SOCIO-ECOLOGICAL SYSTEM (SES) RESILIENCE

AND WATER GOVERNANCE IN OKLAHOMA

By

BRIDGET KERNER

Bachelor of Arts in Environmental Studies

Salisbury University

Salisbury, Maryland

2011

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2015

SOCIO-ECOLOGICAL SYSTEM (SES) RESILIENCE

AND WATER GOVERNANCE IN OKLAHOMA

Thesis Approved:

Dr. Beth Caniglia

Thesis Adviser

Dr. Tamara Mix

Dr. Kelly Hartshorn

ACKNOWLEDGEMENTS

This material is based on work supported by the National Science Foundation under Grant No. IIA-1301789. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or Oklahoma State Regents for Higher Education.

Name: BRIDGET KERNER

Date of Degree: MAY, 2015

Title of Study: SOCIO-ECOLOGICAL SYSTEM (SES) RESILIENCE AND WATER GOVERNANCE IN OKLAHOMA

Major Field: SOCIOLOGY

Abstract: This research examines the Socio-Ecological System (SES) resilience of Oklahoma's water governance through an analysis of Oklahoma's state level water policies and Oklahoma's state level water governance network. The research draws from resilience and natural resource governance literatures in order to enhance connections between the literatures. Oklahoma's water governance needs to be resilient because Oklahoma has a history of drought, a limited water supply, a growing population and an economic reliance on agriculture. Additionally, Oklahoma is predicted to experience more extreme climate variability including longer periods of drought and extreme weather events as a result of climate change. Resilience is important for SESs because it helps social and biophysical systems prepare for and adapt to disturbances. Fragmentation within a governance system reduces the resilience and adaptive features within a governance system enhance the resilience of that system. Thus the research questions I address are: What are the implications for resilience of formal natural resource governance at the state level in Oklahoma? Does Oklahoma experience features of fragmentation within its water governance policies? And does Oklahoma experience features of an adaptive water governance network? I use a mixed methods research design involving a content analysis of Oklahoma's water policies and a network analysis of Oklahoma's water governance network to determine how Oklahoma experiences features of fragmented and adaptive governance within its natural resource governance structure. The results reveal that Oklahoma experiences more forms of fragmentation than expected and more features of an adaptive governance network than predicted. Both policy makers and natural resource managers can use the outcomes of this research to prepare for and respond to changes in the availability of water. These preparations can be made by addressing the areas of fragmentation in water policy and the features of an adaptive governance network that Oklahoma's water governance network is currently lacking. Ultimately, this research provides a thorough analysis of the resilience of Oklahoma's water governance and provides implications for the future of Oklahoma's natural resource governance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Current geographical conditions in the state of Oklahoma make it an ideal case for examining the resilience of water governance. Oklahoma has a history of drought, an increasing population, a limited supply of water, and an economic dependence on agriculture. These current sociological and environmental factors have converged resulting in increased vulnerability to changes in precipitation and temperature patterns. Climate change variability will increase Oklahoma's susceptibility to these changes, since climate change is projected to bring longer droughts and precipitation patterns that result in more run-off and less water table recharge. In order to reduce the vulnerability of Oklahoma's water systems to climate change, Oklahoma needs to enhance its resilience with effective environmental policies and water governance.

A socio-ecological system (SES) is a complex adaptive system, which recognizes the impact of social systems on ecological systems and vice versa. SES's can exist at varying scales, Oklahoma is a SES within the larger regional SES that is the south central United States. The resilience of a SES is the ability of that system "to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al. 2004: 2). If Oklahoma is prepared and able to respond to changes in the biophysical environment, then its socio-cultural systems will not be impacted as greatly. One avenue for developing Oklahoma's SES resilience to environmental changes is through natural resource governance. Natural resource governance implements management strategies for common pool resources, such as water, timber, grazing land, etc.

Water governance, one type of natural resource governance, is central to predicting water usage, availability, and also focuses on monitoring supply sources. According to the 2006 United Nations World Water Assessment Program (UNWWAP), the most important water problem facing the world today is not water scarcity, but rather water governance (Cook 2011). Water is one of Oklahoma's most valuable and vulnerable natural resources (Wertz and Layden 2013), more vigilant management of this resource is required to prepare for the predicted disturbances that will accompany climate change (Oklahoma Climatological Survey 2011).

Legal scholars (Buzbee 2003; Buzbee 2005), as well as resilience scholars (Folke et al. 2005), have both elaborated upon various outcomes associated with natural resource governance. Outcomes such as fragmented governance and adaptive governance impact the ability to effectively manage natural resources.

Fragmented governance is "the allocation of responsibility for governance among multiple actors and/or agencies, with relatively little or no coordination" (Hill et al. 2008:316). Fragmented governance causes confusion about the individual, agency, or institution that is responsible for regulating a particular aspect of a resource which can lead to inaction or conflict over the party responsible for a given situation (Buzbee 2005:2). Fragmented governance can occur at multiple scales (Cook 2011) and reduces the ability of the system to function when disturbances occur, decreasing the resilience (Folke et al. 2005). Thus fragmented governance can be associated with reduced SES resilience.

A SES that experiences adaptive governance "draws upon various knowledge systems and experiences for the development of a common understanding and policies" (Folke et al. 2005: 441). Adaptive governance addresses specific social dimensions of complex SES which will mitigate the impacts of shocks or disturbances (Lee 1993; Walters 1997; Gunderson 1999; Gunderson and Light 2006). Thus, adaptive governance enhances the ability of the system to function despite disturbances from the impacts of climate change. Understanding the nature of governance structures within specific contexts offers an opportunity to inform and improve existing resilience literatures. Further research would lead to enhanced governmental preparation for the impacts of climate change. In the coming decades, the effects of climate change will become more severe, directly impacting natural resources. If water governance in Oklahoma is fragmented, then it will become more vulnerable to potential shocks or disturbances and disrupt the status quo. Therefore, it is necessary now more than ever to determine if the relevant features of resilience are present in Oklahoma's water governance and how those features might be enhanced to increase Oklahoma's ability to adapt in the future.

Oklahoma's geography, history of drought, and complex system of water governance contribute to an ideal scenario for studying governance structure and resilience. In this thesis, I employed both qualitative content analysis and quantitative network analysis methodologies to assess natural resource governance policies and networks in Oklahoma. The qualitative content analysis had a dual purpose, the first purpose was to analyze Oklahoma's water policies for themes and the second purpose was to develop the policy areas in Oklahoma's water network in order to conduct the network analysis. I have also considered the implications of these policies and networks on regional resilience and Oklahoma's water future as it is impacted by climate change. Thus I ask: What are the implications for resilience of formal natural resource governance at the state level in Oklahoma? What features of fragmented governance are found in

Oklahoma's water governance policies? And finally, what features of an adaptive governance network are found in Oklahoma's water governance network?

In the following sections I address these research questions and explain how the current geographical conditions in Oklahoma make it an ideal case for examining resilience and water governance. Next I provide a review of the current literature on resilience, natural resource governance, adaptive and fragmented governance. I then briefly explain of the literature on my chosen methods, followed by a discussion of my mixed methods approach to understanding the resilience of Oklahoma's water governance. The methods and procedure for conducting both a qualitative content analysis and quantitative network analysis are detailed and a discussion of the results as well as a discussion of both the qualitative content analysis and the social network analysis are provided. The document concludes by describing the contributions of this research and identifying other areas which are in need of future research.

Context: Oklahoma and Water

The state of Oklahoma is a prime example of a place that has suffered as a result of a limited water supply. Oklahoma has a history of drought, a reliance on agriculture, and a growing population, all of which impact water availability. The state is predicted to experience more severe droughts and other environmental impacts related to water availability in the future as the impacts of climate change become more intense. Recently, Oklahoma has attempted to address its water availability issues through the Oklahoma Comprehensive Water Plan developed by the Oklahoma Water Resources Board. Despite this effort to address its limited water supply, more research is needed to understand Oklahoma's water governance structure in order to address vulnerabilities which might exist and be exacerbated by climate change.

In the state of Oklahoma, water has been referred to as Oklahoma's "most precious resource" because of its limited quantity (Wertz and Layden 2014:1). Throughout its history, Oklahoma has experienced periods of drought. Records show that a major drought occurred in Oklahoma in 1890s, 1910s, 1930s, 1950s, 1960s, and more recently 2010s. Not only did these droughts impact the ecological systems in Oklahoma by reducing the amount of topsoil and agricultural productivity, but social systems suffered as well. The social impacts of these droughts over time led to both decreased economic activity and a major exodus from the plains region. The most recent drought in Oklahoma not only cost an estimated $1.7 billion in agricultural losses, it also “exposed the vulnerability of industries to water shortages” (EPSCoR 2012:1). In addition to agricultural losses and industrial vulnerability, indirect costs of the drought have impacted both social and ecological systems with the increase of wildfires across Oklahoma, which have destroyed both homes and landscapes (EPSCoR 2012). However, droughts have not been the only impact of Oklahoma’s severe climate variability, “from January 2000 to July 2012, Oklahoma had 33 federally declared major weather related disasters” (EPSCoR 2012:1). These weather related disasters “stressed inhabitants, civil infrastructure, natural-resource related businesses, and rural economies” (EPSCoR 2012:1). Not only is Oklahoma expected to continue to experience instability in weather patterns, climate change is predicted to severely impact the climate variability of this region leading to more severe weather patterns.

Oklahoma is predicted to experience severe changes to its weather patterns as a result of climate change. The seasons in Oklahoma will be impacted by a longer warm season with more intense droughts. The longer warm season will impact the growing season for farmers making valuable crops susceptible to potential freezing in the late spring and impact the energy costs associated with air conditioning. The longer warm season will also lead to decreased soil moisture as a result of evaporation, impacting the water table and erosion rates. Additionally increased drought, extended warm season, and drier soil will contribute to increased wildfires and increased reliance on irrigation. In addition to these changes Oklahoma is predicted to experience fewer precipitation events, though the few precipitation events will be more intense than in the past. The intensity of the precipitation events will increase runoff, soil erosion, and flooding. All of the changes are predicted to impact Oklahoma in the coming years, this intensifies the need to address any vulnerabilities and build resilience (Oklahoma Climatological Survey 2011).

In an effort to address Oklahoma's current and impending water issues, the Oklahoma Water Resources Board recently completed the Oklahoma Comprehensive Water Plan (OCWP). The plan was initiated in 2006 and completed in 2012, though the plan provided an outlook for water use in Oklahoma through 2060 (ORWB 2012). Since the completion in 2012 the OCWP is still evolving as revisions, updates, and additions have continued. This plan is an attempt to assess Oklahoma's water resources, help resource managers, and inform policy makers on multiple scales how to determine and implement appropriate water use strategies. Comprehensively, this plan has provided an unprecedented amount of research and community input into recommendations for water policy. The outcome of the plan was a report which highlighted the most critical needs of Oklahoma's water system which were identified as priority recommendations and supporting recommendations and initiatives. Some of the top recommendations were: water project and infrastructure funding, regional planning groups, water supply reliability, water quality and quantity monitoring, and State/tribal water consultation and resolution (OWCP 2012). Despite these valuable recommendations, policies which are recommended by the OCWP are not automatically adopted into law. It is unclear what, if any, policy changes have occurred as a result of the OCWP. The impacts of climate change, the history of Oklahoma's relationship with water, and the recent acknowledgement of the need to prepare for future water availability, all contribute to the growing need to increase the preparedness and resilience of Oklahoma's water governance.

CHAPTER II

REVIEW OF LITERATURE

This review examines current literature on resilience, natural resource governance, fragmented governance, and adaptive governance. The initial discussion involves the origins of resilience within the field of ecology and the evolution of this concept through different disciplines. Followed by a discussion of the current definition of SES resilience as it applies to complex adaptive systems and the difference between "specific" and "general" resilience. The literature review moves on to address and define natural resource governance and the role it has played facilitating natural resource management strategies. Next the review expands upon the concept of natural resource governance and common complications that arise when attempting to govern common pool resources. Subsequently a discussion in provided explaining how the resilience of a governance system is linked to the resilience of the entire SES. A few examples of the ways in which natural resource governance can be more resilient through adaptive governance of less resilient through fragmented governance. Further discussion details the concept of fragmented governance, as well as different types of fragmentation and in particular emphasizes the concept of jurisdictional fragmentation. The potentially negative impacts on the resilience of SESs as a result of fragmented governance are addressed as well as potential solutions to issues of fragmented governance. Also provided is an overview of the concept adaptive governance and its connection in the literature to the enhanced resilience of a SES. Natural resource governance is a component of a SES, fragmented governance and adaptive governance are outcomes of the natural resource governance structure that either enhance or reduce the resilience of that SES. This thesis is addressing the need for more research to help planners and policy makers prepare for the impacts of climate change on the functioning of a SES. Resilience addresses this through the identification of ways in which a system can adjust and adapt in order to continue functioning without the threat of collapse. Natural resource governance is a component of a SES which is uniquely important because natural resources are going to be greatly impacted by climate change. The more resilient a natural resource governance system is, the less it be affected by the impacts of climate change. In turn the resilience of a natural resource governance system impacts the ability of the entire SES to cope with disturbances, such as extreme weather events. Thus, more knowledge about the adaptive or fragmented features of Oklahoma's natural resource governance will help to identify vulnerabilities and strengths within the system. Ultimately, the literature review illustrates the need for natural resource governance structures to become more adaptive in order to enhance SES resilience so that Oklahoma's SES will not be threatened as a result of the impacts from climate change.

Resilience

Research on resilience has increased exponentially since Crawford S. Holling (1973) first explored the concept of ecological resilience. Ecological resilience "relates to the functioning of the system, rather than the stability of its component populations, or even the ability to maintain a steady ecological state" (Adger 2000:349). Therefore ecological resilience examines the functioning of an ecological system without identifying how the social dimensions would be impacted (Pimm 1984; Holling et al. 1995; Perrings 1996; Gunderson et al. 1997). The concept of resilience eventually broadened into disciplines beyond ecology. Thus, the concept of resilience was adopted from the natural sciences of ecological resilience to the social sciences with social resilience (Adger 2000; Folke 2006; Gallopin 2006; Miller et al. 2010). Initially, the literatures on social resilience and ecological resilience were built and expanded upon as two separate concepts. However, the creation of the Coupled Human and Natural Systems (CHANS) approaches led to the linkage of social resilience and ecological resilience within an overarching systems approach called Socio-Ecological Systems (SES) (Caniglia et al. 2014).

SES's are also referred to as complex adaptive systems and can be defined as systems within which social and ecological dimensions are intertwined and cannot be disentangled from one another. The definition of resilience evolved when it was applied to a SESs approach. SES resilience depends on the diversity of the ecosystem as well as the institutional rules which govern the social system" (Adger 2000:354). Therefore, a SES approach dictates that both social and ecological factors impact the resilience of each other and the system as a whole. One cannot consider social or ecological resilience without considering the implications or impacts of both the social and ecological dimensions of a system (Westley et al. 2002; Berkes et al. 2003; Barr and Devine-Wright 2012). Scholars have noted that SES resilience also encompasses the ability of the system to cope with, respond to, and adapt to both slow moving disturbances and sudden unexpected disturbances to the system (Adger 2000). In addition, to being able to cope with and adapt to changes, resilient SESs have the "capacity to reorganize the system within desired states in response to changing conditions and disturbance events" (Folke et al. 2005:444). SESs are complex adaptive systems which are not only resilient to shocks or disturbances but are also capable of maintaining the status quo. In addition, they have the capacity to shift into a different state in order to respond to the shock or disturbance.

SESs are complex and are more or less resilient to disturbances in two distinct ways. The two types of resilience are "specified" resilience and "general" resilience (Miller et al. 2010). "General" resilience refers to the resilience of the SES as a whole. "Specified" resilience refers to the resilience of a specific component within a SES (Miller et al. 2010; Carpenter et al. 2001; Folke et al. 2010; Resilience Alliance 2009). The "specified" resilience of a component of the system not only informs the reader about the resilience of that component, but it also speaks to the resilience of the SES as a whole. Governance is an example of a component of a SES which can have "specified" resilience, the "specified" resilience of governance then impacts the "general" resilience of the SES. Future research should focus on operationalizing both the "specified" resilience of components within the SES and the "general" resilience of the SES as a whole (Miller et al. 2010).

Natural Resource Governance

SESs have many dimensions, each of which has an impact on the resilience of the SES as a whole. Governance is an important dimension of SESs and can be defined as "the structures and processes by which people in societies make decisions and share power" (Folke et al. 2005:444). Governance structures and processes are different depending on that which they are responsible for regulating. Natural resource governance is widely considered the most complicated form of governance because it attempts to govern common pool resources (Berkes and Folke 1994; Bodin and Crona 2009). Common property or common pool resources are resources, such as water, that do not always: adhere to political boundaries, belong to the public, but can be privatized. Garret Hardin's (1968) Tragedy of the Commons was written as a warning of the potentially negative outcomes of unregulated public use and self-interest on the future availability of common pool resources. "Almost any regulatory challenge, especially in the environmental arena, involves resources that are in some respect unowned or subject to shared ownership claims" (Buzbee 2003:3). Natural resource governance (Anderson et al. 2004; Bartley et al. 2008; Bodin and Crona 2009; Lockwood et al. 2010; Crona and Hubacek 2010) is then complicated because of the malleable boundaries of public-private ownership of common pool resources. Additionally, natural resource governance is further complicated because it exists at various governance levels including: local, municipal, state, regional, and federal institutions. “In the absence of effective governance institutions at the appropriate scale, natural resources and the environment are in peril” from both increased populations and the increased consumption of resources per-capita (Dietz et al. 2003:1907). Natural resource governance structures can create complexities because of overlapping jurisdictions through both vertical and horizontal scales. Vertical scales refer to the different hierarchical levels of government such as federal, state, municipal, etc. Horizontal scales refer to the different governing institutions across the same level of government, such as multiple state level environmental agencies (Hill et al. 2008). These complexities created within natural resource governance highlight the need for more research on the ways in which common pool resources are governed.

Discussions of resilience and natural resource governance are primarily found in policy and CHANS literatures. These literatures elaborate upon two types of governance, adaptive governance and fragmented governance, which are discussed when connecting the concepts of resilience and governance. Adaptive governance and fragmented governance are two conceptually different ways of implementing resource management strategies. Adaptive natural resource governance policies increase the resilience of a SES (Folke et al. 2005). Fragmented governance, on the other hand, decreases the ability of a SES to respond to disturbances, thereby reducing the resilience of a system. Understanding the ways in which dimensions of SESs, such as governance, enhance the resilience of a SES benefits governments and institutions ability to prepare for unpredictable shocks and disturbances (Berkes and Folke 1998; Gunderson and Holling 2002; Berkes et al. 2003; Dietz et al. 2003) such as increased climate variability as a result of climate change (Folke et al. 2005).

A comprehensive understanding of the ways in which fragmentation can apply to certain governance structures, as well as understanding that some forms of fragmentation are more prevalent than others, enhances our ability to increase the resilience of a governance structure.

Additionally, it is important to explore the potential ways in which fragmented governance can negatively impact the efficient and competent governance of a natural resource. The current natural resource governance literature explains one solution in particular, adaptive governance, for an undesirable level of fragmentation. Adaptive governance allows for flexibility within a governance structure to respond to a changing environment. Examples of flexibility in the literature include a variety of innovative and creative methods for solving a problem, as opposed to a rigid governance structure which may have only one method for problem solving. The following information details some of these current ways in which natural resources are governed ineffectively. It also elaborates on the large body of literature on fragmented governance and the ways in which it negatively impacts the resilience of a SES.

Fragmentation Governance

Natural resource governance is extremely important to the sustained future of natural resources because "the health of natural resource systems is inextricably linked to the health of resource management institutions, whether governmental or local" (Berkes and Folke 1994:8). Therefore, more analysis is needed regarding the resilience of governance structures to examine the ways in which those governance structures are operating. A robust body of literature exists on fragmented governance and the consequences of overly fragmented governance. Different types of fragmentation are identified within this literature, and these directly impact the functioning of a governance structure. Fragmentation has the potential to be both a positive or negative attribute of a governance structure. However, a high degree of fragmentation can lead to overlapping and redundancies, which can create confusion regarding the roles of different governing agencies. Several solutions have been proposed to decrease the amount of fragmentation within different natural resource governance structures in order to increase resilience.

Fragmented governance is "the allocation of responsibility for governance among multiple actors and/or agencies, with relatively little or no coordination" (Hill et al. 2008:316). Fragmented governance structures are common among water regulating agencies. Scholars have found that fragmentation of water governance is a "persistent challenge in solving complex water problems" (Cook 2011: 25). However, water governance is not the only natural resource governance structure that consistently experiences regulatory fragmentation; researchers have found that in all areas of environmental law there is evidence of overlapping and redundancy (Buzbee 2005). Researchers have also discovered that different types of fragmentation exist at different levels of the governance structure. Some different forms of fragmentation are: jurisdictional fragmentation, territorial fragmentation, and biophysical fragmentation (Cook 2011; Bakker and Cook 2011). Territorial fragmentation refers to fragmentation caused by political boundaries, and biophysical fragmentation refers to the fragmentation of watersheds and ecosystems through the creation of states or countries. Jurisdictional fragmentation can be defined as "the fragmentation created by the interaction of political and legal institutions that hold or assign authority to a territory" (Cook 2011:26). As such, jurisdictional fragmentation has a negative impact on natural resource governances because "too many separate actors and actions can become dysfunctional" which leads to inefficiencies or inaction in solving resource issues (Cook 2011: 33). Jurisdictional fragmentation is the type of fragmentation most significantly affecting natural resource governance.

Jurisdictional fragmentation has a potent effect on resource governance. One way to observe jurisdictional fragmentation is to analyze institutional policies such as: "constitutions, statutes, regulations, common law rules, international treaties, and policies" (Cook 2011:28). The outcome of jurisdictional fragmentation is a "governance gap", meaning that there is uncertainty between agencies or actors as to who has jurisdiction over a resource (Cook 2011). The "governance gap" can lead to multiple problems, the first is inaction because "where social ill is juxtaposed against multiple potential regulators all will be tempted to ignore that social ill and free ride on the anticipated actions of others" (Buzbee 2003:21). In addition to agency inaction, another issue that arises is over-action. Over-action occurs when multiple agencies attempt to take control of and address a resource situation without a clear understanding of which agency is actually responsible. Thus, when governance becomes fragmented it ineffectively regulates that which it is trying to govern. Despite being ineffective, it is often not clear that fragmentation is occurring until either it is determined through analysis or it is exposed through a shock or disturbance to the system. This is connected to resilience because vulnerabilities within a system are often not exposed until that system experiences a shock or disturbance and is incapable of responding to or adapting to the shock. As climate variability is likely to worsen in unpredictable ways, it is now more important than ever to analyze natural resource governance structures so that governance structures can become prepared before the system is exposed to a shock or disturbance.

Although the discourse within natural and social sciences overwhelmingly considers the concept of fragmentation as a negative attribute within a governance system, a debate exists about the nature of fragmentation. Scholars argue that fragmentation is neither always a positive attribute nor always a negative attribute (Cook 2011; Biermann et al. 2009). The presence of fragmentation within a governance structure has led to primarily negative outcomes; yet fragmentation can occasionally lead to positive outcomes. The concept of fragmentation is complex and requires more in-depth consideration and analysis rather than either a "simplistic embrace or rejection of regulatory fragmentation" (Buzbee 2005:34). The arguments provided for regulatory fragmentation identify the ways in which regulatory fragmentation is capable of providing "diversity, innovation, and functionality to governance" (Cook 2011:37). Teisman and Edelenbos (2011) acknowledge that a certain amount of fragmentation should be considered necessary in order to govern the many different landscapes and ecosystems present within and across nation states. When dealing with complex natural resource governance problems, the most realistic solutions tend to depend upon breaking down a task and solving problems one at a time. However, an undesirable level of fragmentation can and has become a negative attribute of a governance system.

> "Though there may be advantages to fragmented and concurrent authority, so far such fragmentation has not facilitated either inter-governmental learning or the development of responses to large scale problems. As a result of these shortcomings, natural resource regulators and mangers have been slow to respond to the need for comprehensive adaptation to climate change" (Camacho 2009:10).

As such, issues associated with fragmented governance become issues of the degree to which a governance structure becomes fragmented, rather than simply the presence of fragmentation. Fragmented governance keeps governance structures from having too much centralized power, which is generally seen as a necessary attribute within democracies. However, to much fragmentation within a governance structure creates more problems than it solves. Reducing fragmentation in regulatory agencies reduces the jurisdictional confusion between different governing agencies and governing entities at different scales which increases the resilience of the governance structure (Buzbee 2003). Because scholars have recognized that fragmented governance leads to decreased resilience they have begun to expand upon the ways in which governance structures can bridge fragmentations in order to increase resilience.

Scholars have suggested several solutions to try to solve issues of undesirable levels of fragmented governance. One solution is the centralization of resource management under the federal government, though scholars find that there are many problems with extreme centralization. For instance, a severely fragmented governance structure can produce outcomes as negative as that of severely centralized governance structure (Buzbee 2003). Another solution suggested is the idea of more integration and open communication between the different actors or agencies trying to regulate a resource, “integration becomes attractive as a means to improve efficiency and coordination” (Cook 2011:33). A third solution most commonly referenced and comprehensively agreed upon by scholars in resilience discourse is the concept of adaptive governance strategies. Adaptive governance strategies offer a flexible approach to regulation that can change over time and is informed by experiential learning. Adaptive governance is the most frequently referred to solution because it plans for the uncertainty. Climate change has created the need for adaptive coping strategies for governance. Fragmentation in a system causes an inability to be flexible and adapt to the needs of a system. Fragmented governance reduces the resilience of the governance itself as well as the SES because of its inefficient and inflexible qualities. Therefore, adaptive governance strategies should be applied to regulatory governance structures, which have been analyzed as having reduced resilience.

Adaptive Governance

Adaptive governance is both a solution to issues of fragmented governance and a strategy to help to build resilience in a SES. The conceptual development of adaptive governance can be traced back to the beginning of the resilience discourse in the natural sciences. When the concept of ecological resilience first came into use by scholars, a popular method promulgated as enhancing ecological resilience was the concept of adaptive management (Holling 1978; Gunderson and Light 2006). Adaptive management enhances ecological resilience by considering the complex functioning and feedback loops of ecological systems. The outcome of a change to an ecological system is not always certain because of the complex set of interactions that can be influenced through indirect connections. “Adaptive management acknowledges the deep uncertainties of resource management and attempts to winnow those uncertainties over time by a process of using management actions as experiments to test policies” (Gunderson and Light 2006:324-25). By understanding limitations to future scientific projections regarding ecosystem management, the concept of adaptive management was born. Scholars that initially advocated for adaptive management strategies to build resilience in ecosystems have begun to advocate for adaptive governance strategies in order to build the resilience of SES. Adaptive governance came about as an "emergent framework" through which adaptive management strategies could be implemented (Gunderson and Light 2006:325). Adaptive governance takes into consideration the dynamic ways in which social dimensions of SES have impeded the application of adaptive management strategies (Walters 1986; Gunderson 1990; Lee 1999; Gunderson and Light 2006). Adaptive governance, therefore, addressed the social context through which management strategies needed to change to become effective (Dietz et al. 2003).

> "Although adaptive management focuses on understanding ecosystem dynamics and feeding ecological knowledge into management organizations, adaptive governance conveys multi-objective reality when handling conflicts among diverse stakeholders and at the same time adapts this social problem to resolve issues concerning dynamic ecosystems" (Folke et al. 2005:449).

Adaptive management continues to be an integral part of the implementation of adaptive governance in order to provide strategies for resilient ecosystem management (Folke et al. 2005; Scholz and Stiftel 2005; Brunner et al. 2006; Gunderson and Light 2006). Garmestani and Benson (2013) argue that if institutions cannot work toward resilience through adaptive governance then they should not be considered "appropriate for managing social-ecological systems" (2013:3). The concept of adaptive governance has expanded to the resilience discourse as a solution which increases the resilience of the governance structure and therefore the SES as a whole.

SESs are complex with many feedback loops and scales. It is impossible to know the complete ramifications of every action within the system, as well as predict the consequences of disturbances or shocks to the system. Therefore it has become important to recognize the limitations of adaptive management as a strategy with broader implications for resource management (Camacho 2009:14). Scholars agree that as the impacts of climate change continue to worsen our systems need to be prepared "to absorb and respond to multiple climate change scenarios" (Camacho 2009:14). These climate change scenarios require scholars to look at nonlinear strategies that employ the use of reflexive measures to adapt to a changing environment (Booher and Innes 2010), such as adaptive governance strategies.

Methodological Considerations

In the following sections I provide a literature review of the chosen methods in order to support and fully contextualize the decision to use a mixed methods data analysis approach. Literature on the content analysis methodology will be provided first, followed by literature on the network analysis.

Content Analysis

I chose content analysis to examine Oklahoma's water policies for three primary reasons: a lack of research conducted in this area, and the call for more in-depth analysis of Oklahoma's environmental policies by Jantzen (2001), and the acknowledgement from previous scholars that the analysis of government documents is very important. First, sociology as a discipline has, in the past, "been resistant to works that explicitly treat the natural environment as a realm of sociological focus" (Davidson and Frickel 2004: 484). Thus there is a gap in the literature involving sociological research and natural resources. Second, Jantzen (2001) conducted a brief examination of all state level environmental agencies policies in Oklahoma in 1996. This research provided valuable descriptive information about the agencies regulating environmental policy and stated that "splintering environmental regulatory jurisdiction among numerous state agencies complicates matters for the regulated community and the professionals that render technical and legal advice as to environmental matters" (Jantzen 2001:18). However, Jantzen (2001) offered no empirical evidence to support the assertions about the nature of the relationships between the different agencies or any potential overlapping regulations that exist.

Therefore, I use the qualitative content analysis (QCA) methodology to examine Oklahoma's state level water policies in order to offer a more detailed description of Oklahoma's natural resource governance system. Third, QCA provides great value when analyzing themes and concepts within government documents. QCA involves interpreting themes within the data which provide insight into the underlying in meaning of the data. Environmental regulatory institutions are bureaucratically driven institutions and "if one of the central tasks of members in a bureaucracy is to create documents, it is important to understand what these documents do and how they do it" (Espeland 1993:299). Thus, applying QCA to these policies is useful to understanding the ways in which governance is operated. My research offers empirical data and a critical analysis so that research on the current state of Oklahoma's water policies continues to progress and potential solutions can be identified.

Network Analysis

Recently network analysis research has expanded to include the examination of natural resource governance networks (Bodin and Crona 2009). However, this recent trend in network analysis research has only begun to develop, and a more complete understanding of the relationships that exist and social processes that are impacted by the resilience of governance networks is needed. One primary gap in the literature at the intersection of natural resource governance and network analysis is the lack of research on structural characteristics. According to Bodin and Crona (2009) the structural characteristics of natural resource governance networks have not been "explicitly measured and formally analyzed" (367). In a social network, structural characteristics are important to understand because "social processes which underpin the outcome of resource governance are enhanced or inhibited by different structures" (Bodin and Crona 2009:367). This gap in the literature needs to be further developed theoretically and empirically.

A social network can be defined as “one of many possible sets of social relations of a specific content—for example, communicative, power, effectual, or exchange relations—that link actors within a larger social structure (or network of networks)” (Emirbayer and Goodwin 1994:1417). Social network analysis, or network analysis, is a well-documented research method used by social scientists to determine the impact of “social networks on social processes in general” (Bodin and Crona 2009:367). Network analysis developed as a quantitative methodology used to provide information about structural network relationships. The value of studying social networks is the development of a better understanding of “the structure of relations among actors and the location of individual actors in the network have important behavioral, perceptional, and attitudinal consequences for the system as a whole” (Knoke and Kuklinski 1982:13). Network analysis provides the researcher with explicit means for testing network connections and relationships (Wasserman and Faust 1994). Indeed, “the fundamental difference between a social network explanation and a non-network explanation of a process is the inclusion of concepts and information on relationships among units in the study” (Wasserman and Faust 1994:6).

Oklahoma’s water governance network is analyzed using a two-mode affiliation network analysis. The analysis of “affiliation networks describe collections of actors rather than simply ties between pairs of actors”, which means that affiliation networks consider a wider framework of relationships than other types of network analysis (Wasserman and Faust 1994:291). An affiliation network analysis includes two-modes, the first mode is a group of actors and the second mode is a group of events or event. A mode “refers to a distinct set of entities on which structural variables are measured” (Wasserman and Faust 1994:29). The group of events or event is what ties the different actors together. The actors in the first mode of this two-mode network analysis are the formal institutions which regulate water in Oklahoma at the state level. In network analysis it is important to delineate a boundary which clearly establishes whom the actors are in the network. However, the boundary of governance networks is complicated because it is not always clear which actors should be included (Newig et al. 2010). The second mode consists of the events which are the areas of water policy regulation or policy domains that connect the actors to the network. Both of these modes contribute to the construction of an asymmetrical matrix. The matrix row variables are actors and the column variables are the events, this illustrates how the actors are connected to the events instead of representing how the events are connected to the actors (Carrington et al. 2005). The matrix is important because it provides the information regarding the basic network information, which is then used to measure the structural characteristic of the network. The matrix is asymmetrical because the first mode and the second mode are not identical.

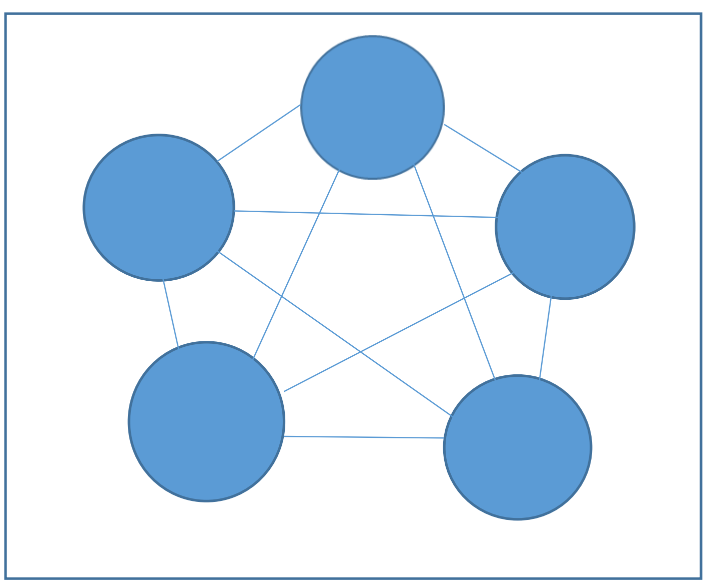
Natural resource management literature has just begun to develop a set of features which can be used to determine if the network is adaptive or non-adaptive (Bodin et al. 2006). Adaptive networks experience enhanced resilience while non-adaptive networks experience reduced resilience. The features which have been identified in adaptive natural resource management networks are applied to my research on natural resource governance networks. Overlap exists between the concepts of natural resource management and natural resource governance (Folke et al. 2003); resource management is the implementation of resource governance (Cook 2011). Therefore the same features needed for successful management also need to be present for successful governance. In order to test for resilience, I draw from work on adaptive features of natural resource management presented by Bodin et al. (2006), because they offer a comprehensive set of features. Using these features not only provides insight into the adaptive nature of governance networks, it also expands the scope of natural resource governance network research.

The features used to determine if Oklahoma's water governance network it is adaptive and resilient are: social memory, learning, trust, adaptive capacity, heterogeneity, and redundancy (Bodin et al. 2006). These features can be determined present within the network through the measurement of four structural characteristics: density, centrality, reachability and betweenness.

The structural characteristics are discussed first in order to give context to the literature on the network features.

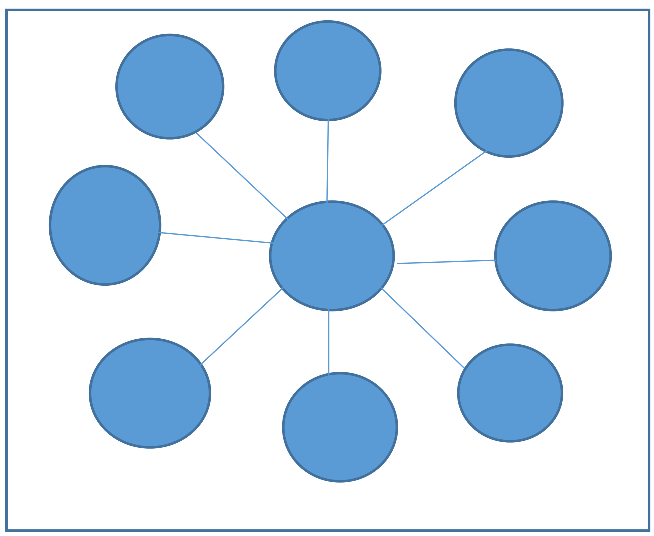
The first structural characteristic of the network is density. Density, or network density, refers to the total number of connections that exist between actors and events in the network, divided by the number of possible connections that could exist between actors and events in the network (Bodin et al. 2006; Newig et al. 2010). These connections or relationships between actors and events are known in network analysis literature as social ties. Social ties can be defined as social relations among the actors (Bodin and Crona 2009). Density can be both a positive and negative attribute within natural resource governance network. Research suggests that high density among actors is essential to collective action (Oh et al. 2004), simultaneously other researchers have found that too many social ties decreases the diversity of information and ideas within a network, decreasing the networks ability to adapt to changing environments (Bodin and Norberg 2005; Bodin and Crona 2009). Density has been connected to a number of features within social network literature and therefore the adaptive nature of a network is not dependent on the amount of density present, but rather it is dependent on the feature that is being analyzed. An image of network density is provided in Figure 1, which represents a network with extremely high density because every social tie that can be connected within the network is connected.

Figure 1.



The second structural characteristic, which is measured to determine the presence of adaptive features in Oklahoma's water governance, is centrality. Centrality can exist in two forms, the first is network structure and the second is a measure of the position of an actor within a network. Centrality of the entire network is determined if the network has a set of well-connected actors. An actor with a high degree of centrality within a network has more social ties then other actors in that same network. Centrality of actors and centrality of the network as a whole can both facilitate resilience of that network or decrease the resilience of that network. The positive or negative effect of centrality on the resilience of a network depends on the context and feature it is being measured for. An image of an actor completely centralized within a network is shown in Figure 2.

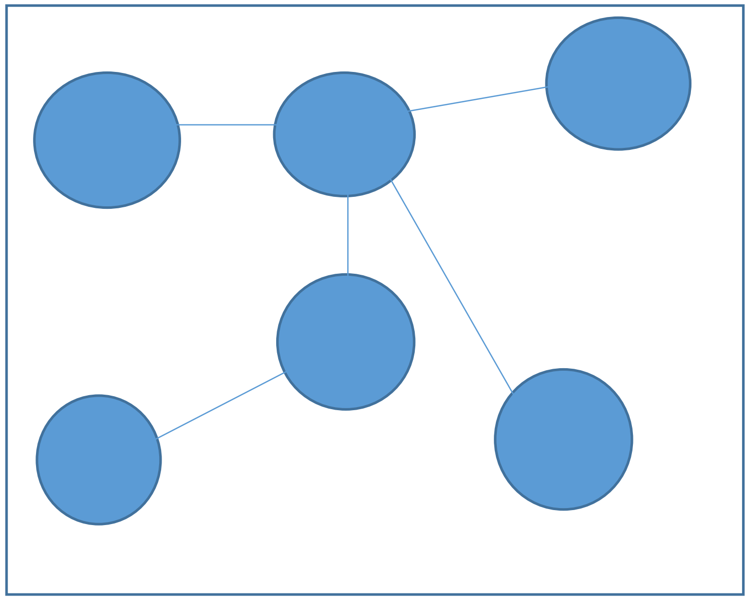
Figure 2.



The third structural characteristic betweenness is used to determine the amount of brokerage actors that exist within a given network. The brokerage actors are actors that form a bridge between two unconnected events or actors (Bodin et al 2006). Actors with betweenness are "in a favored position to the extent that the actor falls on the geodesic paths between other pairs of actors in the network" (Hanneman and Riddle 2005: Chapter 10: Centrality and Power).

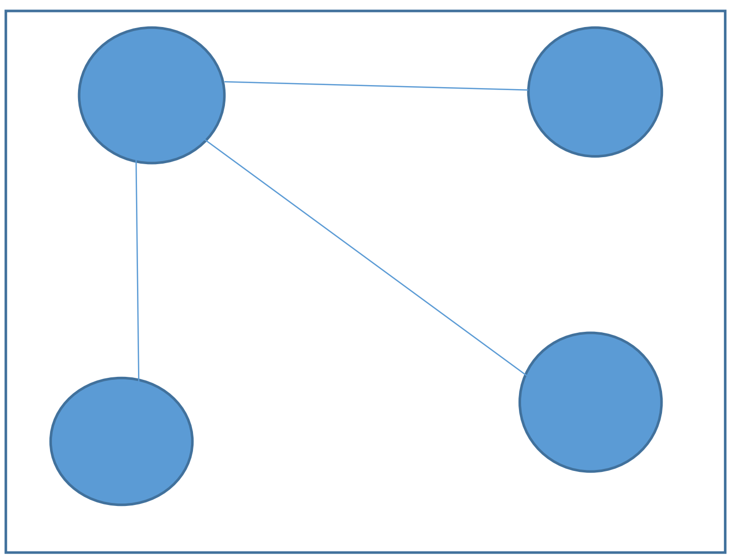
Figure 3 is an example of actors with a high degree of betweenness because the actors are not all connected, some of the unconnected pairs of actors require a brokerage actor to connect them.

Figure 3.



The fourth structural characteristic measured is reachability. Reachability refers to the number of social ties needed to connect any one actor with any other actor in the network. Reachability in a network is important because if there are either actors or events within the network that cannot be reached by other actors then the network could be experiencing division or subgroups. Figure 4 is an example of a high degree of reachability between actors because all of the actors can be reached by a minimum of one or two social ties.

Figure 4.



Features

The first feature needed in an adaptive natural resource governance network is social memory. Social memory is needed in an adaptive network because throughout periods of change, collective memory is relied upon in order to find appropriate solutions to natural resource issues (Folke et al. 2003; Bodin et al. 2006). The presence of social memory in a network can be determined by measuring the structural characteristics reachability and density. A high degree of reachability ensures that many actors in the network can experience social memory and a high degree of density allows for many connections between actors in the network enhancing the potential for social memory to occur. Thus a network that is capable of social memory has a high degree of reachability and a high degree of density (Bodin et al. 2006).

The second feature in an adaptive natural resource governance network is learning. Learning impacts a network because without the ability to learn from previous experiences governments are not able to adapt to changes in the SES (Holling 1978; Bodin et al. 2006; Armitage 2008). Learning has been identified in network literature as essential to the ability of a governance network to address environmental uncertainties (Newig et al 2010). The presence of learning within a network can be determined by measuring the structural characteristics betweenness, centrality, and reachability. A high degree of betweenness is needed to maintain information between actors in the network. A high degree of reachability is needed because the further information can travel the more actors it can reach enhancing collaboration efforts. Finally, a high degree of network centrality is needed because more centralization within the network leads to more cohesive decision-making. Thus a network that is structurally capable of learning has a high degree of betweenness, a high degree of reachability and a high degree of centrality (Bodin et al. 2006).

The third feature in an adaptive natural governance resource network is trust (Armitage 2008). Trust impacts a network by facilitating interactions between resource managers and government actors to solve problems. Trust can be measured in a network through the structural characteristics density and betweenness. A high degree of density enhances trust by creating the potential for collective identity, which enhances connections and supportiveness. A low degree of betweenness is ideal for trust because too much distance between certain actors can foster feelings of uncertainty. Thus a network that is structurally capable of trust has a high degree of density and a low degree of betweenness (Bodin et al. 2006).

The fourth feature of an adaptive natural resource governance network is heterogeneity. Heterogeneity is important to a network because heterogeneity leads to new ideas and innovative problem solving (Bodin et al. 2006). If all of the actors are homogeneous the network may lack new ideas and experience decreased innovation. In other words, if there is not enough diversity among the actors in the network, the network will become stifled and less creative in problem solving. Heterogeneity can be assessed through the measurement of betweenness and density. Some betweenness is required so that the network remains disconnected enough to retain its diversity; however, too much betweenness can create a disconnected network. A high degree of density decreases the heterogeneity because more connected the actors in the network are the less opportunities exist for unconnected actors to contribute new ideas. If all the actors are well connected to the network there will not be a supply of new ideas. Thus a network that is structurally heterogeneous has a moderate degree of betweenness and a low degree of density (Bodin et al. 2006).

The fifth feature in an adaptive natural resource governance network is redundancy. Redundancy is important in a network because it provides the network with the ability to replace any actors that are removed. Redundancy can be tested through the measurement of density and betweenness. A network with a high degree of density is less likely to be impacted if one social tie is broken. If the network is not dense and contains a high degree of betweenness then the removal of one actor could matter a great deal. A high degree of betweenness "of a single actors make the network more vulnerable to fragmentation" in the event that an actor that connects other unconnected actors to the network is removed from the network (Bodin et al. 2006:3). Thus a network that is structurally redundant has a low betweenness of actors and a high degree of density (Bodin et al. 2006).

The sixth feature in an adaptive natural resource governance network is adaptive capacity. Adaptive capacity can be defined as the ability of a network to respond to change and uncertainty (Bodin et al. 2006). The adaptive capacity of the network can be determined by measuring reachability, centrality, and density. A high degree of density limits the ability of actors to innovate or change. A high degree of structural centrality is important because more centrality means that the network can coordinate responses to disturbances. A high degree of reachability is required in order facilitate collective action. Thus a network that experiences adaptive capacity has a low degree of density, a high degree of centrality, and a high degree of reachability (Bodin et al. 2006). These six features can help to identify if and how a network is structurally adaptive and capable of enhanced resilience or non-adaptive and experiences reduced resilience.

Network analysis is important in studying natural resource governance because it identifies the "knowledge transfer, information sharing, consensus building, and power relations" present within a governance structure (Bodin and Crona 2009:367). Structural characteristics can then be measured to determine whether the adaptive features that impact natural resource governance are present and, if present to what degree they are present. Though the application of network analysis to natural resource governance is just beginning to develop (Bodin and Crona 2009), scholars have made a conceptual connection between natural resource governance networks and resilience. Newig et al. (2010) make this connection through the development of the concept of network resilience. Network resilience is "the capacity of a network to remain intact in its basic functions when subject to pressure or sudden change" (Newig et al. 2010:6). Currently, research has yet to transition from the conceptual development of resilience within governance networks to empirically test network resilience. Therefore the contribution of my research is not only to further understand the resilience of Oklahoma's natural resource governance but also the expansion of measurements used empirically test the resilience of governance within a SES.

The literature on environmental policies in Oklahoma calls for more in-depth examinations of the ways in which different agencies regulate resources through policies. The content analysis fills this gap in the literature and provides the ground-work for the development of the network analysis. The network analysis provides empirical testing of structural characteristics within the governance network, which also fills a gap in the network analysis literature. Ultimately, these methods help to advance research on resilience and water governance in Oklahoma. In the next section I elaborate upon the methodological procedure that is utilized in the mixed method data analysis.

CHAPTER III

METHODOLOGY: MIXED METHODS

The purpose of this research is to determine if and how Oklahoma experiences features of resilience within its water governance. In order to empirically test the research questions, a mixed methods research design was used to provide an opportunity for the analysis of both water regulations and regulating agency's networks. The analysis of Oklahoma's water governance was conducted using a content analysis of Oklahoma's water policies and a network analysis of Oklahoma's water governance network. By combining these methods I was able to determine the extent to which Oklahoma's water governance experiences enhanced or reduced resilience.

The mixed methods research design facilitates the development of "a synergistic research approach in which one methods enables the other to be more effective" (Hesse-Biber and Levy 2011: 279). Mixed methods allow for the expansion of understanding about the regulations and the regulating agency's interactions. These two distinct methodologies build off of one another and offer different insights into the same dataset. In addition, the combination of methods offers this research a comprehensive understanding of two different aspects of governance, which could not be attained by utilizing just one of these research methods (Hesse-Biber and Levy 2011).

Both of these methodologies make various contributions to this research. The content analysis serves two purposes, the first is to provide explanatory information on the ways in which agencies are attempting to regulate water resources. This explanatory information was analyzed to determine if agencies have policies which create jurisdictional overlap and fragmentation, impacting the resilience of Oklahoma's natural resource governance. The second purpose for the content analysis was to identify potential policy domains for the network analysis. This identification focused on finding common areas of water regulation.

The network analysis builds on the content analysis and provides a different perspective of the same data. The network analysis evaluates features of adaptive governance by measuring four structural characteristics in the network. Policies drive the work of the different agencies and therefore to understand the network interactions one must first understand the policy interactions. However, understanding the overlapping themes within the regulations does not explicitly explain relationships between the agencies interacting. Thus the network analysis provides a visualization of relationships that exist and enhance the understanding of relational ties between agencies and policy areas. Ultimately, these two methods contribute to furthering our understanding of resource policies and networks between regulating agencies.

Neither the content analysis nor the network analysis require any ethical considerations. All of the data gathered for this research is publicly available on the Oklahoma Secretary of State website <http://www.oar.state.ok.us/oar/code>.

Content Analysis

Oklahoma's environmental policies are "down right confusing" and require more analysis to understand the gaps and potential challenges which exist within them (Jantzen 2001:9). Oklahoma's water policies were chosen for analysis because environmental policies refer to a broad set of regulations and a focus on water reduced the quantity of regulations analyzed. Also, the outcome of the data analysis provided information about the current state of Oklahoma's water governance and insights into Oklahoma's natural resource governance. I analyzed Oklahoma's state level water policies through the use of content analysis to determine if the regulations are indicative of a fragmented governance structure. Analysis of Oklahoma's environmental governance structure helped to determine the resilience of Oklahoma's natural resource governance.

The initial stage of my research design employs QCA. The unit of analysis is a single water policy. A water policy is defined as any regulation, statue, law, or ordinance which controls the way Oklahoman's use water, the amount of water Oklahoma's use, right to water, the quality of bodies of water in Oklahoma, and the management of pollution entering or impacting bodies of water. An example of an Oklahoma water policy is:

> 630:10-1-6. Suspend or revoke license
>
> (a) The OSRC retains the right to suspend or revoke the licenses of any commercial float operation after the OSRC makes a finding that:
>
> (1) The operation has engaged in a pattern of willful violation of OSRC rules and regulations;
>
> (2) The ecosystem of the river section within which the particular flotation device is authorized to float is, or is in danger of being, harmed by the number of flotation devices authorized and it is necessary for the protection of that section of the river to revoke a certain number of licenses;
>
> (3) The health and safety of individuals floating on the river is threatened by the number of flotation devices currently licensed to float on a particular section of the river; or
>
> (4) The commercial operator has failed to comply with licensing requirements of 630:10-1-5.
>
> (b) Except in case of emergency as provided in the Oklahoma Administrative Procedures Act, the OSRC may make such a finding only after the commercial float operation has been given notice and the opportunity for a hearing.
>
> [Source: Amended at 25 Ok Reg 2009, eff 7-1-08]

My dataset consists of Oklahoma's most recent edition of The Oklahoma Administrative Code (OAC), which is published every five years. The OAC contains all of the state level environmental regulations, statues, laws and ordinances in the state of Oklahoma. The data was collected from the Oklahoma Secretary of State online edition of the OAC. The online edition of the OAC is updated every year to include supplemental changes, which occur during the five-year full edition publications. The data I am using comes from the 2011 publication and online supplemental changes from 2012, 2013, and 2014. This is the most up to date information available on water policies in Oklahoma, which allows for the examination of the current state of Oklahoma's water governance.

Analysis of this dataset of Oklahoma's water policies is useful for two reasons. First, Oklahoma has a complex history with water; the added complication of climate change increases the usefulness of the analysis of this dataset. The second reason is to increase the amount and depth of empirical sociological research on environmental governance.

The coding strategy used to analyze Oklahoma's state level water policies is open thematic coding. Coding can be defined as a "conceptual process", which enables the researcher to develop codes for different concepts found in the data (Schreier 2012:37). The coding has two distinct purposes. The first purpose is to identify conceptual themes, which either represent fragmentation or lack thereof in the data. The second purpose for coding is to identify the areas in which water is regulated in order to develop the policy areas or policy domains for the network analysis. The coding for both of the two separate purposes was conducted in unison.

In order to begin coding, I uploaded word documents containing the water policies from the OAC website into the qualitative data analysis software (QDAS) program NVivo 9 (QSR International Pty Ltd. 2012). The state level water policies in Oklahoma span a variety of agencies, including: Oklahoma Water Resources Board (ORWB), Department of Environmental

Quality (DEQ), Oklahoma Department of Agriculture, Food and Forestry (ODAFF), Oklahoma Scenic Rivers Commission (OSRC), Corporation Commission (CC), Oklahoma Conservation Commission (OCC), Department of Wildlife Conservation (DWC), Department of Mines (DM), and Grand River Dam Authority (GRDA). Once the data was uploaded into NVivo 9, the data was coded using a single policy as the unit of analysis; however, some policies contained two or more codes within the same policy (QSR International Pty Ltd. 2012). In this case, the separate instances of the codes were isolated into different coding categories. Once the coding categories began to emerge, I separated the codes based upon the two different coding objectives. The codes created for the network analysis, which included potential policy domains, were set aside until after the QCA could be conducted to determine if fragmentation existed in the water policies. The codes which supported the QCA were then organized and analyzed to determine whether any potential patterns and themes within the data portrayed fragmentation within the water policies. After the theme *overlap* was identified and coded, all of the *overlap* codes were combined and analyzed in order to determine if underlying subthemes existed within the data. The analysis led to the development of the primary theme *overlap*, which was then further analyzed and broken down into several subthemes.

The strengths of using NVivo 9 are the ability reduce the amount of time "used to simply 'manage' data and allow an increased focus on ways of examining the meaning of what is recorded" (Bazeley and Jackson 2013:2). QADS also reduces human error during the process of analysis. Potential weaknesses exist when working with computer software programs instead of coding by hand. The weaknesses of working with computer software for qualitative analysis have been highlighted by scholars for a variety of reasons (Richards 1988; Gilbert 2002; Johnston 2006). Some scholars claim that the software distances the reader from the data. Other scholars have claimed that the use of software can create a 'coding trap' whereby readers overanalyze minute nuances in the data, essentially losing the original purpose of the research (Gilbert 2002;

Johnston 2006). Both of the critiques are valid concerns; however, researchers are responsible for operating the software. In order to address these weaknesses I was reflexive in considering these critiques throughout the process of data analysis.

I ensure reliability and validity of this research in the following ways. Reliability in content analysis can be established through the use of inter-coder reliability. I do not have another researcher code all of my data; however, I had another coder code a sample of my data to ensure the concepts and themes I am drawing from the data are present and can be replicated. The rate of inter-coder reliability for the sample was 90%. Validity is established by the authority of the source of the data that is analyzed, in this case the data comes from the state of Oklahoma's state level policies on the state's official OAC webpage. Generalizability is established to the extent that every state in the United States has state level water regulations. The results of the analysis of Oklahoma's water laws can be generalized to help other states assess their potential degree of jurisdictional fragmentation and structural autonomy within state level environmental governance institutions.

This data analysis provides informative results about the structure of water regulations in Oklahoma and represents an important step toward better understand the specified resilience of governance within SES's. The focus on the state level regulations of one specific resource yields deeper insights into the ways in which natural resources are governed at the state level in the United States. The content analysis establishes themes as well as areas of overlap within Oklahoma's water policies.

Network Analysis

In this section I discuss the methods used to conduct the network analysis of Oklahoma's water governance network. First I discuss the results of the content analysis which defined the policy areas that are used as events within the network analysis. Then I discuss how a two-mode assimilation network is created. Next, the six features of adaptive resource management networks are used to develop six hypotheses that help us to evaluate the adaptive nature of Oklahoma's water governance network. I also explain how these features can be identified through the measurement of four structural characteristics of networks. Finally, I address the validity, reliability, generalizability, and ethical considerations of this research design.

I used network analysis because previous research, current methodological trends, and gaps in the literature suggest that this research adds value to the discourse of resilience, natural resource governance, and network analysis. Coding for different areas of water policy led to the development of many policy areas or policy domains. These policy domains were then analyzed and sixteen were selected to represent Oklahoma's water governance network. Policy domains chosen to represent Oklahoma's water governance network were identified because of their clear ability to be defined and categorized. Other categories such as pollution prevention were not as easily defined or distinguished because they could have many meanings. Pollution prevention could mean pollution control or pollution management, and thus areas which were not easy to define were not chosen for the network. The final categories were: dams (*1), reservoirs (*2), fire protection (*3), fish and wildlife (*4), mining (*5), oil and gas (*6), hydroelectric power (*7), scenic rivers (*8), wastewater (*9), water rights (*10), ground water (*11), well water (*12), surface water (*13), storm water (*14), stream water (*15), and lakes (*16).

The categories were defined and coded for based on references to the category's title. An example is every time the word "dam" was used in a policy, that policy was coded as dam. After the initial coding, the codes were analyzed in NVivo to make certain the policies actually related to the policy domain that each policy was coded for. Table 1 is the water governance network matrix with the water agencies as actors and the policy domains as events.

The two-mode affiliation network matrix in Table 1 was analyzed using the program Ucinet 6 (Borgatti et al. 2002). As mentioned in the literature review, the data entered into the matrix consists of row variables and column variables. The row variables are the nine agencies in Oklahoma that regulate water. The column variables are the sixteen policy domains determined by the content analysis. In the software program Ucinet 6, an excel file is created and the matrix information is filled in with either 0's or 1's. Each box within the matrix has either a "1" in it if the row variable is connected with the column variable area of regulation, or the box has a "0" if the agency is not affiliated with that area of regulation. Ucinet 6 software program analyzes the affiliation matrix and offers a quantitative analysis of the data, which varies depending on the structural characteristic that needs to be measured (Borgatti et al. 2002). Quantitative output is then analyzed for each of the structural characteristics to determine their values in the network and determine what adaptive features are present in the network.

In addition to using the program Ucinet 6 to measure the four structural characteristics, (density, centrality, reachability, and betweenness) I produced a sociogram using the NetDraw link within Ucinet 6. However, NetDraw is a separate software package that comes with Ucinet 6 (Borgatti 2002). The sociogram illustrates the network ties between the actors and events (Borgatti et al. 2002). A sociogram can be defined as "a picture in which people (or more generally, any social units) are represented as points in two-dimensional space, and relationships among pairs are represented by lines linking the corresponding points" (Wasserman and Faust 1994:12). The resulting image represents the connections and potential overlaps between the different institutions through the management of the resource water. This type of sociogram is called a bipartite graph, which incorporates the relationships between both the events and the actors.

In the methodological considerations section, I provide literature supporting the use of the six features: adaptive capacity, heterogeneity, redundancy, social memory, learning, and trust, in order to determine the degree to which a governance network is adaptive. The adaptive nature of the network directly impacts the resilience of Oklahoma's SES. These features have informed the development of six hypotheses in order to empirically test the resilience of Oklahoma's water governance network:

Hypotheses

Hypothesis 1: Oklahoma's water governance network experiences a low degree of adaptive capacity

Hypothesis 2: Oklahoma's water governance network experiences a low degree of heterogeneity

Hypothesis 3: Oklahoma's water governance network experiences a low degree of redundancy.

Hypothesis 4: Oklahoma's water governance network experiences a low degree of social memory

Hypothesis 5: Oklahoma's water governance network experiences a low degree of learning

Hypothesis 6: Oklahoma's water governance network experiences a low degree of trust

In order to determine if these features are present within Oklahoma's water governance network, I measure the structural characteristics: density, reachability, betweenness, and centrality. These four measurements are needed to determine if the hypotheses are true in Oklahoma's water governance network. These hypotheses are then used to determine the adaptive nature and amount of resilience experienced within Oklahoma's water governance.

Density

Network density was determined through the 'Overall Density' measure (Borgatti et al. 2002). The Overall Density is used in order to examine the density of the network as a whole. This measure provides three results: the network density, number of ties within the network, and the average degree. Network density provides a percentage, which is calculated using the number of ties in the network divided by the number of possible ties in the network. The number of ties in the network is the number of total connections between the actors and the events. The average degree is the average number of ties per actor in the network.

Centrality

The centrality of the network is measured using the 'Centrality' feature (Borgatti et al. 2002). Oklahoma's water governance network is a two-mode affiliation network, thus the results of the centrality measurements are displayed in two separate tables of results. The one of the tables is for the centrality of row variables and one of the tables is for the centrality of column variables (Borgatti and Everett 1997). Within each of the tables five different types of centrality results are displayed. Degree centrality for an actor is the number of events they are tied too divided by the number of events total (Carrington et al. 2005). The degree centrality results are most simple assessment of the network's centrality, those results will be interpreted in the results section.

Betweenness

Several features exist within Ucinet 6 to measure betweenness, the best measure for betweenness for Oklahoma's water network can be assessed using the features 'Freeman Betweenness' and 'Nodes' (Borgatti et al. 2002). Unlike the measurements for centrality and density the measurement for betweenness requires a square or symmetrical matrix. Oklahoma's water governance matrix is a two-mode affiliation matrix and is not symmetrical. Therefore, the two-mode affiliation network must be transformed into a one-mode affiliation network. This means that the matrix will be actors by actors, instead of actors by events. The data can be transformed in Ucinet 6 using the features Data> Affiliation (2-mode to 1-mode) (Borgatti et al. 2002). Once the data is transformed the results are provided in a column that shows the various actors and their respective betweenness scores. The results represent the number of times each actor connects two otherwise unconnected actors.

Reachability

The fourth structural characteristic measured is reachability. Reachability refers to the number of social ties needed to connect any actor with any other actor in the network. In order to measure reachability, the two-mode network must be turned into a one-more network through the same process used for the betweenness measurement. Once this is complete network reachability can be measured using the 'Reachability' feature (Borgatti et al. 2002). The reachability results are provided in a table that features actors by actors and distinguishes how many connections are needed to reach any other actor in the network. While reachability is calculated for each of the actors in the network it is not additive, but rather a characteristic of a whole network. Figure 4 is an example of a high degree of reachability between actors because all of the actors can be reached by one or two social ties. These four structural characteristics are measured to determine if and how Oklahoma experiences an adaptive water governance network.

The density, centrality, reachability, and betweenness of the network and actors within the network are used to test the six hypotheses. The empirical assessment of these structural characteristics allows for conclusions to be drawn about the degree of adaptive governance that can be found in Oklahoma's state level water governance network. This is not to say that these are the only measures that can be used to measure for adaptive networks, just that they are measures supported by the literature (Bodin et al. 2006).

The network analysis is reliable because quantitative methods are, in general, easily replicated assuming the same dataset and software are used and the measures are carefully described and documented. Validity is ensured by making sure the research appropriately answers the research questions. The network analysis data is informed by particulars of the content analysis data, because of this generalizability is sacrificed in order to better understand the nuances of this particular network. The lack of generalization does not decrease the value of this research because it still contributes the expansion of the concept of resilience and to the methods used to empirically test it. This research is necessary in order to better understand the specified resilience of water governance within Oklahoma's SES. The focus on the formal state level regulations of one specific resource yields deeper insight into the ways in which natural resources are governed at the state level in the United States.

CHAPTER IV

RESULTS AND DISCUSSION

This section provides a discussion of the QCA as well as the social network analysis results. The results of the QCA are discussed first because the network analysis was conduct using the results of the QCA. The content analysis produced both the policy domains and the water regulatory agencies needed for the network analysis and the key theme *overlap,* which represents the nuances of policy fragmentation in the data. The theme *overlap* was then analyzed and organized into five subthemes: *federal overlap, state overlap, local overlap, multi-scale overlap, and miscellaneous (misc.) overlap*. The five subthemes are outlined with examples, followed by a discussion of the larger implications of fragmentation on the resilience of Oklahoma's water governance. After the discussion of the content analysis, the social network analysis is addressed. First an overview of the network analysis is provided using the content analysis results for the policy domains and the water regulating agencies. Next, the four structural characteristics identified in the methods section are measured and used to test the six hypotheses. The hypotheses help determine what features of an adaptive governance structure are present in Oklahoma's water governance network. The adaptive nature of Oklahoma's water governance network and the fragmented nature of Oklahoma's water governance policies help determine if and how Oklahoma experiences SES resilience in its natural resource governance. Ultimately, this section will conclude with implications of Oklahoma's current SES resilience and directions for future research.

Content Analysis

This section addresses the results of the QCA and the implications for the specified resilience of Oklahoma's state level water governance. One theme in particular, coded as *overlap*, developed from the data analysis, which illustrates the presence of fragmentation within Oklahoma's water policies. The theme *overlap* can be defined as the reference to other water policies or other regulating agencies within a given water policy. The theme *overlap* was determined to represent a feature of fragmentation within the water policies not only because of the amount of overlap present, but the variety of ways in which overlap occurs in the water policies. Literature on fragmented governance supports this finding and notes that overlapping jurisdictions in natural resource governance can directly lead to regulatory inaction and the abdication of responsibility by regulating agencies. Therefore the following analysis of the theme *overlap* represents the nuances of fragmentation supported by the literature within Oklahoma's state level water governance policies.

The subthemes that emerged were then categorized based upon the scale of governance where the overlap occurred. The subthemes identified are: *federal overlap*, *state overlap*, *local overlap*, and *multi-scale overlap*. A *misc. overlap* subtheme was also included in order to organize codes that could not be categorized into the other four subthemes and were not prominent enough in the data to merit an individual categorization. All of the subthemes are indicators of fragmentation. Fragmentation is the overlapping of regulatory jurisdiction between two or more regulatory agencies. *Federal overlap* is the overlapping of a federal policy or department within the state policy. This means the federal policy or federal agency is referenced within the state water policy. *State overlap* is the overlap of other water regulating agencies within a water policy. An example would be if the Department of Environmental Quality had a policy that required the approval of another water regulating agency such as the Oklahoma Scenic Rivers Commission. *Local overlap* is the overlapping of state level policies with local standards or policies. An example of this would be if local standards are referenced within a state level water policy. The subtheme *multi-scale overlap* is the overlapping of more than one scale of governance, such as a reference to 'compliance with all state and federal policies' in the state water policy. The subtheme *multi-scale overlap* is simultaneously the most encompassing and frequently found form of overlap contributing to fragmentation within the policies. The subtheme *misc. overlap* encompasses forms of overlap from regional water compacts to references of state level agencies that do not regulate water. *Misc. overlap* happens infrequently does not contribute to a problematic amount of fragmentation. Policies coded as *misc. overlap* act as outliers that fit the definition of the theme *overlap* without belonging to any of the subthemes. These five subthemes represent the nuances of overlap within Oklahoma's water policies, and help to establish how fragmentation is present in Oklahoma's water governance. The next section expands upon and provides examples of the five subthemes; followed by a discussion of the implications of the content analysis results on the resilience of Oklahoma's water governance.

Subtheme: Federal Overlap

The subtheme, *federal overlap* is coded as any reference to federal policies or federal institutions within a state water policy. Federal overlap was consistently found throughout the data and determined to cause a large amount of fragmentation within Oklahoma's water policies. Based on previous literature, *federal overlap* was an unexpected subtheme discovered in the process of the content analysis. Jantzen (2001) completed an assessment of Oklahoma's state level environmental policies and discovered that the many agencies that oversee those policies experienced overlap. However, this previous assessment was brief and didn't identify any other types of overlap which may be impacting the functioning of Oklahoma's natural resource governance. Therefore, the identification of *federal overlap* as a type of fragmentation contributing to the reduced resilience of Oklahoma's SES resilience is a new contribution to the literature.

Federal overlap is causing fragmentation in a few different ways. One of the simplest ways in which federal policies are overlapping is through citations of a federal law or institution within a water policy. An example of this is the Department of Environmental Quality policy 252:616-11-1, which protects "**threatened or endangered species listed under Section 4, of the Federal Endangered Species Act, 16 U.S.C. 1533(c), or the critical habitat of such species**". A state level policy that references a federal policy creates confusion because if the Endangered Species Act is violated, the jurisdiction between the state and the federal government is unclear. The party responsible for taking action, the state government or the federal government, is questionable because both scales of governance are named as responsible parties to govern the same violation. This is an example of how a simple redundancy of federal laws referenced within state level laws contributes to the fragmentation of environmental policies.

Another more complex way in which overlapping policies create uncertainty about the institution responsible for policy implementation can be observed in the Corporation Commission policy 165:10-7-18, which states: "**Discharge of deleterious substances to streams or other surface waters is prohibited except by order of the Commission; unless permitted by a valid National Pollutant Discharge Elimination System (NPDES) Permit issued by U.S. EPA**". This example gives authority to both the EPA and the Corporation Commission, specifically the use of the word 'unless' distracts from the overall clarity of the policy. When responsibilities are split by two different institutions, the result could be both of the institutions claiming responsibility or neither claiming jurisdiction. Lack of action and the over action are documented potential outcomes of fragmented governance (Buzbee 2003; Buzbee 2005).

The subtheme federal overlap also occurs in the Oklahoma Department of Agriculture, Food and Forestry policy 35:17-3-5, which states:

"In addition to concentrated swine feeding operations, any person who has filed a Notice of Intent (NOI) to be covered under the National Pollution Discharge Elimination Systems (NPDES) General Permit on Concentrated Animal Feeding Operations issued by the Environmental Protection Agency (EPA) on February 8, 1993 or its replacement or possessing an NPDES Permit for a swine feeding operation shall be required to obtain an Oklahoma swine feeding operation license. **Any swine feeding operation may be required to obtain an Oklahoma swine feeding operation license if it is specifically identified as a significant contributor of pollution by either the Director of EPA Region 6 or the State Board of Agriculture**".

This policy gives authority to both the EPA and Oklahoma's State Board of Agriculture. Specifically the use of the word 'or' within the policy opens up jurisdiction to multiple institutions. A federal regulating institution and a state regulating institution are attempting to jointly regulate an aspect of the environment. This is just another example of federal overlap contributing to fragmentation.

The Department of Environmental Quality exhibits another example of federal overlap through policy 252:652-1-3, which states:

"**If there are inconsistencies or duplications in the requirements of those provisions incorporated by reference and the rules in this Chapter, the federal provisions shall prevail, except where the rules in this Chapter are more stringent**. However, the rules in this Chapter shall not relieve any person from complying with the minimum requirements".

In this policy, both the federal government and the state government are given a certain amount of jurisdiction; this causes overlap and fragmentation. This is perhaps the least confusing because it allows for the most stringent policy to take precedence; however, both scales of government are balancing authority of the same policy, which leads to fragmentation. The key word within this example that complicates the overlapping is "except" which establishes dual control over the same policy area between the state water governance and the federal water governance.

Another example of the subtheme *federal overlap* occurs when the policy references a federal policy/agency and in doing so leaves the policy open to interpretation. By leaving policies open to interpretation, multiple parties are given potential control, which creates fragmentation through ambiguous language. An example occurs in the Oklahoma Department of Agriculture, Food and Forestry policy 35:44-3-5, which states:

"**Effluent limitation guidelines for industry categories and pollutants are promulgated by the EPA pursuant to the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 and Water Quality Act of 1987**. EPA guidelines are adopted and incorporated by reference in OAC 35:44-1-2**. If there are no industry category or pollutant guidelines applicable to the applicant's industry, Best Professional Judgment of the permit writer applies**".

This policy referencing both the Federal Water Pollution Control Act and the Oklahoma Department of Agriculture, Food and Forestry, still manages to state that there can be instances when no agency has jurisdiction and the individual should apply the 'best professional judgment'.

The subtheme of *federal overlap* can be seen clearly throughout the data. This form of overlap can manifest in slightly different ways but the outcome is the same, fragmented governance. Federal overlap was prominent throughout the policies and indicates that vertical fragmentation is happening across different scales of governance. This subtheme indicates that fragmented governance is impacting Oklahoma's natural resource governance through reduced resilience towards future shock and disturbances. Ultimately, more research is needed to identify how state governments should address federal overlap so that they might increase resilience and decrease the vertical fragmentation within the natural resource policies.

Subtheme: State Overlap

The *state overlap* subtheme is coded as any reference to state level water agencies or policies within a state level water policy. *State overlap* refers to the overlapping of jurisdictions by two or more state level water regulating agencies/policies. This type of overlap was an expected outcome of the data analysis for two reasons. The first is because of the study conducted by Jantzen (2001) which describes Oklahoma's state level water policies as splintered and confusing due to the vast number of agencies attempting to manage the same resources. *State overlap* is found frequently throughout the data and causes fragmentation horizontally across Oklahoma's state level water governance. The second reason *state overlap* was an expected finding is the data being analyzed consisted of only state level water data. If any overlap could be expected it would most likely be found between the agencies at the same scale regulating the same common pool resource.

Thus, an example of *state overlap* that contributes to fragmentation is the Oklahoma Conservation Commission policy 155:25-1-2 on project funding for nonpoint source management programs, which states:

"(a) **Applications and requests for funding for projects for nonpoint source management programs shall be filed with the Oklahoma Water Resources Board (OWRB)**. **If the application meets the preliminary determination of eligibility the OWRB will forward the application to the OCC. (b) The OCC'S Water Quality Division (OCCWQ) will review the application or request and determine whether the project meets or will meet a critical local or state need**…(c) The Commission shall consult with and obtain comments of the Executive Director of the Department of Environmental Quality prior to making a recommendation on all applications and programs that may involve nonpoint sources subject to the jurisdiction of the Department of Environmental Quality. **The Department of Environmental Quality's comments shall be addressed in the recommendation or attached thereto**.(d) Upon a determination that the proposed project meets the minimum criteria set forth in (b) above, **the proposed project shall be placed on the Commission's list of approved projects. Said list, and the application or request will be submitted to the OWRB with a recommendation that a loan(s) be made for the project(s)**. (e) OCC will make its determination with respect to whether a proposed project meets the minimum criteria set forth in (b) above and, if deciding to place the proposed project on the Commission's list of approved projects, will submit the list, the application or request and recommendation to the OWRB within thirty (30) days of receipt of the application or request from OWRB as set forth in (a) above. If recommending that a loan be denied for the proposed project, OCC will submit the application or request and recommendation to the OWRB within thirty (30) days of receipt of the application or request from OWRB as set forth in (a) above".

This policy states that a project should be filed at the ORWB. If the application meets certain requirements, it will be sent to the Oklahoma Conservation Commission, which will then review the application. Then the Oklahoma Conservation Commission has to get comments from the executive director of the Department of Environmental Quality. Once the comments are integrated, the application can be placed on the Oklahoma Conservation Commission's list of approved projects and submitted to the Oklahoma Water Resources Board with a recommendation for the loan for the project. This means that in order for one project to be accepted or denied it must be funneled through three different water regulating agencies. In effect, three agencies share responsibility, making it unclear how a conflict would be managed between the agencies. This creates fragmentation at the state level because of the confusing and convoluted process the document has to meander through. If one agency could manage the process of the document then the policy would exhibit clearer lines of authority.

Additionally, *state overlap* is found in policies that state that individuals must follow the requirements of a different state level agency to regulate a policy found within the first agency. An example of this can be found in the Department of Environmental Quality policy 252:515-7-3, which states: "**All monitoring wells, borings, and/or piezometers shall be constructed and/or plugged in accordance with the applicable requirements of the Oklahoma Water Resources Board at OAC 785:35**". This policy is found in the Department of Environmental Quality's water policies; however, it clearly is regulating an area that is already regulated by the Oklahoma Water Resources Board. Otherwise the Oklahoma Water Resources Board would not have the necessary requirements in its policies to merit this overlap. Thus, this form of overlap is creating the types of redundancy similar to the *federal overlap* examples. Because the two different agencies are regulating the same area, any conflict that arises has the potential to create a situation where both of the agencies act or neither of the agencies act.

Moreover, another form of *state overlap* can be found in the Department of Environmental Quality policy 252:631-3-23 which states: "**Regulating the removal of brush and trees to the high water elevation, regulating the protection from floods during construction within the control district, and regulating the plugging of wells which are inundated, in accordance with OWRB requirements**". This policy constitutes an overlap because the Oklahoma Water Resources Board already has policies for certain situations and the Department of Environmental Quality is repeating those requirements by stating all of the circumstances in which those policies have to follow. It is unclear which agencies would be responsible in the event of a conflict.

Another example of *state overlap* can be found in the Department of Environmental Quality's policy 252:652-1-2, which states:

"Any person who owns or operates or proposes to own or operate any underground injection well facility, except those wells subject to the jurisdiction of the Oklahoma Corporation Commission, shall be subject to the rules in this Chapter"

This policy reveals the overly complicated methods for regulating injection wells because the responsibility is shared by both the Oklahoma Conservation Commission and the Department of Environmental Quality. The sharing of the responsibility leads to overlap because the multiple agency approach to managing the same area of resource policy contributes to fragmentation.

The *state overlap* subtheme occurs most frequently between the ORWB and the DEQ. These two water regulating agencies have the most water policies as well as the most connections within Oklahoma's water governance network (as we will see later in this chapter). Though this subtheme was an expected finding, *state overlap* was present in the data more than originally anticipated. The fragmentation caused by overlapping in these policies is creating jurisdictional confusion and will disrupt the response of an agency to a problem due to the overlapping authority over the policies. *State overlap* is clearly impacting the SES resilience of Oklahoma's natural resource governance. *State overlap* is one area of vulnerability that needs to be addressed in order to increase resilient governance in Oklahoma.

Subtheme: Local Overlap

The *local overlap* subtheme occurs when there is a reference to local level policies within state water policies. The referencing of the local level policies causes fragmentation through the confusion of jurisdiction between the state and local level. While *local overlap* can be found frequently in the data, it was not an expected finding. Earlier when describing *federal overlap* it was noted that fragmentation was not just a phenomenon limited to the level of the policies being examined. The subtheme of *local overlap* supports this claim further. The overlapping with federal and local policies illustrates that vertical integration of overlap exists consistently across every scale of governance, local, state, and federal.

An example of *local overlap* can be found in the Oklahoma Scenic Rivers Commission policy 630:1-1-6, which states:

"The OSRC is authorized to prepare and establish minimum standards or the planning and other ordinances and rules of local government agencies whose political boundaries cross scenic rivers or lands adjacent and contiguous to scenic rivers. See, 82 O.S. § 1461, paragraph G. (1) Before taking comment on, adopting or recommending any local government planning standard, the OSRC shall give notice of the proposed action to the public and to each local government agency that may be affected by such standard, and shall generally follow the procedures for rulemaking hearings (OAC 630-1-1-5) insofar as they may be applicable. (2) **Minim-um local government standards, while not rules of the Commission, may be adopted by the Commission and may be treated procedurally as if they were rules and subject to petitions for rulemaking and for declaratory rulings. The OSRC shall notify any local government agency that may be affected of the filing of such a petition and allow the agency to comment and intervene if the OSRC convenes an individual hearing**".

This policy is an example of *local overlap* because it creates confusion about the jurisdiction of the local level laws versus the state level laws. The state can adopt local laws but is not required too; however, the state does have to allow local governments the opportunity to intervene in the event that the Oklahoma Scenic Rivers Commission holds a hearing. The essence of this law provides both the local government and the state government veto power over the generation of state minimum standards. Conceptually both the state and local policy makers should be working in unison; however, the format of this policy gives one power and then gives the other power as well. Additionally, it is unclear what constitutes as 'intervening.' *Local overlap* is confusing the jurisdictional control of this policy.

Another example of *local overlap* can be seen in the Department of Environmental Quality's policy 252:623-19-2, which states:

"A user shall have an affirmative defense to an enforcement action brought against it for noncompliance with the general prohibitions in OAC 252:623-1-7(a) or specific prohibitions in OAC 252:623-3-1, if it can prove that it did not know, or have reason to know, that its discharge, alone or in conjunction with discharges from other sources, would cause pass through or interference and that either:

(1) **A local limit exists for each pollutant discharged and the user was in compliance with each limit directly prior to, and during, the pass through or interference**; or
(2) No local limit exists, but the discharge did not change substantially in nature or constituents from the user's prior discharge when the CTT was regularly in compliance with its NPDES permit, and in the case of interference, was in compliance with applicable sludge use or disposal requirements".

This policy constitutes *local overlap* because it is a state level policy that is attempting to govern an issue of noncompliance with local regulations. This policy states that an individual who does not know they are violating a local discharge law is defensible based on the state level law. This goes beyond overlapping and confuses the situation. If an individual does not know local laws they are not responsible for their actions. This calls into question the jurisdiction of local laws and the ability to hold individuals to them at the local level.

The subtheme *local overlap* resembles both the state and federal forms of overlap and causes fragmentation through the confusion of jurisdictional responsibility. *Local overlap*, like federal overlap, causes vertical fragmentation between governance scales and reduces Oklahoma's SES resilience. The subtheme *local overlap* has not been discussed in the literature thus far, making this finding a unique contribution to environmental governance literature.

Subtheme: Multi-scale Overlap

The multi-scale overlap subtheme occurs when there is a reference to more than one scale of governance within a given policy. *Multi-scale overlap* causes fragmentation across all three scales of governance. The subtheme *multi-scale overlap* is both the most frequently found form of overlap in the Oklahoma water policies. This type of overlap was not expected because the only anticipated form of overlap expected to occur was at the state level.

An example of this overlap can be seen in the Oklahoma Department of Agriculture, Food and Forestry policy 35:17-3-17, which states:

"Dead swine shall be disposed of in accordance with a carcass disposal plan developed by the owner and approved by the Department which shall decrease the possibility of the spread of disease, reduce odors, and preclude contamination of ground and surface waters of the state. **Dead swine shall be disposed of properly and in an environmentally safe**

manner in accordance with Federal, State, and local requirements. At all times the facility shall comply with the provisions of Section 1223 of Title 21 of the Oklahoma Statutes, in addition to compliance with the carcass disposal plan".

In this example, the policy is complying with Oklahoma Department of Agriculture, Food and Forestry regulations, which also have to be in accordance with all federal, state, and local requirements. It is unclear whether any of the federal, state, and local requirements are in direct contradiction. In the event the policies do contradict one another, it is unclear which scale of governance would be responsible. The phrase "in accordance with federal, state, and local law," leads the reader to question why this law was necessary given there are other federal, state, and local laws to comply with already.

Another example of *multi-scale overlap* is found in the Oklahoma Scenic Rivers Commission policy 630:1-1-2, which states:

"Severability of rules; rules cumulative; cooperation with other agencies: Nothing within the rules of this chapter shall be read, interpreted, understood, or applied so as to affect the validity and enforceability of any additional requirements, rules, or regulations of any other governmental entity, public agency, or instrumentality which may be otherwise applicable to those transactions, conduct, and facilities regulated herein. The rules of this chapter shall be deemed cumulative and supplemental to all other applicable rules and regulations authorized by law. In the enforcement of the rules of this chapter, **the Oklahoma Scenic Rivers Commission shall work in cooperation with all other interested or concerned state and federal agencies to the extent to which they may be officially interested**."

This policy is considered *multi-scale overlap* because of the overlap with state and federal agencies and the Oklahoma Scenic Rivers Commission. The policy states that the Oklahoma Scenic Rivers Commission is required to work "in cooperation with all other interested or concerned state and federal agencies to the extent to which they may be officially concerned". The ambiguous language used in this policy confuses rather than clarifies which agencies will be involved or have jurisdiction in the event of a disagreement. Without the clear jurisdiction to act, fragmentation occurs because either no agency will act or there may be some discrepancy among which agency should act.

An example of *multi-scale overlap* can be found in the Department of Environmental Quality policy 252:626-1-1, which states:

"This chapter applies to any person or entity that constructs or modifies a public water supply distribution system or water supply system and sets the permit and construction standards for all public water supply systems. The design criteria in this chapter are set at a minimum and will be considered as such by the DEQ. These standards do not prevent the consulting engineer from recommending or the DEQ from approving more effective treatment where local conditions dictate. **Other rules govern public water supply systems, including OAC 252:606, 624, 631, 633, 641, 710, and other appropriate local, state and federal regulations**".

Within this policy the Department of Environmental Quality is asserting rules for the construction or modification of a public water supply system. However, by stating that other rules at every other level of governance also apply, the Department of Environmental Quality is causing overlap. Instead of providing a policy that is supplemental to already existing policies, this policy is stating rules that may or may not be in contradiction to other public water supply rules. Nor does this policy state whose jurisdiction would take precedence in the case of contradicting policies.

Another form of *multi-scale overlap* can be found in the Department of Environmental Quality policy 252:623-5-1, which states:

"Users must provide and operate all wastewater treatment equipment necessary to maintain compliance with categorical pretreatment standards, local limits, prohibitions set out in OAC 252:623-1-7(a), and the requirements in any permit issued pursuant to Subchapter 9 of the Chapter within the time **limitations specified by EPA, the State, or the DEQ, whichever is more stringent**"

This policy leaves open the question of jurisdiction because the user must comply with both the local limits and the limits set by the most stringent authority whether it is the DEQ, the state, or the federal government. This policy does not state which authority's rules should be followed in the event of conflicting interpretations of the word 'stringent.'

The subtheme *multi-scale overlap* represents overlapping which occurs at multiple scales simultaneously and occurs more frequently throughout the data than the other subthemes. The problem with *multi-scale overlap* is that it opens the policy up to jurisdictional complications in the event of contradicting policies. This subtheme can be considered worse than the others because the overlapping is occurring a multiple simultaneously. The other types of overlap are only occurring across one or two scales which make the area of overlap easier to identify and thus easier to remediate. The ambiguous nature of this subtheme coupled with the fact that it is the most populous subtheme will likely be the hardest to ameliorate out of the other subthemes. *Multi-scale overlap* was not an expected outcome of the QCA which makes the finding a contribution to governance literature.

Subtheme: Miscellaneous Overlap

The *misc. overlap* subtheme can be defined as overlap with institutions or policies that fell outside the other three categories. These forms of overlap are found infrequently in the data, which led to the designation of a miscellaneous category. There are only a few cases in this category, and they range from overlapping with regional water compacts to overlapping with state institutions or organizations such as the Oklahoma Historic Preservation Society. An example of this *misc. overlap* can be observed in the Oklahoma Water Resources Board policy 785:20-1-4, which states:

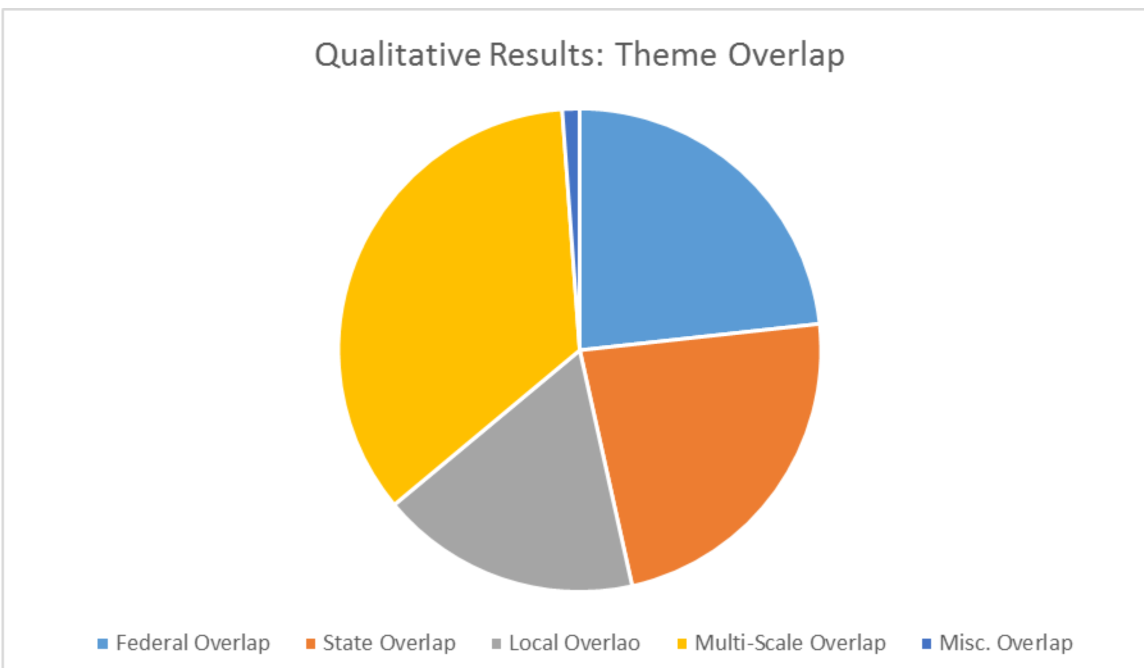
"(c) **The State of Oklahoma is a party to four interstate stream compacts which were adopted by the Oklahoma Legislature as statutes**, including the Canadian River Compact (82 O.S. 1991, §526.1), the Kansas-Oklahoma Arkansas River Compact (82 O.S. 1991, §1401), the Arkansas-Oklahoma Arkansas River Compact (82 O.S. 1991, §1421), and the Red River Compact (82 O.S. 1991, §1431). **Among other matters, the compacts apportion water among the states that are party to the compacts. Water rights subject to regulation under this chapter of the rules are likewise subject to applicable provisions of the compacts. (d) Use of water in a scenic river area in Oklahoma is also subject to applicable provisions of the Oklahoma Scenic Rivers Act**".

This policy refers to the regulation of water regionally through four interstate stream compacts. Thus the stream water is regulated by the regional compacts, by the provisions within the Scenic Rivers Act, by the Oklahoma Water Resources Board which is where the policy is found, and individual's water rights. Therefore, there are potentially four different actors that could claim jurisdiction when regulating the water in those designated stream compacts, which constitutes as overlap within the water governance. This example shows that overlap is happening within the subtheme *misc. overlap*; however, it is not happening with enough frequency to create the amount of jurisdictional confusion seen in other categories. Cleaning up a few of these incidences would increase resilience, but the other areas of overlap are more serious forms of fragmentation.

The subtheme of *misc. overlap* does not contribute to Oklahoma's overly fragmented water governance nor is it the biggest threat to the functioning of Oklahoma's water governance. However, it has the potential to develop into a problem and become more fragmented over time, leading to more categories of fragmentation that need to be addressed in the future. Thus the *misc. overlap* subtheme provides a unique nuance of the theme *overlap* within the data, and helps to provide a comprehensive portrait of Oklahoma's water governance.

Discussion

Figure 5.



The primary theme *overlap* occurs within Oklahoma's state level water policies both between scales of governance and across scales of governance. The subthemes derived from the *overlap* theme that contribute to the most problematic fragmentation are: *federal overlap*, *state overlap*, *local overlap*, and *multi-scale overlap*. An illustration of the frequency of the subthemes found in Figure 5. *Multi-scale overlap* is the most prominent form of overlap in the data. *Federal and state overlap* are found at roughly the same frequency throughout the data and *local overlap* is found with slightly less frequency, though it is still a major contributor of fragmentation. *Misc. overlap* is nearly inconsequential and in comparison to the other forms of overlap is found very infrequently. While some subthemes of the theme *overlap* were identified with more frequency then others, all are important in demonstrating how Oklahoma experiences features of fragmentation within its water governance.

The evidence of several features of fragmentation in Oklahoma's water governance has implications for the resilience of Oklahoma's water governance and the resilience of Oklahoma as a SES. The data on Oklahoma's water policies suggests that while different areas of overlapping jurisdiction are present not all of them are contributing equally to the fragmentation of Oklahoma's water governance, such as those found in the *misc. overlap* subtheme. These policies do not contribute to the problematic fragmentation in Oklahoma's water policies because they do not occur with enough frequency and thus they are less likely to create jurisdictional confusion. However, significant problematic fragmentation is occurring within Oklahoma's water polices which can potentially lead to government inaction and confusion of authority. When a natural resource governance system experiences significant fragmentation, the resilience of the system is reduced, meaning the ability to prepare for and respond to disturbances has been reduced. This creates vulnerability and sensitivity within the system. The resilience of natural resource governance is a component of a SES which means the resilience of a governance system impacts the resilience of Oklahoma's SES. Therefore, both the natural resource governance and Oklahoma are experiencing reduced resilience due to the fragmentation in water policies.

Reducing the fragmentation within the water policies would allow for clear jurisdictions and the responsible regulating authority managing the resource. Data on the current resilience of water governance in Oklahoma coupled with knowledge about specific areas of vulnerability should be used to inform policy makers regarding which policy areas are in need of change.

This content analysis of Oklahoma's state level water policies includes several limitations. Future research should address these limitations in order to better understand methods for enhancing Oklahoma's water governance. The first limitation of this research is that it only examines state level water policy, however environmental regulations exist at many different scales including: local, regional, federal etc. Because of the many scales of governance, future research should focus on how the other scales of water governance are fragmented and impacting Oklahoma. Another limitation is that this research only examines formal governance. Generally, governance implies both state and private actors that influence policy. A third limitation of the content analysis is that it only examines water policies. Nuances may exist which are missed in the data analysis because other types of environmental regulations, such as air quality regulations, were not analyzed. A fourth limitation is that this research only produces a picture of Oklahoma's current water governance. More research is needed to address how Oklahoma's water governance came to exist in its current state in order to determine if it has become more or less fragmented over time. The final limitation of this research is that the coding strategy involved analyzing each policy as a separate entity to discern the theme appropriate for coding. However, examining the policies as a whole could reveal that certain policies exist in contradiction to one another. Contradiction of policies would be another form of fragmentation which could impact the fragmentation of Oklahoma's water governance. Despite these limitations this work is a pivotal first step toward understanding how to increase the resilience of Oklahoma's water governance. Future research should build off of this research in order to address the limitations and comprehensively provide recommendations to resource managers which would enhance the resilience of Oklahoma's water governance.

Network Analysis

This section contains the results of the network analysis measurements of structural characteristics, which are provided first. The results are interpreted and the six hypotheses are addressed. Following the results, an illustration of the network in the form of a sociogram and a discussion of the resilience of Oklahoma's water governance network are provided.

Structural Characteristic Measurement Results

Table 1. Oklahoma's Water Governance Network: Two-Mode Affiliation Network Matrix

Policy Domains	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Water Agency																
Dept. Wildlife Con.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
OK Water Res. Board	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OK Scenic Riv. Com.	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Dept. of Mines	0	0	0	1	1	1	0	0	0	1	1	1	1	1	0	1
Dept. Ag, Food & For	0	0	0	1	0	0	0	1	1	0	1	1	1	1	1	1
Gr. Rv. Dam Auth.	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1
Dept. of Envr. Qual	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
Corp. Comm.	0	0	0	0	0	1	0	0	0	0	1	1	1	0	1	1
OK Cons. Com.	0	0	0	1	1	0	0	0	0	1	1	1	0	1	1	0

*the numbers of the policy domains correlate with numbers given to the policy domains in the list at the beginning of the network analysis results section

In the following section the results of the four structural characteristic measurements are provided and analyzed. The results for Density and Centrality are provided first because they are measured using the two-mode network matrix provided above. After density and centrality results are provided, I provide the new matrix used for the measurements of reachability and betweenness, which require transformation to a one-mode affiliation network. After the results are provided a discussion of the structural characteristics and their impact on the hypotheses and the features of adaptive governance are discussed.

Table 2. Network Density

Density	0.493
Network Ties	71
Average Degree	7.889

The density of Oklahoma's water governance network is moderately high. Nearly 50% of all of the ties possible in the network are present within the network. This indicates that the network is well connected. The number of network ties 71 is not important because every network is unique; however, the number of network ties is used to determine the density and the average degree of the network. The network experiences an average degree of 7.889, which means that the average number of ties for a given actor in the network is about 8. This means the networks actors are well connected to the events or policy domains in the network. The data suggests that the density of Oklahoma's water governance network is moderate to high.

Table 3. Two-Mode Centrality Results for Degree Centrality

Agencies	Centrality
Department of Wildlife Conservation	0.063
Oklahoma Water Resources Board	1.000
Oklahoma Scenic Rivers Commission	0.125
Department of Mines	0.625
Oklahoma Department of Agriculture, Food and Forestry	0.625
Grand River Dam Authority	0.313
Department of Environmental Quality	0.875
Corporation Commission	0.375
Oklahoma Conservation Commission	0.438

The degree centrality results for Oklahoma's water network show that degree centrality is moderate. As the degree centrality results table shows, five of nine of the actors have below 50% centrality; though four of the nine have above 50% centrality and one of those actors is 100% central meaning they are connected to every event or policy domain in the network. Another of the highly centralized actors is close to completely central with a degree centrality of over 80%. This indicates that a few actors are central within the network while others are peripheral. Thus the degree centrality of Oklahoma's water governance network is moderate.

While density and centrality were measured in Ucinet 6 as a two-mode affiliation network, betweenness and reachability require the transformation of the data into a one-mode network in order to analyze a symmetrical matrix. The matrix shown in table 4 is the matrix used to measure the structural characteristic requiring a symmetrical matrix. The matrix changed from actor by event, to actor by actor with the connections to events located in the cells of the matrix. Unlike the first matrix, this matrix can operate with whatever numbers represent the connections between the actors and events and can be any number, instead of only 1's and 0's

Table 4. Oklahoma's Water Governance Network: One-Mode Affiliation Network Matrix

Agency	DWC	ORWB	OSRC	DM	ODAFF	GRAD	DEQ	CC	OCC
DWC	1	1	0	1	1	0	1	0	1
ORWB	1	16	2	10	10	5	14	6	7
OSRC	0	2	2	1	1	0	2	0	1
DM	1	10	1	10	7	2	10	5	6
ODAFF	1	10	1	7	10	1	10	5	5
GRDA	0	5	0	2	1	5	3	1	1
DEQ	1	14	2	10	10	3	14	6	7
CC	0	6	0	5	5	1	6	6	3
OCC	1	7	1	6	5	1	7	3	7

The transition from the two-mode network matrix displayed in Table 1. and the one-mode network matrix in Table 4. can be explained in the following way. The connection between the actors in the new matrix will still represent the connections between actors and events; however, instead of a matrix with portrays either a connection or no connection, the matric will now portray the number of connections each actors has to events which are in common with other actors.

Table 5. One-Mode Results for Network Reachability

Agency	DMC	ORWB	OSRC	DM	ODAFF	GRDA	DEQ	CC	OCC
DWC	1	1	1	1	1	1	1	1	1
ORWB	1	16	1	1	1	1	1	1	1
OSRC	1	1	2	1	1	1	1	1	1
DM	1	1	1	10	1	1	1	1	1
ODAFF	1	1	1	1	10	1	1	1	1
GRDA	1	1	1	1	1	5	1	1	1
DEQ	1	1	1	1	1	1	14	1	1
CC	1	1	1	1	1	1	1	6	1
OCC	1	1	1	1	1	1	1	1	7

The Reachability of Oklahoma's water network is high because all of the actors within the network are reachable by a minimum of one tie. Reachability refers to the number of social ties needed to connect any one actor in the network to another actor in the network. The density results for the Average Degree provide data that the average number of ties per actor in the network is 7.8. This means the number of ties per actor is high and can be used to further support the finding that the reachability of the network is high.

Table 6. One-Mode Results for Network Freeman Betweenness Centrality

Agency	Betweenness
ODAFF	1.000
ORWB	1.000
DEQ	1.000
DM	1.000
OCC	0.000
GRDA	0.000
OSRC	0.000
CC	0.000
DWC	0.000

The betweenness of Oklahoma's water network is low. There are very few brokerage actors within the network. The results show that only four of the nine actors in the network act as brokerage actors between other sets of unconnected actors. This result leads to a low level of betweenness in the network, which is logical given the high reachability within the network. There is not a lot of space for actors in the network to bridge the gap between pairs of actors or events within the network, because most actors in the network are active in common policy domains. Networks with high degrees of density or high degrees of reachability will have low degrees of betweenness because if every actor is reachable by at least on tie then there will not be a need for actors to serve brokerage actors.

Hypotheses Results

Based upon the structural characteristic measurements of the network, the six hypotheses are addressed and discussed. The hypotheses are addressed in the order they are presented in the methods section. The discussion of the hypotheses is broken down into three parts: the hypotheses that were supported by the results, the hypotheses that were partially supported by the results and the hypotheses that were not supported by the results. After explaining the hypotheses, implications for resilience of Oklahoma's water governance are discussed.

Adaptive Capacity

The first hypothesis is: Oklahoma's water governance network experiences a low degree of adaptive capacity. Adaptive capacity can be determined by measuring reachability, centrality, and density. In order for the network to experience adaptive capacity it must have a low degree of density, a high degree of centrality, and a high degree of reachability. The network contains a moderately high degree of density (Table 2.), a high degree of reachability (Table 5.), and a moderate degree of centrality (Table 3.). Therefore the results of the structural characteristic measurements do not support this hypothesis, Oklahoma's water governance network does not experience a low degree of adaptive capacity. However, Oklahoma does not experience a high degree of adaptive capacity either, because centrality is only moderate and density is only moderately high. Therefore Oklahoma is structurally capable of experiencing partial adaptive capacity.

Heterogeneity

The second hypothesis is: Oklahoma's water governance network experiences a low degree of heterogeneity. Heterogeneity can be determined by measuring betweenness and density. In order for heterogeneity to be present in a network, the network must experience a moderately low degree of density and a moderate degree of betweenness. This network contains a low degree of betweenness (Table 6.) and a moderately high degree of density (Table 2.). Therefore, the results of the structural characteristic measurements do support this hypothesis, Oklahoma's Water governance network structure is only capable of experiences a low degree of heterogeneity.

Redundancy

The third hypothesis is: Oklahoma's water governance network experiences a low degree of redundancy. Redundancy can be determined by measuring density and betweenness. In order for redundancy to be present in the network, the network must experience a high degree of density and a low degree of betweenness. The network contains a moderately high degree of density (Table 2.) and a low degree of betweenness (Table 6.). Therefore, the results of the structural characteristic measurements do not support the hypothesis, Oklahoma's water governance network does not experience a low degree of redundancy.

Social Memory

The fourth hypothesis is: Oklahoma's water governance network experiences a low degree of social memory. Social memory can be determined by measuring reachability and density. In order to determine if social memory is present in the network, the network must experience a high degree of reachability and a high degree of density. The network contains a moderately high degree of density (Table 2.) and a high degree of reachability (Table 5.). Therefore the results of the structural characteristic measurement do not support the hypothesis, Oklahoma's water governance does not experience a low degree of social memory.

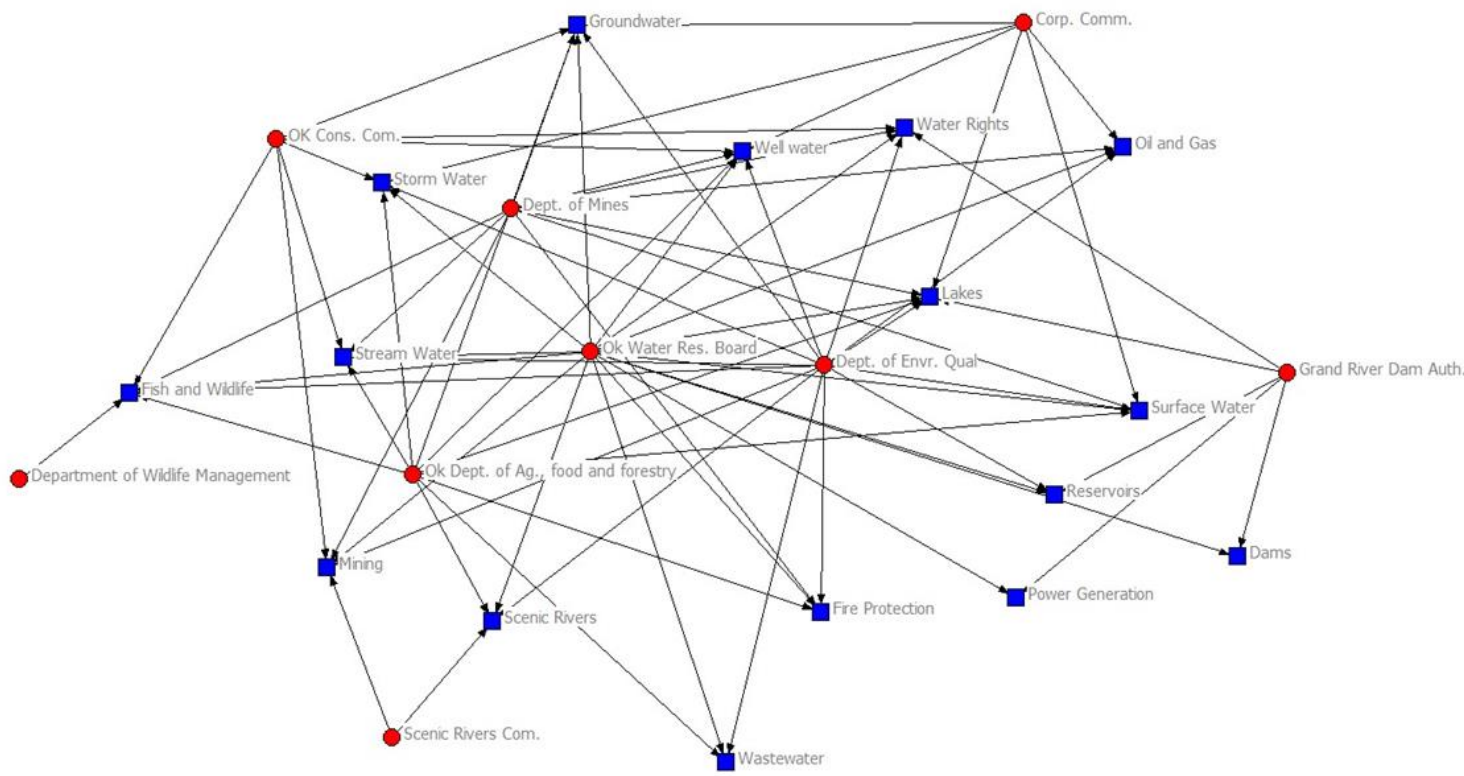
Learning

The fifth hypothesis is: Oklahoma's water governance network experiences a low degree of learning. Learning can be determined by measuring betweenness, centrality, and reachability. In order for learning to be present in the network, the network must experience a high degree of betweenness, a high degree of reachability, and a high degree of centrality. The network contains a low degree of betweenness (Table 6.), a high degree of reachability (Table 5.), and a moderate degree of centrality (Table 3.). Therefore the results of the structural characteristic measurements do not support the hypothesis, Oklahoma's water governance partially experiences learning.

Trust

The sixth hypothesis is: Oklahoma's water governance network experiences a low degree of trust. Trust can be determined by measuring betweenness and density. In order for trust to be present in the network, the network must experience a high degree of density and a low degree of betweenness. The network contains a low degree of betweenness (Table 6.) and a moderately high degree of density (Table 2.). Therefor the results of the structural characteristic measurement do not support the hypothesis, Oklahoma's water governance does not experience a low degree of trust.

Figure 6. Sociogram



This sociogram is a representation of Oklahoma's water governance network. Through this illustration it is apparent that there are a few agencies that are centrally connected to the majority of the events, these agencies are the Oklahoma Water Resources Board, the Department of Environmental Quality, and Oklahoma Department of Agriculture, Food, and Forestry, and the Department of Mines. Simultaneously there are a few agencies, Department of Wildlife Conservation and the Oklahoma Scenic Rivers Commission, which are located on the periphery of the network. This is especially interesting because the Department of Wildlife Conservation is only connected to the event Fish and Wildlife; however, four other actors are responsible for regulating Fish and Wildlife in addition to the Department of Wildlife Conservation. This indicates that the Department of Wildlife Conservation has almost no autonomy within the network.

The visual representation of the network helps to better understand the power dynamics of this network that are not obvious from the four structural characteristics which were measured. Ultimately, the information provided in the sociogram not only supports the data collected about the structural characteristics in the network, it provides a more nuanced observation of the data that cannot be understood from purely quantitative output.

Discussion

The analysis of the structural characteristic measurements revealed that Oklahoma's water governance structure has a low degree of betweenness shown in Table 6., a moderately high degree of density shown in Table 2., a moderate degree of centrality shown in Table 3., and a high degree of reachability shown in Table 5. These results indicate that Oklahoma's water governance network is capable of experiencing some, but not all, of the features of an adaptive governance network. The adaptive features that are present in Oklahoma's water governance network are trust, social memory, and redundancy. The adaptive features that are partially present in Oklahoma's water governance network are adaptive capacity and learning. The adaptive feature that is not present in Oklahoma's water governance network is heterogeneity. The results of the hypotheses are unexpected, Oklahoma's water governance network experiences several features of an adaptive network and is therefore more resilient than originally predicted. Though the network is more adaptive than predicted, there are still areas that need to be addressed in order to enhance the resilience of Oklahoma's water governance network. The network needs to increase its heterogeneity, and could improve its learning and adaptive capacities.

The results suggest that Oklahoma has a moderately adaptive water governance network. The implications of this result for Oklahoma's natural resource governance are that it is currently more resilient than expected and this analysis has identified ways in which the network can become more resilient.

It is important to note that while redundancy or overlap is a feature of a fragmented governance within the water policies, it is also a feature of an adaptive governance network in the network analysis. This seeming contradiction is mediated by the fact that redundancy within a network is good until it is not. Too much redundancy in a governance structure contributes to detrimental fragmentation. However, not enough redundancy in a governance structure and the structure becomes vulnerable to the loss of social ties. Ultimately a balance is required, the overlapping jurisdiction in the content analysis represents too much redundancy, while the redundancy in the network analysis was found in the optimal amount.

One of the only limitations to these results are that some of the features required for an adaptive natural resource governance network have conflicting structural characteristic needs. An example is the feature learning requires a high degree of betweenness and the feature trust requires a low degree of betweenness. This limitation can be mediated by having betweenness present in the network in a moderate amount. While the features do not call for moderate betweenness, they require high or low betweenness, the moderation would help to ensure that each feature is at least partially experiencing the betweenness needed for the feature to be present. By slightly increasing the betweenness in this network Oklahoma would lose some of its capacity for the feature learning. Additionally, it is important to note that because the content analysis was used to create the network analysis, the limitations of the content analysis are also limitations of the network analysis.

CHAPTER V

CONCLUSION

This research expands upon the concepts of resilience and natural resource governance by providing current data on adaptive and fragmented features found within Oklahoma's water governance. Resilience allows SES's to remain functioning in a stable state despite disturbances to the SES. It is important that Oklahoma's natural resource governance is resilient to changes in the SES because the impacts of climate change are predicted to become more sever over time. Previous literature has established that fragmented governance can lead to less effective governance through confusion of authority, while adaptive features in a network can lead to more effective governance. Despite this previous research, little empirical testing has been conducted on the adaptive features of networks and fragmentation literature has not achieved the depth of analysis necessary to determine how state level policies experience fragmentation. Ultimately, this research expands several areas of literature and explores a research areas which have not been sufficiently addressed.

This thesis analyzed Oklahoma's water policies and water network in order to gain a better understanding of the adaptive and fragmented features within water governance. Testing these features required the use of a mixed methods research design involving a QCA and a social network analysis. The content analysis helped to fill a gap in the literature of policy research in Oklahoma, offering a depth of analysis that has not yet been achieved. Additionally, the content analysis established the presence of the theme overlap which provided five areas of policy fragmentation and overlapping jurisdiction in Oklahoma's water policies. The data shows that fragmentation occurs at the local, state, federal, misc. and multi-scale levels, which contributes to reduced resilience in Oklahoma's water governance. The only expected form of overlap was state overlap. The other four forms of overlap were not predicted and contribute to the expansion of knowledge about the ways in which state governance structures can experience fragmentation. The network analysis fills a gap in the literature because network analysis as a methodology for analyzing natural resource governance is new and contains much unexplored potential. The network analysis builds on the content analysis data by illustrating the connections between water regulating agencies and areas of overlapping policies. This network analysis measured four structural characteristics and identified the presence of three of the six features of an adaptive natural resource governance network. The contribution of the network analysis is the empirical testing of the features of an adaptive network. These results provide a picture of Oklahoma's water governance network that is more adaptive and resilient than originally expected. All together this research on Oklahoma's water governance reveals areas where Oklahoma should concentrate on reducing the fragmentation and "governance gaps" present in the water governance policies and enhance the adaptive features of its water governance network.

This research has the potential to develop in a number of different directions and has many broad applications for the future of Oklahoma's water governance structure. Oklahoma is predicted to experience significant changes as a result of climate change in the coming decades. In particular water systems in Oklahoma will become vulnerable due to increased drought, decreased aquifer recharge, increased reliance on irrigation for agriculture, increased wildfires, etc. as a result of climate change. This research on Oklahoma water governance structure can be applied to Oklahoma's state water policies and the water governance network to decrease these vulnerabilities and increase Oklahoma's preparedness for climate variability.

Oklahoma experiences a combination of factors including a history of drought, an economic reliance on agriculture, a growing population and a limited supply of water which make it particularly vulnerable to changes in weather patterns. Enhancing resilience is the best was for Oklahoma to address vulnerabilities and prepare for future uncertainties. One method for enhancing resilience is through natural resource governance, which is a component of a SES. The future of Oklahoma's natural resource governance relies upon the development of resilience, which will help prepare for Oklahoma disturbances and mitigate disasters. The future is uncertain thus the only way to prepare for uncertainty is through the creation of an adaptive governance system that can adapt to changes and respond to extreme weather events without the threat of collapse.

REFERENCES

Adger, Neil W. 2000. "Social and Ecological Resilience: Are They Related?" *Progress in Human Geography*. 24(3):347-364

Alder, Robert W. 2010. "Climate Change and the Hegemony of the State Water Law" *Stanford Environmental Law Journal* 29(1):1-59

Andersson, Krister P., Clark C. Gibson, and Fabrice Lehoucq. 2004. "The Politics of Decentralized Natural Resource Governance" *Political Science and Politics* 37(3):421-426

Armitage, Derek. 2007. "Governance and the commons in a multi-level would." *International Journal of the Commons* 2(1):7-32.

Bakker, Karen and Christina Cook. 2011. "Water Governance in Canada: Innovation and Fragmentation." *Water Resources Development* 27(2):275-289

Barr, Stewart and Patrick Devine-Wright. 2012. "Resilience Communities: Sustainabilities in Transition". *Local Environment: The International Journal of Justice and Sustainability*. 17(5):525-532

Bartley, Tim, Krister Andersson, Pamela Jagger, and Frank Van Laerhoven. 2008. "The Contribution of Institutional Theories to Explaining the Decentralization of Natural Resource Governance". *Society and Natural Resources*. 21(2):160-174

Bazeley, Pat and Kristi Jackson. 2013. *Qualitative Data Analysis with NVIVO*. Second Edition. Las Angeles, CA: Sage Publications Ltd.

Berkes, Fikert, Johan Colding and Carl Folke, editors. 2003. *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK

Berkes, Fikret and Carl Folke. 1994. "Linking Social and Ecological Systems for Resilience and Sustainability" Beijer Discussion Paper series No. 52, *Beijer International Institute of Ecological Economics*

Berkes, Fikret, and Carl Folke. 1998. "Linking social and ecological systems for resilience and sustainability." *Linking social and ecological systems: management practices and social mechanisms for building resilience* 1:13-20.

Biermann, Frank, Philipp Pattberg, Harro Van Asselt, and Fariborz Zelli. 2009. "The Fragmentation of Global Governance Architectures: A Framework for Analysis". *Global Environmental Politics*. 9(4):14-40

Bodin, Orjan and Beatrice I. Crona. 2009. "The Role of Social Networks in Natural Resource Governance: What relational Patterns Make a Difference*?" Global Environmental Change* 19:366-374

Bodin, Örjan, Beatrice Crona, and Henrik Ernstson. 2006. "Social networks in natural resource management: what is there to learn from a structural perspective." *Ecology and Society* 11(2): 1-8

Bodin, Örjan, and Jon Norberg. 2005. "Information network topologies for enhanced local adaptive management." *Environmental Management* 35(2): 175-193.

Booher, David E., and Judith E. Innes. 2010. "Governance for resilience: CALFED as a complex adaptive network for resource management." *Ecology and Society* 15(3):35.

Borgatti SP and Everett M G. 1997. "Network analysis of 2-mode data". *Social Networks* 19:243-269.

Borgatti, S.P., Everett, M.G., and Freeman, L.C. 2002. *Ucinet 6 for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

Burt, Ronald. 1995. *Structural Holes: The Social Structure of Competition*. Harvard University Press: Cambridge, Massachusetts

Burt, Ronald. 1987. "Social Contagion and Innovation: Cohesion versus Structural Equivalence". *The American Journal of Sociology*. 92(6):1287-1335

Buttel, Frederick H. 1987. "New directions in environmental sociology." *Annual Review of Sociology* 13:465-488.

Buzbee, William W. 2003. “Recognizing the Regulatory Commons: A Theory of Regulatory Gaps” *Iowa Law Review*

Buzbee, William W. 2005. "Regulatory Fragmentation Continuum, Westway and the Challenges of Regional Growth, The." *Journal of Law & Politics* 21: 323.

Camacho, Alejandro E. 2009. "Adapting governance to climate change: managing uncertainty through a learning infrastructure." *Emory Law Journal* 59(1): 09-06

Caniglia, Beth, Beatrice Frank, Daisha Delano, and Bridget Kerner. 2014. “Enhancing Environmental Justice Research and Praxis: The Inclusion of Human Security, Resilience and Vulnerabilities Literature” *International Journal of Innovation and Sustainable Development*. (IJISD) 8(4): 409-426

Carpenter, Steve, Brian Walker, J. Marty Anderies, and Nick Abel. 2001. “From Metaphor to Measurement: Resilience of What to What?” *Ecosystems*. 4:765-781

Carrington, Peter J., John Scott, and Stanley Wasserman, eds. 2005. *Models and methods in social network analysis*. Vol. 28. Cambridge University Press

Craig, Robin Kundis. 2008. “Climate Change, Regulatory Fragmentation, and Water Triage” *FSU College of Law, Public Law Research Paper* 288: 825-927

Cook, Christina L. 2011. “Putting the Pieces Together: Tracing Jurisdictional Fragmentation in Ontario Water Governance”. *University of British Columbia* Thesis for PhD

Crona, Beatrice and Klaus Hubacek. 2010. “The Right Connections: How do Social Networks Lubricate the Machinery of Natural Resource governance” *Ecology & Society* 15(4):18-23

Davidson, Debra J., and Scott Frickel. 2004. "Understanding Environmental Governance A Critical Review." *Organization & Environment* 17(4): 471-492.

Dietz, Tom, Elinor Ostrom, and Paul C. Stern. 2003. “The Struggle to Govern the Commons”. *Science* 302:1902-1912

Duit, andreas, Victor Galaz, Katarina Eckerberg, and Jonas Ebbesson. “Governance, Complexity, and Resilience” *Global Environmental Change*. 20(3): 363-368

Emirbayer, Mustafa and Jeff Goodwin. 1994. “Network Analysis, Culture, and the Problem of Agency” *The American Journal of Sociology* 99(6)1411-1454

Environmental Protection Agency. 2011. “How Will Climate Change Impact EPA Region 6 Area?” *EPA’s Region 6 Office* <http://www.epa.gov/region6/climatechange/impact-in-r6.htm>

Espeland, Wendy. 1993. "Power, Policy and Paperwork: The Bureaucratic Representation of Interests" *Qualitative Sociology*. 16(3):297-317

Fiksel, Joseph. 2006. "Sustainability and resilience: Towards a Systems Approach". *Sustainability: Science, Practice, & Policy* 2(2):14-21

Folke, Carl. 2006. "Resilience: The emergence of a Perspective for Social-Ecological Systems Analyses" *Global Environmental Change*. 16:253-267

Folke, Carl, Stephen R. Carpenter, Brian Walker, Marten Scheffer, Terry Chapin, and Johan Rockström. 2010. "Resilience thinking: integrating resilience, adaptability and transformability." *Ecology and Society* 15(4): 20.

Folke, Carl, Thomas Hahn, Per Olsson, and Jon Norberg. 2005. "Adaptive Governance of Social-Ecological Systems" *Annual Review of Environment and Resources*. 30:441-473

Garmestani, Ahjond S. and Melinda Harm Benson. 2013. "A Framework for Resilience-Based Governance of Social-Ecological Systems". *Ecology and Society*. 18(1):9

Gallopin, Gilberto C. 2006. "Linkages between Vulnerability, Resilience, and Adaptive Capacity" *Global Environmental Change*. 16:293-303

Gilbert, L.S. 2002. "Going the Distance: 'closeness' in qualitative data analysis software". *International Journal of Social Research Methodology*, 5(3):215-228

Gunderson, Lance and Stephen S. Light. 2006. "Adaptive Management and Adaptive Governance in the Everglades Ecosystem". *Political Science* 39:323-334

Hafner-Bruton, Emilie M., Miles Kahler, and Alexandra H. Montgomery. 2009. "Network Analysis for International Relations". *International Organization*. 63:559-592

Hanneman, Robert A. and Mark Riddle. 2005. Introduction to social network methods. Riverside, CA: *University of California, Riverside* (published in digital form at http://faculty.ucr.edu/~hanneman/)

Hardin, Garrett. 1968. "The tragedy of the commons." *Science* 162(3859): 1243-1248.

Hesse-Biber, Sharlene and Particia Levy. 2011. "Mixed Methods Research". Pp. 277-297 in *The Practice of Qualitative Research* 2nd edition. Thousand Oaks, CA: Sage Publications Inc.

Hill, Carey, Kathryn Furlong, Karen Bakker, and Alice Cohen. 2008. "Harmonization versus Subsidiary in Water Governance: A Review of Water Governance and Legislation in the Canadian Provinces and Territories". *Canadian Water Resources Journal* 33(4): 315-332

Holling, Crawford S. 1973. "Resilience and Stability of Ecosystems". *Annual Review of Ecology and Systematics*. 4:1-23

Holling, Crawford S. 1978. *Adaptive Environmental Assessment and Management*. Caldwell, NJ: Blackburn Press

Holling, Crawford S., and Lance H. Gunderson. 2002. "Resilience and adaptive cycles." *Panarchy: Understanding transformations in human and natural systems* 25-62.

Jantzen, Stephen L. 2001. "ENVIRONMENTAL REGULATION IN OKLAHOMA: A PATCHWORK GREEN." *Oklahoma Politics* 10: 9-18.

Johnston, L.H. 2006. "Software and method: reflections on teaching and using QSR NVivo in doctoral research". *International Journal of Social Research Methodology*, 9(5): 379-391

Kidd, S and Shaw, D. 2007. "Integrated Water resources Management and Institutional Integration: Releasing the potential of Spatial Planning in England". *Geography Journal*. 173(4):312-329

Knope, David and James H. Kuklinski. 1982. *Network Analysis*. Sage Publications, Inc: Beverly Hills, California

Lockwood, Michael, Julie Davidson, Allan Curtis, Elaine Strathford, and Robert Griffith. 2010. "Governing Principles for Natural Resource Management". *Society and Natural Resources* 23:986-1001

Miller, Fiona, Henry Osbahr, Emily Boyd, Frank Thomalla, Sukaina Bharwani, Gina Ziarvolgel, Brian Walker, Jorn Birkman, Sander van der Leeuw, Johan Rockstrom, Jochen Hinkel, Tom Downing, Carl Folke, and Donald Nelson. 2010. "Resilience and Vulnerability: Complementary of Conflicting Concepts?" *Ecology and Society*. 15(3):11

Newig, Jens, Dirk Günther, and Claudia Pahl-Wostl. 2010. "Synapses in the network: learning in governance networks in the context of environmental management." *Ecology and Society* 15(4): 24.

NPR http://stateimpact.npr.org/oklahoma/tag/water/ "Securing Oklahoma's water future a complex Balancing Act"

Oh, Hongseok, Myung-Ho Chung, and Giuseppe Labianca. 2004. "Group social capital and group effectiveness: The role of informal socializing ties." *Academy of Management Journal* 47(6):860-875.

Olsson, Per, Lance H. Gunderson, Steve R. Carpenter, Paul Ryan, Louis Lebel, Carol Folke, and Crawford S. Holling. 2006. "Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems" *Ecology and Society*. 11(1):18-39

Richards, L. 1988. "Closeness to the Data: the changing goals of qualitative data handling". *Qualitative Health Research*, 8(3): 319-328

Roberts, J. Timmons and Bradley Parks. 2007. *A Climate of Injustice: Global Inequality, North-South Politics, and Climate Policy*. MIT Press: Cambridge, Massachusetts

Schreier, Margret.2012. *Qualitative Content Analysis in Practice*. Sage Publications, Inc.

Teisman, Geert R. and Jurian Edelenbos. 2011. "Towards a Perspective of System Synchronization in Water Governance: A Synthesis of Empirical Lessons and Complexity Theories". *International Review of Administrative Sciences*. 77(1):101-118

Walker, Brian, Crawford S. Holling, Stephen R. Carpenter, and Ann Kinzig. "Resilience, adaptability and transformability in social--ecological systems." *Ecology and Society*. 9(2):1-9

Walker, Brian and David Salt. 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Washington: Island Press

Walters, Carl J. 1986. *Adaptive Management of Renewable Resources*. New York, NY: McGraw Hill.

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis: Methods and Applications*. Cambridge University Press: Cambridge, United Kingdom

Wertz, Joe and Logan Layden. 2013. "Troubled Water: A Deep Divide into Oklahoma's Most Precious Resource*" NPR State Impact* <http://stateimpact.npr.org/oklahoma/2013/02/27/troubled-water-a-deep-dive-into-oklahomas-most-precious-resource/>

Urwin, Kate and Andrew Jordan. 2008. "Does Public Policy support or undermine climate change adaptation? Exploring Policy interplay across different scales of governance". *Global Environmental Change*. 18:180-191

VITA

Bridget Eileen Kerner

Candidate for the Degree of

Master of Science

Thesis: SOCIO-ECOLOGICAL SYSTEM (SES) RESILIENCE AND WATER GOVERNANCE IN OKLAHOMA

Major Field: SOCIOLOGY

Biographical:

<u>Education</u>:

Completed the requirements for the Master of Science in Sociology at Oklahoma State University, Stillwater, Oklahoma in May, 2015.

Completed the requirements for the Bachelor of Arts in Environmental Studies at Salisbury University, Salisbury, Maryland in 2011.

<u>Experience</u>:

Research Assistant, Oklahoma State University August 2013—Present

- Research Assistant National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) Grant "Adapting Social-Ecological Systems to Climate Variability".
- Organize and conduct focus groups with Native tribal communities across the state of Oklahoma to document tribal experiences with climate variability and change.

<u>Publications</u>:

Caniglia, Beth Schaefer, Beatrice Frank, Daisha Delano and **Bridget Kerner**. 2014. "Enhancing Environmental Justice Research and Praxis: The Inclusion of Human Security, Resilience & Vulnerabilities Literature" *International Journal of Innovation and Sustainable Development* (IJISD) 8(4): 409-426