AN ABSTRACT OF THE DISSERTATION OF

Anna Pakenham Stevenson for the degree of Doctor of Philosophy in Public Policy presented on June 9, 2017.

Title: Assessing the Adaptive Governance Capacity of Western Water Communities

Abstract approved: ____

Edward P. Weber

One of the greatest challenges in the West is the sustainable management of limited water resources. In recognition of localized responses to natural resource challenges, there has been considerable work in the area of adaptive capacity and collaborative governance to help understand a community's capacity to manage change. This study combines the adaptive capacity and collaborative governance frameworks to create a new questionnaire to assess "adaptive governance capacity." Mixed-methods, factor, reliability analyses, null hypothesis statistics, and effect size statistics from case data in Upper Deschutes in Oregon and the Big Wood River in Idaho were used to 1) develop a questionnaire to assess capacity, 2) compare the adaptive capacity and collaborative governance frameworks, 3) evaluate the survey's performance under different collaborative contexts, and 4) provide information to water users engaged in a water planning effort. Overall, this research provides local stakeholders and managers with an applied tool to prioritize resources, develop more effective water management strategies that address site-specific needs, and identify barriers and opportunities for change while implementing place-based management. Additionally, this research provides managers with a questionnaire that can assist in the evaluation of change in capacity over time; this is especially needed in times of budgetary constraints and the need to justify engagement processes.

Assessing Adaptive Governance Capacity of Western Water Communities

by

Anna Pakenham Stevenson

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Doctor of Philosophy

Presented June 9, 2017

Commencement June 2018

Doctor of Philosophy dissertation of Anna Pakenham Stevenson presented on June 9, 2017

APPROVED:

Major Professor, representing Public Policy

Director of the School of Public Policy

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes the release of my dissertation to any reader upon request.

Anna Pakenham Stevenson, Author

ACKNOWLEDGEMENTS

"In one drop of water are found all the secrets of all the oceans;

in one aspect of You are found all the aspects of existence."

— Kahlil Gibran

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

Introduction

One of the greatest challenges facing the Western United States is the sustainable management of scarce water resources (Doherty and Smith 2012; National Research Council 1992). This is because growing populations will combine with growing economies to create increased demands on water resources, many of which are already stretched to capacity. At the same time, climate change threatens to alter the timing and supply of water, disrupting historical precipitation and streamflow patterns around which societies have organized their agricultural industries, human settlements, and public policies (Dalton, Mote, and Snover 2013). Moreover, in arid and semi-arid areas, these challenges to water resources management are coupled with changing societal values that have translated into new policy demands for greater environmental and natural resource protection, including the preservation of riparian zone integrity, endangered species, and minimum instream flows (Slaughter et al. 2010). Finally, these supply and demand challenges operate within the rigid management system of prior appropriation water law, where overallocation is common and solutions to water scarcity necessitate creativity.

States across the West are implementing place-based, integrated water resource planning as a way to address water resource management challenges, including meeting water demands, addressing water quality limitations, and adapting to climate change. As used here, place-based planning is a collaboration among communities to develop strategies to meet long-term human and environmental water needs in the face of biophysical and social change. Proponents of place-based management indicate that conditions will vary at the local level; therefore responses are needed to holistically integrate human and ecological systems' needs that are tailored to a particular basin (Adger 1999; Ivey et al. 2004:36; Kelly and Adger 2000).

In recognition of localized responses to natural resource challenges, there has been considerable work in the area of adaptive capacity and collaborative governance to help understand a community's capacity to manage change (Ansell and Gash 2007; Emerson, Nabatchi, and Balogh 2011; Heikkila and Gerlak 2005; Larson and Lach 2008; Leach and Pelkey 2001; Lockwood et al. 2015; Weber 2000). Both the adaptive capacity and the collaborative governance literature provide frameworks to understand which dimensions are critical in determining capacity of communities to manage change. These frameworks have been used to assess community adaptive capacity and collaborative governance in many natural resource contexts (e.g., agriculture, marine, forestry).

The Upper Deschutes Basin in Oregon and the Big Wood River Basin in Idaho have experienced serious water management challenges and utilized collaborative approaches to find water management solutions and were chosen as case studies for this research. In the Deschutes, water has been overallocated, with multiple water demands, and has experienced species listings under the Endangered Species Act, which has resulted in litigation between water user groups. In response to these ongoing challenges, water users in the Deschutes have collaborated for over 30 years on water management to meet current and future water needs. The development of the Upper Deschutes Basin Study Workgroup, funded by the Bureau of Reclamation, Oregon Water Resources Department, and The Deschutes Basin Board of Control, was tasked with developing a comprehensive plan accounting for changing water supply and demand in the future. This is the most recent example of such collaboration.

The Big Wood River basin in Idaho faces similar challenges of overallocation, multiple water demands, and conflict and litigation between water users in the basin. In 2015, senior water users (ground and surface water users) in the southern part of the basin placed a water call on junior users in the northern part of the basin (groundwater users). A water call is the request for appropriation for which a person is entitled under their water right, forcing those users with junior water right to cease or diminish use (Agricultural Water Conservation Clearinghouse 2017). When enforced, this water call curtails or cuts off junior rights holders at times of insufficient flow, usually in the summer months during the irrigation season. As a result of these challenges, a group of diverse water stakeholders in the basin established the Wood River Water Collaborative in 2015 to improve water management, create incentives to change water uses, and create a forum to think about the basin's water resources.

The Upper Deschutes and Big Wood River cases are both examples of water conflict among users in a similar Western water context. The Deschutes River case provides an example of extensive collaboration among water users over three decades. By contrast, the Big Wood River stakeholders have only recently embraced the potential of collaboration as a way to reconcile their differences. Given their distinct difference in time spent collaborating, these basins provide a valuable testing ground for the development and evaluation of a capacity assessment tool.

Specifically, these cases were used to 1) develop a questionnaire to assess adaptive governance capacity, 2) compare the adaptive capacity and collaborative governance frameworks, 3) evaluate the questionnaire's performance under different collaborative contexts, and 4) provide information to water users engaged in a water planning effort. This study combines the adaptive capacity and collaborative governance frameworks to create a new questionnaire to assess "adaptive governance capacity" (AGC). The data from these cases were used in factor and reliability analyses to test the construct validity and internal consistency of the concepts in the questionnaire and to compare the collaborative governance and adaptive capacity frameworks. These analyses helped to determine how adaptive capacity and collaborative governance dimensions overlap, interact, or are distinct (i.e., are they really two distinct frameworks?).

Next, a comparison of data from the Upper Deschutes and Big Wood River basins was conducted to test the questionnaire in different contexts, understand how AGC varies by basin, and compare the results against what we would expect from the collaborative governance and adaptive capacity literature. Finally, an analysis of the survey using data from the Idaho case were then used to demonstrate how results could be applied in a local management effort to inform decision-making in the basin. Overall, this research provides local stakeholders and managers with an applied tool to prioritize resources, develop more effective water management strategies that address site-specific needs, and identify barriers and opportunities for change while implementing place-based management. Additionally, this research provides managers with a questionnaire tool that can assist in the evaluation of change in capacity over time; this is especially needed in times of budgetary constraints and the need to justify engagement processes.

Background

The section below will identify the major challenges facing Western water management in the future. These challenges are complex, involve multiple users with competing interests, are framed in a legal system that is rigid, involves scientific uncertainty, and does not have clear solutions; they are “wicked problems.” Mechanisms to begin to tackle these problems involve adaptive and collaborative processes involving multiple water stakeholder interests. The question becomes- how do we know these processes are working?

Water Pressures

An historic look at water use and future projections in supply and demand can help to understand water challenges that will be faced in the future. Worldwide, there were three major drivers for expanding water infrastructure: population growth, increases in standards of living, and the expansion of irrigated agriculture (Gleick 2000). Population grew nearly four-fold between 1900 and 2000, from 1,600 million people to 6,000 million people (Gleick 2000). During this time irrigated agriculture saw a four-fold increase and water withdrawal saw a seven-fold increase (Gleick 2000). In the United States this water use increase was even more dramatic. Between 1900 and 1980 there was a four-fold increase in population, whereas water withdrawal for all purposes experienced a eleven-fold increase, from 56 to 610 cubic kilometers per year. During this time water use was not only showing an increase in an absolute sense, but also a per-capita increase as well (Gleick 2000).

Although there were dramatic increases early in water development, those trends did not continue past the 1980s. Between 1985 and 2005, water use remained around 400 billion gallons per day (bgd) and by 2010 total water use declined to 350 bgd, representing values lower than 1970’s water use (Donnelly and Cooley 2015). These declines occurred despite population and economic gains during these times (Donnelly and Cooley 2015). The 1980 peak in water use has been attributed to irrigation, thermoelectric-power, and industrial withdrawals during that time (Hutson et al. 2004). Subsequently, agriculture decreases were attributed to climate, crop type, irrigation efficiency, and higher energy costs (Hutson et al. 2004). In 2010, irrigation water use fell to its lowest level in more than 40 years, despite continued growth in the number of acres irrigated (Donnelly and Cooley 2015). The passage of the Clean Water Act in 1972 and amended in 1977 set stricter water quality standards, which resulted in greater conservation, efficiency, and lower water-using technologies, thereby reducing industrial and thermoelectric power withdrawals since 1980s (Hutson et al. 2004). Today thermoelectric withdrawal is still less than what it was in the 1970s (Donnelly and Cooley 2015). Despite the progress made in managing water use, Donnelly and Cooley conclude it is not sufficient to "counter the demands of continued population and economic growth, climate change, and increasing tensions over scarce water resources (2015:11)."

Despite the progress made in reducing water use since the 1980s, trends show that water use rises with increases in population, standards of living, electrical use, and irrigated agriculture. For example, nationally water usage increased by 200% between 1950 and 2000 (Allin 2008; Reimer 2013). Growing populations in the West resulting from nineteenth century expansion policies (e.g., Homestead Act of 1862 and the completion of the transcontinental railroad in 1869) continues today. The Western US has experienced some of the highest population growth in the nation, with its share of the total US population growing every year since 1900 (Culp, Glennon, and Libecap 2014). Furthermore, irrigation accounts for 75% of both surface and groundwater withdrawals in the West, compared to 34% nationally (Bruns, Ringler, and Meinzen-Dick 2005; Kenney 2005). With disproportionate growth and high agriculture demands, it is expected that the West will experience some of the most demand-driven water challenges in the near future.

In addition to increased water demand, changing climate is expected to impact the supply and timing of available water, further stressing the system. Currently in the Northwest, which includes Washington, Oregon, Idaho, and the Columbia River basin, precipitation varies seasonally with relatively wet winters and dry summers, and is also geographically varied with western Cascade regions wetter than the dry and desert-like conditions in the east (Dalton et al. 2013). This strong rainshadow effect of the Cascades can result in 10- to 15-fold precipitation gradients in less than 50km (Mote, Abatzoglou, and Kunkel 2013). Changes and variation in climate are not only influenced by these local conditions due to mountain ranges, but also global processes (Dalton et al. 2013). The Pacific Ocean causes climate variability particularly with El Niño-Southern Oscillation (ENSO). During El Niño conditions, which occur approximately every two to seven years, the jet stream is split with warmer air going toward the Northwest and Alaska, causing winters and springs in the Northwest to be warmer and drier (Mote et al. 2013).

Current trends and future predictions in the Northwest indicate an expected increase in temperature throughout the Northwest. Between 1895 and 2011, the Northwest saw an increase in temperature of approximately 0.7 °C (1.3 °F) and over the past 30 years temperatures generally have been above the 20th century average with only two years since 1998 not higher than the average (Mote et al. 2013). Although the warmest year on record is still 1934 in the Northwest, most of the warmest years are more recent with increasing trends since the 1970s (Mote et al. 2013). These increases in temperature that have been experienced in the recent past, are projected to continue and be exacerbated in the future. Century-scale warming is expected of 2.5 °C (4.5 °F) to 3.4 °C (6.1 °F) depending on the level of emission reductions with the largest change in the summer months (Mote et al. 2013). All temperature models agree that heat extremes will increase and cold extremes will decrease in the future (Mote et al. 2013).

Although the current and future temperature patterns are relatively clear, there is less certainty with precipitation. Mote et al. (2013) note that observed changes in precipitation over the past decades are highly dependent on the period of record and metric used, leading results to be ambiguous. Furthermore, changes in extreme precipitation vary with increases and decreases, and are mostly modest (Mote et al. 2013). Modeling future precipitation patterns is no clearer. Modeled changes in annual average precipitation in the northwest range from -10% to +18% for 2070–2099 (Mote et al. 2013; Mote and Salathé 2010). Models do seem to converge on seasonal changes, with most projecting increased precipitation in the winter, spring, and fall, and a decrease in the summer (Mote et al. 2013).

A changing climate has a direct impact on ecological and socioeconomic water systems. Increases in winter air temperatures will cause a shift in the relative contributions of precipitation in the form of rain or snow, specifically moving watersheds from snowmelt dominant to more mixed rain-snow dominant (Raymondi et al. 2013). These shifts will cause a flattening of peak stream flow, increases in winter flow, and reduced late summer flows (Raymondi et al. 2013). Water use often has multiple competing interests; tradeoffs in water management will have to be made with shifting water availability for reservoir operations to balance recreation, agriculture needs, aquatic species, and hydropower production (Isaak et al. 2012; Kunkel et al. 2013; Raymondi et al. 2013).

Stream flow not only will be impacted by an increase in temperature causing an increase in evapotranspiration (Chang et al. 2010), but also a reduction in summer precipitation (Raymondi et al. 2013), impacting multiple water-needs. Although stream flow is being impacted the greatest during the summer, increase in temperature will likely lead to increased agricultural water demands at the same time, further stressing the systems (Dalton et al. 2013). At the same time, the Washington State Department of Ecology (2011) estimated a 2.2% increase in irrigation demand by 2030 as a result of climate change and crop type use (Raymondi et al. 2013). As climate change increases agriculture demand and also reduces available water, agricultural water users will need to develop strategies to manage for their water needs. Strategies include developing more stored water, shifting to dry land farming, crop rotation, and crop changes (Raymondi et al. 2013).

Altered hydrologic regimes and warming stream temperatures will also impact salmonids and other aquatic species. Raymondi et al. (2013) summarizes the literature and identifies multiple potential impacts to salmonids in particular; high stream temperatures will affect habitat quality, physical and thermal obstacles resulting from higher stream temperatures will inhibit migration, migration will be altered by earlier spring runoff, and increase flooding will scour salmon nests. They further note that although cold-water species will be particularly impacted, there will be some benefits to cool and warm water species, potentially increasing their distribution ranges.

Western Water

These social and ecological changes are all taking place within the Western water context and are constrained by its rigidity. American water law can be grouped into three models of water law- riparian, prior appropriation, and hybrid states (Getches 2009). In riparian law, found in 29 Eastern states, landowners bordering waterways are considered “riparians” and are provided certain appurtenant rights (Getches 2009). A “natural flow” rule allows each owner a right to have the water flow past the land without diminishment in quantity or quality, but riparians are permitted to use water that is “reasonable” relative to other users (Getches 2009). In times of insufficient water supply, all on the system must reduce their usage proportional (sometimes based on size of their land) to their right. Traditionally, this system was established for the operation of mills and for access to fishing, boating, and hunting (Getches 2009).

Western water law is based in prior appropriation, which creates a system of senior and junior water right users (Doney 2010) and also determines water allocation when there are insufficient flows to meet all demands (Bruns et al. 2005). During the settling of the West, public lands were settled for private enterprise, primarily mining. Riparian water law would not work in this system of arid lands west of the one-hundredth meridian because settlers did not own the land and there was a need to move water away from the rivers for use (Getches 2009). This system was adopted for most of the Western US. Unlike riparian water law, prior appropriation depends on usage and not land ownership. This form of water law relies on the miners’ rule that govern mineral disputes on public domain “first in time, first in right” where “the earliest miner to put the water to work had a right to continue using it to the exclusion of others (Getches 2009:6). Senior water rights holders can place a water call requiring any junior water right holders to cease use until the full senior water right is met. Hybrid states are those who initially recognized riparian water law, but then transferred into a system of prior appropriation that preserved existing riparian rights. California, Washington, and Oregon are all examples of hybrid states (Getches 2009).

Water management in the West is arguably one of the most important management issues of the time, but has been criticized as lacking vision, deliberation, coordinated principles, or real public involvement that would account for management beyond Western settlement (Kenney 2005). "The development of water resources has led to the overallocation of most western rivers and in turn, intractable conflict over the allocation and distribution of various waters in the West" (Maloney 2008:14). Given that most rivers in the West were fully appropriated for irrigation in the late 19th and early 20th centuries, new uses including instream water rights established by administrative rule, are left junior and often unavailable during low water years (Garrick, Lane-Miller, and McCoy 2011).

The era of development in water management has come to an end and has transitioned to a time of protection, reallocation, and more intense management as more demands compete for limited resources (Gleick 2000; National Research Council 1992). Past water management has resulted in adverse environmental and social consequences and has translated into new policy demands for greater environmental and natural resource protection, including the preservation of riparian zone integrity, endangered species, and minimum instream flows, which often result in fierce competition among users for scarce water resources (Lach, Rayner, and Ingram 2005). Furthermore, agencies responsible for the management of these environmental and aesthetic values (e.g., fisheries, water quality) have mission conflicts with the water industry and water management agencies. These values are not easily accounted for within the historic water management system (Lach et al. 2005). These changes in values of water create new demands on the water system and also increase the potential for conflict between users.

Changing (and often conflicting) values resulting in increased demand housed within a system that has led to overallocation are all reasons there has been a call for policy reform in water management (Culp et al. 2014; Lach et al. 2005; Scarborough 2010). Examples of reform include redefining water rights in terms of water consumption instead of diversion, establishing a baseline for environmental need, eliminating the beneficial use doctrine, and an outright repeal of the prior appropriation seniority system. However, it is unlikely that the prior appropriation system will be replaced in the foreseeable future because of the history and culture associated with the system, the lack of an organized constituency advocating for its replacement, and the high political costs associated with change (Tarlock 2002).

Increased human demand, conflicting uses, supply and timing of available water impact by climate change, and a system of overallocation are all potential indications that water conflict and vulnerability will increase in the future. Arguably, many water management problems are ‘wicked problems’ (Lach et al. 2005) and developing solutions to these problems necessitates innovation and creative thinking. Although the exact impact of these changing social and environmental conditions is uncertain, it is clear that some areas will be impacted more than others and the coping mechanisms of communities to deal with these changes will vary.

Wicked problems

Traditionally, natural resource planning has been approached with the assumption that the challenges and solutions are scientifically based, data rich, expert driven, single objective, and outside the realm of political and financial restrictions (Lachapelle, McCool, and Patterson 2003). Dealing with these types of planning issues has been based on utilizing the synoptic or rational comprehensive model (Cortner, Moote, and Moote 1999; Hudson, Galloway, and Kaufman 1979; Lachapelle et al. 2003; Poisner 1996) where a simple method of problem definition, identification of alternatives, administration, and implementation solved the problem (Weber and Khademian 2008). However, beginning in the 1960s, academics and management practitioners began to realize that there were limits to this method because the issues they were confronting were far more complex and dynamic (Churchman 1967; Rittel and Webber 1973). These complex and dynamic undefined issues are often termed “messy” or “wicked.”

Some characteristics of wicked problems include: 1) multiple and competing goals, 2) little scientific agreement on cause-effect relationships, 3) stakeholders with conflicting values, 4) inequities in access to information and distribution of power, 5) limited time and resources, and 6) targets that morph and move (Churchman 1967; Lachapelle et al. 2003; Weber and

Khademian 2008). Some of the most urgent and complex natural resource planning issues are wicked problems (e.g., dealing with climate change, spatial planning, endangered species, the depletion of oil reserves). Unfortunately there is no clear, one-size-fits-all method to address their wickedness.

In recognition that these issues simply will not go away, practitioners and academics have devised ways to address some of the issues including: 1) transform the wicked problem into a tame problem by making it more manageable, such as focusing on a problem definition that can be solved (Conklin 2005); 2) develop possible future scenarios to evaluate costs and benefits (Camillus 2008); 3) draw upon a broad range of knowledge to solve the problem (Weber and Khademian 2008); 4) establish and maintain dialog, and involve stakeholders in decision making (Camillus 2008; Lachapelle et al. 2003; Ludwig 2001; McCool, Guthrie, and Stephen F. Mccool 2001; Vacaro et al. 2009). These approaches have been shown to be successful in addressing wicked problems and have begun to be used in water management.

For the first mechanisms to begin to address wicked problems, there is a growing body of literature to understand environmental change, with a focus on climate change and its impact on human populations (Sullivan 2011). Included in this research is the focus on water resource vulnerability worldwide (Chang et al. 2013). Concepts of vulnerability come from the hazard-risk literature where initially vulnerability emphasized the physical system or the hazard it created, and later was expanded to include the social conditions that make a population vulnerable (Adger 2006; Engle 2011; Gain, Rouillard, and Benson 2013). Like many vulnerability assessments, these studies defined vulnerability by the characterization of the physical factors, the hazard, and social characteristics. However, Sullivan (2011) highlights how these indicators do not provide a mechanism for practitioners to address the vulnerabilities identified. Therefore, the third and fourth mechanisms that have been identified in managing wicked problems draw on a broad range of knowledge and engage multiple stakeholders, are necessary.

Funtowicz and Ravetz (1993) propose the idea of post-normal science, which suggests an interactive dialog among those stakeholders impacted by the policy problem beyond the scientific community to increase understanding, represent diverse standpoints, and make decisions associated with wicked problems. There are many tools and processes available to address water challenges. These include drought planning, water conservation, the use of markets for trading, and infrastructure improvements. Key to selection of these strategies is the ability of a community to effectively implement the measures, which is tied to capacity (Ivey et al. 2004). Given that local conditions will constrain or facilitate success of water management, if attempting to evaluate the capacity to adapt over time, place-specific conditions will largely influence success (Adger 1999; Ivey et al. 2004:36; Kelly and Adger 2000). Therefore, to truly address water management problems, community capacity needs to be evaluated. The adaptive capacity and collaborative governance literature can both be used to assess capacity.

Adaptive Capacity

Engle and Lemos (2010) defined adaptive capacity as "the ability to recover or adjust to change through learning and flexibility so as to maintain or improve into a desirable state (p.4)." Regions will vary in their vulnerability as a function of spatial distribution of resources and environmental hazards, but also due to institutional responsiveness and the ability to manage and adapt to stresses (Ivey et al. 2004). Lockwood et al. (2015) and Engle and Lemos (2010) summarize the literature to identify four main components (dimensions) of adaptive capacity: social capital (dimension #1); human, financial, and physical capital (dimension #2); management approach and strategies (dimension #3); and governance and institutions (dimension #4) (Figure 1). These four dimensions have "subdimensions" that are used to explain the dimensions that will be described below.

Social capital (dimension #1) encompasses the social bonds and norms that are essential to sustainability; when high, people are able to invest in collective action with the knowledge that others will do so similarly (Pretty 2003). Social capital "can improve the efficiency of society by facilitating coordinated actions… [through] features of social organization such as trust, norms and networks" (Putnam 1993:167). Social capital facilitates cooperation and therefore lowers the transaction costs for participants working together (Pretty 2003). According to Pretty (2003), features of social capital include relations of trust; reciprocity and exchanges; common rules, norms, and sanctions; and connectedness in networks. Lockwood et al., (2015) specifically identified trust, reciprocity, and networks as three subdimensions of social capital that are posited to affect adaptive capacity.

Knowledge and information, labor and time, and finance and infrastructure are subdimensions of human, financial, and physical capital (dimension #2) that are identified as key components of adaptive capacity (Lockwood et al. 2015). Human capital relates to the availability of skills, expertise, knowledge, and human labor (Gupta et al. 2010; Lockwood et al. 2015; Nelson et al. 2010). Human capital in water management assists in identifying, understanding, and evaluating the problem and alternatives. Financial capital is the financial resources available to support policy measures and create financial incentives (Gupta et al. 2010; Lockwood et al. 2015). An example in water management would include grant funds for water efficiency projects. Physical capital includes resources created by economic production (Ellis 2000; Lockwood et al. 2015) that may include canal pipes and restoration equipment in water management.

According to Lockwood et al. (2015) adaptive capacity is also constrained or supported by approaches to and strategies regarding management. Management approaches and strategies (dimension #3) that are innovative and allow for risk also support adaptive capacity (Lockwood et al. 2015). In water management, multiple tools have been identified to support innovation; these include water markets, efficiency projects, metering and measurement, and conservation of water instream.

Finally, subdimensions of governance and institutions (dimension #4) that contribute to adaptive capacity include legitimacy, accountability, inclusion, leadership, and collaboration (Lockwood et al. 2015). Among all of the other determinants of adaptive capacity, Engle and Lemos (2010) identify governance and institutions as the most critical. This is because governance and institutions can either facilitate or create barriers to adaptation and the other components are related to governance and institutions (Adger et al. 2009; Engle and Lemos 2010). Given the tremendous work that has been conducted in collaborative governance literature, this topic is explored further below.

Collaborative Governance

Many people have come to believe that collaborative dialog is the most productive way to address complex and controversial policy issues (Connick and Innes 2003; Yankelovich 2001). Traditional command-and-control approaches are widely perceived as ill-suited for many environmental and natural resource problems (Durant et al. 2004) and collaborative governance is one institutional arrangement that has emerged in response to failures of top-down management as well as the high cost and politicization of regulations (Ansell and Gash 2007). In contrast to top-down management, collaborative institutions strive to increase public and stakeholder involvement with the goal of removing conflict and scientific disagreements, thus finding lasting solutions. It is believed that if citizens are actively involved, the resulting governance from this process will be more effective and democratic (Irvin and Stansbury 2004).

Collaborative processes aim to have decisions made jointly, with shared authority and collective responsibility of actions and subsequent outcomes by all stakeholders (Selin and Chevez 1995). A goal is to engage all stakeholders in decision-making instead of merely consultants of an advisory group (Ansell and Gash 2007). To minimize power differences, there is an attempt to share authority among levels of government and between private and public stakeholder networks. Leadership in collaborative processes allows for meaningful engagement by multiple stakeholders and increases credibility to the process for stakeholders who will be responsible for implementation (Leach and Pelkey 2001).

These arrangements also strive to create shared understanding of the problem and an agreement of the knowledge needed to address that problem (Ansell and Gash 2007). With free information exchange, a base of shared knowledge is created and owned by all participants in the process (Imperial 2005). A shared vision of the problem and collective knowledge building by participants minimizes the fights of better facts and the manipulation of information to achieve certain ends. This shared knowledge base allows managers to make more informed and better decisions (Imperial 2005; Wondolleck and Yaffee 2000). Proponents of collaborative institutions believe that by allowing all participants to assume roles beyond what is typically allowed in top-down management, they are empowered to more actively engage in the management and often feel more invested in the outcomes.

In the past decade, public participation and collaboration in natural resource decision-making has become more frequent. Some describe this phenomenon as a paradigm shift away from top-down government led decision-making to a more bottom-up and citizen approach to managing problems (e.g., Griffin 1999; Weber 2000). Examples of this increase in collaborative processes include the use of watershed councils across the nation, the Forest Service's Collaborative Forest Landscape Restoration Program, the Environmental Protection Agency's National Estuary Program, and numerous examples of cases in local planning efforts (e.g., Imperial 2005; Tuxill and Mitchell 2010; Weber 2009).

Oregon has a long history of collaborative planning and engaging local communities in decision making- examples include Oregon Commission on Children and Families, Oregon Department of Fish and Wildlife Marine Reserves Process, and the Oregon Board of Forestry Federal Forestlands Advisory Committee. The Oregon Integrated Water Resource Strategy identifies place-based management as a critical strategy to meet water needs in the future (Bateman and Mucken 2017; Bateman, Mucken, and Stahr 2012). This strategy is motivated by the knowledge that each river subbasin has unique ecological issues, community values, and economic dynamics that makes local place-based management critical to meeting water needs (Bateman and Mucken 2017; Bateman, Mucken, and Stahr 2012). Oregon's vision for place-based integrated water resources management is a collaborative planning effort that brings together multiple stakeholder to develop goals and strategies to maintain the water needs of Oregonians and also the environment (Bateman and Mucken 2017; Bateman, Mucken, and Stahr 2012).

Collaborative governance is one governance institution that has been used in the water sector to build capacity to adapt (Engle and Lemos 2010). According to collaborative governance theory, flexible, democratic, and participatory designs are hypothesized to increase adaptive capacity (Engle and Lemos 2010). Furthermore, "if stakeholders are represented, given the opportunity to participate actively, and making decisions equitably and democratically, they would be more likely to buy-in and be empowered to respond effectively to climate change" (Engle and Lemos 2010:6). These collaborative processes over time provide stakeholders with the opportunity to observe the environment and adjust management approaches accordingly over time (Scholz and Stiftel 2005; Ulibarri 2015). Consequently, longer collaborative processes have the potential to create stronger links between collaboration and outcomes (Ulibarri 2015).

The collaborative governance literature can refine and add to the adaptive capacity literature in aiding understanding of a community's ability to handle the stresses that impact its basin, including climate change, increased demand, and conflicting values. The literature on collaborative governance adds to the adaptive capacity literature in its ability to measure *governance*, rather than the traditional role of *government*. Adaptive governance looks beyond the role of government and "Involves the evolution of a new governance institution capable of generating long-term, sustainable policy solutions" (Scholz and Stiftel 2005:5).

Multiple collaborative governance frameworks have been developed to understand the critical elements of collaborative arrangements (Ansell and Gash 2007; Daniels and Walker 2001; Emerson et al. 2011; Innes and Booher 1999; Sabatier et al. 2005). Utilizing multiple existing frameworks, Emerson et al. (2011) developed an integrated framework for collaborative governance that consists of key components that interact to produce actions, outcomes, and adaptation. In a comparison of the collaborative governance and adaptive capacity frameworks, overlap exists among the dimensions and subdimensions identified (Figure 1). In the frameworks, there are aspects of social, human, financial, and physical capital that constrain or promote adaptive governance capacity. Similarly, measures of management innovation, risk, and strategies are also found in both frameworks.

Research Questions

As states across the West attempt to handle wicked problems associated with water management, having an assessment tool to assist in understanding the ability of communities to adapt to changing water conditions will help resource managers and local communities prioritize areas of work, develop strategies to confront changes in the future, and evaluate change over time. This study's first goal is to combine the adaptive capacity and collaborative governance frameworks to create a new questionnaire tool to assess "adaptive governance capacity" (AGC).

Next, this study aimed to understand how frameworks of adaptive capacity and collaborative governance overlap, and how dimensions and subdimensions relate to each other. This study combined the variables from multiple studies drawing from both literatures. The evaluation of how subdimensions and dimensions interact to determine if a clear delineation exists between these components aids in understanding of these frameworks and how they are applied in water management.

After deployment of the questionnaire and evaluation of the theoretical frameworks, a comparison of the Upper Deschutes and Big Wood River basins was conducted to test the questionnaire in different contexts, understand how AGC varies by basin, and compare the results against what would be expected from the collaborative governance and adaptive capacity literature. Given that collaborative arrangements evolve over time and are dynamic in nature, it is expected that there would be differences in capacity between the two study sites (Thomson and Perry 2006). It is expected that the longer time spent in collaboration would lead to a difference in overall capacity and/or the dimensions that contribute to capacity; in the Deschutes Basin, multiple stakeholders have engaged in collaborative efforts over the past 30 years, whereas in the Big Wood River Basin, collaborative efforts have only begun in the past two years.

Finally, questionnaire and interview data from the Big Wood River in Idaho were used to illustrate how results can inform local management and provide support to evaluate change over time. This questionnaire tool provides local stakeholders with the ability to identify barriers and opportunities that might not be clear, address the most pressing challenges, allocate scarce resources to areas of greatest need, and develop more effective water management strategies that address site-specific needs. Additionally, for local and regional water managers, this tool can be used not only in a snapshot assessment, but also provides an approach that can assist in the evaluation of change in capacity over time; this is especially needed in times of budgetary constraints and the need to justify engagement processes.

With both an applied and theoretical perspective in mind, specific research questions include:

1. How can the collaborative governance and adaptive capacity literature be used to inform a questionnaire that measures adaptive governance capacity of Western water communities?
2. How do dimensions and subdimensions contained within adaptive capacity and collaborative governance frameworks interact?
3. To what extent do adaptive governance capacities differ based on the amount of time that communities have spent in collaboration?
4. How can the results be used to inform local water management in Big Wood River, Idaho?

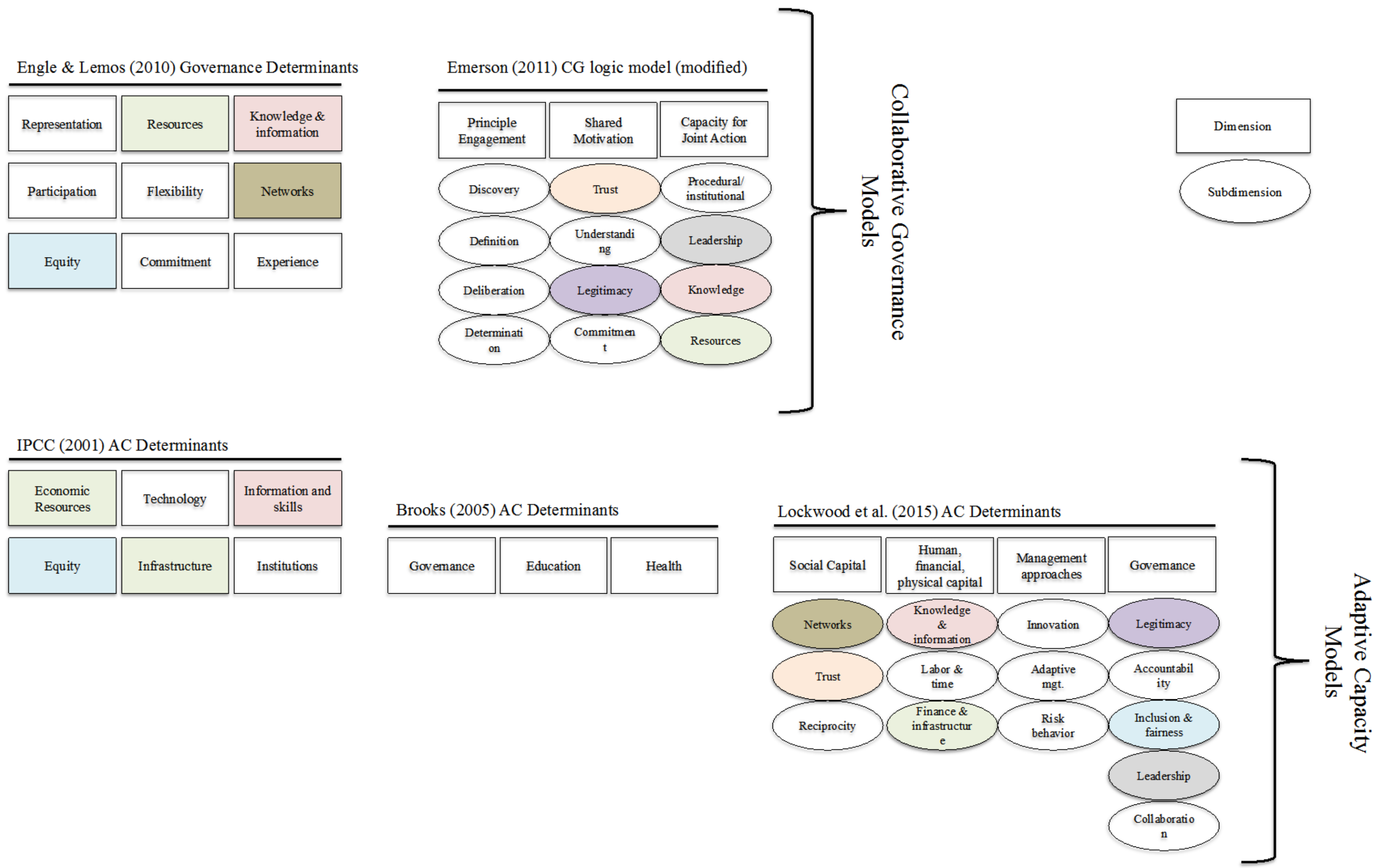


Figure 1: Comparison of Collaborative Governance and Adaptive Capacity Models, overlapping concepts indicated by colors (modified from Emerson et al. 2011; Engle and Lemos 2010; Lockwood et al. 2015).

Study Sites

The Upper Deschutes Basin in Oregon

The Deschutes Basin, located in Central Oregon, is Oregon's second largest river basin and covers 10,700 square miles (Heisler 2012). The geographic extent of this research focused on the upper Deschutes Basin, which includes the Deschutes River, Crooked River, and Whychus Creek river systems, and comprises about 4,500 square miles (Newton and Perle 2006). The upper Deschutes Basin crosses Jefferson, Crook, Deschutes, and Klamath counties and includes the Cities of Redmond, Prineville, Sisters, Bend, Brothers, La Pine, and Gilchrist (Figure 2).

Much of the basin resides in the Cascade Mountain rain shadow in the west; thereby limiting the amount of precipitation the basin receives. Average annual precipitation (primarily snow) on the eastern slopes of the Cascades is often greater than 100 inches, but drops to approximately 10 inches at lower central locations (Northwest Power and Conservation Council 2004). Much of the snow and rain that falls within the basin is absorbed by porous lava formations and volcanic soils, creating a large underground storage (Northwest Power and Conservation Council 2004). This volcanic geology and substantial groundwater storage moves through the aquifer and discharges into streams throughout the basin, thereby creating steady flows through the length of the Deschutes River (Gannett et al. 2001). Groundwater supplies 80% of the mean annual flow in the upper Deschutes River, making the river historically one of the most stable and uniform rivers in the United States (Deschutes River Conservancy 2014).

Irrigated agriculture became the dominant driver of the rural economy in Central Oregon, following the decline of the timber industry in the 1980s, with farms and ranches spread throughout the area (Aylward 2006). Family farming is the most common type of farming in the area with 92% of owners living on the farm. However, only 40% of the farm operators work full time on the farm, explaining how Deschutes County is mostly hobby farming, with very few large commercial farms (Aylward and Newton 2006). The waters of the upper Deschutes Basin supply eight irrigation districts, collectively forming the Deschutes Basin Board of Control (DBBC). With water, these irrigators store and divert water to irrigate approximately 150,000 acres (Bureau of Reclimation and Deschutes Basin Board of Control 2015).

Since the early 1900s, surface water in the basin has been almost fully allocated primarily for agricultural use and currently, in most areas at most times of the year, water in the basin is overappropriated (Britton and Relf 2014; Heisler 2012). The water storage and diversion needed for irrigation has changed the stable natural flows of the Upper Deschutes and has resulted in the dewatering of several Deschutes reaches and its tributaries and impaired water quality. Below Wickiup Reservoir the minimum flow during the storage season (October through March) is 20cfs representing 3% of what naturally occurred, and during the irrigation season (April to October) reservoir storage releases increase the flow of the Deschutes River up to 1500cfs (200% of what would have flowed naturally) (Fitzpatrick, Gorman, and Aylward 2006). These alterations in flow regimes have serious impacts on aquatic resources within the basin.

Upper Deschutes is widely recognized statewide as a recreational, aesthetic, and hydrologic treasure (Deschutes River Conservancy 2014). Known for its world-class fishing, the Deschutes basin draws upon tourism, outdoor recreation, and rural lifestyles to draw visitors and residents, where traditionally the region was supported by a timber economy (Deschutes River Conservancy 2014). The historically unique flow regime of this river basin and the habitats it created supported healthy salmon, steelhead, and resident fish populations. However, flow alteration and water quality issues experienced in the basin at different critical times during the year impact the biological community (Bureau of Reclimation and Deschutes Basin Board of Control 2015). Low winter flows have decreased available habitat for fish species, caused increased competition between native redband trout and non-native brown trout, and increased fish susceptibility to predation and disease (Deschutes River Conservancy 2014). High spring and summer releases associated with the irrigation season have caused increased turbidity, dissolved oxygen, and bank erosion. Furthermore, spawning success of redband trout is limited by high flows (Deschutes River Conservancy 2014). These water quality issues have resulted in the listing of Deschutes impaired waters on the State’s 303(d) list (Aylward and Newton 2006). Furthermore, the United States Fish and Wildlife Service recently listed the Oregon Spotted Frog as threatened under the Endangered Species Act due to the impacts of water withdrawals from some of the most important remaining habitat for this species. Because of the hydraulic connectivity between surface water and groundwater and over-appropriation, Oregon also requires mitigation of any new groundwater water in the upper Deschutes Basin (e.g., instream transfers and leases of existing irrigation water rights) (Bureau of Reclimation and Deschutes Basin Board of Control 2015).

In addition to challenges associated with overallocation and alteration of the natural flow regime, the water demand in the Deschutes Basin also increased with population growth in the region. Deschutes County leads the state with the highest population growth (Northwest Power and Conservation Council 2004). Between 1970 and 2015, Deschutes County sustained a 468% increase in population, from 30,882 to 175,268 people (Headwaters Economics 2017b). Furthermore, between 2014 and 2015 Deschutes County led the state in largest percentage gain in population, with a 2.6% increase (Portland State University College of Urban & Public Affairs 2015). With rapid growth and development, Central Oregon has needed to identify safe and reliable water supply to meet the future communities' needs (Aylward and Newton 2006). Taken together, in order to meet agricultural, instream flow, and municipal needs through 2050, studies indicate a 230,000 acre-foot annual average deficit within the basin (Britton and Relf 2014).

Compounding the challenges associated with water demand, future climate will also be a driver in water supply and demand in this basin. Due to its dominant reliance on groundwater, it is likely the Deschutes basin will be more resilient to a changing climate relative to other rivers in the state (Deschutes River Conservancy 2014). However, a changing climate will alter temperature and snowpack. Waibel et al. (Waibel et al. 2013) predicts a rise in temperature throughout the 21st century in this basin, with a 3.4 degrees C increase in mean annual temperature by the 2080s as compared to 1980s. Similar to other regional precipitation predictions, this basin does not show a clear trend in mean precipitation in the future, but does show a shift towards small snow accumulation, earlier melting, and a diminishing snowpack throughout the 21st century (Waibel et al. 2013).

The community has a long history of working together to meet the multiple water challenges that this basin faces (Deschutes River Conservancy and Deschutes Water Alliance 2013). Multiple collaborative groups have developed in the basin. The Deschutes River Conservancy (DRC) is one such example, founded by the Environmental Defense, the Confederated Tribes of the Warm Springs Reservation, and local irrigation districts, the DRC is a non-profit organization focused on restoring streamflow and water quality in the Deschutes Basin. The DRC received congressional authorization and federal funding beginning in 1996 for a partnership among the environmental community, landowners, and irrigation districts on water efficiency projects and instream leasing to implement stream flow restoration projects in the Deschutes Basin (Aylward and Newton 2006).

The Deschutes Water Alliance (DWA) is another example of collaboration in the basin; comprised of the DRC, Deschutes Basin Board of Control representing the seven irrigation districts in the basin, Central Oregon Cities' Organization, and Confederated Tribes of Warm Springs and formed in 2004 to develop and implement integrated water resource management programs in the upper Deschutes Basin. Another example is the Deschutes Partnership, comprised of the Deschutes Land Trust, DRC, Upper Deschutes Watershed Council and Crooked River Watershed Council, its focus is on habitat restoration for wild salmon and steelhead in the Metolius River, Whychus Creek and the lower Crooked River. With various stakeholder interests and differing areas of focus, all of these groups strive to work with multiple users in the basin to find solutions to water management problems.

As a result of these collaborative efforts, basin stakeholders have embarked on multiple planning efforts for water management in the basin. Plans developed thus far include: Upper Deschutes River subbasin Fish Management Plan (Oregon Department of Fish and Wildlife, 1996); Upper Deschutes Wild and Scenic River and State Scenic Waterway Comprehensive Management Plan (US Forest Service and State of Oregon, 1996); Deschutes Subbasin Plan (Northwest Power and Conservation Council, 2004); and Reintroduction Plan for Anadromous Fish In the Upper Deschutes River Subbasin (Oregon Department of Fish and Wildlife and the Confederated Tribes of Warm Springs, 2008). Most recently was the formation of the Deschutes Water Planning Initiative (DWPI) in 2012, with a goal to identify multiple water needs and options to meet those needs. Building on the information developed in the DWPI, in 2014 the DWA leveraged $1.5

million of federal and state money to develop a long-term water management agreement and to begin to secure investments for implementing that agreement (Deschutes River Conservancy 2014). This basin study and the Basin Study Work Group (BSWG) were the focus of this research.

These collaborative efforts have not been without conflict; there has been litigation between users of the basin over actions associated with the impact of water withdrawal on federal listed endangered species. Bull trout, a threatened species, is present in the Deschutes Basin upstream and downstream of the Pelton Round Butte Project. Steelhead trout, listed as threatened downstream of the Pelton Round Butte Project and designated as experimental and non-essential, is found upstream of the project; and the Oregon spotted frog, listed as threatened, exists in the Deschutes River and tributaries upstream of Bend. The Endangered Species Act (ESA) of 1973 prohibits the unauthorized harming or killing (taking) of threatened and endangered species. Irrigation district activities within the basin alter flow and quality of waters that are inhabited by ESA species and have the potential to harm those species. Under the ESA, an incidental take permit is required to conduct these activities, of which a Habitat Conservation Plan (HCP) identifying how impacts will be minimized or mitigated, is a required component. The incidental take permit provides the irrigation districts and City of Prineville with allowances to continue activities for up to 50 years. In late 2015 and early 2016, WaterWatch and the Center for Biological Diversity filed lawsuits claiming that the management of Crane Prairie and Wickiup dams was driving the spotted frog to extinction and the Bureau of Reclamation failed in consultation (McCarthy et al. 2016). Since the lawsuit, a settlement has been reached modifying the dam operations until the completion of the HCP.

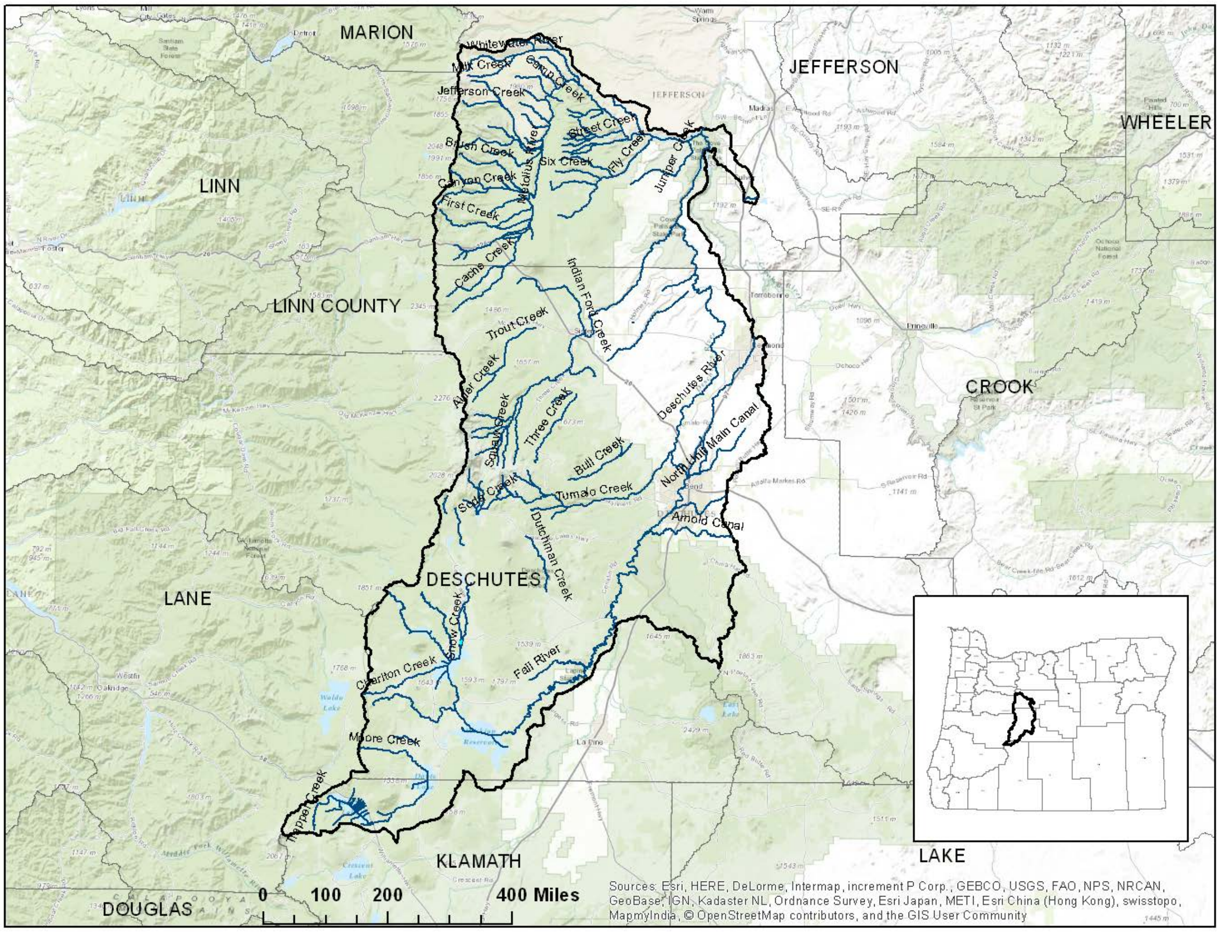


Figure 2: Upper Deschutes Basin Oregon

The Big Wood River Basin in Idaho

The other case study, the Big Wood River Basin, is located in central Idaho and includes the Big Wood, Little Wood, and Silver Creek drainages, encompassing approximately 2,000 square miles (Figure 3). The basin includes Blaine, Camas, Elmore, Gooding and Lincoln counties with major population centers including Ketchum, Sun Valley, Hailey, Bellevue, Fairfield, and Gooding (Bolte 2016). The Big Wood River basin ranges in elevation from 8,700 feet at Galena summit near its headwaters to 3,500 feet before reaching its confluence with the Malad River, a tributary of the Snake River.

The basin relies on both ground and surface water sources for meeting its water needs. Groundwater in the basin is supplied by two aquifers, a single unconfined aquifer beneath the entire valley and a confined aquifer in the south (Bartolino and Adkins 2012). This aquifer system, recharged by snowfall and spring runoff, serves as an important source of water to meet the agriculture demands in the lower watershed (Lousen 2016). The Big Wood River and its tributaries drain most of the surface water in the Wood River Valley except in the southeast where Silver Creek drains the Bellevue fan (Skinner, Bartolino, and Tranmer 2007). Most of the streamflow in the basin is in response to precipitation or snowmelt, with some of the tributaries to the Wood River having perennial streams (Skinner et al. 2007).

The basin has intermountain climate, with temperature and precipitation varying by elevation and by season: mild and arid during the summer and cold and wet in the winter (Bolte 2016; Skinner et al. 2007). Snowpack serves as a storage mechanism to satisfy later spring and summer demand in the lower basin and is the primary supply of water for rivers and streams (Lousen 2016). Average annual precipitation ranges between 20.4 inches in the high ranges (>5800 feet) to 10.2 inches in the lower ranges (<4000 feet) (Buhidar 2001). Between November and March 60% of the total annual precipitation falls mostly as snow (Skinner et al. 2007).

The Big Wood Basin has two distinct areas - the upper and lower valley - and overall is largely undeveloped. These areas and their distinctions are the major drivers in water management in the basin. Overall the majority of land cover (70%) is sagebrush steppe or grasslands with only a fraction of the land developed; approximately 14% is classified as agricultural (Lousen 2016). Thirty four percent of the land is privately owned, and of the 66% that is owned publically, the majority (58%) is managed by the Bureau of Land Management, 35% overseen by the Forest Service, and 5% by the State of Idaho (Inouye 2014). The upper valley in the north contains Gelena summit and is a narrow valley with a maximum width of two miles. This area contains most of the housing developments within the cities of Sun Valley, Ketchum, Hailey, and Bellevue, and is marked by large homes situated with landscaped acreage (Skinner et al. 2007). Extending southward towards Timmerman Hills the valley opens into the Bellevue triangular fan spanning nine miles across (Skinner et al. 2007). The south contains the smaller communities of Gannett and Picabo and is comprised primarily of irrigated farms and ranches (irrigated by groundwater and diverted surface water) (Skinner et al. 2007).

Similar to the Deschutes in Oregon, the Big Wood has experienced a growing population, resource extraction, urban and rural development, and economic growth (Buhidar 2001). Between 1970 and 2015 population in Blaine County increased by 271%, from 5,815 to 21,592 (Headwaters Economics 2017a). During this same time, employment also grew by 489%, from 3,514 to 20,692 full or part time workers and personal income $157.0 million to $1,913.8 million (in real terms), representing a 1,119% increase (Headwaters Economics 2017a). Blaine County includes Sun Valley, world famous as a destination for skiing, hiking, biking, fishing and conventions. Tourism is the primary economic driver in the region with approximately 75% of the 1.8 billion GDP attributable to cultural and recreational visitors (Lousen 2016). Similar to the Deschutes in Oregon, these increases in population and in income will require new water sources in the future. Domestic water supply for the entire population depends on groundwater, and the rapid growth in the basin since the 1970s has raised concerns over how groundwater resources will be sustainable in the future (Bartolino and Adkins 2012).

Although the upper valley relies solely on groundwater, the largest use (97%) of appropriated groundwater in the basin overall is for irrigation, municipal, stock water, domestic, and commercial accounting (Inouye 2014). The amount of groundwater used varies within the basin, with less than half of irrigation water supplied by groundwater pumping in lower Blaine County. As you move south, fiver percent of water use is from groundwater and the rest is supplied with surface water rights (Lousen 2016). The irrigated growing season varies with elevation of the valley, from about three months in the upper valley to about five months in the lower valley (Skinner et al. 2007).

Hydrologic trends in the basin indicate effects of overuse and a changing climate, impacting water availability in the future. Declining trends in mean annual water levels in the groundwater wells indicate poor general conditions of the aquifer system (Bartolino and Vincent 2013;

Skinner et al. 2007). Stream gaging in the Big Wood River over a 90-year period show trends of earlier snowpack runoff and decreasing flow since the 1940s, and gaging in Silver Creek between 1975 and 2005 indicates decreased annual discharge affected by groundwater pumping (Bartolino and Vincent 2013; Skinner et al. 2007). Water supply in the basin over the last five years has been below average; however, "Even in the best water years, water users are curtailed because of insufficient supply; there just isn't enough water to meet all demands (Lousen 2016:6)."

In February 2015, senior surface water users (primarily agriculture) from the lower Little Wood River system and the Big Wood River system below Magic Reservoir placed a water call with the Idaho Department of Water Resources to curtail junior groundwater users in the upper basin comprised of approximately 500 groundwater right holders (Moore 2016; O'Connell 2015). Because of the state's conjunctive management rules, groundwater users are vulnerable to curtailment when senior surface water rights are not being met. For over two years municipalities, environmental groups, recreational interests, surface and groundwater users have been navigating litigation and mitigation for the water call. Part of this effort to solve the water call was the establishment of the Wood River Collaborative, an effort that brought water users together to develop a plan to manage surface and groundwater rights (Moore 2016).

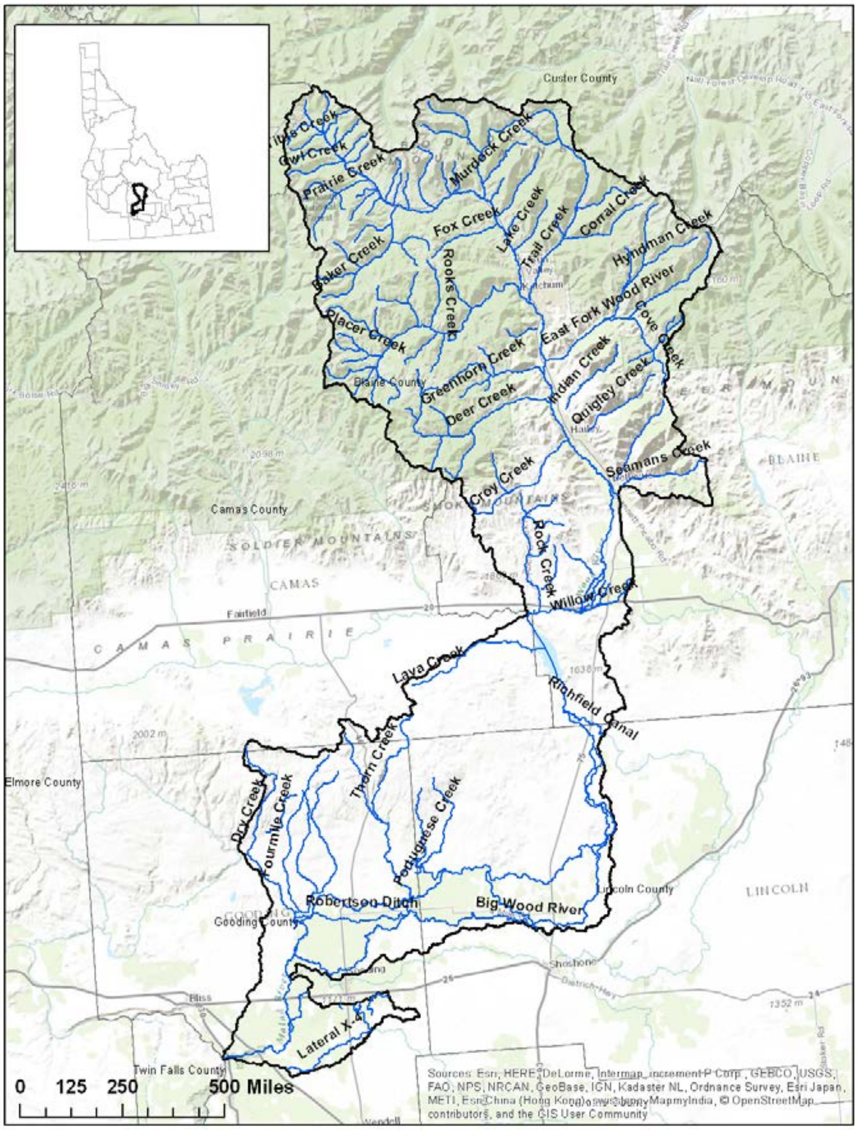


Figure 3: Big Wood River Basin Idaho

Methods

Diverse case selection was chosen to demonstrate the range of dimensions that contribute to adaptive governance capacity (AGC) and how they vary with amount of time participants engaged in collaboration (Seawright and Gerring 2008). Additionally, the development and testing of the questionnaire in more than one context helped to explore how the instrument measures capacity and how the dimensions of capacity varied within different contexts.

Quantitative Questionnaire

Questionnaire variables related to AGC were derived and modified from the adaptive capacity and collaborative governance literature to fit within the Western water context. Specifically, variables used in this study were adapted from previous studies (e.g., Ivey et al. 2004; Lockwood et al. 2015; Weber 2013). Variables in the questionnaire focused on four dimensions of AGC: (a) governance and institutions; (b) social capital; (c) human, financial, and physical capital; and (d) management approaches (Figure 4). An advisory panel, comprised of 13 people involved in water policy and management including state agency water resource staff, policy participants in water nonprofits, irrigation district administrators, and academics, was used to, develop, and pre test the questionnaire for face validity. Additional questions were added to the questionnaire from key representatives of each of the basins to ensure that the questions asked were relevant to them.

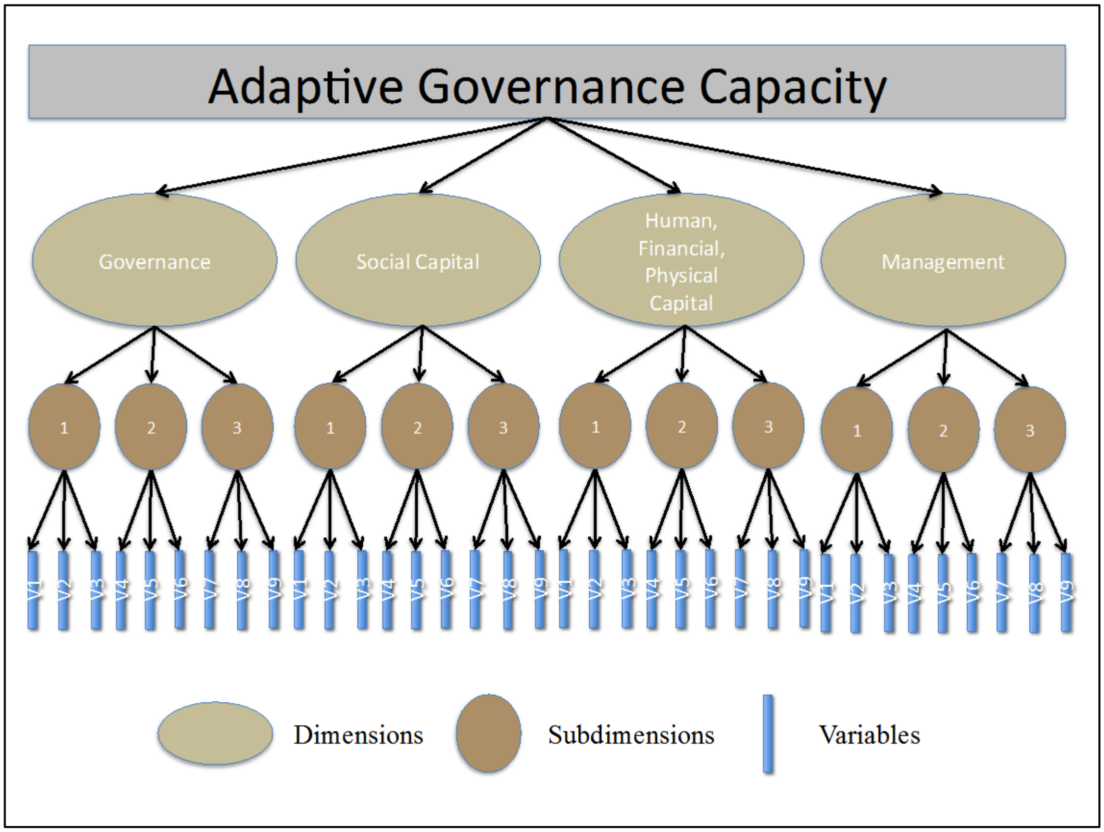


Figure 4: Model of Adaptive Governance Capacity take from the Collaborative Governance and Adaptive Capacity Literature

Responses for variables were generally measured on a 5-point scale from "strongly disagree" (1) to "strongly agree" (5). The scaling on the variables was oriented so that higher scores represent more positive attributes of AGC. Some responses were also measures on 4-point scales, as yes/no, and open-ended. In addition, the questionnaire contained questions about ranking water values in the basin and also about the acceptability of certain management tools to be used in the basin (Appendix A and B).

Questionnaires were administered to existing water policy actors- individuals whose professional focus is on water policy or who are active in water management in the Idaho and Oregon case studies. Water policy actors were identified through the advisory panel, existing water planning listservs, and key informants in each basin. A snowball technique was then used to identify further questionnaire participants. This is a purposeful sampling technique often used when the population of interest is difficult to identify (Robson 2002) or to obtain characteristics of interest (e.g., participating in water policy decision-making) (Berg 2004). Participants included surface irrigators, groundwater irrigators, municipal water users, government officials, environmental groups, watershed councils, and recreational groups.

Data were collected using primarily an online questionnaire, with a postal mail questionnaire sent to select participants without email access. The Deschutes questionnaire was initiated in December 2015 and the Wood River initiated in March 2016. In both cases, reminder emails by both the researcher and key participants followed the initial request to participate. The questionnaire took approximately 20 to 30 minutes to complete. There was a 68% response rate (n=90) for the Upper Deschutes and a 67% response rate for the Big Wood River (n = 77).

Qualitative interviews

In the Big Wood River Basin, the questionnaire participant list was categorized based on stakeholder interest (e.g., irrigator, agency, conservation, rancher). From this categorization, two to three interviewees were identified per stakeholder category. Additional considerations for possible interviewees were the level of involvement in the collaborative and by recommendations of key representatives in the basin, for a total of 24 semi-structured, in-person interviews (Appendix C). Six interview questions were used to further explain the results found in the questionnaire and were followed with prompts to elicit more complete responses.

Interviews were audio-recorded with participant consent, and handwritten notes were taken during interviews. Interviews took place in April 2016. Each interview lasted 60 to 120 minutes. The interviews were used in the analysis to provide examples to illustrate or explain themes found in the quantitative data. Participants in the Upper Deschutes were not interviewed because of time and resource limitations.

Data Analysis

Research question 1: *How can the collaborative governance and adaptive capacity literature be used to inform a questionnaire that measures adaptive governance capacity of Western water communities?* A principal component exploratory factor analysis (EFA) with varimax rotation was used to group variables into subdimensions and to test construct validity of the questionnaire (Vaske 2008). Rather than confirmatory factor analysis, an EFA was used because variables from multiple studies were modified and new variables were added for this study to fit the Western water context. Inclusion of a variable in a subdimension was based on a factor loading ≥ .40 (Tabachnick and Fidell 1996)[1]. Cronbach alpha was then used to test reliability and internal consistency of participant responses to the subdimension (i.e., do respondents answer similarly to questions about the same concept). For a variable to be included in the subdimension, a Cronbach alpha value greater than .60 was used as the cutoff (Cortina 1993; Vaske 2008). Variables with poor factor loadings or reliability scores were excluded from subdimension indices. Data from the Big Wood River and Upper Deschutes cases were used together in these analyses (Table 1).

Research question 2: *How do dimensions and subdimensions contained within adaptive capacity and collaborative governance frameworks interact?* A second principal component EFA with varimax rotation was used to group subdimensions into the four dimensions of adaptive governance capacity found in the literature: social capital; governance and institutions; human, financial and physical capital; and management strategies. This EFA was run twice, once not setting the number of extracted components, and another time, setting the extracted components to four factors. Data from the Big Wood River and Upper Deschutes cases were used together in these analyses (Table 1).

[1] A Harman single factor test showed that common method variance or bias was generally absent (Podsakoff et al. 2003), as this single EFA without rotation and the number of factors fixed to one showed the factor explained less than 50% of the variance (21% of the variance was explained with this dataset).

Research question 3: *To what extent do adaptive governance capacities differ based on the amount of time that communities have spent in collaboration?* To evaluate differences between the Big Wood River and Upper Deschutes cases, factor loadings from a principal component EFA with varimax rotation, percentages, means, independent sample t-tests, and point-biserial correlation (r_{pb}) effect size statistics were compared between cases and used to understand how the questionnaire performed in the two collaborative contexts. The size of the factor loading for each subdimension index was compared between cases to determine the relative importance of that subdimension in interpreting AGC. The subdimension percentages were used to compare the agreement for each variable between the two cases. Point-biserial correlation (r_{pb}) effect size values of .100, .243, and .371 were used to identify minimal, typical, and substantial effects, respectively (Vaske 2008) (Table 1).

Research question 4: *How can the results be used to inform local water management in Big Wood River, Idaho?* This research question was limited to the Big Wood River data because the in-depth analysis and complementary interview data were conducted only in this basin. Percentages, t-tests, chi-square tests, and Cohen's *d* and Cramer's *V* effect size statistics were used to describe overall responses to variables and test for differences among stakeholder groups. For Cohen's *d* effect size, values of .20, .50, and .80 were used to identify minimal, typical, and substantial effects, respectively (Vaske 2008). For Cramer's *V* effect size, values of .10, .30, and .50 were used to identify minimal, typical, and substantial effects, respectively (Vaske 2008) (Table 1).

Participants were allowed to choose more than one stakeholder group they associated with on the questionnaire. However, for the analysis they were limited to one stakeholder group: surface water irrigation (SW), groundwater irrigation (GW), non-consumptive users (NC), government (GV), or municipalities (MN). Water consumptive use (e.g., surface water irrigation) was given grouping priority over non-consumptive use (e.g., recreation). For example, if a participant indicated that they were a surface water irrigator and also a recreational user, they would be classified as a surface water irrigator. The surface water stakeholder group was comprised only of people who identified surface water as their stakeholder group (and not groundwater). The groundwater stakeholder group was comprised of groundwater users and mixed surface and groundwater users. This separation of groundwater and surface water users helped to distinguish responses between senior water right holders in the lower valley (surface water irrigators) and upper valley junior water users (primarily groundwater and surface and groundwater mix). The non-consumptive user group was comprised of recreation interests, environmental interests, and scientists. State, local, and municipal government comprised the government user group. The municipal group was comprised of municipal users, small water users (.5 acres to 20), and communal well and Home Owner Associations (HOA).

This study reports both statistical significance and also effect sizes. First, the *p*-value will indicate if an effect exists, but an effect size statistic is needed to understand how big the effect is. Null hypothesis statistics are effective at determining if there is a statistical relationship between variables, but are sensitive to small sample sizes. With an increasingly large sample, the statistical test will often find a statistical difference, especially with certain tests (e.g., chi-square). Due to the small sample size of subgroupings throughout this study, a *p*-value of .10 was adopted (Agresti and Finlay 2009; Vaske 2008). Furthermore, because effect size statistics are far less sensitive to small sample sizes, effect size differences are reported even if there was not a statistically significant outcome (Vaske 2008).

Table 1: Summary of analysis conducted for each research question

Research question	Analysis	Dataset	Outcome
Question 1	EFA (Variables to subdimensions)	Both cases combined	Construct validity of questionnaire
	Reliability (Variables to subdimensions)	Both cases combined	Internal consistency of questionnaire
Question 2	EFA- single and forced into 4 factors (Subdimensions to dimensions)	Both cases combined	Explore relationship between subdimensions and dimensions
	Reliability (Subdimensions to dimensions)	Both cases combined	Internal consistency of questionnaire
Question 3	EFA (subdimensions to AGC)	Cases run separately and compared	Compared between cases which subdimensions are most important in explaining AGC
	Percentages, means, independent sample t-tests, and point-biserial correlation (r_{pb}) effect size statistics (case data run separately)	Cases run separately and compared	Compared between cases and used to understand how the questionnaire performed in the two collaborative contexts
Question 4	Percentages, t-tests, chi-square tests, and Cramer's *V* and Cohen's *d* effect size statistics	Big Wood River	All participants and comparison among stakeholders
	Interview data	Big Wood River	Support, and explain survey results

Results[2]

To develop a questionnaire to assist in understanding a community's ability to adapt to changing water conditions, participants in water management were surveyed in two study areas. In both cases, a wide range of stakeholders participated in the questionnaire, including conservation, recreation, government, irrigated agriculture, and municipal users. Of note, the list of stakeholder groups in each basin was developed by key informants by basin, resulting in differences seen in the type of stakeholders in each case study. In both cases, some participants chose not to identify

[2] Additional results figures can be seen in Appendix D

their stakeholder group when they participated in the questionnaire, ten in the Upper Deschutes and six in the Big Wood River, which limited the use of their responses in some of the analyses (Figures 5 and 6).

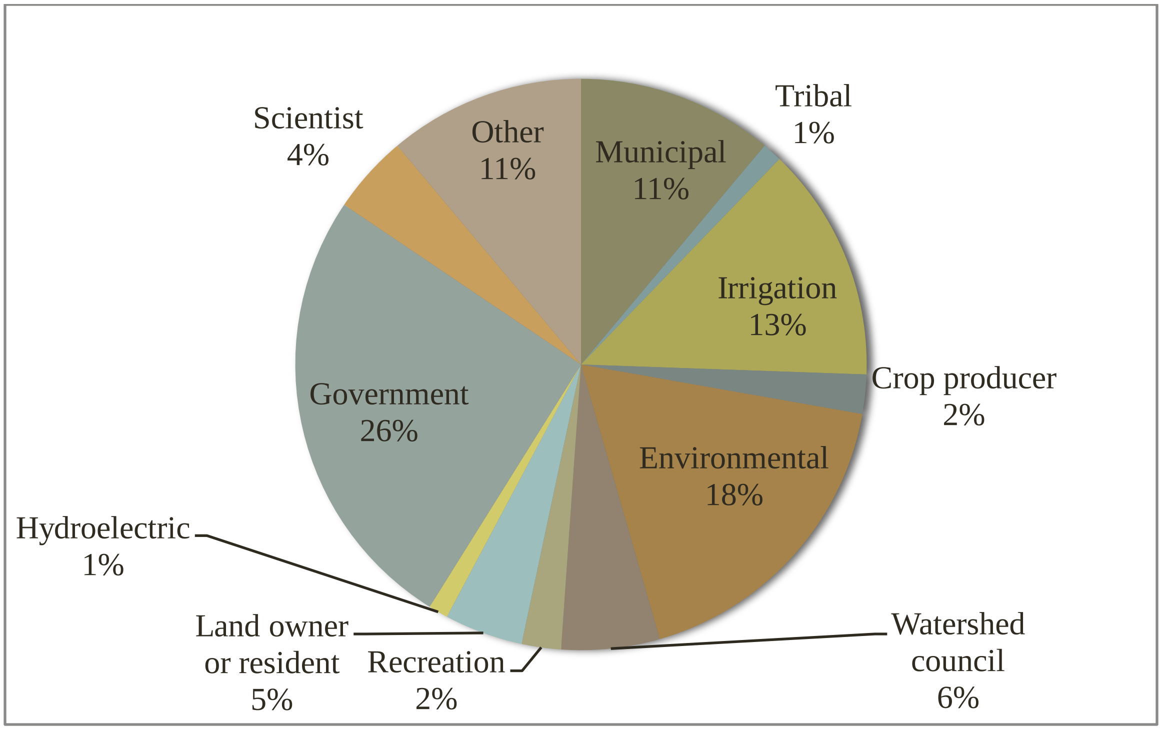


Figure 5: Participation in questionnaire in the Upper Deschutes, Oregon

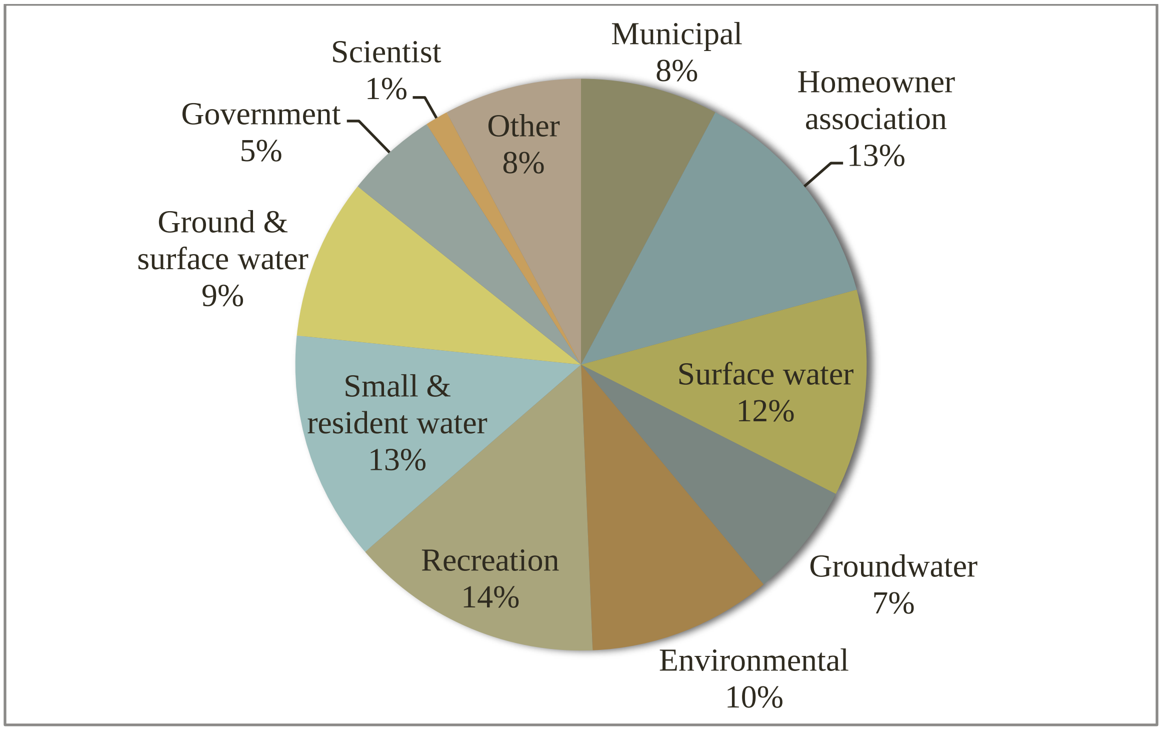


Figure 6: Participation in questionnaire in the Big Wood River, Idaho

Research Question 1:

How can the collaborative governance and adaptive capacity literature be used to inform a questionnaire that measures adaptive governance capacity of Western water communities?

Using the Upper Deschutes and Big Wood River case study data, an exploratory factor analysis (EFA) and Cronbach alpha reliability coefficients were used to validate the questionnaire. An EFA is a data reduction technique that groups similar variables (questions) into one concept. This analysis is used when multiple questions were asked on the questionnaire to determine a concept. For example, three questions were asked to understand the concept of leadership: 'is there someone who helps to bring stakeholders together,' 'is there someone who is trusted,' and 'is there someone who motivates creativity in others.' The EFA combined these variables into the leadership subdimension if they had a factor loading above a certain value. All subdimensions had acceptable factor loading above .40, ranging from .62 to .95, indicating a good fit for variables to be included in the subdimension (Table 2).

Next, Cronbach alpha values were evaluated to determine internal consistency among variables measuring the same subdimension (e.g., did respondents answer similarly on the three questions about leadership as would be expected). Internal consistency for variables reliably measuring each subdimension was demonstrated by the Cronbach alpha values greater than .60. Values ranged from .61 to .91, with an average value of .82 for subdimensions retained. Used in combination, the EFA and Cronbach alpha analyses allowed 34 of the 44 common variables to be grouped into ten subdimensions labeled *mobilize, network, goals, management decisions, reciprocity, leadership, ability to adapt, awareness of impacts, authority, and recent conflict.* [3] Together these ten subdimensions explained 69% of adaptive governance capacity in these two basins. Mobilization explained most of the variance in adaptive governance capacity (7%) and conflict explained the least (4%) (Table 2).

Of the 44 common variables in the two datasets, ten were not grouped into subdimensions due to poor reliability. These ten variables explained only 8% of adaptive governance capacity in the basins. Four of the ten variables were grouped into two additional dimensions from the EFA, but subdimensions were not subsequently created from these variables because their Cronbach alpha values were below .60 (these variables are noted by superscript (c) in Table 2). Six of the variables were not included in other subdimensions because, if deleted, the Cronbach alpha for the subdimension improved dramatically (these variables are noted by superscript (a) in Table 2).

[3] Throughout this document subdimensions will be italicized

Table 2: EFA and reliability using the Upper Deschutes and Big Wood River data. Variables coded on a 5-point scale from "Strongly Disagree" (1) to "Strongly Agree" (5) unless noted. Eigenvalue and percent of total variance explained for each subdimension in footnote (d).

	α	n	Mean	St Dev	Item total correlation	α if item deleted	EFA factor loading
Mobilize	.82						
Opportunity to engage in management decisions.		102	3.66	1.17	.72	.77	.78
Meaningful role in watershed management decisions.		102	3.66	1.20	.78	.75	.73
Those engaging are motivated to get things done.		102	3.74	1.03	.54	.81	.67
Willing to try new things to meet multiple needs.		102	3.28	.94	.53	.81	.53
My stakeholder group is innovative.		102	3.92	.84	.52	.81	.68
Techniques or technologies to share.		102	3.70	.90	.47	.82	.52
Has an increased ability to achieve water sustainability goals.[a]							.51
The way water is managed can meet my water needs.[a]							.47
Network	.89						
Share information.		101	3.44	.88	.51	.89	.56
Supportive of each other.		101	3.16	.94	.76	.86	.70
Willing to work together to solve water problems.		101	3.38	.87	.78	.86	.73
Willing to sacrifice.		101	2.54	1.02	.76	.86	.76
Trust water management decisions.		101	2.96	1.02	.66	.87	.57
Trust stakeholders to keep my needs in mind.		101	2.67	1.10	.73	.86	.64
Common vision for managing water.		101	2.54	1.23	.59	.88	.49
Goals	.91						
Measurable water management goals.		92	3.30	1.15	.85	.86	.82
Progress is evaluated against goals.		92	3.12	1.03	.89	.83	.89
Water management goals reflect the needs.		92	3.03	1.05	.75	.94	.72
Management decisions	.81						
Sufficient access to scientific information.		108	3.28	1.13	.55	.81	.71
Sufficient access to technical expertise.		108	3.63	1.04	.74	.71	.76
Capacity to plan and manage outreach activities.		108	3.70	.90	.69	.74	.63
Capacity to report on outcomes.		108	3.74	.92	.57	.79	.63
Reciprocity	.88						
Personal obligation to find long-term water solutions.		116	4.41	.76	.78	-	.88
Responsibility to help educate others about water needs.		116	4.41	.70	.78	-	.83
I know that my own behaviors impact other water users.[a]							.75

Leadership	.87						
Someone who helps to bring stakeholders together.		114	3.66	1.01	.74	.82	.75
Someone who is trusted by stakeholders to lead.		114	3.04	1.07	.73	.82	.75
Someone that motivates creativity in others.		114	3.30	1.04	.76	.80	.77
There are adequate financial resources available. [a]							.44
Ability to adapt	.90						
Ability to adapt to changes.		102	3.49	1.00	.82	-	.85
Ability to capitalize on that change.		102	3.23	1.12	.82	-	.92
Have the infrastructure needed to optimize water use. [a]							.49
Awareness of impacts	.83						
Bio-physical changes on water resources.		112	4.04	.85	.71	-	.82
Social changes on water resources.		112	3.98	.83	.71	-	.79
Knowing about new technology is important. [a]							.54
Authority	.73						
Who has jurisdictional authority to make decisions.		132	3.53	1.24	.66	.50	.80
Who has senior water rights.		132	3.90	1.23	.50	.69	.67
How groundwater use affects surface water rights.		132	3.14	1.31	.49	.71	.67
Recent conflict [b]	.61						
Level of conflict currently.		110	3.15	.62	.44	-	.73
Level of conflict in the past five years.		110	2.84	.66	.44	-	.60
Non-grouping 1 [c]	.17						
Do more to ensure water solutions are found.							.79
Regulatory changes are necessary.							.43
Non-grouping 2 [c]	.43						
Level of conflict in the past ten years.							.45
There are other more pressing issues facing our community.							.78

a) This variable was not included in the subdimension due to an increase in the Cronbach alpha value for the subdimension if the variable was deleted
b) Variable coded on a 4-point scale from “No Conflict” (1) to “Extreme Conflict” (4)
c) These variables were not grouped into subdimensions because Cronbach alpha value < .60
d) Eigenvalue and percent of total variance explained: Mobilize (4.30, 10%), Network (4.12, 9%), Goals (3.34, 8%), Management decisions (3.32, 8%), Reciprocity (3.14, 7%), Leadership (3.10, 7%), Ability to adapt (2.62, 6%), Awareness of impacts (2.54, 6%), Authority (2.08, 5%), Recent conflict (1.98, 4%).

Research Question 2:
How do dimensions and subdimensions contained within adaptive capacity and collaborative governance frameworks interact?

Another goal of this study was to evaluate the adaptive capacity and collaborative governance models to discover if and how the subdimensions and dimensions relate to each other. The analysis identified ten subdimensions that contribute to adaptive governance capacity, yet was unable to further group those subdimensions into broader dimensions found in established models within the collaborative governance or adaptive capacity literature. When the ten subdimensions were put into a second factor analysis, they did not neatly group into the four major dimensions previously identified as important by the literature: social capital; governance and institutions; human, financial, and physical capital; and management strategies. Three dimensions were identified in the factor analysis, but four of the ten subdimensions did not group under one dimension, rather, they overlapped with more than one dimension (Table 3).

Next, the EFA was conducted again forcing the subdimensions into four factors, which is somewhat analogous to a confirmatory factor analysis approach. Setting the number of factors to four is a way to test and confirm the four dimensions in the adaptive capacity and collaborative governance literature. This analysis resulted in only one subdimension with overlap among factors (*management)*. A reliability analysis was then conducted on three of the four factors (one factor contained only one subdimension). Two of the three Cronbach alpha values were beneath the .60 criteria for grouping. The one factor that had a Cronbach alpha above .60 was factor 1 (alpha = .74), but had five of the ten subdimensions grouped within. Similar to the previous EFA, these results do not clearly identify four factors of adaptive governance capacity (Table 4).

These two analyses indicate that there is not a clear distinction on how subdimensions group into dimensions. The overlap of subdimensions onto multiple factors and low reliability scores for the dimensions that were identified demonstrate inter-correlation among dimensions in this study. This could be an indication that the sample size was too small (n =167), or it could be that the subdimensions of adaptive governance capacity simply cannot be grouped by the current literature's four major dimensions at these sites.

Table 3: EFA analysis to group subdimensions into dimensions with the Upper Deschutes and Big Wood River data.

	Factor loadings		
	Factor 1	Factor 2	Factor 3
Network	.79		
Leadership	.77		
Goals	.70		
Mobilize	.70	.37	
Management	.55	.47	
Authority	.42	.39	
Knowledge		.80	
Conflict			.72
Ability to adapt		.50	-.66
Reciprocity			.60

Table 4: EFA analysis to group subdimensions into dimensions, forcing four factors and reliability analysis using the Upper Deschutes and Big Wood River data.

	Factor loadings			
	Factor 1	Factor 2	Factor 3	Factor 4
Conflict			.65	
Authority		.67		
Knowledge		.81		
Ability to adapt				.94
Leadership	.78			
Reciprocity			.85	
Management	.54	.44		
Goals	.69			
Network	.81			
Mobilize	.69			
Cronbach alpha	.74	.59	.46	
Eigenvalue	2.73	1.49	1.30	1.14
Percentage (%) of total variance explained	27	15	13	11

Research Question 3:
To what extent do adaptive governance capacities differ based on the amount of time that communities have spent in collaboration?

To further test the questionnaire, this study compared the responses from the two cases to what was expected in the literature. Collaborative arrangements evolve over time, are dynamic in nature, and, if successful, increase capacity over time. In the Upper Deschutes Basin, multiple stakeholders have engaged in collaborative efforts over the past 30 years, whereas in the Big Wood River, collaborative efforts have only begun in the past two years. Factor loadings, mean scores, percentages, independent samples t-tests, and point-biserial correlation (r_{pb}) effect sizes were used to understand how responses differed across varying collaborative contexts.

In general, mean scores[4] for subdimensions and variables were higher in the Upper Deschutes case than in Big Wood River, however, in most instances these results were not significant or had less than a typical effect size. The mean scores for eight of the ten subdimensions were higher for the Upper Deschutes, but only significantly higher in two of the subdimensions *reciprocity* and *goals* (p = .014 and .043, respectively) and their effect sizes were typical in both (r_{pb} = .23 and .20, respectively). Similarly, mean scores for 24 of the 34 variables were higher in the Upper Deschutes than Big Wood River basins, but only eleven of the 24 were significantly higher and five showed a typical effect size (Table 5).

For eight of the twelve variables in the subdimensions of *authority, leadership,* and *mobilize (*typically associated with governance), the Upper Deschutes had higher mean values. For subdimensions of *goals* and *the ability to adapt (*typically associated with management approaches and strategies), the Upper Deschutes had higher mean scores for all variables. Similarly, for *awareness of impacts* and *management decisions* (typically associated with human, financial and physical capital), the Upper Deschutes had a higher mean in all but one variable. The pattern of higher mean values changes for *reciprocity* and *network* subdimensions (typically associated with social capital), where the Big Wood River had higher mean values in five of the nine variables (Table 5).

Not only were individual variable mean scores higher in the Upper Deschutes, the mean score

[4] Generally measured on a 5-point scale from "Strongly Disagree" (1) to "Strongly Agree" (5)

across all variables was higher in the Upper Deschutes than the Big Wood River, 3.47 and 3.35, respectively. In both cases, mean responses were positive (greater than three). Similarly, the number of variables with participant agreement[5] greater than 50% was slightly greater in the Upper Deschutes (24 variables) than in the Big Wood River (22 variables). Additionally, the average variable agreement was higher for the Upper Deschutes (59%) than the Big Wood River (54%) (Table 5).

Next, factor loadings were used to determine the contribution of each subdimension in explaining adaptive governance capacity (i.e., which subdimensions are most important to determine AGC in that community). For the Upper Deschutes, the three most important subdimensions in explaining AGC were *mobilize* (.79 factor loading), *goals* (.78 factor loading), and *networks* (.77 factor loading). For the Big Wood River, the most important subdimensions for explaining AGC were also *mobilize* (.82 factor loading) and *networks* (.72 factor loading). However, different than the Upper Deschutes, *leadership* was another subdimension (.69 factor loading). For both cases, *mobilization* was the most important subdimension in determining AGC and *network* was in the top three (number two for the Big Wood River and number three for the Upper Deschutes). In the Upper Deschutes, *goals* had the second highest factor loading (.78 factor loading), whereas for the Big Wood River, *goals* were ranked eighth most important in explaining overall AGC (.30 factor loading) (Table 6).

The greatest difference between cases in factor loadings was found with the *goals*, *conflict*, *reciprocity*, and *adaptability* subdimensions. Although the factor loadings for *conflict*[6] rank tenth in both cases, the amount this subdimension explains AGC varied. Additionally, the relationship between *conflict* and AGC was opposite between cases. For the Upper Deschutes, more conflict contributed to lower AGC (-.37 factor loading) and in the Big Wood River the opposite was true, as more conflict contributed to higher AGC (.20 factor loading). The *reciprocity* subdimension ranked similarly for the Upper Deschutes and the Big Wood River (ninth and seventh respectively), but the relative importance varied (.02 and .33 factor loadings, respectively).

[5] Those respondents that agreed (4) or strongly agreed (5)

[6] Variable coded on a 4-point scale from "No Conflict" (1) to "Extreme Conflict" (4)

Likewise, the *adaptability* subdimension ranked similarly for the Upper Deschutes and the Big Wood River (seventh and ninth, respectively), but the relative importance varied (.37 and .10 factor loadings, respectively) (Table 6).

Subdimensions were not only evaluated by their importance in explaining AGC, but the mean respondent value to each subdimension was used to determine the degree they were successful at implementing that subdimension. In both cases, *mobilization* was the most important subdimension in explaining AGC, and it also had high mean scores (Upper Deschutes = 3.70 and Big Wood River = 3.51), meaning that *mobilization* is important in explaining overall capacity and participants feel as though they are able to engage, have a meaningful role, and are innovative. Although *networks* were important in both cases for explaining AGC, they had the lowest mean score in the Upper Deschutes (2.88) and third lowest in the Big Wood River (3.02). Also, in both cases *knowledge* and *reciprocity* had the second and third highest means, but in the Upper Deschutes these subdimensions were the least important in explaining AGC and in the Big Wood River these factor loadings ranked sixth and seventh. Results indicate that although there are subdimensions that are important for explaining AGC, they are not always the ones that participants are most effectively implementing (i.e., have the highest mean value) (Table 5 and Table 6).

Table 5: Comparison of variable mean and percent agreement in the Upper Deschutes, Oregon and Big Wood River, Idaho

	Upper Deschutes			Big Wood River					
	n	Mean	Percent agree (%)	n	Mean	Percent agree (%)	t-value	p-value	r_{pb}
Recent conflict[1]	64	3.06	80	49	2.89	63	1.64	.104	.16
Level of conflict currently.	64	3.17	91	49	3.10	86	.59	.558	.06
Level of conflict in the past five years.	61	2.97	84	49	2.67	63	2.30	.024	.22
Authority[2]	71	3.60	48	65	3.48	43	.73	.469	.06
Who has jurisdictional authority to make decisions.	72	3.60	63	66	3.48	61	.53	.595	.05
Who has senior water rights.	70	4.01	80	64	3.80	67	1.03	.306	.09
How groundwater use affects surface water rights.	70	3.17	40	65	3.14	45	.15	.884	.01
Leadership[2]	64	3.27	28	54	3.44	39	.99	.325	.09
Someone who helps to bring stakeholders together.	64	3.78	77	56	3.55	57	1.25	.213	.11
Someone who is trusted by stakeholders to lead.	63	2.79	22	54	3.33	48	2.82	.006	.25
Someone that motivates creativity in others.	61	3.20	43	54	3.43	50	1.19	.238	.11
Mobilize[2]	61	3.70	35	51	3.51	22	1.54	.127	.15
Opportunity to engage in management decisions.	59	3.22	30	49	3.33	45	.59	.559	.06
Meaningful role in watershed management decisions.	60	3.98	78	51	3.76	71	1.37	.172	.13
Those engaging are motivated to get things done.	60	3.90	70	49	3.37	49	3.18	.002	.29
Willing to try new things to meet multiple needs.	71	3.76	76	60	3.43	58	1.64	.104	.14
My stakeholder group is innovative.	72	3.74	71	60	3.30	47	2.12	.036	.18
Techniques or technologies to share.	71	3.59	63	58	3.91	74	1.82	.072	.16
Reciprocity[2]	64	4.55	92	53	4.24	81	2.50	.014	.23
Personal obligation to find long-term water solutions.	64	4.52	92	53	4.28	85	1.67	.098	.15
Responsibility to help educate others about water needs.	64	4.58	97	52	4.19	85	3.07	.003	.28
Network[2]	64	2.88	10	52	3.02	13	1.00	.319	.09
Share information.	64	3.50	59	49	3.33	51	1.05	.298	.10
Supportive of each other.	63	3.08	38	51	3.31	45	1.35	.181	.13
Willing to work together to solve water problems.	63	3.32	48	51	3.51	59	1.14	.258	.11
Willing to sacrifice.	64	2.47	17	51	2.61	24	.74	.458	.07
Trust water management decisions.	61	2.90	31	46	2.89	35	.05	.959	.01
Trust stakeholders to keep my needs in mind.	62	2.53	23	51	2.75	30	1.04	.299	.10
Common vision for managing water.	71	2.41	17	69	2.68	38	1.32	.189	.11
Awareness of impacts[2]	63	4.08	75	51	3.94	73	.95	.345	.09

Bio-physical changes on water resources.	63	4.11	79	51	3.96	82	.94	.347	.09
Social changes on water resources.	63	4.05	79	49	3.90	80	.95	.345	.09
Management decisions[2]	63	3.69	48	50	3.46	42	1.51	.134	.15
Sufficient access to scientific information.	62	3.23	48	49	3.39	57	.76	.451	.07
Sufficient access to technical expertise.	63	3.68	73	48	3.54	63	.71	.480	.07
Capacity to plan and manage outreach activities.	61	3.85	74	50	3.48	58	2.12	.036	.20
Capacity to report on outcomes.	61	4.02	87	50	3.42	58	3.49	.001	.32
Ability to adapt[2]	59	3.48	48	51	3.27	39	1.11	.270	.11
Ability to adapt to changes.	58	3.59	60	51	3.43	59	.82	.412	.08
Ability to capitalize on that change.	55	3.36	45	48	3.06	40	1.38	.171	.14
Goals[2]	57	3.30	40	45	2.90	20	2.05	.043	.20
Measurable water management goals.	57	3.58	70	44	2.84	30	3.37	.001	.32
Progress is evaluated against goals.	56	3.29	52	43	2.81	19	2.38	.019	.23
Water management goals reflect the needs.	56	3.05	41	43	2.95	28	.47	.642	.05

1- Variable coded on a 4-point scale from “No Conflict” (1) to “Extreme Conflict” (4)
2- Variable coded on a 5-point scale from “Strongly Disagree” (1) to “Strongly Agree” (5)

Table 6: Comparison of variable factor loadings, rank, and means between Upper Deschutes, Oregon and Big Wood River, Idaho

	Oregon			Idaho		
	Factor loading	Rank	Mean	Factor loading	Rank	Mean
Mobilize	.79	1	3.70	.82	1	3.51
Goals	.78	2	3.30	.30	8	2.90
Network	.77	3	2.88	.72	2	3.02
Leadership	.74	4	3.27	.69	3	3.44
Management	.72	5	3.69	.69	4	3.46
Authority	.54	6	3.60	.53	5	3.48
Adaptability	.37	7	3.48	.10	9	3.27
Knowledge	.31	8	4.08	.46	6	3.94
Reciprocity	.02	9	4.55	.33	7	4.24
Conflict	-.37	10	3.06	.02	10	2.89

Research Question 4:
How can the results be used to inform local water management in Big Wood River, Idaho?

In addition to testing the questionnaire, a key question for this research involved how water managers and users could apply this information in a planning context. As discussed in the methods, the data for this question are limited to the responses from the Big Wood River, Idaho. Although this study was unable to further group the ten subdimensions into the four dimensions found in the literature: social capital; human financial and physical capital; management approaches and strategies; and governance, these groupings were used below to frame the results and are examined further in the discussion. Furthermore, the ten variables on the questionnaire were not grouped into subdimensions, and variables that were only asked in the Big Wood River are still discussed below because they add to the overall understanding of the community's adaptive governance capacity.

The Big Wood River results were examined by the percent agreement with each questionnaire variable by all respondents and also by stakeholder group- surface water irrigation (SW), groundwater irrigation (GW), non-consumptive users (NC), government (GV), and municipalities (MN). The ability to distinguish by stakeholder group was of particular importance to the Big Wood River Basin users to help support the work of the collaborative and to identify differences by water user. For all variables, the average agreement[7] for questionnaire participants was 54%, indicating that on average, participants were slightly positive about the variables of adaptive governance capacity (AGC). Across all variables, municipal water users had the lowest overall agreement (43%), followed by non-consumptive users (55%), surface water users (60%), groundwater (65%), and government (66%) (Table 7).

Governance

As taken from the literature subdimensions on the questionnaire that relate to governance included: *authority, leadership, and mobilization*. For *authority* variables, there was majority agreement across all participants on ‘who has jurisdictional authority to make management decisions’ (61%) and ‘who has senior water rights’ (67%). However, there was less than majority agreement for how groundwater affects surface water (45%). Among stakeholders, there were typical to substantial effect size differences for eleven of the twelve variables ($V > .30$). Often, municipal responses were lower than other stakeholder responses for many of these variables. Furthermore, the users who are arguably the most impacted by ground and surface water interactions, groundwater users, are also the stakeholder group who has the lowest understanding of ‘how groundwater use affects surface water right’ (25% agreement, $V = .33$). These results indicate that water users understand the water management system and prior appropriation, but there is still uncertainty on the hydrological connection between surface and ground water, particularly for groundwater users (Table 7).

For *leadership*, variable agreement ranged from 48 to 57% for all respondents. Although the majority (57%) of participants agreed ‘that there is someone who brings people together,’ fewer agreed ‘that person or entity is trusted’ (48%) or ‘motivates creativity’ (50%). Municipalities and surface water users had the lowest agreement for these variables (31% and 48%, respectively) and groundwater, government, and non-consumptive users had higher agreement (72%, 67%,

[7] Those respondents who agreed (4) or strongly agreed (5)

and 61%, respectively). For all three leadership variables, there was a typical effect size or greater among stakeholder groups (*V* >*.30*). The only variable with a substantial effect size difference among stakeholders was ‘someone that motivates creativity in others’ (*V* = .42). For this variable, municipalities had 22% agreement, whereas the other stakeholder groups had agreement above 56% (Table 7).

For *mobilization*, agreement for the variables ranged from 45% to 74% for all respondents. ‘Those engaging are motivated to get things done’ had the highest agreement (74%), followed by ‘my stakeholder group is innovative’ (71%), and ‘opportunity to engage in management decisions’ (58%). The majority of respondents did not agree with ‘my stakeholder group has techniques or technologies to share’ (49%), ‘my stakeholder group has a meaningful role in watershed management decisions’ (47%), or ‘stakeholders are willing to try new things to meet multiple needs’ (45%). There were typical and substantial differences among stakeholder groups for each of these six variables (*V* = .37 to .47). Interestingly, although government had the lowest agreement for ‘meaningful role in watershed decision-making’ (33%) and ‘techniques of technologies to share’ (50%), it had the highest agreement for the four other variables (100%). These differences will be discussed in comparison to other subdimensions below in Social Capital (Table 7).

Table 7: Percent agreement with variables by stakeholder group in the Big Wood River Basin, ID (Surface water, *n*= *9* (SW), groundwater, *n* =12 (GW), non-consumptive, *n*=20 (NC), government, *n=4* (GV), municipalities, *n=26* (MN).

	Percent agreement (%)									
	SW	GW	NC	GV	MN	Total	n	χ^2	p-value	Cramer's V
Conflict[1]										
Level of conflict currently.	75	83	90	100	87	86	49	2.10	.718	.18
Level of conflict in the past five years.	75	33	90	50	67	63	49	9.02	.061	.42
Level of conflict in past ten years.	50	17	80	33	39	44	46	9.93	.042	.45
Level of conflict expected in next ten years.	100	100	92	100	80	92	51	6.15	.189	.32
Authority[2]										
Who has jurisdictional authority to make decisions.	89	67	56	75	48	61	66	5.90	.207	.28
Who has senior water rights.	100	92	63	75	44	67	64	16.96	.002	.46
How groundwater use affects surface water rights.	67	25	56	75	33	45	65	7.42	.115	.33
Leadership[2]										
Someone who helps to bring stakeholders together.	44	83	57	67	44	57	56	5.64	.228	.31
Someone who is trusted by stakeholders to lead.	44	58	67	67	28	48	54	5.75	.218	.32
Someone that motivates creativity in others.	56	75	58	67	22	50	54	9.81	.044	.42
Mobilize[2]										
Opportunity to engage in management decisions.	78	75	50	100	40	58	60	9.37	.052	.37
Meaningful role in watershed management decisions.	89	58	50	33	20	47	60	14.32	.006	.47
Those engaging are motivated to get things done.	100	83	64	100	58	74	58	11.38	.023	.38
Stakeholders are willing to try new things to meet multiple needs.	43	67	42	100	25	45	49	8.29	.082	.39
My stakeholder group is innovative.	100	67	77	100	50	71	51	10.29	.036	.39
My stakeholder group has techniques or technologies to share.	75	64	54	50	20	49	49	8.76	.067	.41
Reciprocity[2]										
Personal obligation to find long-term water solutions.	100	92	77	67	82	85	53	4.39	.356	.25
Responsibility to help educate others about water needs.	100	92	77	67	81	85	52	4.46	.347	.26
Know that my own behaviors impact other water users.	100	100	77	100	82	89	53	7.55	.110	.32
I can do more to ensure water solutions.	100	100	77	33	77	83	53	11.88	.018	.44
Network[2]										
Share information.	50	67	36	100	44	51	49	5.19	.268	.30
Supportive of each other.	63	83	25	33	25	45	51	13.50	.009	.50
Willing to work together to solve water problems.	63	82	54	100	38	59	51	8.97	.062	.39
Stakeholders willing to sacrifice their needs.	38	50	8	33	6	24	51	10.25	.036	.44

Trust water management decisions.	57	55	27	50	13	35	46	7.28	.122	.39
Trust stakeholders to keep my needs in mind.	25	55	25	33	18	29	51	4.48	.345	.30
Common vision for managing water.	44	58	42	25	24	38	69	4.84	.304	.26
Awareness of impacts[2]										
Human factors that influence water management.	71	75	100	100	67	80	49	8.62	.071	.35
Economic factors that influence water management.	88	75	77	100	56	73	51	4.45	.349	.28
Management decisions[2]										
Sufficient access to scientific information.	50	64	75	100	38	57	49	6.75	.150	.35
Sufficient access to technical expertise.	38	82	83	100	40	63	48	11.49	.022	.47
Capacity to plan and manage outreach activities.	50	82	69	100	31	58	50	10.59	.032	.44
Capacity to report on outcomes.	38	73	62	100	50	58	50	5.05	.282	.29
Ability to adapt[2]										
Ability to adapt to changes.	38	33	75	50	77	30	51	8.42	.077	.40
Ability to capitalize on that change.	50	33	40	0	44	40	49	2.69	.612	.20
Goals[2]										
Measurable water management goals.	25	60	27	50	8	30	44	8.24	.083	.43
Progress is evaluated against goals.	14	40	18	0	8	19	43	4.63	.327	.33
Water management goals reflect the needs.	43	60	18	0	8	28	43	10.42	.034	.48
Non-subdimension variables[2]										
I feel empowered in helping to resolve watershed issues.	75	75	54	67	53	62	53	2.49	.647	.21
Ability to achieve water sustainability goals.	71	75	83	100	81	80	50	1.91	.752	.17
Our watershed has identified and prioritized water values.	14	18	17	67	20	21	48	3.31	.507	.30
Bio-physical factors that influence water management.	100	75	85	100	75	82	51	4.88	.300	.25
Capacity to analyze water management options.	50	82	77	100	44	64	50	7.85	.097	.38
There are adequate financial resources available.	0	33	46	0	53	35	48	11.24	.024	.41
Stakeholders in my watershed have the infrastructure needed.	14	8	17	0	13	13	47	0.68	.954	.11
Learning about new water conservation technologies is important.	88	83	100	100	77	87	53	5.98	.201	.28
The way that water is managed can meet my stakeholder's water needs.	33	42	13	100	40	36	61	13.03	.011	.43
Regulatory changes are necessary to allow more innovation.[3]	22	50	20	33	48	36	58	4.64	.326	.28
Common vision for managing water.	44	58	42	25	24	38	69	4.84	.304	.26

1- Variable coded on a 4-point scale from "No Conflict" (1) to "Extreme Conflict" (4)
2- Variable coded on a 5-point scale from "Strongly Disagree" (1) to "Strongly Agree" (5)
3- Reverse coded

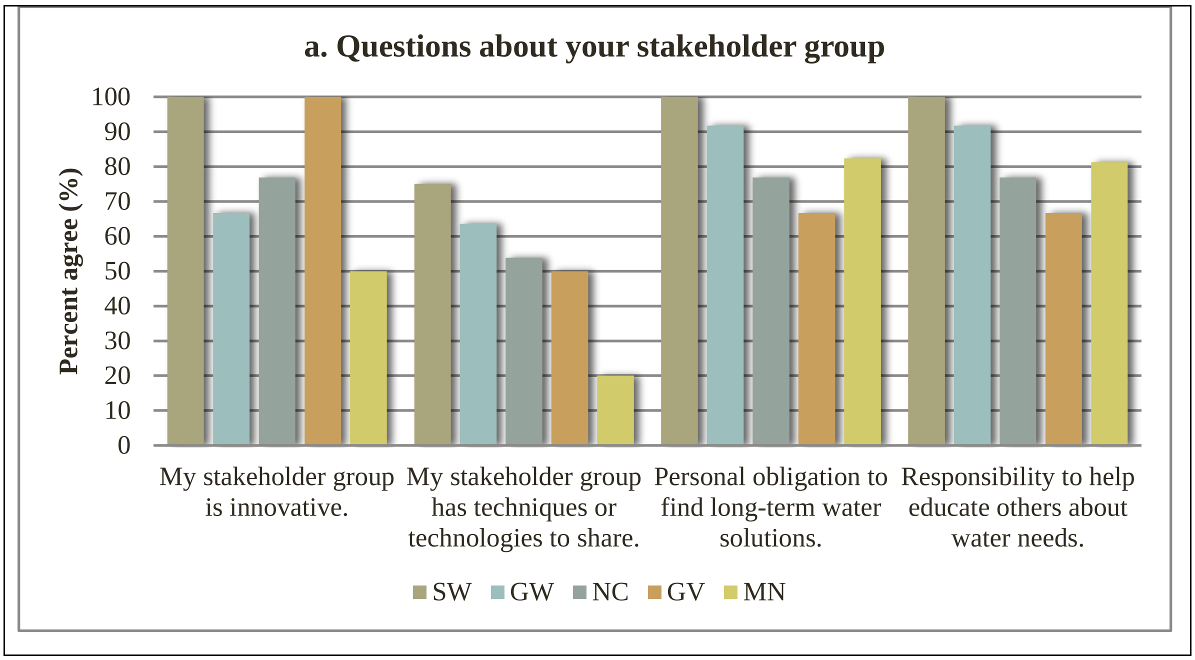
Social Capital

The subdimensions related to social capital include *networks* and *reciprocity*. For all respondents, *network* variables agreement ranged from 24% to 59%. The least amount of agreement was for 'stakeholders willing to sacrifice their needs' and highest for 'willing to work together to solve water problems.' The range of agreement for *network* variables can be explained by differences seen among stakeholder groups. Among the five stakeholder groups, groundwater users had the highest agreement for all *network* variables (64%), followed by government (54%). Less than majority agreement was found with surface water (48%), non-consumptive (31%), and municipal users (24%). These differences among stakeholder groups had typical and substantial effect sizes ($V > .30$) for all but one variable, 'common vision for managing water,' where agreement for all stakeholders was 38% and the effect size differences were between minimal and typical ($V = .26$). Noteworthy was the 100% agreement by the government group that 'there is sharing of information' and 'people's willingness to work together to solve water problems' (Table 7).

An interesting finding was the difference in responses to variables regarding how participants perceived themselves versus how they perceived others. For variables asking how participants viewed themselves and their behavior, there was majority agreement for all respondents. For *reciprocity* variables, there was 85% agreement for both variables asking about 'personal obligation to find long-term water solutions' and also 'responsibility to help educate others about water needs'. Additionally, for 'I know that my own behaviors impact other water users' and 'I can do more to ensure water solutions', agreement was 89% and 83%, respectively. By contrast, there was less agreement among all respondents on *network* variables asking about other stakeholders in the basin- 'I trust that water management decisions will produce good outcomes for all stakeholders' (46%), 'stakeholders are willing to sacrifice their needs' (51%), and 'trust stakeholders to keep my needs in mind' (51%) (Table 7 and Figure 7).

The difference between how respondents viewed themselves (more positively) versus other stakeholders (more negatively) had exceptions when evaluated among the five stakeholder groups. There were typical to substantial effect size differences among stakeholder groups for variables 'stakeholder group is innovative' and 'has technologies to share' ($V = .39$ and $.41$, respectively).

Municipal users had far less agreement regarding their stakeholder's innovation and techniques or technologies to share (50% and 20%) compared to other stakeholder groups. Furthermore, there were typical to substantial effect size differences among stakeholder groups for 'stakeholders are willing to sacrifice their needs for others' (*V*=.44), 'trust in management decisions producing good outcomes for all stakeholders' (*V* = .39), and 'trust in stakeholders keeping their needs in mind when making management decisions' (*V* = .30). Municipal users had lowest agreement and groundwater users often had the highest agreement with these variables when compared with other stakeholder groups (Table 7).



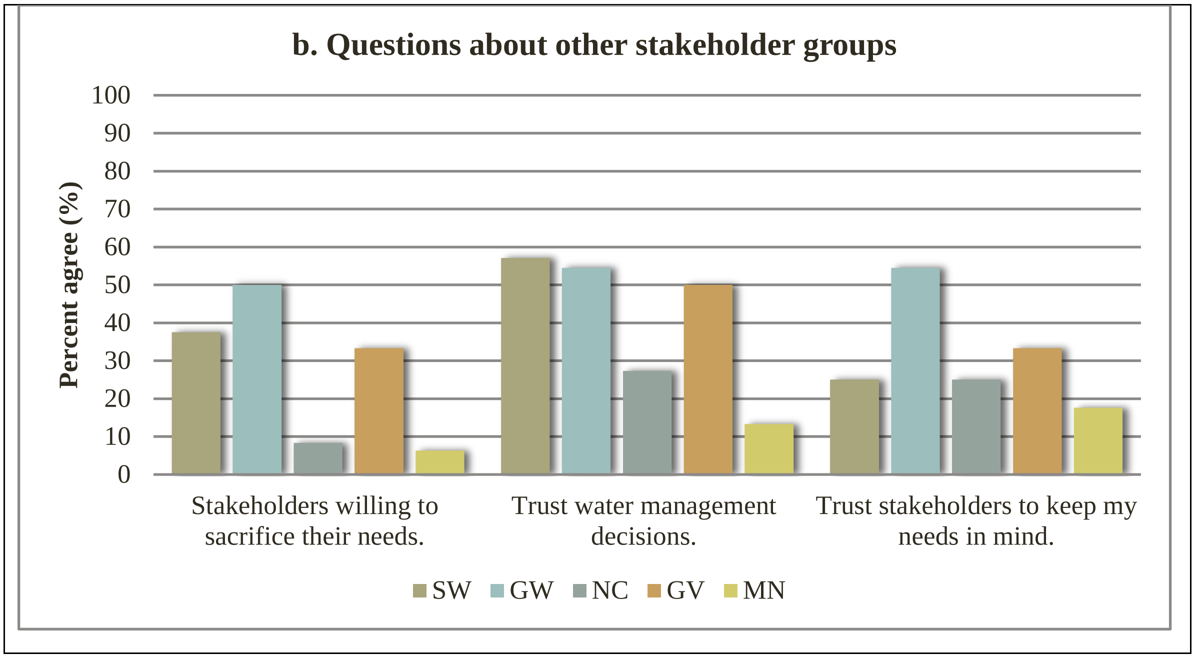


Figure 7: Questions about own versus other stakeholder groups in the Big Wood River, Idaho (these are the same data presented in Table 7).

Trust is another component of social capital that helps to reduce transaction costs by facilitating cooperation (Pretty, 2003). Big Wood River participants were asked how much 'trust they had in each stakeholder to positively contribute to water management'. Across all respondents in this basin, there was highest overall trust[8] in science, scientists, and environmental groups (all greater than 70%). Only 50% of respondents reported trust in groundwater irrigation, municipal water, surface irrigation, and county government. Less than 40% trust in all other stakeholders was reported, with the least amount of trust in residents and small water users (Table 8 and Figure 8).

There were differences among the five stakeholder groups (surface water, groundwater, non-consumptive, government, and municipalities) in the amount of trust they had with the 13 stakeholder categories listed in the question. In seven of the 13 stakeholder categories, there were typical to substantial effect size differences among the five stakeholder groups in the amount of trust they had in others. Furthermore, groundwater users had the lowest trust for all other

[8] Those respondents who trusted (4) or strongly trusted (5) the stakeholder group on a scale from strongly distrust (1) to strongly trust (5)

stakeholder groups (38% average trust for all stakeholders). This was followed by 43% overall trust in others by municipalities, 51% trust in others by non-consumptive users, 57% trust in others by surface water users, and the highest trust in others by government (67%) (Table 8 and Figure 9).

Additionally, the order of trustworthiness of stakeholders varied among the five stakeholder groupings. For example, surface water users had the highest trust in scientific information[9] (100%), groundwater users (88%), and state government (88%). Groundwater irrigators had the highest trust in other groundwater irrigators (91%), surface irrigators (82%), and scientific information (67%). Non-consumptive users had the highest trust in environmental groups (100%), scientific information (100%), and scientists (92%). Similarly, municipal users had the highest trust in environmental groups (81%), followed by scientists (73%), and then scientific information (67%). Government users had four stakeholder groups who were trusted at 100%: scientific information, environmental, groundwater, and recreation (Table 8 and Figure 9).

Table 8: Percent trust among stakeholder groups in the Big Wood River Basin, ID (Surface water, *n= 9* (SW), groundwater, *n* =12 (GW), non-consumptive, *n*=20 (NC), government, *n=4* (GV), municipalities, *n=26* (MN).

	Percent trust (%)								
	SW	GW	NC	GV	MN	Total	χ^2	p-value	Cramer's V
Scientific information	100	67	100	100	67	82	12.77	.012	.43
Scientists	63	58	92	67	73	73	4.79	.309	.29
Environmental	63	25	100	100	81	71	22.96	.000	.62
Groundwater irrigation	88	91	15	100	36	54	24.07	.000	.66
Municipal water	63	42	50	50	50	50	.84	.933	.13
Surface irrigation	75	82	23	50	31	49	12.84	.012	.51
County government	63	17	67	67	47	48	8.01	.091	.39
Recreation/ tourism	38	8	69	100	27	39	17.40	.002	.55
Municipal government	50	25	50	33	38	39	2.10	.718	.20
State government	88	25	42	67	19	39	13.22	.010	.50
Communal well/subdivision	29	18	17	33	43	28	2.87	.579	.25
Small water	14	17	25	50	39	26	2.66	.617	.24
Residential/ private well	14	25	18	50	14	20	1.55	.817	.20

[9] Users in the Big Wood River basin asked to separate trust in scientists and the information they produce (scientific information)

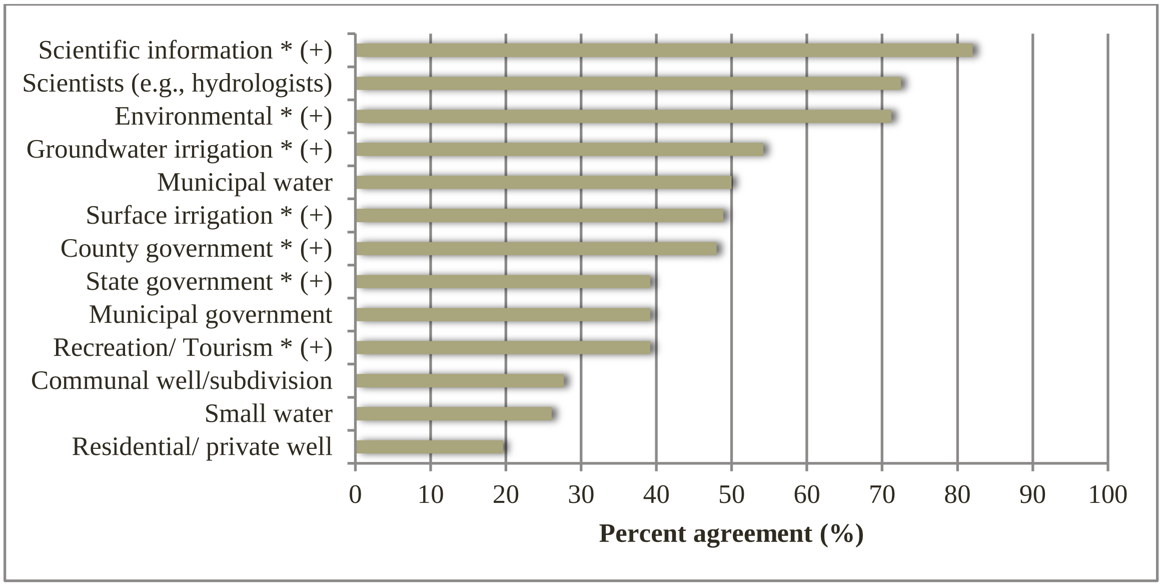


Figure 8: Percent trust in each stakeholder category to positively contribute to water management in the Big Wood River, Idaho (*) p-value < .10; (+) Cramer's *V* >.3 (these are the same data presented in Table 8).

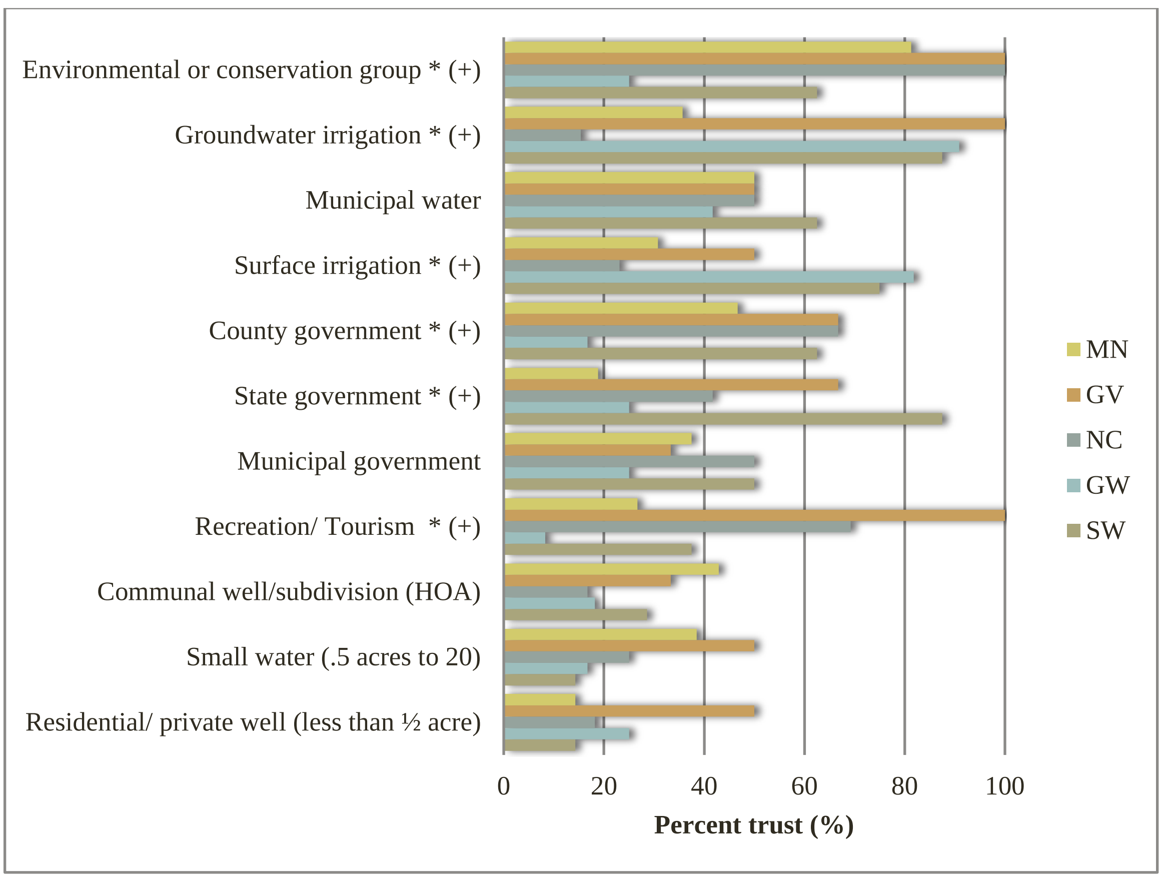


Figure 9: Trust among stakeholders in the Big Wood River Basin, ID (Surface water, *n= 9* (SW), groundwater, *n* =12 (GW), non-consumptive, *n*=20 (NC), government, *n=4* (GV), municipalities, *n=26* (MN) ((*) p-value < .10; (+) Cramer's *V* >.3 indicating typical to substantial effect size) (these are the same data presented in Table 8).

Human, financial, and physical capital

Human, financial, and physical capital assists in identifying, understanding, and evaluating the problem and alternatives and finding resources to implement solutions. The majority of the respondents agreed they were aware of the ‘human factors’ (80%), ‘economic factors’ (73%), and ‘biophysical factors’ (82%) that influence water management in the basin, collectively included in the *awareness* subdimension. The only difference in effect size among stakeholder groups was for the variable ‘awareness of the human factors that influence water management’ ($V = .35$). For this variable, municipal users had the lowest agreement (67%) and government and non-consumptive users had the highest (100%) (Table 7).

In addition, there was majority agreement for *management decisions* variables- ‘sufficient access to scientific information’ (57%) and ‘sufficient access to technical expertise’ (63%), ‘capacity to plan and manage outreach activities’ (58%), and ‘report on outcomes’ (58%). However, agreement for *management decisions* variables varied among the five stakeholder groups; there were typical to substantial effect size differences for three of the four variables. ‘Access to technical expertise’ had the lowest agreement for surface water users (38%) and municipal users (40%)($V = .47$), whereas groundwater, surface water, and government users had majority agreement (82%, 83%, and 100%, respectively). There was also a difference among the five stakeholder groups in ‘capacity to plan and manage outreach’ ($V = .44$). Surface water and municipal stakeholders had less than majority agreement (50% and 31%, respectively), whereas all other users had agreement greater than 69%. For ‘access to scientific information’, there was a typical difference among stakeholders, with agreement ranging from 38% for municipalities to 100% for government ($V = .35$) (Table 7).

In contrast to knowledge and capacity, respondents in general did not agree that there were ‘adequate financial resources’ or ‘infrastructure available’ (35% and 13%, respectively). However, there was between typical to substantial effect size difference among the five stakeholder groups for availability of adequate financial resources- surface water (0%), government (0%), groundwater (33%), non-consumptive (46%), and municipalities (53%)($V = .41$). For ‘needed infrastructure’, minimal effect differences were seen among stakeholders ($V = .11$); all groups had agreement less than 17%. Therefore, in terms of resources, participants in the basin have adequate knowledge and capacity, but would benefit from financial and infrastructure support (Table 7).

Management approaches and strategies

Management approaches and strategies that allow for risk and are innovative, support adaptive behavior, and also provide options for users in the basin. In general, participants disagreed that the basin ‘has a common vision for water management’ (38%) and ‘water management can meet stakeholder needs’ (36%), whereas there was majority agreement that ‘regulatory changes are necessary’ (63%). The only exception was a typical to substantial effect size difference for ‘water management can meet stakeholder’s needs,’ where government had 100% agreement and other stakeholder agreement ranged from 13% to 42% (V = .43) (Table 7).

There was less than majority agreement for all respondents for *goal* variables - ‘goals are measurable’ (30%), ‘progress is evaluated against goals’ (19%), and ‘goals reflect the needs’ (28%). Among stakeholders, there were typical to substantial effect size differences for each of these variables (V = .43, .33, and .48, respectively). Municipal users had the lowest agreement across all three variables (8%) and groundwater users had the highest (53%). Although the majority of participants did not agree with variables associated with current goals, there was majority agreement on the ‘ability to achieve sustainability goals in the future’ (80% agreement, V = .17) (Table 7 and Figure 10).

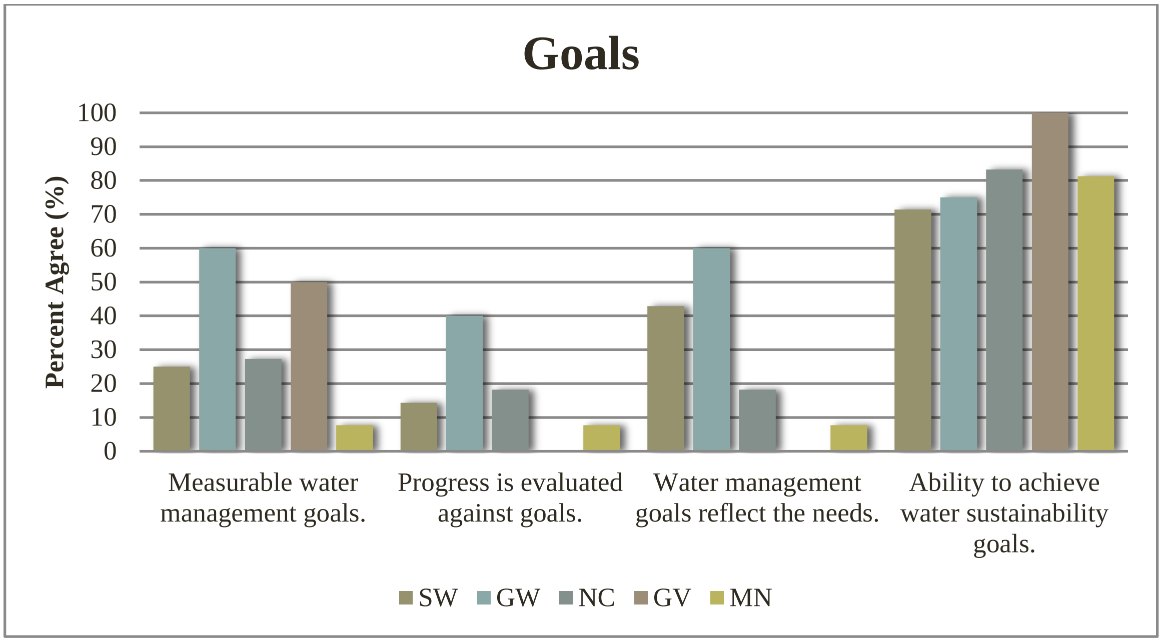


Figure 10: Questions regarding goals by stakeholder groups in the Big Wood River Basin, Idaho (Surface water, (SW), groundwater, (GW), non-consumptive, (NC), government (GV), municipalities (MN)(these are the same data presented in Table 7).

Across participants, there were a range of responses for the *ability to adapt* variables. ‘The ability to adapt to change’ and ‘the ability to capitalize on change’ had less than majority agreement (30% and 40%, respectively). Groundwater and surface water user agreement with the ‘ability to adapt to change’ was 33% and 38%, respectively, whereas non-consumptive, government, and municipal users agreement was greater than 50% (V = .40) (Table 7 and Figure 11).

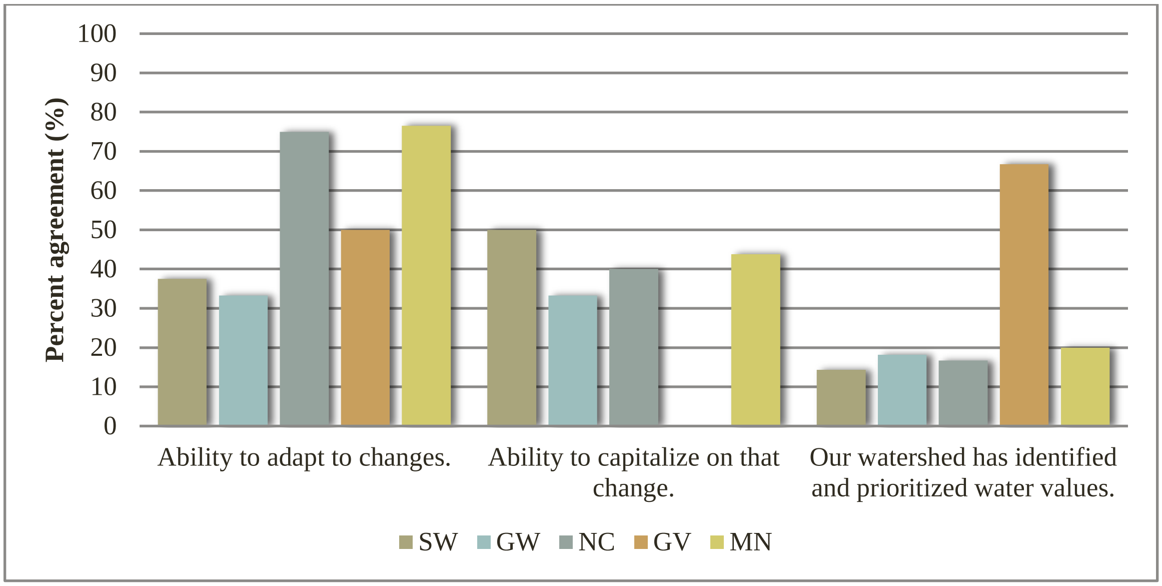


Figure 11: Ability to adapt to change, capitalize on change, and prioritize water values by stakeholder group in the Big Wood River, Idaho (Surface water, (SW), groundwater, (GW), non-consumptive, (NC), government (GV), municipalities (MN)(these are the same data presented in Table 7).

To evaluate the acceptability of various water management options, participants were given a list of water management tools and asked if they supported use of the tool in a regulatory and voluntary context. For all participants, the highest support for the voluntary use of water management tools was for temporary water agreements (71%), water leases through fallowing (61%), long-term basin planning (58%), water delivery efficiency projects (58%), and permanent agreements (58%). The highest support for the regulatory use of water management tools showed a different ordering- water use measurement (56%), setting minimum flows instream (46%), long-term basin planning (42%), groundwater recharge (42%), habitat restoration (39%), and policies for reducing demand (39%) (Table 9 and Figure 11).

The overall average support for voluntary use was higher than regulatory use of all water management tools (50% and 33% respectively). There were also more tools that had voluntary support greater than 50% (11 tools) as compared to regulatory support (one tool). There was a significant difference ($p < .10$) and a typical to substantial effect size (Cohen's $d > .50$) between support for the voluntary and regulatory support in ten of the 19 water management tools, indicating there are tools that participants support on a voluntary basis, but not a regulatory basis (and vice versa) (Table 9 and Figure 12).

Table 9: Percent support for voluntary and regulatory use of water management tools for respondents in the Big Wood River, Idaho.

	Voluntary support (%)	Voluntary support (count)	Regulatory support (%)	Regulatory support (count)	Paired sample t-test value	p-value	Cohen's d effect size
Temp agreements	71	42	22	13	5.56	<.001	1.12
Water leases through fallowing	61	36	27	16	3.67	<.001	.72
Permanent agreements	58	34	31	25	3.02	<.001	.56
Water delivery efficiency projects	58	34	32	19	2.44	.020	.54
Long-term basin planning	58	34	42	18	1.46	.150	.32
On-farm efficiency projects	56	33	29	23	3.02	<.001	.56
Conserved water projects	56	33	34	20	2.27	.030	.45
Habitat restoration	56	33	39	17	1.74	.090	.34
Water banking	54	32	37	22	1.65	.110	.34
Full water markets	53	31	25	25	3.26	<.001	.59
Groundwater recharge	53	31	42	15	1.00	.320	.22
Switching the source of water	47	28	24	23	2.69	.010	.49
Increased reservoir storage	47	28	34	20	1.48	.150	.26
Policies for reducing demand	47	28	39	14	.84	.400	.16
Changing point of diversion	42	25	29	17	1.43	.160	.27
Demand driven water delivery	37	22	12	27	3.59	<.001	.60
Minimum flow	37	22	46	7	.93	.360	-.18
Water pricing (tiered rates)	36	21	36	21	.00	1.000	.00
Water use measurement	29	17	56	33	2.91	.010	.56

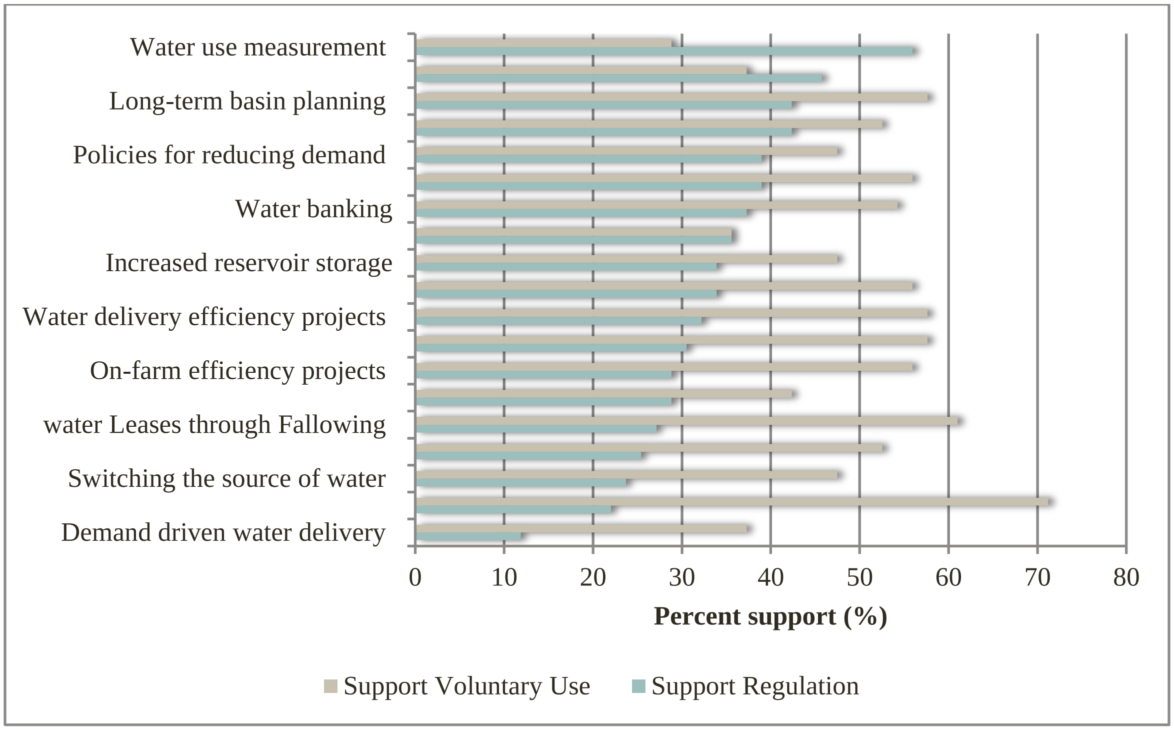


Figure 12: Water management tools voluntary and regulatory use support by all stakeholders in the Big Wood River, Idaho (these are the same data presented in Table 9).

Preference for water management tools not only varied by the voluntary and regulatory use, but also among the five stakeholder groups. There were typical to substantial effect size differences among stakeholder groups for six of the voluntary management tools. For the use of regulatory support, there were typical to substantial effect sizes difference among stakeholder groups for twelve of the tools. Support for the voluntary use of water management tools was greatest for surface water users (17 tools with 50% or greater support) followed by non-consumptive and municipal users (14 tools with 50% or greater support). Groundwater users had the least amount of support for voluntary water tools (seven tools with 50% or greater support). For regulatory use of tools, non-consumptive users had the highest support (12 tools with 50% or greater support), followed by government (nine tools). Groundwater and municipal users both indicated three tools with 50% or greater support, and surface water users indicated one tool with 50% or greater support (Table 10 and Table 11).

Table 10: Voluntary support for management tools by stakeholder group in the Big Wood River, Idaho (Surface water, *n= 9* (SW), groundwater, *n* =12 (GW), non-consumptive, *n*=20 (NC), government, *n=4* (GV), municipalities, *n=26* (MN).

	SW	GW	NC	GV	MN	Total	χ^2-value	p-value	Cramer's V
Temp non-diversion agreements	88	67	80	50	72	74	2.57	.632	.21
Water leases through fallowing	88	58	53	50	67	63	3.51	.477	.24
Long-term basin planning	88	67	53	50	50	60	4.35	.360	.26
Water delivery efficiency projects	63	67	53	50	61	60	.69	.952	.11
Perm agreements	88	25	67	75	61	60	9.71	.046	.40
Conserved water projects	75	75	60	25	44	58	5.68	.224	.31
Habitat restoration	63	42	60	50	67	58	2.06	.725	.19
On-farm efficiency projects	50	33	53	50	83	58	8.73	.068	.38
Water banking	50	67	53	50	56	56	.79	.940	.12
Full water markets	88	33	60	100	39	54	13.03	.011	.44
Groundwater recharge	88	42	53	50	50	54	5.02	.285	.28
Increased reservoir storage	75	33	53	25	50	49	4.55	.337	.28
Switching the source of water	50	50	53	25	50	49	1.10	.895	.14
Policies for reducing demand	50	42	40	75	56	49	2.19	.701	.19
Changing point of diversion	63	42	33	25	50	44	2.72	.605	.22
Minimum flow requirements	50	8	60	25	39	39	9.31	.054	.38
Demand driven water delivery	38	33	40	0	50	39	5.02	.285	.25
Water pricing (tiered rates)	63	25	40	25	33	37	3.34	.503	.24
Water use measurement	25	0	47	25	39	30	11.19	.025	.37

Table 11: Regulatory support for management tools by stakeholder group in the Big Wood River, Idaho (Surface water, *n= 9* (SW), groundwater, *n* =12 (GW), non-consumptive, *n*=20 (NC), government, *n=4* (GV), municipalities, *n=26* (MN).

	SW	GW	NC	GV	MN	Total	χ^2-value	p-value	Cramer's V
Water use measurement	25	58	73	75	56	58	5.67	.225	.31
Minimum flow requirements	50	33	53	75	44	47	2.54	.638	.21
Groundwater recharge	25	50	67	25	33	44	6.02	.198	.32
Long-term basin planning	25	42	53	25	50	44	2.68	.613	.21
Habitat restoration	25	17	60	75	39	40	8.33	.080	.38
Policies for reducing demand	13	17	73	50	39	40	13.04	.011	.47
Water banking	13	17	60	25	50	39	9.54	.049	.40
Water pricing (tiered rates)	13	25	67	50	28	37	9.59	.048	.41
Conserved water projects	38	8	53	75	28	35	9.91	.042	.40
Increased reservoir storage	38	50	40	0	28	35	5.19	.268	.26
Water delivery efficiency projects	13	25	53	50	28	33	5.50	.240	.31
Perm agreements	13	25	33	50	39	32	2.88	.579	.22
On-farm efficiency projects	13	25	53	25	22	30	5.65	.227	.32
Changing point of diversion	13	33	53	0	22	30	8.37	.079	.36
Water leases through fallowing	25	17	40	50	22	28	3.06	.548	.23
Full water markets	13	8	47	25	28	26	6.29	.178	.33
Switching the source of water	38	33	33	0	11	25	6.04	.196	.29
Temp non-diversion agreements	25	8	33	25	22	23	2.67	.615	.21
Demand driven water delivery	0	8	33	0	6	12	8.76	.067	.39

Users in the Big Wood River Basin requested that questions be added to the questionnaire focusing on the prioritization of water uses in the basin. The first question was "to what extent do you agree or disagree, that our watershed has identified and prioritized community values for water use?" Government users had the highest agreement with this question (67%), whereas all other users indicated that the basin had not prioritized the values of water in the basin (agreement ranged from 14% to 20%). The second question was "when you think about the basin in the next 20 to 50 years, please rank from 1 to 7 (with 1 the most and 7 the least important) the uses of water in your basin that are most important to you." From the list of water uses, respondents ranked potable water the highest and scenic enjoyment the lowest (Table 7 and Figure 13).

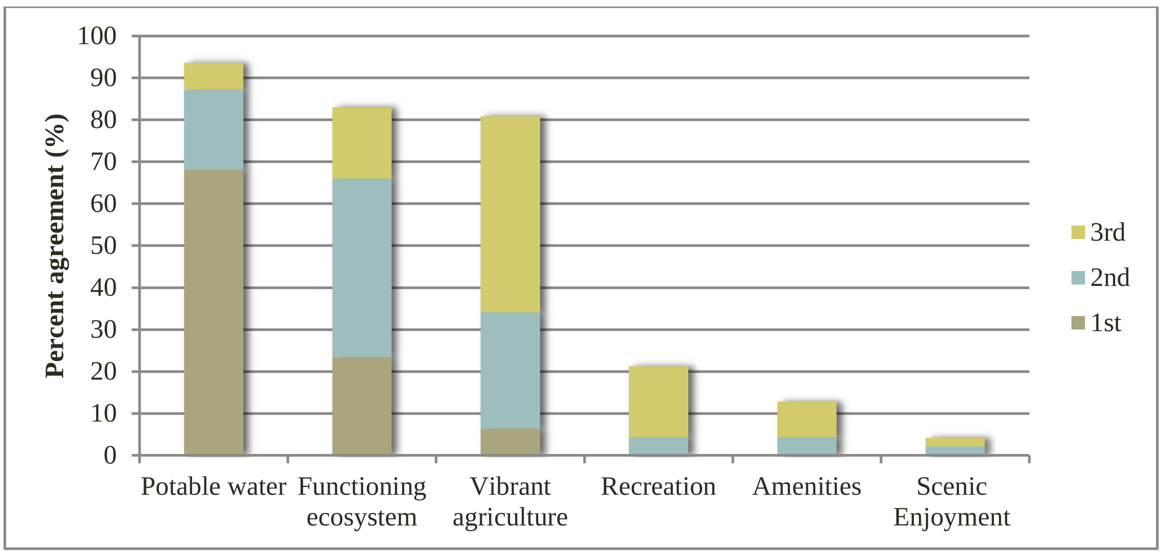


Figure 13: First, second, and third choice ranking of different values of water in the Big Wood River, Idaho

There were typical to substantial effect size differences among stakeholders in their water value rankings in all values. This indicated there is little agreement among users in the basin on how water should be prioritized. The stakeholder interest groups associated with a given value tended to rank that value higher than other values (e.g., municipalities ranked potable water 1st, surface and groundwater users had first and second rankings for agriculture) (Table 12 and Figure 14).

Table 12: Percent support (%) for ranking of values of water use among stakeholder groups in the Big Wood River, Idaho.

	Percent support (%)								
	SW	GW	NC	GV	MN	Total	χ^2-value	p-value	Cramer's V
Potable water									
1st	71	73	50	50	85	68	17.85	0.597	0.35
2nd	29	9	25	25	15	19			
3rd		9	17			6			
4th			8			2			
5th		9				2			
6th									
7th				25		2			
Ecosystem									
1st	29		42	50	15	23	48.49	0	0.46
2nd		9	58	50	77	43			
3rd	29	46			8	17			
4th	29	27				11			
5th	14	9				4			
6th		9				2			
7th									
Agriculture									
1st		27				6	34.6	0.022	0.43
2nd	57	55	8	25	8	28			
3rd	29	18	58	50	69	47			
4th									
5th	14		25	25	8	13			
6th					15	4			
7th			8			2			

	Percent support (%)								
	SW	GW	NC	GV	MN	Total	χ^2-value	p-value	Cra V
Recreation									
1st							18.75	0.538	0.32
2nd	14		8			4			
3rd	14	9	25	50	8	17			
4th	29	18	50	25	62	40			
5th	29	46	8	25	23	26			
6th	14	18	8		8	11			
7th		9				2			
Amenities									
1st							36.14	0.015	0.43
2nd		18				4			
3rd	29	18				9			
4th	29	36	8	25	15	21			
5th	29	27	25	25	54	34			
6th	14		67	50	15	28			
7th					15	4			
Scenic Enjoyment									
1st							25.25	0.192	0.36
2nd		9				2			
3rd					8	2			
4th			8		8	4			
5th	29	9	67	50	23	34			
6th	71	64	25	25	62	51			
7th		18		25		6			

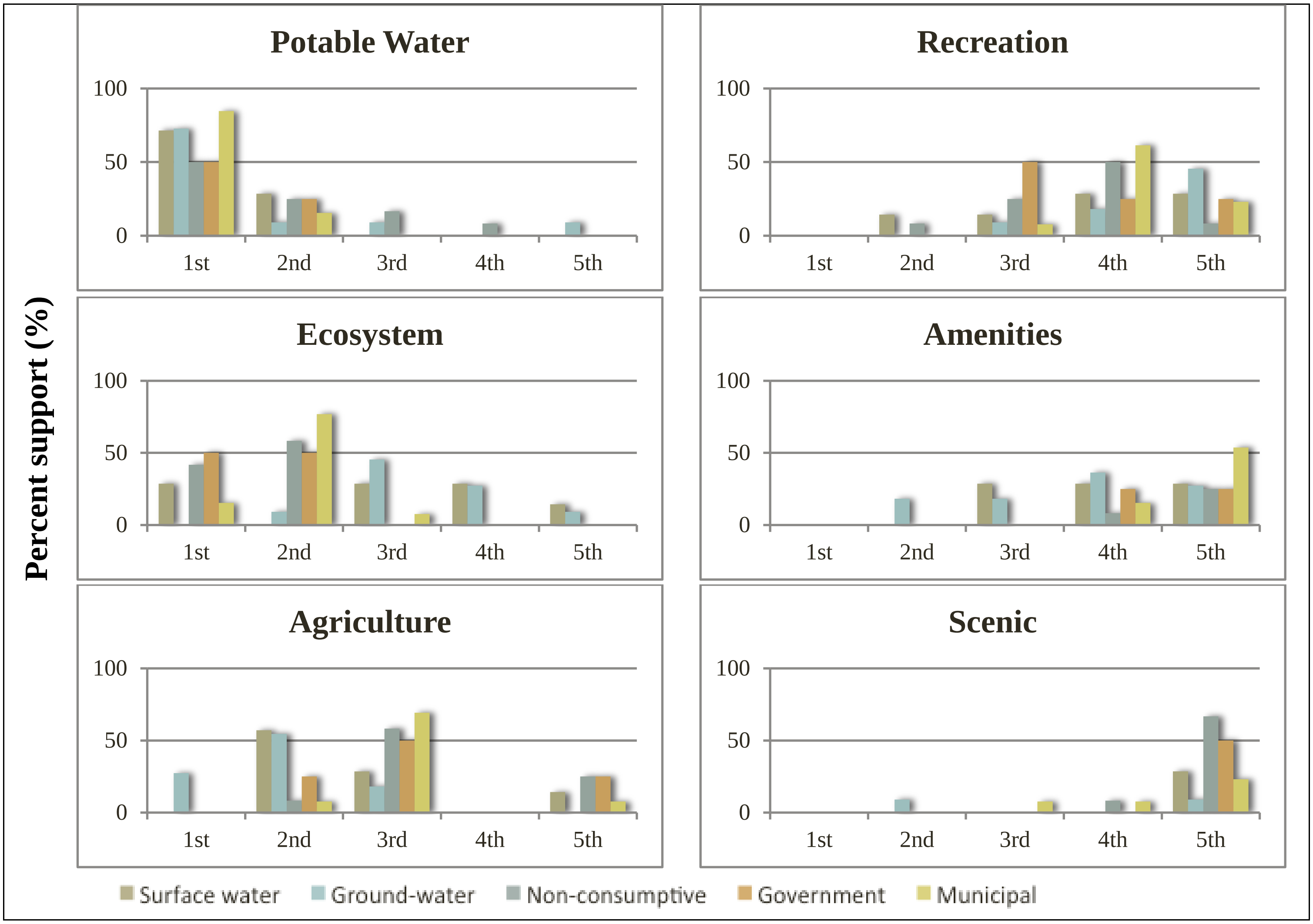


Figure 14: Percent support (%) for ranking of values of water use among stakeholder groups in the Big Wood River, Idaho (these are the same date presented in Table 12).

Discussion

Research Questions 1 and 2:
How can the collaborative governance and adaptive capacity literature be used to inform a questionnaire that measures adaptive governance capacity of Western water communities?

How do dimensions and subdimensions contained within adaptive capacity and collaborative governance frameworks interact?

The need to develop a questionnaire to evaluate collaborative efforts is motivated by multiple rationales. Conley and Moote (2003) submit that evaluation can provide information for participants to improve efforts and meet goals, for facilitators and managers to identify approaches that meet context specific challenges, for policymakers to formulate appropriate rules and regulations, and for agencies and foundations to select which collaborations to support. Furthermore, users and managers can use a questionnaire to track the progress and outcomes of a collaborative over time to discern if improvements have been made or conditions have deteriorated. The results of the first research question empirically verify which subdimensions of AGC to include in a questionnaire. However, to understand how these subdimensions interact and to measure capacity over time, there is need to incorporate complex system theory into our thinking, as examined in the second research question.

Variables used in this study were adapted from previous studies (Ivey et al., 2004; Lockwood et al., 2015; Weber, 2013) to evaluate adaptive governance capacity, with additional questions to fit within the Western water context. Of the 44 initial common variables in the study, 34 were grouped into subdimensions. Taken together, the EFA and reliability analysis verified the validity and reliability of the questionnaire design and also to identify the main subdimensions that contribute to adaptive governance capacity in these cases. The ten ungroupable variables represent concepts that have been identified in the literature and in practice as important. The inability to group these variables could be due to a questionnaire design error (i.e., the wording of questions may not have captured the concept) or to the fact that additional questions need to be asked to develop additional subdimensions. Academics, practitioners, and a subsample of the participants in the communities assisted in the development and testing of the questionnaire, so the face validity (i.e., how understandable are the questions) is likely not an issue. Thus, further research that develops additional variables for each concept and re-runs the EFA and Cronbach analyses may assist in fully developing these variables into subdimensions.

The ability to group variables into subdimensions is consistent with research conducted by Lockwood et al. (2015) from which some variables in this study were based. They developed variables related to governance; social capital; human, financial, and physical capital; and management approaches in their study of rural agricultural communities in South-Eastern Australia. Similar subdimensions were found to be important in this study as in Lockwood et al. (2015) paper. However, this research was able to identify subdimensions of governance, whereas their study did not. Identification of similar subdimensions in different natural resource areas (water vs. agriculture) helps to support the use of subdimensions in this type of evaluation.

There are two primary explanations for why the subdimensions do not group into four dimensions: sample size limitations and the four-dimension model approach needs to be reevaluated. Regarding sample size, according to Grimm and Yarnold (1997), a principle component analysis requires at least five observations per one variable measured. This study had 44 common variables and would have needed a sample size of 220 participants to achieve a five-to-one ratio. The sample size in this study was 167 and therefore may be an inhibitor to grouping these subdimensions into dimensions according to this principle. Future research that includes the addition of other case studies and/or participants to increase the sample size will allow a more robust EFA and/or a first, second, and third order Confirmatory Factor Analyses (CFA). This multi-step CFA can verify the variables that load into the subdimensions (first order), determine if the subdimensions load onto the four dimensions (second order), and if those four dimensions load onto a single concept of adaptive governance capacity (third order).

At the same time, it is possible that the models used to think about these interactions need to be reevaluated. The adaptive capacity and collaborative governance models used in this study rely on research designed to identify and explain the dimensions and subdimensions of these dynamics, especially with regard to which factors improve the achievement of outcomes. Yet the problems being addressed and the interactions among the individuals involved in these processes are highly complex. The results of this research suggest that models may be too simplistic in their assumptions about the relationships between dimensions and subdimensions. Furthermore, there are interactions among the subdimensions of governance; social capital; human financial and physical capital; and management strategies. In other words, these respective subdimensions do not neatly fit into one dimension to the exclusion of another. This strongly suggests that a new model is needed that more accurately describes the interactions among the dimensions and subdimensions of adaptive governance capacity beyond what is found in the adaptive capacity and collaborative governance literature (Figure 15).

Complexity Theory might help explain this problem. Concepts in Complexity Theory have been found throughout the history of philosophy and science; the view that living systems are “self-organizing networks whose components are all interconnected and interdependent has been expressed repeatedly” (Capra 2015:98). Ecosystems that are “heterogeneous assemblages of individual agents that interact locally and are subject to evolution based on the outcomes of those interactions” have been classified as complex adaptive systems (Levin 2005:1077). Messier and Puettmann (2011) identified forests as complex adaptive systems for their attributes including multiple components that interact with each other over spatio-temporal scales, which give rise to structures and relationships that are neither completely random nor entirely deterministic. Furthermore, forests contain negative and positive feedback mechanisms through energy, information, and materials exchange in an open system; their adaptive components give rise to emergent properties. For the same reasons that Messier and Puettmann (2011) call forests complex adaptive systems, water systems can also be classified as complex adaptive systems.

Although originating in ecosystem studies, Complexity Theory has moved beyond natural systems to include human processes as complex systems, including economics and law (Craig Kundis 2015; M. Mitchell 2009). Craig Kundis (2015) argues that ‘stationairity is dead,’ therefore we can no longer look to the past as a reliable predictor of what may come in the future. Instead, she argues that building resilient systems using Complexity Theory will be the most effective way to develop policy in an era of climate change. Consequently, water managers not only need to consider the complexity of ecological systems, but also those of the human systems that are attempting to manage them. Taken together, this complex system is evolving, contains components that interact and entail feedback loops, and has emergent properties. As a result, the model put forward for adaptive governance capacity of these systems needs to reflect these complex interactions and how they will change over time.

Considering these ecological and human water systems together, as a larger complex social-ecological system, it is not surprising that the subdimensions identified in the adaptive capacity and collaborative governance literature do not fall neatly into four dimensions of social capital; human financial and physical capital; management approaches and strategies; and governance. Instead, subdimensions interact across dimension 'silos' and new subdimensions emerge through time. Levin et al. (2012) indicate that the components of these complex systems have to be viewed in an integrated way, rather than through a linear and reductionist lens. Understandably, this need to account for this dynamic creates substantial challenges for creating an evaluative model (Levin et al. 2013).

In addition to examining sample size, future research using Complexity Theory may help guide how best to think about these systems and facilitate the development of a model that accounts for spatio-temporal changes, feedback loops, and emergence inherent in these dynamic systems. Complexity Theory may also assist in how to think about the evaluation of these adaptive governance efforts and how policy decisions are made (described below in research question three). Given this, scholars and decision-makers should probably exercise caution when working with and applying the lessons learned from existing models of collaborative governance and adaptive capacity. They may be the best current guides on understanding these complex systems, but this research tells us there is a need for better, more accurate guides, to do justice to these complex systems. Furthermore, complexity raises the question if models that contain dimensions and subdimensions are even relevant for understanding these systems, i.e., does the categorization help us understand what matters in these processes?

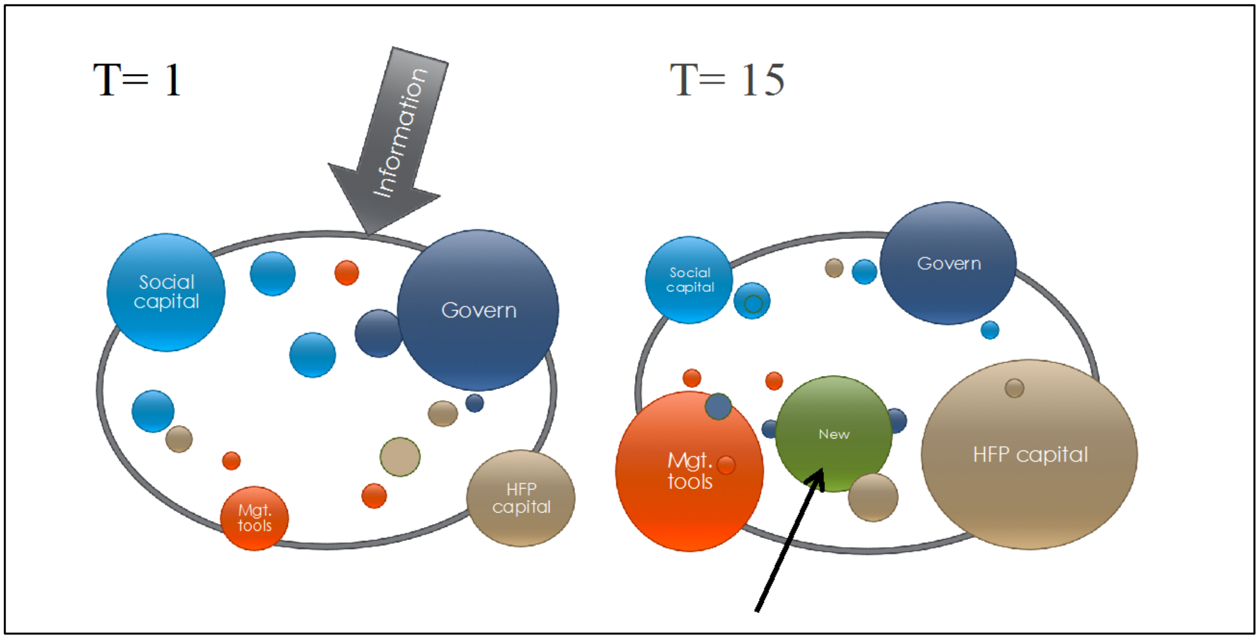


Figure 15: New Model of Adaptive Governance Capacity

Research Question 3:
To what extent do adaptive governance capacities differ based on the amount of time that communities have spent in collaboration?

Research question three was used to test the questionnaire in two basin contexts, understand how AGC varies by basin, and compare the results against what would expect from the collaborative governance and adaptive capacity literature. It was expected that the duration of time spent in collaboration would lead to differences in overall capacity and the factors that contribute to capacity. In the Upper Deschutes, diverse stakeholders have engaged in collaborative efforts over the past 30 years, whereas in the Big Wood River, collaborative efforts began in just the past two years. The results indicate that although the Upper Deschutes in general had higher means values for many of the variables, there was not a clear distinction between the two cases. Furthermore, common subdimensions emerge from both cases to help explain AGC- *networks and mobilize*. Basin context, Complexity Theory, and the adaptive capacity and collaborative governance literature help to explain these results. Given that these processes are dynamic, evolve over time, and operate within a complex system, the ability to make direct comparisons between cases is limited and the importance of longitudinal studies that examine case-specific change over time for evaluation is elevated.

Although overall mean scores for variables and subdimensions measuring AGC were higher in the Upper Deschutes than in the Big Wood River, these differences were only significant for two of the ten subdimensions and eleven of the 24 variables. The multiple planning processes that the Upper Deschutes stakeholders engaged in can help to explain the higher mean scores of *mobilization, authority,* and *awareness of impact* subdimensions. In the Deschutes, stakeholders have participated in numerous water management planning efforts including fish management plans, State Scenic Waterway designation, and multiple subbasin water plans. These planning processes provide many of the same participants the opportunity to continually participate in facilitated and information-rich water management conversations. Therefore, it is not surprising that subdimensions associated with the role participants have in the process, the clarity of authority and seniority of water rights, and knowledge around biophysical and social impacts, have relatively higher values. By contrast, the Big Wood River basin began data gathering, analysis, and conversation around water management only in the past few years. Additionally, the Big Wood River is beginning conjunctive management of surface and groundwater, which contains a considerable amount of uncertainty regarding seniority of water rights.

Higher scores in the Upper Deschutes associated with *goals* and *ability to adapt* can be understood by the solutions that have been developed by the Deschutes River Conservancy and the overall institutional context of Oregon. The Deschutes basin and Oregon have been using water transfers and leases and infrastructure improvements to find mutual benefit between environmental groups and irrigators for decades (Oregon's first instream transfer was approved in 1994). Oregon as a state by far surpasses Idaho in number of transfers and leases instream through the cooperation between irrigators and environmental interests (1913 and 30, respectively) (Fahlund, Choy, and Szeptycki 2014). These types of projects allowed water users to find mutually beneficial outcomes and would likely result in an increased perception by stakeholders in the ability to adapt to change and capitalize on change. Use of these tools could have also increased stakeholders' feelings of innovation and identification of common goals.

In comparison, the Big Wood River is relatively new in developing management solutions to meet multiple needs so it is not surprising that perceptions of innovation and common goals are also lower. It is worth noting that at the time water users participated in this study, the Big Wood was addressing a water call between users in the basin that raised the possibility for junior water rights curtailment and litigation. It was not until after they had participated in this study that users in the basin began to develop a plan that identified basin goals and possible solutions to the water call. It is quite possible that the results of this study would be different if it were administered today.

Although there were variables and subdimensions with higher means in the Upper Deschutes, there were also some that were higher in the Big Wood River. For the *network* subdimension, the Big Wood River's mean scores were higher in five of the seven variables, indicating that informal relationships and bonds between users were strong within their community. The only two variables higher in the Upper Deschutes were 'sharing information' and 'trust in management decisions,' which again could relate to the various management processes that have occurred in the basin. By contrast, *reciprocity* variables were lower in the Big Wood River than Upper Deschutes. *Reciprocity* variables included 'personal obligation to find long-term water solutions' and 'responsibility to help educate others about water needs.' The current water call in the Big Wood River and threat of curtailment may help explain the lack of personal obligation that participants felt for finding mutually beneficial solutions. The regulatory situation established by the water call pits users against one another.

There were also similarities and differences in the contribution of these subdimensions in explaining adaptive governance capacity between the two cases. For both cases, *mobilization* was the most important subdimension in explaining AGC and *network* was the second most influential for the Big Wood River and number three for the Upper Deschutes. *Mobilization* and *network* questions evaluated how participants engage in the discussion as stakeholders, their role in the process, their motivation, and how they work together. It is interesting that *mobilization and network* subdimensions were the most important in explaining AGC despite large differences in the time spent in collaboration among participants from each basin. This may indicate that these subdimensions are influential, regardless of location, throughout the duration of the decision-making process, and therefore important to focus on.

Another common finding was the importance and implementation of *mobilization* and *networking* subdimensions. For example, *mobilization* was not only important in explaining AGC in both cases, but both basins were successful in creating a space for people to engage in a meaningful way. The Upper Deschutes and Big Wood River were also similar in that although *networks* were important in both cases for explaining AGC, neither case had extremely high mean scores associated with this subdimension (though the Big Wood River was higher). This indicates that for both basins to build capacity, they need to focus on sharing information, being supportive, and building trust, with the expectation that a common vision for water management will result. However, the *goals* subdimension was where the cases diverged. *Goals* variables asked participants if there were measureable management goals, was progress evaluated against these goals, and if the goals reflected the needs of the basin. In the Upper Deschutes, *goals* had the second highest factor loading (i.e., important in explaining AGC), whereas for the Big Wood River *goals* were ranked eighth most important in explaining overall AGC. This result indicates that although there are some common subdimensions in explaining AGC, there are differences by basin.

To summarize, these results suggest there are certain subdimensions that each case is more successful in implementing and are more important in explaining capacity, whereas there are also common subdimensions that help to explain AGC in both cases. The adaptive capacity, collaborative governance, and Complexity Theory literature can help explain these results, identify future research, and think about policy implications. Understanding the inherent complexity of these processes helps explain why the Upper Deschutes case did not clearly appear to have higher adaptive governance capacity despite the many years of cooperation among stakeholders and clear successes along the way. These complexities include multiple biological processes influencing the water system, competing interests, overlapping decision-making arenas, and a changing climate. Conley and Moote (2003) describe the unique character of community-based collaboratives, meaning that outcomes and measurement criteria typically vary often widely, from place to place. For example, the individual processes can be quite different from one place to the next, in part, because what is appropriate for one place might not be the same for another. Weber (1998) explains that there is not likely to be one-size-fits-all governance solutions given the diversity of policy problems and community settings. Therefore, these arrangements are unique and change over time and as a result can be quite difficult to compare.

In an effort to evaluate the relationship between water governance and adaptive capacity, Engle and Lemos (2010) formed a governance index based on factors related to stakeholder participation, representation, accountability, knowledge use, and equity of decision making. In a comparison of 18 basins in Brazil, there was variation in the mean scores around the individual variables for each of the basins - there was no clear indication that one basin performed better than others. They identified the need for more analysis on relationships and feedback between indicators and governance mechanisms. Similar to this research in the Upper Deschutes and the Big Wood River, the study by Engles' and Lemos' (2010) indicates that a more nuanced evaluation of the collaboration is needed rather than simply assuming that the time spent formally collaborating leads to higher capacity. The Upper Deschutes has had a non-profit leading the collaborative process for over 30 years, whereas the Big Wood River collaborative has just begun.

Conley and Moote (2003) point out that collaboration has gained popularity over the past two decades and has been lauded for conflict reduction, increased social capital, production of better decisions, and better co-consideration of socio-economic issues. At the same time, they also identify that these processes have been criticized for unbalanced influence of public interest in local decision-making, exclusiveness, and inability to achieve desired outcomes. Not only do site specific conditions vary with both benefits and pitfalls to these processes, but Thomas and Koontz (2006; 2011) indicate that improving one condition may well come at a cost to another as tradeoffs are made.

Overall, the complexity of these systems has implications for how to model and think about adaptive governance capacity in water management, as discussed above. But, it also has implications for evaluating these systems and how decisions are made in other policy contexts. If these arrangements are evolving and dynamic in nature, and are based on complex processes, then linking inputs to outputs and outcomes becomes incredibly difficult (Thomson & Perry, 2006) and raises questions about the ability to compare across cases. For example, in making a decision in the face of budgetary constraints, can two places be compared for which one is doing better and which one should no longer be funded?

These data suggest that a direct comparison between cases does not work because of their complex nature. Mitchell (2009) describes how predict-and-act models are a common strategy in policy making. That is, if X is increased (e.g., increased trust) then it is expected an increase in Y (e.g., better water management solutions). But, these models may be too simplistic to apply to collaborative arrangements because of the internal interaction and emergence of new concepts within human-ecological systems. For example, in each context, subdimensions of AGC will wax and wane over time and result in distinctions that are limited in time and space and difficult to compare across cases. Furthermore, the long time horizons that the adaptive governance processes operate under, which can last decades, presents a challenge for establishing causal inferences. Mitchell (2009) describes how complex systems strain the ability to use ‘factual outcomes’ “especially with respect to choices that involve future states influenced by complex processes in nature and in society” (S. D. Mitchell 2009:86).

If comparison between cases is limited, as this research suggests, case-specific longitudinal evaluation and adaptive management over time may be needed to facilitate decision-making. Future research using this questionnaire to evaluate change in adaptive governance capacity in one community over time will also help validate its use as a measure to track change in capacity. Additionally, further study is needed to assess if the results described above are artifacts of using cross-sectional data on two cases or if it is possible to generalize beyond them to other contexts and collaborative arrangements. These two cases were chosen to demonstrate the range of factors that contribute to adaptive governance capacity and test the questionnaire over cases that vary by the duration that participants engaged in collaboration. The diverse case selection and the common variables used in this study support the generalizability of this questionnaire in other communities engaged in water management. However, including additional cases in variable contexts would help validate the use of this tool in other settings.

Research Question 4:

How can the results be used to inform local water management in Big Wood River, Idaho?

The final goal of this research was to demonstrate how survey results could help inform local water management decisions. The previous research questions highlighted the need to develop models that account for spatio-temporal changes inherent in these dynamic systems and also the limited ability to make direct comparison between cases. Therefore, evaluation of change over time and adaptive management is needed. Research question four demonstrates how this information can be used in such an evaluation to help on-the-ground managers and interested stakeholders to take steps in the direction of adaptive governance capacity. The results in this section are grouped by governance; social capital; human financial and physical capital; and management approaches for ease of explanation. In addition, this section will have quotes from the qualitative interviews to further explain the quantitative survey results. The names of interview participants were omitted to maintain confidentiality and are denoted by number. Although there are many interesting results from the survey and interview responses, this section will only focus on key highlights that may inform how basin users engage in water management and the collaborative process in the future.

Governance

Authority, leadership, and *mobilization* are three components of governance that can facilitate or create barriers to adaptation. With the Wood River collaborative established for less than two years, these subdimension variables may help inform their newly formed process. There are multiple aspects of governance in the basin that provide the opportunity to build upon - there is a strong understanding of water rights and water authority in the basin and participants feel motivated and innovative. There are also places to focus and improve upon including leadership and creating a common vision for water management. Furthermore, the questionnaire results indicate that participants feel the way water is currently managed in the basin does not meet the needs of all stakeholder groups and regulatory changes are necessary, creating the opportunity for change.

In both the survey and interview results, it was clear that participants find their stakeholder group innovative and motivated to find water solutions. It was common for interviewees to identify the tremendous amount of work done by water users to improve water efficiency, which supports the survey finding of high innovation in the basin. Almost every interviewee described work that they and their stakeholder group were doing to find water solutions, to minimize their water use, and to be more efficient (e.g., drip systems to low-flow systems on pivots and farming techniques like cover cropping and fallowing). This motivation to find water solutions makes this basin ripe to implement changes that the participants find necessary.

Although questionnaire results indicated a clear understanding of seniority of water rights and who has authority to make decisions for participants, interview results point to a more complex dynamic. Often interview respondents recognized that people in the basin do not understand water rights and water management; specifically, they believe that education is needed for people living in the upper basin (the population centers) education is needed. Furthermore, a common theme in the interview responses were that although it was clear that the Idaho Department of Water Resources has the authority to manage water, how they manage the water was criticized. Both consumptive and non-consumptive stakeholders spoke to the need for improved state water management. The quote below further elucidates:

> *Every month there is new issue that comes up and the state is much of the problem. They want to appropriate new water for new uses and they want to do it on our backs… They want to screw us down as far as they can so that they will have more water available for new uses, for new appropriations (I12).*

Given that participants indicated that the way water is currently managed does not meet their water needs and regulatory changes are necessary, there is the opportunity for a new mechanism of engagement and management. The Wood River Collaborative may just be that mechanism to engage multiple users in this dialog. The Wood River Collaborative was just beginning at the time of this questionnaire, which may account for the results around leadership. Participants indicated that there was someone bringing stakeholder interests together, but that leadership was not completely trusted. It was noted by an interviewee "there might be strong leadership amongst themselves [stakeholder groups], but different views of the larger group and the collaborative process (I24)."

Summary:

1. There is high motivation and innovation by participants in the basin and at the same time desire for change because the way that water is managed does not currently meet stakeholders' needs. This dynamic coupled with the water call creates the space for change and development of creative solutions for water management in the basin.
2. The Wood River Collaborative is emerging as a place for dialogue, but a focus on building trust in leadership might be needed.

Social Capital

Social capital examines the social bonds and norms, and when there is high social capital people are able to invest in collective action with the knowledge that others will do so similarly (Pretty 2003). Survey results indicated differences in how participants responded to questions about their own stakeholder group (more positively) versus questions related to other stakeholder groups (negatively), thereby creating opportunities and barriers for future work in the basin. In the basin there is a high sense of responsibility by participants; they indicated that they feel an obligation to find solutions, educate others, and do more to ensure water solutions are found. This was consistent with the innovation and motivation results.

However, this high sense of responsibility, motivation, and innovation is countered by a low amount of trust between users overall, and municipal and non-consumptive users had particularly low trust in others. Additionally, low trust was apparent between certain groups (e.g., between the irrigators and non-consumptive users). These differences in trust can be explained by the differences in water use in the basin. It was noted that “historically, there’s been a fair amount of mistrust between the upper watershed and the lower watershed” (Moore 2016). This description of the basin describes a classic water challenge between junior and senior water right holders. The upper basin is the main population center, where most of the wealth is concentrated, and is comprised of junior groundwater water right holders. By contrast, lower in the basin large-scale irrigation is the primary water use, and surface water users are most senior. It was noted by multiple interviewees that there are misunderstandings between different water users in the basin regarding water needs, use, and conservation. One interviewee captured this idea:

> *Let's just say people point the finger at other water users and say ‘you are not being efficient with your use of water.’ Farmers say domestic users waste water that they are not even entitled to in the first place. Domestic users point at farmers and say you guys have almost all the water, you guys are wasteful, you're using too much water, we need to cut you back. And fishermen blame everyone. Then there's climate change and people struggling to understand the impacts of climate change (I2).*

The challenge for the users in the basin then becomes, how to build upon the high sense of responsibility and innovation by individual users to increase trust between users? One user (I21) described the need to-

> *Move from I’m in an uncomfortable position and you must be the reason why, to I have faith that you’re probably a good person and intelligent, and I just don't know what you do; please explain it to me. That is not that easy to get people to move from here to there.*

The large social and economic differences between uses in the basin, coupled by the water call and litigation, creates a need and a challenge for increased understanding and dialog. The work of the collaborative is beginning to address this challenge by creating a space for dialogue and developing solutions. The same interviewee (I21) noted:

> *I think we can do better than what we are doing now. I think it's going to take commitment on both sides and the first thing that has to be established is respect… this group [The Wood River Collaborative] has moved the peanut forward in that respect. It has opened up conversations, it has let people see each other, hear a little about what is on people's minds. I think it has helped. I think it's more than a baby step.*

Questionnaire results established that science, scientists, and environmental groups held the highest trust by other water users. The work in the past four years to assess climate impacts on water use in the basin (Stevenson 2017) has laid a strong foundation for the trust in science and scientists, and can help to explain the trust in science in the basin. Furthermore, the environmental groups have been the conveners of the collaborative effort and it was noted that the environmental groups have worked hard for that trust (I13). Participants' questionnaire responses indicate that more science and information still might be needed regarding groundwater and surface water interactions. The process of information sharing can provide the space for continued conversation around science in the basin initially and could eventually lead to a more difficult dialogue around use and water needs. The collaborative effort would benefit from theses trusted entities creating the space for participants to share their experiences and work they have done in the basin, to help break down misunderstandings between users and to begin to understand water needs of other users.

Summary:

1. Build upon the strong trust in science, scientists, and conservation groups to continue the dialogue around scientific uncertainty concerning ground and surface water interactions in the basin.
2. Use this conversation to continue the dialogue between users about water needs, use, and conservation to break through mistrust in the basin.

Human, financial, and physical capital

Beyond the need to better understand how surface and groundwater interactions impact water seniority, overall basin participants have high knowledge, information, and capacity across users. On the other hand, participants did identify a strong need for financial and infrastructure support for water management. There are differences among stakeholder groups in these overall trends (e.g., information needs are greatest among municipal users and technical expertise needs are greatest among surface water users). Context in the basin helps explain these results and also identify solutions.

Prior to conducting this study, the Climate Impacts Research Consortium engaged many of the basin users in a conversation and assessment on how climate will impact water management in the basin (Stevenson 2017). This work likely explains the high level of knowledge and information around water impacts in the basin. Despite the high level of knowledge articulated by most users, municipal users identified their knowledge as particularly low. It is worth noting that municipal user responses across the survey were often lower than most other responses. The lack of knowledge and low agreement to most variables by municipal respondents can be explained by the overall lack of engagement in water discussions by this user group. Municipalities have a pending lawsuit associated with the water call, which has resulted in them not engaging in the collaborative effort, or negotiating solutions to the call. Another explanation for their low responses could be due to a lack of interaction with water resources. One interviewer’s response helps to explain this result:

> *People [regarding municipal users] are from out of state. They don't understand the whole hydrology system, where the water comes from, why it’s declining, or why ground water levels [are reduced], and they don't understand the relationship between the snow pack… it’s something that a lot of people do not consider at all. A lot of people don't even see their water bills. To be honest other people pay them (I18).*

Another stakeholder specific response, that differs from participants overall, is in regards to the need for technical expertise. Surface water users identified themselves as innovative and having technologies to share (discussed above in governance), but they also had the highest need for technical expertise. This same need for technical expertise is not seen in the groundwater user's results. This contrast in survey responses between groundwater (upper basin, junior water right holders) and surface water (lower basin, senior water right holders) was surprising, but can be illuminated by this interviewee's comment: "Upper valley [agriculture] users have worked with on-farm efficiency, variable rates, because they had to. Surface water users are not in tune with that yet" (I15). It appears that being a junior water right holder, thus having limited access to water full time, has driven those users to more efficient systems out of necessity.

The questionnaire results can help to inform where to focus time, energy, and resources. With the exception of further study of groundwater and surface water interactions, which is at the heart of this water call, further information gathering is not needed to support water management in the basin. Instead, the basin would benefit from focusing resources on providing financial and infrastructure support to find long-term management solutions. While overall consumptive users are utilizing technology and innovation to find more efficient uses of water, some focused investment in providing technical expertise to surface water users in the lower part of the valley would assist in water management.

Summary:

1. Re-engage municipal users when possible, given litigation, to increase their knowledge around water in the basin.
2. Spend more energy and resources on sharing technical expertise and knowledge among irrigators in the basin, infrastructure improvements, and implementing water management strategies (discussed below).

Management approaches and strategies

Management approaches and strategies allow basin users the flexibility to creatively address water management challenges in the face of a changing climate, new water uses, and changing values. The Big Wood River basin has begun to develop water management solutions to resolve the conflict associated with the water call. Lack of measureable goals for water management, evaluation of goals, and goals reflecting water needs, all present challenges in this basin for water management. Additionally, lack of agreement on the ability to adapt to change by ground and surface water irrigators also creates challenges. Despite this, users in the basin are optimistic and believe that they have the ability to achieve future water sustainability goals. This optimism and motivation creates a foundation upon which to build constructive water management decisions. Goal setting by the collaborative, technical assistance for surface and groundwater irrigators, and the use of voluntary water management tools might be able to provide the path to sustainable outcomes.

The lack of goals is consistent with the questionnaire results for variables regarding the prioritization of water use in the basin. Overall, participants did not agree that water uses had been prioritized in the basin. Furthermore, how water use should be prioritized between different types of uses varied by stakeholder group, with each stakeholder identifying their type of use as the most important. The relatively new effort to identify solutions to water scarcity and the water call in the basin can help to clarify this lack of goal setting, goal use, and prioritization of water use. Given that participants were in the early stages of understanding the impacts of their water use on other users in the basin and thinking about solutions, it is understandable that goals might not have been set at the time of the survey. Additionally, basin-wide conversation regarding the multiple water needs have just begun, further explaining why water values have not been prioritized.

One interviewee identified the short-sightedness of the basin users by only thinking of their own use rather than the basin's long-term needs as a reason there are so many different priorities associated with water (I6). The lack of water management goals and differing priorities of water use is associated with a theme discussed above - the lack of understanding among users regarding water needs. In order to bridge misunderstandings and set a common vision for the basin, users need to start identifying goals and solutions that meet multiple stakeholders' needs in order to be successful. An interviewee discusses this:

> *The callers have not had their water in a long time, HELLO (*emphasis included*), so they need their water and I get that. But getting it in a way that doesn't work for both ends of the equation- for the people who are being called on and the people doing the calling- is not a good solution. It's got to work for both (I21).*

In an attempt to find solutions that would be acceptable to multiple water interests, the survey asked participants about their willingness to use certain water management tools on a voluntary and regulatory basis. Although few tools had overall support for their regulatory use, multiple tools had voluntary support across all user groups (non-consumptive water users as well as consumptive users). These data can be used to start implementing voluntary measures in the basin to meet multiple water needs. "Low hanging fruit" projects can help to build trust between users, begin to develop understanding about other water needs beyond individual an stakeholder's group, and hopefully increase the belief that there is the ability to adapt to change in the future.

Summary:

1. Have the collaborative process start to identify long and short term goals for the basin that address the multiple water users' needs.
2. Begin to implement voluntary measures that help to bring people together in the basin and build trust.

These results and discussion from the questionnaire can serve as a starting point to assist the Big Wood River community in addressing their water challenges. Of particular interest to participants in this basin was the ability to separate results by user group, specifically water callers and those called upon. The ability to differentiate responses by stakeholders was limited by the small sample size in this study. In the future, more effort to receive responses for each stakeholder group will allow a more effective comparison between groups. Future questionnaires that include a specific question to identify participants as water callers would provide valuable information for local management decisions. The interview results help explain and contradict results found in the questionnaire. While interview data add richness; it comes at the cost of time when time resources may be limited.

Conclusion

Water management is a complex and wicked problem, particularly because it is confronted by challenges such as climate change, population growth, conflicting values, and an existing, relatively inflexible system of management and legal requirements. As water managers across the West attempt to address these challenges, engagement of local communities in planning has become a more common practice. The ability to understand a community's capacity to adaptively govern over time will assist resource managers and local communities to prioritize areas of work, develop relevant strategies, and evaluate change over time. The adaptive capacity and the collaborative governance frameworks were used as a starting point in this research to evaluate a community's adaptive governance capacity.

Three major findings surfaced through the development of this assessment tool and analysis of various frameworks for stakeholder engagement in adaptive governance processes. First, the complex and dynamic nature of these systems requires a different model for evaluation than what the current literatures have developed. Secondly, because these stakeholder processes evolve and change over time, our ability to compare between cases is limited, especially if assessment is not done over a significant period of time. Finally, despite the need to refine assessment models using complex thinking, evaluation tools are still valuable for considering and informing adaptive management at the local level of water governance.

The first major finding of this study is that Complexity Theory can help inform adaptive capacity and collaborative governance frameworks and can serve as a helpful guide in thinking about these processes. For example, models using complex thinking can account for spatio-temporal changes, feedback loops, and emergence inherent in these dynamic systems. Future research on adaptive governance capacity should think about these systems as complex-adaptive systems and see what model emerges.

Next, this research suggests that comparing two different water management scenarios may not work given the complex, dynamic nature of water resource management at the basin scale. This reality challenges policy-makers to not compare different cases at one point in time, but rather to invest in longitudinal assessments to track progress over time. By evaluating change over longer periods, it is possible to monitor how subdimensions and variables of adaptive governance capacity increase or decrease through time and identify if components emerge. The benefit of ongoing assessments is that the information it provides can enable adaptive management and support strategic decisions and focused investments.

Beyond the findings related to scholarly literature and our attempts to construct explanatory models, many stakeholders found practical value in adaptive governance capacity assessment because it helped to inform local water management decisions. For example, stakeholders from the Wood River Collaborative in Idaho noted “this tool is helpful because it helps [the conveners] to define the collaborative process, [and] identify where the holes are and where to focus their time, regardless of water call (I13).” It was also discussed that “we have a draft management plan that we are working on. Concepts favorable in the survey [voluntary and regulatory water management tools] we could perhaps push harder on and lighter on less favorable ones in the hope of broader buy-in (I9).” These two comments support the efforts to evaluate adaptive governance capacity and the need for evaluation to support decision-making.

There is no doubt that water management in the West will be one of the greatest environmental challenges in the future. Thinking about the human and natural system collectively and how they evolve and change over time will help in developing effective solutions. The ability to refine the models used in evaluation will assist in community' ability to adapt and meet water challenges in the future.

References

Adger, N. 1999. “Social Vulnerability to Climate Change and Extremes in Costal Vietnam.” *World Development* 27(2):249–69.
Adger, W.Neil. 2006. “Vulnerability.” *Global Environmental Change* 16(3):268–81.
Adger, W.Neil et al. 2009. “Are There Social Limits to Adaptation to Climate Change?” *Climatic Change* 93(3–4):335–54.
Agresti, Alan. and Babara Finlay. 2009. *Statistical Methods for the Social Sciences*. edited by Pearson Education.
Agricultural Water Conservation Clearinghouse. 2017. “Agricultural Water Conservation Glossary.” Retrieved June 20, 2017 (http://agwaterconservation.colostate.edu/Glossary.aspx).
Allin, B. 2008. *An Examination of the United States’ System of Water Management.*
Ansell, Chris and Alison Gash. 2007. “Collaborative Governance in Theory and Practice.” *Journal of Public Administration Research and Theory* 18(4):543–71.
Aylward, Bruce. 2006. *Growth , Urbanization and Land Use Change: Impacts on Agriculture and Irrigation Districts in Central Oregon*. Bend, OR.
Aylward, Bruce and David Newton. 2006. “Long-Range Water Resources Management in Central Oregon : Balancing Supply and Demand in the Deschutes Basin DWA Final Report.” (August).
Bartolino, James R. and Candice B. Adkins. 2012. “Hydrogeologic Framework of the Wood River Valley Aquifer System, South-Central Idaho: U.S. Geological Survey Scientific Investigations Report 2012–5053.” 46.
Bartolino, James and Sean Vincent. 2013. *Groundwater Resources of the Wood River Valley , Idaho : A Groundwater-Flow Model for Resource Management*. Boise, ID.
Bateman, Brenda and Alyssa Mucken. 2017. *Integrated Water Resouce Strategy 2nd Edition*. Salem, OR.
Bateman, Brenda, Alyssa Mucken, and Kenneth Stahr. 2012. *Integrated Water Resource Strategy*. Salem, OR.
Bolte, John. 2016. “Exploring Water Futures under Alternative Climate and Management Scenarios.” Retrieved May 20, 2016 (http://envision.bioe.orst.edu/StudyAreas/BigWood/default.aspx).
Britton, Mike and Mike Relf. 2014. “Upper Deschutes River Basin Study Fact Sheet.” Retrieved May 5, 2016 (http://www.usbr.gov/pn/studies/deschutes/).
Bruns, Bryan Randolph, Claudia Ringler, and RS Ruth Suseela Meinzen-Dick, eds. 2005. *Water Rights Reform: Lessons for Institutional Design*. Washington, D.C.: International Food Policy Research Institute.
Buhidar, Balthasar B. 2001. *The Big Wood River Watershed Management Plan*. Twin Falls, Idaho.
Bureau of Reclimation and Deschutes Basin Board of Control. 2015. *Upper Deschutes River Basin Study*. Bend, OR.
Camillus, John C. 2008. “Strategy as a Wicked Problem.” *Harvard Business Review* (May):1–7.
Capra, Fritjof. 2015. “The Systems View of Life a Unifying Conception of Mind, Matter, and Life.” *Cosmos and History* 11(2):242–49.
Chang, Heejun et al. 2013. “Water Supply, Demand, and Quality Indicators for Assessing the

Spatial Distribution of Water Resource Vulnerability in the Columbia River Basin." *Atmosphere-Ocean* 51(4):339–56.

Churchman, C.West. 1967. "Guest Editorial: Wicked Problems." *Management Science* 14(4):B141–42.

Conklin, Jeff. 2005. *Dialogue Mapping: Building Shared Understanding of Wicked Problems*. New York, NY, USA: John Wiley & Sons, Inc.

Conley, Alexander and MA Moote. 2003. "Evaluating Collaborative Natural Resource Management." *Society &Natural Resources* 371–86.

Connick, Sarah and Judith E. Innes. 2003. "Outcomes of Collaborative Water Policy Making: Applying Complexity Thinking to Evaluation." *Journal of Environmental Planning and Management* 46:177–97.

Cortina, Jose M. 1993. "What Is Coefficient Alpha? An Examination of Theory and Applications." *Journal of Applied Psychology* 78(1):98–104.

Cortner, Hanna J., Margaret Ann Moote, and Hanna J.Cortner Margaret A. Moote. 1999. *The Politics of Ecosystem Management*. Island Press.

Craig Kundis, Robin. 2015. "Learning To Think About Complex Environmental Systems In Environmental And Natural Resource Law And Legal Scholarship: A Twenty-Year Retrospective." *Fordham Environmental Law Review* XXIV:1–52.

Culp, Peter W., Robert Glennon, and Gary Libecap. 2014. *Shopping for Water: How the Market Can Mitigate Water Shortages in the American West*.

Dalton, Meghan M., Philip W. Mote, and Amy K. Snover. 2013. *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities.* edited by M. M. Dalton, P. W. Mote, and A. K. Snover. Washington, DC: Island Press.

Daniels, Steven and Gregg Walker. 2001. "Working through Environmental Conflict: The Collaborative Learning Approach." *Working Through Environmental Conflict* 1–299.

Deschutes River Conservancy. 2014. *Upper Deschutes: Conserving a Unique Spring-Fed River System*.

Deschutes River Conservancy and Deschutes Water Alliance. 2013. *Deschutes Water Planning Initiative Water Supply Goals And Objectives*. Bend, OR.

Doherty, Todd and Rod Smith. 2012. *Water Transfers in the West: Projects, Trends, and Leading Practices in Voluntary Water Trading*. Denver, CO.

Doney, Ted. 2010. *Basic Montana Law*.

Donnelly, Kristina and Heather Cooley. 2015. "Water Use Trends in the United States." (April).

Durant, Robert F., Young-Pyoung Chun, Byungseob Kim, and Seongjong Lee. 2004. "Toward a New Governance Paradigm for Environmental and Natural Resources Management in the 21st Century?" *Administration & Society* 35(6):643–82.

Ellis, F. 2000. *Rural Livelihoods and Diversity in Developing Countries.* Oxford, UK: Oxford University Press.

Emerson, K., T. Nabatchi, and S. Balogh. 2011. "An Integrative Framework for Collaborative Governance." *Journal of Public Administration Research and Theory* 22(1):1–29.

Engle, Nathan L. 2011. "Adaptive Capacity and Its Assessment." *Global Environmental Change* 21(2):647–56.

Engle, Nathan L. and Maria Carmen Lemos. 2010. "Unpacking Governance: Building Adaptive Capacity To Climate Change Of River Basins In Brazil." *Global Environmental Change* 20:4–13.

Fahlund, Andrew, Min L.Janny Choy, and Leon Szeptycki. 2014. "Water in the West." *California Journal of Politics and Policy* 6(1):1–42.
Fitzpatrick, Kate, Kyle Gorman, and Bruce Aylward. 2006. "Reservoir Management: DWA Final Report." *Deschutes Water Alliance Issue Paper* (August):55.
Funtowicz, S. O. and Jerome R. Ravetz. 1993. "Science for the Post Normal Age." Pp. 146–61 in *Perspectives on Ecological Integrity*, vol. 5, *Environmental Science and Technology Library*, edited by L. Westra and J. Lemons. Dordrecht: Springer Netherlands.
Gain, Animesh K., Josselin J. Rouillard, and David Benson. 2013. "Can Integrated Water Resources Management Increase Adaptive Capacity to Climate Change Adaptation ? A Critical Review." 2013(April):11–20.
Gannett, M. W., K. E. Lite, D. S. Morgan, and C. A. Collins. 2001. *Ground-Water Hydrology of the Upper Deschutes Basin, Oregon; Water-Resources Investigations Report 00–4162*. Portland, OR.
Garrick, Dustin, Chelsea Lane-Miller, and Amy L. McCoy. 2011. "Institutional Innovations to Govern Environmental Water in the Western United States: Lessons for Australia's Murray-Darling Basin." *Economic Papers: A journal of applied economics and policy* 30(2):167–84.
Getches, David H. 2009. *Water Law in a Nutshell*. St. Paul, MN: Thomson/Reuters.
Gleick, Peter H. 2000. "A Look at Twenty-First Century Water Resources Development." *Water International* 25(1):127–38.
Griffin, Cb. 1999. "Watershed Councils: An Emerging Form of Public Participation in Natural Resource Management1." *Journal of the American Water Resources Association* 35(3):505–18.
Grimm, G. and Paul R. Yarnold. 1997. "Reading and Understanding Multivariate Statistics." *Canadian Journal of Remote Sensing* 4(2):143–48.
Gupta, Joyeeta et al. 2010. "The Adaptive Capacity Wheel: A Method To Assess The Inherent Characteristics Of Institutions To Enable The Adaptive Capacity Of Society." *Environmental Science and Policy* 13(6):459–71.
Headwaters Economics. 2017a. *A Profile of Socioeconomic Measures: Blaine County, ID*.
Headwaters Economics. 2017b. *A Profile of Socioeconomic Measures: Deschutes County, OR*.
Heikkila, Tanya and Andrea K. Gerlak. 2005. "The Formation of Large-Scale Collaborative Resource Management Institutions: Clarifying the Roles of Stakeholders, Science, and Institutions." *Policy Studies Journal* 33(4):583–612.
Heisler, Tod. 2012. *Deschutes Water Planning Initiative Reclamation WaterSMART Water and Energy Collaborative Watershed Management Program Grant Proposal*. Bend, OR.
Hudson, Barclay M., Thomas D. Galloway, and Jerome L. Kaufman. 1979. "Comparison of Current Planning Theories: Counterparts and Contradictions." *Journal of the American Planning Association* 45(4):387–98.
Hutson, Susan S. et al. 2004. *Estimated Use of Water in the United States in 2000*.
Imperial, M. T. 2005. "Using Collaboration as a Governance Strategy: Lessons From Six Watershed Management Programs." *Administration & Society* 37(3):281–320.
Innes, J. and D. Booher. 1999. "Consensus Building and Complex Adaptive Systems: A Framework for Evaluating Collaborative Planning." *Journal of American Planning Association* 65(4):412.
Inouye, Allison Marshall. 2014. "Development of a Hydrologic Model to Explore Impacts of

Climate Change on Water Resources in the Big Wood Basin, Idaho."
Irvin, Renée A. and John Stansbury. 2004. "Citizen Participation in Decision Making: Is It Worth the Effort?" *Public Administration Review* 64(1):55–65.
Isaak, Daniel J. et al. 2012. "The Past as Prelude to the Future for Understanding 21st-Century Climate Effects on Rocky Mountain Trout." *Fisheries* 37(12):542–56.
Ivey, Janet L., John Smithers, Rob C. De Loë, and Reid D. Kreutzwiser. 2004. "Community Capacity for Adaptation to Climate-Induced Water Shortages: Linking Institutional Complexity and Local Actors." *Environmental Management* 33(1):36–47.
Kelly, P. M. and W. N. Adger. 2000. "Theory And Practice In Assessing Vulnerability To Climate Change And Facilitating Adaptation." *Climatic Change* 47(4):325–52.
Kenney, Douglas S. 2005. "Prior Appropriation and Water Rights Reform in the Western United States." P. 336 in *Water Rights Reform: Lessons for Institutional Design*. Intl Food Policy Res Inst.
Koontz, TM and CW Thomas. 2006. "What Do We Know and Need to Know about the Environmental Outcomes of Collaborative Management ?" *Public administration review* 66:111–21.
Kunkel, Kenneth E., Laura E. Stevens, Scott W. Stevens, and Liqiang Sun. 2013. "NOAA Technical Report NESDIS 142-4 Regional Climate Trends and Scenarios for the U . S . National Climate Assessment." (January):1–91.
Lach, Denise, Steve Rayner, and Helen Ingram. 2005. "Taming the Waters: Strategies to Domesticate the Wicked Problems of Water Resource Management." *International Journal of Water* 3(1):1.
Lachapelle, Paul, Stephen McCool, and Michael Patterson. 2003. "Barriers to Effective Natural Resource Planning in A'messy' world." *Society &Natural …* 16(6):473–90.
Larson, Kelli L. and Denise Lach. 2008. "Participants And Non-Participants Of Place-Based Groups: An Assessment Of Attitudes And Implications For Public Participation In Water Resource Management." *Journal of Environmental Management* 88(4):817–30.
Leach, WD William D. and NW Neil W. Pelkey. 2001. "Making Watershed Partnerships Work: A Review of the Empirical Literature." *Journal Of Water Resources Planning And Management* 127(December):378–85.
Levin, Simon et al. 2013. "Social-Ecological Systems As Complex Adaptive Systems: Modeling And Policy Implications." *Environment and Development Economics* 18(2):111–32.
Levin, Simon a. 2005. "Self-Organization and the Emergence of Complexity in Ecological Systems." *BioScience* 55(12):1075.
Lockwood, Michael, Christopher M. Raymond, Eddie Oczkowski, and Mark Morrison. 2015. "Measuring The Dimensions Of Adaptive Capacity: A Psychometric Approach." *Ecology and Society* 20(1).
Lousen, Patti. 2016. *Idaho's Wood River Water Collaborative, Bureau of Reclamation Cooperative Watershed Management Program Grant*. Hailey, ID.
Ludwig, Donald. 2001. "The Era of Management Is Over." *Ecosystems* 4(8):758–764.
Maloney, Meghan L. 2008. *Rivers of Discontent: Indicators of Water Conflict in Interstate River Basins of the American Southwest*. ProQuest.
McCarthy, Jim, Noah Greenwald, Janette Brimmer, and Laurie Rule. 2016. "Agreement Reached to Protect Upper Deschutes River."
McCool, Stephen F., Kathleen Guthrie, and Kathleen Guthrie Stephen F. Mccool. 2001.

“Mapping the Dimensions of Successful Public Participation in Messy Natural Resources Management Situations.” *Society & Natural Resources* 14(August 1999):309–23.
Messier, Christian and Klaus J. Puettmann. 2011. “Forests As Complex Adaptive Systems: Implications For Forest Management And Modeling.” *L’Italia Forestale e Montana* 66(3):249–58.
Mitchell, Melanie. 2009. “Complexity: A Guided Tour.” (July):368.
Mitchell, Sandra D. 2009. *Unsimple Truths: Science, Complexity and Policy*. University of Chicago Press.
Moore, Greg. 2016. “Group Seeks Common Ground on Water.” *Idaho Mountain Express*, August 17.
Mote, Philip W., John T. Abatzoglou, and Kenneth E. Kunkel. 2013. “Variability and Change in the Past and the Future.” in *Climate Change in the Northwest: Implications for Our Lanscapes, Waters, and Communities*.
Mote, Philip W. and Eric P. Salathé. 2010. “Future Climate in the Pacific Northwest.” *Climatic Change* 102(1–2):29–50.
Mucken, Alyssa and Brenda Bateman. 2014. “Place-Based Integrated Water Resources Planning Initial Observations from the State of Oregon.”
National Research Council. 1992. *Water Transfers in the West: Efficiency, Equity, and the Environment*. National Academies Press.
Nelson, R., P. Kokic, S. Crimp, H. Meinke, and S. M. Howden. 2010. “The Vulnerability Of Australian Rural Communities To Climate Variability And Change: Part I-Conceptualising And Measuring Vulnerability.” *Environmental Science and Policy* 13(1):8–17.
Newton, Dave and Mathias Perle. 2006. *Irrigation District Water Efficiency Cost Analysis and Prioritization*.
Northwest Power and Conservation Council. 2004. *Deschutes Subbasin Plan*. Portland, OR.
O’Connell, John. 2015. “Wood River Well Users Face Water Call.” *Capital Press*, March 13.
Podsakoff, Philip M., Scott B. MacKenzie, Jeong-Yeon Lee, and Nathan P. Podsakoff. 2003. “Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies.” *The Journal of applied psychology* 88(5):879–903.
Poisner, Jonathan. 1996. “A Civic Republican Perspective on the National Environmental Policy Act’s Process for Citizen Participation.” *Environmental Law* 26(1):53–94.
Portland State University College of Urban & Public Affairs. 2015. *2015 Population Estimates and Reports*. Portland, OR.
Pretty, Jules. 2003. “Social Capital and the Collective Management of Resources.” *Science* 302(5652):1912–14.
Putnam, Robert. 1993. “What Makes Democracy Work?” *National Civic Review* 82(2):101–7.
Raymondi, Rick R. et al. 2013. *Water Resources Implications of Changes in Temperature and Precipitation*.
Reimer, Adam. 2013. *US Water Policy: Trends and Future Directions*.
Rittel, Horst W. J.HWJ and Melvin M.MM Webber. 1973. “Dilemmas in a General Theory of Planning.” *Policy Sciences* 4(2):155–69.
Sabatier, Paul A. et al. 2005. “Collaborative Approaches to Watershed Mangement.” Pp. 3–21 in *Swimming Upstream: Collaborative Approaches to Watershed Management*, edited by P. A. Sabatier et al. Cambridge, MA: MIT Press.
Scarborough, Brandon. 2010. “Environmental Water Markets: Restoring Streams Through

Trade." *PERC Policy Series* 46:48.
Scholz, John T. and Bruce Stiftel. 2005. *Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning*. Resources for the Future.
Seawright, J. and J. Gerring. 2008. "Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options." *Political Research Quarterly* 61(2):294–308.
Selin, Steve and Deborah Chevez. 1995. "Developing a Collaborative Model for Environmental Planning and Management." *Environmental Management* 19(2):189–95.
Skinner, Kenneth, James Bartolino, and Andrew Tranmer. 2007. *Water-Resource Trends and Comparisons Between Partial-Development and October 2006 Hydrologic Conditions, Wood River Valley, South-Central Idaho*.
Slaughter, Richard A., Alan F. Hamlet, Daniel Huppert, Joel Hamilton, and Philip W. Mote. 2010. "Mandates vs Markets: Addressing over-Allocation of Pacific Northwest River Basins." *Water Policy* 12(3):305.
Stevenson, John. 2017. "CIRC's Big Wood Project." *The Climate CIRCulator*. Retrieved April 18, 2017 (https://climatecirculatororg.wordpress.com/2016/04/19/circs-big-wood-project/).
Sullivan, Caroline A. 2011. "Quantifying Water Vulnerability: A Multi-Dimensional Approach." *Stochastic Environmental Research and Risk Assessment* 25(4):627–40.
Tabachnick, B. and G. Fidell. 1996. *Using Multivariate Statistics*. New York: Harper Collins.
Tarlock, AD. 2002. "The Future of Prior Appropriation in the West." *Natural Resources Journal* (March).
Thomas, Craig W. and Tomas M. Koontz. 2011. "Research Designs for Evaluating the Impact of Community-Based Management on Natural Resource Conservation." *Journal of Natural Resources Policy Research* 3(2):97–111.
Thomson, AM and JL Perry. 2006. "Collaboration Processes: Inside the Black Box." *Public administration review* (December).
Tuxill, Jacquelyn L. and Nora J. Mitchell. 2010. *Leading in a Collaborative Environment: Six Case Studies Involving Collaboration and Civic Engagement.* Woodstock, VT.
Ulibarri, Nicola. 2015. "Tracing Process to Performance of Collaborative Governance: A Comparative Case Study of Federal Hydropower Licensing." *Policy Studies Journal* 43(2):283–308.
Vacaro, Lynn et al. 2009. "Tackling Wicked Problems Through Integrated Assessment A Guide for Decision Makers , Project Leaders and Scientists." 1–27.
Vaske, J. J. 2008. *Survey Research and Analysis: Applications in Parks, Recreation, and Human Dimensions*. State College, PA.
Waibel, M. S., M. W. Gannett, H. Chang, and C. L. Hulbe. 2013. "Spatial Variability Of The Response To Climate Change In Regional Groundwater Systems - Examples From Simulations In The Deschutes Basin, Oregon." *Journal of Hydrology* 486:187–201.
Weber, Edward P. 1998. *Pluralism by the Rules: Conflict and Cooperation in Environmental Regulation*. Georgetown University Press.
Weber, Edward P. 2000. "A New Vanguard for the Environment: Grass-Roots Ecosystem Management as a New Environmental Movement." *Society & Natural Resources* 13(June 2012):237–59.
Weber, Edward P. 2009. "Explaining Institutional Change in Tough Cases of Collaboration: 'Ideas' in the Blackfoot Watershed." *Public Administration Review* 69(2):314–27.
Weber, Edward P. 2013. *Building Capacity for Collaborative Water Governance in Auckland*.

Weber, Edward P. and Anne M. Khademian. 2008. "Wicked Problems, Knowledge Challenges, and Collaborative Capacity Builders in Network Settings." *Public Administration Review* 68(2):334–349.

Wondolleck, Julia M. and Steven Lewis Yaffee. 2000. *Making Collaboration Work: Lessons From Innovation In Natural Resource Managment*. Island Press.

Yankelovich, Daniel. 2001. *The Magic of Dialogue: Transforming Conflict Into Cooperation*. Simon and Schuster.

Appendix

Appendix A: Oregon Survey

Investigating the Adaptive Governance Capacity in Local Watersheds
Welcome to this questionnaire examining local communities' ability to adapt to changing ecological and social conditions in relation to water. We ask that the person completing this survey be over the age of 18. Participation is voluntary and you can refuse to answer any question for any reason. The survey is anticipated to take no more than 15 minutes. Responses will be kept confidential to the extent permitted by law. The security and confidentiality of information collected from you online cannot be guaranteed.
To start the questionnaire, please enter the code listed on email we sent you (this code allows us to check it off our list when the questionnaire is completed and stop sending you reminders):

1. Please identify the watershed in which you primarily work *(drop down state, River Basin (HUC6), watershed (HUC8))*

When responding to the following questions, please use this primary watershed as your frame of reference, even if you work in multiple watersheds. In addition, all of the following questions are related to water management in your watershed, even if water management is not specifically mentioned.

2. When thinking about your involvement in water, what one group or organization do you most strongly associate with?

When responding to the following questions, please use this when asked about your "stakeholder group."

a. Municipal/ potable water/ waste water
b. Tribal
c. Irrigation (i.e. district or canal company)
d. Crops producer (i.e., farmer)
e. Hobby farmer
f. Ranching
g. Timber industry
h. Environmental or conservation group
i. Watershed Council
j. Recreation group
k. Aquaculture
l. Landowner/resident
m. Hydroelectric
n. Scientist
o. Federal government - please indicate which one
p. State government- please indicate which one
q. County government- please indicate which one
r. Local government- please indicate which one
s. Other (please list here)

I. Governance and Institutions

Questions are asked with 1-5 level of agreement on likert scale unless specifically indicated

1. Regarding authority over water in your watershed. It is clear to my stakeholder group…
    a. who has jurisdictional authority to make decisions.
    b. who has water rights.
    c. who has senior water rights.
    d. how groundwater use affects surface water rights.
2. Regarding water management in your watershed…
    a. The current way that water is managed can meet my stakeholder group's water needs.
    b. Regulatory changes are necessary to allow more innovation in our watershed. Please provide example below:
3. To what extent do you disagree or agree?
    a. My stakeholder group has the opportunity to engage in watershed management decisions.
    b. My stakeholder group has a meaningful role in watershed management decisions.
    c. Stakeholders who are engaging in watershed management decisions are motivated to get things done.
    d. Currently, there is a governance structure/institution that is set up to equally represent all of the water interests. Please identify *(Space provide for example)*
4. Please indicate your level of involvement in water management in the watershed during the past year (e.g., attended watershed meetings, worked with other stakeholder groups).
5. Groups outside of the watershed are forcing decision-making in our watershed.
6. Stakeholders and other relevant decision-makers (e.g., elected officials, non-watershed agencies) have a common vision for managing water in the face of challenges in my watershed.
7. In what ways are each of the following groups supportive of local innovation for water management (*you may check multiple*)?

	Financial support	Technical support	Political support
Federal agencies			
State agencies			
State legislatures			

II. Social Capital

Questions are asked with 1-5 level of agreement on likert scale unless specifically indicated

1. To what extent do you disagree or agree?
    a. There is someone who helps to bring diverse stakeholders together.
    b. There is someone who creates a common vision.
    c. There is someone who is trusted by stakeholders to lead.
    d. There is someone that motivates creativity in others
2. In our watershed, stakeholders generally…
    a. share information with each other.
    b. coordinate their water management activities.
    c. are supportive of each other.
    d. are willing to work together to solve water problems.
    e. are willing sacrifice their needs in the short term because they believe that in the long run all needs will be met.
3. As a result of working with others in the watershed my stakeholder group has a better understanding of…
    a. the *human* factors that influence water management (e.g., urban growth).
    b. the *economic* factors that influence water management (e.g., cost of infrastructure improvements).
    c. the *bio-physical* factors that influence water management (e.g., drought conditions).
4. Our watershed has an increased ability to achieve water sustainability goals (economic, ecologic, and social).
5. To what extent do you disagree or agree?
    a. I trust that water management decisions will produce good outcomes for all stakeholders.
    b. I trust other stakeholders to keep my needs in mind when making water management decisions.
    c. There are stakeholders who cannot be trusted to consider my needs in water management decisions in my watershed.
6. How much trust do you have with other stakeholder groups in your watershed to positively contribute to water management?

(list of other stakeholders and scale of trust/distrust)

7. In your estimation what has been the level of water conflict among water stakeholders in your watershed?
    i. now
    ii. in the past 5 years
    iii. in the past 10 years (level of conflict on likert scale)
8. What effect has that conflict had on stakeholders working together in your watershed (you can select multiple choices)? (*range: tear us apart to bring us together*; *skip logic to skip next question if no conflict is selected*)
9. To what extent to you disagree or agree with the following statements?
    a. I feel a personal obligation to find long-term water solutions for my watershed.
    b. I feel a responsibility to help educate others about water needs in my watershed.
    c. I know that my own behaviors impact other water users in the watershed.

d. I can do more to ensure water solutions are found in my watershed.

III. Human, financial, and physical capital

Questions are asked with 1-5 level of agreement on likert scale unless specifically indicated

Information behavior

1. My stakeholder group is aware of the potential impacts from…
   a. bio-physical changes on water resources in my watershed (e.g., timing of available water).
   b. social changes on water resources in my watershed (e.g., urban growth).
2. To make good management decisions, stakeholders currently have sufficient…
   a. access to scientific information
   b. access to technical expertise
   c. access to monitoring data
   d. capacity to plan and manage watershed meetings and other outreach activities.
   e. capacity to administer funds.
   f. capacity to report on outcomes.
3. To what extent to you disagree or agree with the following statements?

There are other more pressing *social* issues (e.g., education) facing our community than water management.

There are other more pressing *economic* issues (e.g., unemployment) facing our community than water management.

There are other *ecological* issues (e.g., endangered species) facing our community than water management.

Finance and Infrastructure

4. To what extent to you disagree or agree with the following statements?
   a. There are adequate financial resources available to implement new management strategies in our watershed.
   b. Stakeholders in my watershed have the infrastructure needed to optimize water use.
   c. Financially, I can afford to take a few risks by experimenting with new ideas.

IV. Management approaches, strategies, and tools

Questions are asked with 1-5 level of agreement on likert scale unless specifically indicated

Innovation

1. Stakeholders in my watershed are willing to try new things to meet multiple needs in our watershed.
2. Below there is a list of water management tools. For your watershed, please identify if 1) the tools are ***available*** to stakeholders, 2) if the **tools *are currently being used***, 3) and if your ***stakeholder group supports*** the use of this tool (*please check all that apply, you can chose multiple options).*
   - Demand projections for municipal/potable supply
   - Minimum flow requirements that meet ecological needs

- Increased protection of water instream
- Habitat restoration as a water management tool (e.g., reconnecting flood plains)
- Conserved water that can be allocated instream, sold, or used on additional lands
- Water forbearance agreements where water user agrees to forego withdrawal
- Water transfers and leases
- Full water markets –easily tradable water rights between willing buyers and sellers based on an agreed price
- Water pricing (e.g., tiered rates based on use)
- Water delivery efficiency projects (e.g., piping and lining)
- On farm efficiency projects (e.g., drip irrigation)
- Demand driven water delivery
- Policies for reducing demand
- Technologies to reduce demand
- Increased reservoir storage or optimization of existing storage
- Groundwater recharge projects
- Long-term basin planning
- Water restrictions triggered by drought conditions
- Management agreements that move water between users or uses
- Changing point of diversion for water withdrawal
- Switching the source of water (e.g., groundwater to surface water switch, tributary to main stem switch)
- Water use measurement (e.g., municipal, point of diversion, on farm)
- Other- please specify

3. To what extent do you disagree or agree?
   a. Knowing about new technology is important to my stakeholder group.
   b. My stakeholder group is innovative.
   c. My stakeholder group has techniques or technologies to share.
4. Regarding management goals in your watershed…
   a. There are measurable water management goals in my watershed.
   b. Progress is evaluated against those management goals.
   c. Water management goals reflect the needs of the watershed.
5. Regarding change in your watershed (e.g., timing of growing season shortened/extended; urbanization)…
   a. We have the ability to adapt to changes.
   b. We have the ability to capitalize on that change.
   c. There are policy barriers to adaptive management; please describe.
6. Stakeholders in the watershed are practiced in learning from success and failure.

V. Other:

1. What do you think your community's ability is to develop innovative strategies to adapt to change?
2. Please provide an example of a successful management projects or collaborations in the watershed (space provided).

VI. Demographic

Questions are asked with answers provided in block ranges

1. What is your age (years old)
2. What is the ***highest*** level of education that you have achieved?
    a. Less than high school diploma
    b. High school diploma or GED
    c. 2-year associates degree or trade school
    d. 4-year college degree (e.g., bachelors degree)
    e. Advanced degree beyond 4-year degree (e.g., masters, Ph.D., medical doctor, law degree)
3. Which of these categories best describes your ***current annual household income before taxes***?
    a. Less than $25,000
    b. $25,000 to $49,999
    c. $50,000 to $74,999
    d. $75,000 to $99,999
    e. $100,000 to $124,999
    f. 125,000 to $149,999
    g. $150,000 to $174,999
    h. $175,000 to $199,999
    i. $200,000 to $224,999
    j. $225,000 to $249,999
    k. $250,000 to $274,999
    l. $275,000 or more
4. Are you (check one)?
    a. Male
    b. Female
    c. Other (e.g., transgender person)
5. How many years have you worked or lived in this watershed?
6. Thank you for participating in this survey. Are you interested in
    a. receiving a summary of the results? If yes, please provide your name and a way to contact you
    b. participating in a follow-up interview? If yes, please provide your name and a way to contact you

Appendix B: Idaho Survey

Water Survey for the Wood River Basin
Thank you for your participation in this survey developed by Oregon State University at the request of water users in the Wood River Basin. Your participation is voluntary, you can refuse to answer any question for any reason, and the data collected will be kept anonymous. The goals of this survey are to support graduate research on water management and to provide information to users and managers in your basin to support management decisions and planning for future water needs. Specifically, this study may identify:

1. Places where information is lacking or resources are needed
2. Areas of conflict and opportunities for resolutions
3. Strategies to improve collaboration
4. Acceptability of water management tools and strategies

You can use this link to take the survey online:
http://oregonstate.qualtrics.com/SE/?SID=SV_bJVLMN1PwXwQZc9

1. When thinking about your involvement in water, what is your **primary water user group**? When responding to the following questions, please use this when asked about your "stakeholder group."

❍ Surface irrigation ❍ Groundwater irrigation; which one: o Galena groundwater district o South Valley groundwater district o Carey groundwater district o Camas area groundwater user o Not within district (Dietrich, Shoshone, Richfield areas)	❍ Small water user (.5 to 20 acres) ❍ Scientist ❍ Residential/ private well (less than ½ acre) ❍ Environmental or conservation group ❍ Recreation/ tourism ❍ Municipal water ❍ Communal well/subdivision (HOA)	❍ State government- which one ____________ ❍ County government- which one ____________ ❍ Municipal government- which one ____________ ❍ Other ____________

2. Regarding authority over water in your watershed. It is clear to my stakeholder group…

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
Who has jurisdictional authority to make decisions.	❍	❍	❍	❍	❍	❍
Who has senior water rights.	❍	❍	❍	❍	❍	❍

How groundwater use affects surface water rights.	❍	❍	❍	❍	❍	❍

3. To what extent do you disagree or agree? Stakeholders have a common vision for managing water in the face of challenges in my watershed.

❍ Strongly Disagree ❍ Disagree	❍ Neither Agree nor Disagree ❍ Agree	❍ Strongly Agree ❍ I don't know

4. Regarding water management in your watershed...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
The current way that water is managed can meet my stakeholder group's water needs.	❍	❍	❍	❍	❍	❍
Regulatory changes are necessary in our watershed for better water management.	❍	❍	❍	❍	❍	❍

Please provide example below:

____

5. To what extent do you disagree or agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
My stakeholder group has the opportunity to engage in watershed management decisions.	❍	❍	❍	❍	❍	❍
My stakeholder group has a meaningful role in watershed management decisions.	❍	❍	❍	❍	❍	❍
Stakeholders who are engaging in watershed management decisions are motivated to get things done.	❍	❍	❍	❍	❍	❍

6. Is there a collaborative effort in place to address future water needs and management? If so, please identify-

____

____

7. To what extent do you disagree or agree? Using a local collaborative approach to water management is preferable to litigation?

❍ Strongly Disagree ❍ Disagree	❍ Neither Agree nor Disagree ❍ Agree	❍ Strongly Agree ❍ I don't know

8. To what extent do you disagree or agree with the following statements? In your watershed…

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
There is an individual or entity that helps to bring diverse stakeholders together.	❍	❍	❍	❍	❍	❍
There is an individual or entity that is trusted by stakeholders to lead.	❍	❍	❍	❍	❍	❍
There is an individual or entity that motivates creativity in others.	❍	❍	❍	❍	❍	❍

9. Below there is a list of water management tools, please check all that apply (you can select multiple options).

	For the following management tools please indicate….			
	If you **currentl y use** this tool	If you **would support voluntary** use of tool in the future	If you support **the regulatory use** of this tool	If you don't understand what this tool is
Instream flow protection to meet ecological needs	❑	❑	❑	❑
Habitat restoration as a water management tool (e.g., reconnecting flood plains)	❑	❑	❑	❑
Temporary non-diversion agreements- where water user agrees to reduce or forego withdrawal for compensation	❑	❑	❑	❑
Temporary water leases through fallowing acres	❑	❑	❑	❑
Permanent water agreements (non-diversion agreements and leasing)	❑	❑	❑	❑
Water banking through IDWR that allows temporary nonuse without forfeiture of right	❑	❑	❑	❑
Water markets (real-time, easily tradable water rights between willing buyers and sellers based on an agreed price)	❑	❑	❑	❑
Water pricing (e.g., tiered rates based on quantity)	❑	❑	❑	❑

Conserved water projects where portion of saved water can be allocated instream, sold, or used on additional lands	❑	❑	❑	❑
Water delivery efficiency projects (e.g., canal lining or piping)	❑	❑	❑	❑
On-farm efficiency projects (e.g., conversion to pivots, variable rate irrigation pumps)	❑	❑	❑	❑
Demand driven water delivery	❑	❑	❑	❑
Changing point of diversion for water withdrawal	❑	❑	❑	❑
Groundwater recharge projects	❑	❑	❑	❑
Increased reservoir storage or optimization of existing storage	❑	❑	❑	❑
Switching the source of water (e.g., groundwater to surface water switch, tributary to main stem switch)	❑	❑	❑	❑
Water use monitoring and measurement devices	❑	❑	❑	❑
Policies for reducing demand (e.g., mandatory reductions in water use)	❑	❑	❑	❑
Long-term integrated basin planning, addressing multiple stakeholder needs)	❑	❑	❑	❑

10. What ideas do you have for your stakeholder group to reduce demand or increase supply (e.g., fallowing)?

____

____

11. In light of future water shortages, how much are you willing to reduce your water use?

❍ Significant water use reduction ❍ Moderate water use reduction	❍ Minor water use reduction ❍ None at all

12. To what extent do you disagree or agree? Our watershed …

	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly agree	I don't know or N/A
Has the ability to achieve water sustainability goals (economic, ecologic, and social).	❍	❍	❍	❍	❍	❍

Has identified and prioritized community values for water use.	❍	❍	❍	❍	❍	❍

13. When you think about the basin in the next 20-50 years, please rank from 1-7 (with 1 the most and 7 the least important) the uses of water in your basin that are most important to you.

Rank from 1 to 7	Use
	Availability of clean potable water
	High functioning river ecosystem
	Vibrant agriculture community
	Recreation (snowmaking for skiing, boating, golf, fishing)
	Amenities in towns and urban centers (residential lawns and parks)
	Scenic enjoyment
	Other :

14. In your estimation, what has been the level of water conflict among water stakeholders in your watershed?

	No Conflict	Slight Conflict	Moderate Conflict	Extreme Conflict	I don't know
In the last year	❍	❍	❍	❍	❍
In the past 2 years	❍	❍	❍	❍	❍
In the past 5 years	❍	❍	❍	❍	❍
What level of conflict do you expect in the next 10 years	❍	❍	❍	❍	❍

15. What effect has conflict had on stakeholders working together in your watershed (you can select multiple choices)?

❑ It created lasting divides between stakeholders ❑ It caused some animosity between stakeholders	❑ No impact on how people work together ❑ It motivated people to work together	❑ It helped people to collectively solve problems ❑ I don't know/ too early to tell

16. To what extent do you disagree or agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
I feel a personal obligation to find long-term water solutions for my watershed.	❍	❍	❍	❍	❍	❍
I feel a responsibility to help educate others about water needs in my watershed.	❍	❍	❍	❍	❍	❍
I know that my own behaviors impact other water users in the watershed.	❍	❍	❍	❍	❍	❍
I can do more to ensure water solutions are found in my watershed.	❍	❍	❍	❍	❍	❍
I feel powerless in helping to resolve watershed issues.	❍	❍	❍	❍	❍	❍

17. In our watershed, stakeholders generally…

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
Share information with each other.	❍	❍	❍	❍	❍	❍
Are supportive of each other.	❍	❍	❍	❍	❍	❍
Are willing to work together to solve water problems.	❍	❍	❍	❍	❍	❍
Are willing to sacrifice their needs in the short-term because they believe that in the long-run, all needs will be met.	❍	❍	❍	❍	❍	❍

18. To what extent do you disagree or agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
I trust that water management decisions will produce good outcomes for all stakeholders.	❍	❍	❍	❍	❍	❍
I trust other stakeholders to keep my needs in mind when making water management decisions.	❍	❍	❍	❍	❍	❍

19. How much trust do you have with each of the below groups to positively contribute to water management?

	Strongly Distrust	Somewhat Distrust	Neither Trust or Distrust	Somewhat Trust	Strongly Trust	I don't know or N/A
Municipal water	❍	❍	❍	❍	❍	❍
Communal well/subdivision (HOA)	❍	❍	❍	❍	❍	❍
Surface irrigation	❍	❍	❍	❍	❍	❍
Groundwater irrigation	❍	❍	❍	❍	❍	❍
Residential/ private well (less than ½ acre)	❍	❍	❍	❍	❍	❍
Small water (.5 acres to 20)	❍	❍	❍	❍	❍	❍
Environmental or conservation group	❍	❍	❍	❍	❍	❍
Recreation/ Tourism	❍	❍	❍	❍	❍	❍
Municipal government	❍	❍	❍	❍	❍	❍
State government	❍	❍	❍	❍	❍	❍
County government	❍	❍	❍	❍	❍	❍
Scientists (e.g., hydrologists)	❍	❍	❍	❍	❍	❍
Scientific information (e.g., groundwater, climate model)	❍	❍	❍	❍	❍	❍

20. To what extent do you disagree or agree with the following statements? To make good management decisions, stakeholders currently have sufficient...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
Access to scientific information.	❍	❍	❍	❍	❍	❍
Access to technical expertise.	❍	❍	❍	❍	❍	❍
Capacity to manage watershed meetings and other outreach activities.	❍	❍	❍	❍	❍	❍
Capacity to analyze water management options.	❍	❍	❍	❍	❍	❍
Capacity to report on outcomes.	❍	❍	❍	❍	❍	❍

21. My stakeholder group is aware of the potential impacts from…

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know or N/A
The human factors that influence water management (e.g., urban growth).	❍	❍	❍	❍	❍	❍
The economic factors that influence water management (e.g., cost of infrastructure improvements).	❍	❍	❍	❍	❍	❍
The bio-physical factors that influence water management (e.g., drought conditions).	❍	❍	❍	❍	❍	❍

22. Water management is the most pressing issue facing our community right now?

❍ Strongly Disagree ❍ Disagree	❍ Neither Agree nor Disagree ❍ Agree	❍ Strongly Agree ❍ I don't know

23. To what extent do you disagree or agree with the following statements? In order to implement new water management strategies…

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
Our watershed has adequate financial resources available.	❍	❍	❍	❍	❍	❍
Our watershed already has the necessary infrastructure (e.g. irrigation delivery, sprinklers, storage in place).	❍	❍	❍	❍	❍	❍

24. In general, stakeholders in my watershed are willing to try new things to meet multiple needs in our watershed.

❍ Strongly Disagree ❍ Disagree	❍ Neither Agree nor Disagree ❍ Agree	❍ Strongly Agree ❍ I don't know

25. To what extent do you disagree or agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
Learning about new water conservation technologies is important to my stakeholder group.	❍	❍	❍	❍	❍	❍
My stakeholder group is innovative.	❍	❍	❍	❍	❍	❍
My stakeholder group has techniques or technologies to share.	❍	❍	❍	❍	❍	❍

26. Regarding management goals in your watershed...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I don't know
There are measurable water management goals in my watershed.	❍	❍	❍	❍	❍	❍
Progress is evaluated against those management goals.	❍	❍	❍	❍	❍	❍
Water management goals reflect the needs of the watershed.	❍	❍	❍	❍	❍	❍
Stakeholders have a firm grasp of our opportunities and alternatives.	❍	❍	❍	❍	❍	❍

27. Regarding change in your watershed (e.g., growing season shortened or extended, urbanization) ...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I dont' know
We have the ability to adapt to change.	❍	❍	❍	❍	❍	❍
We have the ability to capitalize on that change.	❍	❍	❍	❍	❍	❍

28. How would you describe your community's ability to adapt to changes in water supply and demand?

❍ Poor	❍ Good	❍ Excellent
❍ Fair	❍ Very Good	❍ I don't know

29. Thank you for participating in this survey, your input is extremely important! Are you willing to participate in a follow-up interview? If yes, please provide your name and a way to contact you:

-
____

If you have any questions about this questionnaire, please contact Anna Pakenham Stevenson pakenhaa@oregonstate.edu or (541) 272-9911.

Please use this link to take the survey online:
http://oregonstate.qualtrics.com/SE/?SID=SV_bJVLMN1PwXwQZc9

Please return the survey by mail to:
Anna Pakenham Stevenson
300B Gilkey Hall
Oregon State University
Corvallis, OR 97331

Appendix C: Interview Protocol

Investigating the Adaptive Governance Capacity in Local Watersheds
You are being asked to participate in an interview examining local communities' ability to adapt to changing environmental and social conditions as they relate to water. Participation is voluntary and you can refuse to answer any question for any reason. The interview is anticipated to take no more than one hour.

Interview guide:

1. Please tell me a little about yourself and work (plug what you have heard about them) and how it relates to the use of water.
2. For your watershed, what would a successful water management look like?
   - Probe: What is the best way to get there?

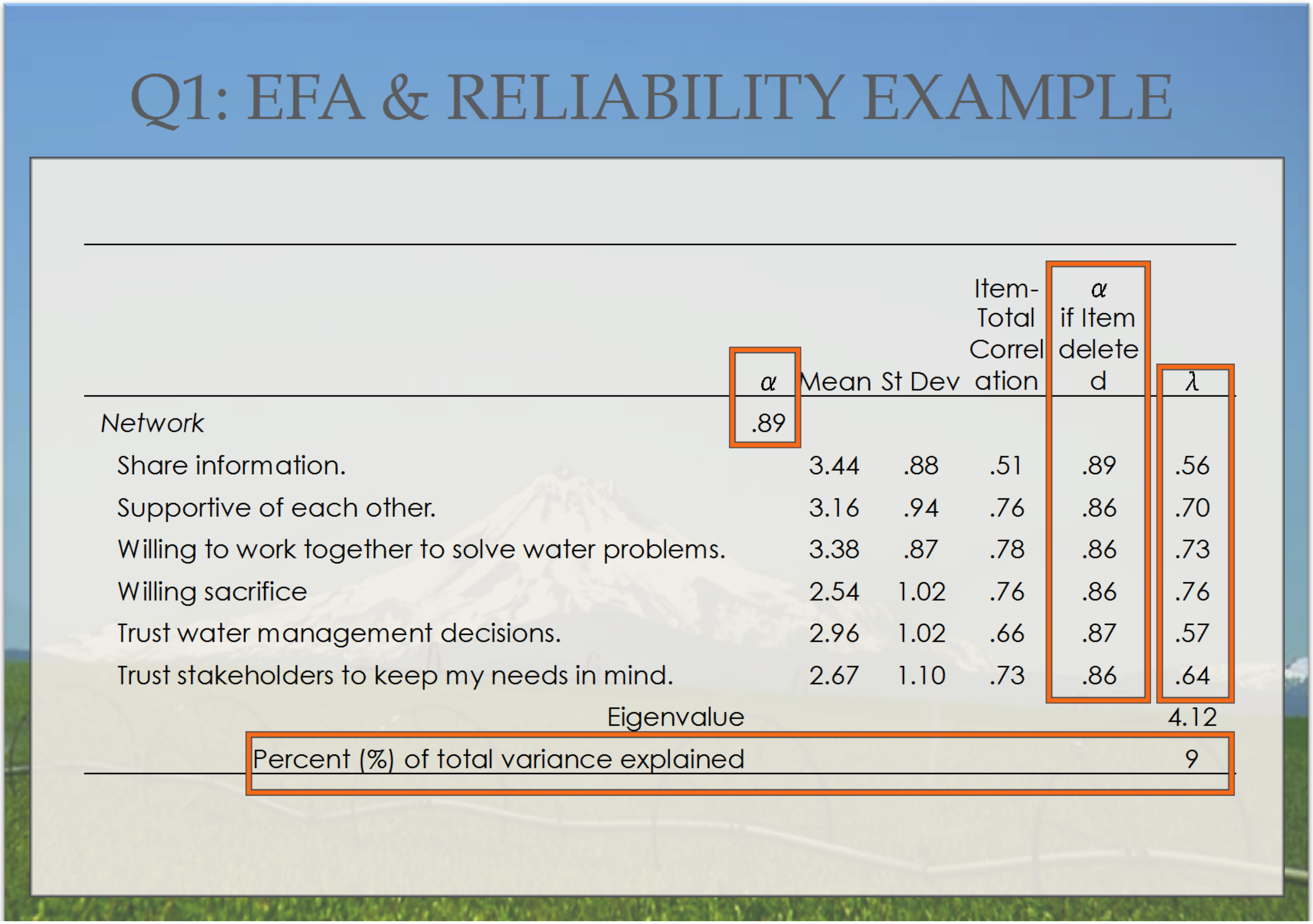
3. Within the context of your community, what are the factors that matter the most in water management?
   - Probe: How does technology and infrastructure impact water management in your basin?
   - Probe: What financial challenges surround water management in your basin?
   - Probe: social/cultural
   - Probe: Environmental

4. There are multiple water needs within this basin… what do you want other water users to understand about your water use needs, that you are not sure they understand?
   - Probe: Are you are aware of any misunderstandings within the Basin??

5. What have been your experiences in working collaboratively with other water users to manage water in the basin?
   - Probe: How might your involvement in collaborative efforts change the way you think about water management?
   - Probe: What opportunities and challenges to you see for working collaboratively?

6. How should your community address future changes to water supply and demand?

Appendix D: Additional Results Figures



Q1: EFA & RELIABILITY EXAMPLE

	α	Mean	St Dev	Item-Total Correlation	α if Item deleted	λ
Network	.89					
Share information.		3.44	.88	.51	.89	.56
Supportive of each other.		3.16	.94	.76	.86	.70
Willing to work together to solve water problems.		3.38	.87	.78	.86	.73
Willing sacrifice		2.54	1.02	.76	.86	.76
Trust water management decisions.		2.96	1.02	.66	.87	.57
Trust stakeholders to keep my needs in mind.		2.67	1.10	.73	.86	.64
Eigenvalue						4.12
Percent (%) of total variance explained						9

Q2: DIMENSIONS AND SUBDIMENSIONS

	Factor loadings		
	Factor 1	Factor 2	Factor 3
Network	.79		
Leadership	.77		
Goals	.70		
Mobilize	.70	.37	
Management	.55	.47	
Authority	.42	.39	
Knowledge		.80	
Conflict			.72
Ability to adapt		.50	-.66
Reciprocity			.60

Q2: DIMENSIONS & SUBDIMENSIONS

	Factor Loading			
	Factor 1	Factor 2	Factor 3	Factor 4
Conflict			.65	
Authority		.67		
Knowledge		.81		
Ability to adapt				.94
Leadership	.78			
Reciprocity			.85	
Management	.54	.44		
Goals	.69			
Network	.81			
Mobilize	.69			
Cronbach alpha	.74	.59	.46	
% of total variance explained	27	15	13	11

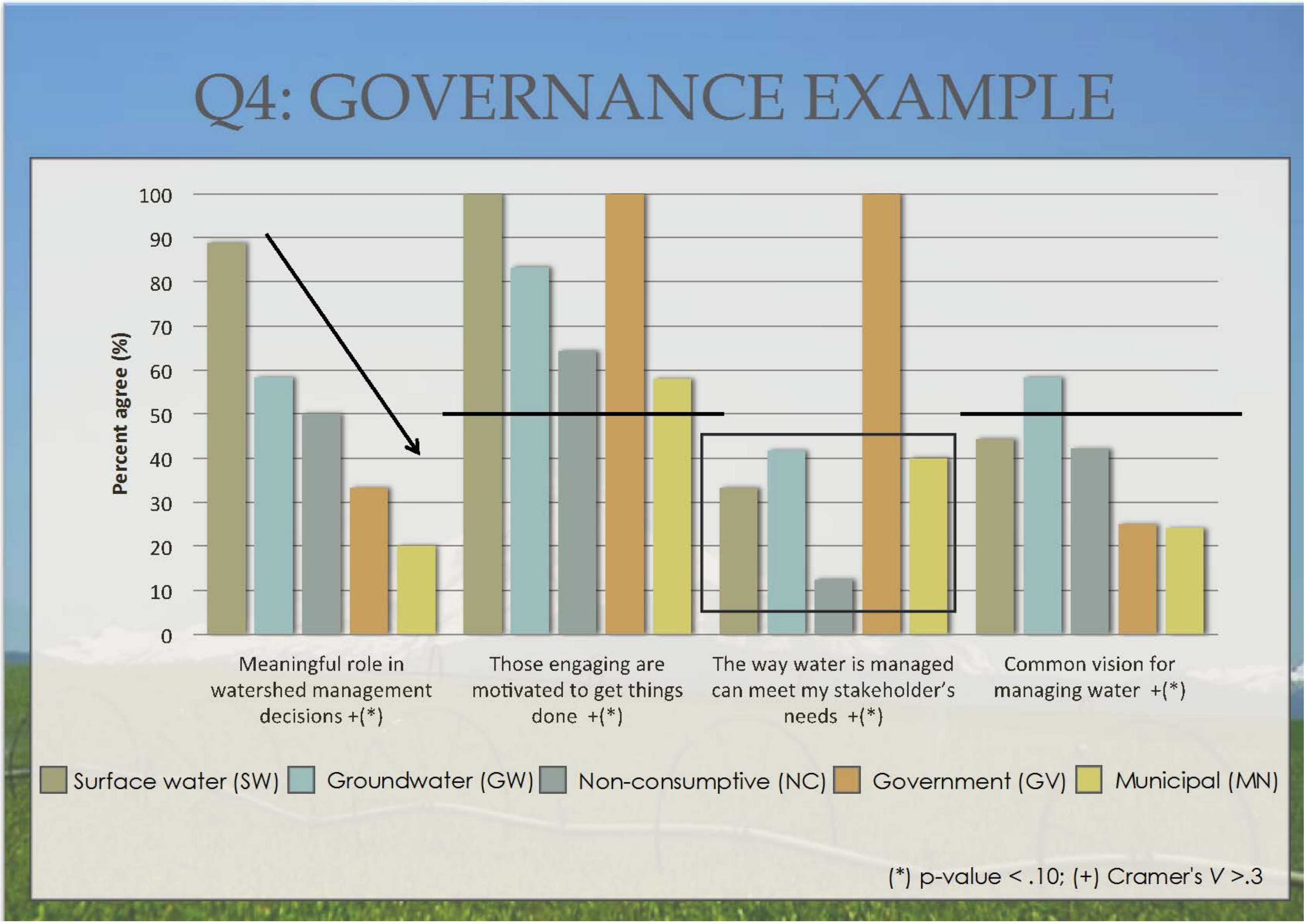
118

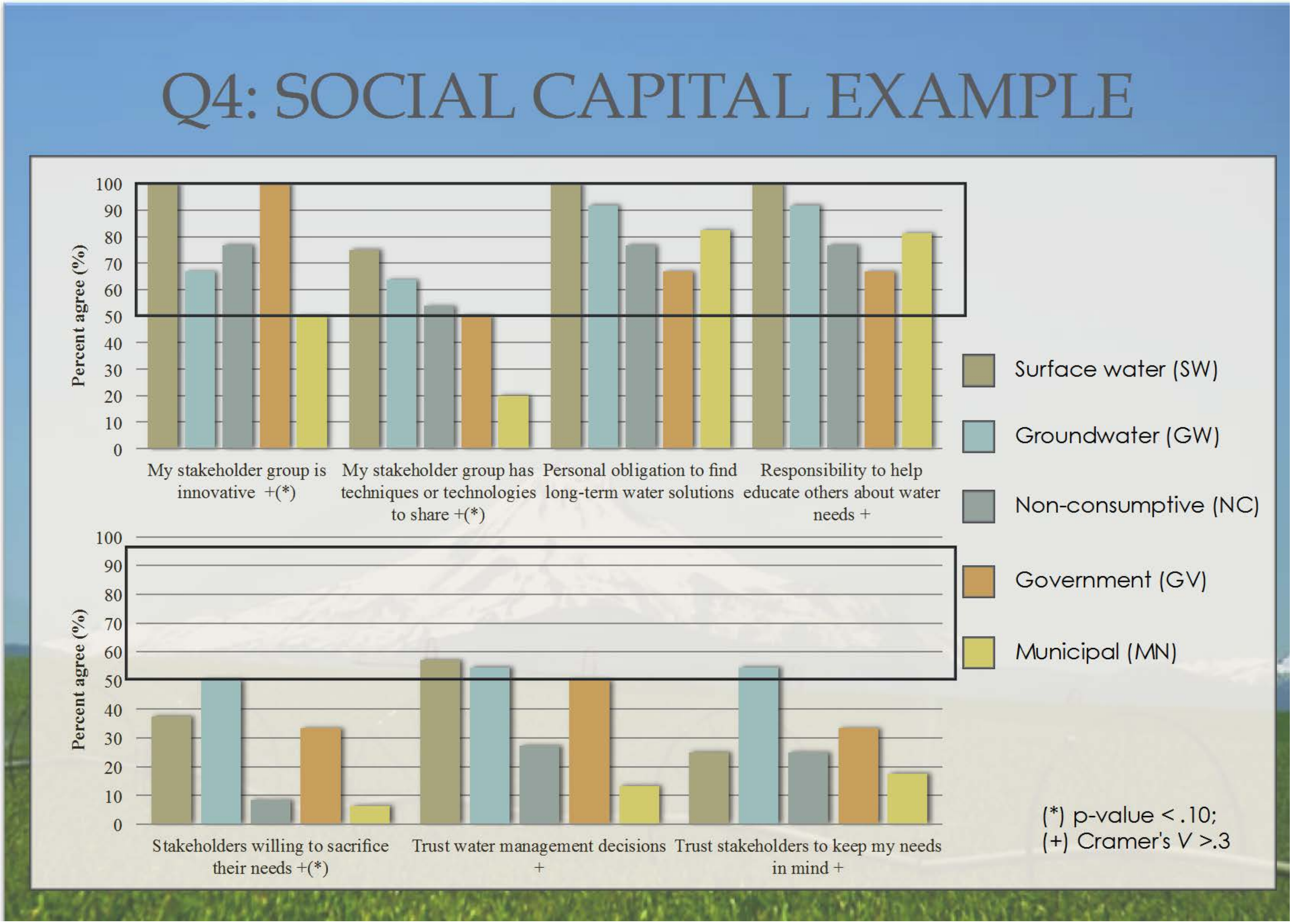
Q3: EXAMPLE

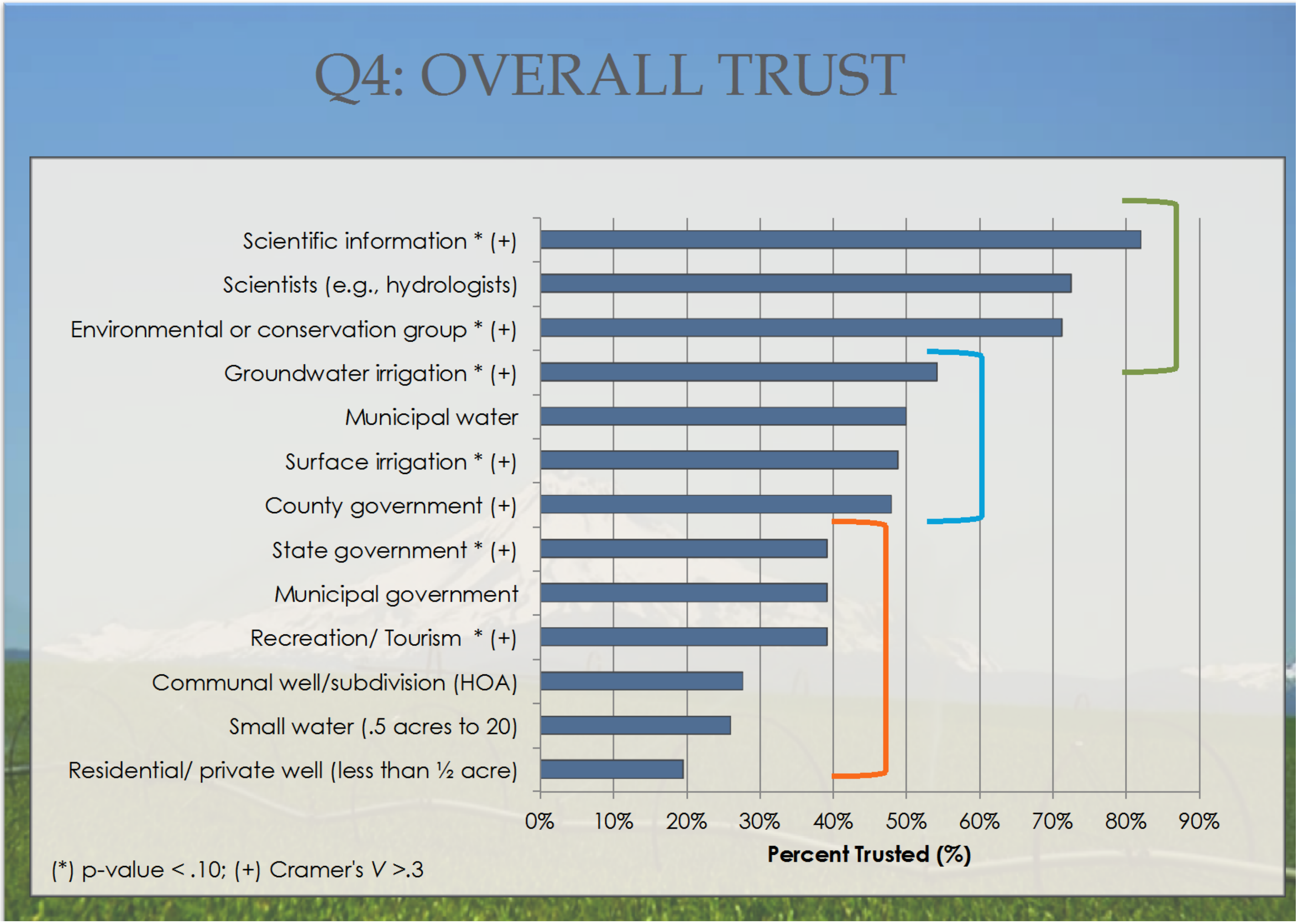
	Upper Deschutes			Big Wood River			Combined		
	n	Mean	% Agree	n	Mean	% agree	t-value	p-value	r_{pb}
Management decisions	63	3.69	48	50	3.46	42	1.51	.134	.15
Sufficient access to scientific information	62	3.23	48	49	3.39	57	.76	.451	.07
Sufficient access to technical expertise	63	3.68	73	48	3.54	63	.71	.480	.07
Capacity to manage outreach activities.	61	3.85	74	50	3.48	58	2.12	**.036**	.20
Capacity to report on outcomes.	61	4.02	87	50	3.42	58	3.49	**.001**	**.32**
Ability to adapt	59	3.48	48	51	3.27	39	1.11	.270	.11
Ability to adapt to changes.	58	3.59	60	51	3.43	59	.82	.412	.08
Ability to capitalize on that change.	55	3.36	45	48	3.06	40	1.38	.171	.14
Goals	57	3.30	40	45	2.90	20	2.05	**.043**	.20
Measurable water management goals.	57	3.58	70	44	2.84	30	3.37	**.001**	**.32**
Progress is evaluated against goals.	56	3.29	52	43	2.81	19	2.38	**.019**	.23
Water management goals reflect the needs.	56	3.05	41	43	2.95	28	.47	.642	.05

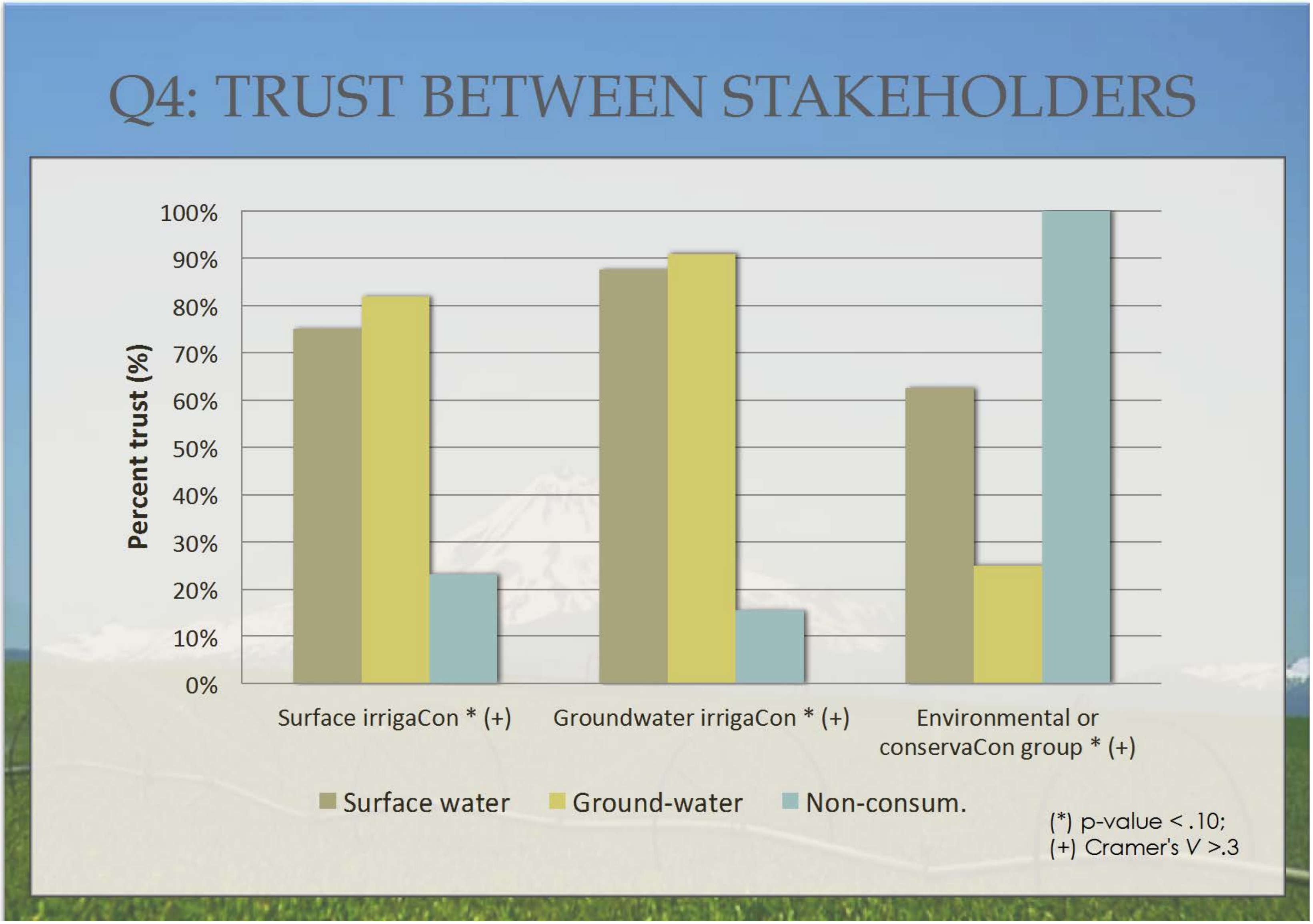
Q3: EFA

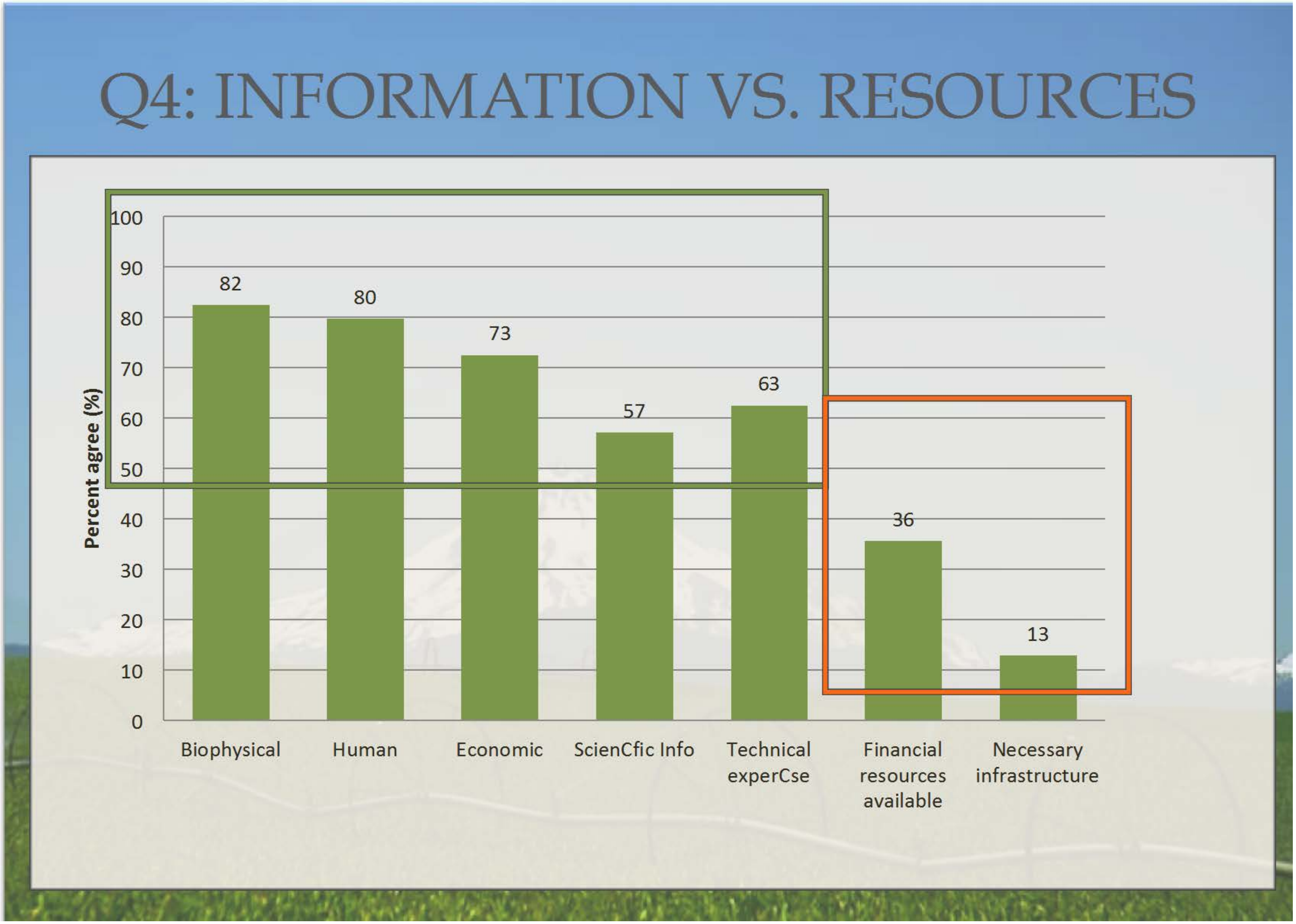
	Upper Deschutes			Big Wood River		
	Factor loading	Rank	Mean	Factor loading	Rank	Mean
Mobilize	.79	1	3.70	.82	1	3.51
Goals	.78	2	3.30	.30	8	2.90
Network	.77	3	2.88	.72	2	3.02
Leadership	.74	4	3.27	.69	3	3.44
Management	.72	5	3.69	.69	4	3.46
Authority	.54	6	3.60	.53	5	3.48
Adaptability	.37	7	3.48	.10	9	3.27
Knowledge	.31	8	4.08	.46	6	3.94
Reciprocity	.02	9	4.55	.33	7	4.24
Conflict	-.37	10	3.06	.02	10	2.89

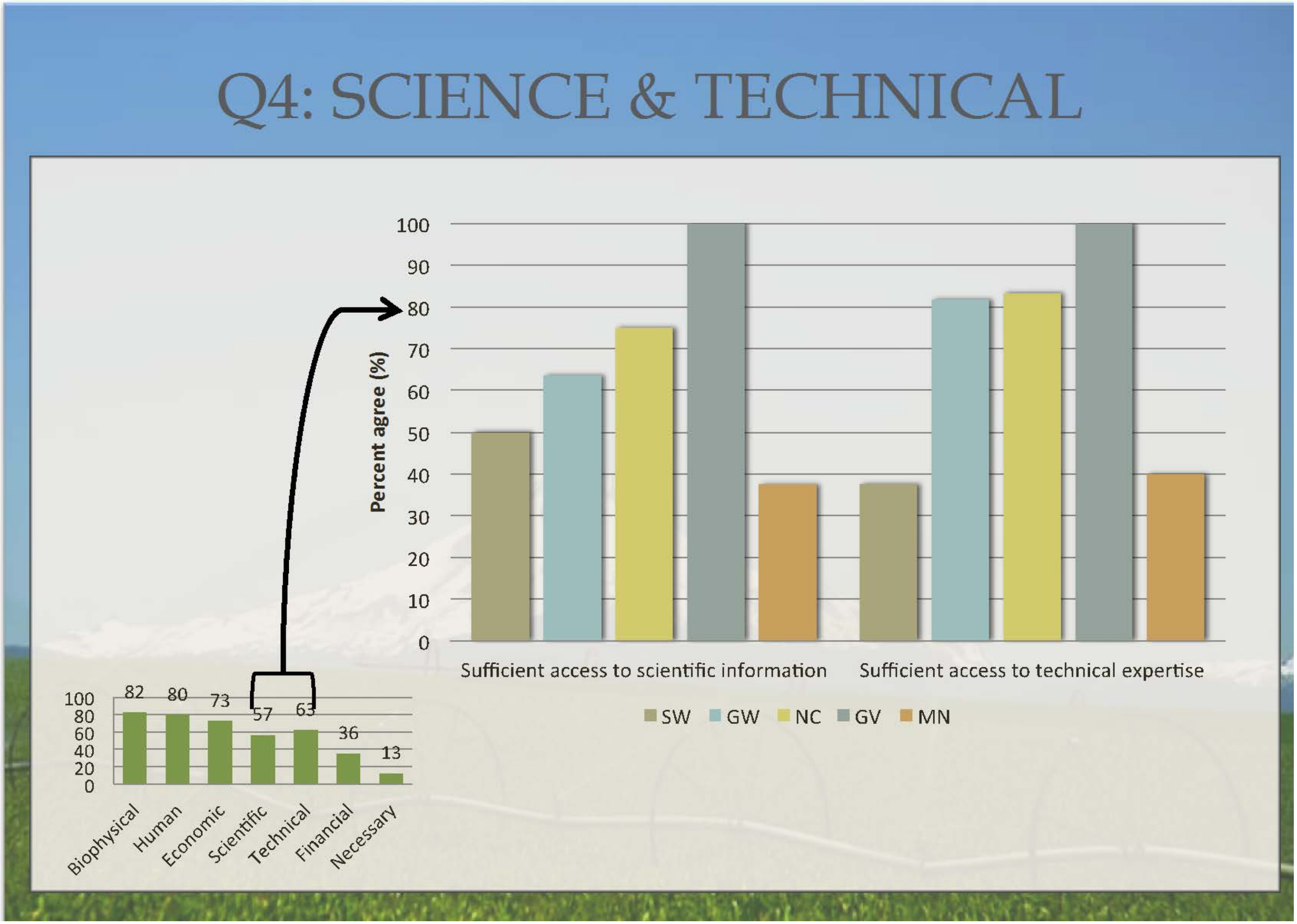

Q4: GOVERNANCE EXAMPLE
Percent agree (%)
100
90
80
70
60
50
40
30
20
10
0
Meaningful role in watershed management decisions +(*)
Those engaging are motivated to get things done +(*)
The way water is managed can meet my stakeholder's needs +(*)
Common vision for managing water +(*)
Surface water (SW)
Groundwater (GW)
Non-consumptive (NC)
Government (GV)
Municipal (MN)
(*) p-value < .10; (+) Cramer's V >.3


Q4: SOCIAL CAPITAL EXAMPLE
Percent agree (%)
100
90
80
70
60
50
40
30
20
10
0
My stakeholder group is innovative +(*)
My stakeholder group has techniques or technologies to share +(*)
Personal obligation to find long-term water solutions
Responsibility to help educate others about water needs +
Stakeholders willing to sacrifice their needs +(*)
Trust water management decisions +
Trust stakeholders to keep my needs in mind +
Surface water (SW)
Groundwater (GW)
Non-consumptive (NC)
Government (GV)
Municipal (MN)
(*) p-value < .10;
(+) Cramer's V >.3


Q4: OVERALL TRUST
Scientific information * (+)
Scientists (e.g., hydrologists)
Environmental or conservation group * (+)
Groundwater irrigation * (+)
Municipal water
Surface irrigation * (+)
County government (+)
State government * (+)
Municipal government
Recreation/ Tourism * (+)
Communal well/subdivision (HOA)
Small water (.5 acres to 20)
Residential/ private well (less than ½ acre)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
Percent Trusted (%)
(*) p-value < .10; (+) Cramer's V >.3


Q4: TRUST BETWEEN STAKEHOLDERS
Percent trust (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Surface irrigaCon * (+)
Groundwater irrigaCon * (+)
Environmental or conservaCon group * (+)
Surface water
Ground-water
Non-consum.
(*) p-value < .10;
(+) Cramer's V >.3


Q4: INFORMATION VS. RESOURCES
Percent agree (%)
100
90
80
70
60
50
40
30
20
10
0
82
80
73
57
63
36
13
Biophysical
Human
Economic
ScienCfic Info
Technical experCse
Financial resources available
Necessary infrastructure



Q4: SCIENCE & TECHNICAL
Percent agree (%)
100
90
80
70
60
50
40
30
20
10
0
Sufficient access to scientific information
Sufficient access to technical expertise
SW
GW
NC
GV
MN
82
80
73
57
63
36
13
Biophysical
Human
Economic
Scientific
Technical
Financial
Necessary

Q4: TOOL RANKINGS- TOP 5

	Overall Ranking		Voluntary Support				
	Regulatory	Voluntary	Surface	Ground	Non-consumptive	Government	Municipal
Water use measurement (+)	1						
Minimum flow requirements	2				3		
Long-term basin planning	3	3	1	2		3	
Groundwater recharge (+)	4		1			3	
Policies for reducing demand (* /+)	5					2	
Temp non-diversion agreements		1	1	2	1		2
Water leases through fallowing		2	1			3	3
Perm agreements (* /+)		3	1		2	2	4
Water delivery efficiency projects		3		2		3	4
Full water markets (* /+)			1		3	1	
Conserved water projects (+)				1	3		
Water banking				2		3	
Habitat restoration					3	3	3
On-farm efficiency projects (+)						3	1