THESIS

SOCIAL NETWORKS FOR COLLABORATIVE WATER MANAGEMENT: A METHODOLOGICAL APPROACH TO ADDRESSING WICKED ENVIRONMENTAL PROBLEMS

Submitted by

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ABSTRACT

SOCIAL NETWORKS FOR COLLABORATIVE WATER MANAGEMENT: A METHODOLOGICAL APPROACH TO ADDRESSING WICKED ENVIRONMENTAL PROBLEMS

Lake pollution caused by human activity on nearby land is currently seen as one of the most pressing issues facing fresh bodies of water worldwide and particularly in the Midwestern United States. In Menomonie, a small lakeshore town in Wisconsin, lake pollution from phosphorus eutrophication has become an unhealthy nuisance for the residents that reside there. Eutrophication is the build-up of algae in waterways when there are too many nutrients, such as phosphorus, concentrated in the water. Attempts have been made by government officials, practitioners, researchers, and community members to clean up the lake or tackle the root of its cause with limited success. This research argues that this "wicked" pollution problem, while environmental and scientific in nature, cannot be resolved without a much more thorough analysis of the social aspects involved in decision-making and collaborative knowledge acquisition. I conducted a mixed methods study using interviews, digital surveys, and Social Network Analysis (SNA) of the community in question to reveal how network structure, network interactions, and actor characteristics play a role in this community's collaborative effort to address lake pollution. The following research shows that SNA, alongside qualitative field study, can reveal significant findings about the network and the environmental problem.

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CHAPTER 1: INTRODUCTION

On the edge of a 1009-acre lake sits the small town of Menomonie in eastern Wisconsin. Every summer, this lake is plagued by a large and smelly green algae bloom. These recurring algae blooms negatively affects aquatic systems, resulting in fish kills and overall poor environmental quality for other aquatic organisms. Boat landings and restaurants sit on the shore of this lake, allowing for recreation and enjoyment of the nearby scenic views. However, the algae blooms that turn nearby lakes and streams green severely reduce the appeal of these lakeshore activities. This lake pollution further negatively affects human health, home values, and local businesses.

Lake Menomin is classified as a drainage basin, or watershed, which means that all the precipitation and upstream waters runoff into this reservoir (USGS 2016). The Department of Natural Resources (DNR) collects data about the quality of this lake primarily through volunteer monitoring. Exceedingly poor quality of this lake has been, and continues to be, a major concern, as monitoring began in 1990 and is continued by volunteers today. The graph and table on the following page show that the pollution and appearance of the lake has not changed much in the past 15 years and is consistently eutrophic. Figure 1 shows average Secchi TSI data on an area of the lake during the summer months (July-August) from 1990 to 2016. The Trophic State Index (TSI) is a way to measure nutrients in a body of water, ranging from 0 to 110. At levels of 50-60 TSI, the lake is eutrophic: there is decreased water clarity, and high levels of oxygen in the water. At levels of 60-70 TSI, the water is highly eutrophic: algae blooms dominate the surface, and limit light penetration. Table 1 shows negative visual perceptions of water quality in the months of July, August and September in 1990 and 2016.

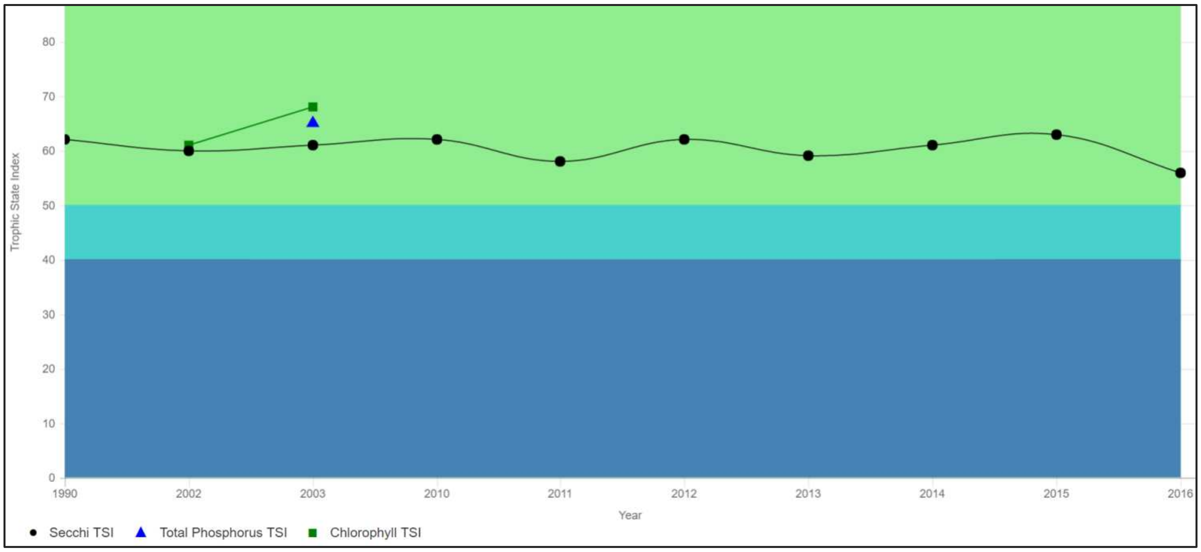


Figure 1- Secchi TSI index by year (dnr.wi.gov)

Table 1- Lake Perceptions over time

Date	Color	Perception
07/02/1990	Brown	Enjoyment somewhat impaired (algae)
07/10/1990	Green	Would not swim but boating OK (algae)
07/18/1990	Green	Would not swim but boating OK (algae)
07/25/1990	Green	Would not swim but boating OK (algae)
08/01/1990	Green	Would not swim but boating OK (algae)
08/08/1990	Green	Would not swim but boating OK (algae)
08/15/1990	Green	Would not swim but boating OK (algae)
08/22/1990	Green	Would not swim but boating OK (algae)
08/27/1990	Green	Would not swim but boating OK (algae)
09/07/1990	Green	Would not swim but boating OK (algae)
09/16/1990	Green	Would not swim but boating OK (algae)
07/05/2016	Green	Enjoyment somewhat impaired (algae)
07/15/2016	Green	Would not swim but boating OK (algae)
07/18/2016	Green	Would not swim but boating OK (algae)
07/26/2016	Green	Enjoyment somewhat impaired (algae)
08/02/2016	Green	Would not swim but boating OK (algae)
08/09/2016	Green	Would not swim but boating OK (algae)
08/15/2016	Green	Would not swim but boating OK (algae)
08/24/2016	Green	Would not swim but boating OK (algae)
08/29/2016	Green	Would not swim but boating OK (algae)
09/12/2016	Green	Would not swim but boating OK (algae)
09/20/2016	Green	Would not swim but boating OK (algae)

The community hopes to see this lake pollution reduced and many members of the community are trying to find the best solution to this problem. Government officials, university research groups, and others in the community have dedicated considerable time to solving this lake pollution, still not much has changed in the past 10 years. This thesis will reveal that lack of success in policy solutions and lake pollution clean-up or mitigation is a result of a combination of technical, political, and social limitations. From a technical point of view, lake pollution is difficult to address as the exact source of pollution is often hard to identify and can come from many places in the watershed. Politically, this issue involves many stakeholders, there is a need to utilize various resources, and there may exist multiple solutions to the problem. Finally, individuals within this context may be included or excluded due to existing social norms or institutions. Individuals affected by or influencing this problem may be spread out and have diverse values, beliefs, and knowledge. Therefore, this lake pollution cannot be resolved without addressing these constraints directly.

Agricultural Run-off and Non-Point Source Water Pollution

Runoff can broadly be defined as "that part of precipitation which ends up in streams or lakes (i.e. the combined flow of surface water, subsurface drainage and groundwater pathways)" (McDowell et al. 2004: 3). Phosphorus is a very common mineral and one of the main nutrients for plants. Historically, plants could obtain Phosphorus naturally from nutrient rich soil. The depletion of healthy and fertile soil has led farmers and property-owners to cover their lands with fertilizers concentrated with minerals, including Phosphorus (Liu et al. 2008). Runoff of these enriched fertilizers into bodies of water leads to surface water eutrophication which is highly problematic as it "has become the primary water quality issue for most of the freshwater and coastal marine ecosystems in the world" (Schindler and Smith 2009: 201).

Eutrophication, defined as "excessive plant growth resulting from nutrient enrichment by human activity" is "one of the most visible examples of human changes to the biosphere" (Schindler and Smith 2009: 201). While this is a global problem, eutrophication affects the United States extensively as: "the US Environmental Protection Agency (1996) identified eutrophication as the most ubiquitous water quality impairment in the US, with agriculture a major contributor of [phosphorus]" (McDowell et al. 2004: 1). Disrupting the water quality of these areas also has significant economic and social impacts such as "decreased health of lake residents, lower property values, and decreased tourism revenue for local businesses" (Anson and Paulson 2016: 426).

Furthermore, the algae bloom created by eutrophication is difficult to address due to the sources of this phosphorus runoff. Research has shown that "while point source polluters are held responsible for pollutants and regulated by government policies, non-point source pollution comes from storm water runoff and agricultural runoff which are not easily regulated" (Anson and Paulson 2016: 426). Non-point source pollution is therefore one of the most challenging pollutants to manage as it could be caused by a "wider range of human activities which may be: long term in nature; socially, politically and institutionally complex; spatially diverse; and difficult to influence" (Patterson 2013: 442). Addressing this complicated environmental problem thus requires a detailed analysis of all involved stakeholders and their actions.

Lake Pollution as a Wicked Problem

In general, a wicked problem occurs because "the problems of governmental planning-and especially those of social or policy planning-are ill-defined; and they rely upon elusive political judgment for resolutions" (Rittel and Webber 160: 1973). Rittel and Webber famously describe the term "wicked" as being:

> *akin to that of "malignant" (in contrast to "benign") or "vicious" (like a circle) or "tricky" (like a leprechaun) or "aggressive" (like a lion, in contrast to the docility of a lamb). We do not mean to personify these properties of social systems by implying malicious intent. But then, you may agree that it becomes morally objectionable for the planner to treat a wicked problem as though it were a tame one, or to tame a wicked problem prematurely, or to refuse to recognize the inherent wickedness of social problems.*

In this research, I argue that the problem facing this small town in Wisconsin is indeed a "wicked" one. Wicked problems are highly relevant in this context as they involve uncertainties that are cognitive, strategic, and institutional (van Bueren et al. 2003). Cognitive uncertainty occurs when "causal relations are numerous, interrelated, and difficult to identify" (van Bueren et al. 2003: 193). The existence of non-point source pollution means there is no one source of pollution entering the lake, and the problem is a combination of many sources, actions, and actors, not just one. This relates to strategic uncertainty as well, which occurs when "many actors are involved [and] their strategies to address the problem are based on their perceptions of the problem and its solutions" (van Bueren et al. 2003: 193). Strategic uncertainty is evident in how individuals in the small town discuss this lake pollution. Many residents in town believe farm agriculture is to blame, while some farmers will point to lakeshore homeowners as the actors who need to stop fertilizing lawns and spilling motorboat oil near the lake. Finally, institutional uncertainty occurs when "decisions are made in different places, in different policy arenas in which actors from various policy networks participate" (van Bueren et al. 2003: 194). Highly fragmented networks therefore become problematic in addressing complex wicked problems. It is because of this complicated fragmentation and uncertainties inherent in wicked problems that it is necessary to look toward social network analysis to better understand the structure of this network's decision-making processes.

Weak Governance and Procedural Justice

In addition to water pollution in the area being a wicked problem, there is also weak governance surrounding this issue. For this analysis, I draw on Faysse et al.'s conception of weak governance which is defined as "the occurrence of weak interactions between the actors who use natural resources and the actors in charge of the management of these resources and of activities related to the use of the resources" (2014: 250). When policy of a natural resource does not align with local knowledge and experience it may be due to the weak interactions of actors within the network. Thoroughly understanding who is participating in the governance process will allow for better policy formulation.

The environmental justice movement overall, "has worked to ensure the voices of those most affected by environmental decisions are involved in a transparent decision making process" (Gleick et al. 2012: 54). As one of the main tenants of environmental justice, procedural equity refers to "fair practices in the application, enforcement, and implementation of laws and regulations regarding environmental toxins" (Floyd and Johnson 2010: 62). This would include all stakeholders, those at fault and those affected by the environmental toxin at hand. In this case, procedural equity would include all actors causing the pollution as well as those affected by it during the decision-making process.

My previous data collection has revealed that although local farmers are frequently blamed for water pollution and algae blooms in the area, they are often not adequately included in the social network of water policy actors. Because of this, it appears that the necessary knowledge and information about water pollution is not being spread equally across this network. This present study seeks to determine how knowledge is being transferred throughout the network which involves an analysis of who is included in knowledge sharing, where these individuals are positioned in the network, and what attributes these individuals have that are associated with knowledge transfer. By understanding the role network structure has in this knowledge network, water policy can be more effectively implemented and areas where resources are most needed can be identified. I argue that this interpretation of procedural equity and inclusion should include all associated stakeholders surrounding the management, use, and harm of this water resource. This new interpretation and definition of procedural justice should start with the use of Social Network Analysis (SNA) and qualitative data collection in the evaluation of water resources and environmental management.

Knowledge Networks for Collaboration

Phelps et al. describes a knowledge network as "a set of nodes—individuals or higher level collectives that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge—interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer, and create knowledge" (2012: 3). This definition of a knowledge network as well as the distinctions between acquiring, transferring, and creating knowledge will be the guiding framework of this research.

When it comes to common natural resources, focusing on knowledge is paramount as there is often a disconnect between available knowledge and policy action taken. Laurance et al. (2004) suggests that scholars and scientists are disconnected from conservation practitioners and are therefore less able to facilitate productive change through knowledge production towards environmentally sustainable solutions. Laurance et al. explains that "two-thirds of the conservation assessments published in the peer-reviewed scientific literature did not deliver any conservation action…this disconnect promotes misconceptions about how conservation works and what practitioners actually need" (2004: 165). It is therefore necessary to evaluate how knowledge is transferred within the network of knowledge producers, activists, polluters, and regulators to better understand how this transfer of science and knowledge can be applied to the environmental problem at hand. In conservation efforts, practitioners are often aware of what problems exist, but when it comes to implementing solutions with stakeholders, their work falls short.

With many stakeholders involved in this case study, it is evident that there are many beliefs and diverse knowledge about this lake pollution. While some residents accept the condition of the lake as natural and inevitable, others find it troublesome and think serious action should be taken. Those involved in addressing this local environmental dilemma include local community residents, government officials, farmers, academics, and scientists. Therefore, it is critical to understand how the network is structured, how network actors interact in the network, and who these network actors are. These variables of a network could facilitate or hinder effective water policy solutions and lake clean-up efforts. Understanding these three areas of network research in this case study will provide a more thorough understanding of why Social Network Analysis should be used to address environmental problem persists and what opportunities exist for implementing positive change.

Need for Social Network Analysis (SNA) and Qualitative Methods

Social Network Analysis (SNA) has and will continue to become increasingly more relevant, particularly in understanding environmental problems. SNA is necessary for interpreting environmental problems as "the structural pattern of relations (i.e. the topology) of a social network can have significant impact on how actors actually behave" (Bodin and Crona 2009:367). The ability for actors to implement solutions within this network is not only dependent on their willingness to participate or their access to resources but also the structure of their network. Where individual responsibility for the lake pollution is difficult to pinpoint, SNA can be used to identify the level of stakeholder involvement in decision-making across the network. Network analysis also allows for direct interpretations of existing relations between individuals or groups. This is significant as these relations with others "affect how we behave, what we believe, how we understand the world around us and how we navigate through it, what constraints we labor under, and what avenues and opportunities are open to us" (Giuffre 2013: 10). I argue that the structure of the network of actors and the existing relations play a key role in determining the success of remediating or mitigating this lake pollution.

While the benefits associated with using SNA for evaluation are numerous, it may not be effective as a standalone method. Research has shown that networks are constantly changing and there "have been dramatic shifts in patterns even after a brief interval" (Cross and Parker 2004: 133). Using SNA can only tell us about a specific moment in time and may fall short when it comes to explaining contextual or specific events associated with the research. Additionally, other cases utilizing SNA have found that their research was much more thorough and complete with the use of supplemental qualitative methods (Prell et al. 2009). Therefore, a mixed methods approach that includes both quantitative SNA and qualitative data collection is particularly necessary to understand a community network fully. Because of the constantly changing nature of social networks, this research will also observe the community network at two different time periods.

Finally, "Sociology, to put it kindly, does not have a rich history of working effectively with other water-related disciplines on a common water resources agenda" (Freeman 2000: 484). This is problematic as water resource issues are often inherently social. This research will provide a framework for ways in which Sociology can be successfully incorporated into water resource management by using Social Network Analysis (SNA), interviews, and surveys.

Research Questions

Runoff into streams and waterways has led to algae bloom growth in a small town of Wisconsin, creating a wicked environmental problem. Problems such as these require collaborative solutions and strong governance among stakeholders and policy actors. This begins by transferring and acquiring shared knowledge across the local social network. Social Network Analysis (SNA) and qualitative analysis can provide insight into how knowledge is transferred across this network and how individuals interact within the network. By understanding how knowledge is transferred across the network, water policy actors and practitioners can determine where their resources can be most effectively placed to improve water quality in the local community. This research seeks to determine the advantages of using a Mixed Methods approach of quantitative network analysis and qualitative interviewing and how this approach can help practitioners address local lake pollution. Because of this, my research seeks to answer three research questions:

1. *What role does the* ***network structure*** *have in shaping social interactions?*
2. *What roles do* ***network interactions*** *have in transferring knowledge across the network?*
3. *How do* ***characteristics of the actors*** *affect collaboration within the network?*

CHAPTER 2: LITERATURE

Environmental pollution continues to be one of the most pressing issues facing society today. These environmental problems often involve a vast array of stakeholders and necessitate collaborative solutions. Sociology and Network Theory provide a key to evaluate these problems and practical solutions effectively. My research seeks to identify how a network of actors surrounding local lake pollution attempt to address these issues and how Social Network Analysis (SNA) provide insight into the networks effectiveness. This research takes a network theory approach to interpreting the problem at hand and the literature below will evaluate the problem as well as emphasize how network theory will be useful in this case study.

The specific problem of focus is algae blooms caused by high nutrient levels in local bodies of water. Particularly, "in the United States, the extent of phosphorus loss through runoff and groundwater transport is stunning, resulting in 75,000 tons annually transported from Midwest farms into the Mississippi River alone" (Anson and Paulson 2016: 426). Non-point source pollution is one of the largest water quality problems in the state of Wisconsin as these pollutions are "estimated to cause water quality impacts on 40% of state streams and about 75% of state inland lakes" (Kent and Dudiak 2001: 107).

This case study involves specific stakeholders that influence and are influenced by this water pollution. The state Department of Natural Resources (DNR) and the Department of Agriculture, Trade and Consumer Protection (DATCP) are largely the actors responsible for water quality issues in Wisconsin (Kent and Dudiak 2001). While these groups may make up the central focus of this study, SNA can reveal how other actors are involved in addressing this problem and who might be important to include in the conversation. Concerned citizens, researchers, and academics take it upon themselves to get involved in solving this water quality issue as well. Also, in the state of Wisconsin, counties, cities, and towns can enact ordinances regarding land management regulation and non-point source pollution (Kent and Dudiak 2001). When addressing water resource management, this fragmentation of responsibility and effort could be an opportunity for many points of change or an inconvenience of conflicting goals and agendas.

The research presented in this thesis is significant because "resent research has identified the existence of social networks as a common and important denominator in cases where different stakeholders have come together to effectively deal with natural resource problems and dilemmas" (Bodin and Crona 2009: 367). There is ample evidence that the existence of social networks is useful in the management of resources as Bodin and Crona (2009: 367) highlight:

> *Social networks can improve collaborative governance processes by facilitating, (i) the generation, acquisition and diffusion of different types of knowledge and information about the systems under management, (ii) mobilization and allocation of key resources for effective governance, (iii) commitment to common rules among actors fostering willingness to engage in monitoring and sanctioning programs, and (iv) resolution of conflicts.*

The context associated with this lake pollution presents a strong need for water resource management in the area to be assessed using sociological theory and network analysis. In this review, I will provide a background of network theory as it is used in the field of Sociology. The remainder of this chapter will discuss the various literature associated with network structure, network interactions, and characteristics of actors. The focus will be on "wicked" problem solving, water resource management, collaborative governance, procedural justice, and knowledge transfer; as well as how these subject areas relates to Social Network Analysis (SNA). While these five subject areas are distinct, their work frequently overlaps. Throughout this chapter, I will emphasize particularly case studies that utilize network analysis as well as showcase the usefulness of knowledge networks in collaborative resource management.

Theoretical Foundations of Network Theory

The importance of social network theory can be found in one of the earliest social theorists, Emile Durkheim. Because Durkheim saw human societies as biological systems, "the reasons for social regularities were to be found not in the intentions of individuals but in the structure of the social environments in which they were embedded" (Borgatti et al. 2009: 892). Acknowledging the embeddedness of the individual allows researchers to evaluate actor's position within a network and the role that the structure of relations has on the individual. I am therefore using an ontology in which social structure is significant to creating and maintaining social relations. This entails both that the patterns of relations in the network affect interactions of individuals as well as individuals' position in the network affects that individual (Borgatti et al. 2009).

It is necessary to distinguish the significant differences of traditional social research and social network research as Borgatti et al. (2009: 894) details:

> *Whereas traditional social research explained an individual's outcomes or characteristics as a function of other characteristics of the same individual (e.g., income as a function of education and gender), social network researchers look to the individual's social environment for explanations, whether through influence processes…or leveraging processes.*

A network is simply a set of relationships. Since SNA is a quantitative approach to social research, network theorists use mathematical terminology to describe relations within the network. An individual or a single group within a network is called a node. A relationship between nodes is described as a tie or an edge. Networks are often depicted algebraically in a matrix or visually in the form of a "sociogram" through which relationships can be quantitatively analyzed (Kadushin 2012). Below is a simplified version of a matrix (Figure 2) and a sociogram (Figure 3) in which there are three nodes and three mutual relationships, or ties. A matrix is how social network data is often input into quantitative software, and a sociogram is the output that appears from that matrix. So in this example, the matrix below as an input would produce the output of the sociogram below.

	A	B	C
A	-	1	1
B	1	-	1
C	1	1	-

Figure 2- Simplified Matrix

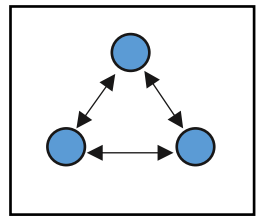


Figure 3- Simplified Sociogram

Another way to think about the importance of networks in a community is through an understanding of social capital. Using Putnam's famous interpretation of social capital, Gilchrist summarizes: "social capital reflects shared norms and values that are affirmed through sustained interaction and co-operation" and "social capital resources include trust, norms and networks…, which gathers consistently for a common purpose" (2009: 10). Also, Lubell and Fulton have found that "Social capital is particularly important in the case of collective action problems where the costs and benefits of behavior are influenced by the decisions of multiple other actors in the social system" (2007 :4). Many network theorists such as Burt (2000), Cook et al. (2001), and Lin (2002) believe network structures are very important when attempting to understand social capital (Gilchrist 2009). While network structures help us to understand the significance of social capital, social capital itself is not easily created and may take a lot of time and repeated interactions to cultivate. Finally, "high levels of social capital appear to be correlated with several core policy objectives around improving health, reducing crime, increasing educational attainment and economic regeneration." (Gilchrist 2009: 20). Because of this, policy actors and practitioners may seek to improve social capital and network relations to improve their governance strategies. These theoretical foundations of network theory will provide a base for moving forward in the literature review.

Wicked Problems and Water Resource Management

Wicked problems are known to be especially challenging problems for public policy actors. This section will lay out where the literature on wicked problems has gone thus far and the potential opportunities for its expansion. David Freeman (2000: 483) further specifies the wickedness of these problems because:

> *because they involve multiple definitions as to their nature, because they are the object of multiple and conflicting criteria for defining solutions, because the "solution" to one interested party is a "problem" for others, and because there are no obvious stopping rules that define when enough has been accomplished. Wicked problems are those found in the domain of public policy (e.g., urban renewal, crime, and water resources).*

Not only are wicked problems unstructured, cross-cutting, and value-driven; they are also often connected to other problems (Weber and Khademian 2008). A key emphasis of wicked problems is that since there is no singular cause, there is also no singular solution that fits best. The fundamental limitations of the wicked problem could be either an uncertainty of the cause or a divergence in perspectives (Head 2008). If the problem is cause based, more research needs to be done to eliminate uncertainty and evaluate available solutions. However, if the problem is viewpoint based "the implied solution is to establish processes of participation, debate and mediation that lead to a workable consensus" (Head 2008: 106). In this present case study, the scientific cause is well researched and widely known. A divergence of viewpoints appears to be more prominent in this case study as all stakeholders have different interpretations of how the problem should be addressed and who should resolve it. With fragmentation of actors involved in the lake pollution, conflicting strategies or solutions may arise as different groups try to implement different goals, policies, and practices (Carter et al. 2005).

One of the most widely recommended approaches to addressing wicked problems is the bettering of knowledge. As Head argues, “investment in more research to address gaps in knowledge is necessary, especially in relation to understanding causal links; since better knowledge can contribute both to ‘evidence-informed’ policy and to good processes for increasing the scope of consensus” (2008: 114). To effectively manage any wicked problem, knowledge must be used, transferred, and integrated in such a way to allow for the creation of innovative solutions to the problem at hand (Weber and Khademian 2008). Therefore, the transfer of knowledge is particularly useful to study when understanding non-point source lake pollution.

Water resource management is a known wicked problem for policy actors and practitioners. This is because water is difficult to manage and “represents a common-property resource requiring organized collective action for its provision” (Freeman 2000: 486). For effective management of water resources to occur, Blomquist argues that analysts “must clearly define the problem, the actors and their stakes, [and] the various resources that actors have at their disposal…” (2004: 934). SNA can address these aspects by identifying relations and positions within the network. Studying local policy networks in the context of natural resource management is relevant as these networks can “spread information about behaviors and policies, provide reservoirs of social capital, and enable cultural change” (Lubell and Fulton 2007: 21).

Policy networks are also relevant in watershed management because “these networks spread information about the existence and effectiveness of different types of BMP [Best Management Practices], the existence of water quality issues and polices, and the decisions and viewpoints of other producers" (Lubell and Fulton 2007: 4). By understanding the structure of the network and the actors involved, one can understand where this valuable information is or is not being spread. Moreover, adopting different farming or resource management practices has been largely shown to be affected by the overall structure of a network or an individual's position in the network (Lubell and Fulton 2007).

Social networks are beginning to be "instrumental in enabling communities to adaptively respond to environmental change and to initiate and sustain successful co-management of natural resources…but the precise mechanisms by which this happens are rarely discussed" (Crona and Bodin 2006: 14). Therefore, a much more formal framework for utilizing SNA must be established to determine how social networks can best meet the needs of stakeholders practicing co-management of natural resources.

The literature on wicked problems and water resource management reveals that pollution of collectively used water resources results in many affected stakeholders with divergent solutions and interpretations of the problem. Collective action and knowledge sharing is the most effective way to address these wicked water management problems. Furthermore, social networks can be useful in managing these resources but only if they are methodically and thoroughly studied.

Network Structure: Collaborative Governance

Collaboration and cooperation is a common goal when policy actors seek to tackle the wicked problem of water resource management. For this research, I am using a broad interpretation of collaborative resource management described by Conley and Moote as "multiparty natural resource management projects, programs, or decision-making processes using a participatory approach." (2003: 372). This section will present why collaboration seems so appealing in these cases and why scholars should be cautious to assume collaboration to be the necessary end goal. Collaboration may not be the only end goal but specific network structures and relations may be required to have the most fruitful environmental problem solving.

While collaboration can facilitate network connections, the overall structure of the network can also influence the ability for collaboration to occur. It is often cited that the more social ties that exist within a network (i.e. density), the more likely it is that collaborative actions can take place (Bodin and Crona 2009, Cross 2009). Network density is defined by social network analysts as "the mean strength of connections among units in a network, or (for dichotomous measurements) the proportion of links present relative to those possible" (Marsden 1990: 453). Because density is a proportion, density scores range from 0 to 1 in which 1 would mean that every possible direct connection is made in the network. Therefore, more links to others within a network imply more collaborative efforts.

Provan et al. shows that while practitioners might wish to increase connections and strength of connections across a network, they must be cautious as "increased collaboration is not always a desirable goal" (2005: 611). In fact, "very high tie density can…reduce a groups' effectiveness in collective action" (Bodin and Crona 2009: 368). Practitioners and researchers must also be careful to assume that collaboration can resolve all problems associated with the management of shared resources. In fact, even when collaborative partnerships are created, there is no guarantee that they will remain fruitful. Research has shown that while there have been "widespread efforts to build community capacity through the formation of multi-organizational partnerships, such networks are difficult to establish and even harder to sustain" (Provan 2005: 603).

A main principle of collaboration is the inclusion of many and diverse stakeholders. A stakeholder is any individual who could affect or be affected by a decision related to the issue at hand (Evans 2012). Addressing this lake pollution spans many governing bodies and includes many stakeholders. The diagram below illustrates the various levels where water policy is intercepted and affected.

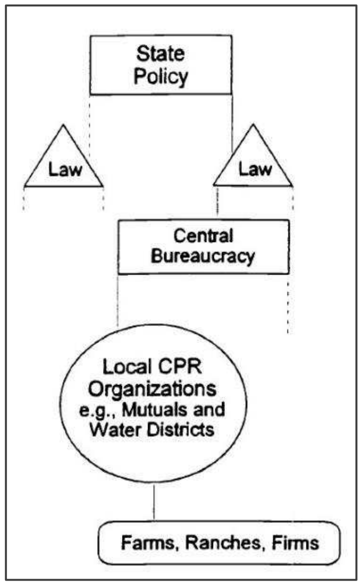


Figure 4- Levels of Analysis (Freeman 2000:486)

Not included in this diagram would also be local community members or residents of the polluted area. Research has found that top-down approaches to resource management are ineffective in these scenarios where environmental resources are commonly used and shared. This has led to a focus on co-management "where the underlying rationale is that by involving different actors in the governing process, the complexities inherent in both ecosystems and the social arrangements constructed around these…can be more adequately addressed" (Bodin and Crona 2009: 366).

In this work, I recognize that inclusion of all key stakeholders within the analysis may be difficult as "certain categories of stakeholder may be historically marginalized from management decisions…[and] pre-existing conflicts between different groups may preclude a willingness to join a deliberative process" (Prell et al. 2009: 502). Often policies and regulations do not include input from stakeholders even though "case studies indicate that strategies that stakeholders help to create are often more widely supported, promoted and implemented" (Carter et al. 2005: 117).

As stated previously, Procedural Justice involves the "fair practices in the application, enforcement, and implementation of laws and regulations regarding environmental toxins" (Floyd and Johnson 2002: 62). Robert Lake argues that "a more radical and far-reaching definition of procedural justice is required if the environmental justice movement is to accomplish more than a merely cosmetic change in the distribution of environmental problems across communities" (1996: 162). According to Lake, "procedural equity entails full democratic participation not only in decisions affecting distributive outcomes but also, and more importantly, in the gamut of prior decisions affecting the production of costs and benefits to be distributed" (1996: 165). Additionally, "If the environmental justice movement is to go beyond the surface of social inequities, it must necessarily place vulnerable people in decision-making positions" (Floyd and Johnson 2002: 62). This is significant in this case study because oftentimes farmers in the area are minorities in water policy decision-making processes and are the ones most vulnerable to changes in regulations on water quality.

Prell et al. (2009) present a case study in which SNA can be used to at least identify relevant stakeholders to participate in future management initiatives surrounding the natural resource in question. Ego-network SNA may not capture all individuals within the network, but it can make gaps in participation and inclusion evident. In other words, 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" (Prell et al. 514).

Social network analysis can reveal significant strategies for measuring the inclusiveness of stakeholders. Certain individuals can act as "Bridging ties [to] provide access to external resources of various kinds, and are often needed to help actors initiate or support collective action…both of which are vital for resource governance" (Bodin and Crona 2009: 369). Cross and Parker (2004) refer to the individuals that bridge ties as "Boundary Spanners." These ties between individuals are highly important as Bodin and Crona (2009: 369) point out:

> *The positive effect of bridging ties in natural resource governance extends beyond the exchange of information and knowledge. They can foster trust among previously unconnected groups which facilitates collective actions among different types of actors, such as farmers and governmental officials. This is crucial in natural resources governance which typically affects many different sectors of society*

In the Social Network literature, a bridge tie can be created "from the connections between people who have less in common, but may have an overlapping interest, for example, between neighbours, colleagues, or between different groups within a community" (Gilchrist 2009: 12). This is highly relevant in the present case study as bridge ties may be able to connect individuals from different groups with different types of knowledge.

A case study by Rathwell and Peterson (2012) shows how SNA can be used to evaluate successful bridging organizations in watershed management. These authors found that the more connected a municipality was, the more likely they were to engage in water quality management issues (Rathwell and Peterson 2012). While there were bridge ties in their network, they still noted that some groups continued to remain isolated. Their piece advocates for using bridging organizations to connect larger groups of people and their research using SNA in water resource management found "collaborative hotspots and gaps" within the landscape (Rathwell and Peterson 2012: 12).

Furthermore, assuming a community can come together collectively may also be problematic as "communities are rarely just one single group of local stakeholders; rather, they are defined by complicated patterns of subgroups with different perceptions, interests, resources, and amounts of influence" (Crona and Bodin 2006: 1-2). Collaboration may therefore be stalled by the extant groups within the larger community as "the existence of subgroups can pose challenges for joint action aimed at governing a common natural resource, due to the risk of 'us-and-them' attitudes among actors" (Bodin and Crona 2009: 368). This is further connected to how the network is structure as "people outside the 'inner circle' sometimes charge that their views are excluded" (Conley and Moote 2003: 373). Also, "many environmental groups charge that these [collaboration] efforts are co-opted by local economic development interests while industry groups contend the opposite" (Conley and Moote 2003: 373). Evaluating the network structure of the overall community and associated subgroups rather than just viewing density could create a more thorough understanding of the appropriate way to create collaborative partnerships.

Community detection is a method used in SNA to identify the existence of possible subgroups within a larger network. This is useful and practical because "communities in a social network might represent real social groupings, perhaps by interest or background" (Girvan and Newman 2002: 7822). Additionally, "the identification of communities within a network can reveal functional groups and the gaps between them" (Cross 2009: 312). An algorithm named after the creators, Girvan and Newman, can run this analysis in SNA software. Network analysis software such as UCI-NET can run these community detection algorithms (Cross 2009).

Caniglia et al. (2016) utilizes SNA as well as content analysis to demonstrate fragmentations and connections in a water governance network of Oklahoma. The authors' focus in this case study is climate change, which is one of the most commonly cited wicked environmental problems. Importantly, this research reveals the significance of SNA by arguing that "the ability to clearly conceptualize and measure the extent to which existing governance systems are fragmented and/or adaptive will provide important information to local authorities regarding potential vulnerabilities within their governance systems" (Caniglia et al. 2016: 842).

Researching collaborative natural resource management can be done in myriad ways. Some researchers have found it useful to have unbiased outside members researching collaborative efforts, while others think participatory research is more effective where individuals are familiar with the problem at hand (Conley and Moote 2003). The scholars who find the latter to be more effective "emphasize the importance of participatory evaluation, in which groups conduct self-evaluations, and/or the evaluate works closely with those involved in and affected by a project or process" (Conley and Moote 2003: 374). Therefore, finding a way in which participants can be included in the evaluation project and objective outsiders can observe is the most effective way to evaluate collaborate resource management. Often, "surveys or semi-structured interviews ask respondents to identify and assess an effort's outcomes, the factors that led to those outcomes, and the appropriateness of the processes used" (Conley and Moote 2003: 380). This can be a way to thoroughly include participants in the evaluation process.

The extensive literature on Collaborative Governance shows that while there are many different approaches to collaborative natural resource management, each option is not always the best for the case. Similarly, other critics question "whether successful collaborative efforts are replicable in other communities." (Conley and Moote 2003: 373). Therefore, identifying collaborative efforts at certain points in time or in certain cases may not truly represent the collaborative capability of the network overall or across different circumstances. Even still, Conley and Moote claim that "building networks connecting researchers, participants in collaborative efforts, policymakers and critics will greatly facilitate identifying relevant research questions and applying the results to management" (2002: 382). Using Social Network Analysis and qualitative interviews can reveal what connections in the network currently exist and what gaps exist where collaborative connections can be more successfully made.

This literature shows that bringing together diverse stakeholders for problem solving is a key tenant for collaborative resource management, however this issue is much more complex than just increasing connections and network actors. There must also be a sophisticated understanding of network relations, fragmentations, and sub-communities.

Network Interactions: Knowledge Transfer and Social Learning

Knowledge research is a growing field of study and most commonly focuses on knowledge creation, transfer and adoption. While all three aspects of knowledge networks are relevant, knowledge *transfer* is "necessary for discrete, embodied knowledge to be adopted and used" (Phelps 2012: 5). A review of the knowledge network body of literature has revealed that knowledge transfer is the most common way of studying knowledge networks at 44% of all knowledge network studies (Phelps 2012). As Hassanein has argued, "only recently have social movement theorists treated knowledge as a critical dimension in their analysis" (1999: 7). This presents a great opportunity to include an assessment of knowledge transfer in a network context when looking at problems in need of social change.

Social learning has been another way in which practitioners have attempted to correct for weak governance. This social learning is defined by Muro and Jeffrey (2012: 1) as a:

> *process of communicative action where multiple actors collectively learn about and develop an understanding of each others' interests, concerns, and preferences through dialogue and deliberation, thereby opening up new*

> *opportunities to arrive at a shared diagnosis of a specific environmental situation as a precursor to agreeing upon interventions and solutions*

When governance is weak, it may be difficult to identify where social learning can occur most effectively and how it should be conducted in the given context. Even so, learning is central in governance as it "is required to understand and cope with the dynamics of social–ecological systems and the possibilities and limitations of their management; different sources of knowledge can aid in this" (Newig et al. 2010: 2).

Sharing ideas and learning from others appear to be significant when attempting to find collaborative solutions. This learning, or knowledge transfer, is "the efforts of a source to share information and knowledge with a receiver and the receiver's effort to acquire and absorb (i.e., learn) it" (Phelps et al. 2012: 5). Newig (2010:6) argues that this mutual learning can also lead to effective deliberation:

> *Based on ideas by Habermas (1981), deliberation refers to a genuine exchange of ideas and arguments, regardless of societal power asymmetries. Networks are expected to provide opportunities for deliberation, e.g., by way of group interactions. Through intensive group interactions, deliberation is expected to produce more creative ("emergent") ideas and solutions, as compared to a situation in which actors are reasoning by themselves.*

A network theory perspective can also allow for better understanding of how the positionality of individuals within the network may affect the implementation of policy solutions or change. Betweenness Centrality refers to the measure of the number of shortest paths between pairs of nodes that pass through a node. Someone with a high Betweenness measure is a "connecter among different nodes in the network" (Giuffre 2013: 121). Degree Centrality is the measure of the number of direct ties that each node has to other nodes in the network. A higher score in this type of centrality would refer to having many connections or relationships within the network. Both Betweenness and Degree are significant characteristics of actors within a network because an individual with both high Betweenness and Degree Centrality "could disseminate his ideas widely and they were accepted as trustworthy by those who came in contact with him" (Giuffre 2013: 131). According to Holman, the network statistic closeness "registers the speed of information transmission from one actor to another within the network, and indicates efficiency of communication" (2007: 535). Closeness, in network analysis refers to "how near or far a given node or position is from all other nodes in the figure" (Kadushin 2012: 96). These characteristics of an individual are relevant when it comes to determining the level of involvement of stakeholders in decision-making.

Network Analysis can help us see where this knowledge transfer is occurring most frequently as "direct ties enable greater communication frequency and the sharing of more relevant and higher fidelity information than indirect ties" (Phelps et al. 2012: 8). While an individual may be able to receive information indirectly from another in the network, they can much more effectively receive information when they have more direct connections. Also, overall, "a higher degree of Betweenness is needed in a network to maintain flows of information between actors" (Caniglia et al. 2015: 14). As stated before, centrality is a significant measure of actors within the network. While they can be influential over more individuals within the network, actors with high centrality also have greater access to information and greater control over the spread and flow of information across the network (Phelps et al. 2012). However, sharing ideas one time is not enough for successful organizational performance and effective knowledge transfer requires "continuous and persistent interaction" (Bodin and Crona 2009: 368). Therefore, whenever possible, communities must be studied at various points in time to understand the development or continuation of knowledge transfer.

Actor Characteristics: Acquired Knowledge and Perceptions

A criticism of many Common Property scholars is that they have "ignored how rural residents can shape attempts by outside agents such as the state or aid agencies to intervene in their lives and modify existing patterns of resource use" (Agrawal 2003: 257). Therefore, researchers must award more credibility to individual actors within a social network. The literature evaluated thus far involves characteristics of the overall network and nature of interactions, however as Bodin and Crona (2009: 370) emphasize:

> *it is often equally relevant to assess structural characteristics at the level of individual actors (i.e. the nodes of the network) to understand how actors can use their structural position to influence the natural resource governance process. By occupying certain central positions in a social network…actors are able to exert influences over others in the network, and are better situated to access valuable information which can put them at an advantage.*

This work is particularly important as "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" (Prell et al. 2009: 502). There is a need to address the role individuals have as they exist in the network. While my research attempts to understand characteristics of the social network overall, I am also interested in characteristics of *individuals* within the social network that can create successful resource management.

Social network analysts are often more concerned with structure rather than motivation or beliefs. Wellman presents Milgram's study on obedience as an emphasis of the importance of structure over attitude. In this case study, many individuals were morally against their own actions, however that did not stop them from following through with the action (Wellman 1983). Therefore, these researchers argue that one must look to the surroundings and contextual structures as a more powerful indicator of individual action.

This may be true, but one cannot fully disregard characteristics of an actor either. For example, individuals with different characteristics may hold different levels of knowledge: "research suggests that rural residents have higher levels of general environmental concern, environmental knowledge, and environmental behaviors than urban residents" (Mobley 2016: 1152). There may be different levels of knowledge and values, and there may also be varying perceptions of success and motivation to consider. When describing effective organizational efforts, Cross and Parker (2004) argue that network actors need to feel a sense of progress or a feeling that problems can be resolved. Even if collaborative connections are being made across the network, there may still be constraints when it comes to the perceptions of individuals. Therefore, not only do the characteristics of network actors matter, but so do their perceptions.

Common resource theorists claim that institutional change mainly occurs because of a specific social actor, but more importantly, "institutional change is likely to occur only when relevant political actors perceive gains from institutional change" (Agrawal 2003: 245). Understanding the structure of a network can allow for identification of "central and potentially influential actors" (Crona and Bodin 2006: 18). This is why these characteristics of the network need to be evaluated simultaneously because not only do perceptions of actors within the network matter, but perceptions of *certain* actors within the network could be of high importance.

Homogeneity is an interesting topic as it could either help or hinder communication. Homogeneity, sticking with individuals who share similar characteristics, could either: reduce conflict, facilitate communication, and enhance knowledge, or could reduce diversity and access to resources (Crona and Bodin 2006). Therefore, the characteristics of individuals must be considered when determining the effectiveness of network relations and structures. For example, those with similar careers may be more willing to interact than others, which would reduce diversity but may also reduce conflict.

Even if network analysis results are inconclusive or do not identify any characteristics of actors that can improve collaborative efforts, communities can still benefit from seeing visual representations of the structure of the network of actors and the characteristics of those actors. While the results to network analysis may not seem relevant to local communities at first, Provan et al. argues that discussing the results "can lead to the addition of new network members and stronger inclusion, involvement, and commitment of previously underutilized members" (2005: 611). Even if the network structure does not reveal key actors or focal points for collaboration, SNA can allow for "participants to see 'the forest' of the network rather than just 'the trees'" (Provan 2005: 611).

Since this analysis focuses on participants who are most closely associated with water policy management (e.g. government officials and practitioners), it is unlikely that key stakeholders such as farmers will be listed in an ego-network approach. Arrangements such as "the Wisconsin Idea" have been created to attempt to bridge knowledge between agricultural farmers and university scientists. While not ever clearly defined, "the Wisconsin Idea" is often described by the phrase "the boundaries of the University are the boundaries of the state" (Stark 1995). Stark goes on further to describe the university's role in contributing to the state, be that through advice on public policy, exercising technical skills, or directly helping the government solve problems (1995).

Hassanein argues that in this arrangement "scientists tried to overcome farmers' resistance to accepting their advice" (1999: 13). Therefore, this approach was less of a dialogue and more of a persuasion tactic. Freeman describes this issue as two types of conflicting knowledge. There is scientific knowledge, utilizing predictions and explanations often found in published texts; and there is site-specific knowledge that is not easily generalizable and may be more readily understand by locals (Freeman 2000). However, these two types of knowledges must both be acknowledged, as Evans points out, "only recognizing expert knowledge as a valid basis for decision-making excludes the knowledge and experience of people who live and work in ecosystems" (2012: 192). This approach uniting landowners and scientists appeared to be optimistic and helpful, however the Wisconsin Idea "slowly faded and was replaced by the perception that the scientific expert knew more than the farmer" (Hassanein 1999: 13). This perception inherent to the Wisconsin Idea ran deep as Hassanein found that "the communication flow has been from the scientist to the practitioner…Meanwhile the farmer-generated knowledge that had shaped agriculture for thousands of years was slowly hidden from history" (1999: 13). Even though the knowledge gap between farmer and policy worker is evident, there is yet to be a clear solution that can effectively address this gap.

Finally, Crona and Bodin (2006) present a case study of SNA and qualitative work in which fishermen utilizing the same equipment communicate more often and therefore are only receiving knowledge through those relationships. Those with similar occupations and activities were more likely to interact than those across varying occupations. So not only can SNA identify gaps, it can also identify characteristics of individuals and opportunities that lead to more collaborative efforts.

The literature on actor characteristics show that individual actors can have an influential role on knowledge transfer and policy implementation. This can be through the knowledge that the actors retain or their perceptions on the problem at hand. This literature emphasizes that there may also be key actors responsible for change within a network and the perceptions of these specific actors could affect outcomes in water resource management.

Conclusion

This review evaluated the most relevant ways in which network theory can be incorporated into water resource management of a polluted lake and case studies similar to the problem faced by these Wisconsin residents. The literature has shown that water resource pollution and management is in fact a wicked problem that requires a collaborative solution and inclusive decision-making processes. Collaboration, while generally seen as productive, may also have complications involved. The involvement of certain actors in collaboration is highly influential but there can also be dire consequences if some actors are excluded in the decision-making process. Knowledge throughout a network of actors is complex and the way it is transferred can severely influence successful communication and collaboration across the network. Based on the current literature on this topic, SNA alongside qualitative research is the most effective way to gain a better understanding of collaboration resource management and stakeholder involvement of this water policy network in rural Wisconsin.

CHAPTER 3: METHODS

Overview

This is a mixed method study that seeks to understand a small community plagued by a toxic lake. The lake in Menomonie was so polluted that a National Science Foundation (NSF) Grant was given to the University of Wisconsin-Stout, in hopes that local researchers could find a solution to this problem. I was a part of this NSF team in 2014, tasked with creating a better understanding of what social factors are influential in the mitigation and remediation of this algae bloom. While on this project, a mentor introduced me to Social Network Analysis (SNA) and the importance of social capital in addressing environmental problems. Myriad conclusions were made from this research in 2014, including how different types of social capital create different types of environmental activism (Anson and Paulson 2016).

Throughout my time in Wisconsin in 2014, I was intrigued by the lack of farmer involvement in water policy discussion and creation, which led me to question whether certain knowledge may also be missing from this network. Research surrounding the issue following the 2014 study focused on many topics, from how to convince farmers to implement Best Management Practices (BMPs) to understanding how residents place economic value on a clean lake. During this time, my passion for SNA grew as I learned more about its theoretical foundations and its applications in Community Sociology. By 2016, researchers in Wisconsin had not yet followed up on how policy makers were engaging with farmers and with one another, creating an opportunity for further research. That is why, in the summer of 2016, I returned to the small Wisconsin town with a similar network survey and a goal to more deeply understand the dynamics of this policy network.

Consequently, this thesis seeks to emphasize how whole network structure, network interactions, and actor characteristics can be influential in implementing collaborative environmental solutions and policy.

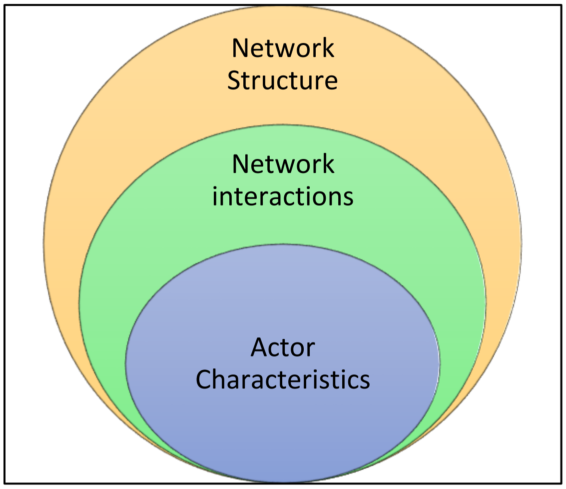


Figure 5- Structure of Thesis

First, the results of this research will develop a broad understanding of how the policy network surrounding this lake pollution is structured in both 2014 and 2016. By looking at the colleague relationships and respondent job types within the network, the results will show what work relations look like and how network structure might affect these relations. Between 2014 and 2016, community members have raised more public awareness about the local lake pollution through conferences, forums, meetings, and presentations to try to explain what is needed to solve the lake pollution and what problems currently exist. This climate of increased public awareness creates a unique pressure on the network that I hope to evaluate here. Next, this study takes a closer look at how knowledge and information is being transferred throughout the network at one point in time. It is important not only to understand how network structure is influential, but to also understand how relations are utilized within the network at any given point. To evaluate network interactions, I studied learning relationships between network actors. Finally, this research used qualitative interviewing to understand actor characteristics and their perceptions on the effectiveness of policy implementation and collaborative efforts.

For this mixed methods approach, I used Social Network Analysis (SNA) and Qualitative Coding. I collected Social Network data through an online survey and qualitative data through semi-structured field interviews and open-ended online survey questions. The research done during the NSF grants in the summers of 2014, 2015 and 2016 was widely known and spread throughout the community. The entire town was buzzing about how researchers were going to figure out how to fix the lake pollution. While awareness of the problem and its complexities grew, the community still struggled to enact positive change. SNA is a necessary tool for evaluating and addressing environmental problems such as lake pollution and SNA alongside qualitative field work can address how the network structure affects social interactions, what role actors play in transferring knowledge, and how actor perceptions can influence network relations.

<u>How does **network structure** affect collaboration in the network?</u>

Research has shown that the structure of networks can affect the level of success for collaboration efforts and how knowledge is transferred throughout the network (see Lubell and Fulton 2007, Crona and Bodin 2006, and Provan 2005). Rather than farmers choosing whether to be involved in policy creation, I questioned how the network is structured which may make it difficult for the inclusion of farmers as adequate stakeholders. A structural hole is a feature of a network that could inhibit interaction. This occurs when one member of the network can link two clusters, however without this individual, there would be no connection between the two groups

(Kadushin 2012). Likewise, homogeneity (similarity among actors) can decrease availability of resources and diverse collaboration (Crona and Bodin 2006).

Hypothesis 1: Work between close colleagues is generally clustered between individuals of the same occupation or organization.

Hypothesis 2: A structural hole exists in the network, disconnecting many farmers from other network actors.

What roles do **network interactions** have in transferring knowledge across the network?

The role of actor interaction within a network may influence collaborative efforts as well. Not all individuals have the same attributes, making it necessary to understand who has a more influential role in the network and why this might be the case. Just as the structure of the network can influence actors, actors are also able to influence network relations (see Agrawal 2003, Bodin and Crona 2009, and Giuffre 2013). To understand the role actors play in this network I used the social network statistics of Betweenness and Degree Centrality.

Hypothesis 3: The people in the network providing the most knowledge are also receiving the most knowledge.

Hypothesis 4: Overall knowledge transfer in the network is dependent on the ties of a few central actors.

How do **characteristics of the actors** affect collaboration within the network?

Finally, research also reveals that not only does the positionality and the network structure of individuals affects collaboration, but so does perceptions or characteristics of the actors (see Mobley 2016, Cross and Parker 2004, and Agrawal 2003). Therefore, it is necessary to obtain in-person accounts of how individuals within the network perceive their collaborative efforts. To study this phenomenon, I used qualitative interviews in 2016 alongside open-ended survey responses from both 2014 and 2016. From this qualitative data, key themes will emerge that will further explain collaborative relations in this network.

Sample

Survey

In 2014, I sent an online questionnaire via email to an initial sample of environmental activists, researchers, agency workers and practitioners. These people included local civil society actors such as those involved in the local Lake Improvement Association, members of County Conservation Divisions, City Council, the state Department of Natural Resources, University-Extension conservation workers, political leaders, university researchers, and organizers of farmer led councils. I compiled this list in 2014 by researching local political organizations as well as those engaged in lake improvement activities in the area. I asked initial respondents to list their five closest colleagues who work on water quality improvement along with the emails of those individuals. Only 18 individuals from the initial sample list of 65 submitted a survey and identified colleagues for the network. I used the emails provided from the first round of respondents to send the same survey to the listed colleagues. I repeated this process until the total emails sent out was 203 and the total responses for the 2014 survey reached 140. However, it is important to note that while 140 individuals identified themselves in the network, only 73 respondents listed other colleagues in the network.

In 2016, I sent another online questionnaire via email. I sent this survey to all 140 individuals that at least partially completed a survey response in the summer of 2014 as well as those who were on the initial sample list in 2014. Since 18 of the individuals who completed the survey in 2014 were also on the initial sample list, the total email surveys first sent out in 2016 was 122. I sent three rounds of reminder emails to participants that had not completed the survey.

I used network (or snowball) sampling in which individuals are added to the study based on being named as members of the network by survey participants in earlier rounds. The responses provided by these subsequently identified individuals add an additional 69 respondents to the respondent pool. Overall, 191 individuals were emailed this survey, creating a similar sample size to the 2014 survey. Of the 191 people who were emailed this survey, I received 121 survey responses. Of those 121 survey responses, only 75 identified their names in the network and only 53 of those 75 listed additional colleagues in their network. This response rate will make a network slightly smaller than the one in 2014. In both surveys, there are more nodes within the social network analysis than completed the survey. This is due to the ability of respondents to identify members within their own network who did not complete the survey themselves.

Table 2- Survey Response rates

2014			**2016**		
Surveys Sent Out	Respondents	Respondents who listed other colleagues	Surveys Sent Out	Respondents	Respondents who listed other colleagues
203	140	73	191	75	53
	69% response rate	36% response rate		39% response rate	27% response rate

In addition to emailing and snowballing these surveys, I travelled back to Wisconsin to get a closer look at the current state of the problem. I also attended a local community forum in August 2016 where students presented posters about research completed over the summer involving the polluted lake. At this event, I could mingle with individuals in this water policy network, many of which I recognized from my previous research and knew they would be filling out my survey.

Field

At the community forum, I found participants who were in the network from 2014. I asked these participants if they would be willing to take part in an interview the following week. In addition to reaching out to these participants, a question on the 2016 survey asked respondents to identify if they would like to meet for an interview. I completed convenience sampling and nine participants were selected randomly from the first who selected “yes” for an interview. I knew one of the interviewees was very central to the network, however at the time I was not aware that he was the most central actor, presenting a unique perspective to view the network.

Data Collection

IRB approval was received in the summer of 2014 to survey and interview local policy actors and investigate the sociology behind local water pollution and policy concerns. That approval was maintained throughout the second round of data collection, which occurred in August 2016 (see Appendix D).

Survey

The surveys in both 2014 and 2016 requested individuals to identify their five closest colleagues in relation to water policy implementation. To create accurate Social Network Diagrams, I asked respondents to list their full name as well as the full names of individuals they identified within this network. I also asked respondents to identify the job that everyone they identified held. These connections were identified as non-directional colleague connections for both rounds of surveying. The survey from 2016 was live for nine weeks and the survey from 2014 was live for five weeks.

In 2016, the survey additionally asked respondents about learning and teaching connections. The survey asked both “who did you learn from?” and “who learned from you?”

For the first question, respondents could select from the five colleagues they identified as well as write in up to five more individuals. For the second question, respondents could select from the five colleagues they identified, the additional individuals they learned from, and could write in up to five additional individuals. Therefore, one individual (ego) could have up to 15 individual connections to others (alters) identified from these questions. I presented "Who learned from you?" second to give them the most number of individuals to select from as individuals often claim to learn more than they teach.

The survey in 2016 asked participants to identify others within this network who were farmers in the local watershed. I asked this question at the end of the survey so respondents could select from all the individuals they previously identified. The characteristic of "farmer" then became a "node attribute" in the Social Network Analysis.

Additionally, both rounds asked an open-ended question at the end of the survey, asking respondents to describe their responses or add additional thoughts. I coded these open-ended responses alongside interviews from 2016 for contextual references.

Field

I conducted semi-structured interviews in August 2016 to understand how individuals that are most closely working in this field perceive and interpret the problem and the people that work alongside them in this network. Many of these individuals served dual roles within the network of water policy, thus providing interesting perspectives on the issue. Four of the interviewees were members of the local Lake Improvement Association. Four of the interviewees worked at the County Land, Water, and Conservation Agency, which works closely with farmers and on water issues. Two individuals worked at the state level Department of Natural Resources and two individuals were affiliated with the university in town.

I conducted two interviews at a local coffee shop, one at the State Department of Natural Resources Office, two at the County office, and one on a demonstration farm. I conducted three interviews over the phone. I recorded all interviews and all interviews lasted approximately 30 to 60 minutes. In each interview, I asked participants to identify their role or job within the community and how it related to water policy. I then asked individuals to identify the root of the water quality issue in their own words. I also asked interviewees about the nature of conversations they have at work related to water quality and water policy. I asked interviewees to think about the network of people they work with and to describe what they think might be missing or what really makes the network effective. Finally, individuals that I interviewed who resided in the area in 2014 were asked to identify what changes (if any) they saw in the network, the problem, or the water quality field in general.

Analysis

Social Network Analysis

I downloaded the data from both 2014 and 2016 from the Qualtrics software into an Excel sheet in October of 2016. I recoded these Excel sheets into node and edge lists for Social Network Analysis. I thoroughly cleaned the data from the survey to correct for differences in name identification either by spelling error or nickname. For example, I cleaned names like "Mike Smith" and "Michael Smith" to one consistent name. I attached the node attribute of "farmer" as well as "job type" to both the 2014 and 2016 network diagram to assess the characteristics of individuals included in the network. I categorized occupations into distinct categories held consistent across both the 2014 and 2016 networks (see Appendix B for full list of occupations). I then imported the appropriately formatted excel data into UCINET Social Network Analysis software.

The 2014 and 2016 surveys asked for colleague connections identically for longitudinal comparison. This allowed for the creation of comparative colleague network diagrams. Additionally, I combined the learning and teaching relations from the 2016 survey to create a more thorough network of knowledge transfer. To do this, I reverse coded "taught" to "learned" so that the network connections or "edges" were only learned connections. Therefore, to know how many individuals a person learned from one would look at their InDegree, and to know how many individuals a person taught one would look at their OutDegree. As this thesis will reveal, the network of individuals a respondent learns from may vary greatly from who they work with, necessitating a separate analysis. I ran network statistics utilizing UCINET to identify certain network characteristics of individuals such as Centrality, Closeness, Betweenness, Community Detection, and Degree. I used NetDraw to visually represent these characteristics alongside other node attributes.

Finally, I used SPSS statistics software to run a bivariate correlation on the InDegree and OutDegree of the learning relationship between the 40 individuals who completed the survey fully in 2016. I removed individuals from the correlation who had 0s on both InDegree and OutDegree because a zero means that individuals either did not identify anyone they learned or taught from, or did not complete the survey.

Coding

I transcribed nine interviews from 2016 and then imported this qualitative material into the Qualitative coding software Nvivo and analyzed the content accordingly. I began with preparatory Holistic Coding where coding was "lumped" rather than line by line (Saldana 2016). This allowed me to identify paragraphs with overlapping themes and categorical codes. These categorical codes were farming, social relations, political/bureaucracy, time, money, ideology (values), and change. The second round of coding identified the most frequent terms identified by participants which were time, bureaucracy, ideology, and change. These terms were relevant because they overlapped frequently with one another and they were spoken about in similar ways across many interviews and responses. Semi-structured interviews with water policy actors focused on the one problem of lake pollution in a local context, because of this, I used Causation Coding to identify how my broader themes connected. The goal of Causation Coding is to "locate, extract, and/or infer causal belief from qualitative data" (Saldana 2016: 187).

This methodological approach represents a useful integration of qualitative and quantitative methods that supplement and reinforce one another. Quantitative analysis that uses online survey responses and social network analysis will provide statistical and structural significance of characteristics of this network structure. Qualitative analysis that incorporates open-ended survey responses and interviews will provide the contextual background of the network as well as in-depth network perceptions of the community.

CHAPTER 4: RESULTS

In this section I will first provide a general overview of the networks of this case study from both 2014 and 2016. Then I will evaluate how these social network results alongside qualitative analysis relate to the research questions and associated hypotheses. The overall results of this study have shown that SNA alongside qualitative field interviewing can reveal significant insight into water policy implementation and are informative when evaluated together.

The Networks

There are three variations of network focused on in this Thesis: the 2014 colleague network, the 2016 colleague network, and the 2016 learning network. In 2014, the colleague network contained 213 individuals (nodes) and 308 ties in the main connected component. Nodes not connected to the main connected component were individuals who were not identified by others or they were not connected to anyone other than the few individuals they listed. Because of this, the main connected component will be the focus for all networks in this study. The average degree in the 2014 colleague network was 1.388 and density was .006. As a reminder, degree refers to the number of times a node was mentioned in the network and density refers to the proportion of actual connections to possible connections.

In 2016, the colleague network contained 123 nodes and 202 ties in the main connected component. The average degree in the 2016 colleague network was 1.424 and density was .008.

Like the network from 2014, there were nodes that were not connected to the main component by colleague connections. However, the additional ties of learning and teaching (See Figure 6), connect all the nodes to the main component (See Figure 7), when mapping the network with all reported ties.

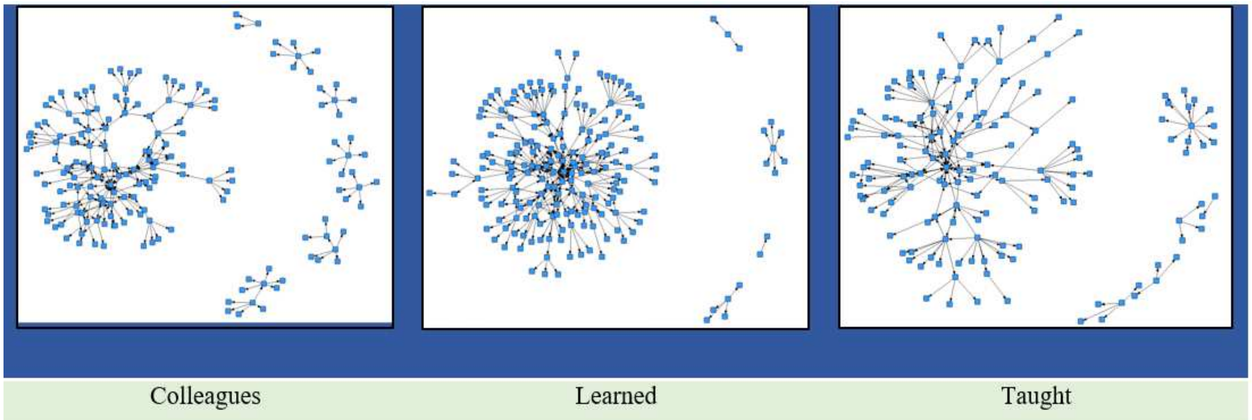


Figure 6- Comparison of network relations for 2016

When focusing on learning and teaching relations in the 2016 network, the diagram shows fewer connected components. The colleague sociogram presented 8 connected components (see Figure 6). However, focusing on just the respondents five closest colleagues does not give an in-depth understanding of the network because learning and teaching relations can change the structure of the network. Furthermore, the individuals that respondents identified as people they learned from or taught may also be considered one of their colleagues, making the network denser. For the purpose of this analysis, a 'teaching' relation was reverse coded to represent a learning relationship. The total learning network contained 223 nodes (100 more connected nodes than the colleague network). Incorporating learning relationships into the network more than doubled the number of ties from 202 to 457 in the main connected component. Represented visually in Figure 7 below, an arrow pointing toward a node represents knowledge being *received* by that node. This diagram of all learning relations in the main connected component contains 457 ties and 223 nodes.

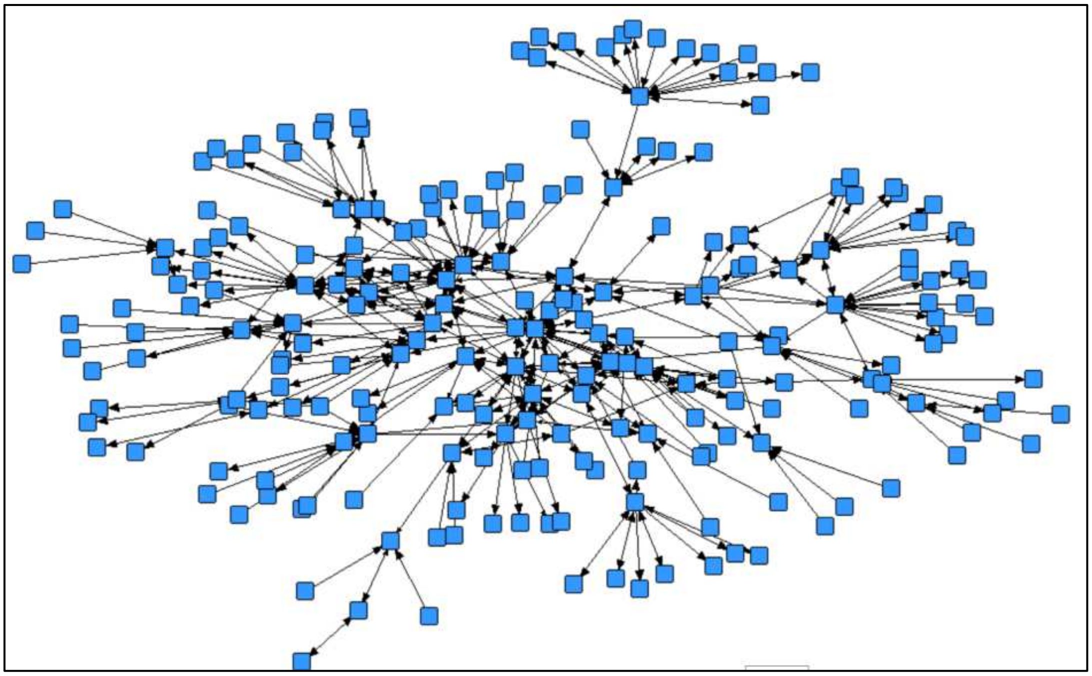


Figure 7- Main Learning Connected Component: 2016

Network Structure

The results of this research emphasize the difficulty of identifying the role of the network structure and complexity of network interactions. I examined the overall network structure to test these hypotheses: ***(1)*** work between close colleagues is generally clustered between individuals of the same occupation or organization and ***(2)*** a structural hole exists in the 2016 learning network, disconnecting many farmers from most network actors. SNA can identify relationships between nodes, but this software can also identify attributes of nodes. For example, the 2016 colleague network with nodes colored by job type is shown below. At first glance, it appears that there is some clustering occurring by specific job type (Figure 8). However, the Girvan-Newman algorithm of community detection can allow for a more accurate quantitative analysis community structure.

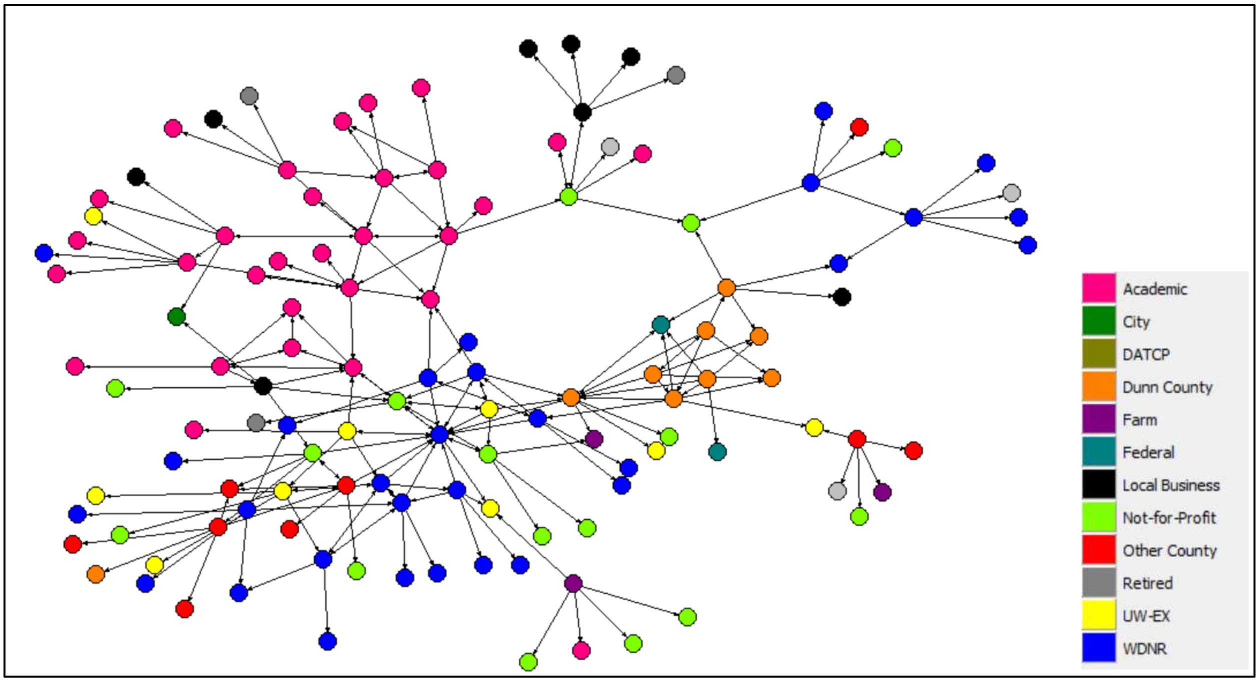
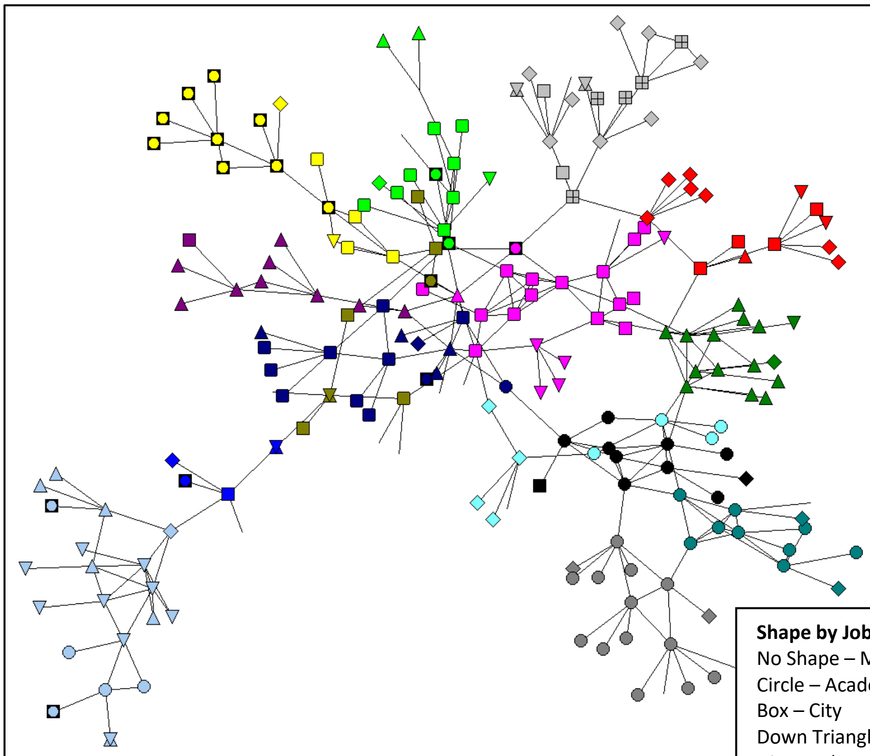


Figure 8- 2016 Colleague Network: Jobs by Color

Girvan and Newman's algorithm identifies community structure with a variable, *Q*. "If the number of within-community edges is no better than random, we will get Q=0. Values approaching Q=1, which is the maximum, indicate networks with strong community structure" (Newman and Girvan 2004: 7). This Q therefore seeks to determine if the community detected is meaningful or random. The algorithm looks for "peak values, which indicate particularly satisfactory splits" (Newman and Girvan 2004: 7). Figures 9 and 10 on page 46 depict a Girvan-Newman analysis for the 2014 and 2016 colleague networks in which Q is at its peak values. The color of the node represents the community cluster they belong to, and the shape of the node represents job type. For 2014, a partition with 15 clusters presented the highest Q value at .813. For 2016, a partition with 12 clusters presented the highest Q value at .709.

The high Q values found in this community detection reveal that the network clusters identified are not random but are satisfactorily split into the clusters identified below. When represented visually with job type represented by shape, these results do not clearly support or contradict the first hypothesis that workers on this project are clustered by job type. There is no cluster in either 2014 or 2016 that is made up solely of one job type, implying there is an amount of collaboration occurring in this network. On the other hand, there are a few clusters in which more than 80% of the individuals are of the same job type. Overall, there appears to be a bit more collaboration in 2016 when compared to 2014. The 2016 network represented here has 90 nodes less than that of 2014, which may affect the appearance of job collaboration and makes comparative analysis between the two years difficult.

The high Q values found in the Girvan-Newman analysis reveal strong community structure within this network as "in practice, values for such networks typically fall in the range from about .3 to .7. Higher values are rare" (Newman and Girvan 2004: 7). This community structure was not clearly delineated by job type, but instead many job types were scattered throughout the detected communities. As the diagrams revealed, some of the clusters were dominated by one job type, but often there was variation throughout. I can therefore conclude that individuals in this network do not only work with people in their job type to address this problem, but will reach across occupations if necessary to arrive at the most desirable results. At the same time, density scores for all networks presented in this research are less than .10. This means there are many more possible direct connections to be made that were not actually made in the network.



Shape by Job Type
No Shape – Missing job type
Circle – Academic
Box – City
Down Triangle – Federal
Diamond – Local Business
Square – Not for Profit
Rounded Square – County Official
Circle in Box – University Extension
Up Triangle – Department of Natural Resource

Figure 9- Colleague Clusters 2014 (15 clusters with 213 nodes)

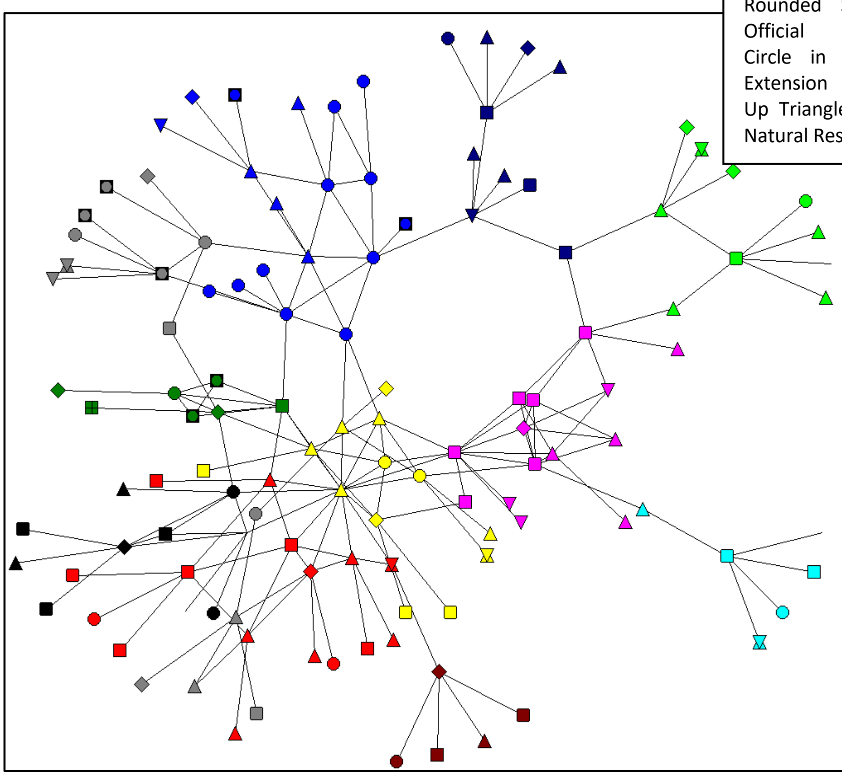


Figure 10- Colleague Clusters 2016 (12 Clusters with 123 nodes)

To evaluate farmer connectivity in the 2016 learning network, I distinguished each node that had the attribute of "farmer" with a triangle and bolded outline. Using the Girvan-Newman iterative algorithm again, two distinct subgroups appear (Figure 11). As the diagrams below shows, this network has one large subgroup of 202 nodes and another smaller subgroup of 21 nodes.

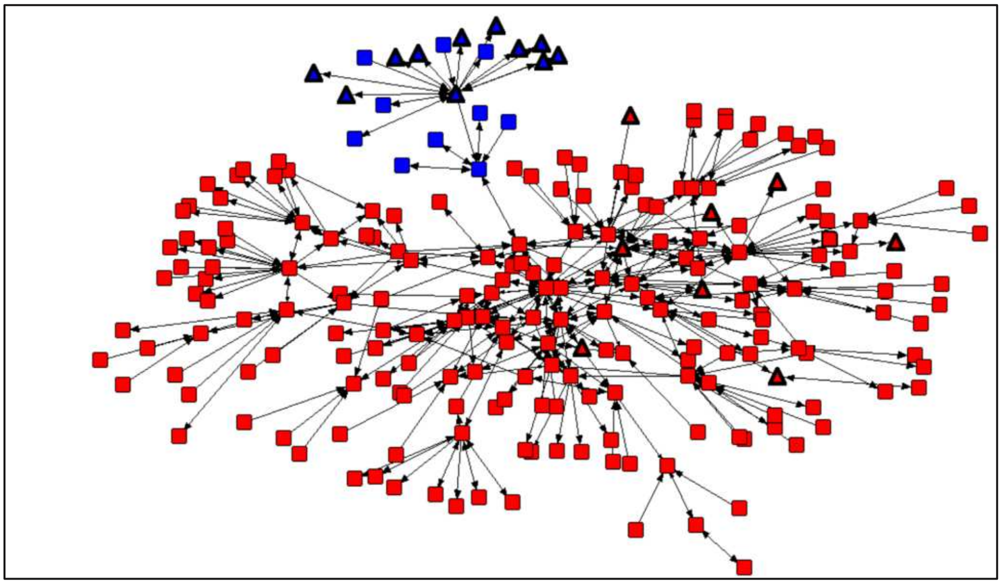


Figure 11- Learning Network 2016 (Triangles = farmers)

This diagram reveals that 11 of the 19 farmers in this learning network are in the second smaller detected community. Therefore, over 50% of the farmers present in this network study belong to a smaller, less diverse and less connected community. Additionally, the second community of 21 nodes contains 11 farmers. So not only do more than 50% of the total number of farmers in the network belong to the smaller community, they also are the majority of that community. The only connection between a blue node and a red node represents a structural hole. If this relation did not exist, the smaller blue component would have no contact with the larger connected component. The existence of this structural hole proves the second hypothesis to be correct. This result also reveals that the community attached to the larger network by a structural hole is also relatively homogenous.

Network Interactions

To answer the research question, what roles do network interactions have in transferring knowledge across the network, I hypothesized that ***(*3)** the people in the network providing the most knowledge also receive the most knowledge and **(4)** overall knowledge transfer in the network is dependent on the ties of a few central actors. To determine who was providing the most knowledge and receiving the most knowledge, I ran a bivariate correlation on InDegree and OutDegree. Where InDegree was an attribute of nodes representing the number of people that each node learned from and OutDegree represented the people that the node taught. In this analysis, with N = 40, I find that InDegree and OutDegree were moderately positively correlated at .369 and significant at p=.019.

Table 3- Correlation of learning and teaching relations

Correlations		**InDegree**	**OutDegree**
InDegree	Pearson Correlation	1	.369
	Sig. (2-tailed)		.019
	N	40	40
OutDegree	Pearson Correlation	.369	1
	Sig. (2-tailed)	.019	
	N	40	40

Even though N is relatively small in this instance, these results support the third hypothesis that individuals in the network who are learning the most are also teaching the most. Because this correlation is positive, I am also able to conclude that those who learn less also teach less.

To identify central actors within this network, I used individuals' Betweenness Centrality and Degree Centrality. As the literature revealed, a high Betweenness Centrality represents a person who is central and a connector to many other nodes while a high Degree centrality emphasizes a nodes popularity in the network (Kadushin 2012). In the 2016 learning network, there are a few actors with large centrality scores and one individual stands higher than the rest on both Betweenness and Degree Centrality; this is represented visually in sociograms on the following page (Figures 13 and 14).

I ran whole network measures first with that central actor and then again with the actor removed. I found that all network connectivity scores declined in the learning network after this actor was removed. The average Degree of the network dropped by 0.095 and the connectedness dropped by .011. The sociograms on page 51 show all the individuals connected to the most central actor in pink, and the central actor in green (see Figure 15 and 16). These two diagrams show that 28 of 177 individuals in the network have a direct connection to this central actor.

When looking at the same diagram, with nodes sized by Betweenness Centrality, it is revealed that the individuals with the highest Betweenness score are connected to the most central actor. When the five individuals with the highest Betweenness score were removed from the network, the number of total ties in the network drops from 445 to 341.

Because Betweenness centrality is a measure for an individual to show how frequently information, or in this case specifically "knowledge", flows through that actor, these results support the 4th hypothesis of this thesis that claims that connectivity is dependent on the ties of a few central actors.

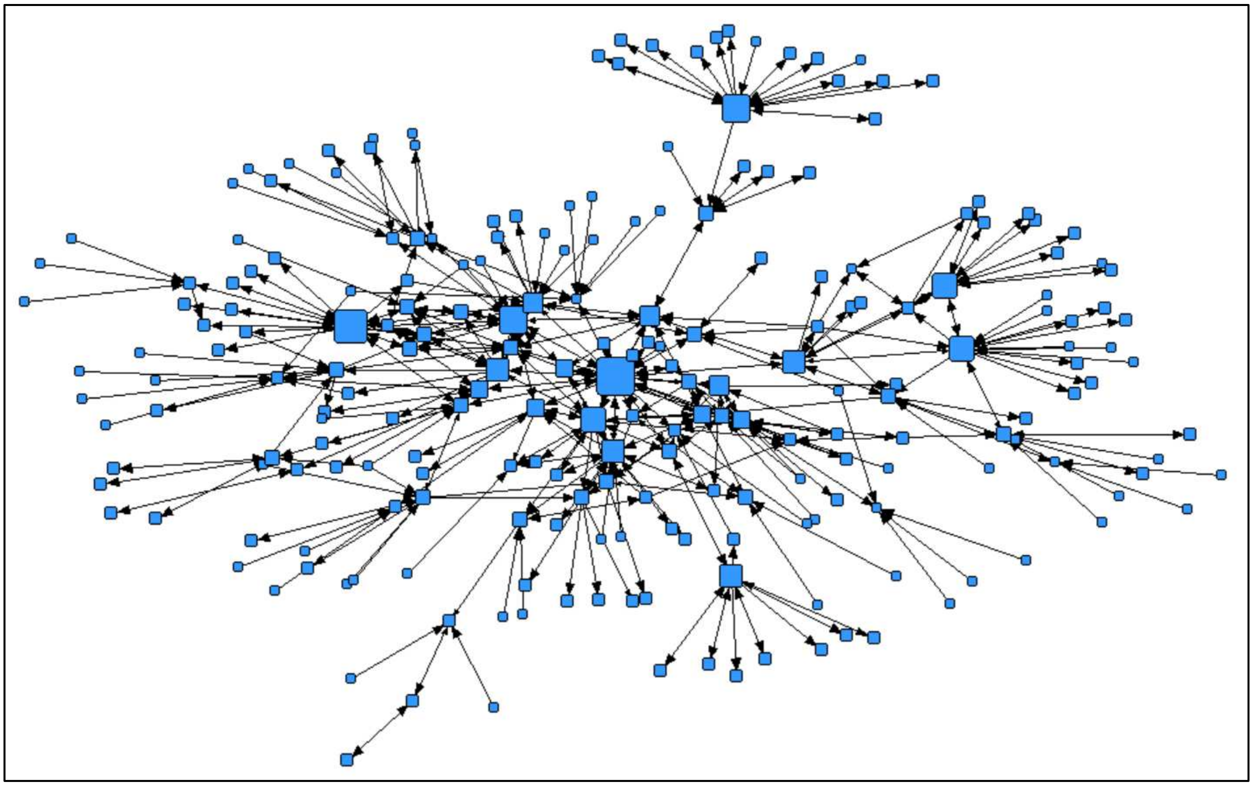


Figure 12- Node Size by Degree Centrality

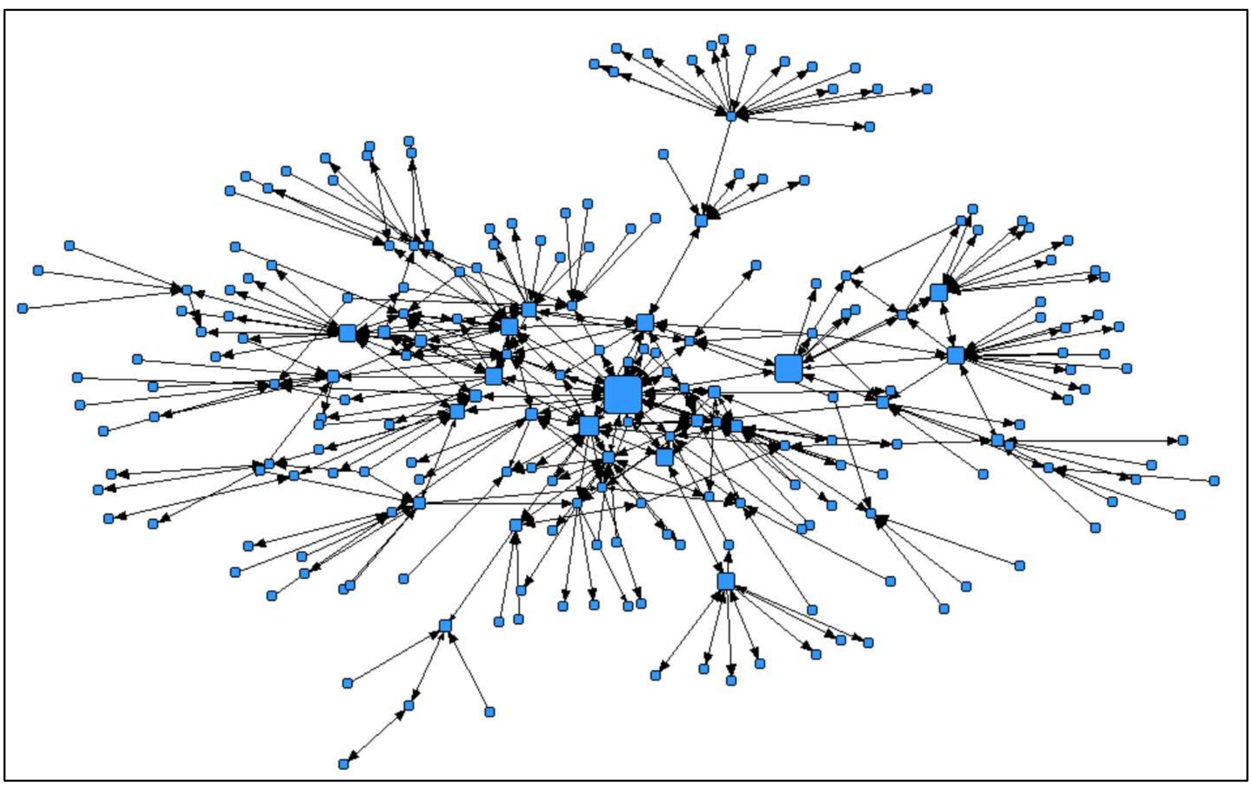


Figure 13- Node size by Betweenness Centrality

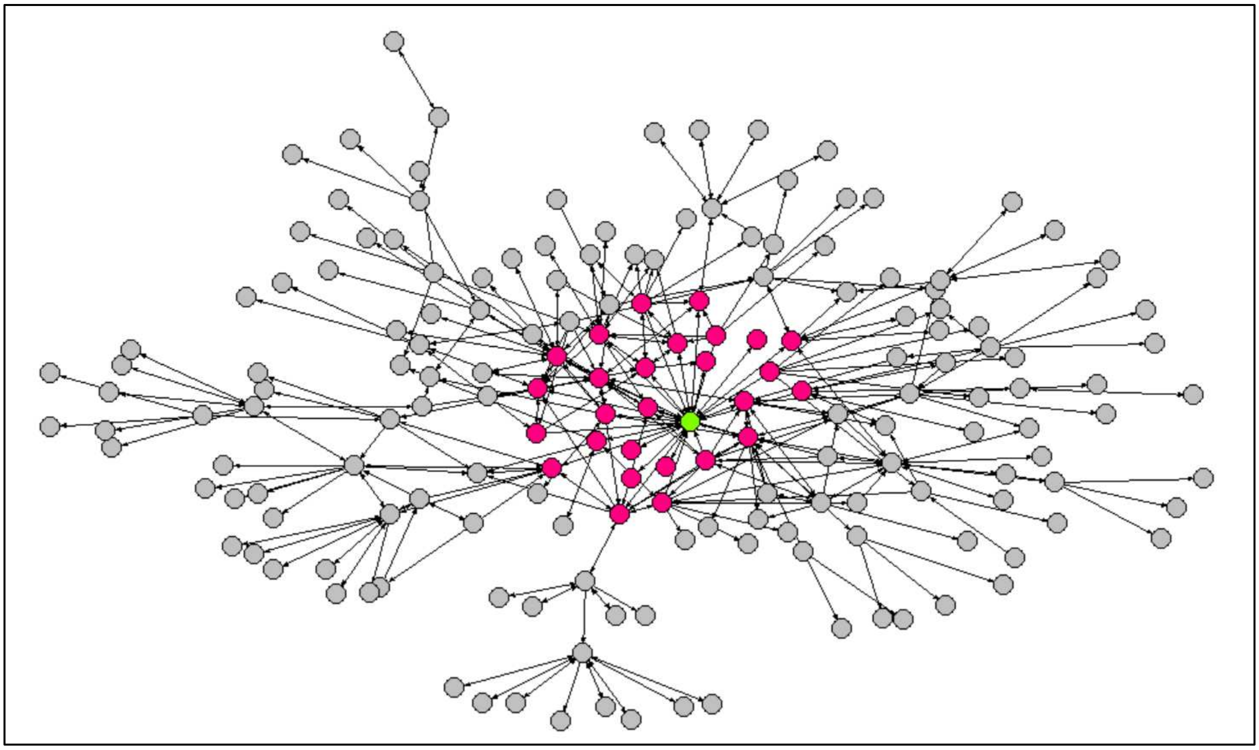


Figure 14- Connections to most central actor

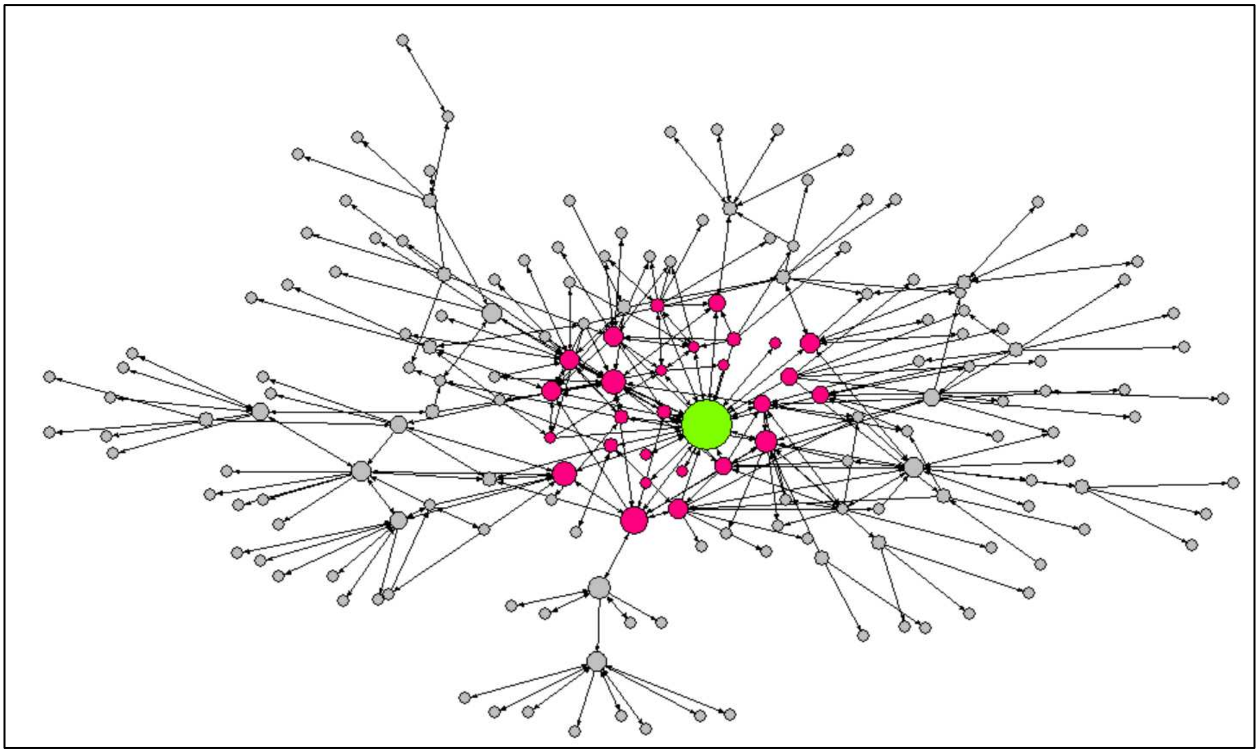


Figure 15- Connections to most central actor by color, size by Betweenness

Sociograms are useful to present a visual of node connectivity in the network, however it is sometimes difficult to study Betweenness scores comparatively in this way. Therefore, I used STATA 14 to display the comparison Betweenness Centrality score and Degree Centrality score on all individuals in the 2016 learning network graphically. The scatter plot below shows a positive association between Degree and Betweenness, revealing that those with high Degree scores generally have higher Betweenness scores. However, there are actors that lie significantly outside of what is expected, with one individual lying particularly far outside. This means that these actors are much more connected to the network than their Degree score would demonstrate.

After evaluating the data, I determined a predicted regression was not suitable for this analysis. This is because many individuals had a Degree Centrality score of either 1 or 2. 110 of 178 individuals in the network had a Degree score of 1. This means that they were identified in the network, but were not connected to others. The first graph below depicts the Degree and Betweenness score of all actors in the network, while the second graph shows the same scatter plot when the most central actor and the actors with only 1 Degree are removed. This result not only further proves the 4^{th} hypothesis, but also tells a more interesting story of important actors within the network.

In the learning network, the most central actor has a Degree Centrality score of 27 and a Betweenness Centrality score of 10836. These scores are 13 and 32 times higher than the network averages, respectively. It is also important to note that 109 people in the network had a degree score of 1 and a Betweenness score of 0, which is why the averages are quite low. This is partially because not all individuals in the network completed a survey. However, this also confirms the fractured nature of the network and the over-involvement of some individuals compared to others. The Betweenness centrality is highly significant as this score represents the number of shortest paths that pass through this individual to reach other individuals.

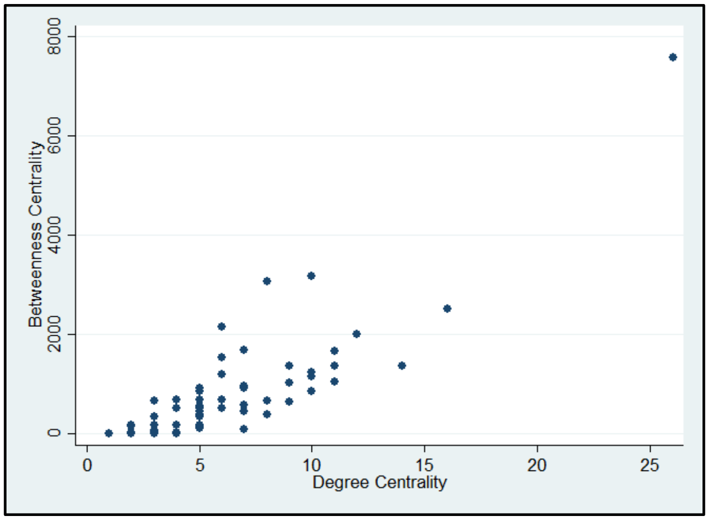


Figure 16- All Network Actors: Betweenness by Degree

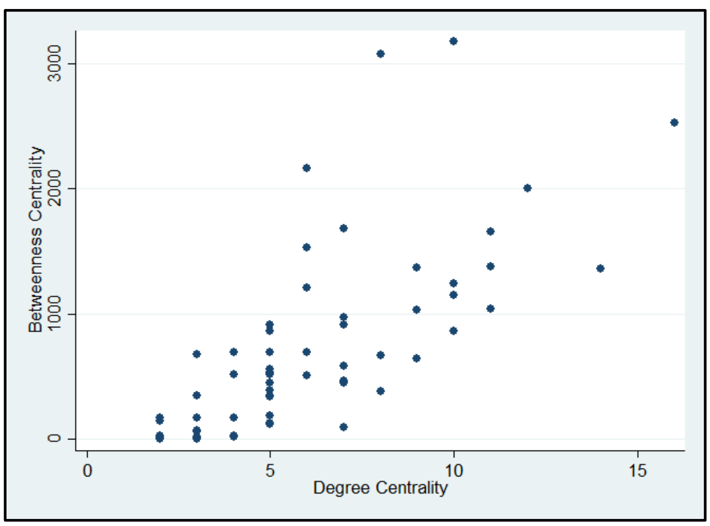


Figure 17- Scatter plot of Betweenness by Degree when omitting abnormal Degree scores

When Degree Centrality scores of 0 and 1 are excluded from the analysis, the average degree is 6.5 in the 2016 learning network, in this case the most central actor still has a degree centrality score that is 4 times the average. The next two most central actors have a degree centrality score of 17, which is approximately 2.6 times the adjusted degree centrality average. The fact that quantitative analysis finds one actor to be so much more central than others in the network necessitates a further understanding about the qualities and characteristics that these actors may have in the network.

Actor Characteristics

To answer the final research question about how actor characteristics influence network interactions, I used qualitative interviews and open ended survey questions to develop a more in-depth understanding of the actors in this network. For example, the quantitative data revealed outliers, but to understand why these outliers exist, I needed to talk directly with the source. The results of the qualitative analysis revealed three key themes. First, the most central actor has personal attributes that facilitate their centrality. Additionally, the nature of the project and lake pollution as well as the job responsibilities of actors in the network affect network actors' perception of success. Finally, in this network there is a distinction between farmer knowledge and scientific knowledge, which creates an ideological divide in the network. Qualitative interviewing filled many of the gaps in the quantitative research or solidified the need to emphasize specific research areas.

Having one actor that is so central to the network compared to others is very significant in this research. While the positionality of this actor in the network is relevant, I also inquired about certain attributes specific to the actor that may allow for this central position to occur. When interviewing this actor, he describes social connections and interactions to be a priority in his work, as he says: "I'm the guy that builds the relationships." Frequently, this actor referenced himself as someone who enjoys building these social relationships. He stated:

> *I probably do it much differently than many folks because I'm kind of a people person....I enjoy learning about folks and what they do and after you get to know who you're talking to so to speak...Then you can start talking business about, well, how do we work our projects or our priorities to get this work done.*

While he enjoys what he does, this actor acknowledges that a lot of his time and effort goes towards maintaining these relationships:

> *I think that my first meeting with them was back in the late 80's. So, you do develop these relationships and trust over time.*

Not only does this individual give specific attention to the role of getting to know individuals in the network, he also emphasizes the informality of these relations:

> *… over time you just kind of, you know, it never hurts to sit down and have a cup of coffee or a beer after a meeting or whatever to just chat.*

These qualitative results have shown that the most central actor does in fact have characteristics that differ from others in the network. This actor spends considerable time on developing network relationships, enjoys the process of getting to know others, and works both formally and informally to address the local problem with the community. This actor has spent years on the project and working in this network, building a trust that is difficult to create in a short time. He also enjoys his work, which makes him more willing to take extra steps to meet with network actors and harvest strong relationships. The informality of his work is also significant because it may seem that the formal work relations between colleagues is what is most important in addressing this lake pollution, but it is in fact the informal relationships that play a key role in influencing who these individuals work with a trust for addressing this problem.

When coding interviews, three key themes emerged when participants discussed what their work around lake policy includes. These are listed in the table on the following page alongside relevant participants' statements. One of the most influential statements made about the length of time this lake clean-up takes was from an interviewee who has worked on the project for many years:

the improvements we've made over the last just say 4 years...have been significant from what has been done in the previous 20. But if I gauge that level of improvement, we are talking about 10-20 years to finally reach our goal. That's going to be out of my lifetime. I don't like that situation. I don't like that. I don't like having my grandchildren stay away from my home in the summer because I've got water they can't use.

Table 4- Qualitative Themes: Role of Actors

Theme	Phrases
Time needed to complete project	▪ It takes a lot of windshield time-a lot of one on one just hanging out ▪ A lot of planning, a lot of time, a lot of resources ▪ So, community building— This stuff takes years. Years and years of problem solving ▪ It takes a whole year to find out what works and what doesn't. And that's the way with farmer led watersheds, with everything. ▪ It's an ongoing problem ▪ We plan for so long, we need to start doing. ▪ I need to just completely stop this because I need to have a little bit more of my life back. ▪ You're fighting tradition so much. Farms don't change fast; I think that's the biggest thing.
Limited evidence of progress	▪ It's hard to see that we're getting somewhere on a day to day basis ▪ Patience runs thin and in that case, we're telling people "it's going to be decades before you see...you can see a difference in that lake because this is a huge watershed and we have to work with hundreds of thousands of acres so that's going to take a long time." That's always a hard sell. ▪ I think everybody I listed in my [survey] acknowledges that the solutions aren't a one step, one year, you know, solution. These are, like I said, 10 or 15-year solution.
Job Responsibilities	▪ I actually have been spending a lot of time on that project which I do feel takes me away from focusing on the Red Cedar in general ▪ I focus a lot of my time on keeping those relationships alive ▪ I do a lot with, yeah, besides that; I do a lot with invasive species work…I'm also a chair of the county Environmental Steering Committee of Education… It's a little bit of everything and not a lot of one thing. ▪ Recently, paperwork becomes atrocious, it's increased everything, it's required us to be in the office more and it's really detrimental to our cause. There's too much documentation in the office that stops us from going on and doing these things we want to do. ▪ Right now, our big project is we're rewriting our land and water management plan. Which is a 5-10-year document that sets our work

	priorities for the land and water conservation department and how we're going to achieve those priorities.

While the research reveals that network actors do appear to become fatigued as the project goes on, there are other characteristics of the actors as well as their roles in occupation and the nature of the problem that affect their perceived success. The qualitative data has shown that the lake pollution problem takes a lot of time and effort to put forth solutions and make productive relationships. This is partially due to the nature of the problem and how it is spread out across a large watershed but is also due to the fight against tradition and a culture that has dominated for a long time. Additionally, even when progress is being made on the problem, results are often difficult to see. This can create an environment in which workers may lose hope that the project can ever be solved or that one individual could possibly make a difference. I also argue that because of the nature of this work, individuals may be less motivated to work on this specific project and more motivated to work on projects that provide more immediate results. This speaks directly to the research by Cross and Parker (2004) in which they argue that network actors need to feel a sense of progress or feel that the problem can be resolved for productive collaboration; both characteristics seem to be lacking in this network.

The problem is further compounded as it appears that most individuals within this network have job responsibilities and time commitments that pull them from one project to another. This on top of a struggle to fight through bureaucratic rules and paper work make it difficult to stay on task. These factors also make it difficult for people in the network to work in the same way that the most central actor does, dedicating significant time to making social relationships. Even if individuals in the network did have time to dedicate to fully addressing this problem, the lack of results may make them feel as though their work is irrelevant. Additionally, the qualitative data shows us that the project of focus in this research takes a long time for change to be seen, causing a decline in hope or perception that the problem can be solved or individuals can participate in the solution.

The distinction between relevant farmer knowledge and scientific knowledge came up frequently when interviewing. In my interviews, participants often noted that the problem was already identified and a scientific solution already exists. Interestingly, the farmer in the network who identified the most other farmers in the network and completed the survey most thoroughly was not very specific about the knowledge he taught others. This individual said he discusses "what we think we have learned in our own farming business." On the other hand, the individuals who focused more on the science and policy side also acknowledged the limited involvement landowners had in the policy process. These two themes are exemplified in the table on the following page (Table 3).

Not only did interviewees discuss the separation of farmers from the science and policy network, some also emphasized how there could be negative perceptions between the two groups:

> *Well I think the problem has been with a solution oriented conversation today, you know, and the solution with people is they're very quick to point to the farmer. And the solution is "we have to tell farmers to stop doing that". And this is not a solution, I mean, it's blaming. That solution propagates a blame game which isn't very productive.*
>
> *Sometimes the other problem is we have farmers in the room who are like "well it's not us, it's the shoreline landowners." I don't know how to politely say "you're wrong" because it's pretty obvious when you own 40% of the watershed, where do you think the problems coming from?*
>
> *I don't think we can tease land owners or tempt land owners to changing significant practices by giving them money.*

Table 5- Qualitative Themes: Science and Landowners

Theme	Phrases
Scientific solutions already exist	▪ We were always really good at the Biophysical, Chem[istry] and Watershed Modeling and water quality response modeling. That was very easy for the people we have in our agency, that's how we're trained. ▪ On a lot of levels there's still a lot of expert mindset around the state. ▪ I think the information...There's sufficient information out there now that suggests our problems are solvable. I mean the techniques are there, the science is there. It's all about changing mindsets and people's views. ▪ There isn't much internal debate about the ecological science. I think we're kind of on the same page with that. ▪ We've always focused on the science; the ecological science will carry the day if you just show the problem with enough information that people will get it. ▪ For what all that's worth, that's kind of the story, at the end of the day we can always get the right science.
Landowners not involved in policy solutions	▪ I think most land owners feel like they're doing a good job and if we run them through some scientifically based calculation and it shows that they're maybe not doing a good job...what faith do they have that that, say soil loss calculation, is, has any accuracy to it. ▪ The problem with forums or these meetings is that it's typically way outweighed by non-agricultural producers. ▪ I think the biggest thing we need to figure out is how do we connect with the silent landowners who don't participate. ▪ We've got contacts with [farmers] here and there but they're not persistently involved as a mass because we've got organizations like farm bureau and farmers union that they go to and they're on totally different topics they're interested in and committed to. ▪ It's just hard to get people engaged in something when their schedules are full and farming's a 24-hour operation. ▪ We're usually working with the crowd who we've worked with in the past. It's the same people, trying to reach those new folks is always a challenge. ▪ But how do you reach the farmers that aren't into groups, that aren't into joining farmer led networks? Those are the problem children I guess. Not that they're all bad performers, but we don't have a relationship with them because they keep to themselves and it's really hard to reach them.

The literature has shown that marginalization of farmer knowledge occurs because science is perceived as the ultimate right information (Hassanein 1999). I saw this frequently while interviewing as those in the academic and science fields often noted that the problem was already identified and a scientific solution already exists. While actors acknowledged both that the science was all there and that landowners were not involved in policy making, no participants suggested that farmers may have different or better knowledge to contribute to the science. The collective "we" seemed to have all the answers and did not address why others may disagree. As seen above, a farmer said he discusses "what we think we have learned in our own farming business." This quote is insightful as it could reveal that farmers have specific local knowledge that they share among one another, but may not necessarily be willing to share it elsewhere.

While the quantitative data allowed for the creation of a dense learning network, people are often unable to identify what they have taught others. Individuals may be aware that they are both learning and teaching from individuals, but it is not always clear what. When participants identified what they learned, answers varied from conservation practices, soil health, and water sampling to details on laws and regulations, lobbying, and leadership. But when asked what they taught others, answers were much more unclear. For example, when asked what he taught others, one respondent in this network wrote: "stuff, you'd have to ask them" for each of his network relations. Similarly, multiple respondents wrote that they taught all individuals in their network the same exact topic, whether it be budgeting, water quality testing, or identifying native plant species.

Mixed-Method Comparison

These results, when evaluated together can convey unique information about the nature of this network and the ways in which collaborative governance can be implemented. The qualitative interviews allowed us to understand certain characteristics of the network that were not visible using network statistics alone. Similarly, the network revealed certain positions of actors as well as interactions that would not have been evident from interviewing.

While SNA shows the various connections between actors within the network, there is no way of knowing what project these individuals are working on or what role they play in that position without asking them. The qualitative interviews illustrate that individuals within this network have a lot of roles and responsibilities within this network, might be working on various projects, and may find it difficult to prioritize certain tasks relevant to problem at hand.

The second hypothesis hoped to emphasize a better understanding of farmer involvement in the structure of the social network. The network statistics detect two different communities which would appear to prove my hypothesis to be correct. However, the survey results reveal that other factors may have played a role in detecting these distinct communities. Surveying individuals already active in the water policy network meant inadvertently *not* surveying farmers. Many of these respondents held occupations in water policy work, while farmers' main career goal is not water quality improvement but farm yields. Also, the qualitative data reveals that there are ideologies specific to these groups that may either be caused by the network structure or may be causing the network to be more divided. Not only did the qualitative data reveal different ideologies, it also showed that there are not always positive emotions associated between the two groups. While the connectivity is shown by the network analysis, perceptions of these relations are revealed from the qualitative work.

SNA of the 2016 learning network identified one actor as having the highest centrality score by both Degree and Betweenness. The interview with this individual showed how the positionality of this actor related to his perceptions. SNA alone may not have shown how the actor feels about his work and how he prioritizes tasks, leading network analysts to speculate that perhaps his job or his skills make him central. Similarly, an interview without SNA would not fully capture how central and influential this actor is within the network. A researcher might speculate that the relationships he values are close knit and informal, not broad and far reaching.

Next, the qualitative research showed that people in this network have a much harder time addressing the lake pollution in the area because of the nature of the problem as well as the roles and responsibilities they carry in their work. Through network data analysis I found that many actors are connected in the network and learned a lot from one another. However, the qualitative data shows that rather than these individuals collaborating to work on the same project, they may be working together on other projects, goals, and tasks.

Finally, the qualitative results revealed that there are different perceptions of the problem and different understanding of farmer and scientific knowledge. Analysis of these results alone may lead researchers to assume that there is just a hostility between groups, or a deep-rooted difference of opinions causing this fracturing. While this may be true, network analysis represents these fractures structurally and shows that these two results may reinforce one another.

CHAPTER 5: DISCUSSION AND CONCLUSION

This research focused on a small Wisconsin community negatively impacted by large green algal blooms in the summer months. This interdisciplinary problem involves complex social, environmental, and political interactions. Non-point source lake pollution is best addressed by collaborative solutions between stakeholders and policy actors. Social Network Analysis (SNA) alongside qualitative field research has proved useful in determining what problems exist and what opportunities and constraints exist for addressing this lake pollution.

The results above have demonstrated how Social Network data and qualitative interviews can be used together to understand this environmental problem more broadly. This concluding chapter will discuss how these results complement one another as well as what they mean for addressing local lake pollution. This chapter will conclude by emphasizing the myriad opportunities for future research as well as limitations to the study at hand.

Interpretation

How does **network structure** affect collaboration in the network?

The first hypothesis suggested that individuals collaborate with colleagues in their same occupation more than occupations that differ from theirs. This is significant because the structure of the network can inform how individuals view the problem and as the theory of homophily has revealed: those with like interests and beliefs tend to spend more time together (Kadushin 2012). The results did not clearly support or contradict this hypothesis as there was some homophily within clusters but also some colleague relationships across job types. More research should be completed to evaluate what knowledge is being transferred between certain individuals and how strong relationships are across job types.

The results also revealed very low overall density scores on all networks studied. This fact could be either promising or problematic. On the one hand, this lack of density could be caused by the network actors ability to draw on many diverse individuals in the network, allowing for more weak ties where “through two or three steps, one can encounter worlds that one might not otherwise know” (Kadushin 2012: 206). On the other hand, this lack of density could be caused by network actors’ limited ability to work with one another on a centralized project, and instead only work with a select few in their network.

The second hypothesis suggested a structural hole made farmers less able to connect to others in the network. As the Girvan-Newman algorithm and the sociogram on the 2016 learning network has shown, there is one relation between two actors that connects two separate clusters. This is evidence that a structural hole exists within the learning network in which farmers belong to a smaller community that is less connected to the whole. This structural hole is particularly significant because those with the actor attribute of “farmer” vary from one side of the structural hole to the other, confirming assumptions about homophily in networks. While this hypothesis appears to be correct as people with the same attribute of “farmer” tend to be closer associated with one another, I must also acknowledge that not every individual in the smaller connected community completed the survey. If they had, there is a chance that more relations to the larger connected component would be revealed. Farmers may not be included in this network for methodological reasons, however there may be other characteristics of the network composition that are creating this low response rate. On the one hand, water policy actors may not be effectively including or communicating with farmers, and this could explain their absence from the main component. Additionally, this result may reveal a genuine gap in problem definition and recognition in the community. If farmers genuinely do not agree that the lake pollution is a substantial problem, they may be unlikely to engage in efforts to improve water quality in the lake. In this scenario, the absence of farmers from the policy network might reflect a cleavage in knowledge and problem recognition in the community. Further research would need to examine this more closely. In all of these scenarios, this result illustrates that farmers and landowners are a difficult population to survey and include in analysis.

The network in rural Wisconsin is an open network as individuals often seek knowledge outside of their workplace or inner circle. So even if there were not marginalized groups in the network, it is still unlikely that one could compile a list of *all* actors in this specific network. Because this network is so open, the most viable option for collecting network data is the personal (egocentric) network approach in which a survey "requests a person to identify other people who are important for a given function or task (such as learning or information) and then answer a set of questions regarding each of these people" (Cross & Parker 2004: 143). This approach allowed individual actors to identify other community members that they feel are relevant in their own learning and working.

A key goal of this research was to evaluate what actors were included in the network of actors implementing water resource management policy in the area. An important criticism I received throughout this research is that I should have interviewed farmers to see who they interacted with. While this research may have been interesting, my goal was to determine who was included as well as *excluded.* The research as it stands now, highlights the difficulty of including underrepresented populations in decision making processes. The survey discussed in this study needed three rounds of email sampling before a farmer was named who identified a close colleague network that was comprised mostly of other farmers. The fact that this individual was even found and completed the survey is noteworthy.

Network structure does strongly influence social interactions. Network structure influences who actors can reach within their network as well as who they are more likely to collaborate with. In this specific network, colleague connections are being made across job types, providing opportunity for diverse collaboration and knowledge transfer. However, most of the policy network is still not engaging in learning interactions frequently with those who may be seen as most responsible for causing the lake pollution.

What roles do **network interactions** have in transferring knowledge across the network?

To answer this question, I looked at who is transferring knowledge in the network and how network connectivity is affected by the ties of a few central actors. This research has revealed that actor interactions can also affect how knowledge flows across the network as some individuals have more interactions in the network than others.

Through a bivariate correlation, this research has shown that individuals within this network who learn from others at a high rate also teach others at a high rate. This result emphasizes the importance of specific actors taking central roles in social relationships and interactions. Because there is a correlation between learning and teaching, I can conclude that there is a balance of knowledge transfer within the network which could lead to effective collaboration between actors. While there is a balance of knowledge transferred through some network actors, there may be actors with key information or knowledge that is not being shared broadly throughout this network.

This research has also shown that there are individuals that play a key role in connecting others in the learning network. When looking at Centrality of Actors by Betweenness and Degree, there are actors that lie outside of the regression line, showing that some individuals are much more central to the network than predicted. As the literature revealed, individuals with high Betweenness and Degree Centrality "could disseminate his ideas widely and they were accepted as trustworthy by those who came in contact with him" (Giuffre 2013: 131).

These actors are even more relevant because when they are removed from the network, they reduce the network ties from 445 to 341. This shows that these actors play a vital role in who is participating within this network. Also, the most central actor in the network is connected to 28 individuals directly. Therefore, there are many individuals who come in contact with him who generally find his ideas as trustworthy. This also allows the central actors perspectives and knowledge to be widely disseminated across the network. As before, this could be promising or problematic. If this individual has been absorbing diverse knowledge and spreading key information across the network, his positionality is promising. However, if the actor's values and subjective opinions guide conversation in a biased or unproductive way, his positionality could be problematic. Consequently, researchers must also look to qualitative research and that nature of the information being transferred to best understand the productivity of knowledge dissemination. I can conclude that learning is closely associated with teaching and overall network connectivity is dependent on the ties of a few central actors, however perhaps much more so on the ties of one central actor.

Due to the nature of the survey and way in which Social Network data is collected, it is difficult to present a full network that conveys significant meaning as to the position of every actor. While these results did identify key actors, many actors needed to be left out of the analysis. Rather than assume that this network data collection is too difficult to be significant, I argue that this further confirms the need to create a more structured governance framework in which many actors can be centrally located and do not need to reach out so broadly to access the resources and knowledge they seek.

How do **characteristics of the actors** affect collaboration within the network?

This research has shown that some characteristics and perceptions of actors are in fact important in making change within this network. Perceptions of the problem are also important when collaborative solutions are being made. The results have revealed the wickedness of this lake pollution; however, the results also show a more complex interaction between the problem and those working directly on the project than just its difficulty.

Individuals working within this network find their work are very goal oriented and often think a change can be made to improve the quality of the lake. However, the nature of the problem and their work make it a bit more complicated than expected. The qualitative data showed that this project takes a lot of time and resources to complete. Even when work on the progress is made, individuals find it difficult to see positive results. Finally, these workers are drawn from one project to another and the responsibilities of their job may require more than just focusing on lake pollution.

It seems that from the policy side, individuals see a dichotomous relationship where farmers are on one side and academics and scientists are on the other. This is consistent with the literature that emphasizes a disconnect between conservation practitioner and farmers (Laurence et al. 2004) as well as the lack of success when attempting to make collaborative solutions between farmers and scientists (Hassanein 1999) One interviewee in the academic group stated numerous times in frustration: “we already have all the knowledge.” This network may have all the scientific knowledge but inclusion of farmers’ perspective or farmers’ social knowledge is severely lacking.

Farmers have specific knowledge in terms of practices and farming strategies. It is also evident that water policy actors lean heavily on science to implement policy. However, what is not clear is how much of this knowledge is being translated between one another. There is no way of knowing if farmers are using science in their practice or if policy practitioners are including farmer knowledge in their implementation. By using the quantitative results to see the structural isolation of farmers and the qualitative results to see the ideological differences between these actors, we can see that more cross-stakeholder engagement is necessary for more useful collaboration. As it stands now there is no strategic process of knowledge sharing in this network.

Implications for Water Governance

This research has illuminated a few key elements that may be useful for networks governing shared water. First, social network analysis should be used to identify key individuals in the network. This includes boundary spanners and individuals with central positions. Network structure has revealed that some actors are capable of bridging between clusters within the network. Boundary Spanners, individuals who are a critical link between two groups, may present a new opportunity or direction for this network. These people are rare but often hidden gems because they "play an important role when people need to share different kinds of expertise" (Cross and Parker 2004: 74). When social network analysis identifies central actors in the network, these actors need to be acknowledged for their accomplishments. Being central to the network may consume many more hours and when these people are recognized through SNA, "it is usually one of the first times that others see and appreciate their efforts" (Cross and Parker 2004: 72).

Furthermore, this research emphasizes the importance of understanding characteristics of individuals within the network. While network analysis reveals a structural hole in the network, qualitative interviewing show how actors feel about this divide. The capability of building trusting relationships was a key characteristic of the central actor. If other people in this network are not garnering the same level of trust across the network then the network is limiting. The results above show that perhaps the fracturing between farmers and the science community leads to more animosity and blame rather than trust. Improving translation of science to practice and farm practice to policy could greatly improve the level of trust occurring within this network.

Recommendations for Local Community

In my research, I found a significant Boundary Spanner connecting the farming community to the policy community. By acknowledging this individual and giving him and those around him more resources and the opportunity to take on a leadership role, there is immense potential for a more cohesive overall network. While having one Boundary Spanner is important, this network needs to find other individuals capable of bridging across the divide of farmers and policy actors. People who work heavily in policy but are also able to work closely with farmers will be necessary to affectively address this problem. As previously stated, finding the structural hole within the network not only emphasizes a lack of farmer connectivity but also confirms the notion that farmers and landowners may be a hard to reach population. Therefore, more extensive and directed work is required to include these actors in the decision-making process. As others have found: “strategies that stakeholders help to create are often more widely supported, promoted and implemented” (Carter et al. 2005: 117).

I found that some interactions are more central to the network than others. While some people are responsible for the most frequent knowledge transfer, this may mean other actors with crucial knowledge are not having their voice heard or they are not receiving central knowledge. Therefore, the network needs to expand both who is receiving knowledge and who is giving knowledge. The central actors identified in this research need to be a starting point for expanding the spread of information. Moreover, these actors need to be evaluated to determine what knowledge is being transferred; assessing what information these individuals are transferring would largely represent what much of the network is discussing overall.

One of the more pressing problems facing individuals of this network was revealed in my qualitative interviewing process. Many individuals in the network are concerned because the most central actor in the network is retiring from his line of work. These individuals fear that the work done in this network thus far will be lost or there will be no individual to propel the work ahead. While this individual may still be socially involved, his time commitments will probably be greatly reduced, which may fracture the network of knowledge transfer. It is necessary, then, to determine which other actors are most central in the network as well as find innovative ways of including more peripheral actors. As Floyd and Johnson (2002) emphasized, those in vulnerable and minority positions need to be put in decision-making roles for effective inclusion of these stakeholders. The most central actor put an emphasis on informal relationships. To mirror his success, more actors within the network should not only cultivate formal work relations with others in the network but also informally socialize with these actors, finding a common ground.

When actors are spread out and diverse within a network Provan and Kenis argue that "the structural solution is to centralize network governance activities around a broker organization" (2008: 238). The research shows that governance may benefit from a lead organization. The Department of Natural Resources and the Department of Agriculture Trade and Consumer Protection are held most responsible for water quality issues in the state (Kent and Dudiak 2001). Therefore, these organizations should be given a leadership role in the network of governance.

Finally, the divide between farmer knowledge and scientific knowledge may reveal a deeper gap in understanding of the problem rather than just ideological differences. Perhaps farmers in the area do not see the lake pollution as a problem, and therefore have no incentive to come to the table and be a part of the discussion. There are two approaches that may make farmers more willing to become a part of the water policy discussion. First, regulations on fertilizer use and runoff could directly incentivize farmers to participate and make a case for their traditional farmer practices. Additionally, an environmental crisis or a direct environmental impact on farmers may also cause them to join in the conversation. Until the farmers and other landowners see the lake pollution as a personal problem for them, it is unlikely that they will willingly leave their busy work to join in the conversation.

Limitations and Future Research

This research faced many limitations due to the exploratory nature of studying this community utilizing a Network Analysis perspective. However, this research also provides an abundance of opportunity for future research and analysis of data collected during this case study. Solely using SNA without including qualitative analysis will continue to be severely limiting. Without understanding the context and the nature of interactions, connections between individuals has potential to be misinterpreted or misrepresented.

Collecting SNA data is often difficult for many reasons. As you can see from the low response rate, individuals are often not willing to disclose personal information about their friends and colleagues. I received a few emails from respondents claiming they were opting out because of the need to keep personal names confidential in their workplace. Additionally, SNA at its current stages is time consuming and data manipulation to correct formats is prone to human errors. When inputting SNA data there needs to be properly formatted excel documents, clearly labelled nodes and consistently formatted matrices. SNA software usage is relatively new and is continually improving and updating to make the input of this complicated data easier and more comprehensible.

Additionally, reaching other individuals who were listed in a survey can be difficult. Particularly, this research relied on email surveys and digital survey responses which may exclude individuals who do not regularly check email, are not interested in online surveys, or who have no access to internet. In-person surveys, while more time consuming, could create more reliable results and allow for a much wider outreach of participants. This point also speaks to the difficulty of including farmers in stakeholder analysis. I did not purposely reach out to farmers because I hoped by studying only those in water policy occupations, I would have a more accurate understanding of how often those individuals reached out to farmer networks. Had this network been a closed network, in which all actors were identified and asked questions of, this research could be much more accurate.

As stated before, this research is further limited because SNA can only measure a network of relationships at one point in time. Additionally, the very specific nature of this case study makes it difficult to generalize these results to other networks and organizations. For this reason, the conclusions of this analysis focus on the success of the methods used in identifying relevant characteristics inherent in networks such as the one presented, rather than specific findings.

Future research could begin with a more in-depth analysis to include all nearby stakeholders affected by the problem. This study could reasonably begin where this one left off, building on the small cluster of farmers identified in this survey. Surveying farmers in much different than surveying policy actors and questions may need to be framed in ways that better address their concerns and interests. These questions could address farming practices, community ties, and an inquiry into what problems they see in the area. Also, many individuals in this network mentioned a watershed conference that draws more and more community members every year. Attending this event with a goal of understanding the network structure of attendees would also greatly improve the understanding of this network.

Further methodological studies need to be done to evaluate the nature in which individuals identify what they teach and learn. As Phelps et al. (2012) shows, the characteristics of knowledge being transferred is the least studied feature in knowledge networks. It appears that individuals are much better able to recall what they learn rather than what they teach. The research presented above used a methodological approach to attempt to correct for this inconsistency. In my study, individuals were asked to identify who they taught *after* they identified who they learned from. This allowed respondents to select from individuals previously listed as colleagues or teachers. This approach hoped to capture individuals they may have taught but not thought of initially. Even still, when respondents described what they taught others, their responses were much more limited than when they described what they learned. Future research could evaluate effectiveness of the methods utilized in this research by switching the order of these questions in a comparative analysis. Other research could also attempt to find other more effective ways to measure or correct for this unique phenomenon.

The research conducted in 2016 contained many survey items that were not used in this current study. The survey asked participants who they learned from and who they taught, but it also asked participants to identify what information they learned and taught. Participants often found it difficult to verbalize what they taught to others or were reluctant to fill out that section of the survey at all. This outcome is not surprising as “properties of knowledge constitute the least examined aspects of knowledge networks" (Phelps et al. 2012: 35). Researchers struggle to quantify and study the properties of knowledge, creating a large gap in knowledge network literature and research. Further analysis of data collected in 2016 could evaluate what kinds of knowledge are being transferred and if some knowledge is more commonly transferred than others within this network.

The 2016 survey asked respondents to identify how often they communicate with each of the individuals they identified. This question was not utilized in this current analysis but could have improved understanding of the social network. Research has shown that "strong interpersonal ties…are more effective than weak ties in enhancing knowledge transfer and learning" (Phelps et al. 2012: 10). Future research could utilize this question of frequency of contact to create a clearer understanding of the strength of ties in this network which could identify differentiations of knowledge transfer according to closeness of relationships.

The 2016 survey also asked respondents to identify who do they trust of the individuals they. Provan and Kenis (2008) argue that governance is most likely to be effective if there are many relations of trust in the network. Therefore, further research could include an understanding of trusting relationships within the network as another factor determining how collaborative management of a resource occurs.

Conclusion

Failure to alleviate or correct water pollution caused by agricultural run-off is not simple but is in fact technologically, politically, and socially situated in local and historical contexts. Social Network Analysis and qualitative data collection allow for a more thorough interpretation of the problem and approaches toward solutions. This Thesis has revealed that collaborative networks can be affected by their structure, the interactions between actors, and characteristics of actors within the network. Also, this research has shown that by interpreting these collaborative networks with SNA and qualitative analysis, researchers can gain a more fruitful understanding of how this network can best implement positive change.

Network structure affects collaborative efforts by making it easier to be in contact with those of the same occupation type and more difficult to reach out to and interact with diverse stakeholders such as farmers. This network is quite collaborative in their work relations however there are still many connections lacking in the network. While this research shows a push to diversify relationships across job types, the network is still highly dependent on a few central actors to make collaboration occur. Finally, the characteristics of the actors in this network may affect how successful collaboration efforts are. The actor most centrally engaged has unique characteristics that make him accessible to the network. By understanding his characteristics, more network actors could adopt his practices to improve connectivity in the network. Moreover, not only does the nature of non-point lake pollution make it tough to address, the nature of individual's job responsibilities and time availability make this problem even more difficult to tackle. Social network analysis and qualitative analysis are necessary tools for evaluating the effectiveness of collaborative environmental projects and in the words of an actor in this network: "sometimes all it takes is just getting the right people in the room."

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APPENDIX A: 2016 FULL NETWORK SURVEY (ONLINE QUESTIONNAIRE)

Thank you so much for your interest and participation in this survey.
This research project is a continuation of one that began in Summer 2014. The intent of this survey is to understand the knowledge network of policy makers, practitioners, officials, and community organization members in Wisconsin. This knowledge network can inform effective policy and actions. I will ask questions about your colleagues, but NO names will be used in the reporting of this research. In order to get an idea on what policy maker and practitioner social networks look like, we will follow up with a few of those you identify in this survey. However, your identification of them as colleagues will not be communicated to them by us. I will simply send them the same survey you are taking here. This survey will greatly help us understand the challenges and constraints for addressing water pollution in the area. Because this survey is confidential there is no foreseeable harm to you. All responses will be securely stored in the investigator’s computer, and no names will be included in any reports from those data. These will be stored for 10 years before being destroyed. Your participation in this study is strictly voluntary. You may choose at any point in time to withdraw yourself, with no consequences to you. This survey will take you approximately 25 minutes to complete. The first part of this survey will ask you about people in your network and when knowledge transfer and learning occurs. The second part will ask a few follow up questions about individuals within your network as well as your thoughts on water policy in the Red Cedar Basin. This research seeks to better understand how knowledge is transferred when working to solve issues of water quality. It is being carried out by Master's student, Alison Anson of Colorado State University for her thesis. For more information on other work related to this topic,
please visit www.uwstout.edu/lakes.
Student Investigator: Alison Anson, Colorado State University
Local Adviser Contact: Dr. Nels Paulson, University of Wisconsin-Stout

By completing this survey you agree to participate in this study.

Q1 Personal Information
Name (First and Last):
Place of Employment/Organization Affiliation:
Position Currently Held:

Q2 Please indicate the level of education you have completed.
- ❍ Less than high school
- ❍ High school
- ❍ 2-year degree
- ❍ 4-year degree
- ❍ Graduate/professional degree

Q3 Are you a resident of Dunn County?
- ❍ Yes
- ❍ No

Q4 Please list, in any order, your five closest colleagues' first and last names, as well as where they work or what organization they are affiliated with and their email addresses. These individuals will be selected to participate in this survey, but all names will remain confidential. We will not disclose that you have identified these individuals in this survey.

	First and Last Name	Email Address	Place of Employment/Organization Affiliation
Individual #1			
Individual #2			
Individual #3			
Individual #4			
Individual #5			

Q5 The following questions refer to individuals you have associated with either formally or informally in relation to water policy or water quality. Your five closest colleagues will appear as choices in the following questions. However, you may list any additional people in your network. If listing new names, please provide first and last names. These names will remain confidential and we will not disclose that you have identified these individuals in the survey.

Q6 Who have you learned from in the past year? These individuals can be the same as those previously listed or different. Use the blank spaces below to add additional individuals that you have learned from in the past year. Please click all that apply.

- ❑ ${q://QID4/ChoiceTextEntryValue/1/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/2/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/3/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/4/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/5/1}
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________

Q7 Please tell us a little bit more about what you learned from these individuals and where.

	--	--
	Where were you when you learned from each individual? [ex. meeting, community forum, social event, etc.]	What did you learn from this individual?
${q://QID4/ChoiceTextEntryValue/1/1}		
${q://QID4/ChoiceTextEntryValue/2/1}		
${q://QID4/ChoiceTextEntryValue/3/1}		
${q://QID4/ChoiceTextEntryValue/4/1}		
${q://QID4/ChoiceTextEntryValue/5/1}		
${q://QID6/ChoiceTextEntryValue/6}		
${q://QID6/ChoiceTextEntryValue/7}		
${q://QID6/ChoiceTextEntryValue/8}		
${q://QID6/ChoiceTextEntryValue/9}		
${q://QID6/ChoiceTextEntryValue/10}		

Q33 The following questions refer to individuals you have associated with either formally or informally in relation to water policy or water quality. Your five closest colleagues will appear as choices in the following questions. However, you may list any additional people in your network. If listing new names, please provide first and last names. These names will remain confidential and we will not disclose that you have identified these individuals in the survey.

Q9 Who has learned from you in the past year? These individuals can be the same as those previously listed or different.   Use the blank spaces below to add additional individuals that have learned from you in the past year. Please click all that apply.

- ❑ ${q://QID4/ChoiceTextEntryValue/1/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/2/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/3/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/4/1}
- ❑ ${q://QID4/ChoiceTextEntryValue/5/1}
- ❑ ${q://QID6/ChoiceTextEntryValue/6}
- ❑ ${q://QID6/ChoiceTextEntryValue/7}
- ❑ ${q://QID6/ChoiceTextEntryValue/8}
- ❑ ${q://QID6/ChoiceTextEntryValue/9}
- ❑ ${q://QID6/ChoiceTextEntryValue/10}
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________
- ❑ Additional Individual: ____________________

Q13 Please tell us a little bit more about what these individuals learned from you and where.

	--	--
	Where were you when these individuals learned from you? [ex. meeting, community forum, social event, etc.]	What did this individual learn from you?
${q://QID4/ChoiceTextEntryValue/1/1}		
${q://QID4/ChoiceTextEntryValue/2/1}		
${q://QID4/ChoiceTextEntryValue/3/1}		
${q://QID4/ChoiceTextEntryValue/4/1}		
${q://QID4/ChoiceTextEntryValue/5/1}		
${q://QID6/ChoiceTextEntryValue/6}		
${q://QID9/ChoiceTextEntryValue/7}		
${q://QID9/ChoiceTextEntryValue/8}		
${q://QID9/ChoiceTextEntryValue/9}		
${q://QID9/ChoiceTextEntryValue/10}		
${q://QID9/ChoiceTextEntryValue/11}		
${q://QID9/ChoiceTextEntryValue/12}		
${q://QID9/ChoiceTextEntryValue/13}		
${q://QID9/ChoiceTextEntryValue/14}		
${q://QID9/ChoiceTextEntryValue/15}		

Q27 Who do you consider to be leaders within your network? These individuals can be the same as those previously listed or different.   Use the blank spaces below to add additional individuals that you consider to be leaders. Please click all that apply.

❑ Individuals 1-20 available to select

Q28 Of all the individuals you identified in this survey, who would you go to when seeking professional advice? Please click all that apply.

❑ Individuals 1-20 available to select

Q29 Of all the individuals you identified in this survey, who do you trust? Please click all that apply.

❑ Individuals 1-20 available to select

Q30 Of all the individuals you identified in this survey, who, if any, is a farmer in the Red Cedar Basin? Please click all that apply.

❑ Individuals 1-20 available to select

Q31 Please slide the bar to indicate how often you communicate with each of the individuals you listed on about water quality and water policy. From 0-Never to 5-Very Often. All relations are set at Sometimes for default.

❑ Individuals 1-20 available to select

Q18 As a representative of my organization, I feel I have the ________________ to effectively improve water quality in Wisconsin.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
knowledge	❍	❍	❍	❍	❍
funds	❍	❍	❍	❍	❍
time	❍	❍	❍	❍	❍
people	❍	❍	❍	❍	❍
authority	❍	❍	❍	❍	❍

Q19 I feel the policies I have to work with are adequate to improve water quality in Wisconsin

❍ Strongly disagree
❍ Disagree
❍ Neither agree nor disagree
❍ Agree
❍ Strongly agree

Q25 What additional thoughts would you like to share about water quality and policy in the Red Cedar Basin?

Q21 Would you be interested in speaking for an interview to further discuss the network of water policy actors in the Red Cedar Basin? If after August 10th, 2016 the interview will be conducted over the phone.

❍ Yes
❍ No

Q23 Is there anyone else who should take this survey that would help us better understand this network? Please list their names and email addresses. I will not disclose that you have identified these individuals in this survey

	First and Last Name	Email Address
1.		
2.		
3.		
4.		
5.		

APPENDIX B: FULL LIST OF OCCUPATIONS BY JOB TYPE

Attribute Given	Occupation
Academic	faculty, staff, and researchers
UW-Extension	
Not-for-Profit	West Wisconsin Land Trust (WWLT), Tainter/Menomin Lake Improvement Association (TMLIA), Midwest Organic & Sustainable Education Service (MOSES), Red Cedar Basin Monitoring Group, NW Wisconsin Lake Leader, The Prairie Enthusiasts, WestCAP, Desair Lake Restoration, Great Lakes Commission, Minnesota Personal Care Assistant, St. Croix County Sportsman Alliance, The Alliance of Dunn County Conservation and Sports Clubs, St. Croix Flowage Association, Michael Fields Agricultural Institute
Local Business	Cedar Corp, Menomonie Market Food Coop (MMFC), St. Joseph School, Schofield & Higley, Book Publisher, Wisconsin Liquid Waste Carriers Association (WLWCA), Cedar Falls Heating, Glenwood City Library, Mayo Clinic, Enbridge Energy, Consultant, Harmony Gardens, 4-H Youth Educator, Music Teacher, Aquarian Gardens, Self-Employed, Fairmont Minerals Sand Co., Northflow LLC, Colfax High school, Prairie Farm School District, People's State Bank, 3M
City	City of Menomonie, Chamber of Commerce, City Council, Menomonie Police Department
Dunn County	
Other County	Pierce, Barron, St. Croix, Polk, Pepin, Vernon
DATCP	Department of Agriculture, Trade, and Consumer Protection
WDNR	Wisconsin Department of Natural Resources
Other Federal	EPA, USDA, National Estuarine Research Reserve, National Parks Service, US Forest Service
Farm	Yahara Pride Farms, Independent Operators, Farmer's Union, WESTconsin Credit Union

APPENDIX C: NETWORK CONCEPTS RELEVANT TO NR 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

(Prell et al. 2009)

APPENDIX D: IRB APPROVAL DOCUMENT

Research Services
152 Voc Rehab Building

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July 1, 2014

Nels Paulson, Tina Lee, Chris Ferguson
Alison Anson, Peng Vang, Zakia Elliott, Matthew Flyr, Cassandra Beckworth
Lauren L' Esperance, Courtney Worthington, Blake Lea, Rachel Flana
Applied Social Science
UW-Stout
RE: People and Land Use in West Central Wisconsin – REVISION

Dear Nels, Tina, Chris, Alison, Peng, Zakia, Matthew, Cassandra, Lauren, Courtney, Blake and Rachel:

The IRB has determined your revised project, *"People and Land Use in West Central Wisconsin,"* is **Exempt** from review by the Institutional Review Board for the Protection of Human Subjects. The project is exempt under **Category #2/3** of the Federal Exempt Guidelines and holds for 5 years. Your **REVISED** project is approved effective **June 30, 2014**, through **August 8, 2018 (original approval date of protocol)**. Should you need to make modifications to your protocol or informed consent forms that do not fall within the exemption categories, you will need to reapply to the IRB for review of your modified study.

If your project involved administration of a survey, please copy and paste the following message to the top of your survey form before dissemination:

> This project has been reviewed by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46

If you are conducting an **online** survey/interview, please copy and paste the following message to the top of the form:
"This research has been reviewed by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46."

Informed Consent: All UW-Stout faculty, staff, and students conducting human subjects research under an approved "exempt" category are still ethically bound to follow the basic ethical principles of the Belmont Report: 1) respect for persons; 2) beneficence; and 3) justice. These three principles are best reflected in the practice of obtaining informed consent from participants.

If you have questions, please contact Research Services at 715-232-1126, or foxwells@uwstout.edu, and your question will be directed to the appropriate person. I wish you well in completing your study.

Sincerely,

Susan Foxwell
Research Administrator and Human Protections Administrator,
UW-Stout Institutional Review Board for the Protection of Human Subjects in Research (IRB)

***NOTE: This is the only notice you will receive – no paper copy will be sent.**