solely through weak ties. Stakeholders who "disappeared" from the network once we concentrated on strong ties are only linked through weak ties to the network. They are stakeholders who, because they do not have such an active communicative role in the network, most likely hold diverse opinions and potentially different values from those stakeholders linked together through strong ties. Thus they are important to involve in future discussions, and our next question became, which actors from the stable and peripheral sections of the network ought to be invited to further deliberations?
2. Locating central actors: Because a simple analysis of strong and weak ties still left us with a large amount of "peripheral" stakeholders from which to select, we calculated degree and betweeness scores to highlight which particular stakeholders were playing a more active, communicative role in the network. This analysis was based on our network composed of both strong and weak ties, where all ties were then converted to 1s and 0s, and then used in calculating centrality scores for individual actors. A careful comparison of degree and betweenness centrality scores, alongside the composition of actors' neighbors' categories, revealed some central stakeholders who held strong, immediate ties with diverse others as well as performed broker roles in the network. Involving such brokers in our dialogue will potentially result in involving stakeholders who have a more "holistic" view of resource issues and who can better diffuse information and new ideas outward into the network. In addition, such actors could potentially help mediate between different conflicting groups of interest.
3. Centrality analyses resulted in a smaller number of stakeholders on which to focus our attention, and in doing so, it became very obvious that few to no stakeholders from certain categories were playing central roles (e.g., stakeholders from forestry and statutory bodies). Such noncentral stakeholder categories represent areas of the network where more tie formation can be encouraged through inclusive dialogue.

These findings were shared with some of the stakeholders at a conference (Reed et al. 2004) where feedback from the audience reinforced our interpretations of how certain groups and individuals were isolated while others played a more central role and were well connected. The overall reaction from those present at this conference suggested to us that our findings largely coincided with stakeholders' own perceptions.

Conclusions

Environmental applications of social networks are just beginning to emerge, and so far have focused on understanding the characteristics of social networks that increase the likelihood of collective action and successful natural resource management (Bodin et al. 2006; Crona and Bodin 2006; Newman and Dale 2004; Schneider et al. 2003; Tompkins and Adger 2004). These discussions focus on linking well-known social network analysis concepts to issues and theories found in the resource management literature. In this article, we move beyond these discussions to demonstrate how knowledge gained from analyzing the social networks of stakeholders can be used to select stakeholders for participation in natural resource management initiatives.

This article has proposed methods for improving stakeholder representation in participatory processes. Such information can be critical for natural resource management initiatives that require small group sizes for deliberative processes. For example, in the United Kingdom, many landscapes outside National Parks are protected as Areas of Outstanding Natural Beauty. They are managed by committees composed of rural communities and local authorities that need to balance fair representation of diverse interests with a group size that can effectively take management decisions. Our proposed combination of stakeholder analysis and SNA can help identify stakeholder categories, ensure key groups are not marginalized, and specify representatives that are well connected with and respected by the groups they need to represent. This is done by identifying which individuals and categories of stakeholder play more central roles and which ones are more peripheral, and by gaining a sense for how the overall network is shaped. Such information is also crucial for natural resource management initiatives that aim to influence the behavior of stakeholder categories through key players. For example, agricultural extension services around the world employ agricultural demonstrators from among farming communities to showcase innovative crops and methods to their neighbors. The diffusion of innovative practices in this way requires that those selected are sufficiently well connected and respected in the local community (Rogers 1995).

We conclude by discussing some of the limitations in using social network analysis and stakeholder analysis in the way proposed here. By locating central actors according to our initial measure of frequency of communication, we potentially overlook how some stakeholders might derive their influence from sources other than their communication roles in the network. For example, statutory bodies do not appear as very central in our network, but they have a lot of influence over the ways policies are written and enacted, and thus influence the day-to-day lives of stakeholders. Taken together, we advise that social network analysis is a tool to be used in conjunction with other methods and approaches. In our case, we had qualitative data against which to compare our SNA findings. Rather than using the numbers from the SNA at face value, we used these findings as heuristics and as an input in discussions with stakeholders on how to interpret and use the data (Prell et al. 2008). This approach to stakeholder analysis is more time-consuming and costly than focus groups, but can provide more in-depth information than traditional approaches. Thus, SNA is a sophisticated technique that brings precision and a deeper understanding of social relations among stakeholders, but used in isolation from other data the results may lead to simplistic decisions about stakeholder involvement in natural resource management.

Notes

1. By "stakeholders" we refer to individuals who affect or are affected by certain decisions and actions (Freeman 1984). These individuals can be clustered into stakeholder categories according to their similarity in views, position(s) on an issue, and/or how they affect or are affected by the issue under discussion.
2. This discussion of weak and strong ties relates to and (partially) draws from an extensive discussion on social capital. For example, the following authors discuss social capital by linking strong and weak ties to the accruement of certain benefits and/or disadvantages for individuals, groups, and society: Ron Burt (e.g., Burt 1997, 2000, 2001), Volker and Flap (1999), and Putnam (1993, 2001). These authors refer to strong and weak ties within a discussion of "closure," "cohesion," or "bonding" for strong ties and "brokerage," "structural holes," or "bridging" for weak ties (for an in-depth discussion see, e.g., Prell 2006). This article is not a social capital paper, but rather draws on the ideas (taken from this literature and from other literature cited in the paper) that tie strength coincides with the ability of actors/groups to accrue certain resources for themselves. A paper that wishes to truly tackle the issue of how social capital relates to resource management would, among other things, consider the norms of trust and (generalized) reciprocity among this group of actors. This would make for an interesting study, and in fact, the authors are currently gathering data on social capital of stakeholders from a network perspective.
3. Name generators are a common method for gathering SNA data (Wasserman 1994; Knoke and Kuklinski 1982).
4. We are aware that additional measures for tie strength could have been developed to measure the other dimensions of tie strength as outlined by Granovetter (1973; and quoted earlier in this article). Unfortunately, three main constraints barred us from pursuing this: (1) We were not the only researchers approaching this group of respondents, i.e., time was of the essence; (2) SNA data are gathered through asking the same question multiple times regarding others—a more traditional questionnaire is not faced with this constraint and can thus hold multiple items for one concept; and (3) focusing on communication ties was deemed most pragmatic, as questions about emotional intensity etc. were deemed too private/sensitive for this research context.
5. This is a software package for analyzing social network data.
6. Please see Wasserman and Faust (1994) for explanation on calculating centrality on valued, directional data. Also, one needs to keep in mind that there is a certain level of measurement error in our identification of central actors: Our stakeholder analysis was iterative, and we triangulated our data to provide as complete a view as possible of the network boundary before approaching respondents with our name generator question. However, determining network boundaries is a common problem in SNA, similar to other social research where sampling frames are unavailable or the population number unknown. Although some of the individuals from our name generator turned out to be central nodes, several of them did not, suggesting that although one can never fully rule out error and bias, our central nodes were not simply an artifact of the sampling technique, but rather our stakeholder analysis had adequately outlined our network boundary.

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