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Improving Drought Management for Transboundary River Basins in the United States through Collaborative Environmental Planning

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IMPROVING DROUGHT MANAGEMENT FOR TRANSBOUNDARY RIVER BASINS IN THE UNITED STATES THROUGH COLLABORATIVE ENVIRONMENTAL PLANNING

by

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Increasing demand for water and the uncertainty of climate change have put pressure on the global water supply, presenting one of the greatest challenges of the 21st Century for human development. Drought is a natural hazard that further compromises water supply and increases competition among water use sectors. These challenges confirm the need for comprehensive water supply and drought planning. Planning for water, however, is often conducted within political boundaries that are not consistent with the water resource's natural boundaries, which can result in conflict. Collaborative environmental planning is a sub-discipline of planning that can address the occurrence of drought in a transboundary river basin. Little research has been done to explore drought planning for transboundary basins at the U.S. state level. This research answers the following question: How are water planning agencies using collaborative planning to improve the management of drought in transboundary basins in the U.S.?

To address this question, 12 basins in the U.S. that are planning for drought were identified, and semi-structured phone interviews were conducted with basin-level drought planners. Participants were interviewed about drought management strategies, the role of collaboration and coordination in the planning process, and recommendations for drought planning in a transboundary basin based on experiences with successes and barriers.

It was found that while the drought planning process is similar for all basins, each basin implements drought management strategies that are unique to their circumstances in the basin. The research also found that collaboration and coordination are necessary components of drought planning for transboundary basins. Recommendations made by interview participants based on their experiences with successes and barriers centered upon increasing collaboration and coordination, increasing communication, addressing government and legal matters, improving the quality of information, refining the planning process, and identifying and engaging stakeholders. Further research is recommended to determine the necessity of having an institution for coordination to assist with planning in a transboundary basin.

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DEDICATION

This dissertation is dedicated to my fiancé, Joshua Gale Stiles. Josh, of all of my family, friends, and colleagues, your support of me pursuing my dream to become a doctor and academic professional means the most to me, and you encouraged me more than anyone to follow my dreams. You understood that the best institution for me to make those dreams happen was 11 hours away, and you did not object. You were patient with me when I struggled, you listened when I complained and even cried, and you assured me when I worried about the future. You came to see me many times, and you are the only person from home who truly knows about and understands my life in Lincoln. We endured a long-distance relationship of three years and four months that most would not have been able to endure, and we are now stronger than ever. I cannot wait to start my life with you as husband and wife and see where life takes us. I love you more than you know and I thank you from the bottom of my heart for your support and for believing in me.

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CHAPTER 1

INTRODUCTION

According to the United Nations' (U.N.) Secretary-General, "Safe drinking water and basic sanitation are intrinsic to human survival, well-being and dignity" (UNESCO 2012). Both of these necessities require an adequate and sustainable global water supply. Water scarcity is currently affecting more than 40% of the global population and is negatively impacting most aspects of local and regional economies, such as public health, food production and security, domestic water supply and sanitation, energy, industry, and environmental sustainability (U.N. 2013a). Less than one percent of the Earth's freshwater is available for use by humans and ecosystems, and this supply is being consumed at an unsustainable rate (U.N. 2013a). As a result, the global water crisis is being addressed internationally as an important component of the U.N.'s Millennium Development Goals and presents one of the greatest challenges of the 21st Century for human development (UNDP 2006).

Water was, at one time, considered a renewable resource with a limitless supply. The evolution of several natural and societal factors have changed this perception to one that considers water a finite resource that is increasingly threatened by rapid change across the Earth's landscape. For example, the demand for water has increased dramatically due to population growth. Global population reached seven billion in 2011, and it is projected to reach 9.3 billion by 2050 and 10 billion by 2100 (U.N. 2011). Increasing population puts pressure on agriculture, which is completely dependent upon water, to produce a greater global food supply. In developing countries, the demand for water is increasing at a more rapid rate due to industrial development. Although the acceleration of such human practices enhances the quality of life, they threaten both water quality and water supply.

A second factor, climate change, is also considered a major global water problem that is threatening water supply (Eden and Lawford 2003, Biswas 2008). While some components of the climate change issue are still being debated, it is the general consensus of scientists that climate change is indeed occurring and action should be taken to reduce its risks (U.S. EPA 2012a). Precipitation has generally decreased since the 1970s in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia, and drought has become more common in the tropics and subtropics (Trenberth et al. 2007). It is projected that drying in the subtropics will continue to prevail into the future. Factors such as timing, quantity, intensity, and location of precipitation further contribute to the uncertainty of having a water supply that is adequate for supporting life on Earth.

A task as daunting as ensuring a sustainable global water supply certainly requires careful planning. Planning is simply “figuring out what needs to be done and how to do it” (Randolph 2004). It is a basic process for problem solving. In the U.S., planning was first used to design and develop cities as early as the mid-1800s. The application of planning has since broadened to other disciplines, including the environment. Environmental planning may be used to solve issues regarding land use and development, waste management, plants and wildlife, and water resources, to name a few.

Planning occurs at many scales, depending on the type of governing body. Planning commonly takes place at the federal, tribal, state, regional, county, and city scales, and it also occurs across sectors and jurisdictions at the same scale. The boundaries that form these planning units are all political, or defined by people. Planning around political boundaries is suitable for urban planning and design or other governmental-type planning disciplines, but planning for natural resources around political boundaries is far more complicated. Water, for example, creates natural boundaries in the form of lakes, rivers, and streams. Although these natural boundaries were formed first, they have generally not been used to partition land, resulting in a mismatch between natural and political boundaries. This mismatch has caused rivers and other bodies of water to be transboundary in nature, meaning they cross or are contained within more than one political jurisdiction.

Transboundary water bodies have been the cause of many conflicts between nations for centuries and are well documented (Pacific Institute 2009). For example, Israel and Palestine have been involved in ongoing disputes over water for decades. The water crisis in this region is primarily due to the uneven and unequal distribution of water among all parties (Isaac n.d.). Turkey's Southeastern Anatolia Project, which involves creating dams and reservoirs on the Euphrates River to support hydropower and irrigation, has created conflict with the downstream countries of Syria and Iraq due to reduced flows in the river (Pulsipher and Pulsipher 2011). Climate change, which may cause a reduction of precipitation in some regions, is expected to become an additional challenge to managing transboundary water resources (Cooley et al. 2009), and it has already posed concerns over the U.S.'s national security (Defense Science Board 2011). Approximately 60% of the world's transboundary river basins lack a cooperative management framework, meaning that while countries may have transboundary water management agreements, the agreements are not legalized (U.N. 2013b). The U.N.

(2013b) went on to say, however, that since 1947, there have been 300 international water agreements but only 37 conflicts between nations over water, so cooperation between nations appears to be outweighing conflict.

The U.S. also has its share of transboundary water bodies among its states and bordering nations. John Wesley Powell, an American naturalist and explorer, proposed to Congress that government boundaries in the West be established around hydrologic systems because river basins are holistic natural systems separated by well-defined boundaries. He did not think Western river water could be divided among the states and distributed to individual owners, which is evident from the following excerpt from his article "Institutions for Arid Lands" (1890):

> "How can this be done? Lands can be staked out, corner-posts can be established, dividing lines can be run, and titles to tracts in terms of metes and bounds can be recorded. But who can establish the corner-posts of flowing waters? When the waters are gathered into streams they rush on to the desert sands or to the sea; and how shall we describe the metes and bounds of a wave? The farmer may brand his horses, but who can brand the clouds or put a mark of ownership on the current of a river?"

Despite Powell's declarations, boundaries of Western states were drawn to accommodate political interests. As a result, many rivers and other water bodies in the U.S. are transboundary in nature, crossing both state and international boundaries.

The U.S. has also endured conflicts over water between its states and with its bordering nations. It shares rivers and lakes internationally with both Canada and Mexico. Treaties have been established between the U.S. and the two countries regarding management of these transboundary river basins and are discussed further in Chapter 2. The Colorado River has been the focus of extensive negotiations and litigation involving several U.S. states and Mexico for decades, partly because the Colorado River Compact of 1922 was based on an overestimation of the river's average annual water supply (Pulwarty et al. 2005). Even in the Southeast where water supply is more ample, the states of Georgia, Alabama, and Florida entered into litigation over the rights of water use in the Apalachicola-Chattahoochee-Flint River Basin. While international treaties have helped to avert conflict between the U.S. and its bordering nations, not all transboundary river basins within the U.S. have water use treaties or agreements.

Managing transboundary water resources is complex enough when water is plentiful, but the occurrence of drought further exacerbates this issue and often causes or worsens conflicts between competing water users. In 2011, drought accounted for 17 of 39 global climatological disasters and US$10.4 billion of US$14.2 billion in total damages, with economic losses mostly coming from the United States, Mexico, and China (Guha-Sapir et al. 2012). Drought and food crises also affected an estimated 17 million people in Africa. In the U.S., drought cost an estimated $243.3 billion (2013 Consumer Price Index cost adjusted value), or an average of $7.4 billion, per year from 1980-2012 (Lott et al. 2013).

Drought has recently gained more attention in the U.S. due to its vast expanse across the country during the summer of 2012. In mid-July 2012, the U.S. Drought

Monitor indicated that just over 50% of the country was in some stage of drought, which was the largest area in at least moderate drought at one time since the first U.S. Drought Monitor map was created in 2000 (NDMC 2012a). Impacts were widespread across many sectors, including agriculture, water supply, and the environment. The cost of this drought was estimated at around $30 billion (Lott et al. 2013). Drought is expected to be a threat to the U.S. in the future as well. Climate change projections indicate that annual mean precipitation will decrease across the U.S. Southwest, and greater temporal variability in precipitation will increase the risk for drought nationwide (Field et al. 2007).

Drought is a normal part of climate, and it is evident that there is a need for planning and preparedness for drought. Multiple drought episodes in the U.S. have prompted water planning agencies to develop drought plans or planning activities for their jurisdictions. Currently, drought planning is occurring at many scales and levels of government. There are water planners from Native American tribes, states, basins, counties, cities, and even public water utilities who have determined that drought is a relevant threat in their jurisdictions, justifying the need for planning efforts that are specific to the hazard.

Several U.S. organizations and experts have stated that planning for water at the scale of a basin is the best way to manage transboundary water bodies (U.S. Congress 1993, NRC 1999, NDPC 2000, Ruhl et al. 2003, NIDIS 2007, Wilhite et al. 2007, Heathcote 2009). Most of the literature concerning transboundary water resources management, however, focuses on transboundary water bodies shared between two nations, not U.S. states. There is also very little literature on drought management at the basin level. This research aimed to fill the gap in the literature by providing an overview of transboundary water resources management between states, as well as drought management at the basin level, within the U.S. Additionally, the terminology used in the literature that refers to hydrologic systems, such as "watershed" and "basin," is rather ambiguous and has further added to the complexity of understanding management of hydrologic systems. The terminology issue is addressed in this research to provide clarity and reduce confusion. (For uniformity purposes, the term "basin" will be used throughout the document to describe the drought planning that is occurring within natural boundaries in the U.S.)

One approach to managing drought in transboundary water bodies is through collaborative planning. Collaborative environmental planning has emerged as an approach to planning that emphasizes stakeholder involvement, a scientific basis on which to base decisions, a holistic and proactive approach to addressing environmental issues, and integrated solutions (Randolph 2004). Watershed management is a type of collaborative environmental planning that emphasizes addressing environmental issues at the scale of a watershed, and it can be applied to drought management. It has been suggested that watershed management is best approached using collaborative planning (NRC 1999). Collaborative environmental planning and watershed management have only been around since the 1990s, however, so there is much to be learned about the effectiveness of collaborative environmental planning methods (Bentrup 2001, Imperial 2005).

The need for long-term drought planning and coordination across boundaries provide the justification for this research. The National Drought Resilience Partnership, which was introduced in 2013 as part of President Barack Obama's Climate Action Plan, calls for the development of long-term planning and resilience strategies to improve the nation's drought preparedness (NIDIS 2014a). Additionally, coordination across boundaries, especially regarding river basins, was a recommendation that arose from a National Integrated Drought Information System (NIDIS) workshop held in 2008 in Kansas City, Missouri (NIDIS 2008). The purpose of this workshop was to conduct a knowledge and service assessment regarding the status of Drought Early Warning Systems in the U.S., which are discussed below. The workshop report stated that workshop participants, including researchers, decision-makers, and drought planners representing many key sectors, recommended that improvements in communication and coordination be made in basins that span political boundaries. Participants also recommended a regional approach to drought planning. The results of this research could lead to NIDIS engaging with the basins found to be planning for drought to learn how coordination across boundaries can be improved.

This research also contributed to the body of literature on collaborative environmental planning and drought. The research has contributed more examples of collaborative environmental planning and watershed management to the field of planning to enhance the understanding of how these management techniques are used by U.S. water planning agencies to address drought at the basin scale. It has also contributed to the body of knowledge regarding drought planning to improve the drought risk management activities of the National Drought Mitigation Center (NDMC) and NIDIS, which are discussed further in Chapter 2. The NDMC currently has a comprehensive database of drought plans and planning activities primarily at the state level, but the

NDMC's extent of knowledge and information regarding drought planning at the basin scale is more limited. NIDIS has developed and is continuing to develop Regional Drought Early Warning Systems (RDEWs), which are pilot areas where NIDIS is engaging stakeholders in drought preparedness activities. Several of the RDEWs are at the basin scale, so NIDIS would benefit from this research because the results could help integrate existing transboundary planning efforts within future NIDIS pilot areas.

The results of this research answered the following principal research question: How are water planning agencies using collaborative planning to improve the management of drought in transboundary basins in the U.S.? The following three subsidiary research questions were answered to help address the principal research question: What is the status of drought planning for transboundary basins in the U.S.? How are collaboration and coordination playing a role in addressing the transboundary issue? Based on their experiences with successes and barriers encountered during the planning process, what strategies do water planning agencies recommend that would increase successful collaboration and ultimately improve drought planning and management of transboundary river basins in the U.S.? The following chapters provide a background on the literature surrounding these topics, the methods employed to collect and analyze data, the results of the research, a discussion on the significance of the results, and conclusions that were drawn from the research.

CHAPTER 2

BACKGROUND

2.1 The Concept of Planning

The concept of planning can be broadly defined as an avenue for “linking scientific and technical knowledge to actions in the public domain” (Friedmann 1987). Friedmann (1987) also stated that the purpose of planning is less concerned with the actual knowledge or actions and more concerned with linking the two concepts. The primary functions of planning are improving the efficiency of outcomes, counterbalancing market failures, enhancing the consciousness of decision-making, and improving civic engagement (Alexander 1992). As mentioned in Chapter 1, planning occurs at a variety of scales and across sectors and jurisdictions at the same scale. There are also many different types of planning, such as planning for community development, transportation, housing, and land use. One type of planning that is of particular interest in the context of this study is environmental planning.

2.2 Environmental Planning

Environmental planning is planning and problem solving applied to a number of environmental concerns, such as natural hazards, ecosystems, and the management of natural resources (Randolph 2004). Planning became particularly important in this area after a series of environmental laws were passed by the federal government, beginning in the 1960s, in response to growing concern of loss of wildlife habitat and adverse impacts on public health (Daniels and Daniels 2003). Perhaps the most important environmental law established was the National Environmental Policy Act (1969), which required that federal projects be reviewed in the form of Environmental Impact Statements to determine potential threats to environmental quality and natural resources before implementation. Since then, the establishment of many major federal laws has followed, such as the Clean Air Act (1970), the Clean Water Act (1972), the Endangered Species Act (1973), The Superfund Law (1980), and the National Flood Insurance Reform Act (1994).

Addressing environmental issues requires that planners follow a general process that lays out the important steps needed to solve the problem. First and foremost, there must be a recognized need for environmental planning (Daniels and Daniels 2003) and available data, resources, and time (Randolph 2004) before any planning occurs. A generic process for environmental planning is proposed in Figure 1. Scoping is an important first step because it involves identifying key stakeholders that are needed to solve the environmental issue. Stakeholders are people who effect change as well as those affected by it (Randolph 2004). Issues and specific objectives to support the goals are then identified to lay the groundwork for the design of the project. Stakeholders then analyze the planning situation, which includes determining the scope, method(s), and limitations of data collection. Alternative approaches to those that were initially identified are then discussed. Next, the potential economic, environmental, and social impacts of the proposed project are assessed by the stakeholders. The stakeholders then evaluate those potential impacts and select the most appropriate plan. Finally, the last step is an adaptive element that includes the implementation, monitoring, evaluation, and modification of the plan as needed. It is important to note that while these steps are arranged sequentially, the process is usually iterative and most of the steps are considered simultaneously (Randolph 2004).

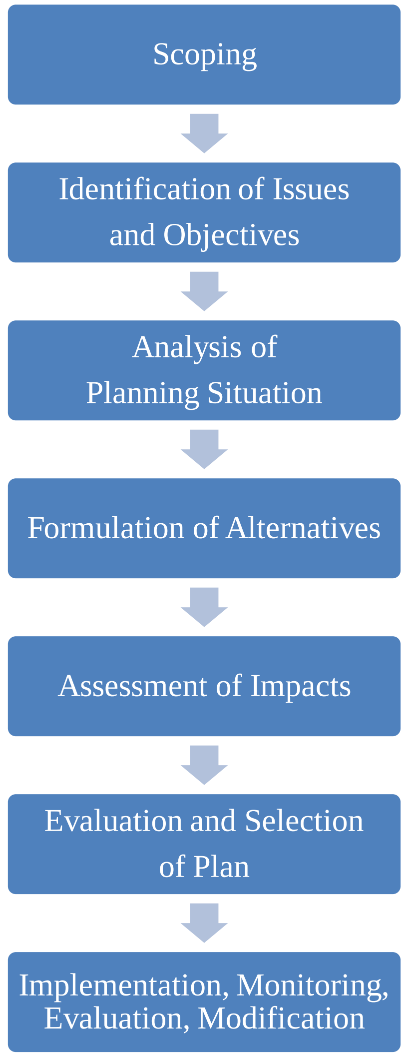

Figure 1. Generic planning process that is applicable to most environmental planning problems. Adapted from Randolph (2004).

The product of planning, or the plan, can take on many different forms and is appropriate to develop at the federal, tribal, regional, state, basin, county, and city levels, as well as many levels in between. One of the most common types of plans developed at the local and regional levels is the comprehensive plan. The comprehensive plan lays out the vision and the functionality of a particular region for the next 10 to 20 years, but it focuses more on growth and development and less on environmental planning (Daniels and Daniels 2003). Developing an environmental plan using the generic process shown in Figure 1 or a variation of that process can supplement the comprehensive plan.

The inherent nature of environmental planning requires participation and engagement of stakeholders who have vested interests in a particular environmental issue. Research has indicated that the participation of key stakeholders in the environmental planning process is more likely to result in higher plan quality (Brody 2003), and it is widely viewed as the single most important element of a successful planning outcome (Randolph 2004).

2.2.1 Collaborative Environmental Planning

The initial "command and control" approach to environmental management and decision-making began to diminish in the 1980s due to deregulation, reduced federal budgets, and increased protection of private property rights (Randolph and Bauer 1999). Negotiation and alternative dispute resolution became increasingly favored over litigation as means of solving environmental problems, resulting in greater public participation of environmental issues. Additionally, most major environmental issues had been resolved by this time period, but more complex problems, such as how to address nonpoint source pollution, still remained. It was recognized that the resolution of these types of issues would require collaborative approaches (Randolph and Bauer 1999, Koontz and Thomas 2006). In the 1990s, a variety of collaborative approaches to environmental and natural resources management emerged. These approaches are known by many names, such as partnerships, consensus groups, community-based collaboratives, and alternative problem-solving efforts (Conley and Moote 2003). For the purpose of consistency, the term Collaborative Environmental Planning (CEP), used by Randolph (2004), will be used throughout this research.

According to Randolph (2004), CEP has four basic elements: stakeholder involvement; scientific basis; holistic, proactive approach; and integrated solutions. Stakeholders should be engaged early and often in the planning process. The decision-making process should be based on accurate scientific information and analysis. These first two elements demonstrate the balance that must be achieved between the political basis and the scientific basis of making decisions. Environmental issues should be viewed holistically due to their complexities, and a proactive approach should be taken to resolve them. Solutions to the environmental issues should be innovative and integrated from a wide range of options. These last two elements allude to the importance of a broad viewpoint of environmental issues.

Randolph (2004) also discussed three primary objectives of CEP: develop a "shared vision," resolve conflict, and formulate creative solutions. It is important for the stakeholders to determine a vision or direction for their project that satisfies everyone to increase the likelihood of a successful outcome. Resolving conflicts through negotiation or mediation efforts early in the planning process can ensure successful collaboration throughout the duration of the project. Collaboration among stakeholders can generate innovative ideas and foster creative solutions to environmental issues.

Randolph and Bauer (1999) stated that stakeholder involvement is at the heart of collaboration. They went on to say that there are six primary tasks that lead to effective stakeholder involvement (Table 1). Inclusion of important stakeholders is emphasized; exclusion of stakeholders may undermine the process. The process must have structure to avoid confusion regarding the goals of the project. Achieving trust among stakeholders is very challenging, especially if stakeholder groups have diverse interests, but collaboration and team-building exercises with a good facilitator can accomplish this task. Collaborative learning is the desired result of CEP and leads to successful planning outcomes.

Table 1. Six tasks that lead to effective stakeholder involvement.
Adapted from Randolph and Bauer (1999).

Task	**Description**
Stakeholder Identification	Identify stakeholders at the beginning of the planning process; identify additional stakeholders as needed during the process
Commitment and Authority	Allow stakeholders to fully participate in all parts of the process; give them authority and responsibility so they will take ownership of the process
Process	The process should allow for full participation by stakeholders, have specific milestones and deadlines, and have a structure that organizes stakeholders into subgroups to make the work more manageable
Trust	Trust should be established early, as it is a critical component of achieving success of the planning effort
Leadership	"Quiet leadership" (e.g. facilitator) is needed to provide structure for the process, even though stakeholders should generally have shared authority
Collaborative Learning	Collaborative learning is the main goal of stakeholder involvement

Several benefits of CEP have been recognized in the literature. Active public involvement in the collaborative environmental decision-making process increases citizen power, which in turn creates a "strong democracy" (Barber 1984). Consensus building and collaboration can increase a community's social, intellectual, and political capital (Innes 1996, Mandarano 2008), and the same applies to CEP (Randolph 2004). Communities that are sustainable and promote economic development are most likely utilizing several types of capital (Flora et al. 2004). Collaboration has been found to reduce conflict among stakeholders and help them make better decisions (Conley and

Moote 2003). In the environmental realm, collaboration can help policymakers manage environmental systems and transboundary resources more effectively, preserve the integrity of ecosystems, and broaden the range of alternatives through innovative thinking (Randolph 2004). CEP has yielded success through many projects implemented across the country; contributions of some of those projects are highlighted in Table 2.

Table 2. Case studies where CEP was implemented to solve or manage an environmental problem.

Project	Contributions	Reference
Oregon Dunes National Recreation Area	CEP as applied to ecosystem-based management offers: • a systems approach to solving problems • realistic expectations for progress • accommodation of a wide range of worldviews about land management	Daniels and Walker (1996)
Chesapeake Bay Program	Improvement in bay quality achieved through partnership between members of all levels of government, the private sector, landowners, and citizens because of three factors: • clear regulations established and flexibility provided to achieve compliance • technical assistance and implementation grants available to finance compliance • effective partnership involving all stakeholders	Randolph and Rich (1998)
Brownfields Redevelopment	Since 1995, the EPA's Brownfields Program has engaged stakeholders to facilitate the prevention, assessment, cleanup, and redevelopment of brownfield sites in locations such as Gardena, California; Houston, Texas; and Boston, Massachusetts.	U.S. EPA (2009)

Wondolleck and Yaffee (2000) proposed four major reasons to collaborate: to build understanding; make wise decisions and build support for them; get work done; and develop agencies, organizations, and communities (Table 3). Environmental problems can be solved more easily when stakeholders share knowledge and educate each other. Collaboration can also reduce or even prevent conflicts among stakeholders, and it serves as a tool for determining solutions to problems that satisfy everyone. The work that is required to solve a problem can be done faster and more efficiently when stakeholders coordinate their efforts, share the workload, and pool their resources. Agencies, organizations, and communities can be developed or improved through collaboration, which can lead to better management of natural resources.

Table 3. Benefits of collaboration. From Wondolleck and Yaffee (2000).

Reasons to Collaborate	Examples
Building Understanding	• Information sharing • Learning from the public • Educating the public • Managing uncertainty through joint research and fact-finding
Making Wise Decisions and Building Support for Them	• Solving common problems • Resolving disputes • Building concurrence and support
Getting Work Done	• Coordinating efforts • Sharing management responsibility • Mobilizing resources
Developing Agencies, Organizations, and Communities	• Building staff capabilities • Developing communities

Wondolleck and Yaffee (2000) also said that along with the benefits, there are barriers to collaboration. They can be divided into two groups: institutional and structural barriers and barriers due to attitudes and perceptions. These barriers are listed in Table 4. Collaboration can be hindered when stakeholders do not see reasons to collaborate, stakeholders do not have enough common interests to see the project through to the end, bureaucracy causes institutional inflexibility, and resources for collaborating are inadequate. Lack of trust among stakeholders, stereotypes or false assumptions about stakeholder groups, differing values and traditions of stakeholders, and uncertainty regarding the unseen consequences of collaboration also contribute to the hindrance of collaboration. It is important to note that in some cases, collaboration may not be an ideal method of solving a problem. For example, Wondolleck and Yaffee (2000) said that collaboration should probably not take place when it would compromise the values of stakeholders or when there is an imbalance of power among them.

Table 4. Barriers to collaboration. From Wondolleck and Yaffee (2000).

Institutional and Structural Barriers	Barriers Due to Attitudes and Perceptions
Lack of opportunity or incentives	Mistrust
Conflicting goals and missions	Group attitudes about each other
Inflexible policies and procedures	Organizational norms and culture
Constrained resources	Lack of support for collaboration

The dynamic nature of social and political environments and the complexity of environmental issues underscore the need for the implementation of a sound collaborative process in environmental planning. Collaborative theory can help resource managers identify strengths and weaknesses in their collaborative process. Selin and Chavez (1995) developed a collaborative process, which was later revised by Bentrup (2001), that can be applied to natural resource management. This general process calls for finding reasons to collaborate, determining the problem to be solved and which stakeholders are needed to solve it, deciding how to go about solving the problem, formulating a plan of action, then implementing that plan. Perhaps the most important component of a collaborative process is recognizing that it is an iterative process, and that some steps may need to be revisited before implementing a plan of action.

CEP can be applied to an array of specific environmental problems that require environmental management. Several studies have applied CEP to ecosystem management (Brody 2001 and 2003, Mandarano 2008) and watershed management (McGinnis et al. 1999, Bentrup 2001, Leach et al. 2002, Imperial 2005, Hermans et al. 2007). Randolph (2004) stated that ecosystem management and watershed management are examples of comprehensive approaches to planning that incorporate several aspects of environmental management. These approaches take into consideration ideas such as planning at variable scales, engaging stakeholders, and using adaptive management, which is an iterative process that addresses uncertainty, to improve the planning process. Randolph (2004) went on to say that it has been recognized that combining ecosystem management or watershed management with collaborative planning practices results in more effective environmental management. Watershed management is relevant to this research and is discussed further in the following section.

2.2.2 Watershed and Transboundary Water Resources Management

The U.S. Environmental Protection Agency (EPA) recognized that federal laws lacked an integrated approach to managing nonpoint sources of pollution that threaten water quality and developed “A Watershed Approach” in 1996 (U.S. EPA 2012b). This approach to planning applies the concepts of watershed management in that it is hydrologically defined, involves all stakeholders, and addresses specific water resource goals (U.S. EPA 2012c). The EPA developed the “Handbook for Developing Watershed Plans to Restore and Protect our Waters,” and the handbook’s purpose is to provide “information on developing and implementing watershed management plans that help to restore and protect water quality” (U.S. EPA 2012d). Water supply planning is not addressed in the handbook.

The importance of addressing water quality issues at the watershed level is explained by Schueler and Holland (2000). As the size of the watershed management unit decreases, the influence of impervious cover increases, leading to a greater risk for poor water quality. This relationship calls for different management strategies for different sizes of hydrologic areas (Table 5). Schueler and Holland (2000) made the argument that the subwatershed is an ideal level for planning because impervious cover strongly influences hydrology, water quality, and biodiversity, while the number of political jurisdictions and stakeholders involved is reduced due to the small size of the planning unit.

Table 5. Characteristics of watershed management units. From Schueler and Holland (2000).

Watershed Management Unit	**Typical Area (square miles)**	**Influence of Impervious Cover**	**Sample Management Measures**
Catchment	0.05 to 0.50	Very strong	Practices and site design
Subwatershed	1 to 10	Strong	Stream classification and management
Watershed	10 to 100	Moderate	Watershed-based zoning
Subbasin	100 to 1,000	Weak	Basin planning
Basin	1,000 to 10,000	Very weak	Basin planning

As mentioned in Chapter 1, the terminology used to describe hydrologic regions is ambiguous and rather confusing. Some terms, such as “watershed” and “basin,” are often used interchangeably, but in some cases they have different definitions according to their size (see Table 5). In order to avoid confusion over terminology, this research attempts to separate the various terms for hydrologic regions. The U.S. Geological Survey (USGS) defines hydrologic regions in a more systematic fashion. The USGS’s standardized hydrologic mapping system is used in this research and is explained further in Appendix A.

Watershed management often involves addressing the issue of transboundary water resources. Issues that must be considered regarding transboundary water resources management for basins that cross international boundaries have been well documented (Varady and Morehouse 2003, Biswas 2008, Valiante 2008, Ganoulis and Fried 2011, Nitikina et al. 2011). The U.S. shares a geopolitical border with Canada and Mexico, and there are several transboundary river basins shared by the U.S. and Canada, as well as the U.S. and Mexico. Transboundary water resources management has been addressed by treaties and the creation of commissions, which are discussed below.

The International Joint Commission (IJC) is an organization that was created by the U.S. and Canada to foster cooperation between the two countries regarding transboundary water resources issues (IJC 2014). It is guided by the Boundary Waters Treaty of 1909, which provides principles for the U.S. and Canada to follow for resolving water disputes and other transboundary issues. The primary responsibilities of the IJC are to regulate shared water uses and investigate transboundary issues, recommending solutions that satisfy all parties involved. The IJC also aims to improve water and air quality.

The International Boundary & Water Commission (IBWC) is concerned with water resources and international boundary issues between the U.S. and Mexico (IBWC 2014). Initially, the International Boundary Commission was established in 1889 to enforce the international boundary between the U.S. and Mexico. Since that time, water usage of the Colorado River and the Rio Grande River has increased due to rapidly growing population. In 1994, the organization expanded to become the International Boundary & Water Commission, which addresses the allocation of water between the U.S. and Mexico regarding the two rivers. In addition to water allocation, the IBWC protects lands from flooding along the two rivers through various projects and addresses water quality issues at the border.

In order to discuss watershed and transboundary water resources management with respect to drought, it is important to examine how drought is addressed in natural hazard planning, which is a sub-discipline of environmental planning. An overview of natural hazard planning and how drought fits in as a unique natural hazard is discussed in the following section.

2.2.3 Natural Hazard Planning

Another component of environmental planning is natural hazard planning. Natural hazards are often very costly and endanger people's lives. Most hazards are either geologic in nature, such as earthquakes and volcanic eruptions, or they are caused by weather and/or climate, such as tornadoes and hurricanes. Very few, if any, regions are safe from all natural hazards, so planning for them is necessary. Assessing the risk that natural hazards pose to people, their property, and the environment requires understanding what types of hazards might occur in a particular region, who and what are exposed to the hazards, and how vulnerable are the exposed population and environment to the hazards (Figure 2). Planning can reduce risk if people are educated on how they can decrease the degree of a hazard, as well as decrease their exposure and vulnerability to a hazard. This type of planning is part of hazard mitigation, which aims to reduce the effects of natural hazards in the long term (Randolph 2004). The need for managing natural hazards more effectively led to the creation of the Natural Hazard Mitigation Program, initiated by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (hereafter referred to as the Stafford Act) that was signed into law in 1988. The Stafford Act (1988) requires states to have a natural hazard mitigation plan, which is called a 409 Plan. The plan is approved by the Federal Emergency Management Agency, and the Act promotes the development of mitigation-related projects through the provision of grants. The Act was amended in 2000 in part to improve the 409 planning process and require local mitigation plans.

Figure 2. Relationship between hazard, exposure, vulnerability, and risk. From Randolph (2004).

Several approaches to planning have been offered that are intended to protect life and property from a number of natural hazards (Burby 1998, Godschalk et al. 1998, Randolph 2004), but none of these approaches seem to be a good fit for drought. Drought is a natural hazard that is not like any other. It often develops and abates slowly, and it can have a broad spatiotemporal extent. Impacts are mostly nonstructural, causing very little physical harm to life and property and making them difficult to quantify. Some impacts, such as those on agriculture, may occur outside of the region that is directly experiencing drought. Drought is not easily defined because differences in regional climate make it a relative condition. As mentioned in Chapter 1, drought is very expensive, costing an average of $7.4 billion per year in the U.S. from 1980-2012 (Lott et al. 2013). While droughts and heat waves only constituted 17% of the total frequency of billion dollar weather disasters from 1980-2003, they accounted for 41.2% of the damages (Ross and Lott 2003). It is evident that planning for drought is as important as planning for other natural hazards, but planners should develop strategies that consider drought's uniqueness as a natural hazard.

2.2.3.1 Drought Planning

Drought planning is occurring at a variety of scales (NDPC 2000, Wilhite et al. 2007). The scope of drought planning activities commonly centers upon a geopolitical unit, such as a state. This research focuses on planning for drought at the scale of a basin, which is defined by natural boundaries. The following section provides an overview of drought planning in the U.S. at various scales, beginning with planning that takes place around geopolitical boundaries, and then planning that occurs around natural boundaries.

2.2.3.1.1 Planning for Drought around Geopolitical Boundaries

As stated by Wilhite (1983), the federal government's role in drought can be traced back to the late 1800s. Historically, its earliest efforts to address drought consisted of relief and response activities. He went on to say that federal drought relief became more formalized during the Dust Bowl drought of the 1930s under the administration of President Franklin D. Roosevelt. During this time period, the U.S. Department of Agriculture (USDA) implemented the first federal drought planning activities to help Great Plains farmers reduce drought risk through better agricultural management practices. The USDA then pioneered an effort to develop long-range water resources planning during widespread drought in the 1950s.

After the U.S. suffered from drought episodes in each decade following the 1950s, and especially drought episodes in the mid-1990s, it was evident that a national drought policy that takes a coordinated, proactive approach to drought planning was needed to reduce vulnerability to and improve preparedness for drought. The National Drought Policy Act (NDPA) was signed into law in 1998 and called for an integrated and coordinated federal policy that emphasizes risk management over crisis management (NDPA 1998). The NDPA also established the National Drought Policy Commission (NDPC), which was chaired by the Secretary of USDA and was comprised of representatives from the private sector and federal, tribal, state, and local levels. In its report, the NDPC outlined how to integrate drought programs at each level of government, improve public awareness of the importance of drought preparedness, and coordinate drought response and mitigation efforts of both governmental and nongovernmental institutions (NDPC 2000).

The NDPC's recommendations eventually led to the enactment by Congress of the National Integrated Drought Information System (NIDIS) Act in 2006. NIDIS is under the umbrella of the National Oceanic and Atmospheric Administration (NOAA) and is intended "to improve drought monitoring and forecasting capabilities" (NIDIS 2006). NIDIS was envisioned by the Western Governors' Association and NOAA as an entity that would include a collaboration of federal and non-federal partners, scientists, water users, and policymakers to facilitate a proactive approach to drought (WGA 2004). NIDIS's governance structure, working groups, and pilot program were outlined in an implementation plan (NIDIS 2007). Currently, NIDIS has seven active pilot regions in which early warning and drought risk reduction strategies are occurring. The pilot regions are as follows: Apalachicola-Chattahoochee-Flint (ACF) River Basin, California, Coastal Carolinas, Four Corners Tribal Land, Midwest, Southern Plains, and Upper Colorado

River Basin. NIDIS houses drought information on the U.S. Drought Portal, found at www.drought.gov.

According to Wilhite and Wood (1985), severe drought episodes in the 1970s caused some state officials to recognize the value in developing a drought plan for their states to reduce the effects of water shortages and address localized drought impacts. Wilhite and Wood (1985) also said that despite their wetter climate, states in the eastern U.S. first began developing drought plans to manage higher demand on water supplies caused by increasing population. Other reasons found to explain development of state drought plans during this time period include adoption of the New Federalism initiative under the Reagan administration that called for the reduction of governmental influence in local affairs, and the desire of states to maintain jurisdiction over their own water resources (Wilhite and Rhodes 1994). Subsequent drought episodes have continued to prompt the development of state drought plans.

Unpublished research conducted by National Drought Mitigation Center (NDMC) staff found that state drought plans have historically been response-oriented, but many states have been developing plans that emphasize mitigation since the mid-1990s. They said this could be due to the occurrence of major regional drought events, such as those that occurred in the late 1990s and early 2000s. Additionally, the pattern of development of mitigation-based state drought plans could be explained by the implementation of national drought policy initiatives, such as the creation of the NDMC in 1995 and the passing of the National Drought Policy Act of 1998, which established the National Drought Policy Commission.

The NDMC has worked to keep up to date on the status of state drought plans as they are developed or revised. The NDMC maintains a database that contains details on the characteristics of each plan (NDMC 2014a). Currently, there are 45 states that have drought plans, 13 of which are mitigation-based (Figure 3). Five states do not have drought plans, but two of them are in the process of developing plans. Mississippi is a special case, as it delegates drought planning to local authorities.

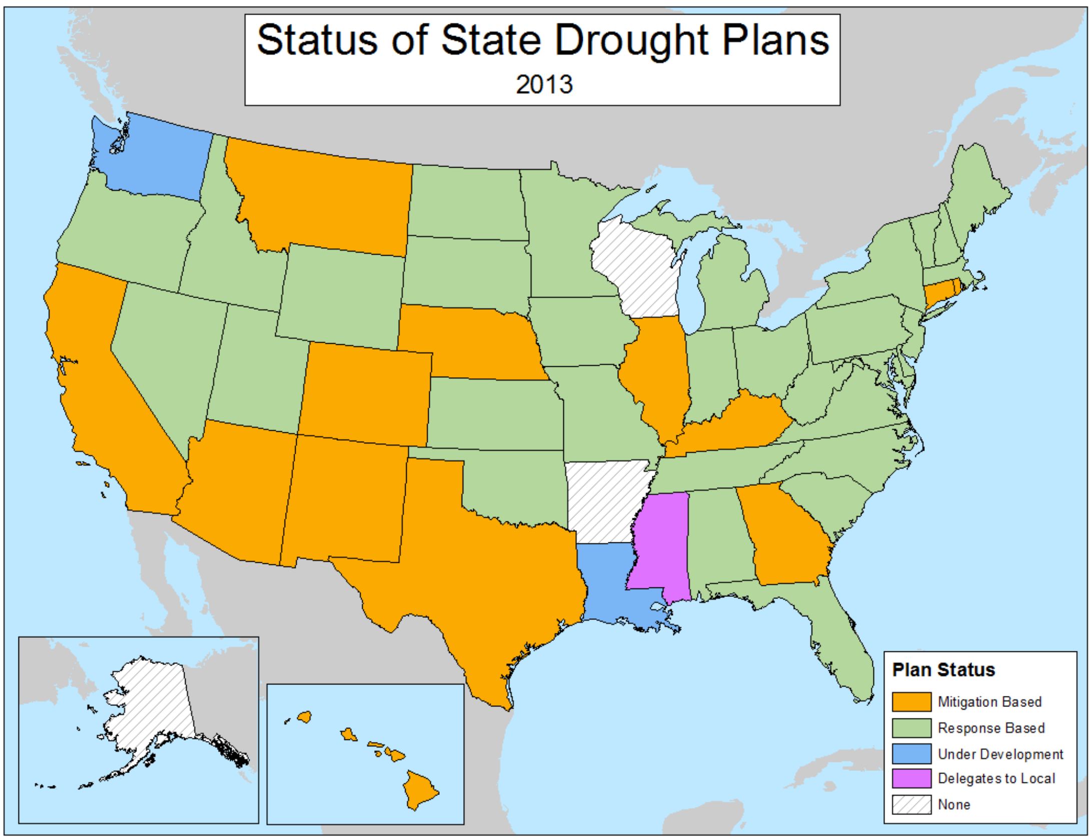

Figure 3. Status of state drought plans 2013. From NDMC (2014a).

Native American tribes have also recognized the value of planning for drought. According to the NDPC (2000), approximately 95% of tribal lands are located west of the Mississippi River where water is limited even without the presence of drought. The

NDPC (2000) went on to say that several tribes were working with the U.S. Bureau of Reclamation to develop drought contingency plans. The NDMC has also worked with Native American tribes to assist them with the development of their plans. One tribe in particular, the Hualapai tribe, experienced several drought episodes in the 2000s and subsequently developed a drought plan that became the first of its kind in the Lower Colorado River Basin (Knutson et al. 2007). Knutson et al. (2007) found that while Native American tribes must contend with challenges similar to those encountered by non-tribal groups when planning for drought, they do encounter unique issues, such as resistance to drought planning due to cultural and religious beliefs.

Drought planning also occurs at the local level, which includes counties, cities, and even public water utilities. For example, Santa Barbara County, California; Chandler, Arizona; and Denver Water all have drought plans (NDMC 2012b). Drought-Ready Communities is a project that was developed from a partnership between several institutions, led by the NDMC, which aims to assist local-level planners with reducing the risk of drought through use of the “Guide to Community Drought Preparedness” (NDMC 2014b). Case studies were conducted in three pilot communities: Nebraska City, Nebraska; Decatur, Illinois; and Norman, Oklahoma. Also, the American Planning Association published “Planning and Drought,” a publication that was made possible through a joint effort with the NDMC and NIDIS that discusses how planners can approach the issue of drought (Schwab 2013). Case studies that were discussed in the publication include Athens-Clarke County, Georgia; Albuquerque, New Mexico; and Tampa Bay Water. The case studies from both of these publications were conducted to provide examples of how planners address drought at the local level.

2.2.3.1.2 Planning for Drought around Natural Boundaries

It was mentioned in Chapter 1 that planning for water around natural boundaries can be rather complex given that political boundaries were not established to accommodate natural systems. Larger river basins require regional, and sometimes national, policy and management (NRC 1999). Planning activities that occur in transboundary basins require the involvement and collaboration of stakeholders from all geopolitical jurisdictions that are wholly or partially contained within the basin (Randolph 2004). A major key to effective basin planning is to bring water users together to discuss their needs, and then ensure that water is appropriately allocated among competing uses (Daniels and Daniels 2003).

Planning for transboundary basins can be challenging even when water is plentiful, so the presence of drought further complicates planning at this level. Water use sectors find themselves competing over water more than ever during drought episodes. In the western U.S., the prior appropriation doctrine permits senior water rights holders to use all of the water they are entitled to during a drought, leaving the junior water rights holders with no water at all (Daniels and Daniels 2003). In spite of this issue, a basin is highly recommended as the optimal planning scale for drought (NDPC 2000, Wilhite et al. 2007, NIDIS 2008) and general water management (Powell 1890, U.S. Congress 1993, NRC 1999).

According to the National Research Council (1999), the federal agencies with the most significant responsibilities related to water supply planning at the basin level are the U.S. Bureau of Reclamation and the U.S. Geological Survey (Department of the Interior), the International Boundary and Water Commission (Department of State), the Tennessee Valley Authority (TVA), and the Bonneville Power Administration. Agencies with some related responsibilities are the U.S. Forest Service and the U.S. Agricultural Research Service (Department of Agriculture), the U.S. Army Corps of Engineers (Department of Defense), and the U.S. Environmental Protection Agency. TVA is one of the earliest examples of planning at the basin level in the U.S. and is discussed below.

Created by the Tennessee Valley Act of 1933 as an independent federal agency, TVA was established by Congress under the administration of Franklin D. Roosevelt as part of the New Deal to help bring the U.S. out of the Great Depression through delivery of low-cost electricity and integrated resource management (TVA 2012). TVA has built dams and undertaken hydroelectric projects to generate enough electricity to claim the title as the nation's largest public power provider, and it has been fully supported by power revenues since 1999. The generation of electricity is perhaps TVA's greatest contribution to improving the quality of life in the region because it attracted industries that created jobs and it provided affordable energy to supply power to modern appliances. According to TVA (2012), TVA operations initially focused on flood control, navigation, and hydropower, but operations have since expanded to consider recreation, water supply, water quality, and the aquatic environment.

TVA is engaged in and takes a regional approach to drought planning. In 2007, the Tennessee River Valley was experiencing severe drought, and it was successfully managed with guidance from the Tennessee Valley Water Partnership, a group that was created to improve regional cooperation of water resource management (TVA 2007). The partnership is comprised of representatives from each Tennessee River Valley state, the

U.S. EPA, and the U.S. Geological Survey (USGS), with TVA serving as the facilitator. According to the TVA (2007), the partnership recognizes that the Tennessee River is a shared resource that flows across political boundaries, and it has fostered communication and collaboration among the states while allowing them to retain autonomy over their own planning strategies, laws, and regulations. TVA's role in drought planning for the Tennessee River Basin is discussed further in Section 4.1.10.

Planning for water resources at the basin level became more prevalent in the 1940s-1950s when the government established interagency committees in several river basins, and then in the 1960s-1970s due to the establishment of several river basin commissions through the Water Resources Planning Act (NRC 1999). Congress established this act in order to address increasing water demands across the country (WRPA 1965). The National Drought Policy Commission (NDPC) (2000) stated that a severe drought was plaguing the northeastern U.S. during this time period, and high water demand in New York City and the risk of saltwater intrusion into Philadelphia's water supply prompted President Lyndon Johnson to call a meeting in the Delaware River Basin to address these issues just one month after the act was signed into law. The NDPC (2000) went on to say that President Johnson requested funds from Congress to create the North Atlantic Regional Study (NARS), a framework that could be followed for river basin studies in the North Atlantic region. NARS and the Water Resources Planning Act were precursors to current federal rules for water resources planning that emphasize a basin perspective. The NDPC (2000) noted that federal funds for this program were terminated in 1981, but some river basin commissions survived by locating alternate funding. The commissions that survived have taken different directions in addressing water resource issues, and some of them are addressing drought.

The Delaware River Basin Commission (DRBC), created in 1961, is very active in drought management and boasts a number of drought mitigation programs being implemented in the basin. Hansler (1991) stated that at the time of the DRBC's formation, the Delaware River Basin was following a 1954 U.S. Supreme Court decree that apportioned the river through the implementation of release requirements and the construction of reservoirs based on the drought of the 1930s. He went on to say that the drought of the mid-1960s was much more severe than the 1930s drought in the Northeast and became the Delaware River Basin's new drought of record. As a result, the U.S. Army Corps of Engineers (hereafter referred to as the Corps) undertook what they called the Tocks Island Project, aimed at providing adequate water supplies based on the new drought of record, but concerns voiced by environmentalists ultimately led to the suspension of this project and the conduct of the Level B comprehensive restudy by the DRBC. Hansler (1991) said that as part of this restudy, parties of the 1954 decree (Delaware, New York, New Jersey, Pennsylvania, and New York City) entered into "good faith negotiations" and developed recommendations that later became part of the basin's drought management plan. The plan was implemented successfully during the mid-1980s drought that occurred in the basin, and the DRBC has continued to build upon those successful drought mitigation strategies. The Delaware River Basin's drought management program has been praised and cited as an example of a basin that is successful at coordinating drought management procedures across several levels of government (U.S. Congress 1993, NDPC 2000, Randolph 2004). DRBC drought planning activities are discussed further in Section 4.1.3.

Drought management is also occurring in the Susquehanna River Basin. According to the NDPC (2000), the Susquehanna River Basin Commission (SRBC) was created in 1970 and bases much of its structure on that of the DRBC. It allows stakeholders the opportunity to evaluate the drought management process, especially after a drought has ended. The SRBC has developed a drought plan for the basin, which heavily emphasizes coordination among the states of New York, Pennsylvania, and Maryland, to solve drought-related issues in the basin (SRBC 2000). The plan addresses drought management activities of the three signatory states and the Corps, as well as coordination with the DRBC. SRBC drought planning activities are discussed further in Section 4.1.9.

Water management in the Potomac River Basin is governed by the Interstate Compact on the Potomac River, formed under the Potomac Valley Compact of 1940 (NDPC 2000). Congress ratified the interstate compact but the member states (Maryland, Virginia, and the District of Columbia) never signed it. The NDPC (2000) stated that the Interstate Commission on the Potomac River Basin (ICPRB) is currently responsible for drought planning activities in the basin, and the core of activities centers upon the execution of annual drought exercises, which involve several agencies from Maryland, Virginia, and the District of Columbia. The NDPC (2000) went on to say that the exercises are intended to educate new personnel and refresh older personnel on water management issues in the basin. The ICPRB, in contrast to the DRBC, has no regulatory authority, but it has been deemed successful at mediating disputes and managing water supplies for a highly populated basin (U.S. Congress 1993). ICPRB drought planning activities are discussed further in Section 4.1.7.

As stated by Crane (1991), the Great Lakes Commission (GLC) is a multistate compact agency that was formed in 1955 to facilitate the sharing of information and regional coordination on water resource issues that impact the Great Lakes Basin. Crane (1991) stated that under the Great Lakes Basin Compact, the GLC ensures that water is conserved and used appropriately throughout the basin, and it allocates water to various water use sectors. He went on to say that after a severe drought in 1988, the GLC made drought management a high priority and proposed a coordinated regional planning framework for the basin. This framework included the establishment of a task force made up of the eight U.S. states in the basin, the Canadian province of Ontario, and several American and Canadian federal agencies. The task force published a guidebook for drought planning and response to be used by local officials, conducted a symposium on how to deal with changing water levels due to drought and other climate events, and developed policy recommendations related to taking a regional approach to drought planning. Crane (1991) noted that one issue that the Great Lakes region continues to deal with is requests for water diversions and out-of-basin transfers. The Great Lakes Charter, created in 1985, addresses such requests, and its signatory members consult on the proposed projects and then approve or disapprove them. While many requests for diversions and out-of-basin transfers have been rejected by the signatories of the Great Lakes Charter, the potential for reduced water due to climate change may increase the demands for these types of projects in the Great Lakes Basin (Koshida et al. 2005). Despite these challenges, the U.S. and Canada have developed a solid working relationship to address water resource issues across this transboundary basin (NDPC 2000). The GLC drought planning activities are discussed further in Section 4.1.4.

Drought planning in the Missouri River Basin has historically been the responsibility of the Corps. The Corps is the nation's largest water resource developer and addresses water resource development activities such as flood control, navigation, recreation, and infrastructure (USACE 2014). According to Opper (1994), in 1960 the Corps drafted what became known as the Master Manual, a planning framework for the Missouri River that addressed issues such as minimum pool storage, length of the navigation season, and minimum flow levels required for navigation purposes during times of drought. He stated that the Master Manual was tested during the severe drought of 1987-92 in the basin, but it did not prove to be an effective process to follow during drought. As the drought that began in the late 1980s continued into the early 1990s, the Corps developed several drafts of the Missouri River's Annual Operating Plan, but lawsuits were filed against the Corps over disputes among water use sectors and the Corps' management of the river system during the drought. The Missouri River Basin Association (MRBA) then stepped in and began working with the Corps to improve drought management strategies in the basin, including assisting with the development of the Missouri River's Annual Operating Plan. Opper (1994) said that the intervention of the MRBA contributed to the successful resolution of many conflicts in the basin, and it was determined that the MRBA drought management process was a more befitting method for addressing drought. Thomsen (1994) recommended that stakeholders plan in advance for drought in the Missouri River Basin to reduce complacency between drought periods. After following up on drought planning activities in this basin, it was determined that, according to D. Kluck (NOAA, 2011, personal communication), there were no formal drought planning activities occurring at the time of correspondence in the Missouri River Basin. More recently, however, NIDIS has announced that the Missouri River Basin is going to become a new NIDIS pilot region and it had a kickoff meeting in February 2014 (NIDIS 2014b), which may prompt new drought planning activities.

It was mentioned earlier in Chapter 2 that NIDIS currently has seven active pilot regions that are called Drought Early Warning Systems. These systems were established to determine best practices for integrated drought management that can be transferred to underserved regions of the country (NIDIS 2012a). Two of the regions focus on the basin scale; one of these regions is the Colorado River Basin. According to NIDIS (2007), the Colorado River Basin was chosen by NIDIS as a pilot region because drought has persisted and population is growing rapidly in the basin, causing a substantial increase in water demand. Also, the basin is shared by seven U.S. states and Mexico, which further exacerbates water management issues. Initial focus has been placed on the upper portion of the basin while second-stage activities are planned for the lower portion of the basin. Pulwarty et al. (2005) suggested regional basin planning as one viable approach to conservation and demand management of the Colorado River, as well as reduction of its vulnerability to drought. Upper Colorado River Basin drought planning activities are discussed further in Section 4.1.11.

The other NIDIS pilot region that focuses on a basin is the Apalachicola-Chattahoochee-Flint (ACF) River Basin. NIDIS (2012b) stated that activities for the ACF River Basin pilot began in December 2009 with a kick-off meeting in Lake Blackshear, Georgia. Issues being addressed in this pilot region include gaps in understanding, gaps in measurements, presentation of information, education, drought indicators, and forecasting. ACF River Basin drought planning activities are discussed further in Section 4.1.1.

2.3 Summary

While the practice of collaborative environmental planning (CEP), watershed management, transboundary resource management at the international level, and drought planning have been documented in the literature, there are several gaps in the literature that this research has attempted to fill. CEP has become a popular sub-discipline of planning since its inception in the 1990s and, as mentioned in Chapter 1, more research is needed to assess its effectiveness with regard to solving environmental problems. Watershed management is an even newer planning approach that deserves further research on its applicability to different types of environmental issues. The literature indicates that watershed management largely focuses on smaller watersheds where water quality is a bigger problem than water supply (Schueler and Holland 2000, U.S. EPA 2012d). This research shows how CEP is being used to address drought that occurs in transboundary water bodies, and it demonstrates how watershed management differs depending on the size of the water body and the types of environmental issues being addressed. Additionally, no literature was found that directly addresses transboundary water resources management at the U.S. state level, so this research helps fill that gap in the literature.

While it is clear that drought planning that focuses on basins is occurring in the U.S., the basins discussed in the literature are not the only ones planning for drought.

Also, some of the literature that highlights the aforementioned basins is not very recent, so an update on the status of drought planning in these basins is needed. A more comprehensive inventory of basins that are planning for drought would contribute to an overall understanding of why agencies are choosing to plan for drought at this level, as well as how they approach planning similarly or differently at this level, as opposed to planning for drought around political boundaries.

Overall, the review of literature concerning CEP and drought planning for basins was very influential in informing the methodology of this research, which is described in the following chapter. The results of this research are expected to contribute to both bodies of literature mentioned above because the research explored how CEP is being used to address drought planning for transboundary basins. This contribution to the literature was accomplished by interviewing basin-level drought planning experts about how their agencies address the challenge of collaborative planning for a transboundary water resource. The conclusions of this research will be shared with drought planning experts so that they have the opportunity to implement innovative strategies that were developed by experts in other basins.

CHAPTER 3

METHODS

3.1 Determination of Study Regions

This chapter on the research methodology describes the process that was used to address the research questions presented in Chapter 1. The first task was to determine which basins would be included in this research as study regions. The criteria that were used to select the study regions are as follows: 1) the study region had to have natural boundaries, such as a river basin, 2) the study region had to have either a drought plan or drought planning activities focused around the scale of a basin, and 3) the study region had to be transboundary in nature, preferably crossing multiple state or international boundaries.

In order to find basins that meet these criteria, several methods were employed. The NDMC has collected drought and water management plans and planning information for all levels of planning, including basins, so the NDMC's collection of plans was examined first. After reviewing the NDMC's collection, an Internet search was conducted to find additional basins engaged in drought planning activities that were not in the NDMC's collection of plans. Some of the NDMC personnel, who have gained knowledge of drought planning activities through involvement in a variety of projects, provided expertise to help determine specific basins that should be included in the Internet search. Phone calls were made and e-mails were sent to verify that the collected data were accurate. It should be noted that surveys were not used as a method for obtaining this information because basins comprise multiple scales and categories, so it would be difficult to target a specific group to survey (see Seaber et al. 1987). Additionally, the difficulty of finding a representative sample of survey participants that could adequately discuss drought management for basins would have made the utilization of the survey method rather complex and likely would not have revealed the information needed to answer the research questions proposed for this project.

After the initial round of Internet searches, spatial gaps were identified where no basins were found to be planning for drought and no one had been contacted regarding this type of drought planning in those regions. The chain referral method was used to carry out this task. The chain referral method is an alternative to snowball sampling that involves strategically accessing several networks and groups to expand the scope of the research (Penrod et al. 2003). Several climate and water groups, including NIDIS, staff from Regional Climate Centers, state climatologists, and water resources personnel, were consulted to obtain information on drought planning for basins in their respective regions. These individuals helped to confirm or disconfirm the occurrence of drought planning at this level in their regions. It is important to note that the study regions identified by this research may not be an exhaustive list of basins planning for drought in the U.S., but it does represent those identified in the literature and by experts in the field.

The research conducted using the methods discussed above yielded twelve basins that met the criteria to become study regions for this research (Figure 4). According to the USGS's hydrologic mapping system, the smallest hydrologic unit of the study regions is a basin, so for uniformity purposes the study regions will be referred to hereafter as basins. These basins represent a variety of sizes, climate types, and have experienced various major drought events (Table 6), and they also represent different population sizes, water uses, and management styles (Table 7).

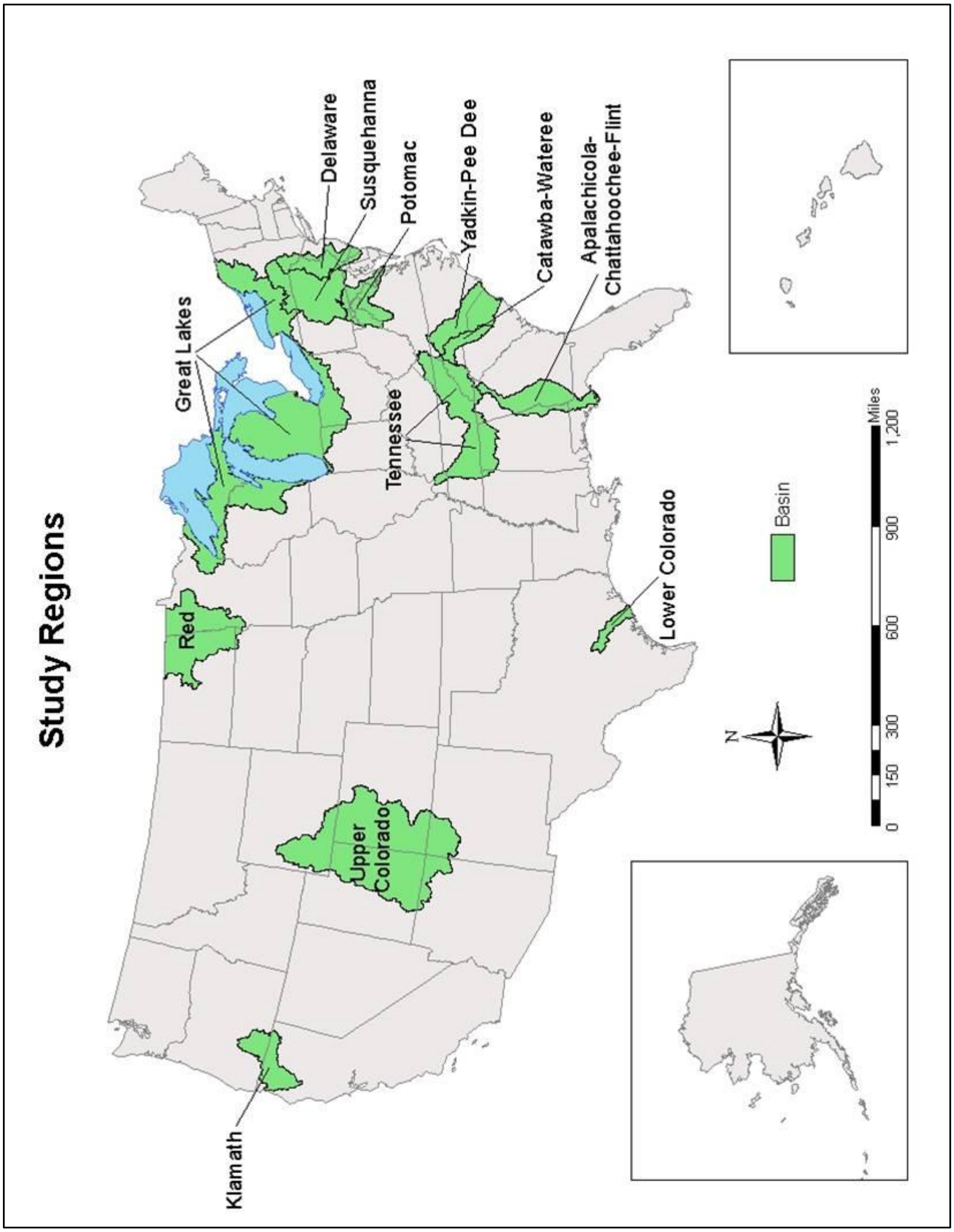

Figure 4. Basins where drought planning is occurring and that were included for analysis.

Table 6. Sample of physical characteristics of basins in the U.S. where drought planning is occurring.

Basin	Hydrologic Unit*	Primary Climate Type(s)**	Drought of Record
Apalachicola-Chattahoochee-Flint	Subregion/ Basin***	Warm temperate (fully humid, hot summer)	1986-1988
Catawba-Wateree	Basin	Warm temperate (fully humid, hot summer)	2007-2008
Delaware	Subregion	Warm temperate (fully humid, hot summer), Snow (fully humid, warm summer)	Mid-1960s
Great Lakes	Region	Snow (fully humid, warm summer)	1988
Klamath	Basin	Warm temperate (summer dry, warm summer)	1992 and 1994
Lower Colorado (Texas)	Basin	Warm temperate (fully humid, hot summer)	1950s
Potomac	Subregion/ Basin***	Warm temperate (fully humid, hot summer)	1930s
Red	Subregion	Snow (fully humid, warm summer)	1930s
Susquehanna	Subregion	Warm temperate (fully humid, hot summer), Snow (fully humid, warm summer)	1960s
Tennessee	Region	Warm temperate (fully humid, hot summer)	2007
Upper Colorado	Region	Arid (Steppe, cold arid), Snow (fully humid, warm summer & cool summer)	2000s
Yadkin-Pee Dee	Basin	Warm temperate (fully humid, hot summer)	2001-2002

*From U.S. Geological Survey (Seaber et al. 1987)
**Using Köppen-Geiger Climate Classification System (Kottek et al. 2006)
***Units have same name and square mileage

Table 7. Sample of social characteristics of basins in the U.S. where drought planning is occurring.

Basin	**Transboundary States**	**Approximate Population (millions)**	**Primary Water Use**	**Participant(s) Agency Type and # of People Interviewed**
Apalachicola-Chattahoochee-Flint	Alabama, Florida, Georgia	3.5-4	Flood control, energy, navigation	State government (1)
Catawba-Wateree	North Carolina, South Carolina	2	Energy, public water supply	Energy company (1)
Delaware	Delaware, New Jersey, New York, Pennsylvania	15	Energy, public water supply	Basin organization (3)
Great Lakes	Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Ontario†, Pennsylvania, Quebec†, Wisconsin	35	Public water supply	Basin organization (1)
Klamath	California, Oregon	0.114	Agriculture, habitat, tribal	State government (1)
Lower Colorado (Texas)	None	2	Agriculture, public water supply	Basin organization (1)
Potomac	District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia	5.3	Public water supply	Basin organization (1)
Red	Manitoba†, Minnesota, North Dakota, South Dakota	1.3	Public water supply, agriculture	Basin organization (1)
Susquehanna	Maryland, New York, Pennsylvania	4.2	Public water supply, energy	Basin organization (2)
Tennessee	Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, Virginia	4.7	Energy, public water supply	Energy company (3)
Upper Colorado	Arizona, Colorado, New Mexico, Utah, Wyoming	30 (entire Colorado Basin)	Agriculture, public water supply	State government (1), federal government (1)
Yadkin-Pee Dee	North Carolina, South Carolina	1.7 (North Carolina portion of the basin)	Recreation, habitat, energy, public water supply	Energy company (1)

†Canadian province

Since only twelve basins were identified as meeting the study region criteria, it was decided that all of them would be included in the research to become case studies rather than taking a sample of them to study. Another reason for including all of the basins relates to one of the purposes of this research: to increase the breadth of knowledge of drought planning for basins. The Lower Colorado River Basin (Texas) is a special case because it does not meet the criterion of crossing multiple state or international boundaries. It was still included in this research as a study region because the basin organization responsible for water and drought planning for the basin has been recognized by other Texas basin organizations as setting a good example for how a basin should be managed during drought, according to the participant who was interviewed on behalf of the Lower Colorado River Basin. The Lower Colorado River Basin does span multiple counties and includes the city of Austin, Texas, so collaboration and coordination are necessary components of the management of the river during drought. The basin also experienced severe drought in 2011, making it a very interesting case study.

3.2 Data Collection Methods

After determining the study regions for the research, it was decided that interviews would be conducted to collect the data because there were only 12 basins meeting the criteria for the research. The first task of data collection was to identify interview participants. Since this research involved human subjects, the project underwent review and was approved by the Institutional Review Board at the University of Nebraska-Lincoln (UNL). All participants were required to sign an informed consent form before they were allowed to participate in the project. It was important that the interview participants were the ones most knowledgeable about drought planning in a particular basin to ensure that the most in-depth and accurate information was collected. Initially, potential participants were identified by finding information on contact persons listed on a basin’s drought plan or agency’s website, or through the NDMC’s list of contacts. In some cases, it was determined that the person initially contacted on behalf of a basin was the most appropriate one to interview. In other cases, the person initially contacted referred the researcher to another person thought to be a more appropriate candidate for being interviewed, and then in yet other cases that person may have referred the researcher to another potential interview participant, and so forth, until the most knowledgeable and appropriate person was identified to be interviewed. In the case of three of the basins, two or three interview participants were permitted to participate because the initial participant recommended that other experts participate in the interview in order for the researcher to get several perspectives on drought management in the basin. A total of 18 people representing the 12 basins were interviewed for this research.

Semi-structured phone interviews were conducted to give participants the opportunity to elaborate on topics they deemed important or relevant to drought management for their particular basin. Initial interviews were conducted between December 2011 and August 2012. After follow-up with interview participants, one additional interview was conducted in February 2014 to clarify some information provided by another interview participant. The interview methodology was based on the protocol provided by Krueger and Casey (2009) and Longhurst (2003). Participants were asked to provide a description of characteristics unique to the basin, discuss the drought planning process that is in place for the basin, provide information on collaboration and coordination methods that are used to address the transboundary nature of the basin, talk about successes of and barriers to the planning process, and provide recommendations to improve drought planning in transboundary basins (see Appendix B for complete interview questions). In some cases, interview participants elaborated on certain topics and covered other topics that were going to be addressed later in the interview, so questions related to those topics may not have been asked. Due to this circumstance, interviews varied in length, ranging from approximately 45 minutes to two hours. This was expected, as it is part of the nature of a semi-structured interview.

3.3 Data Analysis Methods

Methods used for data analysis largely came from King and Horrocks (2010), although Creswell (2009) was also consulted. The thematic analysis approach, which is the method of developing themes from data, was used to extract the most frequently discussed issues from the data. This approach supports grounded theory, or the discovery of theory from data (Glaser and Strauss 1967). Grounded theory methods were employed by transcribing and coding data, and then conducting a thematic analysis.

All participants indicated on the informed consent form that they were agreeable to being audio recorded, so the interview data were transcribed in full with the aid of transcriptional software called Express Scribe. This ensured that the most accurate data were being used for analysis and to reduce researcher bias. Transcriptions were then uploaded into MAXQDA, a software program that aids researchers with qualitative and mixed methods data analysis. MAXQDA was used because consultation with an expert about how to use the software was available at UNL through the Office of Qualitative and Mixed Methods Research (OQMMR). The software does not perform qualitative data analysis, but it helped the researcher organize the data and it simplified the process of comparing data segments.

Data analysis was performed using three different methods. Data on basin characteristics and drought planning strategies that are part of the planning process were summarized for each basin and described in Section 4.1. Individual descriptions were provided to give an overview of the unique drought planning strategies and characteristics of each basin. Supplemental sources were used to provide additional information on some basins to fill in holes regarding basic descriptions of the basins. Due to the nature of the questions and responses regarding collaboration and coordination, responses for each basin were summarized into bulleted points, and the most recurrent responses were discussed in the results (Section 4.2). Responses to questions regarding the topics of successes, barriers, and recommendations were more straightforward, so the interview data were coded and then the codes were summarized into themes, which are discussed in Section 4.3. Responses to all of the questions that were part of this interview topic were coded together using the same list of codes, which produced the same themes, but the context of responses that generated the codes was slightly different depending on the question. The process for coding the responses to questions that were asked about successes, barriers, and recommendations is described below.

In addition to working with the OQMMR consultant, several texts were utilized to guide the coding process (Cope 2003, Saldaña 2009, King and Horrocks 2010). The researcher read through each transcription one time before applying any codes. For the first transcription, the data were divided into segments according to the content, and then an interpretive code, which was either a word or a phrase, was assigned to each segment that summarized the content of that segment. An interpretive code is a code that is intended to interpret what the participant is trying to say in a particular data segment. An interpretive code provides analysis at a higher level of abstraction than a descriptive code, which just simply describes the content of the data segment. The step of analysis that involves coding the data with descriptive codes is optional and was skipped in this analysis. New codes were created and existing codes were applied to data segments where appropriate. Each transcription was coded in this fashion, and existing codes were used wherever possible. After coding all of the transcriptions, the researcher had created a list of 33 codes, and then the codes were organized into themes (see Appendix C). The themes provided the basis for the results that are discussed in Section 4.3. A theme provides analysis at a higher level of abstraction than an interpretive code and is the ideal level of abstraction for describing the content of the data (King and Horrocks 2010).

Figure 5 is a tree diagram that provides an example of interpretive codes that were grouped into a theme that emerged from the topic of successes, barriers, and recommendations. (All of the tree diagrams that display the themes and their associated interpretive codes can be found in Appendix C.) Participants talked about stakeholders engaging with one another, understanding their roles in the planning process, developing relationships, exhibiting leadership skills, arriving at consensus on issues, and having different attitudes and perceptions (e.g. trust, resistance, credibility, etc.). All of these topics relate to the greater theme of stakeholders, which was discussed frequently by interview participants.

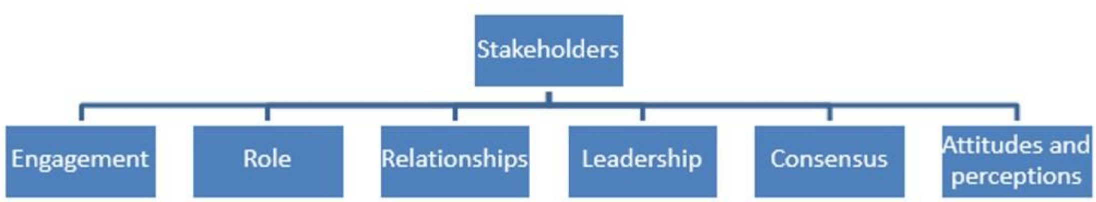

Figure 5. Example of a tree diagram showing how interpretive codes were grouped into a theme.

An important component of conducting qualitative data analysis is ensuring the analysis is of high quality by reducing the researcher bias as much as possible. King and Horrocks (2010) suggested using respondent feedback to assess the quality of research. Interview participants were contacted by e-mail and were given the opportunity to provide feedback on the results of the research that related to their respective interviews. The primary purpose of using the respondent feedback method to assess quality was to increase the credibility of the research by ensuring that the researcher did not interpret the content of the interviews incorrectly. Additionally, written publications and electronic documents were analyzed to verify the statistics provided by interview participants in the results chapter. Both methods can be seen as additional stages of data collection.

CHAPTER 4
RESULTS

The results of this research attempt to answer the research questions laid out in the introduction. The principal research question is, how are water planning agencies using collaborative planning to improve the management of drought in transboundary basins in the U.S.? In order to answer this question, three subsidiary research questions were posed: What is the status of drought planning for transboundary basins in the U.S.? How are collaboration and coordination playing a role in addressing the transboundary issue? Based on their experiences with successes and barriers encountered during the planning process, what strategies do water planning agencies recommend that would increase successful collaboration and ultimately improve drought planning and management of transboundary river basins in the U.S.? Section 4.1 addresses the first subsidiary research question, Section 4.2 addresses the second question, and Section 4.3 addresses the third question.

4.1 The Status of Drought Planning for Transboundary Basins in the U.S.

The following descriptions, alphabetized by basin name, summarize responses by interview participants regarding drought planning activities for each of the basins. Descriptions may include the physical characteristics, primary stakeholders involved in the planning process, specific planning activities, and why drought planning is occurring at the basin level. Supplemental material, wherever it was needed, is specifically cited. For generalized maps of the study regions, please see Appendix D.

4.1.1 Apalachicola-Chattahoochee-Flint River Basin

The Apalachicola-Chattahoochee-Flint (ACF) River Basin is a network of three rivers that drains parts of western Georgia, eastern Alabama, and the Florida panhandle (USGS 2013a). The Chattahoochee and Flint Rivers converge at Lake Seminole to form the Apalachicola River, which eventually empties into Apalachicola Bay and then the Gulf of Mexico.

There is no single agency responsible for drought planning for the basin, but it was mentioned in Chapter 2 that the ACF Basin was selected as a pilot for the NIDIS Regional Drought Early Warning System, so there are some drought management activities occurring at the basin scale. Litigation over reservoir operations in the ACF Basin was filed in 1990. According to the interview participant who represented the ACF Basin, litigation began as a result of proposals by the Corps, who primarily operates the river system, and Georgia to reallocate water out of Lake Lanier (and Lake Allatoona in the neighboring Alabama-Coosa-Tallapoosa Basin) to support the increasing demand due to rapid growth of the Atlanta metropolitan area. These proposals concerned downstream users in Alabama and Florida because Lake Lanier holds the vast majority of storage in the ACF Basin, and its operation heavily impacts the flows downstream. For example, Florida claimed that a large reallocation of water out of the system threatened downstream uses, such as flow requirements to support diverse habitat in the Apalachicola Bay. Agricultural uses on the Flint River, primarily in the form of irrigation, also impact flows into the rest of the system, and the fact that this portion of the system is unregulated further complicates the issue. The three states entered into negotiations in the late 1990s that resulted in an interstate compact, but the compact collapsed just a few years later and the states reverted back to the original litigation. The issue has finally been resolved in the short-term through adjudication, which is a court decree, but residual legal actions still remain. (For more information on the ACF Basin dispute, see Lathrop 2009.)

The occurrence of drought has played an indirect role in the litigation of the ACF Basin. According to the interview participant, drought in the mid-late 1980s was the drought of record in many parts of the basin, and it may have prompted officials to reexamine the water supply that existed for the Atlanta area at the time and develop those proposals for reallocation that prompted the litigation. The participant stated that this drought may have also challenged the assumptions made by some people in the southeastern U.S. that water is plentiful and drought is short-lived, resulting in the realization that water supply in this region is finite and can be limited. Additionally, severe drought occurred again in the region in 2007 while the three states were amid negotiations to reach a new agreement after the compact had failed. These efforts to reach a new agreement were unsuccessful. The interview participant had the following to say about the role the drought played in the failure to reach an agreement: "…my personal opinion is that the droughts complicated the ability to reach an agreement because trying to reach an agreement while all the systems are stressed to the degree they're stressed was very technically difficult and politically problematic."

The interview participant stated that while a stand-alone drought plan does not exist for the ACF Basin, the Corps describes policies and protocols for drought contingency operations in its ACF Master Water Control Manual (USACE 2013). As a result of the litigation, the Corps is in the process of updating the manual to improve operations and reflect changes made since the manual was developed in 1958. According to the interview participant, the revised manual was expected to be released in the latter part of 2013. According to USACE (2013), a final scoping report that includes a revised environmental impact statement was published in March 2013. The interview participant said that the update to the ACF Master Water Control Manual is not expected to be released until late 2014 or 2015.

4.1.2 Catawba-Wateree River Basin

The Catawba-Wateree River Basin is comprised of one river that changes names partway through the system. The Catawba River begins in the Appalachian Mountains in North Carolina and flows east and south into South Carolina through Lake Wateree Dam. It is above this dam where the river's name changes to the Wateree River. The Wateree River ends at the confluence with the Congaree River above Lake Marion near Columbia, South Carolina. According to the participant who was interviewed on behalf of the Catawba-Wateree Basin, water usage in the basin is primarily due to power and municipal needs, followed by industrial and agricultural needs.

The Catawba-Wateree Basin has eleven reservoirs and is managed by Duke Energy, the licensee of a hydroelectric project that is regulated by the Federal Energy Regulatory Commission (FERC). FERC is an independent federal agency that licenses and inspects private, municipal, and state hydroelectric projects (FERC 2014). The interview participant explained that many reservoirs are needed in the basin because the drainage area is very small due to the topography of the region. The Appalachian Mountains cut off drainage from the north and west, and water has only a small area to drain to the coast, resulting in small drainage areas. The participant stated that these conditions cause the basin to be very sensitive to precipitation extremes. For example, a drought of short duration can result in a significant loss of water storage, but a slight recovery in precipitation can fill the reservoirs rather quickly. Planning, therefore, has been paramount in this basin because of its small storage capacity and high demand for its water. The interview participant stated that these circumstances have improved Duke Energy's planning strategies related to water needs in the basin and stated that the Catawba-Wateree Basin is "…probably one of the most planned [for] and studied basins in the world."

Several drought episodes have occurred in the Catawba-Wateree Basin in the last century. According to the participant, a drought occurred from 1998-2002 that became the drought of record at that time. A drought of record is the worst drought that has occurred since the beginning of the meteorological data record. After the drought was over, it was weighing heavily on the minds of stakeholders. Stakeholders who were impacted by the drought included state and federal agencies, homeowners' groups, fish and wildlife agencies, recreational organizations, and nonprofit organizations. Also, the FERC license was set to expire in 2008 and the renewal process had to be initiated by at least 2003, so the stakeholders began a thorough assessment of drought and water supply planning for the basin. A consulting firm was hired to conduct this assessment in the form of a water supply study that projected 50-year water demand based on factors such as population growth and economic development. Demand projections were used in conjunction with a hydraulic model and the Low Inflow Protocol (LIP). The participant stated that the LIP is a form of a drought plan containing triggers and associated actions to be taken by Duke Energy if those triggers are reached. A trigger is a threshold value of a drought indicator, such as streamflow, that determines the beginning or ending of a drought response action (Steinemann 2003). The participant stated that the conjunctive use of these tools has significantly improved drought and water supply management in the basin.

Stakeholder groups are an important component of the Catawba-Wateree Basin's drought management activities. According to the interview participant, there is a drought management advisory group that includes Duke Energy, water suppliers, state and federal agencies, and emergency management personnel. The purpose of this group is to manage the basin through a drought. The group is activated when certain triggers are reached in the LIP. There is also a water management group that is a non-profit corporation, consisting of Duke Energy and the water suppliers. The purpose of this group is to conduct activities related to long-term water supply planning in the basin. According to the interview participant, Duke Energy has maintained a close relationship with the local communities in the basin, so the company had never charged for water withdrawals because providing water brought the company new electricity customers. Eventually, Duke Energy determined that this situation was not going to be sustainable due to increasing demand for water, so they initiated a discussion with the water suppliers about charging them for water withdrawals. This discussion created some tension with the water suppliers. Duke Energy explained to them that rather than wanting the money, they were more concerned about promoting good stewardship through water conservation. The water management group was formed from this discussion and then decided to pay themselves dues that were proportionate to the amount of water withdrawn from the basin by each water supplier. The interview participant said that the good working relationship that was previously established between Duke Energy and the water suppliers proved to be beneficial in easily resolving what could have been a serious conflict.

During the FERC license renewal process, a drought occurred from 2007-2008 and became the new drought of record. The interview participant stated that the in-depth planning that took place by stakeholders after the previous drought of record ended in 2002 contributed to relatively smooth operations during the new drought of record, and their drought management process performed “exceedingly well.” The LIP was implemented, the drought management advisory group was activated, and water suppliers even took proactive measures to conserve more water than what was required by the LIP. The interview participant noted that frequent communication with the public regarding water conservation measures also occurred. After the drought ended, the stakeholders determined that they could improve their drought management strategies. Some of the triggers in the LIP were tweaked, and additional groundwater wells were installed throughout the basin to use as indicators for stream recovery.

4.1.3 Delaware River Basin

The Delaware River begins near Hancock, New York, and it flows 330 miles to the Delaware Bay where it empties into the Atlantic Ocean, making it the largest undammed river in the U.S. east of the Mississippi River (DRBC 2013). Three-quarters of the non-tidal Delaware River (approximately 150 miles), which is the portion of the river that is not subject to the ebb and flow of the ocean tide, is included in the National Wild and Scenic Rivers System. This is significant because, according to one of the interview participants who represented the Delaware Basin, less than one-quarter of one percent of rivers in the U.S. is included in this system. According to the Delaware River Basin Commission (2013), although the basin drains only four-tenths of one percent of the total land area of the continental U.S., approximately five percent of the nation's population (over 15 million) depend on its water supply. About seven million of those people live outside the basin in New York City and northern New Jersey. Water is primarily used for electric generation, public water supply, and industrial needs.

The Delaware River Basin Commission (DRBC) manages the basin, and, like the Catawba-Wateree Basin, the Delaware Basin is managed solely by one basin-scale entity. As stated by the DRBC (2013), it has planning, management, and regulation authority, and it operates many programs, including water quality protection, water supply allocation, regulatory review (permitting), water conservation initiatives, basin planning, drought management, flood loss reduction, and recreation. One of the participants who was interviewed on behalf of the Delaware Basin stated that the DRBC uses an integrated water management concept, meaning they take a holistic systems approach to addressing issues in the basin by considering water quality and quantity, wastewater, storm water, groundwater, and surface water.

The interview participants stated that the river flows in the Delaware Basin are highly regulated due to a Supreme Court decision that was made in 1931 and then amended in 1954 regarding the amount of water that could be diverted to New York City and New Jersey. This decision is enforced by the DRBC through their regulatory water code. The DRBC was then established in 1961 under the Water Resources Planning Act, as mentioned in Chapter 2. Shortly after the creation of the organization, the drought of record occurred in the mid-1960s, and, according to the interview participants, the member states of the DRBC (Delaware, New Jersey, New York, and Pennsylvania) quickly realized the Supreme Court decree of 1954 was not sufficient in those drought conditions. As Hansler (1999) stated, the member states then entered into “good faith negotiations.” One of the participants said that the negotiations ultimately led to a “good faith agreement” among Supreme Court litigants (the four member states and New York City). As part of these negotiations, New York City and the four states “took an equal amount of pain” and committed to reducing their water use during drought warnings and drought emergencies. One of the interview participants stated that these negotiations prompted the member states to take a closer look at how water is used in the basin. Eventually, these discussions led to the codification of drought operating plans by the DRBC; the identification of water storage, water supply, and flow augmentation projects to be included in the DRBC Comprehensive Plan; and the implementation of multiple water conservation programs. According to one of the participants, water conservation has become an integral component of the commission’s strategy to manage water supplies in the basin since the late 1980s. The development of operating plans, construction plans, and programs continue to guide the DRBC’s approach to managing the reservoirs on the Delaware River’s tributaries.

According to one interview participant, the facility-oriented Comprehensive Plan, authorized by the compact that created the DRBC through the Water Resources Planning Act, was augmented through a stakeholder-driven planning process in the 2000-2004 time frame to establish high-level principles, goals, and objectives for wise stewardship of the basin’s resources. The governors of the four member states joined the leaders of five federal agencies at that time to endorse a 30-year vision plan that focused on five key result areas: sustainable use and supply, waterway corridor management, linking land and water resource management, institutional coordination and cooperation, and education and involvement for stewardship. Currently, the DRBC is working on a strategy for sustainable water supply out to the year 2060 that would use models to test scenarios that factor in elements such as future population, an increase in extreme weather events, and climate change. The interview participants said that the DRBC also requires facilities such as power companies to develop drought management contingency plans that include measures taken to conserve water during times of drought.

In addition to the aforementioned plans and strategies, the DRBC has implemented some proactive measures to reduce the basin's vulnerability to drought. According to the interview participants, the electric utilities use water for cooling, and that water does not get returned to the river during normal climatic conditions. During drought conditions the DRBC requires them to make up or offset the water that they do not normally return to the river so that they can still operate at full capacity during a drought. Also, the participants said that the DRBC has recently evolved its water conservation program by implementing a practice they call "water loss accounting," where they track the movement of water from the source to the customer to determine possible water loss due to leaky pipes or other inefficient practices. They encourage the water suppliers to set an example for their customers so that customers will hopefully follow suit and implement water conservation practices in their homes and businesses. One of the participants stated that these practices have likely offset the increasing demand for water in the parts of the basin where population is increasing, and water usage has actually declined where the population is not increasing. Finally, the interview participants noted that the Delaware Basin is a pilot area for the National Water Census, a USGS-led program that is dedicated to developing tools to assess water availability at regional and national scales (USGS 2013b). The DRBC is interested in developing a modeling capability to conduct scenario planning for a new drought of record. The interview participants said that this project is important to the DRBC because they are concerned about not being able to handle a new drought of record.

4.1.4 Great Lakes Basin

The Great Lakes Basin is a large hydrologic region that spans across parts of the United States and Canada. The Great Lakes region has the largest surface area of freshwater in the world. It contains approximately 90% of the U.S.'s freshwater supply and about 18% of the world's freshwater supply (NOAA 2013). The region has a very diverse economy, including agriculture, industry, and recreation and tourism, and the large cities of Chicago, Milwaukee, Detroit, Cleveland, and Toronto were built upon the lakes' shorelines.

The Great Lakes Commission (GLC) serves in an advisory capacity regarding water management concerns in the Great Lakes Basin. As stated by Crane (1991), the GLC is a multistate agency that was established in 1955 by the Great Lakes Basin Compact to facilitate the sharing of information and regional coordination on water resource issues that impact the Great Lakes Basin. The GLC is not to be confused with the Great Lakes Basin Commission, which was formed in the 1960s under the Water

Resources Planning Act and was later terminated due to lack of funding. The Great Lakes Basin Commission had a stronger planning emphasis than the GLC.

It was mentioned in Chapter 2 that a severe drought occurred across much of the Great Lakes region in 1988 (Crane 1991). This drought was significant because, according to the participant who was interviewed on behalf of the Great Lakes Basin, it is unusual for the majority of the basin to be in drought at any particular time. Despite the fact that the region had experienced major flooding just a few years prior, lake levels returned to normal in 1989 after the drought, which was contrary to scientists' predictions that lake levels would take 10-12 years to return to normal levels after the flooding. The interview participant stated that this phenomenon caught the attention of the GLC and other stakeholders in the region. It led to the establishment of a drought management task force and subsequent publication of a guidebook for drought planning to be used by local officials titled, "A Guidebook to Drought Planning, Management, and Water Level Changes in the Great Lakes," as well as the development of policy recommendations regarding a regional approach to drought planning, that were mentioned by Crane (1991) in Chapter 2.

Regional water management has been an ongoing issue in the Great Lakes region. One particular issue mentioned by Crane (1991) and also by the interview participant is the region addresses requests for water diversions and out-of-basin transfers. By the late 1990s, it was determined that legally binding agreements were needed to address proposed diversions, so the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement and the Great Lakes-St. Lawrence River Basin Water Resources Compact were eventually established in 2005 and 2008, respectively (CGLG 2013). The

Council of Great Lakes Governors, an organization consisting of the governors and premiers of the Great Lakes U.S. states and Canadian provinces, is responsible for overseeing the implementation of the agreement and the compact.

The interview participant said that the Great Lakes region has generally taken a reactive approach to drought planning in the past. As mentioned earlier, it is uncommon for the majority of the basin to be in drought at one time. It is not uncommon, however, for parts of some states and provinces in the basin to be in drought. In this case, state and provincial drought officials and stakeholders manage drought response activities. The participant went on to say that drought planning activities are also driven by the U.S. states and Canadian provinces, but the GLC serves as an information-sharing and coordination body for the Great Lakes states and provinces. At the time of the interview, the interview participant stated that the GLC was considering re-engaging in drought planning activities because the region was experiencing abnormally dry conditions.

4.1.5 Klamath River Basin

The Klamath River begins at Upper Klamath Lake in southern Oregon and flows across the state boundary of California, and then empties into the Pacific Ocean near Crescent City, California. The river is supplied primarily by groundwater infiltration from snowpack that mostly originates in the Cascade Mountains. According to the interview participant who represented the Klamath Basin, the basin supports many water uses. The Bureau of Reclamation uses water from the basin for its federal irrigation projects for agricultural purposes. The basin has great environmental significance, as it serves as a refuge for wildlife and endangered species. According to the U.S. EPA

(2013), the river is believed to be the third-largest producer of salmon on the West Coast, behind the Sacramento and Columbia Rivers. Hydroelectric generation, primarily by PacifiCorp, is a big user of water in the basin. The basin is also home to six federally-recognized Native American tribes that hold senior water rights. Conflicts over these competing uses for water have been ongoing for quite some time, but several specific issues, including drought, that have arisen since the early 2000s have prompted stakeholders to attempt to resolve some of these longstanding disputes through the negotiation of agreements.

The Klamath Basin Restoration Agreement (KBRA) is one such agreement that was signed on February 18, 2010 by several federal agencies, the states of Oregon and California, three Native American tribes, and other interested parties. In general, the goals of the KBRA are to sustain fish species in the basin; ensure reliable water and power supplies to support agriculture, communities, and wildlife refuges; and resolve certain disputes over the basin's resources as outlined in the Agreement (KBRA 2010). The KBRA is important for drought planning because it contains a section that calls for the development of a drought plan for the basin. According to the interview participant, the requirement to develop a drought plan was put into the KBRA because stakeholders were concerned about how to manage the water needs of many sectors during a drought situation. The participant stated that although the KBRA was signed by the interested parties in 2010, it has not yet received federal authorization due to resistance at the congressional level. The participant thinks the drought plan portion of the KBRA has not yet been implemented because there has not been a drought of long enough duration to cause Congress to move it forward.

The development of triggers became an important part of the proposed drought plan in the KBRA. The interview participant stated that stakeholders determined they must specifically define "drought" and "extreme drought" if they were going to serve as triggers in the plan. In fact, the interview participant claimed, "…if you have a floating definition of drought, you're in trouble because everybody can think of a way to examine and define drought for their own interests, and so having a threshold, some idea of what extreme drought meant, was extremely helpful to the negotiations and to the discussion." The development of triggers for the plan was especially important to irrigators because they wanted certainty as to how much water they would receive in a given year to help them make planting decisions.

Another important issue that impacts the drought plan within the KBRA is the Klamath River Basin Adjudication. In this instance, adjudication is the process by which claims to use of surface water in the Klamath Basin are being determined. This is a common practice in the western U.S. where prior appropriation water rights are dominant. The interview participant stated that the adjudication has caused conflicts, one of which concerns claims to water by some of the Native American tribes being highly contested. There are treaties that date back to the mid-1800s with tribes concerning their use of water in the Klamath Basin, and if those treaties are honored, there would be little water left for other uses. The tribes have agreed to relinquish the claims to water stated in the treaties, so that became part of the KBRA, and subsequently, the interests of many of the water users were satisfied. As a result, the adjudication has helped ease concerns for allocating water during drought conditions. The first phase of the adjudication was completed in 2013, and it was determined that the Klamath tribes would hold the most senior claims, which carry a priority date of “time immemorial” and predate other water rights in the basin, but claims to water in streams that are outside the boundaries of the former Klamath Indian Reservation were denied (OR WRD 2013).

The increasing occurrence of drought, as well as climate change projections that indicate a drying trend in the basin, has stakeholders concerned about future water allocation. According to the interview participant, major drought episodes occurred in the basin in the 1930s, 1950s, 1990s (defined in the KBRA as an extreme drought period), and 2000s. There is concern that the triggers currently outlined in the drought plan will be inaccurate in as little as ten years, so those who are responsible for the drought plan are attempting to integrate climate change projections into their basin models. Also, the interview participant stated that recent droughts have caused water users to pump groundwater at an unsustainable rate to make up for less surface water, and this issue must be addressed.

4.1.6 Lower Colorado River Basin (Texas)

The Lower Colorado River Basin is the region below the confluence of the Colorado River and the Pecan Bayou in east-central Texas, and it empties into the Gulf of Mexico. (This Colorado River is completely separate from the Colorado River that flows from the state of Colorado down to Mexico. In this section, references to the Colorado River are regarding the one that flows through Texas.) The basin’s topography is widely varied with sharp, contrasting hills upstream and flatter, gentler slopes downstream. According to the participant who was interviewed on behalf of the Lower Colorado Basin, the basin is made up of spring-fed streams that feed the Highland Lakes, a chain of reservoirs built in the basin during the 1930s-1950s. Average annual precipitation is also widely varied across the basin, ranging from about 20 inches at the far upstream reaches of the basin to about 50 inches at the coast. The interview participant stated that drought has been a common occurrence in the Lower Colorado Basin. The drought of the 1950s is considered the drought of record in the basin, and the drought of 2011 is considered the most severe one-year drought since record-keeping began. The primary use of water in the basin is for agricultural and municipal purposes.

According to the interview participant, the Lower Colorado River Authority (LCRA) is a river authority created by the Texas legislature in 1934 to develop water supplies in the Colorado River Basin. The LCRA is a state entity and is considered a water district in the state of Texas. Its revenue is generated from electricity and water sales; it does not have taxing authority. Although the Lower Colorado River does not cross any state boundaries, it was included for analysis because, as mentioned in Chapter 3, the LCRA does have to coordinate its drought planning activities with multiple agencies and it is highly regarded as a basin-level drought planning authority in the state.

The LCRA developed a water management plan in 1989 as a result of requirements that came out of settlements from the state's adjudication process. While the LCRA manages six reservoirs, the water management plan only applies to how Lakes Buchanan and Travis, the two water supply reservoirs, are managed. Drought management is a component of the water management plan. According to the interview participant, the plan outlines how the LCRA can allocate water to interruptible customers while ensuring that firm customers' water needs are still met through a drought of record scenario. Interruptible customers are those whose water supply can be curtailed or cut off during drought conditions, while firm customers are those whose water needs must be met even during drought conditions. The LCRA had to determine the firm yield of the lakes, which is the amount of water that can be withdrawn from the lakes during a drought of record, while also considering the inflows that would occur during drought under the prior appropriation doctrine and evaporative losses. The LCRA determines firm yield by using water availability models. Water that is not currently being used by firm customers can be distributed to interruptible customers. Some of the interruptible water supply is used to meet environmental needs downstream. The water management plan is updated with the help of an advisory committee that consists of the LCRA, firm customers, environmental groups, irrigation customers, and other various groups.

4.1.7 Potomac River Basin

The Potomac River Basin is located in the mid-Atlantic region of the U.S. The river flows 383 miles and empties into the Chesapeake Bay. Approximately six million people live in the basin, the majority of which reside in the Washington, D.C. metropolitan area. The interview participant who represented the basin stated that the Potomac has encountered several notable drought episodes during the past century that occurred in the 1930s (the drought of record), the 1960s, and the late 1990s-early 2000s.

As mentioned in Chapter 2, the Interstate Commission on the Potomac River Basin (ICPRB) was established by compact in 1940. The interview participant stated that the initial purpose of the ICPRB was for managing water quality in the Potomac Basin. Severe drought in the 1960s caused the ICPRB member jurisdictions and key stakeholders to focus dually on water quality and water supply, so the ICPRB now takes an integrated approach to managing water in the basin. As part of the compact, and due to other agreements, the ICPRB created the Section for Cooperative Water Supply Operations on the Potomac, which calls for three major water utilities supplying the metropolitan Washington, D.C. area to work with the ICPRB to develop a drought management program for their operations. The ICPRB is a non-regulatory entity, so its primary purpose is to communicate with interested parties and offer solutions to issues related to water management in the basin.

The drought of the 1960s raised awareness among the ICPRB and other stakeholders regarding how the waters of the Potomac Basin should be managed during a drought. The Corps, who developed the water supply for the Washington, D.C. metropolitan area, conducted the Northeast Water Supply Study and subsequently recommended that multiple dams be built on the Potomac River to supply water to Washington, D.C. According to the interview participant, these dams were never built because they were too expensive and environmentalists were not in favor of such construction.

After further discussions about drought management of the Potomac Basin, two agreements were implemented in the 1970s. The Low Flow Allocation Agreement is an agreement among the federal government, the states and the District of Columbia that comprise the basin, and the aforementioned major water utilities that defines how water is to be allocated during drought if the Corps determines that there is inadequate water in the river to meet the demand of its users. The other agreement that was developed of which the ICPRB is a signatory is called the Water Supply Coordination Agreement, and its purpose is to implement the provisions of the Low Flow Allocation Agreement. As part of the Water Supply Coordination Agreement, the three water utilities give the ICPRB the authority to provide technical assistance and management support on how to operate during drought to prevent implementing the provisions of the Low Flow Allocation Agreement. The interview participant stated that the water utilities would much rather cooperate with each other and share water during a drought by viewing the system holistically than have to resort to following the restrictions required in the Low Flow Allocation Agreement. A drought operations manual that contains specific triggers related to streamflow was created as an attachment to the Water Supply Coordination Agreement. According to the interview participant, the manual has performed well under drought conditions, but it performed better during a drought in 2007 than the one in 1998-2002. The participant stated that the likely reason was because drought was still on the minds of stakeholders due to the short period of time between the droughts, and they were more attuned to some of the issues that arose during the previous drought.

The ICPRB engages in activities that strengthen their drought management program. As mentioned in Chapter 2, one particularly interesting activity of the regional entities and ICPRB is an annual drought exercise. The interview participant stated that the purpose of the drought exercise is not only to practice operations during a simulated drought episode, but to address the staff turnover issue by helping new staff learn how the ICPRB operates during drought conditions. The participant said that the drought exercise is also a communications exercise. As part of the exercise, stakeholders come together to practice communication methods. Computer models and a variety of scenarios can be used to simulate flows and releases from reservoirs under desired drought conditions. Stream gauge data, tree ring data, and climate change impacts can be incorporated into the models to improve future utility operations and drought planning for the basin. According to the interview participant, these activities help the ICPRB and regional entities improve communication and build trust with stakeholders during non-drought periods so that a strong foundation of these qualities is in place when drought does occur.

4.1.8 Red River Basin

The Red River Basin begins in South Dakota and flows north between North Dakota and Minnesota, crosses the international border into Manitoba (Canada), and eventually empties into the Hudson Bay. The last ice age is largely responsible for the topography of the basin. Glaciers created a river valley with steep escarpments and a flat bottom, making the Red River prone to flooding. The combination of fall moisture conditions, runoff from snowmelt during the spring, and spring precipitation create the largest floods of record in the basin. The participant who was interviewed on behalf of the Red River Basin said that the basin is also prone to drought because the population is highly dependent on surface water for water supply due to limited groundwater, as there are few useable or adequate recharge areas in the basin. Water demand is also increasing in the basin, and much more quickly than projected, due to the oil boom in the West and the rapid growth of urban areas such as Fargo and Grand Forks.

The Red River Basin Commission (RRBC) is addressing drought management through coordination with the U.S. states and the Canadian province that share the basin. According to the interview participant, the RRBC is a nonprofit organization that consists of board members from the sectors of local government, state and provincial government, tribes, the environment, and the general public. (It should be noted that, according to the interview participant, only about one percent of the basin is contained within South Dakota, and its state government has chosen not to actively participate in the RRBC's activities.) It was created in 1979 after a devastating flood so that local leaders, especially mayors, could address flood management in the basin. Since that time, the RRBC's mission has been broadened and state, provincial, and federal governments have been brought into the organization, and the commission formed under a new directive in 2001. Local, state, and provincial governments currently fund the RRBC to work across geopolitical boundaries on issues of importance to all jurisdictions. The interview participant stated that the RRBC has no authority in the basin other than a shared vision of future desired outcomes and a path forward to achieve this vision.

The RRBC decided to engage in drought planning for two primary reasons. According to the interview participant, one of the reasons is because there is no apportionment agreement between the U.S. and Canada on the Red River. This means that during a drought, the U.S. can legally use all the water it wants and is not required to send a minimum amount of water across the border to Canada. The RRBC and stakeholders from both countries were concerned that they would end up in litigation during a severe drought. They decided, therefore, to work together cooperatively to develop a path forward for jurisdictional communication, public conservation, and a management strategy that would avoid litigation during a long-term drought. The participant said that a second reason for planning for drought in the basin was because the Red River serves as a divider between riparian and prior appropriation water law. Minnesota follows riparian doctrine, while North Dakota follows prior appropriation doctrine, and Manitoba follows a water law that is similar to prior appropriation doctrine.

After a drought of relatively short duration occurred in 1989, stakeholders realized that the drought operations of North Dakota and Minnesota were completely different under the two water laws, and a drought of longer duration would likely cause conflict between them. Drought planning, therefore, was deemed necessary for the basin.

After the RRBC was formed under the new directive, its members developed a very specific vision called the Natural Resources Framework Plan (NRFP), published in May 2005. The NRFP has 13 goals, and there are objectives and specific action items under each goal. The interview participant stated that the development of the goals resulted from discussions at public meetings that had been ongoing since the late 1990s about basin issues. One of the goals is to manage the water supply of the basin in a sustainable manner. A solution that is being proposed by one of the states in the basin is to divert water from the Missouri River to the Red River Basin in order to have a more dependable water supply. The state is still waiting on the record of decision for a federal project, which is a formal document that states the decision on a proposed action and becomes official public record, but in the meantime the state has begun exploring the possibility of a state project. The interview participant stated that early communication with other jurisdictions creates the potential for a basin-wide solution. While waiting on the record of decision regarding the water diversion project, the RRBC is continuing to develop alternative jurisdictional sharing and public conservation plans in case long-term drought occurs in the basin and the diversion proposal is not approved.

The interview participant said that the cornerstone of the RRBC's drought management efforts was accomplished with the assistance of a consulting firm to develop a basin-wide drought strategy. The resources required and the timeline needed to prepare the strategy are outlined in the Red River Basin Drought Preparedness Strategy Scoping Document, published in January 2008. The strategy takes current jurisdictional laws and regulations into account, and it addresses how to share water among the jurisdictions during drought. According to the interview participant, the recommendations that were made in the scoping document can be categorized into the following three broad areas: jurisdictional matters, public education of water conservation, and modeling. The participant stated that the RRBC has implemented some of the recommendations related to jurisdictional matters and public education of water conservation. The consulting firm determined, however, that the modeling that was recommended would cost nearly $1 million to implement, so the RRBC is working to raise the money needed for that project.

4.1.9 Susquehanna River Basin

The Susquehanna River Basin is the second largest river basin east of the Mississippi River, behind the Ohio River Basin (NYDEC 2013). The river begins in Cooperstown, New York, and then flows through Pennsylvania and ends in Maryland where it empties into the Chesapeake Bay at Havre de Grace. According to the participants who were interviewed on behalf of the Susquehanna Basin, the topography of the basin is diverse and consists of glaciated, karst, and piedmont regions. Like the Catawba-Wateree Basin, the Susquehanna Basin has limited storage, so it is also very sensitive to precipitation extremes. Notable droughts in the basin include the 1930s, 1960s (drought of record), and the late 1990s/early 2000s. The river is mostly unregulated in the upper portion of the basin where there are flood control reservoirs operated by the Corps, but it is more regulated in the lower portion where there is a greater occurrence of hydroelectric dams.

The Susquehanna River Basin Commission (SRBC) serves as a coordinating body for the states sharing the basin. It was previously mentioned in Chapter 2 that the SRBC was established by compact in 1970. The compact was signed by the federal government and the three member states: Maryland, New York, and Pennsylvania. Like the DRBC, the SRBC was established by the Water Resources Planning Act and continues to operate despite the termination of federal funds originally allocated to support its operation. The participants stated that the SRBC was established because the member states recognized common interests in the basin's water resources. They went on to say that the SRBC has broad responsibilities, and due to the aforementioned sensitivity of the basin to precipitation extremes, its staff addresses both flood management and drought management.

According to the participants, the SRBC has broad authority in the basin regarding drought management. It can declare a drought emergency, although it typically defers to, and supports, such declarations by the member states. It regulates groundwater withdrawal, surface water withdrawal, diversions, and consumptive water use in the basin. The SRBC implements low flow protection, including specific flow thresholds at which withdrawals must cease if drought conditions warrant such measures. The SRBC also has a consumptive use mitigation program that is similar to activities of the DRBC in that some users replace water that is consumptively used during low flow periods. The SRBC has a drought coordination committee that convenes when the basin is in an extended period of abnormal dryness. The committee consists of a representative from each of the member states, the Baltimore District of the Corps, and other pertinent agencies such as the National Weather Service (NWS) and the USGS. Also, as mentioned in Chapter 2, the SRBC developed a drought coordination plan because of the desire of the SRBC and the member states to coordinate drought management in the basin. According to one of the interview participants, the drought that occurred in the late 1990s/early 2000s likely contributed to the plan being pushed forward. Drought has not occurred in the basin since the creation of the plan, however, so the plan has not really been tested.

4.1.10 Tennessee River Basin

The Tennessee River begins in the Smoky Mountains region and flows through seven states before emptying into the Ohio River near Paducah, Kentucky. The topography of the basin varies from mountainous terrain to plateau to the Mississippi Alluvial Plain. One of the three participants who was interviewed on behalf of this basin noted major drought episodes that occurred in the basin in the 1920s, 1940s, 1980s, and 2007, which is considered the drought of record for the basin. As mentioned in Chapter 2, the river is regulated by the Tennessee Valley Authority (TVA).

The interview participants stated that current drought planning activities by TVA began in the early 1990s. In 1991, a lake improvement plan was developed that included minimum releases from many of the system's reservoirs. In 2004, TVA implemented a new reservoir operations policy, which was based on a three-year study to determine how the overall public value of the reservoir system could be improved. One of the drought response features of the operating policy is that TVA immediately shifts the reservoir system into a water conservation mode when reservoir water in storage drops below a predefined system minimum operating guide that varies throughout the year. In 2006, TVA developed a drought management plan that describes its response to five phases of drought: watch, precautionary, action, emergency, and recovery. When the system experienced a new drought of record in 2007, actual river operations were superior, in terms of minimum flows and reservoir elevations, to drought planning hydraulic model results that were based on historic records.

4.1.11 Upper Colorado River Basin

The Colorado River begins in high mountain regions of Colorado and then flows through seven U.S. states and part of Mexico before emptying into the Gulf of California. The Colorado River Compact divides the river into the Upper Basin and the Lower Basin at Lees Ferry (Colorado River Compact 1922). According to this compact, the Upper Basin includes the portions of the states of Arizona, Colorado, New Mexico, Utah, and Wyoming that drain into the Colorado River above Lees Ferry. The Lower Basin includes the portions of the states of Arizona, California, Nevada, New Mexico, and Utah that drain into the Colorado River below Lees Ferry. The Colorado River is highly managed and legislated with multiple withdrawals and diversions on it, including the two largest man-made reservoirs in the U.S.: Lake Powell, which is controlled by Glen Canyon Dam in the Upper Basin, and Lake Mead, which is controlled by Hoover Dam in the Lower Basin. The Upper Colorado Basin was chosen for analysis because, like the ACF Basin, it is a NIDIS Regional Drought Early Warning System. Notable drought periods in the basin include the 1950s, 1970s, and since the year 2000, especially 2002 and 2012.

One of the agencies that has a role in managing water in the Upper Colorado Basin is the U.S. Bureau of Reclamation (USBR). The USBR's Upper Colorado Region has several ongoing activities and programs that can be useful during drought, including water conservation, water use efficiency improvements, and resources planning and management (USBR 2006). According to one of the interview participants representing the Upper Colorado Basin, the USBR works with the Upper Basin states to facilitate water storage to ensure the availability of water for everyone, as stated by the Upper Colorado River Basin Compact of 1948.

The USBR published a water supply and demand study for the entire Colorado River Basin in 2012. One of the interview participants stated that this study was conducted in part due to ongoing drought in the basin since about the year 2000. The participant went on to say that the study also addresses concerns about climate change and its potential consequences for water supply in the basin, and it also addresses excessive use of water by the Lower Basin states beyond what it was allocated in the Colorado River Compact of 1922. One of the climate models used in the study projected that the frequency and duration of drought compared to historical observations and paleo-based scenarios would increase, and the median of the mean natural flow of the Colorado River at Lees Ferry would decrease by approximately nine percent (USBR 2012). Additionally, the study indicated that the model projected that droughts lasting at least five years would occur 50 percent of the time over the next 50 years. Due to projected future imbalances between supply and demand of water in the Colorado River Basin, the study recommended that investments be made in water conservation, reuse, and augmentation projects to address future water needs in the entire basin.

Another agency that has a role in managing water in the Upper Colorado Basin is the Upper Colorado River Commission (UCRC). According to the Water Information

Program (WIP) (2014), the UCRC was established in 1948 as part of the Upper Colorado River Basin Compact and is an organization that acts as a water master for the Upper Basin states. The UCRC member states (Colorado, New Mexico, Utah, and Wyoming) and the President of the United States each appoint a commissioner to serve the UCRC and the aforementioned Upper Basin states. The WIP (2014) also stated that the UCRC and its member states helped establish the 2007 Interim Guidelines for Shortage Management and Coordinated Reservoir Operation, which guide how Lake Powell and Lake Mead are governed, as well as when the Lower Basin states must take shortages.

4.1.12 Yadkin-Pee Dee River Basin

The Yadkin-Pee Dee River begins as the Yadkin River in the Appalachian Mountains in North Carolina, flows through the piedmont region where it changes names to the Pee Dee River, and then encounters the coastal plain where it empties into the Atlantic Ocean near Georgetown, South Carolina. The basin is highly forested, and the only large urban area is Winston-Salem, North Carolina. The river is managed by several hydroelectric projects, but one particular project that involves drought management of part of the basin is managed by Alcoa Power Generating, Inc. (hereafter referred to as Alcoa Power). Alcoa Power holds a FERC license for several of the reservoirs on the Yadkin-Pee Dee River.

According to the interview participant who represented the Yadkin-Pee Dee Basin, drought had not really been an issue in the basin until the last 10-15 years. The participant stated that it is likely because water demand has increased since the 1990s due to population growth in the basin. In 2002, a severe drought occurred, and although

Alcoa Power followed the protocol outlined in the FERC license agreement, citizens were unhappy with drought operations. The protocol permitted only one reservoir to be drawn down, and citizens living near that particular reservoir did not think it was fair to not draw down any of the other reservoirs. When another drought occurred in 2007, Alcoa Power asked for a variance from FERC to draw down an additional reservoir, and as a result, citizens were much happier that they were sharing the pain of the drought, and the company gained credibility. The interview participant said that educating the stakeholders on the perspectives of others played an important role in improving the company's credibility, and "…some of our biggest adversaries became our biggest advocates."

After the drought in 2002, Alcoa Power created a drought contingency plan for the basin. It uses the U.S. Drought Monitor as a trigger to initiate communication among the stakeholders regarding the potential development of a drought. Transparency is important to the stakeholders, so discussions during conference calls and meetings are summarized and published on Alcoa Power's website. Alcoa Power is in the process of renewing its FERC license for the project, and it is taking the opportunity to incorporate more drought planning information into the relicensing agreement, such as better-defined triggers and low inflow protocols. Alcoa Power has also recognized that more comprehensive management of the river is necessary, especially during drought conditions, so it is making an effort to consider environmental flows and water quality as part of its management scheme.

An explanation of why drought planning activities developed in the basins further describes the status of drought planning for transboundary river basins in the U.S. The occurrence of drought prompted development and revision of drought planning activities in all of the study regions. The development of state plans has followed a similar pattern. Figure 6 overlays the development of drought planning activities of basins and states with the percent area of the U.S. that has been in severe to extreme drought since formal record-keeping of climate data began in 1895. (State data came from unpublished research by NDMC staff.) Four major drought episodes prompted drought planning activities in the basins: the 1960s (Potomac), the late 1980s (ACF, Delaware, Great Lakes, Lower Colorado, Red, Tennessee), the late 1990s/early 2000s (Catawba-Wateree, Susquehanna, Yadkin-Pee Dee), and the decade of the 2000s (Klamath, Upper Colorado). The most notable increase in the number of basins developing drought planning activities occurred after the late 1980s drought, and this is also the case for states developing drought plans.

In some cases, policy was implemented as a result of drought. For example, as mentioned in Chapter 2, the Water Resources Planning Act was established to address increasing water demand across the country, and the drought of the 1960s contributed to this realization. Some of the river basin commissions that are currently planning for drought, such as the Delaware and Susquehanna River Basin Commissions, were established by the Act. The NDMC and NIDIS both promote drought planning and management at multiple scales, so the formation of the NDMC and the implementation of the NIDIS Act have likely influenced development of drought planning activities over the past 10-20 years.

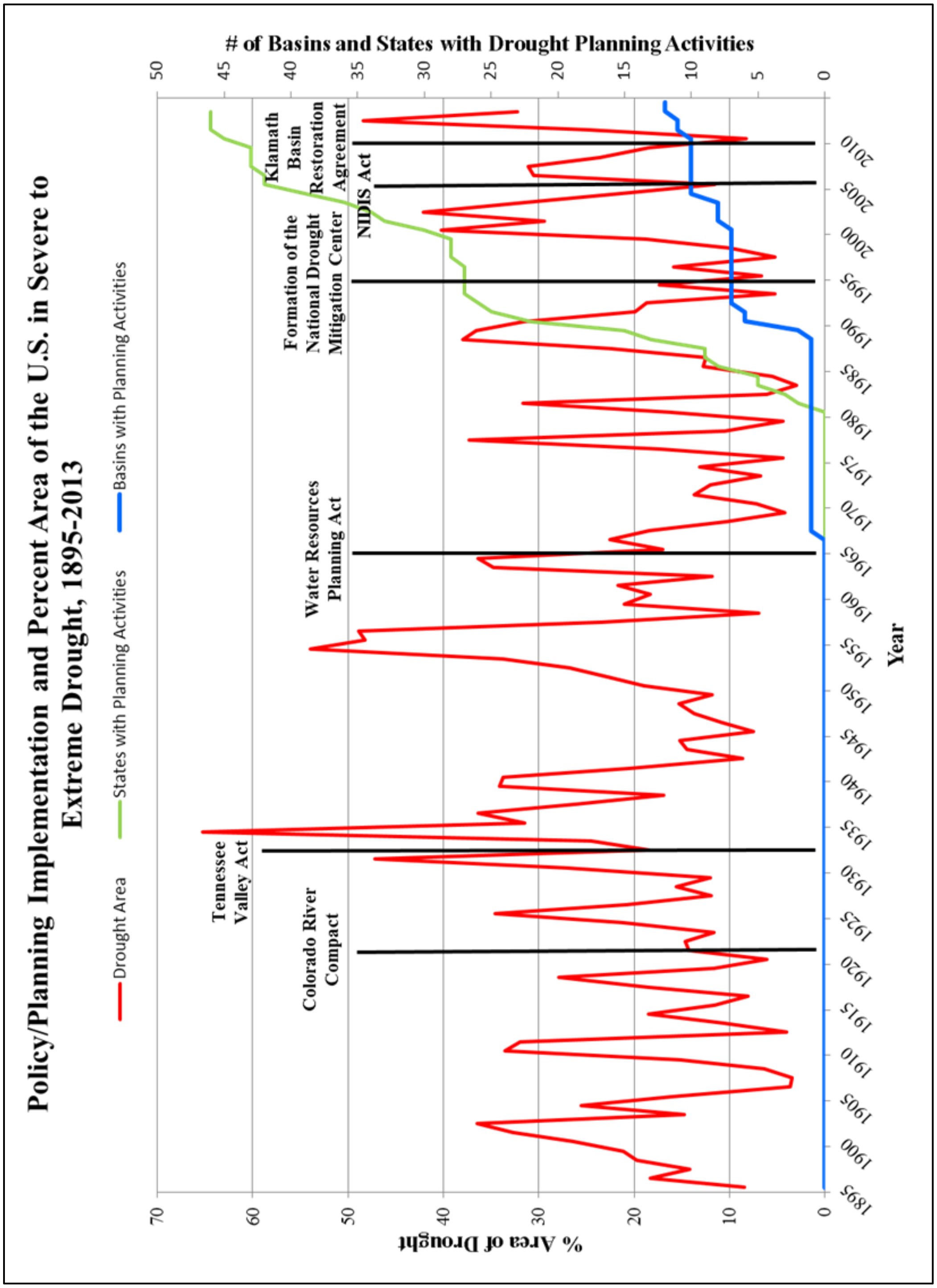

Figure 6. Development of basin/state drought planning activities and major drought events. Percent area of drought data from NCDC (2014).

4.2 The Role of Collaboration and Coordination

Interview participants were asked about their experiences with collaborating and coordinating across jurisdictional boundaries. The terms collaboration and coordination are similar and often used interchangeably, but they are defined differently in the context of this research. The term collaboration is used here to refer to people or agencies working together on an issue. The term coordination refers to agencies, especially from different states, working together to avoid duplications or conflicting drought planning activities. There were two recurring themes that emerged from responses to the question interview participants were asked about collaboration and coordination. One of the themes relates to having an institution for coordination, while the other concerns political issues.

Several of the basins have an institution for coordination, such as a river basin commission, whose primary purpose is to address the transboundary issue by serving as a forum for agencies to collaborate and coordinate on water resource issues. Other basins have a basin-level organization that controls the river and has the authority to make regulatory decisions regarding its use. Nearly every basin interviewed that has a coordinating body or a basin-level regulatory agency stated that this type of structure has been extremely helpful for the planning process. The Great Lakes Basin participant talked about the role of its commission in building stakeholder relationships in the following statement: “What’s worked well is the fact that a commission like ours exists because we have twice a year opportunities for…officials to come together to talk about issues, so that…creates those opportunities for those relationships to form for people to be talking to each other…” According to one of the Delaware Basin participants, “It's nice if you have an institution whose reason for being is to pull both parties together on a day to day basis…" One of the Susquehanna Basin participants mentioned not being able to imagine how to plan for a transboundary water resource without its commission in the following quote: "…The commission and its role of filling regulatory gaps and facilitating the coordination of water resource issues across state boundaries is really critical to allowing us to take on an effort like this. Without the commission, I can't see us realizing the successes we have in drought planning or coordination."

Other participants stated that politics hindered collaboration and coordination among stakeholders in their respective basins. In all cases, stakeholders attempted to ignore politics and continued to collaborate and coordinate on a technical level, but ongoing political issues significantly slowed progress and created roadblocks for stakeholders to overcome. The ACF Basin participant explained how political issues in the basin over water use were exacerbated by drought in the following statement:

> "At the technical level, we've been able to maintain some pretty good relationships…The problem…is when they get to a political level, you get parties that have to take positions to sort of fly the flag or represent their interests in a way that are sometimes contrary to reaching a compromise…In 2007, we had a very significant drought and then it became an argument of who was managing water most efficiently on either side of the line, and there was a lot of finger pointing back and forth about who's making the problems worse or reacting appropriately, and

> so as the drought continued to get worse…some of the discussions began to play out in the press and it challenged the ability to make as impartial decisions as you could."

The Catawba-Wateree participant talked about how stakeholders attempted to ignore ongoing litigation in the basin: "While [litigation] was going on in contention, the people that [were] actually dealing with the drought and this planning stuff on a day to day basis – it meant nothing to them." The Klamath Basin participant discussed the opposition by politicians to the implementation of the Klamath Basin Restoration Agreement (KBRA): "On the congressional level, there are strong interests in California and their congressional delegation in northern California that is really opposed to the KBRA implementation."

Participants were also asked about issues of consistency, duplication, and conflicting actions regarding the overlap of basin planning activities with planning activities at other scales. It was discussed in Chapter 2 that 45 of the 50 U.S. states have drought plans. (Washington and Louisiana have plans under development, and Alaska, Arkansas, and Wisconsin do not have drought plans.) Also, four Native American tribes have drought plans: the Hualapai Reservation, the Navajo Nation, the Northern Cheyenne Tribe, and the Zuni Tribe. Figure 6 shows the overlap of drought planning activities among basins, tribes, and states. The figure indicates that drought planning activities for all 12 basins overlap with at least one state that is engaged in drought planning activities. Some basins, such as the Upper Colorado Basin, overlap with multiple states with drought plans. Planning activities of the Upper Colorado Basin also overlap with those of the Navajo Nation. Drought planners for the Red and Great Lakes Basins must contend with Canadian drought planners who may also be engaged in drought planning for their provinces. The scale of this map does not show drought planning that may be taking place at smaller scales, such as for counties or cities. In some cases, drought planning activities occurring at multiple scales may be significantly different, and the overlap may not cause any issues. In other cases, the overlap of drought planning activities at multiple scales may be confusing and may result in duplicate or even conflicting efforts unless drought planners communicate and attempt to coordinate their efforts.

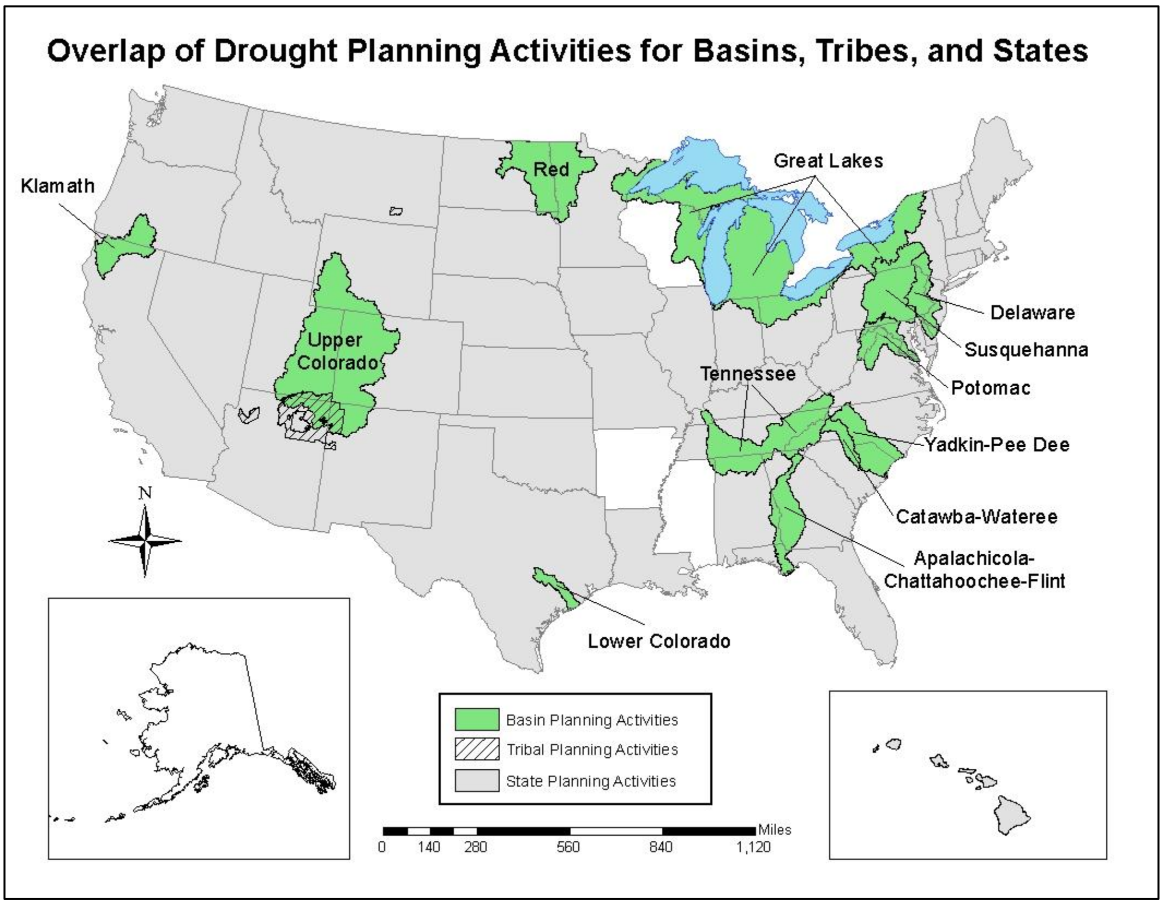

Figure 7. Overlap of drought planning activities for basins, tribes, and states.

For the most part, participants said that their agencies coordinate their drought planning activities across jurisdictional boundaries and levels. Those who represent an institution for coordination said that their primary role is to ensure planning activities are coordinated among all parties. A few participants noted that although agencies representing different levels of planning do not work independently of each other, they all have their own roles and purposes for drought planning that may be different from others. Interview participants noted different coordination strategies that work for their respective basins. For example, the Lower Colorado River Authority requires the drought contingency plans that are followed by wholesale water suppliers to be consistent with its plan. The Red River Basin Commission has to contend with different water laws and governmental structures due to the international boundary between the U.S. and Canada. They recognize the challenges of coordination in this situation, so they are formalizing a process for coordination through their drought preparedness strategy that was previously mentioned in Section 4.1.8. Several of the agencies hold conference calls during drought to ensure that everyone is on the same page regarding their plans of action for responding to the drought. Some participants mentioned the importance of the standardization of indicators and triggers to ensure smoother operations during drought. While the methods for coordination vary, all participants noted that a concerted effort was being made to coordinate their drought planning strategies across all jurisdictional levels.

4.3 Successes, Barriers, and Recommendations

The last part of each interview consisted of questions regarding successes and barriers that the interview participants have encountered while planning for drought for their particular basins, as well as recommendations they would make for basin-level drought planning based on their experiences. The following six themes emerged from participant responses regarding successes, barriers, and recommendations: collaboration and coordination, communication, government and legal matters, information, planning process, and stakeholders. (See Appendix C for the list of codes that correspond to the themes.) Tables 8, 9, and 10 summarize the key points made by interview participants regarding successes of, barriers to, and recommendations for drought planning for river basins, respectively.

Table 8. Successes of drought planning for transboundary river basins.

Collaboration and Coordination	Communication	Government and Legal Matters	Information	Planning Process	Stakeholders
• Having an institution for coordination • Cooperation among agencies and stakeholders • Collaboration is occurring	• Communication is occurring among stakeholders	• Regulations ensuring smoother planning process	• Good baseline information • Good stakeholder and public education	• Good planning strategies	• High engagement • Good relationships

Table 9. Barriers to drought planning for transboundary river basins.

Collaboration and Coordination	Communication	Government and Legal Matters	Information	Planning Process	Stakeholders
• Lack of coordination among agencies	• Lack of communication among stakeholders	• Litigation • Governmental fragmentation • Politics	• Data gaps • Loss of institutional knowledge • Lack of awareness of issues	• Lack of or strained resources • Lack of experience with drought • Outdated plan/ planning process	• Lack of credibility, trust among stakeholders • Lack of participation, inclusion

Table 10. Recommendations for drought planning for transboundary river basins.

Collaboration and Coordination	Communication	Government and Legal Matters	Information	Planning Process	Stakeholders
• Have a good facilitator/ facilitation • Have an institution for coordination • Find a reason to collaborate	• Increase communication • Communicate between droughts	• Avoid litigation • Increase regulation	• Promote education, knowledge, and awareness of basin issues • Improve quantity and quality of information	• Identify resources • Identify issues, goals • Implement plan/ planning process • Update plan continuously • Use hydrologic modeling	• Identify and engage all key stakeholders (including federal and state) • Make stakeholder roles clear

Collaboration and coordination were combined into one theme, although their definitions are slightly different. One of the codes that was commonly used within this theme is institution for coordination. It was discussed in Section 4.2 that an institution for coordination may be a river basin commission or other organization whose primary purpose is to serve as either a neutral coordinating body or a regulatory agency that addresses water resource issues in a transboundary river basin. When asked about successes and recommendations for planning for drought in a transboundary river basin, several of the interview participants noted again that having an institution for coordination has been extremely helpful for their drought operations. Additionally, lack of coordination among agencies was noted as a barrier.

Facilitation is another commonly used code in the theme of collaboration and coordination. Facilitation refers to a specific person or group of stakeholders who can remain neutral and address the needs of all the parties who have interests in the basin. Some of the interview participants who praised having an institution for coordination recommended that coordinating institutions should have good facilitators to ensure that coordination is successful. Also, interview participants recommended that planning agencies find a reason to collaborate before beginning the planning process; otherwise, the collaborative effort will likely fail.

Communication was usually mentioned in a general sense by stakeholders. It was discussed as both a success of and a barrier to drought planning in a transboundary river basin. Sometimes participants discussed their preferred method of communication, such as gathering for a workshop, belonging to an e-mail group or listserv, or participating in a phone conference. The interview participant from the Potomac Basin stated, "…communications…is probably one of the key factors that needs to be built into any drought-type operation." Some participants recommended that communication should not only occur during drought, but also between droughts so that everyone is prepared and up to speed on issues before a drought occurs.

The theme government and legal matters refers to discussions by interview participants on topics such as politics, litigation, and regulations or laws. Participants said that litigation, politics, bureaucracy, and governmental fragmentation hindered the planning process. The participant from the Red River Basin said that these issues cannot really be avoided when planning for transboundary river basins, stating, "No matter what level of drought planning you want to do, you're going to encounter political boundaries, and you're going to encounter agency infrastructure and management issues. No matter where you are. If you cross out of a county boundary, you've done it." On the contrary, some participants stated that being a regulatory agency has actually made the planning process easier and recommended implementing regulations or mandates if possible.

References to information were frequently made by interview participants, such as knowledge, awareness, and education. Participants stated that having good baseline information and data were important for drought planning. They also talked about the importance of promoting education of stakeholders and the general public on the drought planning process and water resource issues in the basin. One barrier mentioned by interview participants is the loss of institutional knowledge that occurs when stakeholders retire or move on to other jobs. The ICPRB addresses this issue through its annual drought exercise. The interview participant from the Potomac Basin stated the following: "We…have staff turnover, and an annual exercise gives us a chance to familiarize folks with the procedures that would be followed if we had a drought."

The theme called planning process encompasses several activities, such as problem identification, identification of resources needed for planning, planning approach, the creation of a plan (a planning outcome), plan implementation, and evaluation and updating of the plan or planning process. The broadness of this theme resulted in frequent references to its various components by interview participants. Lack of, or strained, resources was most commonly mentioned as a barrier related to the planning process. Participants stated that it is very difficult to successfully manage drought in a transboundary river basin when financial resources, human resources, or time are limited. It was recommended that adequate resources be located and secured before starting the planning process. Additionally, several of the participants representing basins in the eastern U.S. noted that inexperience due to infrequent drought was a barrier. This barrier is related to the recommendation that the planning process should be updated on a regular basis to avoid following outdated procedures when a drought does occur.

Several participants also recommended incorporating hydrologic or hydraulic models into the planning process to simulate different drought scenarios and improve drought planning for the river system.

While addressing stakeholder involvement is traditionally a part of the planning process, it was discussed often enough by interview participants to be a theme. Several codes were used to describe stakeholders, such as relationships, engagement, consensus, and their role in the planning process. The code “attitudes and perceptions” was used to describe references to values, credibility, trust, and civility of stakeholders. Participants who cited successes regarding stakeholders said that stakeholders were engaged in the planning process and had developed good relationships with each other. Others who mentioned stakeholder issues as a barrier to planning said that some key stakeholders were left out of the planning process, and stakeholders lost credibility or failed to gain trust with one another. Participants recommended that agencies identify and engage key stakeholders early in the planning process, and make sure they each know their role and why they are being included. Several participants said that federal and state agencies are key stakeholders that must be part of the planning process. Also, participants said that stakeholders should build relationships based on integrity and trust.

The last question participants were asked was whether they recommended planning for drought at the basin level or that it be implemented at other scales. Almost all participants said that drought planning should be implemented at the basin scale, but several participants stated that drought planning is appropriate at other scales as well, and planning activities at the various scales should be integrated. Some participants said that drought planning may not be appropriate for all sizes of basins. Some hydrologic regions may be too small and agencies that manage them may not have the resources to plan for drought. Other hydrologic regions may be too large, making the coordination of planning activities difficult to manage. Participants generally agree that factors such as the size of the basin, available resources, and the transboundary nature of the basin must all be considered when determining how to approach planning for drought for river basins.

CHAPTER 5
DISCUSSION

The participants who were interviewed for this research project shed a great deal of light on issues that relate to collaborative environmental planning (CEP), drought planning at different management scales, and transboundary water resources. The themes that emerged from the interviews (collaboration and coordination, communication, government and legal matters, information, the planning process, and stakeholders) are considered by these experts in water resources planning to be the most important components that are encountered and must be considered when planning for drought in a transboundary river basin. A discussion of how the results of this research compare to the literature that was discussed in Chapter 2 can contribute to the body of literature on the topics of CEP and drought planning. Observations made by the researcher that speak to the significance of the research, as well as some thoughts on the importance of having an institution for coordination, are presented in the following sections.

5.1 Comparison between the Results and the Literature

Statements made by interview participants regarding their experiences with planning for drought for transboundary river basins echo the literature on some of the basic elements and primary objectives of CEP. Recall that Randolph and Bauer (1999) and Randolph (2004) discussed the importance of stakeholder involvement being at the heart of collaboration and as one of the basic elements of CEP, respectively, and many interview participants said the same. Several participants mentioned the importance of identifying key stakeholders, achieving trust, having good leadership or facilitation, and fostering collaborative learning at some point during their interviews, and these items are all mentioned by Randolph and Bauer (1999) as leading to effective stakeholder involvement. Another basic element of CEP, as discussed by Randolph (2004), is that decision-making should be based on accurate scientific information and analysis. Participants cited information as an important consideration frequently enough that it became a theme when discussing successes, barriers, and recommendations as they relate to drought planning for transboundary river basins. Also, participants verified that a shared vision or direction is important for a successful CEP outcome, which was discussed by Randolph (2004) as a primary objective of CEP.

Experiences regarding the CEP process and barriers to CEP that were discussed by interview participants were also in line with the literature. Participants cited lack of or strained resources, mistrust, and bureaucracy as barriers to planning that were encountered in their basins, and these are all barriers to CEP that were mentioned by Wondolleck and Yaffee (2000). Additionally, participants stated that collaborative planning for drought in a transboundary river basin is an iterative and evolving process, which is consistent with Selin and Chavez's (1995) collaboration process and Bentrup's (2001) update to that process.

Several of the basin-level drought management strategies that were examined as part of this research could be considered success stories and could contribute to the growing number of case studies that have successfully implemented CEP, and more specifically, watershed management. For example, the ICPRB's annual drought exercise could be considered successful because stakeholders engage with each other and review drought management strategies every year, and the Low Flow Allocation Agreement that declares how water is divided among the member states during a drought has never been implemented. Duke Energy has been successful because its drought management strategies for the Catawba-Wateree Basin were sound enough that the basin endured a new drought of record without the various water use sectors having inadequate water for their needs. The metrics of success in the case of this research have not been determined, however, so this perspective deserves further study.

Overall, CEP as applied to drought planning for transboundary river basins was found to have similar elements to other applications of CEP that were mentioned in the literature. One recommendation made by interview participants that is specific to drought is the importance of communicating and updating the drought management strategies between droughts. This was found to be especially true for basins in the eastern U.S. that do not experience drought as often. Inexperience with drought was cited as a barrier to planning, and those participants recommended that stakeholders continue to communicate even during wetter periods and use that time to update drought management strategies. On a similar level, one participant stated that barriers to planning and stakeholder issues that have been encountered should not be addressed during a drought because the presence of drought is likely to exacerbate those issues.

This research also made a significant contribution to the drought planning literature. While extensive research has been conducted on drought planning at other levels, such as the state level, studies published on drought planning for river basins are rather limited. The literature primarily addresses drought planning by the Tennessee Valley Authority and some of the river basin commissions created by the Water Resources Planning Act that have remained in existence. This research has revealed additional basins planning for drought, and it has provided an update on drought planning activities occurring in basins that have been addressed in previous literature. Additionally, interview participants from this research confirmed that drought planning should be occurring at the basin scale, which is consistent with previous studies mentioned in Chapter 1.

5.2 General Observations and Significance of the Results

One observation that was made from interviewing experts on behalf of basins in the eastern U.S. is that traditional perceptions of water and drought are being challenged. In the wetter East, people often have the perception that water is plentiful, and even though droughts do occur, they are usually short-lived and will not reduce the water supply for very long. Participants from basins in the East, however, mentioned that population is increasing and is causing an increase in the demand for water. This is especially evident in rapidly growing urban areas in the Southeast, such as Atlanta, where conflicts over water have already occurred. The participant from the Yadkin-Pee Dee Basin said the following about this issue:

> "As time goes on, it's going to do nothing but get worse, bigger populations, more use of the water, it'll become much more of a passionate fight for folks… Atlanta [was] nearly running out of water. Well, it wasn't that the drought of 2007 was so…bad, but this is the only one that about took them to the brink and it's just because of how much water they use and how many people are there, and it's just

> a much greater strain on the resources. And I don’t see that getting any better in the future. So that's going to be our biggest problem, and I think it's probably going to be the biggest problem we'll all deal with in the next generation, is we do a lot of talking about carbon and other problems we've got to deal with going forward, but I think water will be the number one problem.”

The increasing population and subsequent demand for water will not necessarily cause an abrupt change in perceptions of water in the eastern U.S. Cultural values tend to change slowly, so officials who manage water resources are presented with the challenge of changing this perception through public education and instilling the culture of water conservation practices.

Several participants recommended the basin level as the optimal management level for drought planning, especially in a transboundary basin. As a planning unit, the basin is large enough that there are often resources available to plan at this level, yet it is small enough that the number of stakeholders involved and the size of the area of interest are more manageable. Some responses indicated that integrated planning efforts are necessary for a successful planning outcome. There were quite a few participants who emphasized the importance of federal agencies being included as key stakeholders so that they can serve in advisory roles, provide resources that may not be available at smaller scales, and provide information and data needed for the implementation of drought management strategies. Specific national and federal agencies that were mentioned (often multiple times) include NIDIS, the NDMC, NOAA and the NWS, USGS, the U.S.

Department of Agriculture, and the EPA. The ACF Basin participant's greatest recommendation is regarding the importance of including federal agencies as stakeholders, which is discussed below:

> "One of the strongest recommendations I would make is the value of advisory federal agency roles, and in some cases, that means an investment by those agencies in terms of time and dollars and energy into providing baseline information or helping to provide assessments of the resource or helping potentially in the states' efforts and again, in that advisory capacity... one of my strongest recommendations would be for agencies – for support for agencies to do the kind of things they do well; for example, NOAA, the USGS, and other agencies to help provide baseline information. Not to make decisions for the state, but to help in an advisory capacity to help understand what's going on with the resource and what are the implications of potential options relative to future use and trends."

The Great Lakes Basin participant talked about the role of federal agencies in regard to filling data gaps and providing programmatic support to the states:

> "There probably needs to be an understanding of the role of the federal government and how that impacts…what the

> states are trying to do as they come together to address an issue of common interest. So for instance, in the drought area, it would be things like, what are the data and information needs? What role does the federal government play in that? Some of the USGS programs are going to be really important to support the data and information needs. Other agencies like NOAA, for instance, would probably have a big role, maybe U.S. EPA in some cases, Department of Agriculture, so having some sort of a mechanism to coordinate with those federal agencies and to begin to look at where are the programmatic gaps within the federal infrastructure and for those programs that are in place, are they supported well enough to provide the support and service that is needed to address the issue? So I think all of those things would come into play."

Participants were asked about their interest in communicating with and learning from agencies that are planning for drought in other basins. While the responses differed in terms of how they might communicate, most of the participants stated they would be interested in learning about drought management strategies being implemented in other basins in some capacity so that they could consider innovative ideas and practices that might work in their basin. One participant suggested having a website that contains information on all of the basins known to be planning for drought in the U.S. so that their drought management strategies could be compared and contrasted to generate new ideas.

The interest indicated by participants is an opportunity for NIDIS and the NDMC to engage drought planning officials at a level that necessitates coordination among states, as well as the development of partnerships between states, with the intention of improving planning and reducing future conflict over water resources.

The discussion of drought management strategies occurring in each of the basins that can be found in Section 4.1 reveals that there is no one group of strategies that is suitable for all basins. While a great deal of common ground was found among the basins in terms of the primary elements that make up the structure of a drought planning process, it is evident that agencies responsible for planning for drought in each of the basins have had different experiences, they encounter different challenges, and they plan according to their unique circumstances and the characteristics of the basin. One example that illustrates this observation is the use of regulation as a drought management strategy. The DRBC is a regulatory agency, and the interview participants from this basin stated that having regulations in place are especially helpful during drought because they force customers to comply with their rules, resulting in adequate water for all water use sectors. On the contrary, the ICPRB is non-regulatory in nature, and the interview participant said the Potomac Basin’s organization has been successful at getting customers to cooperate during drought through the basin’s annual drought exercise that emphasizes frequent communication with customers and education of stakeholders during both drought and non-drought periods. One of the most important points to make is that the agencies and stakeholders that are managing drought in a basin should learn about the characteristics and mechanisms of the basin, play to their strengths and focus their efforts on the areas where they can make the most progress, and recognize limitations or barriers that could compromise the planning process.

On a theoretical level, the results of this research confirm that while agencies are slowly beginning to realize the benefits of drought mitigation and preparedness gained by developing drought plans and planning activities, drought policy is usually only implemented after the occurrence of a major drought that is costly and has caused many far-reaching impacts. The reactive nature of society to drought has long been an obstacle to increasing resilience and reducing vulnerability to it. The increase of drought planning at the basin level, however, provides optimism for the future in regard to addressing the challenge of providing adequate water to meet the needs of water use sectors.

5.3 Reflections on the Necessity of an Institution for Coordination

It was discussed in Section 4.2 that the participants who manage drought in their basins through an institution for coordination (e.g. a river basin commission) said that it was necessary for coordination, and some participants said they did not know how coordination could be successful without it. One interesting observation that was made is that two of the basins that have been involved in litigation, the ACF Basin and the Klamath Basin, do not have an institution for coordination. In fact, the interview participant who represented the ACF Basin said that politics among the states who share the basin would possibly prevent an institution for coordination from being successful. Neither of the interview participants from these two basins mentioned not having an institution for coordination as a barrier or needing one to be more successful.

This observation raises the question of whether an institution for coordination would improve planning for transboundary river basins. Since all of the basins are unique and agencies have developed different drought management strategies, it is quite possible that having an institution for coordination would not work for every basin. The idea is certainly worth further consideration because increasing water demand and the uncertainty of the occurrence of climate extremes due to climate change are putting the U.S.'s water resources in jeopardy, so sound planning efforts at the basin level through effective coordination are critical for preparedness. Also, when coordination attempts fail, basins often resort to litigation, but solving water resource issues in this manner only places further strain on relationships between state agencies and their stakeholders and may hinder future coordination efforts.

CHAPTER 6
CONCLUSIONS

This research has examined how water resources management officials address drought in transboundary river basins in the U.S., particularly through collaborative environmental planning. This research intended to identify the basins in the U.S. that are engaged in drought planning and provide an overview of the drought management strategies that have been developed and executed by various water resources management agencies. The role of collaboration and coordination in the development and implementation of agencies' drought management strategies and their recommendations for improving drought planning at this management level were also studied. The following sections highlight a discussion of the research questions presented in Chapter 1, recommendations for NIDIS and the NDMC, and suggestions for next steps that would further contribute to this research.

6.1 Discussion of the Research Questions

In Chapter 1, the following principal research question was presented: How are water planning agencies using collaborative planning to improve the management of drought in transboundary basins in the U.S.? Three subsidiary research questions were then presented. A discussion of the subsidiary research questions is intended to provide the best answer to the principal research question, so the subsidiary questions are discussed in the remainder of this section.

The first subsidiary research question that was presented is as follows: What is the status of drought planning for transboundary basins in the U.S.? At least a dozen basins were found to be planning for drought, although it is possible that there are more basins that were not discovered through this research. The basins are located in different geographic regions across the country and in different climate zones, so there does not appear to be a spatial pattern regarding basin-level drought planning in the U.S. Agencies are planning for drought at the basin scale in the Pacific Northwest, the Southwest, the Great Plains, and all along the East Coast, and in wet climates as well as dry climates. The basins are different sizes and constitute different levels of hydrologic units, although drought planning was not found to be occurring in smaller watersheds where water quality appears to be the primary concern. Management styles are very different and no two basins were found to have the same characteristics or drought management strategies. In fact, after conducting this research, it is evident that agencies representing different basins should develop and implement their own unique drought management strategies, even if the basins are in the same geographic region or are of similar size, because the topography and flow of every basin are very unique. Also, it was found in several cases that drought planning is occurring in a basin because a major drought occurred that prompted agencies to take a more proactive approach to drought management. Conflicts that developed between states during these major drought episodes necessitated that collaboration and coordination be built into the planning process.

The second subsidiary research question that was presented is as follows: How are collaboration and coordination playing a role in addressing the transboundary issue? Collaboration and coordination were found to be elements of the planning process followed by all of the basins that were studied in this research. One could argue that collaboration and coordination are elements of planning that are most important at the basin level, especially if it is a transboundary river basin, because a basin is the only planning unit that is defined by a natural boundary instead of a political boundary, and this research has shown that natural and political boundaries often do not match. Although agencies use different drought management strategies for their basins, the general planning process that is followed still has all the hallmarks of collaborative environmental planning that were discussed in the literature. It was found that several of the basins have an institution for coordination, such as a river basin commission or some other basin organization, that is responsible for planning and sometimes the allocation of water among states. The participants who work for an institution for coordination said that having such an institution made planning much easier because it provides a forum for communication among states, and it encourages cooperation. Also, in some cases, state agencies work closely with basin organizations to coordinate their planning efforts, while in other instances, planning efforts by state agencies and basin organizations are not integrated. Regardless of the extent of collaboration between them, participants said that state agencies and basin organizations recognize the importance of each other’s roles with respect to water resources management, and they do usually promote integrated planning through the coordination of their efforts if their drought planning activities overlap.

The third subsidiary research question that was presented is as follows: Based on their experiences with successes and barriers encountered during the planning process, what strategies do water planning agencies recommend that would increase successful collaboration and ultimately improve drought planning and management of transboundary river basins in the U.S.? The participants who were interviewed for this research project are most knowledgeable about planning for water, and especially drought, in transboundary river basins in the U.S. Participants discussed how they have been successful and how they have been challenged in their current water resources management positions, and then they made recommendations based on those experiences. Participants recommended that the planning process be well thought out, including the identification and engagement of key stakeholders, consideration for resources, and having provisions for implementing and updating the process. The planning process should be based on complete and high-quality information and data. Communication between stakeholders should occur often, and especially between drought episodes, so that precious time is not lost trying to reestablish relationships during a drought. The planning process followed by those who plan for a transboundary river basin should outline how states or other political jurisdictions will collaborate and coordinate with each other to share the water in the basin. Finally, participants recommended that planners recognize and anticipate government and legal issues, such as politics and litigation, in order to reduce their impact on the planning process.

6.2 Recommendations

The results of this research brought about recommendations for NIDIS regarding engagement with basins planning for drought. It was discussed in Chapters 1 and 2 that NIDIS has developed pilot regions that are intended to be Drought Early Warning Systems. Some of these pilot regions are basins, such as the Upper Colorado River Basin and the ACF River Basin. According to the NIDIS Implementation Plan (2007), one focus of NIDIS is coordinating disparate federal, state, and local drought early warning planning by becoming a clearinghouse for information and ideas related to drought preparedness at a variety of scales. Focusing the pilot regions around basins provides NIDIS with the opportunity to connect with several states on a regional level, which is helpful since drought often has a large spatial extent and impacts multiple states at one time. Additionally, this research has shown that federal- and local-level stakeholders are also important participants in basin-level drought planning, so focusing NIDIS pilot regions around basins can link all planning levels. Currently, NIDIS does not have any pilot regions in the Northeast. The basins in this area where drought planning is taking place could help fill regional gaps in pilot regions and would be excellent potential pilot regions for NIDIS to consider in the future. The development of the new pilot region focused around the Missouri River Basin provides an opportunity for NIDIS officials to implement recommendations made by interview participants from this research.

This research also brought about recommendations for the NDMC and its role regarding basin-level drought planning. The NDMC currently has a web page containing information and links to drought and management plans at a variety of scales in the U.S., including the basin scale. The plans are not categorized by planning scales, however, so it is somewhat difficult to locate and compare plans of the same scale. Also, this research found additional basins planning for drought that are not found on this web page. Most interview participants showed interest in learning about drought management strategies that are being implemented in other basins. The NDMC is in a unique position to provide and organize that information on its website in such a way that people interested in learning about drought management strategies that are being implemented in different basins across the country can compare and contrast them in one place. The researcher is currently working with NDMC staff to include new plans and planning activities on the site, as well as reorganize the information on the site to make plans easier to locate.

The NDMC currently has a comprehensive dataset that outlines all of the U.S. state drought plans, and a great deal of that information is available through their website, so it is recommended that a more comprehensive basin-level drought plan dataset is created and then modeled after the state drought plan dataset on the website. While a great deal of information about basin-level drought planning in the U.S. was revealed through this research, there are still gaps in data that can be filled by future research. Due to the inconsistency in the sizes of hydrologic regions and the ways in which they are managed, the creation of a database with standardized information about basins would be challenging, so the representation of information may need to be tailored to each unique basin. Sharing information on basin-level drought management strategies in this manner may further promote collaboration and communication, as well as generate innovative ideas, among those currently planning for drought at the basin level. Additional interest may also be initiated among others who are searching for improved or additional drought management strategies.

6.3 Suggestions for Future Research

This research provided a more general overview of transboundary basin drought planning in the U.S. because it was important to first identify the status of drought planning at this management level. Due to the uniqueness of each basin's characteristics and drought management strategies, it would be worth studying them individually to gain further insight into how and why their strategies were developed and how the occurrence of drought has prompted the revision of those strategies over time. Also, it would be interesting and insightful to study the transboundary nature of these basins and how that might influence water resources management. For example, one interview participant made the point that a river can bisect two states, or it can serve as a boundary between two states. The participant stated that basins are managed differently in each of these instances, so studying this phenomenon would be a nice contribution to this field of research.

One of the questions that this research raised is whether an institution for coordination is necessary for planning for a transboundary river basin. Further research could examine the development of these institutions and especially why some of them have been so successful. Taking this idea a step further, such research could explore the feasibility of developing additional institutions for coordination in other transboundary river basins in the U.S. It would also be interesting to investigate the potential usefulness of an institution for coordination for basins that have been involved in litigation. NIDIS is currently working with stakeholders in the ACF River Basin to improve stakeholder relationships while they address drought issues in the region, so the ACF River Basin could be a good case study in this regard.

The results of this research that are related to the basin-level drought planning process could be incorporated into other existing drought planning processes. The successes, barriers, and recommendations discussed with respect to the planning process in Tables 8, 9, and 10 in Section 4.3 are mostly applicable to planning processes at other levels where drought planning is taking place. This type of research could also create opportunities for drought planners at different scales to engage in collaborative learning and ultimately improve communication across jurisdictional levels.

6.4 Concluding Thoughts

Managing water resources, especially in transboundary river basins, is a very complex issue that deserves further study. It was discussed in Chapter 1 that increasing population, economic development, and climate change uncertainty are all factors that threaten global water supply and quality, and these issues present some of the greatest challenges faced by humans in the 21st Century. River basin boundaries continue to be ignored as people redraw political boundaries, causing conflicts over water that result in bloodshed. The negative impacts of these issues can be reduced, or even avoided altogether, if people work together instead of against each other and learn to share the most precious resource that is needed for life on Earth.

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APPENDIX A

TERMINOLOGY USED FOR HYDROLOGIC REGIONS

There are several terms used in the literature to describe hydrologic regions or boundaries, so it is important to sort out the different uses of the terminology in order to adequately describe the scales at which drought planning is occurring. The term “watershed” can be used to describe hydrologic regions of different sizes and is often used interchangeably with “drainage basin” and “catchment” (USGS 2012a). In general usage, “watershed” is often used to refer to a small drainage area, whereas “river basin,” or simply “basin,” refers to a much larger area (NRC 1999). When discussing specific levels of hydrologic units, however, “watershed” and “basin” have very different meanings (USGS et al. 2012). The following is an overview of the development and evolution of the U.S. Geological Survey’s (USGS) hydrologic unit system.

In 1972, the USGS, in partnership with the U.S. Water Resources Council, initiated the Hydrologic Unit Maps project, which involved the development of a standardized hydrologic mapping system that was to be used for land and water resources planning (Seaber et al. 1987). The U.S. was divided into four levels of hydrologic regions, called hydrologic units (HUs), and the units were assigned numeric codes, called hydrologic unit codes (HUCs). The terms used to describe HUs, from largest to smallest in area, were “region,” “subregion,” “accounting unit,” and “cataloging unit,” and the units were identified by 2-, 4-, 6-, and 8-digit codes, respectively.

While the 8-digit HU system developed by the USGS has been widely used, there are some applications of the system that require HUs smaller than the cataloging units.

By the late 1970s, the Soil Conservation Service, known since 1994 as the Natural Resource Conservation Service (NRCS), began subdividing the cataloging units to create fifth-level HUs, and 3-digit extensions were added to create 11-digit HUCs (USGS 2012b). In the 1980s, the NRCS finished mapping the fifth-level HUs for the U.S. and began subdividing the fifth-level HUs to create sixth-level HUs, which were identified by 14-digit HUCs.

By the early 1990s, advancements made in computer mapping technology led to an interagency effort to create a national initiative that would improve accuracy and consistency in HU mapping. The increasingly popular and widely used Geographic Information System (GIS) made it feasible to map HUs digitally. The NRCS partnered with multiple agencies to delineate the fifth- and sixth-level HUs and create an accurate and consistent hydrologic GIS database. This database was to meet U.S. National Map Accuracy Standards at a scale of 1:24,000 and match the USGS topographical 7.5 minute quads (USGS 2012b). The fifth- and sixth-level HUs were named “watersheds” and “subwatersheds,” respectively. The initiative was formalized in 1992 by National Instruction (NI) 170-304 to ensure that HU mapping is accurate and consistent nationwide and the database can be used with other digital data in a GIS.

In the early 2000s, the NRCS worked with the Federal Geographic Data Committee (FGDC) and the Advisory Committee on Water Information to write new and improved guidelines for delineation of fifth- and sixth-level HUs, so NI-170-304 was replaced with a new interagency standard (USGS 2012b). The most prominent changes made to the national standard included renaming the third- and fourth-level HUs and recoding the fifth- and sixth-level HUs. The name for third-level HUs was changed from “accounting units” to “basins,” and the name for fourth-level HUs was changed from “cataloging units” to “subbasins.” Fifth-level HUCs were changed from 11 digits to 10 digits, and sixth-level HUCs were changed from 14 digits to 12 digits.

After creation of the new national standard, the USGS worked with the FGDC and its member agencies to hold regional workshops aimed at improving and refining the national digital HU dataset, which is now referred to as the Watershed Boundary Dataset (WBD) (USGS et al. 2012). In June 2008, a Memorandum of Understanding was signed between the USGS National Geospatial Program and the NRCS National Cartography and Geospatial Center, now known as the National Geospatial Management Center, that defines the agencies’ roles in enhancement and maintenance of the WBD, integrates the WBD with the National Hydrography Dataset, and includes the WBD as a component of The National Map. As of 2012, the USGS and NRCS were copartners on the WBD, and seventh- and eighth-level HUs (14- and 16-digit HUCs, respectively) are being developed. See Table 11 for characteristics of the HU levels that are currently used.

Table 11. Characteristics of hydrologic unit levels. Adapted from USGS et al. (2012).

Hydrologic Unit Name	**Historical Name**	**Average Size (square miles)**	**Approximate Number of Hydrologic Units**
2 digit	Region	177,560	21 (actual)
4 digit	Subregion	16,800	222
6 digit	Basin (formerly Accounting Unit)	10,596	370
8 digit	Subbasin (formerly Cataloging Unit)	700	2,270
10 digit	Watershed	227	20,000
12 digit	Subwatershed	40	100,000
14 digit	(None)	Open	Open
16 digit	(None)	Open	Open

APPENDIX B

INTERVIEW QUESTIONS

Opening Question:

- What are your primary job duties and responsibilities?

Introductory Questions:

- Describe the basin with which you are involved, especially the primary issues that are addressed.
- What has been your general experience working with this basin?
- How often has drought occurred in the basin, and what was the severity and duration of each drought as best as you can recall?

First Topic: Planning Process

- What reason(s) was a drought plan created for the basin?
- How did you decide who would be involved in developing and executing the plan?
- What are the roles of those involved in developing and executing the plan?
- How did you determine which components were necessary to include in the drought plan?
- Has this basin experienced drought since the creation of the plan? If so, was the plan executed? How do you think the plan performed on a scale of 1-5, one meaning it performed very poorly, and five meaning it performed excellently? Why did you choose the number that you did?

Second Topic: Coordination and Collaboration

- Have coordination and collaboration with political entities that share the basin occurred? If so, who have you coordinated and collaborated with and why? What coordination and collaboration methods have been employed? Or if not, why have coordination and collaboration not taken place?
- Are you aware of drought plans at other scales that overlap with your basin drought plan? If so, is coordination and collaboration taking place to ensure all the drought plans are consistent in their procedures? If so, what coordination and collaboration methods have been employed? If they are not taking place, do you think they should be taking place and why?

Third Topic: Successes and Barriers of Planning

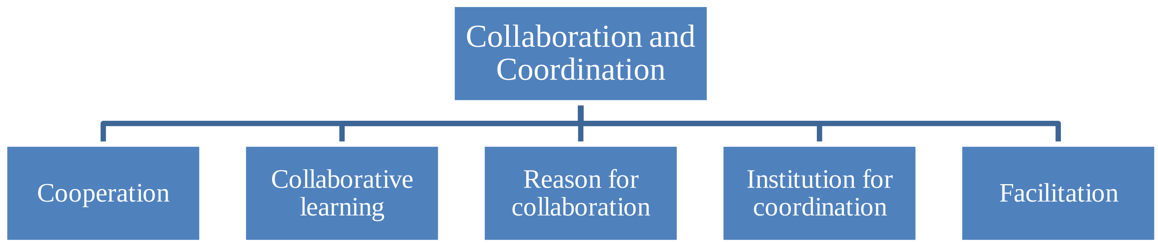
- Have you experienced any successes regarding coordination and collaboration with other agencies and/or political entities regarding drought planning for the basin? If so, please tell me about them and why you think they are successes. If not, how do you think coordination and collaboration could be more successful?
- Have conflicts or barriers arisen as a result of your basin drought plan overlapping with other drought plans at different scales? If so, what are those conflicts or barriers?
- Do you think you would benefit from learning of successes and barriers of others who are planning for drought for a basin? If so, how would you like to learn about others' experiences: A best practices document? A drought planning online forum? Other methods?

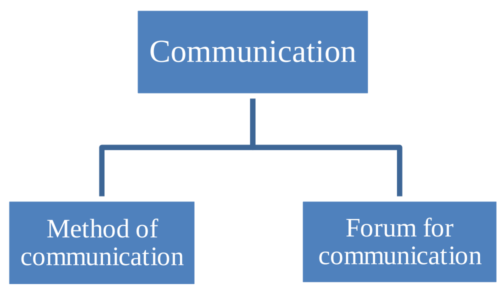
Fourth Topic: Recommendations

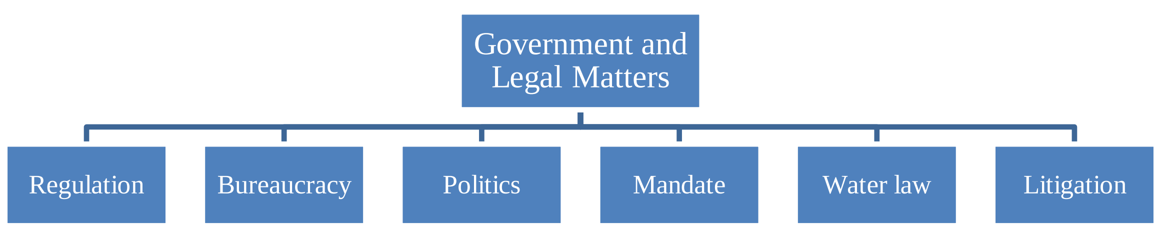
- How do you propose that the successes you documented regarding your drought plan be reinforced so that others may benefit from your experiences?
- How do you propose that the barriers or conflicts encountered during drought planning for your basin be avoided so that others may learn from your experiences?
- What would you recommend to others wanting to create a drought plan that would make coordination and collaboration more successful?
- Do you recommend planning for drought at the basin level, or do you think it is best implemented at other scales, and why?
- Is there any additional information that you would like to provide that would offer insight into how to improve drought planning for transboundary basins, based on your experiences?

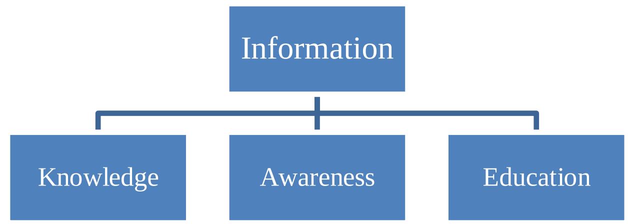
APPENDIX C

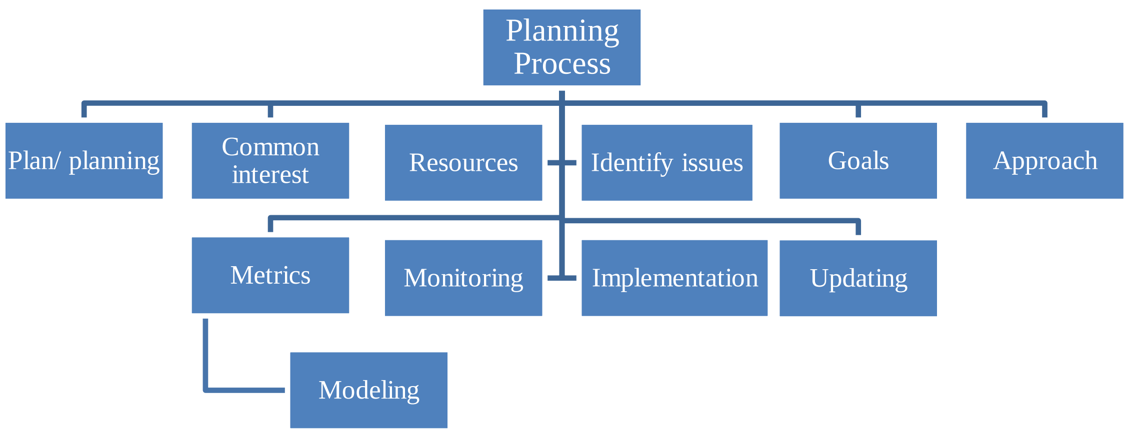
INTERPRETIVE CODES USED FOR ANALYSIS

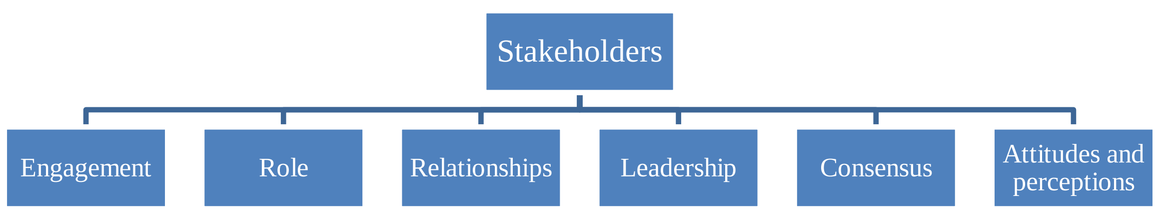







Information
Knowledge
Awareness
Education


Planning Process
Plan/ planning
Common interest
Resources
Identify issues
Goals
Approach
Metrics
Monitoring
Implementation
Updating
Modeling

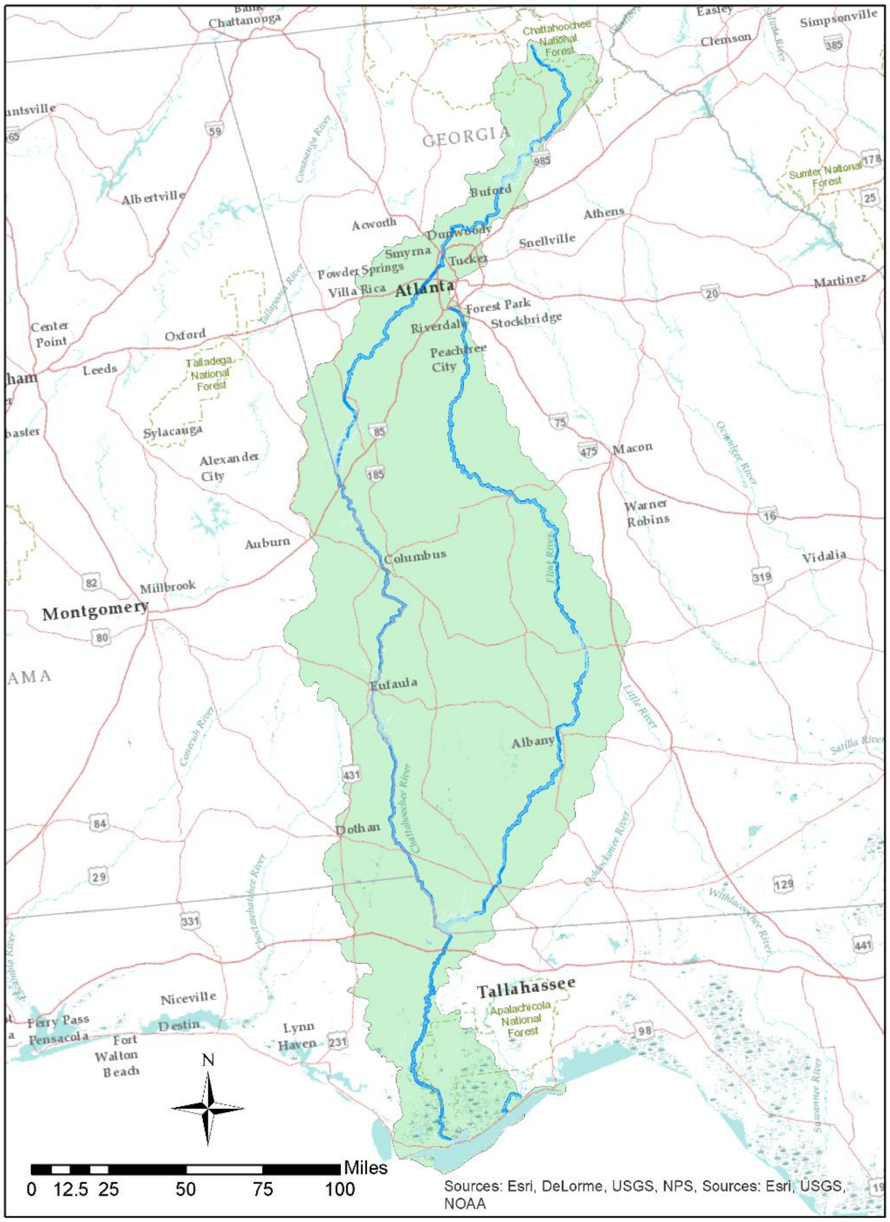

Stakeholders
Engagement
Role
Relationships
Leadership
Consensus
Attitudes and perceptions

APPENDIX D

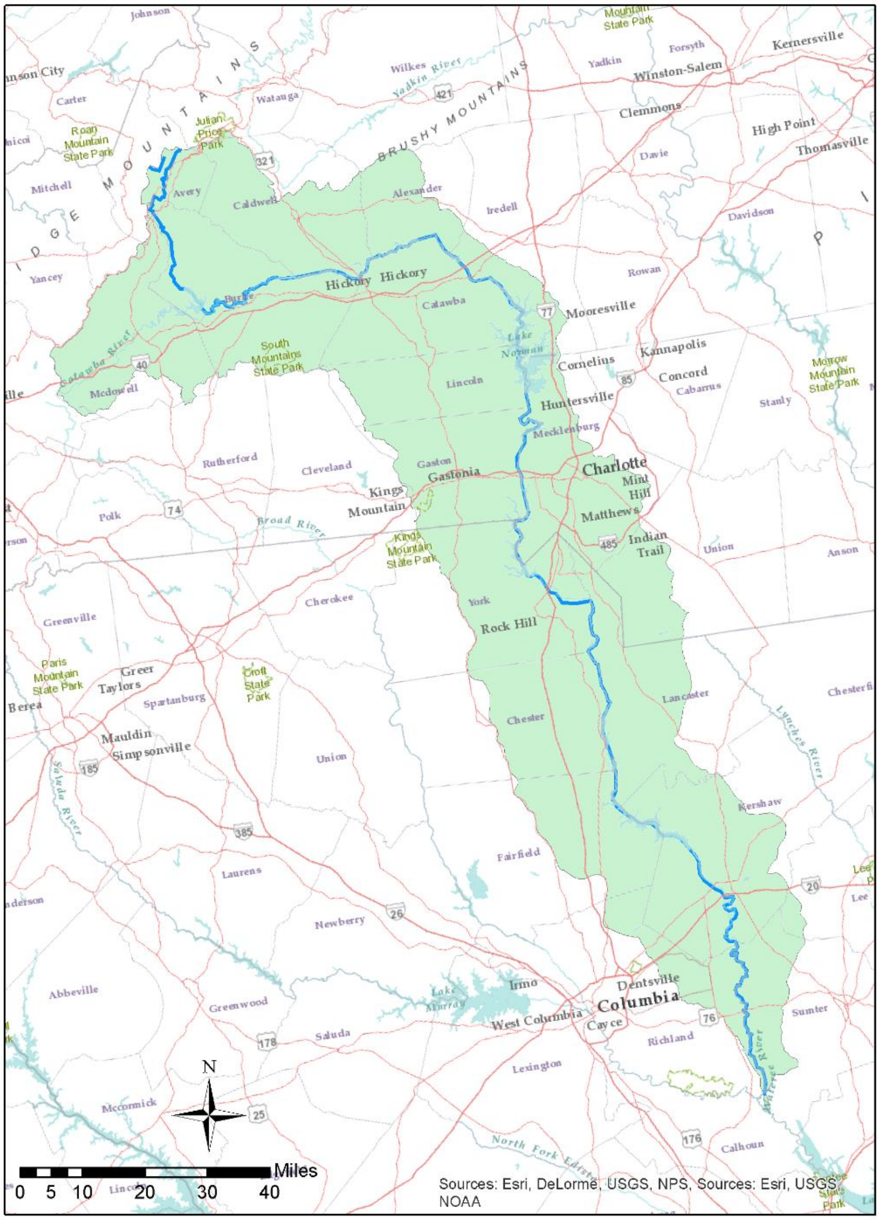
MAPS OF STUDY REGIONS

The following maps of the study regions were created in ArcGIS® using ArcGIS® basemaps. The maps were created in this manner for uniformity purposes and display primary rivers, cities, and other topographic features in and around the basins. They are intended to provide the reader with more detail regarding the basins than what is provided in Figure 4. Each map is displayed on its own page.

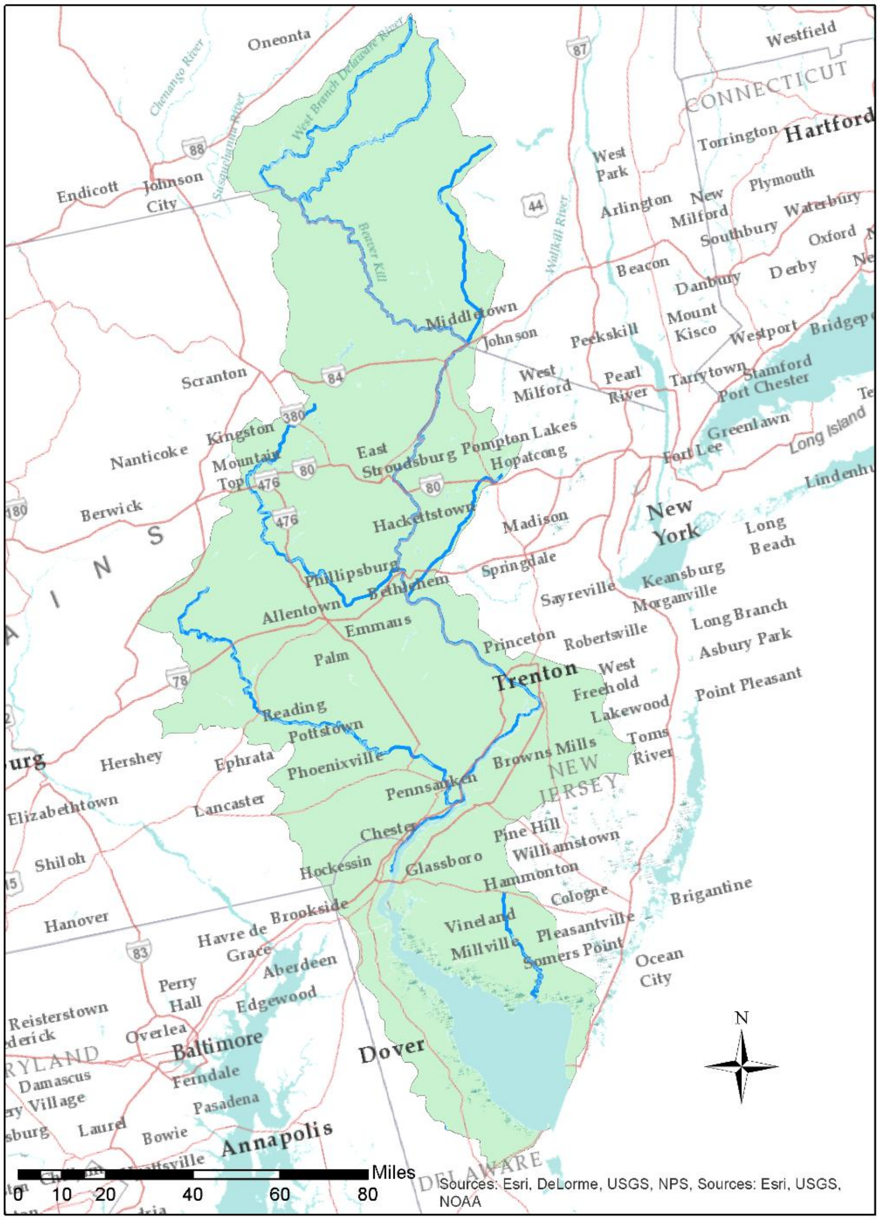
Apalachicola-Chattahoochee-Flint River Basin



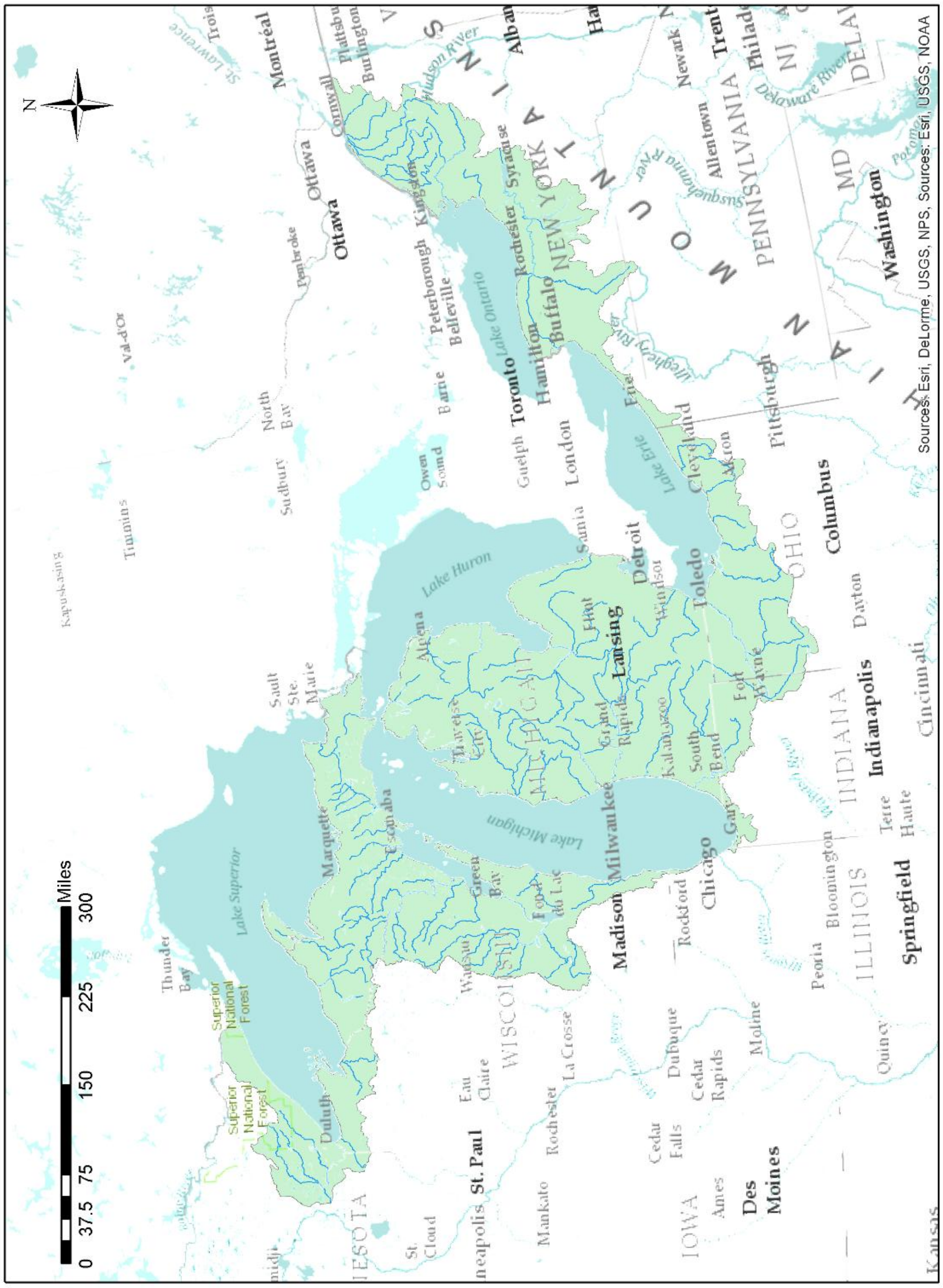
Catawba-Wateree River Basin



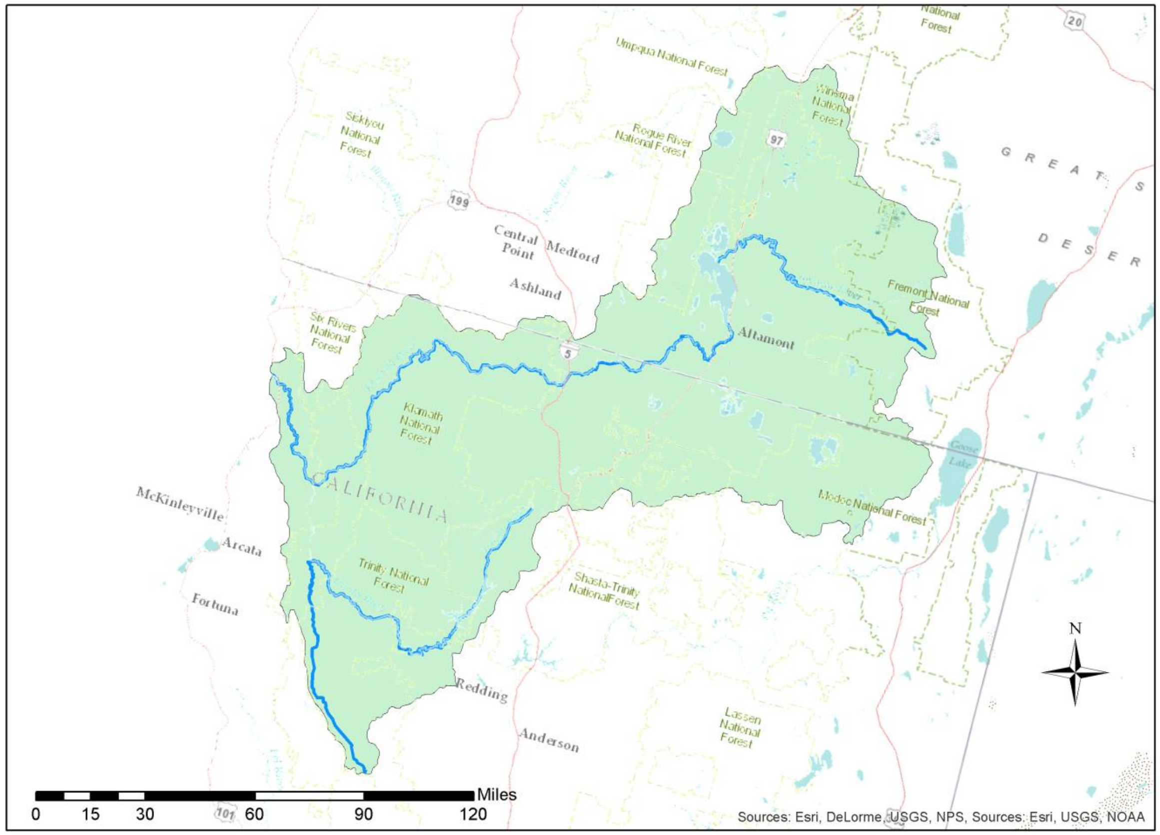
Delaware River Basin



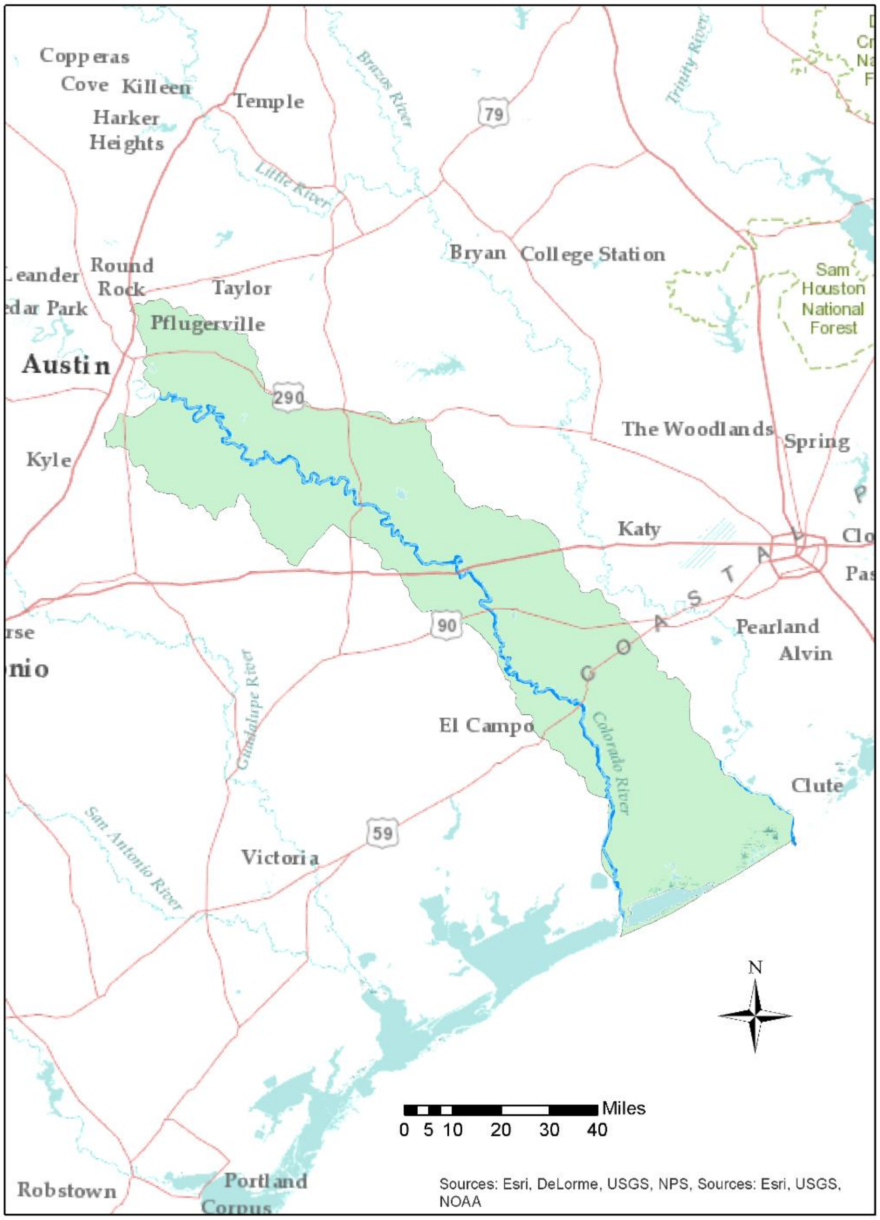
Great Lakes Basin



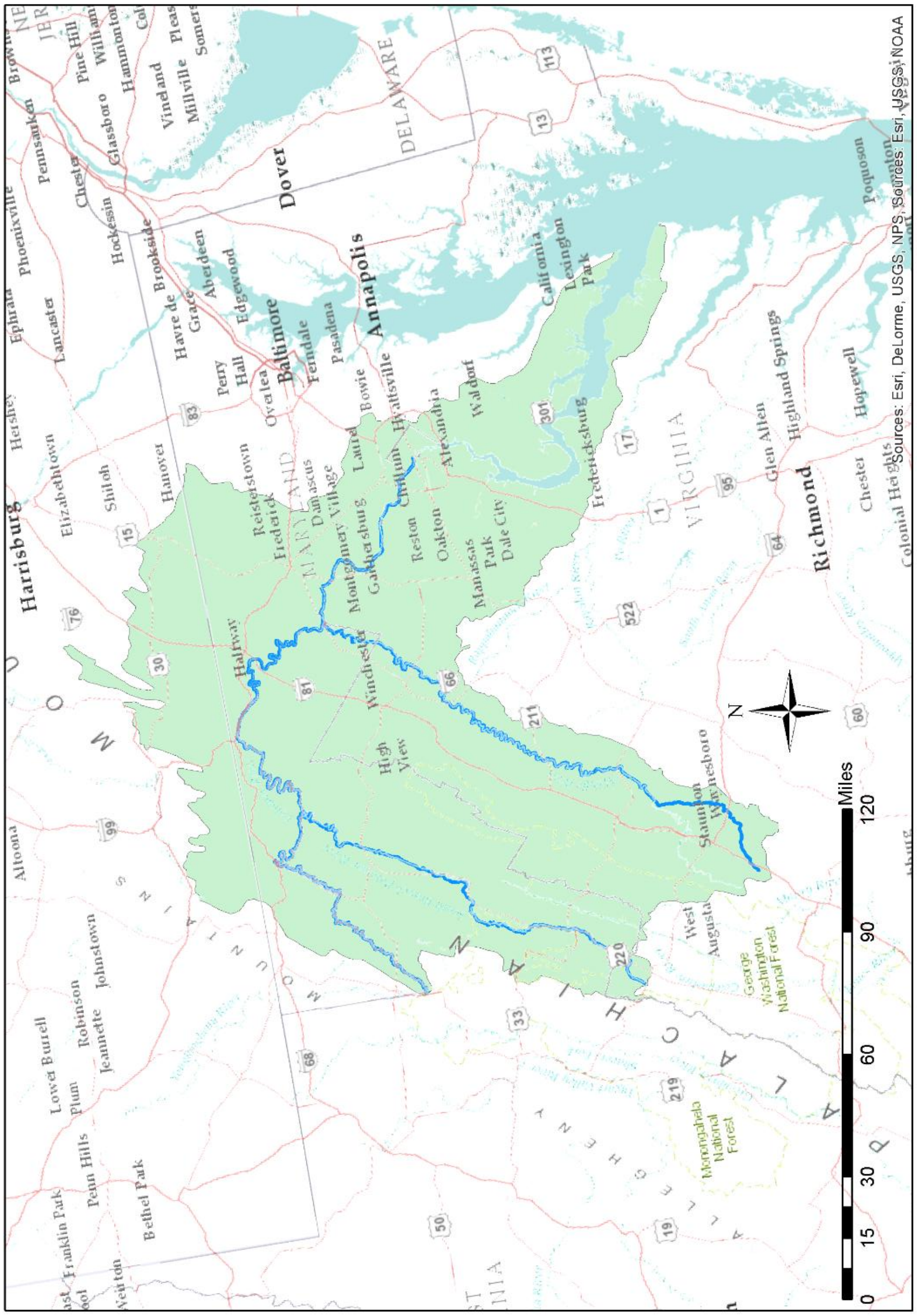
Klamath River Basin



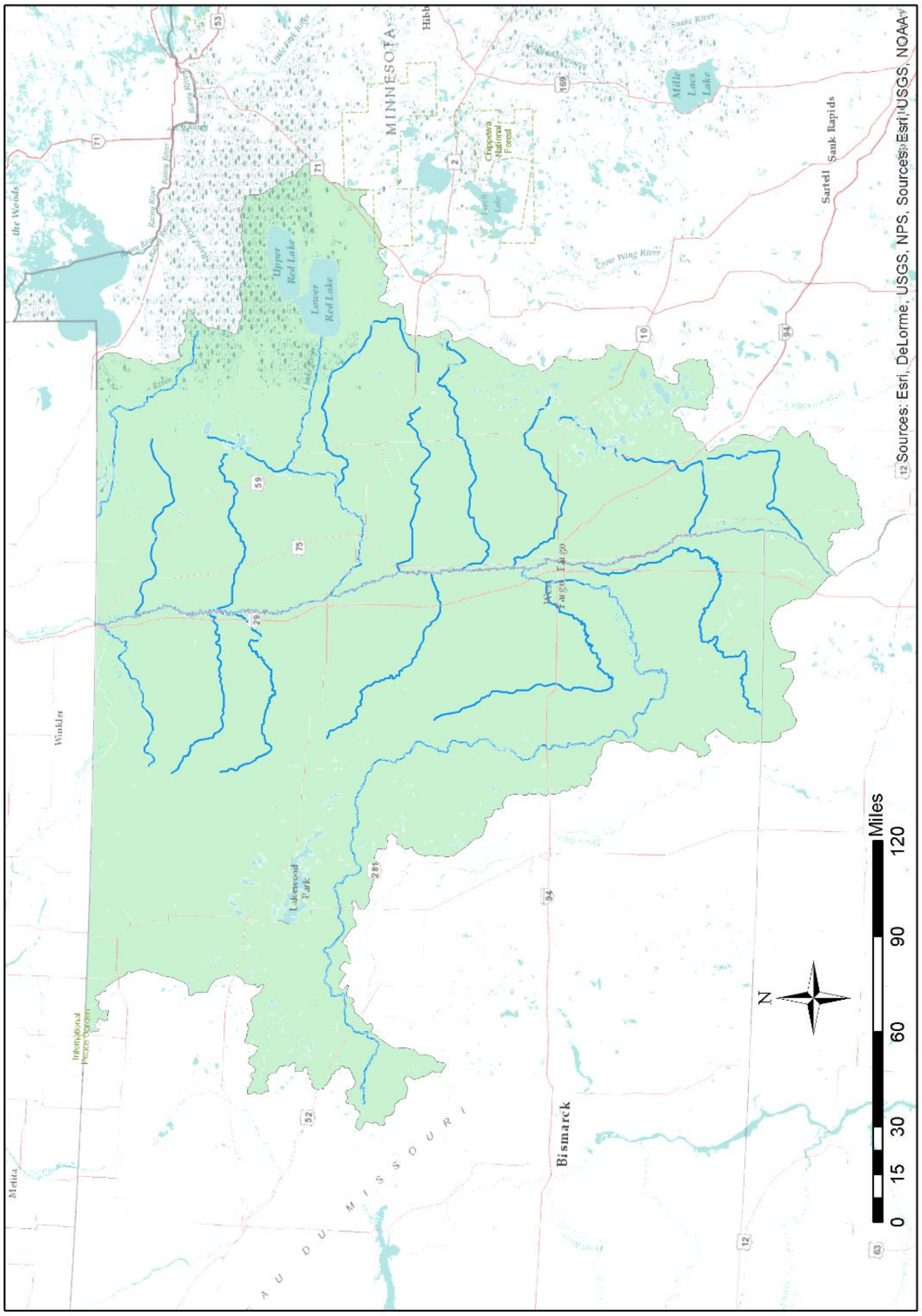
Lower Colorado River Basin



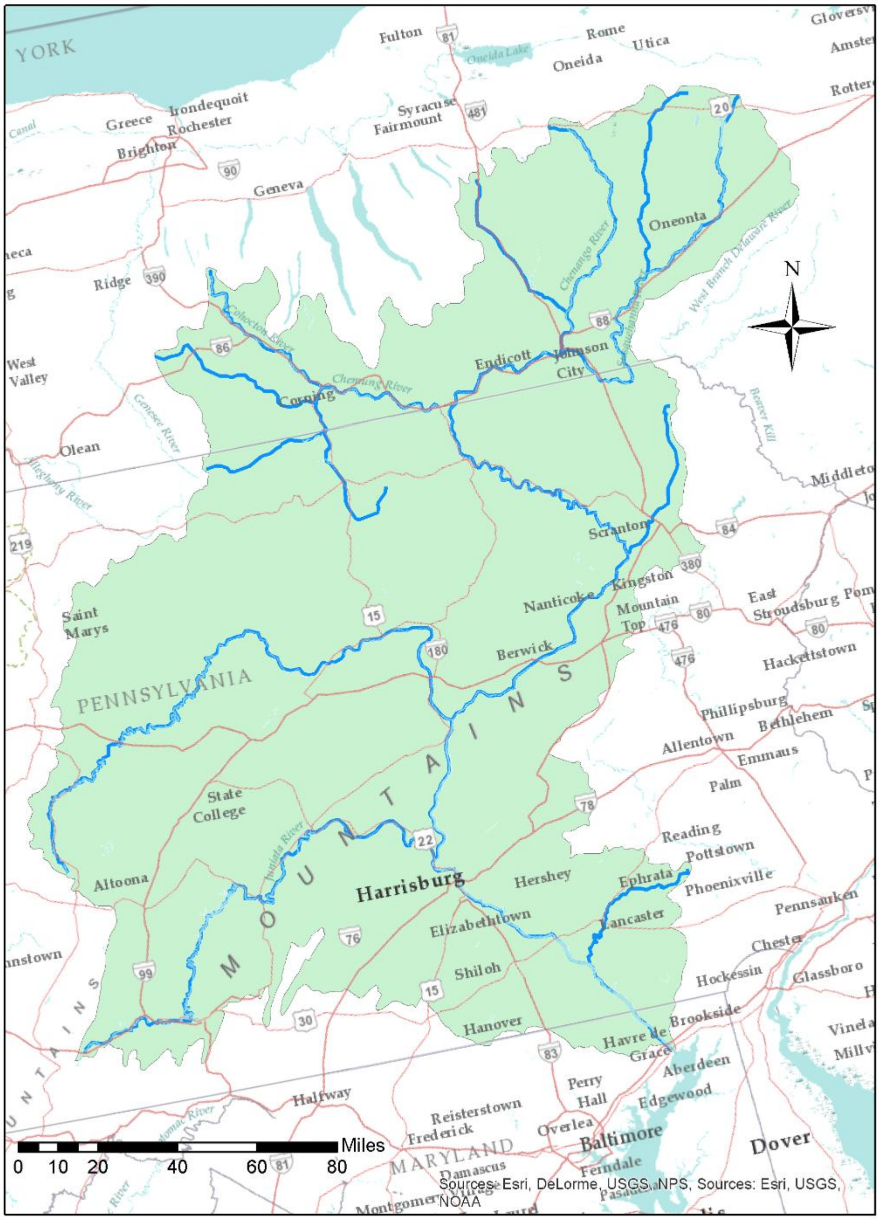
Potomac River Basin



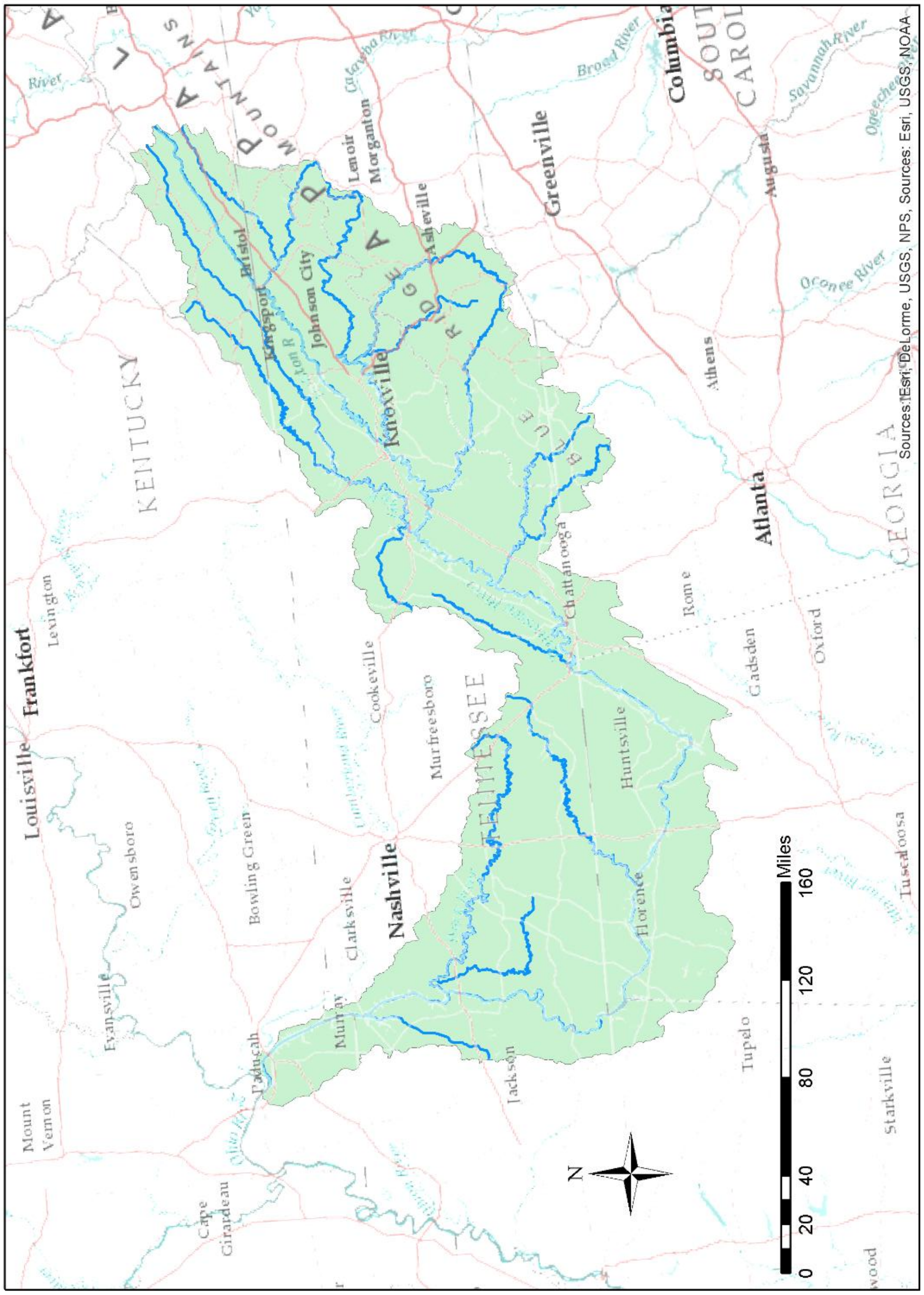
Red River Basin



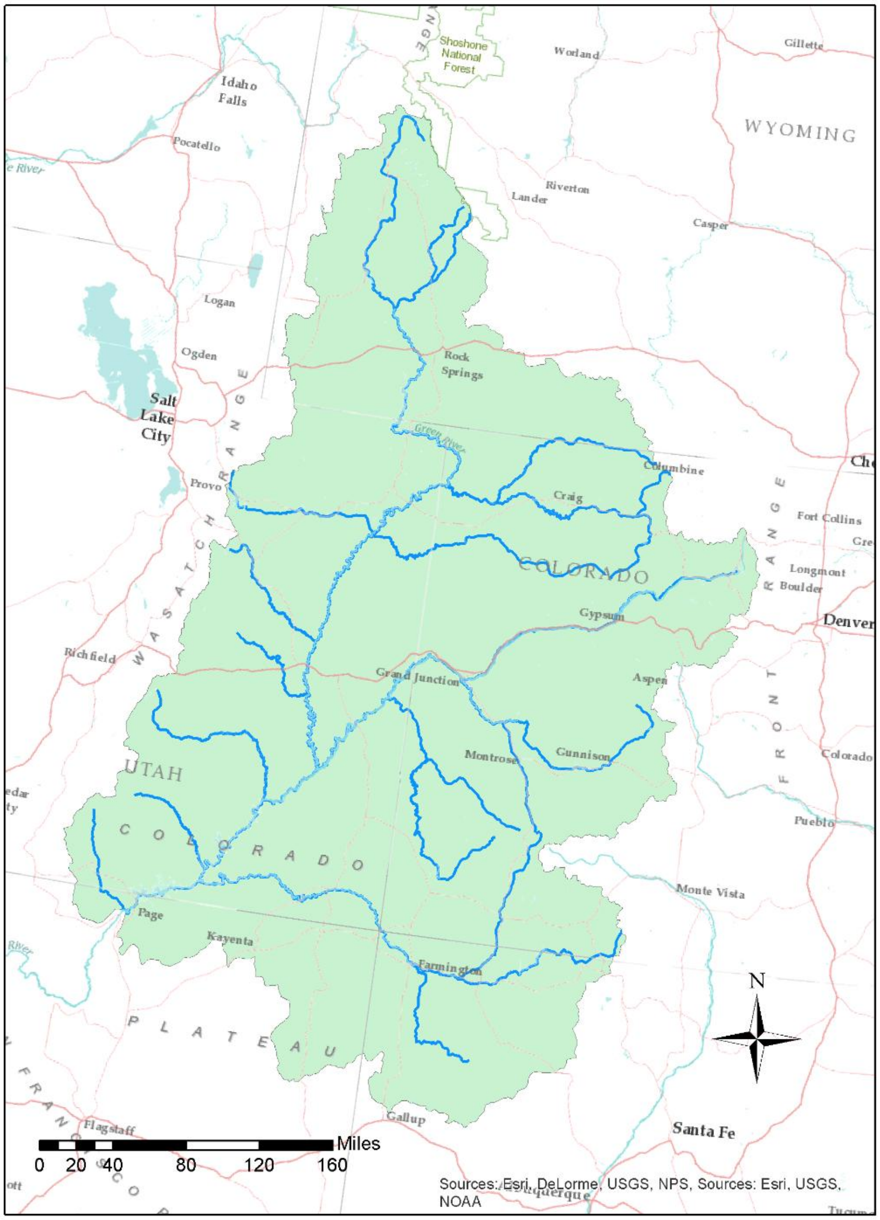
Susquehanna River Basin



Tennessee River Basin



Upper Colorado River Basin



Yadkin-Pee Dee River Basin