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# Water Demand, Adaptive Capacity, and Drought: an Analysis of the Upper Klamath Basin, Oregon and California

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WATER DEMAND, ADAPTIVE CAPACITY, AND DROUGHT: AN ANALYSIS OF THE UPPER KLAMATH BASIN, OREGON AND CALIFORNIA

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ABSTRACT

WATER DEMAND, ADAPTIVE CAPACITY, AND DROUGHT: AN ANALYSIS OF THE UPPER KLAMATH BASIN, OREGON AND CALIFORNIA

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Freshwater demand and scarcity issues are an issue of global concern, in particular for the American West as global climate models suggest precipitation regime changes and an increase of drought. This research conducts a case-study of the Upper Klamath Basin, located in south-central Oregon and northern California, a microcosm of the arid and semi-arid American West that experienced an economically, socially, and ecologically impactful drought in the early 2000s. Through a mixture of qualitative and quantitative methods this research: 1) identifies key stakeholders, their goals and key policies; 2) conducts an adaptive capacity assessment of water management within the basin; and 3) makes future recommendations for water policy and management within the basin. To achieve these objectives content analysis, semi-structured interviews, and an event history calendar were completed. Results indicate that adaptive capacity is tied, in addition to occurrences of drought, to events on the sociopolitical landscape and is variable to each stakeholder group examined. This research shows that adaptive capacity overall was on the rise following the early 2000s, peaking with the signing of the Klamath Basin Restoration Agreement (KBRA) and Final Order of Determination but has begun decreasing again following the sunset of the KBRA in 2015.

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This work is dedicated to my father, Stephen Snyder, who always told me I could.

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# CHAPTER 1

# INTRODUCTION

Globally, the availability of freshwater resources, as well as the demands on those resources are of concern (Döll, Kaspar, and Lehner 2003; Mekonnen and Hoekstra 2016). Temporal precipitation regime changes can add a complex layer to water resource management, particularly in regions that depend on snowmelt for a significant portion of their freshwater resources (Stewart, Cayan, and Dettinger 2004). Competing demands complicate water management in basins where water scarcity is an issue; water conflicts in the American West, for example, are certainly not a new phenomenon (Moore, Gollehon, and Carey 1994; Moore, Mullvile, and Weinberg 1996; MacDonnell 1999; Davis 2001; Lempert and Groves 2010). Drought is a common theme in the West; one that is often part of a natural climatic regime. Global climate models suggest that the region is likely to experience drought with greater frequency and intensity as climate change progresses (Dettinger, Udall, and Georgakakos 2015).  The Upper Klamath Basin, which straddles the border between south-central Oregon and northern California, is included in this agglomeration of western U.S. basins that experience water conflicts (Boehlert and Jaeger 2010). The Upper Klamath Basin is a microcosm of the significant challenges basins within the semi-arid and arid American West face. Water management in the Upper Klamath Basin (UKB) is complicated by overlapping legal frameworks, various scales of institutions and stakeholders, and a clash of cultures.

Both California and Oregon utilize the doctrine of prior appropriation (Oregon Water Code 1909; California Code, Water Code, Division 2 2016; Davis 2001). This management structure allows older water rights holders to receive their full allotment in times of scarcity before junior water right holders receive their allotments (Davis 2001). It also requires that water right holders utilize their allotment towards "public benefit"; states have been historically vague in defining what exactly this entails, though generally irrigation is an accepted "public benefit", more commonly referred to as a beneficial use (Davis 2001, 532). This translates into a permitting system (excepting in Colorado, which utilizes a "water court system") (Beck et al. 1991, 12-5) that is given a "priority date" upon completion of the permitting process (Beck et al. 1991, 12-4). This priority date becomes fundamental in any discussion of appropriative water rights; it dictates who receives their full allotment of water and who receives partial allotments, or none at all, based on the amount of water available in a given year (Beck et al. 1991). Water rights in the West fall under a special category of property rights: usufructuary, which give water right holders the right to use their allotment of water and is handled differently than other property rights (Matthews 2004). Water rights under appropriative rights are also appurtenant and can be sold together or separately from land (Matthews 2010; Adler, Craig and Hall 2013). This discrepancy between "true" property rights and the usufructuary nature of water rights is a foundation of the conflicts found in the UKB.

Another complicating factor within the water management structure of the UKB is the adjudication of water rights. Adjudication is the legal process that establishes who has which water rights, the priority date of a specific water right, and quantifies it (Milner 2015). Watersheds throughout the American West remain unadjudicated, adding to the complexity of management (Matthews 2004). Adjudication is inherently a long and expensive process taken on by state water management agencies; following an adjudication process both permit applicants and the public have the right to appeal, which will generally lengthen the amount of time until the adjudication process is finished (Adler, Craig, and Hall 2013). California has not started an adjudication process but has listed the KIamath River from below Iron Gate dam to its outlet at the Pacific Ocean as fully appropriated (Milner 2015). Oregon, conversely, started an adjudication process in 1975 that was completed as of 2013 and has now entered the phase involving appeals (Milner 2015). The adjudication process, completed in 2013, established the Klamath Tribe as having the oldest and largest water right in the basin (Cosens and Chaffin 2016).

Appropriative rights are a standard among western states, while eastern states utilize a management framework known as riparian rights, which, unlike appropriative rights, are tied to the land itself (Milner 2015). Many states in the West, including California and Oregon, have water law systems which include “dual systems” of both riparian rights and appropriative rights (Milner 2015, 101). The riparian system limits water rights to land that is directly bordering a body of water; it also requires that each water right be applied to the land it is tied to and shared among users (Milner 2015). In eastern states with higher amounts of precipitation and reduced water scarcity, this management framework makes more sense. California went through significant growing pains in the establishment of its water rights framework (Adler, Craig, and Hall 2013). By 1928, California established a system that allowed for both appropriative and riparian rights but discontinued the practice of allowing riparian right holders to "enforce his right to the entire natural flow of a stream even if his use of the water was wasteful or unreasonable" (Adler, Craig, and Hall 2013, 105). Similar to appropriative rights, riparian rights must be put to "reasonable and beneficial uses" (Adler, Craig, and Hall 2013, 105). Conversely, Oregon started by recognizing riparian rights but adopted appropriative rights by the early 20th century (Adler, Craig, and Hall 2013). In 1909, Oregon officially adopted the doctrine of prior appropriation; the state recognizes riparian right holders prior to 1909 but cut off any future establishment of riparian rights (Adler, Craig, and Hall 2013). These overarching themes of water management can become quite complicated in drought years when surface waters are over appropriated, especially as these times of water scarcity are likely to increase in frequency and intensity with the progression of global climate change (Dettinger, Udall, and Georgakakos 2015).

Atmospheric warming brought on by global climate change presents a problem for the American West in general and the UKB in particular Siegel 2009; Dettinger, Udall, and Georgakakos 2011). Like many western watersheds, the UKB is snowpack dominated and overall warming trends can wreak havoc on these systems (Dettinger, Udall, and Georgakakos 2011). This warming has two primary effects which complicate matters for the basin: a rise in winter temperatures, meaning less snowpack to recharge groundwater resources, and an overall temporal shift in precipitation regimes (Aldous et al. 2011). This temporal shift in precipitation regimes can present significant challenges for water managers, as it creates a situation that involves more water scarcity during a time frame when demands are already at their peak (irrigation season) (Dettinger, Udall, and Georgakakos 2015).

The causes of drought most often experienced within the Pacific Northwest center around low precipitation or high temperatures: 1) low winter precipitation, which can lead to an agricultural drought during irrigation season; 2) low summer precipitation, which can lead to a hydrologic drought; and 3) high winter temperatures, which also leads to low snowpack, are all prevalent within the region (Bumbaco and Mote 2010). Because of its dependency on snowpack for water resources (Aldous et al. 2011), low winter precipitation and high winter temperatures tend to be the most concerning for the UKB. Snowpack percolation into groundwater systems allows for pumping of groundwater during times of the year when precipitation is low (Gannett, Wagner, and Lite 2012). This is especially pertinent as the timing of greatest need for water and greatest amount of water scarcity correspond in the summer months (Gannett, Wagner, and Lite 2012). Irrigation needs peak in the summer, as do the need for in-stream flows to provide suitable fish habitat (Aldous et al. 2011). This can create a clash in water demands that complicates water management in the basin.

The lens of political ecology can help in understanding these clashes and the pendulum swing of policy and strategies used by water managers over the years. Though the definition of what is encompassed within political ecology is broad and varies dependent on what the researcher is attempting to uncover, there are three main tenets found throughout. First, it is an antithesis to “apolitical” ecology: in other words, because humans are involved it is inherently political and can never include solely the scientific aspect. Second, there is a foundational set of assumptions. Finally, the "mode of explanation" tends to be consistent (Robbins 2004). The most relevant assumption found within the framework of political ecology to the UKB is the unequal distribution of cost and benefits associated with environmental change amongst actors. The multimodal narratives of political ecology each attempt to answer specific questions about the human-environment relationship (Robbins 2004). The ways in which the socio-political landscape impacts the natural landscape and connection between humans and their environment is at the heart of conflict around water resources in the UKB.

Such a conflict was experienced in 2001 (Boehlert and Jaeger 2010). The UKB experienced a drought that resulted in millions of dollars of agricultural losses (Boehlert and Jaeger 2010). The drought was sparked by an intensely dry winter in 2000-2001 (Doremus and Tarlock 2003). At the peak of the drought, over 82% of the Klamath River Basin was categorized as experiencing "extreme drought" (National Drought Mitigation Center et al. 2016). An extreme drought is defined as having both significant agricultural losses and pervasive water shortages or restrictions; this is quantified as a range between -1.6 to -1.9 on the Standardized Precipitation Index (National Drought Mitigation Center et al. 2016). The Standardized Precipitation Index (SPI) is a commonly used index to catalogue drought and measures the probability of precipitation for a specific time scale; it can provide both early warning for drought as well an accurate assessment of drought severity (Integrated Drought Management Programme 2018).

Drought has physical manifestations in the form of water scarcity but these can become even more complicated when there are multiple and conflicting demands.

The 2001 drought was complicated by the designation of two species of fish, the shortnose, *chasmistes brevirostris*, and Lost River suckers, *deltistes luxatus*, under the Endangered Species Act (Endangered Species Act 1973; National Research Council of the National Academies 2008). The Klamath River, which flows through the entire basin also provides significant habitat for coho salmon, a listed threatened species; this particular salmon species was historically found in the UKB but has been extirpated in recent memory (Milner 2015). Low flows from the upper to the lower portions of the basin can impact the coho salmon (Milner 2015). The endangered designation for both species of suckers meant that higher levels were required to remain in Upper Klamath Lake during a period that was already experiencing significant drought; the dependency of the threatened coho salmon, *oncorhynchus kisutch*, on the Klamath River also required higher amounts of in-stream flows (Doremus and Tarlock 2003). This directly corresponded to the severe economic losses, valued in the tens of millions of dollars, seen within the agricultural community (Boehlert and Jaeger 2010). It is estimated that curtailment of water allotments, through the Bureau of Reclamation's 2001 Operation Plan (Doremus and Tarlock 2003), affected nearly 100,000 acres within the UKB in 2001 (Boehlert and Jaeger 2010). Following the curtailment of irrigation deliveries, irrigators pursued an injunction against the plan arguing that the best available science was not used; however, they were not successful (Doremus and Tarlock 2003). These losses also exacerbated a cultural clash in the region relating to the value and use of water

(Doremus and Tarlock 2008). In July of 2001, irrigators protested the water curtailments, culminating in cutting a fence and forcing open the valve feeding the main canal (Doremus and Tarlock 2003). Law enforcement officers did not intervene and following the restoration of the head gates, refused to protect them (Doremus and Tarlock 2003). At the height of tensions, violence was experienced when three men shot at buildings and signs in Chiloquin, OR, the center of the Klamath Tribe's reservation, who they referred to as "sucker lovers" (Jenkins 2008). This highlights the cultural clash of "fish versus farms" that had been brewing in the basin and was exacerbated through the extreme water scarcity of the 2001 drought (Doremus and Tarlock 2003, 321).

Measures taken to alleviate the economic hardship placed on irrigators through water allocation curtailment (i.e., decreasing the in-stream requirements) likely influenced massive fish kills the following year (Boehlert and Jaeger 2010). It should be noted this claim is debated within the Basin to this day. Less restrictive flow requirements under the Endangered Species Act (1973) are thought to have contributed to parasite blooms, which caused fish kills in the tens of thousands for both Chinook and coho salmon in the Lower Basin (Boehlert and Jaeger 2010). The lower in-stream requirements in the Klamath River likely caused higher temperatures, contributing to the proliferation of parasites and subsequent fish kills (Boehlert and Jaeger 2010). While the situation within the UKB was an extreme one, it illustrates the sectoral conflicts (i.e., the demands from often opposing sectors) that many basins face in times of water scarcity. These sectors include tribes, municipalities, endangered species/in-stream flows, hydropower, and irrigation/ranching.

Following the drought in the UKB, a great amount of research showed the damage done and ways hardships could have been mitigated (Poff et al. 2003; Doremus and Tarlock 2003; Boehlert and Jaeger 2010). Changes in water policy and management in the UKB ostensibly resulted from the lessons of the early 2000s drought and led to a work plan for adaptive management completed in 2003, a drought plan completed in 2011, and a comprehensive agreement for water management completed in 2010 (USDA and NRCS 2003; Oregon State Office of the Governor 2010; Klamath Tribes 2014). A great deal of research within the basin was completed in the realm of adaptive governance and adaptive capacity, directly following the severe drought of 2001 (Gosnell and Kelly 2010; Hill and Engle 2013; Chaffin, Craig, and Gosnell 2014; Chaffin and Gunderson 2016). Adaptive capacity, for the purposes of this research, is defined as the ability of institutions to prepare for and mitigate water scarcity (Hill and Engle 2013). A gap exists in the literature in assessing the adaptive capacity that the basin now has, particularly as drought becomes an increasingly frequent occurrence.

Purpose and significance

This research assessed how adaptive capacity in the UKB has changed, following the disastrous events of the 2001 drought through its adaptive capacity. Specifically, it assessed the effectiveness of the goals of water management institutions and stakeholders within the basin, built upon the research following the 2001 drought, in terms of the drought in 2011-2015. The following objectives were to: 1) identify key stakeholders and their ability to influence water policy within the region; 2) identify the water management policies, goals, and strategies put in place following the 2001 drought; 3) conduct an adaptive capacity assessment; and 4) make future recommendations for water policy and management within the basin, particularly as they relate to demand-side solutions.

This research fills a gap within the literature in the UKB. The crux of this research is evaluating the temporal relationship between adaptive strategies put in place by water managers and occurrences of drought. This will help to uncover how adaptive the basin has become, an indicator of the resiliency of both the socio-political landscape and the water management institutional framework. Using the 2011-2015 time frame is an important indicator because of the occurrences of drought during that time, as well as the changes on the social landscape (e.g., ending of adjudication, ratification attempts of multiple agreements between stakeholders). Because the demands facing the UKB are significant throughout the whole of the American West, the basin is essentially a condensed version of the varied demands facing watersheds in this region. This research can also potentially be transferable to other basins that also face water scarcity and demand issues. This is particularly true as the effects of climate change increase and water scarcity (particularly seasonal water scarcity, which can have a disproportionally adverse effect on certain stakeholders) becomes an increasingly normal occurrence (Schewe et al. 2013). It may also have implications for drought management and sectoral demand conflicts overall, which are both issues facing watersheds across the globe.

Chapter Progression

Chapter 2 examines the study area, including the biophysical landscape and water supply as well as the social landscape. A brief history of settlement of the region is included to help better inform the differences in cultural connections to water and to the rivers found in this watershed. Chapter 3 reviews literature that helps to explain the context of the situation in the Klamath. The literature review covers seven main topics. First covered is water management in the West, which examines not only the existing management structure in the UKB but also delves into water rights in the American West and provides some foundational knowledge of water law. Next, stakeholders and demands are discussed, providing a more thorough investigation of the various stakeholder groups, their water needs and the legal framework that governs them. Thirdly, climate change, drought, and water supply are examined. This is an important component in understanding the situation in the UKB because of the precipitation regime shifts and greater frequency of droughts projected by global climate models. Fourth, drought management and its history in the United States is discussed. Fifth, political ecology is used as a framework for helping to understanding the pendulum swing of policy within the UKB. Next, drought is considered as a natural hazard, paying special attention to the “swiss cheese” model, which looks at natural hazards as having multiple safeguards that have failed, culminating in a worse disaster, much like lining up the holes in layered slices of swiss cheese. Lastly, an overview on the relevant literature on adaptive capacity and adaptive governance is provided. Chapter 4 outlines the details of the methods used to identify the adaptive capacity of the basin. Chapter 5, which includes results, provides an analysis of the research. Finally, chapter 6 provides some conclusions and recommendations for future research.

CHAPTER 2

THE UPPER KLAMATH BASIN

## Location

The UKB is located in south-central Oregon and northern California (Figure 1). The generally accepted border between the UKB (Figure 2) and Lower Klamath Basin

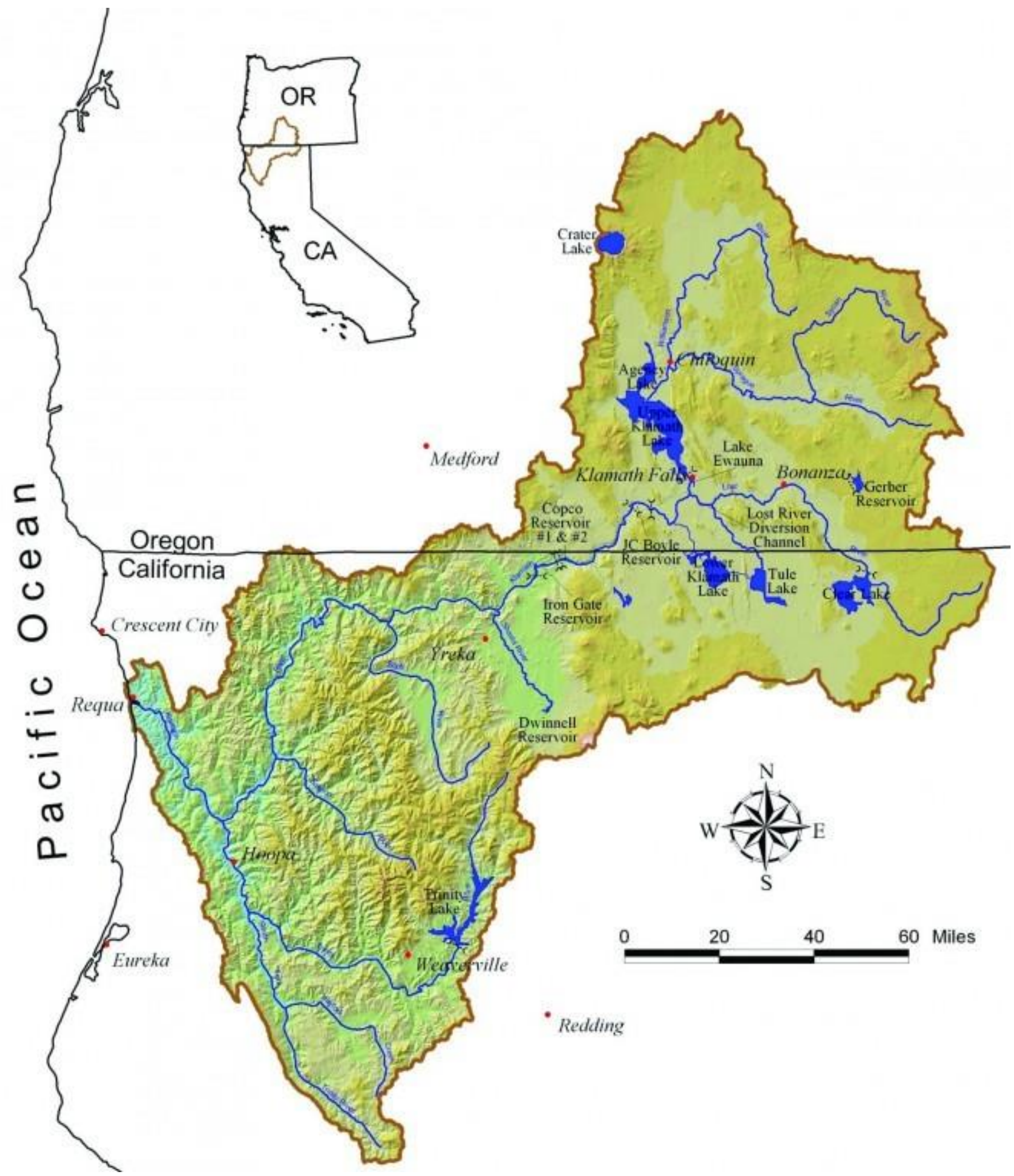


Figure 1. Klamath Basin Oregon and California (Aschbrenner 2012).

is Iron Gate Dam, located just south of the Oregon-California border on the Klamath River (National Research Council of the National Academies 2008). This is the accepted border between the basins because of the change in geology from this point on (USGS 2010). Past Iron Gate Dam the terrane changes from highly permeable volcanic rock to low permeability; it is therefore less likely that the flow of ground-water interacts past this point (USGS 2010). The basin rests on a plateau of volcanic material, nestled between the Cascade Range to the west and the Basin and Range geologic province to the east (USGS 2014). The Oregon portion of the basin is found mainly within Klamath County, with smaller portions of the basin found in Jackson and Lake Counties, (Oregon State University 2016). The California portion of the basin is split between Modoc County, and Siskiyou County (Oregon State University 2016).

Climate

The UKB's location to the east of the Cascade Range ensures that the majority of the basin is considered a semi-arid climate, as the range blocks most of the moisture coming from the east (USGS 2014). Precipitation is highly variable throughout the basin, averaging approximately 70 cm in the uppermost portions and falling to approximately 30 cm at Klamath Falls, OR (Figure 3) (National Research Council of the National Academies 2008). The majority of precipitation within the basin, approximately 70% (Bradbury, Colman, and Rosenbaum 2004), tends to fall during the winter months, in the form of snow (Figure 4), while summer months are generally hot and dry (Figure 5) (Aldous et al. 2011; USGS 2014). Snowpack is an important part of water resources for many basins throughout the Pacific Northwest (Safeeq et al. 2012). Watersheds that sit at high elevations, such as those found on the western Cascades in Oregon and

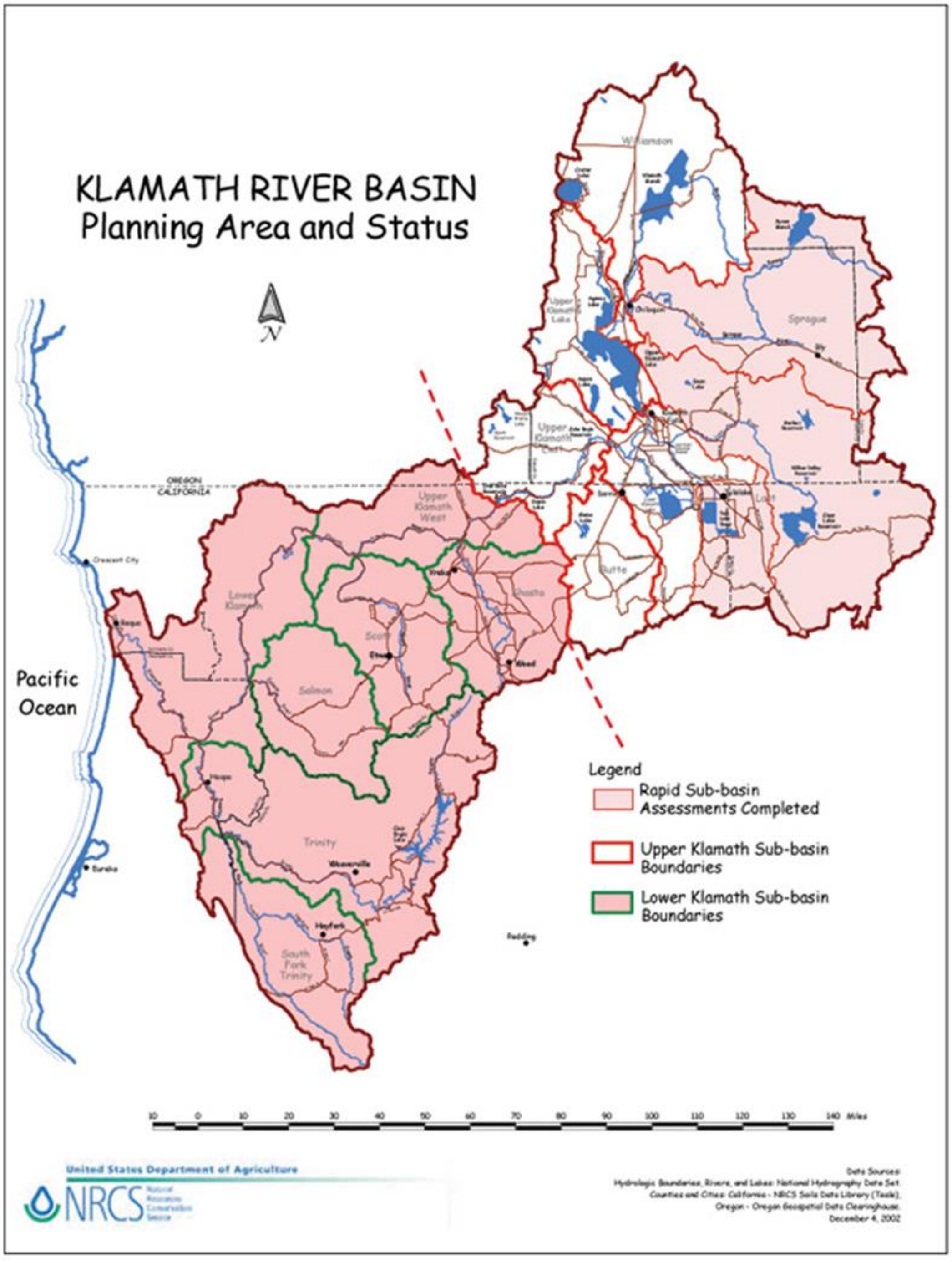


Figure 2. Klamath Basin with upper and lower delineation (Natural Resources Conservation Service ND).

Washington, experience high winter flows with early melting and low summer flows (Safeeq et al. 2012). High alpine watersheds, such as those found in the Sierra Nevada, have later melts that recede quickly (Safeeq et al. 2012).

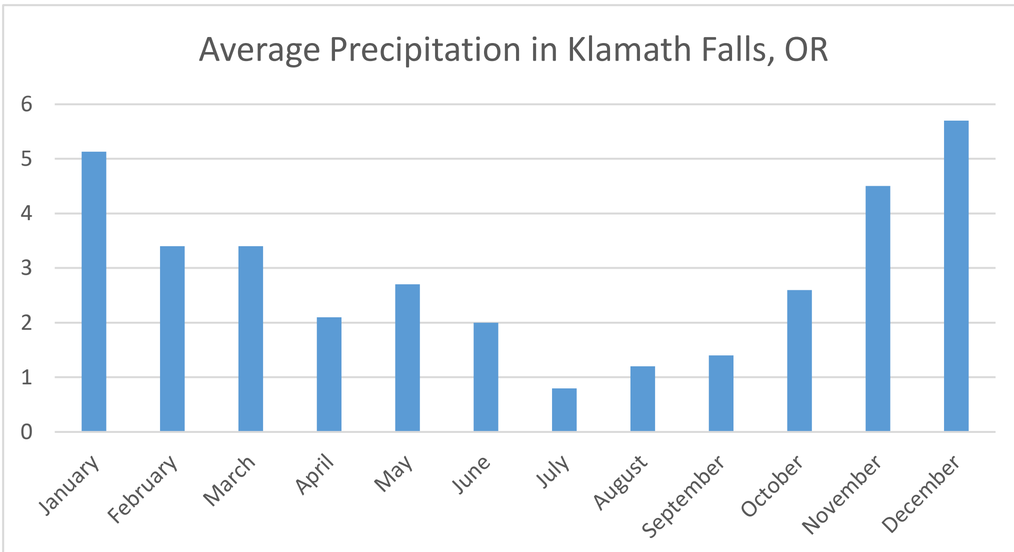


Figure 3. Average precipitation in Klamath Falls, OR 1928-2001 (Western Regional Climate Center 2017).

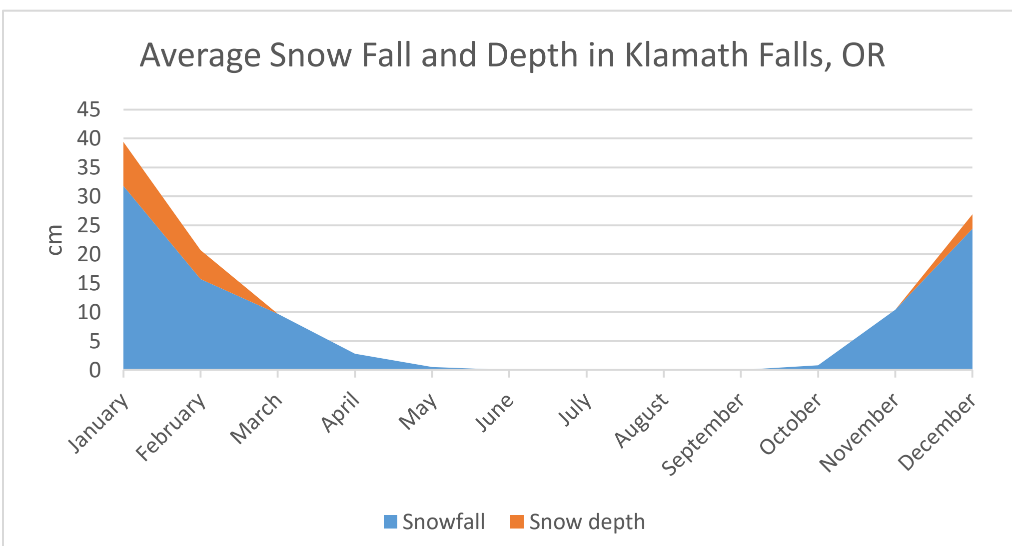


Figure 4. Average snowfall and depth in Klamath Falls, OR 1928-2001 (Western Regional Climate Center 2017).

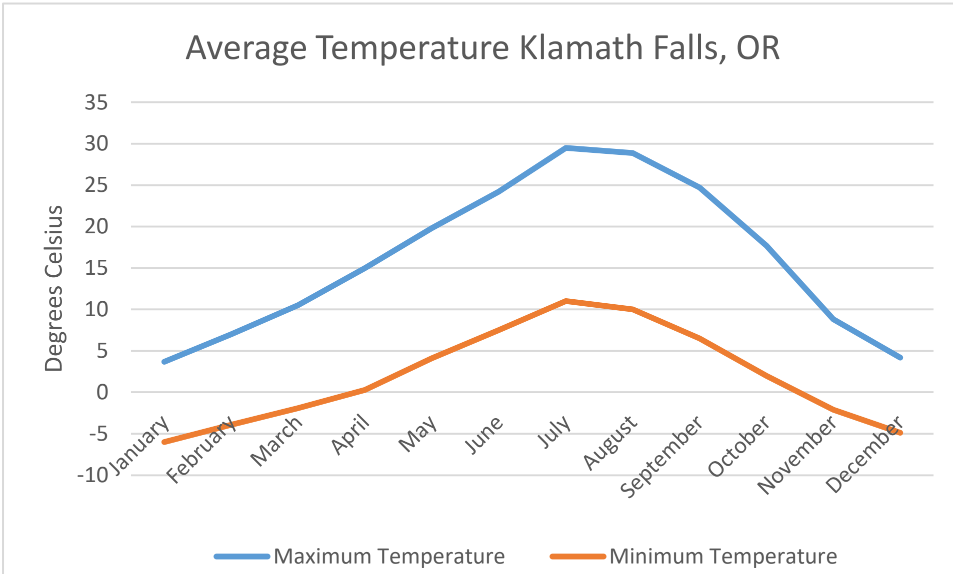


Figure 5. Average temperature in Klamath Falls, OR 1928-2001 (Western Regional Climate Center 2017).

<u>Hydrology</u>

Precipitation within the UKB, averaged over the years 1971-2000, is over 12 billion cubic-meters per year (USGS 2010). Of this amount, almost 10.5 billion cubic-meters per year is returned to the atmosphere through evapotranspiration (USGS 2010). The remaining nearly 2 billion cubic-meters per year flows past Iron Gate Dam, the boundary of the UKB (USGS 2010). The permeable volcanic rock found throughout the UKB ensures a high amount of hydraulic conductivity, as opposed to much of the Klamath Basin past Iron Gate dam, which includes older rocks that are far less permeable (USGS 2010; USGS 2014). Due to the groundwater storage (Figure 6) within the UKB, groundwater levels are directly related to both wet and dry periods and periods of significant pumping of groundwater (Gannett, Wagner, and Lite 2012). Upper Klamath Lake, a major hydrologic feature of the basin, is fed from the north by the Wood, Williamson, and Sprague rivers (Bradbury, Colman, and Rosenbaum 2004). These sub-watersheds above Upper Klamath Lake include privately irrigated lands, often referred to as off-project, while the irrigated areas below the lake are generally found within Bureau of Reclamation's Klamath Project (Jaeger 2004). The Klamath Project also receives water from the Lost River system, which include two reservoirs: Clear Lake and Gerber and a total of 7 dams that assist in water storage and supplies (Jaeger 2004; Bureau of Reclamation 2011). The lake is the largest in Oregon and is about 40 km long and 9-22 km wide, with a surface area of approximately 155 $km^2$ (National Research Council of the National Academies 2008). Lake level is controlled at its southern outlet by Link River Dam, which feeds water into both the Klamath River to continue past Iron Gate Dam and into the Klamath Project, to provide irrigation supply (Jaeger 2004). The Klamath River is a major hydrologic feature of the basin, over 400 kilometer long (USGS 2014). Stream flows within the basin tend to be low during the summer, because of the hot, dry climate and lack of summer precipitation (Aldous et al. 2011), exemplifying a distinguishing characteristic of rivers throughout the West: a high proportion of reservoir storage in comparison with annual flow (Anderson and Woosley 2005).

The drainage of lakes and wetlands for agriculture use and the diversion of surface water for irrigation has had a significant impact on the surface-water hydrology of the basin (USGS 2014). Between 1905 and the 1960s, nearly 80% of the wetlands in the UKB were drained, diked, and converted to agricultural use (Perry et al. 2005) Approximately 500,000 acres of land within the basin is irrigated (USGS 2014). Relatively small amounts of irrigation water is diverted upstream of Upper Klamath Lake and a larger amount is pumped from groundwater (USGS 2014). The largest portion of irrigation water is provided by Upper Klamath Lake, this is often in direct conflict with ecological demands for fish survival (USGS 2014). Irrigated agriculture is still a major component of the American West's water use, using approximately 90% of extracted water (Fort 2002; USDA 2015). Within the Klamath Project, there are a variety of canals, laterals, and drains that help to move water, including 19 canals that cover 185 miles and are able to divert a wide range of amounts of water from 35 to 1,150 cfs (Bureau of Reclamation 2011). Though irrigable acres vary depending on the western basin, it is a land-use type typically found throughout the majority of them. As of 2008, the state of Oregon includes over 1.5 million acres of irrigated land and California over 7 million (USDA National Agricultural Statistics Service 2008).

In addition to water availability, water quality, a problem throughout many Western states, is also of concern within Upper Klamath Lake (Bradbury, Colman, and Rosenbaum 2004). Because of the amount of water used by irrigated agriculture throughout the Western states, contamination caused by agricultural runoff is a common theme, the main constituents of concern being: salinity, nutrients, trace elements, trace organic compounds, and pesticides (Anderson and Woosley 2005). Upper Klamath Lake is hypereutrophic, meaning it experiences a high amount of nutrient loading (Perkins, Kann, and Scoppettone 2000; Bradbury, Colman, and Reynolds 2004). Though the lake has been documented as being eutrophic since the late 19$^{th}$ century, its current hypereutrophic status is exacerbated by its shallowness (mean depth in the summer is as low as 2 meters) in combination with agricultural runoff (Perkins, Kann, and Scoppettone 2000; Bradbury, Colman, and Reynolds 2004).

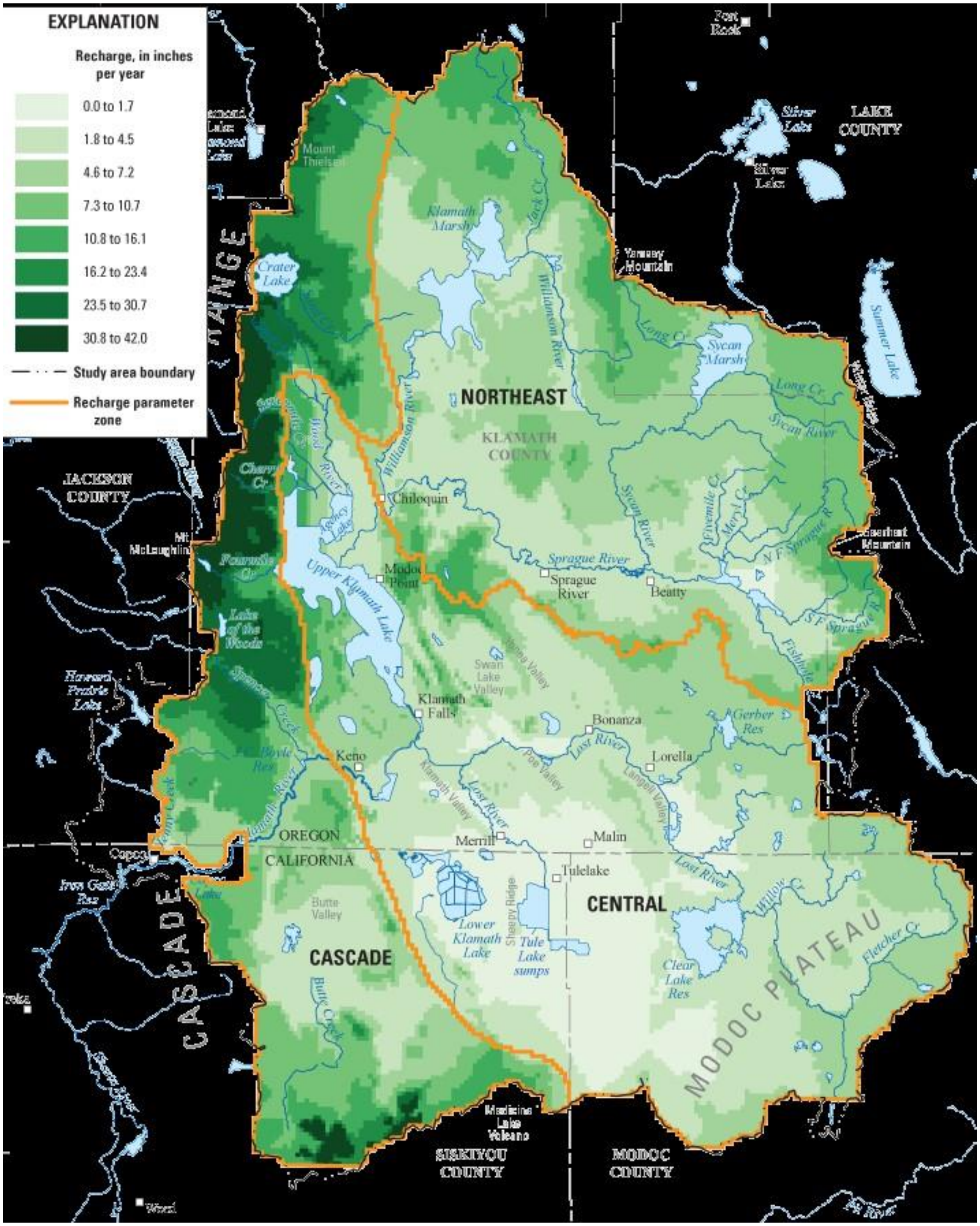


Figure 6. Estimated mean annual groundwater recharge from precipitation in the Upper Klamath Basin, Oregon and California, 1970–2004, in inches, and recharge parameter zones. (USGS 2012).

Cyanobacteria forms regularly, particularly during summer stratification and although the lake remains oxygenated due to mixing, the biochemical oxygen demand is generally quite high and low oxygen levels can result in fish kills (Colman, Bradbury, and Rosenbaum 2004).

Biota

The Upper Klamath River, above Iron Gate Dam, has historically provided habitat for a large amount of anadromous salmon and steelhead (Hamilton et al. 2005). Prior to the damming of the river, it is estimated that the Klamath-Trinity River systems were home to 650,000 to 1 million salmon (Hamilton et al. 2005). Fishing has been and continues to be of great economic and cultural importance for many in the region (Hamilton et al. 2005). Upper Klamath Lake also provides habitat for various species of fish, boasting 18 native species (National Research Council of the National Academies 2008). Two endangered fish species are found within the UKB, both reside in Upper Klamath Lake: the shortnose and Lost River suckers (National Research Council of the National Academies 2008). The coho salmon was historically found throughout the entirety of the Klamath Basin but has been extirpated from the upper portion following the installation of Iron Gate dam (Milner 2015). The UKB is still an integral part of the coho salmon's habitat through the movement of water, or lack thereof, to the Lower Basin (Milner 2015). Both the coho salmon as well as another fish species, the bull trout, are listed as threatened through the Endangered Species Act (National Research Council of the National Academies 2008). The decline of fish species is another common theme found throughout the American West; the highest rate of endemism, the restriction of species to a particular location, is found in the western states (particularly in the Southwest) on the continent (Anderson and Woosley 2005).

## Land Use

The population of the UKB is relatively low, with about 70,000 as of 2006 (USGS 2010). The largest majority of this population resides within Klamath County on the Oregon side of the border, with Klamath Falls being the largest city (USGS 2010). Population on the California side of the UKB is hard to estimate due to the dispersed nature of settlement, however, a 2000 estimate puts the number around 3,000 (USGS 2010). Historically, the land has supported the uses of the Klamath and Modoc tribes, neither of whom utilized irrigation as a farming technique but relied heavily on the fisheries in the area (Doremus and Tarlock 2008). The federal reclamation movement began a shift in land use and fueled white settlement of the region by creating a more agriculturally productive area (Doremus and Tarlock 2008). The establishment of appropriative rights and irrigation projects within the basin were an added incentive to begin more heavily settling (Doremus and Tarlock 2008). The Klamath Project, built in 1902, was one of the first to be built under the federal reclamation program (Doremus and Tarlock 2008). The Project diverts almost 1.7 billion cubic-meters of water for irrigation purposes; there are over 970 square kilometers of land irrigated through the Klamath Project in Oregon and California, as well as at least another 700 square kilometers of privately irrigated lands (Doremus and Tarlock 2008). Water projects are a common theme throughout the West, thanks to responses to the droughts of the late 1800s and early 1900s, which solidified the need for dependable water resources in water manager's minds. In order to increase agricultural production many hydrologic changes took place, not just in the form of dam building, but also draining of wetlands, and diverting of water from aquatic systems (Bradbury, Colman, and Reynolds 2004).

Agriculture, made possible through the Klamath Project, still plays a significant role in land use in the UKB and the often opposing demands of irrigators and fish is key to understanding the conflicts within the region (Doremus and Tarlock 2008). Agricultural production and ranching represent a large amount of the land use within the UKB, primarily grass/pasture and alfalfa crops. The crop types within the UKB have shifted since in the 2001 drought; mainly from potatoes to more drought-resistant crops like alfalfa (Doremus and Tarlock 2008; USDA 2016). Alfalfa uses a large amount of water, compared to many other crops due in part to its lengthy root system and relatively long growing season (Shewmaker, Allen, and Neibling n.d). Because of the high amount of consumptive water use, it may seem counter intuitive to shift towards alfalfa in regions facing water scarcity, such as the UKB. However, alfalfa can be quite flexible in its water consumption and is relatively drought tolerant (Orloff, Bali, and Putnam 2014). Estimates range from approximately 50 to 120 cm of water requirements per season, with variables such as the number of cuttings, variety, and climate responsible for the large variation (Shewmaker, Allen, and Neibling n.d.). Its deep root structure can be helpful in times of water scarcity because it allows the plant to access moisture deeper in the soil profile (Orloff, Bali, and Putnam 2014). Alfalfa is also able to enter “drought-induced dormancy”, surviving relatively long periods without water from irrigation (Orloff, Bali, and Putnam 2014).

Culture

The Klamath and Modoc have a deep connection to the Klamath River, culturally, spiritually, and in terms of historic subsistence (Doremus and Tarlock 2008). “Their connection to the natural landscape is centered on the river where traditional salmon fishing provides sustenance; the river and its salmon have produced culture” (Jenkins 2011, 71). The Klamath tribe was given a reservation through an 1864 treaty; however, the Modoc tribe was also forced to share the reservation (Doremus and Tarlock 2003). Neither group was particularly happy with the situation; the Klamath did not want to pursue irrigated agriculture that was part of the federal government’s plan nor did the Modoc want to live with the Klamath (Doremus and Tarlock 2008). Following World War II, a period known as the ‘termination era’ (*US v. Adair* 1983) the Klamath reservation was all but eliminated, leaving just 372 acres between not only the Klamath Tribe but also the Modoc and Yahooskin tribes (Doremus and Tarlock 2008). These termination policies, like House Concurrent Resolution 108, were utilized as an effort to force assimilation into white culture from Tribes and for them to be “freed from Federal supervision and Control” (Walch 1983, 1185). Loss of their land has been keenly felt by the Tribes and the Klamath have offered irrigators the opportunity to “subordinate its water rights” (essentially placing irrigator water rights as a higher priority date) in exchange for 695,000 acres of national forest (Doremus and Tarlock 2008, 66). This state of affairs also complicates water management in the basin. Although the Klamath have lost the bulk of their land, they have retained water rights because of their right to fish, hunt, and trap, all of which depend on in-stream flows (Doremus and Tarlock 2008). Because of the precedent setting case *United States v. Adair*, these rights are viewed legally as "time immemorial", which places them as a first priority right (Doremus and Tarlock 2008, 72).

Although agriculture is declining as an economic source within the region (the largest shares of household incomes now stem from pay outside of the basin), it remains an integral part of the identity of people living within the basin (Doremus and Tarlock 2003), especially the UKB, which is still relatively unpopulated. For example, Klamath County, OR, the majority of the basin, is home to just over 66,000 people and is experiencing a population decrease (U.S. Census Bureau 2015). "For many, this attachment to farming is tied to a sense of heritage and obligation to preceding and succeeding generations" (Doremus and Tarlock 2003, 296). This makes the demand conflicts about much more than just water and increasingly about a way of life, a much harder thing to grapple with and far more sensitive topic.

# CHAPTER 3

# LITERATURE REVIEW

This research resides at the intersection of several well-established research fields (Figure 7). In reviewing the existing research, a temporal gap in the literature was revealed. Addressing the effectiveness of the policies put in place by water managers following the drought of 2001 and assessing the current adaptive capacity of the UKB resides at the confluence of seven separate subtopics: water management in the West, stakeholders and demands, climate change and water supply, drought management, political ecology, natural hazards, and adaptive governance (Figure 1).

Water management in the West revolves around the laws pertaining to water rights (Singleton 2002), which add a complex layer to allocation and management during drought years (Davis 2001). Stakeholders and demands are at the crux of this research: the demand conflicts that surround water allocation are directly related to the various sectors, both in terms of the amount of water needed and the perceptions regarding water use (Doremus and Tarlock 2003). Climate models suggest that climate change may affect the overall water supply, as well as the temporal precipitation regime in the Pacific Northwest, which may create more water scarcity seasonally, adding another component for water managers in the UKB to consider (Aldous et al. 2011). Drought management is an integral foundation for this research as it historically has been reactive and crisis-driven; this research will evaluate whether the UKB is moving


Figure 7. Nodes of literature review.

towards more adaptation in planning for and mitigating water scarcity issues within the basin (Wilhite, Sivakumar, and Pulwarty 2014). Examining the UKB through the lens of political ecology will help to explain the "pendulum swing" of policies, which began with the curtailment of irrigation water in 2001, swung the opposite direction in 2002 with the releasing of more water (that likely influenced massive fish kills) (Boehlert and Jaeger 2010) and has continued throughout the basin to the present. There has been much research completed in the realm of adaptive governance, which has suggested a shift towards more adaptation, simultaneously suggesting that the adaptive capacity of the region is also shifting (Gosnell and Kelley 2010; Chaffin, et al 2016).

Water Management in the West

Water allocation is of particular importance within the arid and semi-arid West; the various demands on often already scarce resources can become more complicated by conflicts in values (Tarlock and Van de Wetering 1999; Davis 2001). This inherent conflict is most obvious in demands and cultural perceptions that utilize water for economic benefit versus the demands and cultural perceptions that insist on leaving some amount of water within streams and rivers for non-use values (Davis 2001; Singleton 2002). These conflicts are complicated by the overarching water management structure in the American West, which features stakeholders and management authorities from a variety of levels (i.e., federal, state, local) (Davis 2001). The doctrine of prior appropriation, which allows those with senior water rights to utilize their full allotment first, and is in use by most Western states, can highlight and exacerbate these conflicts (Davis 2001).

The prior appropriation system's foundation is the establishment of a priority date for that particular water right (Davis 2001). The differences between this system and the riparian system, utilized in the eastern states, is a significant reason why the West was able to be settled (Dunlap 2013). The history of prior appropriation resides in mining camps and irrigation settlements in Colorado and California (Tarlock 2002). One of the foundations for the establishment of this system was the necessity for security regarding water (Tarlock 2002). Rather than utilizing a correlative framework, as in the riparian system in place in the far more humid east, the semi-arid and arid west required a certain amount of assurance that if irrigation canals, diversions, etc. were put in place (a costly endeavor), water would be available (Tarlock 2002). It also ensured to whom water would be allocated in times of water scarcity, or at least gave the illusion of this (Tarlock 2002). The establishment of when a person first began utilizing water and associated priority date means that, in times of water scarcity, like the 2001 drought in the UKB, those with older, or "senior" priority dates will receive their allocation of water rights either before or in lieu of those with younger, or "junior", priority dates (Davis 2001). The second principle on which the system resides is that of beneficial use, the idea that a given water right must be put to a specific use and not "wasted" (Tarlock 2002). At the heart of the prior appropriation system, and many of the demand conflicts in the semi-arid and arid American West, is the idea of water as a property right.

Consumptive water users tend to view water rights as, "vested and inviolable", a viewpoint much more akin to a traditional property right, rather than the fluidity of a water right (Gray 2002, 17). "Because water molecules commingle, use at a given point may affect other uses at the same point, and because water is a universal carrier, there may be synergetic effects" (Ditwiler 1975, 666). Stakeholders interested in maintaining levels of in-stream flows often argue that water rights are unique and do not fit into the traditional property right structure (Gray 2002). It is true that the dependency on hydrologic variability on water rights, in addition to demand conflicts and federal and state laws affecting water quantity, make water rights seem like a separate kind of property right (Gray 2002). In addition to these issues, there are also contract rights (Gray 2002), established between specific users and multi-scalar governmental agencies.

One of the largest institutions in many water contracts is the United States Bureau of Reclamation (USBOR), created by the Reclamation Act of 1902 (Reclamation Act 1902; Milner 2015). The Act and agency were established to encourage development of the West and to provide the mechanism for funding and developing water storage projects large enough to support irrigated agriculture (Dunlap 2013). The USBOR continues to manage water projects and is involved in delivery contracts across the West (Dunlap 2013). In the UKB, the Klamath Project was one of the first of these new water projects, beginning in 1905 (Dunlap 2013). The Klamath Project provides water to almost half of the irrigated acres within the UKB (Milner 2015). One of the difficulties within the Klamath Project's deliveries of water is the geology within this portion of the basin is not conducive to large water storage projects (Dunlap 2013). This complicates water deliveries in times of water scarcity and adds tension to competing demands already in place.

## Stakeholders and Demands

The history of water use in the UKB is a microcosm of much of the American West and the basin has, in many ways, been defined by its water resources (Davis 2001). Potential stakeholders within the UKB include: recreational users, irrigators, fish (both commercial interests, as well as endangered species in-stream flow requirements), hydropower, tribes, and municipalities (Doremus and Tarlock 2003). Geographic scale can also play a role in the definition of this landscape (Doremus and Tarlock 2003). While many natural resource managers subscribe to the idea that smaller sub-groups allow for a more participatory experience for stakeholders, within the realm of water resource management, smaller basins can make the management of scarce resources more difficult (Doremus and Tarlock 2003). This is true for four main reasons: 1) smaller basins delineate the line between “winners and losers” more clearly; 2) conservation costs tend to be local, and benefits tend to be on a more diffuse, larger geographic scale; 3) smaller basins generally correlate with entrenchment in specific water use; and 4) the margin of error in terms of poor management decisions is smaller (Doremus and Tarlock 2003, 337).

The most significant conflict in the UKB is between farming and the tribes and fishing communities, all of whom have their own set of cultural traditions and values (Doremus and Tarlock 2003). The necessity for in-stream flows, either to ensure viable fisheries for commercial/cultural purposes downstream or legal requirements under the Endangered Species Act (1973), makes allocating the often-scarce water resources, both within the UKB specifically and within the broader region of the American West, more difficult (Moore, Mulville, and Weinberg 1996). This is also complicated by requiring other demands to take into account the goal of preserving the listed species, conflated by the sheer number of listed species of fish which are dependent on waterways within the West (Moore, Mulville, and Weinberg 1996). This can often lead to a “farms versus fish” mentality, which complicates stakeholder participation within a specific basin (Doremus and Tarlock 2003, 337).

The Endangered Species Act is the vehicle for bringing environmentalism to the UKB (Tarlock 2007). Given the history of water rights within the West, the establishment of federal jurisdiction over water has caused significant tension (Moore, Mulville, and Weinberg 1996). The conflict seen in 2001 had been brewing within the basin since the establishment of two endangered species in 1988 (USFWS 1993). The Endangered Species Act (1973) affects water in the UKB in a few ways. Firstly, §7(a)(2) of the Endangered Species Act requires consultation between federal agencies (Parobek 2003). This translates into a requirement for any federal agency to consult with USFWS if an endangered species is involved (Parobek 2003). Secondly, the taking of an endangered species, defined in §2(a)(19) to include harassment of killing/collecting/otherwise removing of a listed species, is prohibited under §9 of the Act (1973). An incidental take permit can be issued, which lifts this prohibition up to a certain extent and for very specific uses, but are often difficult to obtain (Parobek 2003). In terms of aquatic species, these limitations are most influential regarding the amount of water that remains in both rivers and lakes to promote aquatic habitat, in addition to accidental takes of fish in irrigation canals (Parobek 2003). In water-scarce, western basins, like the UKB, this shift in how water is allocated can cause conflicts in a few different ways. The foundational conflict is the legal framework that encompasses water in the West is predicated on the idea of water as a property right, rather than a common resource. The curtailment of these rights is often seen by those who subscribe to that idea as federal government overreach and an underlying cause of much of the conflict (Parobek 2003).

Legally, this conflict is manifested through legislation around takings, as they relate to water rights.

The U.S. Constitution protects property owners from a) federal government seizure of property (U.S. Const. amend. IV) and b) the loss of economic viability of said property through the Fifth Amendment, also referred to as the Takings Clause. "Nor shall private property be taken for public use, without just compensation" (U.S. Const. amend. V). Through case law, two distinct types of takings evaluations have evolved: the physical seizure of property and a regulatory taking, which is subject to a balancing test (Echeverria 2005). In *Penn Central v. City of New York* (1978), a three-part balance test was established (Echeverria 2005). This test includes the economic effect of the government action, the amount to which this action disrupted the plaintiff's investment backed expectations, and the character of the government's action (this last test is usually interpreted by the "reasonableness" of the action (Echeverria 2005). *Lucas v. South Carolina* (1992) established the exception of a categorical taking, in which the action(s) of the federal government have robbed the property of all economic value (Westbrook 2006). The importance of these precedent-setting cases is seen in the UKB in *Klamath Irrigation District v. United States*.

The differences in demands of stakeholders in the UKB is highlighted in the *Klamath Irrigation District* case. After the 2001 drought, irrigators whose water rights were curtailed filed an inverse condemnation claim, which purports that the federal government has violated a property owner's rights under the Fifth Amendment. The complaint hinged on a claim of both takings and a breach of contract under the Klamath River Basin Compact (1957). This compact determines water allocation between California and Oregon (Westbrook 2006). An earlier decision in Tulare Lake Basin Water Storage District v. United States (2001) found in a Federal Claims Court that the Bureau of Reclamation was within their right to curtail water but in doing so must provide compensation; ultimately deciding in favor of the Lake District (Westbrook 2006). This finding heartened Klamath irrigators for their own case. The original takings case, however, was dismissed but has been revived upon appeal (Spohr 2012).  "The Klamath litigation highlights the ongoing cultural war that is waging in the American West. It showcases the battle between the status quo of the irrigation culture and the changes in demand that have occurred in response to the booming populations of western cities" (Dunlap 2013, 114).

Tribes are another important stakeholder in the UKB. The Klamath and Modoc have historically occupied much of the upper portion of the basin, depending on fisheries for both economic and cultural benefits (Doremus and Tarlock 2008). *Winter v. U.S.,* in 1908, established the Reserved Right Doctrine. This ensures land reserved by the federal government for a specific purpose (e.g., Tribal reservation) water rights necessary to fulfill that purpose are implicitly reserved as well (Benson 2002). Although, this doctrine is most often referenced regard tribal water rights, it can also be applied to other forms of federally reserved lands, like national wildlife refuges. Post World-War II, termination policies, which dissolved reservations, were put in place in an attempt to integrate Tribe. This affected the Klamath Tribe through the Klamath Termination Act of

1954 but *U.S. v. Adair* (1983) legally preserved Tribal water rights even without a reservation (Hood 1972). The *Adair* case confirmed the Tribe's water rights to protect their hunting and fishing rights on former reservation lands, in addition to ensuring water for agriculture (Hood 1972). Conflicts between tribes and other stakeholders arise in terms of fish habitat: the Klamath Tribe's water rights include in-stream flow requirements (Milner 2015). These requirements are due to the importance of fishing to the Tribe culturally, and are not lost through non-use, unlike the majority of appropriative water rights holder who are required to put their rights to beneficial use (Milner 2015).

Climate Change and Water Supply

The UKB regularly faces issues with water scarcity. These issues stem from demand conflicts on an already stressed system (Aldous et al. 2011). The summer months tend to be the times of highest water demands, mainly because of the requirements for irrigation and they correspond to the driest times of the year (Aldous et al. 2011). Throughout much of the Pacific Northwest, including the UKB, it is expected that climate change will affect the timing more than the amount of overall precipitation, although a decrease in overall precipitation is possible (Aldous et al. 2011). The water resource challenges faced in the UKB, as in many basins in the American West, to shape it. "Climate change adds to those historical challenges, but does not, for the most part, introduce entirely new challenges; rather it is likely to stress water supplies and resources that are already in many cases stretched to, or beyond, their limits" (Dettinger, Udall, and Georgakakos 2015, 2088).

Due to the groundwater storage within the UKB, groundwater levels are directly related to both wet and dry periods and periods of significant pumping of groundwater (Gannett, Wagner, and Lite 2012). This means that in times of seasonal water scarcity (e.g., irrigation season), there may not be sufficient storage availability in place. The temporal precipitation regime shift projected by various global climate change models (Aldous et al. 2011; Hamlet 2011; Madadgar et al. 2013; Dettinger, Udall, and Georgakakos 2015) increases the severity of this issue. In basins like the UKB that are heavily snowpack dominated, a temporal precipitation regime shift can wreak havoc both ecologically and economically by increasing water scarcity as well as the conflicts between various demands (Dettinger, Udall, and Georgakakos 2015).

Drought Management

Historically, drought management has been reactive and crisis-driven, rather than focused on having an adaptive plan that prepares for the potential of a drought (Wilhite, Sivakumar, and Pulwarty 2014). This crisis-driven drought management often results in less effective measures to deal with water scarcity. It has become clear, as water scarcity becomes a more pressing problem for large portions of the American west, that a) having a myriad of tools to address drought (e.g., water banks, water reserves, etc.) and b) states should prepare their management framework prior to its occurrence (Pease and Snyder 2017). The inherent qualities of drought: its creeping nature, its enigmatic beginning and ending, and various modes of impact make it a difficult natural hazard to manage; it is, however, a normal occurrence in many climatic regimes, especially in arid and semi-arid systems (Wilhite, Sivakumar, and Pulwarty 2014). The intensity, duration, and spatial coverage are the main characteristics in identifying various kinds of drought (Wilhite, Sivakumar, and Pulwarty 2014). Early warning systems can be some of the most effective management tools in relation to drought; these are utilized through assessing a region's vulnerability to drought as well as putting in place a drought plan (Wilhite, Sivakumar, and Pulwarty 2014). Drought plans focus on a cyclical process, which begins at protection, utilizing mitigation techniques, planning, and monitoring (Wilhite, Sivakumar, and Pulwarty 2014). Once a drought event occurs, the plan moves towards recovery through utilizing impact assessments (Wilhite, Sivakumar, and Pulwarty 2014). The plan then comes full circle, beginning again at mitigation techniques (Wilhite, Sivakumar, and Pulwarty 2014).

There are generally four types of accepted drought: 1) meteorological; 2) hydrological 3); agricultural; and 4) socioeconomic (Wilhite and Glantz 1985). Meteorological drought is most commonly defined through a comparison to the average amount of precipitation for a region (Wilhite and Glantz 1985). Hydrological drought refers to a lack of precipitation and its effect on both surface and groundwater levels; it is generally measured on a watershed scale (Wilhite and Glantz 1985). Agricultural drought utilizes criteria from both meteorological and hydrological drought and links those to impacts on agriculture (e.g., the difference between potential and actual evapotranspiration, etc.) (Wilhite and Glantz 1985). In assessing the impacts, agricultural drought often needs its own set of management tools, given the uniqueness of the spatial and temporal variability inherent within this kind of drought (Nam et al. 2012). The steps are often similar, however, the data required are different; both meteorological and soil characteristic data are required to get a full analysis of agricultural drought (Nam et al. 2012). Socioeconomic drought takes into account the criteria of the other three to measure the supply and demand characteristics of a given good (e.g., a drought has influenced the growth of a particular crop which, in turn, has influenced the economics of a region) (Wilhite and Glantz 1985).

## Political Ecology

Political ecology has been defined various ways. A difficulty in utilizing political ecology as a lens to understand events and actions surrounding the human-environment relationship is this lack of an accepted definition. One of the simultaneous strengths and weaknesses of the discipline is its ability to be applied to a varied range of scenarios, making it difficult to define and grasp but also useful in explaining and understanding. The multimodal narratives found within political ecology each attempt to answer specific questions about the human-environment relationship. Robbins (2004) defined three main tenets found within any definition of political ecology: 1) it is an antithesis to "apolitical" ecology; 2) there is a foundational set of assumptions; and 3) the "mode of explanation" tends to be consistent. In the first tenet, Robbins (2004) is referring to the inherent political nature of any decision or event made in regards to the human-environment relationship. The second tenet understands that any definition of political ecology accepts particular assumptions about this relationship. For example, a common assumption particularly relevant to research on water resources within the UKB is the unequal distribution of costs and benefits associated with environmental change amongst actors (Robbins 2004). Finally, the last tenet suggests that whatever the definition or its application, the final result of explaining this relationship is generally consistent (Robbins 2004).

The history of political ecology is deeply rooted in environmental determinism. Kroptokin (1888) sets precedent through a focus on production and, in particular, focusing on marginalized people. This encouraged a shift in human-environment research and the foundation of what we recognize as political ecology today. The role of hazards research is particularly relevant to the UKB and the mode of explanation within political ecology can be compared to that of the "Swiss Cheese Model" in natural hazards research. The recognizable traits of political ecology, determined by Kroptokin, are a focus on production (e.g., farming, ranching), archival and field-based research, a focus on communities that are or have historically been marginalized or disenfranchised, the inclusion and emphasis on of traditional environmental knowledge, and the building from the landscape up (Kroptokin 1888; 1985; 1987; 1990). The result of this framework suggests that, without outside influences, localized production systems for the purpose of subsidence are generally sustainable as well as cooperative (Robbins 2004). This work is flawed in some respects (e.g., the romanticizing of cooperation on a local scale) and there has been much research following, which is beyond the scope of this literature review. However, Kroptokin's work is included because it sets the foundation for what is recognized today as political ecology. This foundation understands that larger political decisions unduly influence local production systems and the human-environment relationship.

Robbins (2004) identifies four main theses within political ecology; two of which are prevalent in the UKB. How these theses relate specifically and help to explain events within the UKB will be further examined in the discussion section of this text; it is important first to understand the framework in which they fall. The first is the degradation and marginalization thesis. This thesis rests on the idea that local production systems, which may not be environmentally harmful and are generally sustainable, become harmful and promote overexploitation of resources with the increasing assertion of and integration into regional and global markets and the transfer/imposition of new power structures on local collective property (Robbins 2004). This then results in a marginalization of producers, reduced returns, and degradation of the resources themselves (Robbins 2004). This thesis attempts to explain environmental change in terms of why and how it is occurring (Robbins 2004). The second envisions that environmental conflict is part of a broader conflict that encompasses race, gender, and class and that these conflicts influence each other (Robbins 2004). This thesis attempts to explain environmental access through how resources are accessed and who is able to access them (Robbins 2004).

In any discussion on the human-environment relationship, particularly through the lens of political ecology, a segment must be included on the construction and destruction of nature. In many ways, the natural landscape is also a social one; nature can be viewed as a human construction (Robbins 2004). Our understanding of what is "natural" is inherently predicated on our worldview and therefore so is the destruction of nature (Robbins 2004). To decide to what point to restore an ecosystem, recover a species, or at what point a population is healthy requires some assumptions. Those assumptions, while they can be influenced by science and objective data, are ultimately a human construction (Robbins 2004). The markers that are used to identify environmental destruction (e.g., loss of biodiversity, loss of natural productivity, loss of usefulness, etc.) and which of those are deemed more relevant are of a social construction that cannot be separated from culture and the particular worldview of those doing the determining (Robbins 2004). This complicates policy and the allocation of resources but also helps to explain events and reactions within the human-environment relationship.

There has been a large amount of research done through the lens of political ecology on water resources, particularly focusing on developing countries and urban water systems. That it is not to say, however, that the lessons from these discussions cannot be transferred to a rural, more developed world context, like the UKB. For example, Mehta (2011) determines four main lessons in regards to water scarcity: 1) there are inherent problems in focusing on the use of a resource (or its value); 2) technological solutions are not neutral as they are often purported to be; 3) conflicts arise not over scarcity but over unequal access and control; and 4) socio-political views of scarcity need to focus on views that are discursive and materialist. The case study Mehta utilizes to uncover these four points is in western India and the scenario, stakeholders involved, and over water availability is different from that of the UKB (Mehta 2011). However, comparisons can be made, particularly in the context of focusing on the use value of water. The UKB's economy is still highly driven by agricultural production, including traditional farming and ranching. In this case, the argument is that water should go to the highest economic use value and not take into account nonuse valuation. This means, the cultural value of healthy fisheries and habitat to the Klamath Tribes, the ecosystem services value to the region, and the aesthetic value to recreationalists are not taken into account.

Similarly, the water privatization debate, which exists solely on an urban plane (Bakker 2011) and is not relevant to the UKB, can lend knowledge to the water property debate. The two center on the same question: what precisely is water? We, of course, know the physical properties that make up water but the role it plays on the socioeconomic landscape is a far more complex and pervasive question. Bakker (2011) discusses the idea that water is a human right. Because the UKB is such a rural location and water privatization in this particular context (i.e., urban) has not been discussed, it may seem that this conversation is irrelevant. However, in the UKB, the question is the same, though in a different context: is water a "commons" or a commodity? If a commons, then the federal government should have the ability to limit water use in order to promote fish health, habitat, and protect the cultural resources of the Klamath Tribes. If, however, it is a commodity than agriculturalists are owed compensation for the irrigation curtailments of 2001.

Natural Hazards

A natural hazard is defined as, "any natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption or environmental damage" (UN/ISDR 2009). There are many difficulties in planning for and recovering from natural hazards. One of these difficulties is accurately accounting for losses (Gall, Borden, and Cutter 2009). Because these losses can be both direct and indirect, they can be difficult to aggregate. Direct losses refer to those losses sustained by infrastructure: buildings, machinery, roads, crops, etc. (Gall, Borden, and Cutter 2009). Indirect losses can be harder to define; they can range from economic losses (e.g., temporary or permanent closure of businesses) to societal/cultural losses, as well as the loss of ecosystem services (Gall, Borden, and Cutter 2009). Depending on which measure is being used, how "indirect losses" are defined, and the method used to determine these losses, the effects of various natural hazards can appear very different. Gall, Borden, and Cutter (2009) identified six biases within natural hazard reporting that underscore the difficulties in accurately reporting the losses with which they are associated: hazard bias, in which reporting may be different for various hazards based on the priorities of the reporting agency; temporal bias, in which not all losses are comparable over time; threshold bias, in which small losses often go unreported, resulting in inaccurate loss accounting; accounting bias, or inaccuracies in disaster loss estimation; geography bias, in which because of political political/administrative boundaries, losses are not always comparable across space; and systemic bias, in which losses are not always adjusted for inflation.

Within the natural hazard literature exists quasi-natural hazards, or those hazards that are triggered by natural processes but exacerbated by the actions of humans, whether intentional or not (Smith 2013). Drought is a hazard that falls into this category. Although the triggers of drought are natural, they are often exacerbated by humans; examples of this can be seen through lack of drought planning and over-allocation of water resources even in good water years.

Although, it fits within this framework of quasi-natural hazards, drought is often forgotten as a natural hazard. In part, this is because of its nature (i.e. creeping, multi-modal, difficult to define beginning and ending, large spatial extent, prolonged period, complex). It is also difficult to quantify the effects of drought and this has translated into inconsistent recording into natural hazard databases such as the Emergency Events Database (EM-DAT) (Below, Grover-Kopec, and Dilley 2007). Efforts have been made to revise the methods with which drought events are recorded to better document these natural hazards (Below, Grover-Kopec, and Dilley 2007). These include establishing distinct start and end dates and using hierarchy of binary events to determine how best to record multi-year and multi-country events (Below, Grover-Kopec, and Dilley 2007). Start and end dates are important because drought losses typically lag, sometimes by several months, to when a meteorological drought is established (Below, Grover-Kopec and Dilley 2007). Ensuring the most up-to-date information is available allows decision and policy makers to better react and prepare for drought. Utilizing geospatial information and drought information tools can help policy makers better understand where vulnerabilities lie and allow for better drought-preparedness (Vincente-Serrano et al. 2012).

The Swiss Cheese model (Figure 8) of disasters was initially developed to explain technological disasters (Reason 1990) and has also been applied to the aviation industry (Petley 2009). The framework behind the Swiss Cheese model, is that strategies put in place to defend against a particular hazard represent each slice of cheese, the holes represent weaknesses in each of those particular lines of defense and when they line up it results in higher losses than would otherwise be seen (Reason 1997). Although the model was developed for technological disasters, it can very easily be applied to natural and quasi-natural disasters.


Figure 8. Swiss Cheese model of disasters (Reason 1997).

The Swiss Cheese model is a good tool to help explain the losses experienced by the UKB in the 2000/2001 drought. The natural hazard of drought by itself may not have resulted in the severe losses felt by the agricultural industry but the added complexity of legal requirements for both lake levels and instream flow intensified those losses. Likewise, the fish kill seen in 2001 was likely influenced by larger than normal Chinook salmon returns and high water temperatures but was likely complicated by Bureau of Reclamation's annual operation plan, which reduced flow past Iron Gate Dam and allowed for regular water deliveries to irrigators (California Department of Game and Fish 2004; Belchick, Hillemeir, and Pierce 2004). It is easy to see how various circumstances, some human-caused and some natural-caused, can complicate and intensify losses a natural hazard; the underlying theme of the Swiss Cheese model.

<u>Adaptive Capacity</u>

Adaptive capacity can be a difficult concept to fully understand: in part because researches have defined it in different ways. For the purposes of this research, it is defined as the ability of institutions to prepare for and mitigate water scarcity. It is important that agencies and stakeholders, across various spatial and institutional scales, are able to adapt to changing weather and climate regimes, particularly in places like the American West that depend so heavily on precipitation during specific times of year (Hill and Engle 2013). This is especially true for water management resources as population grows and demand subsequently increases, again, particularly in areas like the arid and semi-arid American West, where demand conflicts over water already abound (Hill and Engle 2013). In the case of water resources, those new conditions are often centered on the occurrence of drought.

Adaptive capacity is often closely linked with environmental governance, "processes for making decisions about the use and conservation of natural resources" (Chaffin et al. 2016) and vulnerability research, which in terms of natural resource management, examines where people are most at risk of loss via a natural hazard over a discrete geographic area or sector, often utilizing various temporal or spatial scales (Adger et al. 2004). Water scarcity is not defined as a natural hazard, because it is a human-caused condition, however, it can be caused or worsened by drought. The decisions that water managers make (i.e. environmental governance) can often determine the degree to which these losses are experienced. It is the purpose of this research to test whether adaptive capacity has changed in the UKB, and more specifically, to see how those decisions employed by water managers are effected by occurrences of drought.

Adaptive capacity can be defined by many realms from economic resources, infrastructure, technology available, to awareness (Juhola and Kruse 2015) but it also must address social networks and the relationships and communication between institutions that manage natural resources (Chaffin et al. 2016). "The interaction of environmental and social forces, determines exposures and sensitivities, and various social, cultural, political, and economic forces shape adaptive capacity" (Smit and Wandel 2006, p. 286). Therefore, an adaptive capacity assessment must examine not only the institutions and their individual resources but the relationships between institutions that manage the same resource, or influence policies or management of said resource.

Assessing adaptive capacity can be done in a variety of ways, across different scales; in fact, scale can be one of the most important beginning qualifications in determining how to conduct an adaptive capacity assessment (Hill and Engle 2013). These scales can be either temporal or spatial or both. This research utilizes both temporal and spatial scales by limiting the study area to the UKB and examining a discrete time-frame and the how of completing an adaptive capacity assessment will be discussed in greater detail in subsequent chapters.

The UKB has been especially fraught with tensions between stakeholders following the severe 2001 drought (Doremus and Tarlock 2003). However, previous research suggests that the basin is shifting toward a more collaborative institutional structure and the capacity of the UKB to deal with demand conflicts and water scarcity issues is becoming more adaptive (Gosnell and Kelley 2010; Chaffin, et al 2016). It is becoming increasingly better understood how a social structure (e.g., experience, commitment, relationships, leadership, collaboration, and trust) (Hill and Engle 2013) can heavily impact the adaptive capacity across a specific scale (Gupta et al. 2010; Engle and Lemos, 2010; and Hill 2013).

Research mapping social networks, which visualizes the relationships between distinct stakeholder groups, has shown that stakeholder relationships have shifted over time, implying a movement towards more adaptive capacity (Chaffin, et al 2016). Further support for this movement is shown by agreements (e.g., Klamath Basin Restoration Agreement) decided upon between stakeholders with historically conflicting usage demands, indicating a power shift within the basin (Chaffin, Craig, and Gosnell 2014). Despite this, the situation is still tenuous and the shift towards adaptive capacity could easily recede (Chaffin, Craig, and Gosnell 2014), especially given the uncertainties that remain regarding water supply, particularly seasonal water supply (Aldous, et al 2011).

# CHAPTER 4

# METHODS

This research is meant to fill a temporal gap in the literature focused on water management in the UKB. This research identifies key stakeholders and the amount of effort placed on water management strategies. It conducts an adaptive capacity assessment and helps inform whether the strategies and policies put in place following the severe drought of 2001 are temporally linked with occurrences of drought. Understanding this link, or lack thereof, will show whether these strategies and policies moved towards adaptive management or remained reactive. This will add another data point in understanding the adaptive capacity of the UKB. Recommendations for future policies within the UKB will be included in subsequent chapters. To achieve these objectives, a mix of qualitative and quantitative methods were used by: 1) utilizing content analysis to assess various water management policies; 2) conducting semi-structured interviews; and 3) compiling an event history calendar.

## Content Analysis

During the first phase of this research, content analysis techniques were utilized to assess and organize water management policies in the UKB. The first step was to identify which texts should be analyzed. A total of 13 texts were chosen (Table 1); all are water management texts and involve plans for the water management of the basin, or evaluation of multiple plans. The oldest text was published in 2003 by the Klamath

Irrigation District and the most recent text was published in 2016 by the Bureau of Reclamation. Other agencies included National Fish and Wildlife Foundation, Natural Resources Conservation Service, USGS, Klamath Water and Power Agency, OR Water Resources Department, and the plethora of state and local governments, state agencies, organizations related to the Klamath Reclamation Project, Upper Basin irrigators, and environmental/other organizations who were signatories of the KBRA and KHSA. Texts varied in length, with the shortest being just eight pages and the longest 378 pages.

Table 1. List of water management texts chosen for content analysis.

| **Title** | **Agency** | **Stakeholder Group** | **Year** | **Length (pages)** |
|---|---|---|---|---|
| 2011 Klamath Project Annual Operations Plan | Bureau of Reclamation | Federal | 2011 | 8 |
| 2012 Klamath Project Annual Operations Plan | Bureau of Reclamation | Federal | 2012 | 10 |
| 2013 Klamath Project Annual Operations Plan | Bureau of Reclamation | Federal | 2013 | 7 |
| 2014 Klamath Project Annual Operations Plan | Bureau of Reclamation | Federal | 2014 | 9 |
| 2015 Klamath Project Annual Operations Plan | Bureau of Reclamation | Federal | 2015 | 11 |
| Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River | Bureau of Reclamation | Federal | 2015 | 40 |
| 2016 Klamath Project Annual Operations Plan | Bureau of Reclamation | Federal | 2016 | 8 |
| Water Management and Conservation Plan | Klamath Irrigation District | Regional | 2003 | 36 |
| Draft Business Plan for the Upper Klamath Basin | National Fish and Wildlife Foundation | Regional | 2008 | 31 |

Table 1, Continued.

| Title | Agency | Stakeholder Group | Year | Length (pages) |
|---|---|---|---|---|
| Work Plan for Adaptive Management Klamath River Basin Oregon and California | Natural Resources Conservation Service | Regional | 2004 | 21 |
| Evaluation of Alternative Groundwater-Managements Strategies for the Bureau of Reclamation Klamath Project, Oregon and California | USGS, Klamath Water and Power Agency and Oregon Water Resources Dept. | Federal and state | 2014 | 58 |
| Klamath Basin Restoration Agreement for the Sustainability of Public and Trust Resource Affected Communities | Various | All | 2010 | 378 |
| Upper Klamath Basin Comprehensive Agreement | Various | All | 2014 | 96 |
| **Totals** | **Various** | **Various** | **2003-2016** | **921** |

Content analysis is a method that allows researchers to make inferences that are both "valid and replicable" from a varied sources of texts (Berelson 1952; Krippendorff 2004, 18; Hsieh and Shannon 2005). The first step in the content analysis process involves identifying documents, which can vary greatly in type. Media analysis, which utilizes newspaper articles and other forms of media, is becoming more common in many social sciences. Because this research is attempting to uncover water managers' strategies and overall adaptive capacity of the UKB, only management documents were used. Key terms and words are then identified and analyses constructed (e.g., how many times a word or term was used, etc.) (Krippendorff 2004). Content analysis can also be utilized subjectively by the researcher, "coding" media based on *a priori* classification (Krippendorff 2004). The key terms and words identified in this research were adapted from Engle's (2013) study on state and community water systems. Some terms were excluded because they fell outside of the scope of the research or were redundant. For example, "Governor's role and drought committee", while pertinent to this research falls outside of the scope of that which is being examined. "Water plan" meanwhile, is redundant as these are management texts relating to water, meaning they could all generally be considered a "water plan". Adapted terms (Table 2) highlight the original wording, as well as the adapted version used. Adaptations were made to some terms to promote the likelihood of the software program search tool finding them or to better specify the term for this research. For example, "planning and management" was changed to "regional and local planning and coordination" to better delineate sources that discuss regional/local planning/coordination and Federal/state planning/coordination. Meanwhile, "physical-environment connection" was changed to "human-environment connection" because the latter was thought to be a more commonly used term. Some terms were added that are specific to this research. For example, "fish health" may not necessarily have been a relevant term in Engle's (2013) research but is relevant in the UKB. Following this adaptation, each key term or word was quantified within the texts.

Table 2. Analysis of key words and terms within water management texts of the UKB.

| Theme | Key word or term | Change made |
|---|---|---|
| *Water Management* | Water rights | From water permitting and rights |
| | Water law/legislation | |
| | Climate change planning | |
| | Banking and transfers | |
| | Valuing, pricing, and commodification | |
| | Human-environment connection | From physical-environment connection |
| | Water availability | |
| | Security and scarcity | |
| | Surface water dependence | Separated surface and ground water into two nodes |
| | Ground-water dependence | Separated surface and ground water into two nodes |
| | Monitoring and metering | |
| | Reservoirs and storage | |
| | Conservation, efficiency, and consumption | |
| | Water information and knowledge | |
| | Habitat degradation | |
| | Fish health | |
| | Commercial fishing interests | |
| | Water quality | |
| | Cultural considerations of fish vitality | |
| | Surface-groundwater interaction | |
| | Water management agencies | |
| | Alternative models for water management (on the horizon) | |
| | Water planning | |
| | Water plan | |
| *Drought/ scarcity planning* | Declarations, triggers, warning systems | |
| | Mitigation and planning | |
| | Regional and local planning and coordination | From planning and management |

Table 2, Continued.

| Theme | Key word or term | Change made |
|---|---|---|
| | Federal and state planning and coordination | From state-local coordination |
| | Tribal and Federal planning and coordination | |
| | Tribal and state planning and coordination | |
| | Governor's role and drought committee | |
| *Drought/ scarcity response* | General response and emergency management | |
| | Restrictions | |
| | Recent drought impacts and timeline | |
| | Intersection with other stresses | |
| | Previous drought events and experience | |
| | Drought and water politics | |
| | Climate and drought information and knowledge | |
| | Conflict between stakeholders | |
| | Coordination between stakeholders | |
| | Emergency well permitting | |
| **Key** | | |
| | Excluded | |
| | Used as is | |
| | Adapted--change noted | |
| | Author addition | |

Interviews with Water Managers in the Upper Klamath Basin

The second phase of this research focused on the water management institutions and stakeholders within the basin. Semi-structured interviews were used to identify perceptions of water managers of the adaptive capacity within the basin. This provided the foundation for the following phase, the creation of an event history calendar, as well as for providing recommendations in subsequent chapters. Semi-structured interviews are a balance between heavily structured survey questionnaires and open-ended interviews (Schensul, Schensul, and LeCompte 1999). This method allows for some amount of structure through pre-formulated questions but allows the answers to be open-ended and can be expanded by both the interviewer and interviewee (Schensul, Schensul, and LeCompte 1999).

It was imperative to identify key stakeholders and institutions within each demand in the region (i.e., hydropower, irrigation, municipalities, tribes, and in-stream flows/endangered species). This was done through research into the water management structure of the basin (e.g., institutional framework, main organizations or people associated with each stakeholder group, etc.). Following identification, a short list of questions was developed that aided the semi-structured interview process, though some questions were adapted for specific interviewees based on their knowledge base. A foundational set of questions (Table 3) was asked of each interviewee.

The utility of a semi-structured interview format depends on its flexibility. While this research utilized a guide of topics/questions to cover and a pre-established time-frame with the interviewee, interviewees were also allowed to follow topical trajectories and go outside of the agreed upon time frame (Schensul, Schensul, and LeCompte 1999). Interviews were set up utilizing two methods: the first took the stakeholder research

Table 3. Semi-structured interview questions.

1. How has the overall health of the watershed changed since 2001? In 2011-2015?
2. Have the main water resource concerns shifted since 2001? In 2011-2015?
3. What do you see as the important strategies being used by [interviewee's agency or stakeholder group] to mitigate and prepare for water scarcity?
4. Who do you see as the important stakeholders/institutions in the UKB?
5. How has [interviewee's agency or stakeholder group] collaborated with these stakeholders?
6. How have relationships between these stakeholders, both with the [interviewee's agency or stakeholder group] and with each other, shifted since 2011? In 2011-2015?
7. How do you think the Final Order of Determination affected stakeholder relationships in the basin?
8. How do you think Drought Declarations in 2013-2015 and the Klamath calls have affected stakeholder relationships in the Basin?
9. How would you describe [interviewee's agency or stakeholder group] goals for the UKB? What do you see as the main barriers to achieving these goals?
10. What funding has been set aside by [interviewee's agency or stakeholder group] for drought mitigation measures? What about drought adaptation measures?

done and began pulling names of individuals found within official documents, newspaper articles, etc. that fit within one of these key stakeholder groups. The second used “snowball sampling”, in which the researcher asks interviewees already participating to identify other potential interviewees, to augment the original sample (Schensul, Schensul, and LeCompte 1999). To ensure that these potential interviewees could provide valid information, background research was done to identify whether these individuals had a role in water management in the UKB and if they fell into one of the previously identified stakeholder groups. To protect interviewee’s anonymity, it was not disclosed whether recommendations were interviewed or even contacted.

Over the summer of 2015, a total of 16 interviews were conducted. Interviews ranged from the shortest of 30 minutes to the longest of 3.5 hours. In total, over 20 hours of interview data were collected. To comply with institutional policies and state and federal laws, Human Subjects Research Council (HSRC) guidelines were followed. This research received approval by HSRC. Each interviewee was briefed prior to being interviewed and signed a consent form (a blank copy can be found in Appendix A). This consent form identified procedures for interviews, risks/benefits associated with being interviewed, highlighted voluntary participation and withdrawal, outlined confidentiality, and identified contact persons in case of questions or concerns. Because of the nature of the topic and relatively low population of UKB, interviewees were not identified by name or agency but rather by their overarching stakeholder group. This was done to protect anonymity to the maximum extent practicable, to encourage stakeholder’s honesty while being interviewed.

Interview research often includes quotes that help the researcher justify their conclusions. In filling out the HSRC application, quotes were not identified as a method and were therefore not specifically identified in the consent form signed by all respondents (Appendix A) and, therefore, cannot be used in this research. To best utilize the interview data collected, each interview was coded using content analysis techniques. The framework below (Figure 9) has been adapted for this research to complete coding. Juhola and Kruse (2015) focused on analyzing adaptive capacity

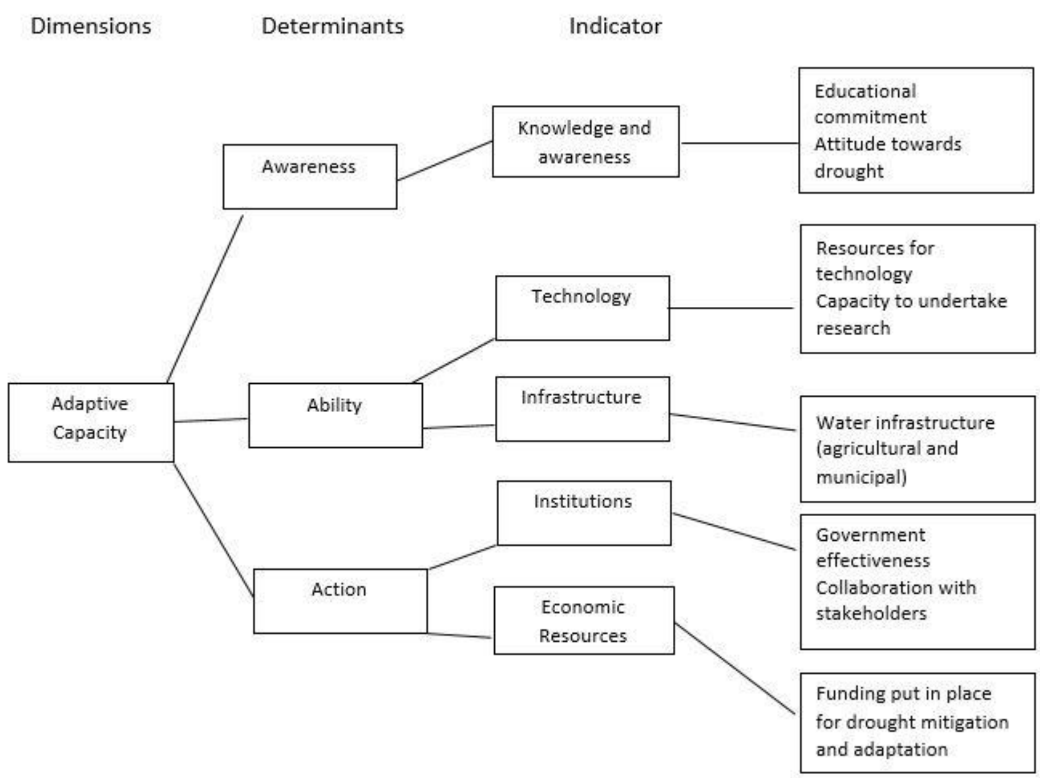


Figure 9. Determinants and dimensions of adaptive capacity adapted from Juhola and Kruse 2015.

assessments, particularly as they relate to climate change. The indicators were evaluated based on what information the interviewee discussed (e.g., what water infrastructure is discussed, how much funding is specifically set aside for drought mitigation/adaptation, etc.). Mitigation techniques would include any that limit the impact of the drought, whereas adaptive management moves towards the ability to adjust to new conditions i.e., drought). This framework outlines three determinants: awareness, ability, and action. These, including knowledge and awareness, technology and infrastructure, as well as institutions and economic resources, determine associated adaptive capacity and are influenced by the indicators listed. The last column provides examples of indicators. Knowledge and awareness, for example, may be demonstrated by an agency's educational commitment, pushing the awareness level higher and serving as a way to define an increase in adaptive capacity. Funding put in place for drought mitigation and adaptation, as another example, is one way economics resources can be measured and a lack thereof would demonstrate a low action determinant, likely signifying a low adaptive capacity in this area. While coding the interviews, it became clear that events on the socio-political landscape beyond drought were catalysts for changes in adaptive capacity. In order to better illustrate this, the Juhola and Kruse (2015) framework was adapted to better reflect impacts of catalyst events (Figure 10). When respondents suggested that adaptive capacity had increased, boxes that delineated how that increase had occurred were filled in with green. Meanwhile, when respondents suggested that adaptive capacity had decreased, boxes were filled in with red.

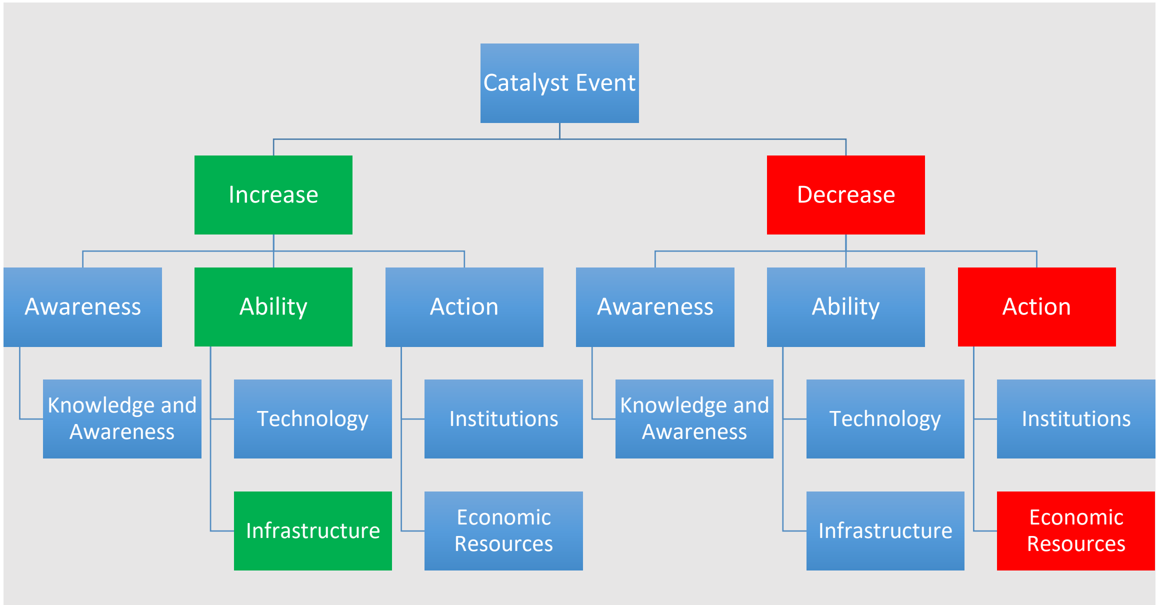


Figure 10. Example of coding framework.

<u>Event History Calendar</u>

The temporal nature of this research lends itself to compiling an event history calendar. This method has been used extensively in ethnographic research but, to the author's knowledge, this is the second time it is has been used in research of this kind (Engle 2013). An event history calendar attempts to uncover not only the details of an occurrence but its temporal relationship to other occurrences or actions (Box-Steffensmeier and Jones 2004). In the UKB, specific events contribute greatly to the overall understanding of the water management structure for the basin as a whole. An event history calendar's strength relies on its dependence of both qualitative and quantitative data (Engle 2013).

Through the utilization of interviews, data was collected from water managers specifically on the strategy and policy changes by their agency (Box-Steffensmeier and Jones 2004), their perceptions of timing and causality, and overall perceptions of the adaptive capacity of their agency (Engle 2013). Engle's (2013) assessment of drought preparedness in state and community water systems and in semi-structured interviews with water managers within institutions was adapted to fit this research. Through this adaptation, the utilization of various approaches for drought preparedness was quantified within 6-month timeframes.

To accomplish this, each timeframe was discussed with each interviewee. In this discussion events, identified by respondents themselves, were pulled out from each of the corresponding timeframes to help remind respondents of specific actions and occurrences. Examples from Engle's (2013) assessment include, "collaboration (regional/local, state/federal, and other), consideration of natural processes, and long-term drought planning" each given a rating between 1 and 3, or low to high on the amount of emphasis placed on each approach (Engle 2013, 297). Collaboration is broken into three sub-questions.  One evaluates collaboration on a regional to local level, another evaluates on a state to federal level, and "other". The "other" almost entirely referenced collaboration with Tribal governments. Consideration of natural processes included focusing on specific indicators within the hydrologic cycle. Long-term drought planning included planning for the effects of drought over 10+ years. Table 4 shows the full list of approaches over a period of one year.

This information was evaluated in comparison to the Standardized Precipitation Index (SPI) for the basin (Figure 11), and USGS Upper Klamath Lake (Figure 12) USGS stream flow data (Figure 13). The SPI data was collected from the Western Regional Climate Center (Western Regional Climate Center, ND) and compared to the matrices collected using a statistical panel analysis. A panel analysis involves running a regression

Table 4. Matrix adapted from Engle 2013 for Event History Calendar.

| **Approach** | **Amount of Effort:** (Rating 0-3) | |
|---|---|---|
| | January-June, 2011 | July-December, 2011 |
| Supply Diversity | | |
| Infrastructure<br><br>a) Supply<br>b) Demand | | |
| Conservation | | |
| Collaboration<br><br>a) Local/Regional<br>b) State/Federal<br>c) Other | | |
| Climate-information and Scenarios | | |
| Uncertainty Communication | | |
| Stakeholder Participation | | |
| Consideration of Natural Processes | | |
| Thinking 'outside of the box' and experimentation | | |
| Long-term Drought Planning | | |

model (Hsiao 2003) and can be done utilizing a statistical software package. In Engle's (2013) research, the data was analyzed using generalized estimating equations and cumulative logit models to discover statistically significant relationships. In this research a type of generalized linear model, Poisson Regression Model, was used. This test is ideal for analyzing relationships of event counts and contingency tables (King 1988).

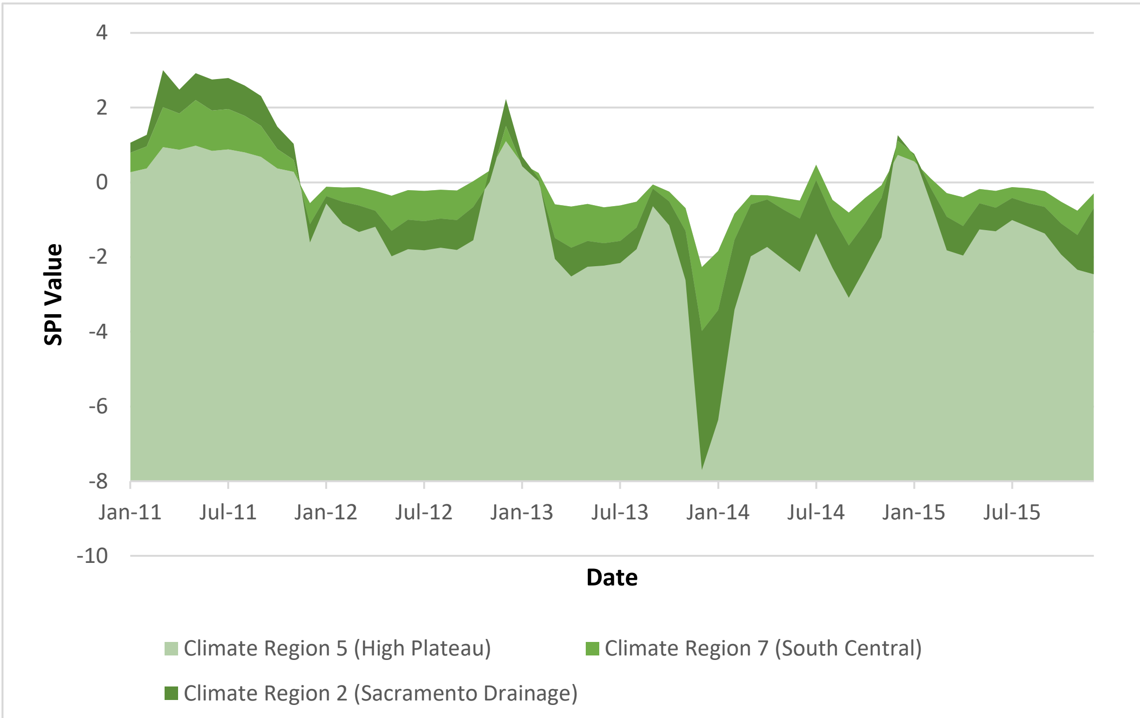


Figure 11. SPI data for climate regions 2, 5, and 7, 2011-2015.

The three data sets were chosen as variables to best reflect meteorological and hydrological drought. SPI data relates most closely to meteorological drought because of its dependence on precipitation data. Streamflow and lake level data were chosen as two ways to measure hydrological drought. Groundwater was discussed as a measure and, it is believed, would be another good indicator of hydrological drought. However, there was not sufficient data coverage to utilize it as a variable.

The Standardized Precipitation Index defines and monitors drought; specifically, it is based mathematically on the probability of rainfall at a particular point (National

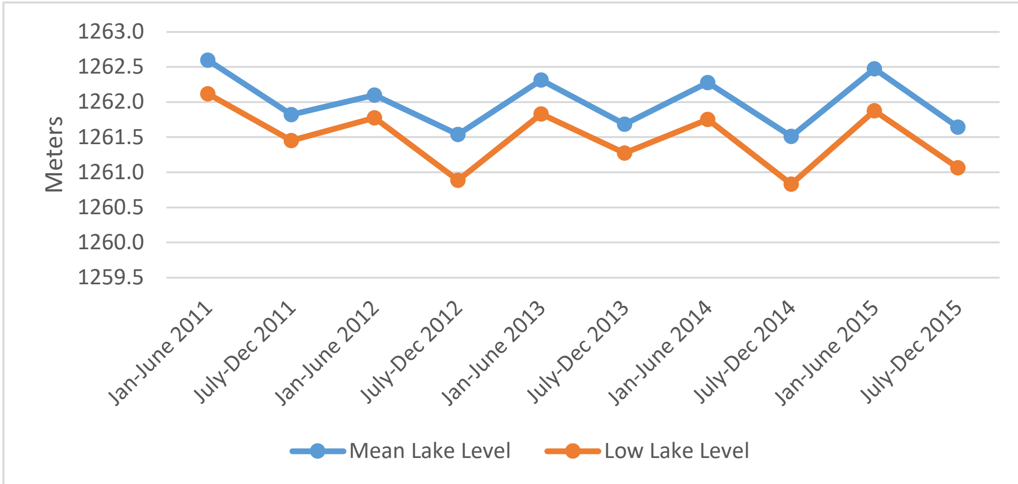


Figure 12. Upper Klamath Lake levels, USGS monitoring station 11507000, average and low levels in meters.

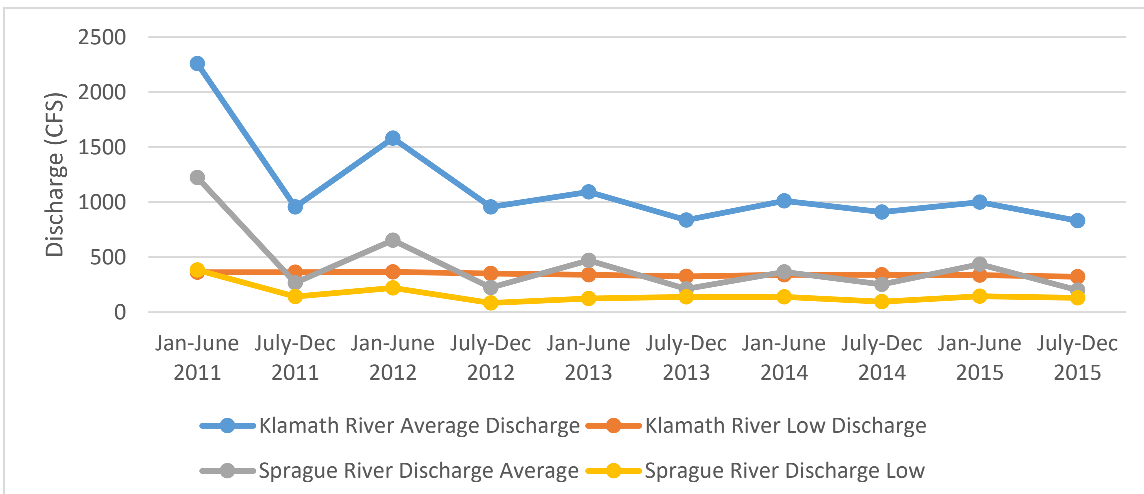


Figure 13. Klamath and Sprague River discharges, USGS Monitoring Stations 11510700 and 1150100, January 2011-December 2015

Oceanic and Atmospheric Administration 2016). This index is better suited than others for temporally based drought research. For example, the commonly used Palmer Drought Index, a more complicated index which measures conditions causing drought over the long-term, is less suited because, given the enigmatic beginning of drought in

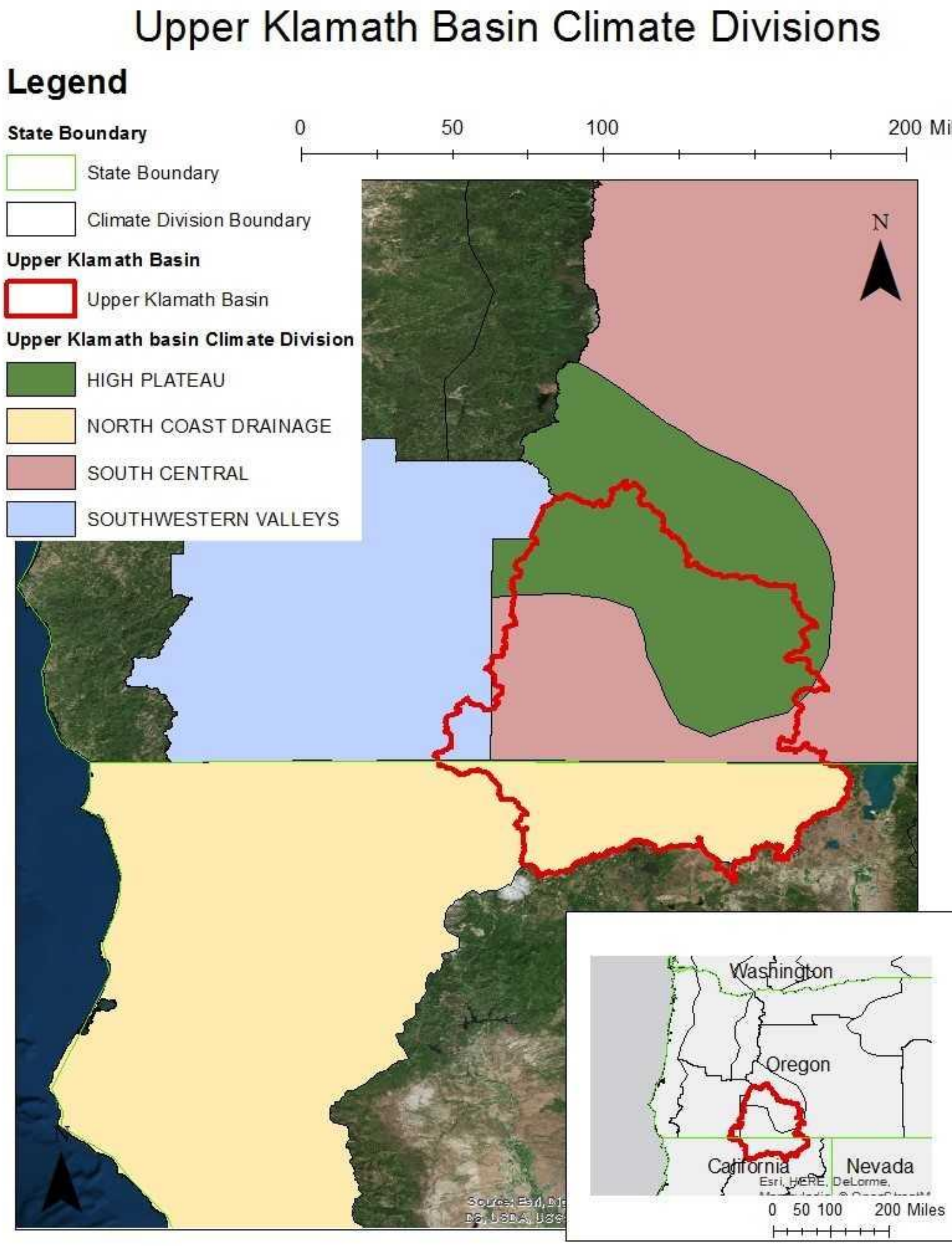


Figure 14. Upper Klamath Basin climate divisions. (Keffer 2017).

combination with the index variables, the index may reflect a lag in the beginning of drought by a few months (National Drought Mitigation Center 2016).

SPI data is delineated by climate regions that do not generally conform to river basin delineations. Figure 14 notes the three main climate regions that encompass the UKB. Climate region Southwestern different; it represents a low percentage of the total area of the UKB; and the small portion of this region that is a part of the UKB is relatively uninhabited.

The other two measures of drought tested included: flow data from USGS monitoring stations and lake levels from Upper Klamath Lake (station 11507000). Two points of USGS collected data, Sprague River near Chiloquin, OR (station 1150100) and Klamath River below JC Boyle dam (station 11510700), were chosen for streamflow data. These points were chosen because of: their location within the UKB; the Sprague River point being above one of the four dams discussed for removal and  the Klamath River point being below; and, pragmatically, because both stations had easily accessible streamflow data for the time frame being examined. Using Statistix, the matrices collected during interviews were compared with: SPI data, USGS stream flow data, and USGS Upper Klamath Lake level data (Table 5). Within matrices, each approach was given a numerical rating, 0-3, on the amount of effort for that specific time frame. These numbers were then compared to the variable data.

The averages and maximum low levels over the same 6-month time frames used in the matrix were tested for the entire period, 2011-2015, identified in the event history calendar matrix. The SPI data best reflects any lag that may be experienced from drought; however, to ensure lags were accounted, different time frames were also used for stream flow and lake level data; each matrix dataset was compared to stream flow and lake level data from the 6-month time period directly before it. For example,

Table 5. Drought indicator datasets.

| **Drought indicator data** | **Time frame(s) used** | **Additional information** | **Source** |
|---|---|---|---|
| Standardized Precipitation Index | 2011-2015 | Three climate regions used: 5 (High Plateau), 7 (South Central), and 2 (Sacramento Drainage) | Western Regional Climate Center |
| Klamath River, below JC Boyle<br><br>(USGS: 11510700) | 2010-2015 | Both six-month averages and maximum lows were used | US Geological Survey |
| Sprague River, near Chiloquin, OR<br><br>(USGS: 11501000) | 2010-2015 | Both averages and lows were used | US Geological Survey |
| Upper Klamath Lake, near Klamath Falls<br><br>(USGS: 11507000) | 2010-2015 | Both averages and lows were used | US Geological Survey |

data collected for the January-June, 2011 time period was compared to both average and low stream flow and lake level data for July- December, 2010. Statistical patterns were identified to make comparisons between the implementation of each policy/management adaptation identified in interviews, and the onset of drought (Engle 2013). This statistical analysis helps to understand how the adaptive capacity of water managers in the UKB has shifted. By statistically comparing the policies and strategies put in place to time periods when drought has actually occurred, inferences were made on whether management has remained reactive (e.g., crisis-driven and reacting to drought) or has become more adaptive (e.g., preparation and mitigation techniques are discussed and put in place even before drought is occurring).

# CHAPTER 5

# RESULTS

This chapter provides quantitative and summary results from each of the three methods used: content analysis, semi-structured interviews, and the event history calendar. Further discussion of how these results interrelate and conclusions that can be drawn will be found in Chapter 6.

## Content Analysis of Management Texts

To complete content analysis, 13 management texts were analyzed. Analysis included identifying texts in which key words or terms were found and the percentage of those to the total texts. Those key words and terms that were not found in any management text were also identified, with a reminder on how those words and terms are broken down into three themes: water management, drought/scarcity planning, and drought/scarcity response.

Following analysis, a few patterns emerge (Table 6). The highest words and terms (in order of most frequent usage) are: reservoirs and storage, used a total of 3.04% in 11 different management texts; water rights, used a total of 1.89% in nine different texts; coordination between stakeholders, used a total of 0.85% in eight different texts; mitigation and planning, used 0.55% in ten different texts; water quality, used a total of 0.43% in six different texts; and banking and transfers, used a total of 0.43% in five different texts. The last two terms, water quality and banking and transfers, were used an equal number of times. Water management, as a theme, has the highest number of key words and terms found in all 13 management texts: a total of

Table 6. Results of content analysis of texts

| Theme | Key word or term | Percentage Found [Total (range)] | Number of Texts |
|---|---|---|---|
| Water management | Water rights | 1.89 (0.02%-0.39%) | 9 |
| | Water law/legislation | 0.07 (0.01%-0.02%) | 5 |
| | Banking and transfers | 0.43 (0.01%-0.13%) | 5 |
| | Water availability | 0.18 (0.01%-0.15%) | 4 |
| | Monitoring and metering | .03 (0.01%-0.02%) | 2 |
| | Reservoirs and storage | 3.04 (0.02%-0.55%) | 11 |
| | Conservation, efficiency, and consumption | 0.14 (0.01%-0.1%) | 5 |
| | Fish health | 0.13 (0.01%-0.12%) | 2 |
| | Water quality | 0.43 (0.01%-0.16%) | 6 |
| | Cultural | 0.15 (0.01%-0.04) | 8 |
| Drought/Scarcity Planning | Declarations, triggers, warning systems | 0.07 (0.01%-0.05%) | 3 |
| | Mitigation and planning | 0.55 (0.01%-0.16%) | 10 |
| | General response and emergency management | .01 | 1 |
| | Previous drought events and experiences | 0.07 | 1 |
| Drought/Scarcity Response | Conflict between stakeholders | 0.11 (<0.01%-0.04%) | 5 |
| | Coordination between stakeholders | 0.85 (0.07-0.19%) | 8 |

10 out of the original 21 are included within this theme. Drought/scarcity planning has a lower number but higher percentage, with four out of the original six key words and terms found in a total of 12 of the analyzed management texts. Drought/scarcity

response, as a theme, has the lowest number of key words and terms, found in only 11 of the management texts: a total of two out of the original 10 included in this theme. A complete table listing each text a key word or term was found in, as well as specific percentages can be found in Appendix A.

Although this kind of content analysis cannot unequivocally state what strategies water managers were using when writing these texts, the frequency of words and terms used can help to uncover their priorities. In this case, it is clear that reservoirs and storage, the most common key term used a total of 3.04% in 11 different management texts, was a high priority. Largely this is because of the amount with which it is found in the Klamath Operations Plans. However, it is still a theme that is found in texts written collaboratively between various stakeholders, including both the KBRA and KHSA. Increasing storage is often supported by irrigators as a method for dealing with seasonal water availability issues (Irrigators Association 2010) and in basins where climate change is likely to cause or increase precipitation regime shifts this can seem an obvious solution. However, large water projects are intensive in both time and funding and their implementation has declined in recent years. A federal 2016 report on large transportation and water projects of major economic significance identifies only 3 water resource projects in the West (Horst et al. 2016).

Because appropriative water rights play such an integral role in Western water management it is intuitive that water rights, used 1.89% in 9 different management texts, is one of the highest terms found in all texts. The next two terms used most frequently are coordination between stakeholders, used 0.85% in eight different management texts, and mitigation and planning, used 0.55% in 10 different management texts. The former falls under the theme of drought/scarcity response, while the latter falls under the theme drought/scarcity planning. Coordination between stakeholders is discussed at greater length in many of these texts and is a term that is difficult to evaluate in this context as coordination is often discussed outside of specific terms. For example, texts may list specific agencies or groups that will coordinate without using the phrase "coordination between stakeholders" or even simply "coordination". It is interesting to note that few of the key words and terms within the theme of drought/scarcity planning were explicitly discussed in the management texts and, as is shown in Table 7, most of those key words and terms within the drought/scarcity response theme did not make their way into the management texts.

Water quality and banking and transfers were terms that came up an equal amount of times, a total of 0.43%. Water quality, however, was found in six different management texts, while banking and transfers were found in five. That banking and transfers was a term found so (relatively) frequently and on par with water quality is surprising. There has been a general resistance from residents within the UKB to water banking and transfer measures (Burke et al. 2004; Clarren 2005), while water quality seems to be a higher priority issue. This is particularly true when considering the health of federally listed endangered species in the basin.

Table 7. Key words and terms with no results in any text.

| | |
|---|---|
| **Water Management** | Climate change planning |
| | Valuing, pricing, and commodification |
| | Human-environment connection |
| | Security and scarcity |
| | Surface water dependence |
| | Groundwater dependence |
| | Water information and knowledge |
| | Habitat degradation |
| | Commercial fishing interests |
| | Surface-groundwater interaction |
| **Drought/scarcity planning** | Regional and local planning and coordination |
| | Federal and state planning and coordination |
| | Tribal and federal planning and coordination |
| | Tribal and state planning and coordination |
| **Drought/scarcity response** | Restrictions |
| | Recent drought impacts and timeline |
| | Intersection with other stresses |
| | Drought and water politics |
| | Climate and drought information and knowledge |
| | Emergency well permitting |

When reviewing the key words and terms that were not found in any management texts, a pattern emerges. The majority of those terms related to drought, planning, and climate change are not found within the management texts. Two terms that were of the greatest surprise given their importance in the basin are: climate change planning and surface-groundwater interaction. Figure 15 identifies the 100 most frequently used words in all texts.

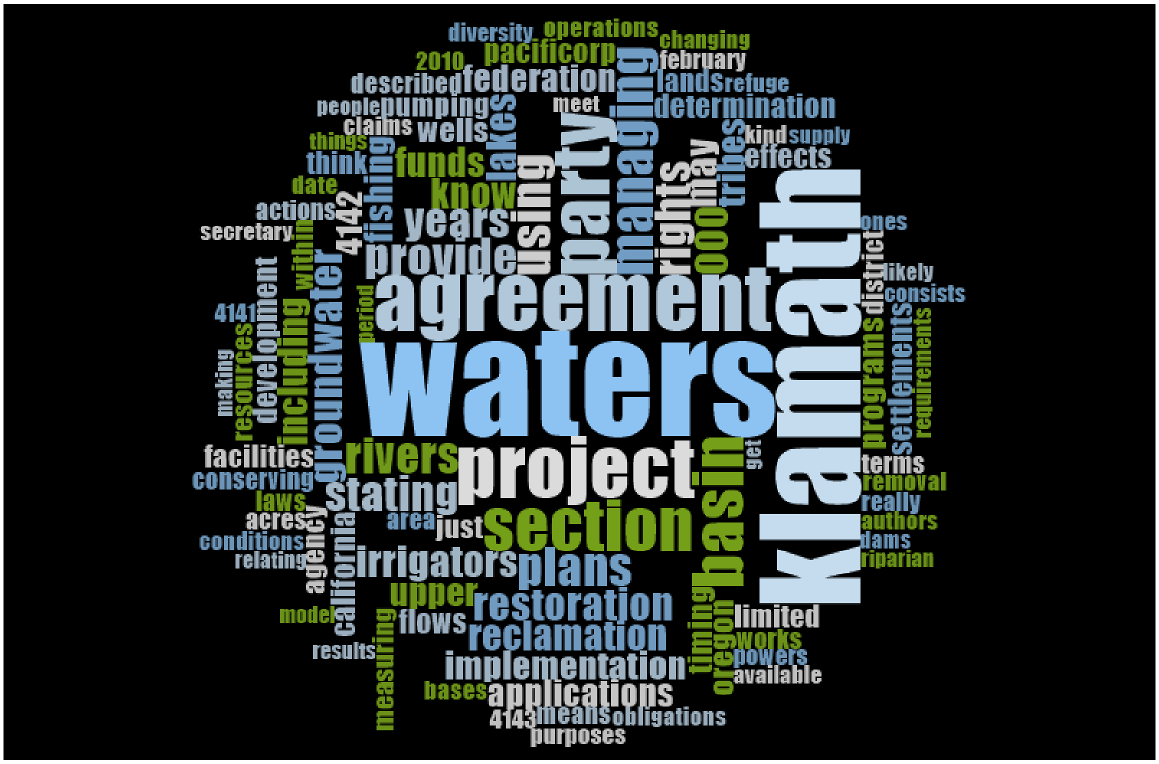


Figure 15. Most frequently used words in all management texts analyzed, NVivo Qualitative Data Analysis Software.

<u>Content Analysis of Semi-structured Interviews</u>

Results of content analysis of semi-structured interviews are presented in a slightly different format than those of the management texts (Table 8). In analyzing word frequency, it was important to exclude those words which were part of questions by the interviewer and not those used by the respondent. Because interviews also needed to be classified by their stakeholder group, as a protection of respondents' anonymity, it made most sense to represent key words and terms by the total number of references and not include the percentage of the total words spoken.

Table 8. Results of content analysis of semi-structured interviews

| **Key word or term** | **Stakeholder group** | **Number of references** |
|---|---|---|
| *Water rights* | Tribe | 6 |
| | Federal | 4 |
| | Regional | 6 |
| | Local | 10 |
| | Other | 9 |
| *Water law/legislation* | Regional | 1 |
| *Banking and transfers* | Other | 1 |
| *Water availability* | State | 3 |
| | Local | 1 |
| *Security and scarcity* | Tribe | 2 |
| | Federal | 1 |
| | Regional | 4 |
| | Other | 4 |
| *Monitoring and metering* | State | 2 |
| *Reservoirs and storage* | Federal | 2 |
| | State | 1 |
| | Other | 19 |
| *Conservation, efficiency, and consumption* | Federal | 2 |
| | Regional | 4 |
| | State | 4 |
| | Local | 4 |
| *Water information and knowledge* | Tribe | 2 |
| | Federal | 3 |
| | Regional | 1 |
| | State | 2 |
| *Fish health* | Other | 8 |
| *Water quality* | Tribe | 8 |
| | Federal | 16 |
| | Regional | 14 |
| | State | 14 |
| | Other | 19 |
| *Cultural* | Tribe | 9 |
| | Federal | 3 |
| | State | 4 |
| *Declarations, triggers, and warning systems* | Other | 2 |
| *Mitigation and planning* | Federal | 3 |
| | State | 1 |

Table 8, Continued.

| **Key word or term** | **Stakeholder group** | **Number of references** |
|---|---|---|
| *Tribal and Federal planning and coordination* | Tribe | 1 |
| | Federal | 1 |
| *Tribal and state planning coordination* | Tribe | 2 |
| | State | 5 |
| *Recent drought impacts* | Tribe | 7 |
| | Federal | 8 |
| | Regional | 7 |
| | State | 30 |
| | Local | 10 |
| | Other | 8 |
| *Previous drought events and timelines* | Tribe | 4 |
| | Federal | 6 |
| | Regional | 1 |
| | State | 21 |
| | Local | 10 |
| | Other | 2 |
| *Drought and water politics* | Tribe | 14 |
| | Federal | 4 |
| | Regional | 6 |
| | State | 6 |
| | Local | 5 |
| | Other | 1 |
| *Climate and drought information and knowledge* | Other | 1 |
| *Conflict between stakeholders* | Tribe | 8 |
| | Federal | 2 |
| | Regional | 3 |
| | State | 5 |
| | Local | 2 |
| | Other | 2 |
| *Coordination between stakeholders* | Tribe | 5 |
| | Federal | 3 |
| | Regional | 2 |
| | State | 5 |
| *Coordination between stakeholders* | Local | 1 |
| | Other | 5 |

When reviewing these results it is apparent that water quality, recent and historic drought events and impacts, drought and water politics, and water rights are the most prevalent in respondents' minds. In part, this is because of the nature of the questions asked (identified in Table 3, Chapter 4). However, semi-structured interviews were chosen over structured interviews or surveys because this method allows respondents to choose the information they share and veer away from the questions, if they so choose. Water quality was referenced a total of 71 times by all stakeholder groups. It was referenced the most by those respondents who fall into the other stakeholder group, this was generally made up of non-profit organizations and other non-governmental agencies who have direct ties to water management in the UKB. Water quality was also the term most frequently referenced by those within the federal, regional, and state stakeholder groups, a total of 16 times for the federal stakeholder group and 14 times for both the regional and state stakeholder groups.

Recent drought impacts were close behind in terms of use, referenced a total of 70 times by all stakeholder groups. The respondents who referenced these the most frequently fell into the state stakeholder group, made up of respondents who are employed by state agencies directly related to water management in the UKB. Previous drought events and timelines were referenced a total of 44 times by all stakeholder groups but referenced the most, again, by those respondents who belong to the state stakeholder group. Drought and water politics was referenced a total of 36 times by all stakeholder groups but most frequently, by more than twice as much as the next highest use, by those respondents who fall into the Tribal stakeholder group. This key term was also the most frequently used by those respondents within the Tribal stakeholder group.

Water rights were referenced a total of 35 times by all stakeholder groups and the most frequently by the local stakeholder group, made up of respondents who are employed by local agencies/organizations directly related to water management in the UKB. The most frequent key terms used by those within the local stakeholder group were all tied with 10 references each: water rights, recent drought impacts, and previous drought events and timelines. Water quality and reservoirs and storage were tied for most frequent usage by those within the other stakeholder group; each term was used a total of 19 times.

It is interesting that water scarcity and security was a term without a high frequency of use, used only a total of 11 times by four stakeholder groups. Of the groups who used this term, the lowest use was the federal stakeholder group and those respondents within the state and local stakeholder groups did not use it at all. This seems counterintuitive as water security in particular seems within the realm of federal water management. Fish health was only used by stakeholders in the other group. It makes sense that the word cultural would be used more frequently by respondents who fall into the Tribal stakeholder group, but it is worth noting the comparatively low frequency with which it was mentioned by stakeholders within the Federal and state stakeholder groups: nine times by respondents within the Tribal stakeholder group versus a total of seven combined usages between respondents in both the Federal and state stakeholder groups. It is also interesting to note the low frequency with which water availability was referenced, as this is a key part of the conflict between stakeholders within the UKB. Water law/legislation, banking and transfers, monitoring and metering, fish health, declarations, triggers, and warning systems, and climate and drought information and knowledge were all only referenced by respondents within one stakeholder group (Table 9).

Table 9. Key words and terms referenced by no more than one stakeholder group.

| **Theme** | **Key Word and Term** | **Stakeholder Group** |
|---|---|---|
| *Water management* | Water law/legislation | Regional (1 reference) |
| | Banking and transfers | Other (1 reference) |
| | Monitoring and metering | State (1 reference) |
| | Fish health | Other (1 reference |
| *Drought/scarcity planning* | Declarations, triggers, and warning systems | Other (2 references) |
| *Drought/scarcity response* | Climate and drought information and knowledge | Other (1 reference) |

A parallel between content analysis of semi-structured interviews and content analysis of management texts is the low use of words and terms that fall under the drought/scarcity response theme. Climate-change planning and surface-groundwater interaction are terms not found in either interviews or content analysis of texts (Table 10).

Table 10. Key words and terms with no results in any interview

| Theme | Key word or term |
|---|---|
| *Water Management* | Climate change planning |
| | Valuing, pricing, and commodification |
| | Human-environment connection |
| | Surface water dependence |
| | Groundwater dependence |
| | Habitat degradation |
| | Commercial fishing interests |
| | Surface-groundwater interaction |
| *Drought/Scarcity Response* | General response and emergency management |
| | Drought restrictions |
| | Intersection with other stresses |
| | Emergency well permitting |

Coding of Semi-Structured Interviews

In coding interviews, changes were noted in respondent's perception of adaptive capacity, as well as the reasoning behind each respondent's answer, utilizing a framework identified by Juhola and Kruse (2015). A pattern quickly began to emerge that each increase or decrease was precipitated by particular events, identified moving forward as catalyst events. This pattern is represented by changes of color in the corresponding block and grouped by catalyst event. For example, all respondents recognized a decrease in adaptive capacity following the 2001 drought and the reasoning behind this perception fell under the "action" determinant, tied to institutions (examples include government effectiveness and collaboration with stakeholders) (Figure 16). However, the Federal respondents also identified the ability determinate, specifically tied to infrastructure, and awareness determinate as additional reasons behind this decrease.

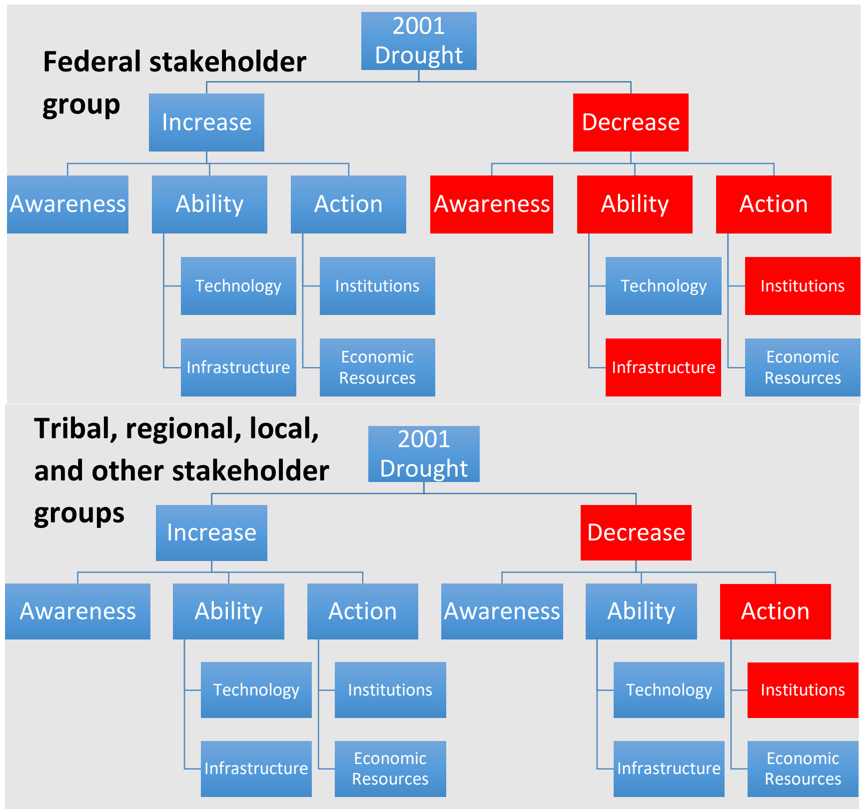

Figure 16. Results of coding interviews in relation to 2001 Drought

Results indicate that there was general agreement among water managers in the UKB that adaptive capacity decreased in response to to the 2001 drought. It is important to note that this research cannot show a high level of detail to pinpoint whether groups differ on how much adaptive capacity increased or decreased, simply that there was an overall increase or decrease. The federal stakeholder group alone tied this decrease to all three determinants: awareness, ability, and action. The ability determinant generally refers to infrastructure; in this case water infrastructure. The other groups all also identified action as a determinant and institutions as the indicator of a decrease in adaptive capacity. This makes logical sense, given the context of the basin. It was generally agreed by all respondents that collaboration between stakeholders was at one of its lowest points in the UKB during this time.

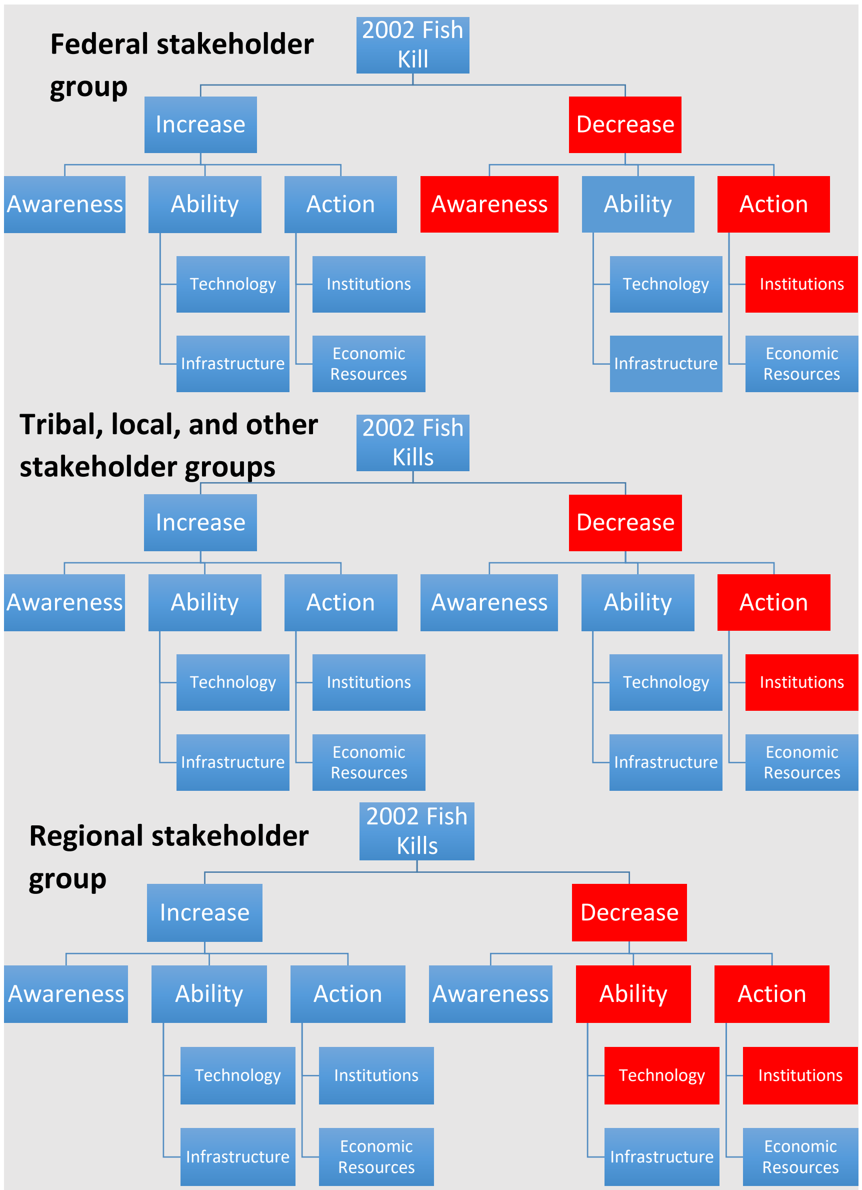


Figure 17. Results of coding interviews in relation to 2002 fish kills.

Adaptive capacity responses to the 2002 fish kills also show a pattern. There is more variety from respondents on reasoning behind the associated decrease in adaptive capacity but it is generally agreed to have decreased. Respondents in the regional stakeholder group, categorized technology as an indicator of a decrease in adaptive capacity. An example of this is the capacity to complete research. This, again, makes logical sense as there was, and in some cases still is, disagreement on the cause of the 2002 fish kills. In relation to the 2002 fish kills, "ability" dropped off as a determinant for the federal stakeholder group. This does not necessarily mean that infrastructure was improved or put in place, but rather, that it did not represent a partial cause in the decrease of adaptive capacity this respondent group perceived. Tribal, local, and other stakeholder groups all listed institutions, (examples include government effectiveness and collaboration with stakeholders) under the action determinate, as a reason behind the decrease.

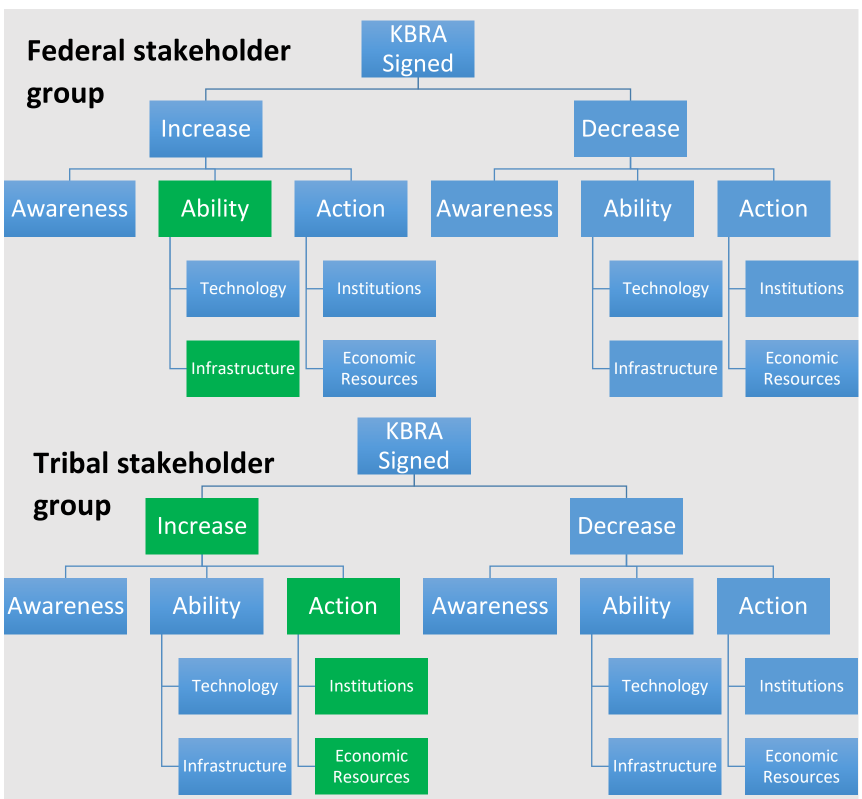

Figure 18. Results of coding interviews in relation to the signing of the KBRA

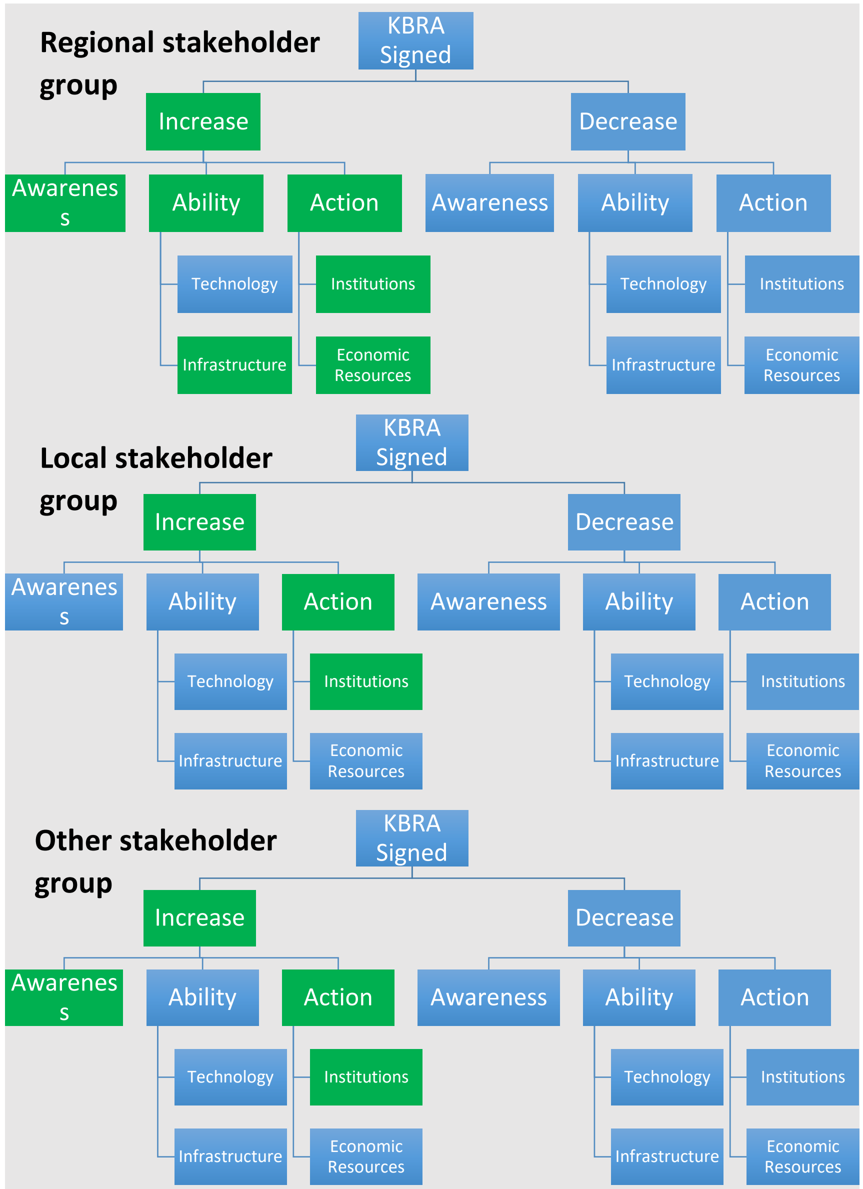


Figure 18. Results of coding interviews in relation to the signing of the KBRA.

There was general agreement between respondents that at the time of the signing of the KBRA there was an increase in adaptive capacity.  Nearly every group identified institutions as an indicator for this change. Considering the amount of collaboration between stakeholders and relationship building that went into the drafting of the KBRA, this makes sense. It is interesting to note that the federal stakeholder group was the only outlier; instead noting the ability determinant and infrastructure indicator as their reasoning behind this increase. The regional stakeholder group associated all determinants with the increase, noting both institutions and

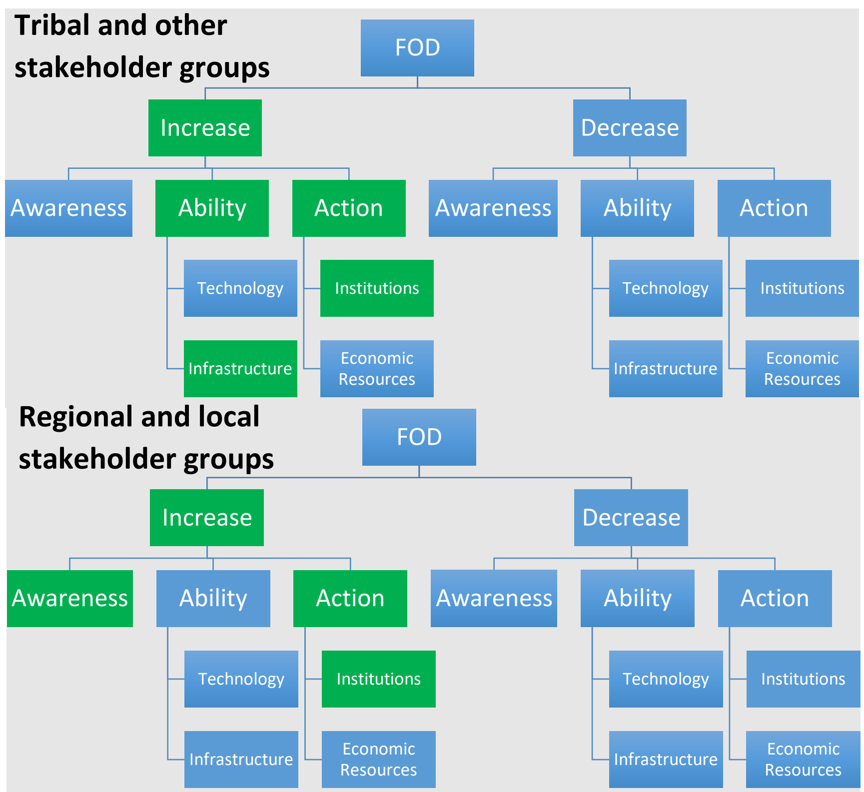

Figure 19. Results of coding interviews in relation to the Final Order of Determination.

economic resources as indicators as well as infrastructure, under the ability determinant. The Tribal group also noted economic resources as an indicator; this is due to the economic benefits associated with the KBRA for the Klamath Tribe.

The Final Order of Determination (FOD) officially quantified and prioritized the Klamath Tribe's water rights, making them more easily enforceable. It is interesting, and perhaps counterintuitive, that every stakeholder group associated this with an increase in adaptive capacity. Each group identified the institutions indicator as part of their reasoning for this increase. The FOD forced some collaboration, particularly between off-project upper basin irrigators and other stakeholders; the result of which was the UKBCA. It seems that this collaboration was perceived to have increased adaptive capacity even if it was, for some, forced by the FOD. Respondents in the other, or non-governmental organization, stakeholder group and Tribal stakeholder group also indicated infrastructure as part of their reasoning for the increase. Regional and local stakeholder groups indicated that the awareness determinant (examples include educational commitment and attitude towards drought) was part of their reasoning behind the increase in adaptive capacity. The federal stakeholder group did not discuss the FOD in enough detail to code, so is not included here.

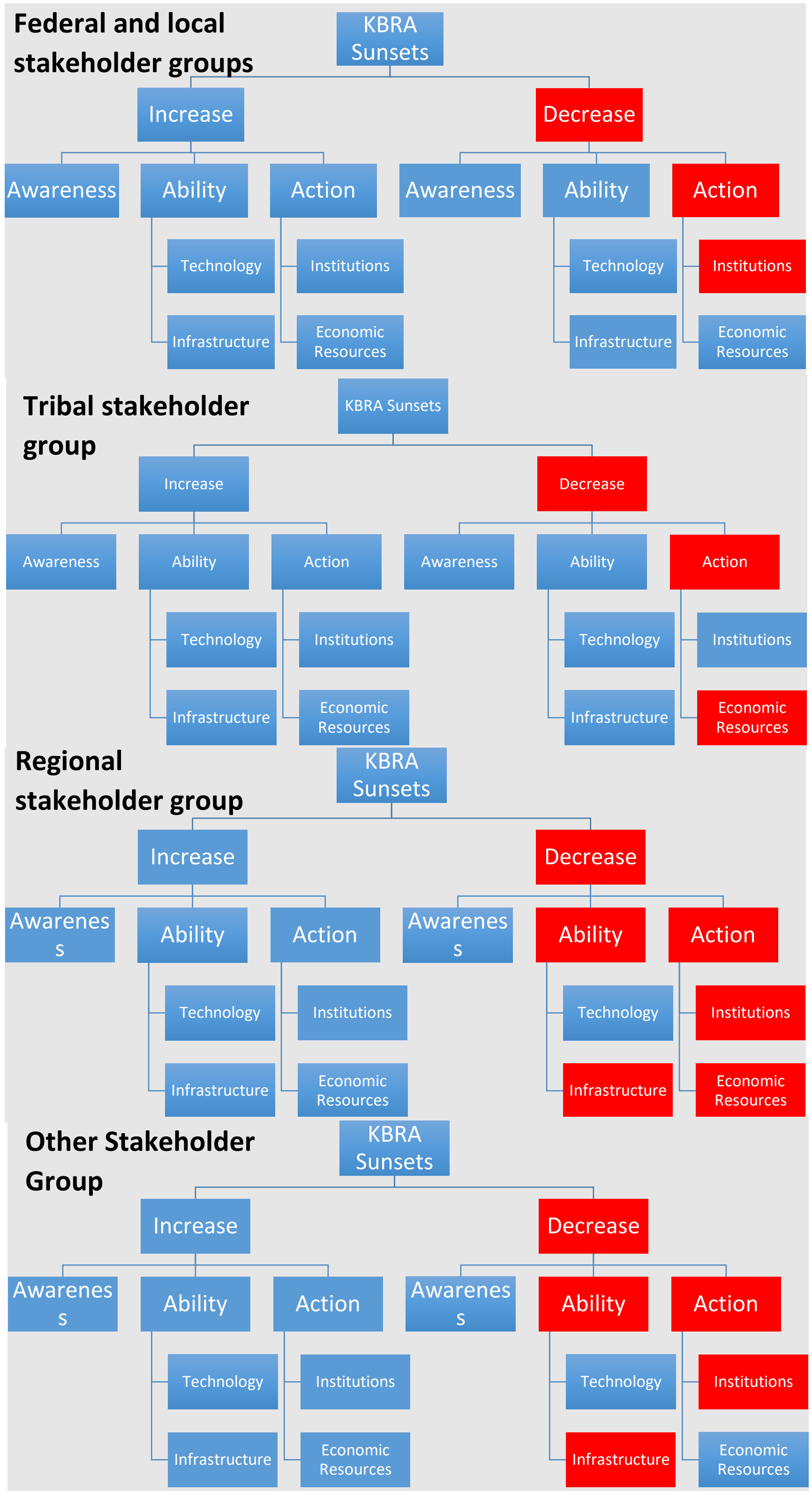


Figure 20. Results of coding interviews in relation to the subset of the KBRA.

Every respondent group agreed that a decrease in adaptive capacity occurred following the sunset of the KBRA (Figure 20). The federal, regional, local, and other stakeholder groups all list institutions as an indicator of the decrease in adaptive capacity. This makes intuitive sense: tensions were high and frustrations amidst stakeholder groups grew with the continued inability to ratify the KBRA. Stakeholder groups lost some of the collaboration that is so important to high adaptive capacity. Both the other and Tribal groups also referenced economic resources as an indicator in the decrease to adaptive capacity, referring to the loss in economic resources that would have been available had the KBRA been enacted. Both regional and other stakeholder groups also referred to infrastructure as an indicator, some discussing the dam removal that would have been part of the ratified KBRA. Although there are differences between the stakeholder groups on the reasoning behind increases and decreases in adaptive capacity, it is interesting to note the pattern surrounding these catalyst events. It suggests that events on the socio-political landscape may be equally, or perhaps more, important as those on the natural landscape, such as drought events.

Event History Calendar

Significant results of the event history calendar have been identified (Tables 11-14) and those matrices without significant results noted (Table 15). The overarching stakeholder group to which the specific respondent(s) belong are noted, along with the approaches that were significant and, in the case of the SPI data as an independent variable compared to the matrix, the climate region to which those data are tied.

Not every respondent interviewed completed a matrix. In general, this was due to a lack of historical/institutional knowledge: not every respondent had been working in the UKB since the 2001 drought/2002 fish kills. In some cases, multiple respondents worked on the same matrix to fill in knowledge gaps. SPI data associated with climate regions 5 and 7 only produced significant results. These regions make up the largest area of the UKB and are climatically more alike than either are to climate region 2. No SPI data that incorporated a lag time produced significant results. This is consistent with literature (Vicente-Serrano et al. 2012; Integrated Drought Management Programme 2018) that suggests SPI is a drought index that already incorporates lag times well; the dynamic and diffuse nature of drought and its impacts is one reason that it can be a difficult natural hazard to index (Wilhite 2000; Wilhite, Sivakumar, and Pulwarty 2014).

In the case of the federal stakeholder group: as drought increases, certain approaches decrease (Table 11). These include collaboration on every level, thinking “outside of the box”/experimentation, and long-term drought planning. Coefficients ranged from -0.558 to -1.314 (Poisson Regression Model, $p \leq 0.05$). The amount of effort placed on long-term drought planning represents the weakest negative relationship between occurrences of drought, while collaboration on every level and thinking “outside of the box” and experimentation represented the strongest negative relationship. In this case, it would appear that adaptive capacity has remained the same or decreased, leaving drought-management to remain reactive and crisis-driven. Although it may seem counterintuitive that collaboration, in particular, would decrease as droughts intensify, it makes sense when thinking in the context of reactive, crisis-driven drought management. If an agency is underprepared, for whatever reason, for a drought, it can limit their ability to be proactive.

Table 11. Relationships between drought preparedness of federal stakeholder group approaches and measures of drought (Poisson regression model, $p \leq 0.05$).

| **Approach** | **Independent Variable** | **Coefficient** | ***P*-Value** |
|---|---|---|---|
| *Climate Region 5* | | | |
| Local/Regional Collaboration | SPI Average | -1.018 | 0.005 |
| State/Federal Collaboration | SPI Average | -1.018 | 0.005 |
| Other Collaboration | SPI Average | -1.018 | 0.005 |
| Thinking “Outside of the Box” and Experimentation | SPI Average | -1.018 | 0.005 |
| Long-term Drought Planning | SPI Average | -0.558 | 0.005 |
| *Climate Region 7* | | | |
| Local/Regional Collaboration | SPI Average | -1.314 | 0.037 |
| State/Federal Collaboration | SPI Average | -1.314 | 0.037 |
| Other Collaboration | SPI Average | -1.314 | 0.037 |
| Thinking “Outside of the Box” and Experimentation | SPI Average | -1.314 | 0.037 |

Within the regional stakeholder group (Table 12), we see a similar theme. Collaboration on every level decreases as drought increases, with coefficients ranging from -0.749 to -1.018 (Poisson Regression Model, $p \leq 0.05$). Here, however, there is one key difference: as drought increases, regional water managers rely more heavily on climate-information and scenarios, with coefficients ranging from 0.626 to 0.812 (Poisson Regression Model, $p \leq 0.05$). This suggests a certain amount of drought-planning. For the regional stakeholder group, adaptive capacity seems to have remained the same or decreased. The increase in utilizing climate-information and scenarios, as opposed to long-term drought planning when drought is not occurring, indicates that water managers are still thinking short-term. Again, this makes sense if an organization is under-prepared for drought, it is harder to think beyond the emergency occurring into the long-term.

Table 12. Relationships between drought preparedness of regional stakeholder group approaches and measures of drought (Poisson regression model, $p \leq 0.05$).

| **Approach** | **Independent Variable** | **Coefficient** | ***P*-Value** |
|---|---|---|---|
| *Climate region 5* | | | |
| Local/Regional Collaboration | SPI Average | -0.749 | 0.006 |
| State/Federal Collaboration | SPI Average | -1.018 | 0.005 |
| Other Collaboration | SPI Average | -1.018 | 0.005 |
| Climate-information and Scenarios | SPI Average | 0.625 | 0.023 |
| Stakeholder Participation | SPI Average | -1.018 | 0.005 |
| *Climate Region 7* | | | |
| Local/Regional Collaboration | SPI Average | -1.181 | 0.037 |
| State/Federal Collaboration | SPI Average | -1.312 | 0.037 |
| Other Collaboration | SPI Average | -1.312 | 0.037 |
| Climate-information and Scenarios | SPI Average | 0.812 | 0.039 |
| Stakeholder Participation | SPI Average | -1.312 | 0.037 |

This first state stakeholder matrix (Table 13) shows that in terms of collaboration it is much of the same, with coefficients ranging from -0.833 to -1.312 (Poisson Regression Model, $p \leq 0.05$). However, we begin to see some movement towards an increase in adaptive capacity within this matrix. The pattern here is interesting: the data show the same decrease in collaboration when drought increases as in the regional stakeholder group,(-0.834, Poisson Regression coefficient), we also see that utilizing climate-information and scenarios and long-term drought planning, (0.816), and consideration of natural processes, (0.349) increase with drought (Poisson Regression

Model, $p \leq 0.05$), though the latter strategy is only associated with the low Sprague River discharge (USGS station 1150100) dataset. The lack of collaboration while drought is occurring, may also reflect other agencies and organizations unpreparedness, rather than an unwillingness or inability to collaborate on the part of the state agency. The positive relationship of utilizing climate-information and scenarios, long-term drought planning, and consideration of natural processes and drought events indicate that adaptive capacity has slightly increased from the identified low-point of the 2001/2002 drought/fish kills.

Table 13. Relationships between drought preparedness of state stakeholder group, respondent 1 approaches and measures of drought (Poisson regression model, $p \leq 0.05$).

| **Approach** | **Independent Variable** | **Coefficient** | ***P*-Value** |
|---|---|---|---|
| *Climate Region 5* | | | |
| Conservation | SPI Average | -0.833 | 0.003 |
| Local/Regional Collaboration | SPI Average | -0.833 | 0.003 |
| State/Federal Collaboration | SPI Average | -0.833 | 0.003 |
| Climate-information and Scenarios | SPI Average | 0.488 | 0.020 |
| *Climate Region 7* | | | |
| Long-term Drought Planning | SPI Average | 0.488 | 0.020 |
| Conservation | SPI Average | -1.312 | 0.037 |
| Local/Regional Collaboration | SPI Average | -1.312 | 0.037 |
| State/Federal Collaboration | SPI Average | -1.312 | 0.037 |
| Climate-information and Scenarios | SPI Average | 0.816 | 0.039 |
| Long-term Drought Planning | SPI Average | 0.816 | 0.039 |
| Consideration of Natural Processes | Low Sprague River Discharge | 0.349 | 0.057 |

In this second state stakeholder matrix (Table 14), the pattern between stakeholder groups disappears. Collaboration of Regional/Local and State/Federal level have no relationship to the occurrence of drought. Unfortunately, looking at these results alone, it would be impossible to say whether collaboration has overall increased or decreased; only that the level of emphasis placed on it is not related to the occurrence of drought. These results can be difficult to interpret in comparison to the other matrix results. It appears that, in this case, adaptive capacity has remained at a similar level, with concerns over supply increasing with the occurrence of drought but no long-term planning or preparedness emphasis related to occurrences of drought.

Table 14. Relationships between drought preparedness of state stakeholder group, respondent 2 approaches and measures of drought (Poisson regression model, $p \leq 0.05$).

| **Approach** | **Independent Variable** | **Coefficient** | ***P*-Value** |
|---|---|---|---|
| Climate Region 5 | | | |
| Supply Infrastructure | SPI Average | 0.488 | 0.020 |
| Climate Region 7 | | | |
| Supply Infrastructure | SPI Average | 0.816 | 0.039 |

It appears from those matrices with significant results that adaptive capacity in the UKB has remained at similar levels from the identified low-point of the 2001/2002 drought/fish kills, with some mild decreases in specific stakeholder groups and some mild increases in others. Indicators of this are found in the positive relationships between approaches of drought preparedness and actual drought events. However, the larger pattern that becomes clear when analyzing all matrices is that drought is not as strong a driver of approaches water managers utilize in the UKB as previously thought. Four matrices resulted in no significant relationships (Table 15). Of the matrices that found statistically significant results (Tables 11-14), many of the relationships found were the same approaches. For example, uncertainty communication resulted in no relationship to drought in any matrix and stakeholder participation and consideration of natural processes were related in only one matrix each. A potential explanation for this is that there are other drivers for the approaches used by water managers in the UKB. Additionally, this research suggests that SPI data is perhaps the most effective measure of drought; the vast majority of significant results were found in comparison to SPI data.

Table 15. Stakeholder groups with no significant results

| **Stakeholder Group** | **Number of Matrices within each Stakeholder Group** |
|---|---|
| Tribe | 1 |
| Local | 2 |
| Other | 1 |

# CHAPTER 6

# DISCUSSION AND CONCLUSIONS

The objective of this research was to uncover how the adaptive capacity of the UKB has changed. The crux was determining what temporal relationship exists between occurrences of drought and strategies put in place by water managers in the UKB. In analyzing the results of this research, it became clear that events on the socio-political landscape are also important drivers, potentially stronger, of these shifts in strategies and policies. The results of content analysis of over 900 pages of management texts show that drought planning, drought mitigation, and climate-change planning are not discussed as frequently as the more day-to-day strategies of water management (e.g., water rights, storage).

Drought/scarcity planning is a theme that was noticeably lacking in many of the management texts. Water demand in the summer, combined with the driest months of the year create timing issues for water managers (Aldous et al. 2011). Climate change models predict increased temporal precipitation regime shifts for much of the Pacific Northwest (Aldous et al. 2011; Hamlet 2011; Madadgar et al. 2013; Dettinger, Udall, and Georgakakos 2015), including the UKB, which will likely exacerbate already sensitive timing issues. The lack of drought and water scarcity planning in management texts corresponds with the literature on drought management in the US. Historically, drought in the US has remained reactive and crisis-driven (Wilhite, Sivakumar, and Pulwarty 2014). In part, this is because of the multi-modal and diffuse nature of drought.

However, early warning systems that address and measure a region's vulnerability to drought can serve as the basis of necessary drought planning (Wilhite, Sivakumar, and Pulwarty 2014). The lack of key words and terms found in the drought response theme indicates this is not occurring (at least on a UKB-specific level) and drought management/preparation has largely remained reactive and crisis-driven.

It is not possible to draw concrete conclusions from the results of content analysis alone. However, it can help to uncover the priorities when the texts were written. For the purposes of this research adaptive capacity was defined as, "the ability of institutions to prepare for and mitigate water scarcity" (Hill and Engle 2013). The content analysis portion of this research show key terms and words relating to collaboration between stakeholders, drought/scarcity preparation and planning, and institutional capacity are far less utilized than those focused on day-to-day water management needs. This suggests low adaptive capacity. It is interesting that those key terms and words relating to collaboration between stakeholders were less utilized, considering the at times at-odd demands and conflicting values of stakeholders (Doremus and Tarlock 2003).

Semi-structured interviews revealed more emphasis on drought, its impacts, and planning. Coding of these interviews allowed for patterns to be identified, which resulted in a timeline of catalyst events. These catalysts have pushed water management strategies and policies one way or another, like a pendulum. These events on the socio-political landscape include: 2001 drought, 2002 fish kills, signing of the KBRA, Final Order of Determination, and the sunset of the KBRA. The lens of political ecology helps bring context to these catalyst events: a common assumption as a basis for political ecology is the unequal distribution of costs and benefits associated with environmental change amongst actors (Robbins 2004). Responses varied on the cause of adaptive capacity increases or decreases however there was agreement that adaptive capacity decreased following the 2001 drought, 2002 fish kills, and sunset of the KBRA and increased following the signing of the KBRA and Final Order of Determination. The different reactions to these events by respondents tie into the viewpoint of nature as a human construction; the view of what is "natural" rests mainly in one's world view (Robbins 2004) and various stakeholders may view the same event as beneficial or detrimental even while agreeing on the same overarching goal.

A large component of preparing for and mitigating water scarcity is collaboration between water managers and their agencies and organizations. It is rare that one agency or organization has the ability to do both of these tasks on their own and as the research surrounding adaptive capacity grows, it is becoming better understood that social structure (e.g., experience, commitment, relationships, leadership, collaboration, and trust) (Hill and Engle 2013) can heavily impact the adaptive capacity across a specific scale (Gupta et al. 2010; Engle and Lemos 2010; and Hill 2013). Rather than acting alone, most agencies/organizations work on one piece that makes up the broader view of adaptive capacity. The complex layers of water management in the West can complicate this through competing water rights and varying agency oversight (Davis 2001; Dunlap 2013). Negotiating and completing the KBRA represents an increase in adaptive capacity, even if only in the context of collaboration. The results from semi-structured interviews conducted throughout this research suggests that adaptive capacity was on the rise from 2001 drought/2002 fish kills, peaked with the signing of the KBRA and FOD, and then began decreasing again following the sunset of the KBRA.

The event history calendar helps to underscore this relationship between events on the socio-political landscape, occurrences of drought, and water management. In times of drought the collaboration within the UKB, for most stakeholder groups, decreases. This can be seen in the negative relationship between many of the approaches used (e.g., collaboration between stakeholders and long-term drought planning) and occurrences of drought, as measured principally by the SPI. The matrices collected from respondents in the state stakeholder group have the most positive relationships of any group tested. Climate-information and scenarios, long-term drought planning, and consideration of natural processes all have positive relationships with occurrences of drought; meaning as drought increases, so do these approaches.

None of the approaches with a positive relationship to occurrences of drought were statistically significant when tested against independent variables adjusted for a 6-month lag time. This suggests that in each of these stakeholder groups, the agency or organization already had a fair amount of adaptive capacity and were capable of pushing these approaches when needed in a relatively short period (less than 6-months). Identifying whether adaptive capacity has increased or decreased is not as simple as looking at whether there is a positive or negative relationship to drought. The SPI data resulted in the most statistically significant relationships, indicating this may be a more accurate measure of drought. The SPI data that incorporated a 6-month lag time resulted in no statistically significant results, this may suggest that the SPI already sufficiently incorporates lag times into its index. The other datasets, Upper Klamath Lake levels and streamflow data, only produced one statistically significant result that is found in the state stakeholder group. This may indicate that these are not sufficient measures for drought and could suggest that respondents within the state stakeholder group utilize these measures with more frequency and therefore are more in-tune to changes, adjusting their water management strategies accordingly. For many of the strategies tested, there was not a statistically significant relationship between the effort placed on those strategies and occurrences of drought. This indicates that there is another driver dictating this emphasis.

The purpose of using multi-modal quantitative and qualitative methods was to try to triangulate how the adaptive capacity in the UKB has shifted. We can now say that there have been shifts, which are likely influenced by occurrences of drought and, potentially to a larger extent, catalyst events on the socio-political landscape. This understanding helps to project how things will continue to shift in the future. The former may be discussed as a timeline (Figure 21), pulling out those catalyst events, which have become clear through analysis of the results of this research.

Catalyst Events

The ESA listing of two fish species in 1988 is included on this timeline because without those listings, conflict over water demands would have likely been greatly reduced. These listings created a federal mandate for protection of these species and increased the demand for both water levels in Upper Klamath Lake and in-stream flow, often at critical times of the year. The listing of these species was both the vehicle for bringing environmentalism to the UKB (Tarlock 2007) and exacerbated the competing demands between stakeholders (Moore, Mulville, and Weinberg 1996). The 2001 drought pushed strategies used by water managers and mandates from federal agencies (i.e. irrigation curtailment) towards prioritizing these endangered and threatened species of fish. The following year, political pressure (Doremus and Tarlock 2008) was able to force the pendulum the other way, and the delivery of water and reduction in in-stream flow, in combination with other factors (i.e. large number of salmon migrating up the Klamath River) likely influenced the massive fish-kills seen in 2002 (California Department of Game and Fish 2004). All stakeholder groups identified both of these events as preceding a point of very low adaptive capacity in the UKB but it did set the stage for stakeholders to come to the table and begin negotiation.

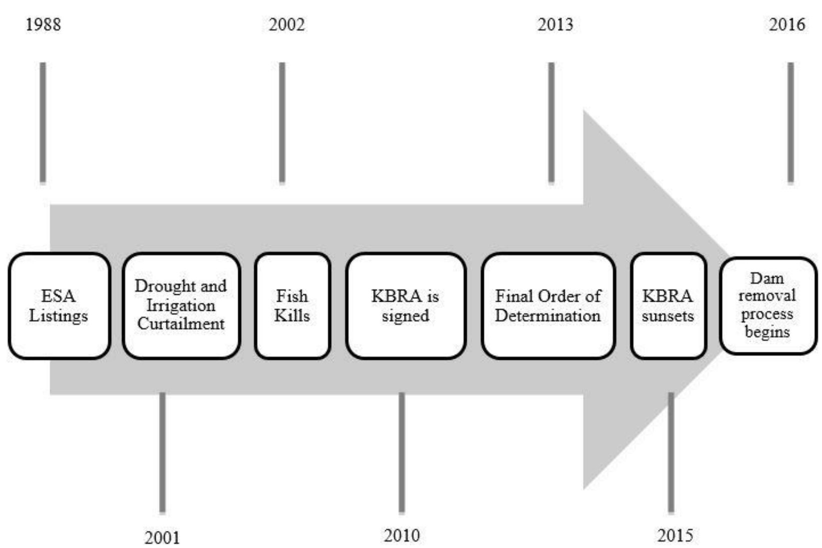


Figure 21. Timeline of catalyst events in the UKB (Snyder 2018).

This negotiation and increased collaboration also increased adaptive capacity in the region, and resulted in the signing of the KBRA in 2010. The coding of interviews showed that stakeholders agreed the signing of the KBRA preceded an increase of adaptive capacity in the UKB. The main components of the KBRA were: 1) riparian area restoration; 2) removing four dams: J.C. Boyle, Copco 1 and 2, and Keno; 3) acquisition and transfer of the Mazama Forest to the Klamath Tribes; and 4) water security assurances to irrigators, accompanied by infrastructure assistance. It is important to note that energy rate increases helped to push along the completion of this agreement; the energy-water-food nexus goes beyond the scope of this research but its connection to the UKB, and specifically the KBRA, is important and will be discussed more in the section on future research at the end of this chapter.

Although the KBRA represented a huge increase in collaboration between stakeholders whose relationships have historically been fraught with tension, it was not universally supported. Irrigators in the upper portion of the UKB, in particular, generally opposed the agreement. Their arguments against it pivoted around ESA requirements, water security, and, for many most contentiously, the purchase of the Mazama Forest on behalf of the Klamath Tribes (Krizo 2009). These first two concerns are linked: many felt that regardless of whatever agreement was signed the ESA designations of two species meant that a) water availability would be limited and b) because the federal government had not been able to recover these species, a new agreement would not help (Hearden 2011). The contention over the Mazama Forest harkens back to federal termination policies in the mid-20$^{th}$ century, which vastly reduced the Klamath Tribe's lands (Hood 1972). Some felt that, despite this huge reduction, the Klamath had been paid for their land and the purchase of the Mazama Forest was akin to trading land for water; the in-stream flow requirements that protect Tribal hunting and fishing rights has also been a source of contention (Milner 2015). This is perhaps best demonstrated by then chairman of the Klamath Basin Alliance, "There is a bigger question of the great injustice of Tribal sovereignty where the tribes have used the endless checkbook of the federal government, attacking our agricultural community." (Bayona 2002; Kelly, Bliss, and Gosnell 2013).

These underlying fears of water security, the idea of government overreach (Parobek 2003), the idea of water as a property right (Gray 2002), and concern of ownership shifts of land, would likely have resulted with increased resistance to the KBRA by irrigators within the upper portion of the UKB. This research indicates that the event with the strongest impact in changing that viewpoint was the 2013 Final Order of Determination. With the FOD the water rights of the Klamath Tribe were not only quantified but, most importantly, they were more easily enforceable. This event pushed irrigators previously unwilling to negotiate to the table, the direct result of which was the UKBCA. Coding of interviews shows that respondents across stakeholder groups agree this event preceded an increase in adaptive capacity.

In 2015 the KBRA sunset, which facilitated a push of the strategies water managers use away from prioritizing fish and their habitat. Coded interviews of stakeholder groups again agree that this event preceded a decrease of adaptive capacity in the UKB, although they disagreed on the why. All but those respondents in the Tribal stakeholder group agree that the institution indicator was at least partially an explanation (examples of this indicator include government effectiveness and stakeholder collaboration). Both the Tribe and those respondents in the other stakeholder group include economic resources as an indicator of this decrease in adaptive capacity, while respondents in the regional and other stakeholder groups include infrastructure. The dissolution of the KBRA was caused by a lack of congressional action and has re-polarized many of the stakeholder groups. It has invigorated efforts by those opposed to a large agreement and discouraged those who worked for its implementation. It appears that this event has pushed stakeholder groups farther away and, though the relationships forged since the 2002 fish kills will help increase collaboration, it is likely that this re-polarization will be represented by an increase of tensions in the UKB and the advent of more legal battles.

One of the most contentious aspects of the KBRA was the removal of four dams. But it appears this may be one component that survives the agreement. In 2016, pushback from dissolution of the KBRA resulted in the signing of a new document: the Klamath Power and Facilities Agreement and amendments to the KHSA (Klamath River Renewal 2018). This new agreement and amendments to the KHSA, laid a path forward for removing all four dams, provided some protections for irrigators regarding endangered species, highlights the importance of implementing the UKBCA for “off-project” irrigators within the UKB, and reiterates the necessity to work collaboratively and find solutions to natural resource conflicts. The Klamath River Renewal Corporation has applied to the Federal Energy Regulatory Commission (FERC) for a transfer of license; upon obtaining transfers for all four dams, removal would begin (Klamath River Renewal Corporation 2018). The plan, known commonly as the Definite Plan, identifies the details of the dam removal process and post-construction activities (Klamath River Renewal Corporation 2018). The next step is waiting for FERC approval of the license transfer, expected later in 2018 or 2019. Although dam removal without additional agreements do not include many of the benefits to the Klamath Tribe that the combination of the KBRA, UKBCA, and KHSA did, the Tribe is generally in favor of dam removal as a move toward sustainable fisheries. Chairman for the Klamath Tribe, Don Gentry, said, “The c’yaal’s, which means salmon in the Klamath language, were placed in these waters by our Creator and was essential in sustaining the people for centuries, but when the dams were built we have not seen salmon in the Klamath Basin for almost 100 years. We won’t be whole, and we won’t be complete as a people, until we can once again fish for our c’yaal’s” (Klamath Tribe 2018).

## The Current Situation

*Klamath Irrigation District v. United States* came to a close in late 2017. The opinion is complicated, thorough, and important for Western water law. The main question in this case was: did the U.S. government illegally take irrigators’ water in 2001? First the U.S. Court of Federal Claims examined each contract, some were deemed invalid because they included the phrase (or similar), “On account of drought or other causes, there may occur at times a shortage in the quantity of water available in Project reservoirs” (*Klamath Irrigation District v. United States 2017*, p. 8). The phrase “other causes” *(Klamath Irrigation District v. United States 2017*, p. 8) was, according to the court, sufficient to remove liability from the federal government. Klamath Irrigation District was one of those plaintiffs whose claims were dismissed and, consequently, the case was re-captioned. The case is now referred to as *Lonny Baley et al. v. United States*.

For water delivery contracts deemed valid the court, similarly to *Lucas v. South Carolina,* stated that because the decisions made by the Bureau of Reclamation translate into real water, the action should be viewed as a physical taking. This was similar to the decision in *Tulare Lake Basin Water Storage District v. United States* (2001), which encouraged plaintiffs in the *Klamath* case. *Tulare* decided, in a Federal Claims Court, that the Bureau of Reclamation was within their right to curtail water but in doing so must provide compensation to those whose water was curtailed (Westbrook 2006).

The ultimate conclusion of the court was that the irrigation curtailments did constitute a physical taking, that it did not matter how long the water was taken for because the water right is appurtenant to the land, but, most importantly, that irrigators could not hold the U.S. government liable because Tribal water rights, which are time immemorial, superseded those of irrigators (*Lonny Baley et al. v. United States* 2017). This is despite that at the time (2001) adjudication was not yet complete (Oregon Water Resources Department 2018). Adjudication is the process by which water right claims are officially quantified and a priority date applied. Without adjudication completed, the Klamath Tribe's water rights were not yet quantified nor easily enforceable. "Although the court recognizes that many plaintiffs, including those who testified before the court, were severely and negatively impacted by the government's actions, the government's decision in 2001 to withhold water from plaintiffs in order to satisfy its Endangered Species Act and Tribal Trust obligations did not constitute an improper taking of plaintiffs water rights or an impairment of plaintiffs' water rights because plaintiffs' junior water rights did not entitle them to receive any Klamath Project water in 2001. For the same reason, the government's actions did not improperly impair plaintiff's right to Klamath Project water in violation of the Klamath Compact." (*Lonny Baley et al. v. United States 2017*, p. 74).

This case is interesting for Western water law. First, the court makes clear that the water is appurtenant to the land, which seems to support the idea of water as a property right (Gray 2002). Second, the case fails because of the most fundamental piece of appropriative water rights: junior versus senior rights (Milner 2015). And lastly, the importance of this case for other basins in the West is that the court upheld the Klamath Tribe's senior water rights (Hood 1972), even before the Final Order of Determination, which semi-structured interviews showed as being an important catalyst event for all stakeholder groups. This also underlines the importance of water rights, the second most used term in content analysis completed for management texts. Water management as a theme in content analysis resulted in the most frequent usage of key words and terms within the texts analyzed.

Although the KBRA was terminated in 2015 and the links between the KBRA and UKBCA are unavoidable, the latter was able to continue until late 2017. In December, 2017 the Department of the Interior (2017) issued notice, terminating the UKBCA. The KBRA, KHSA, and UKBCA were inherently linked. This is because the agreements were seen by many stakeholders as a package, each providing different benefits to various stakeholders. This is particularly true for the Klamath Tribes for whom all the benefits agreed upon between parties could not be realized without all three agreements.

The 2018 water year was a difficult one. In May, irrigators with secondary water rights were already feeling the effects but without a federal drought declaration, there was little aid available (Dillemuth 2018). Bureau of Reclamation temporarily curtailed irrigation deliveries to maintain water levels in Upper Klamath Lake, in order to abide by the 2013 Biological Opinion (BiOp) issued by USFWS and NMFS (Dillemuth 2018). One of the mandates within the joint USFWS and NMFS BiOp (2013) is to implement dilution flows at specific intervals that are tied to rates of infection of fish in the Klamath River. The Bureau of Reclamation argued that dilution flows needed to be scientifically re-evaluated and appealed to the US District Court in Northern California for relief from the requirements outlined in the 2013 BiOp (Dillemuth 2018). The United States District Court, Northern District of California, however, did not agree and sided with the Tribes, who argued these requirements were critical for the health of federally listed fish species (*Yurok Tribe et al. v. Bureau of Reclamation et al.* 2017). The decision in this case is currently under appeal.

Shortly after this decision was announced, the Klamath Tribes filed suit over water levels in Upper Klamath Lake, arguing that scientific measures identified in the 2013 BiOp were not being completed, resulting in Lost River and shortnose sucker declines (Klamath Tribes 2018). A U.S. District judge moved the case from a California federal court to Oregon and in early November, 2018 while still awaiting a trial date, the

Klamath Tribes withdrew the lawsuit, citing Bureau of Reclamation's announcement that a new BiOp would be released in April, 2019 (Klamath Tribes 2018). The clash between stakeholder groups continues and will likely grow worse as drought proliferates and its impacts intensify; the EHC shows that, for many stakeholder groups, collaboration between stakeholders decreases as drought increases. As of June, 2018, regular water deliveries resumed and the complicated process of disbursing federal drought relief funds began (Dillemuth 2018).

Management Recommendations

The following management recommendations stem from the results of this research and are divided into multiple parts. It should be noted that the Upper Klamath Basin has, in some ways, experienced research fatigue. The provocative events of the 2001 drought/2002 fish kills and the UKB's characteristics that make it a good microcosm of many basins in the American West also make it an ideal place to conduct both physical and social science research. Much of this research has been conducted from outside the basin but there is a vast array of local knowledge that should be incorporated as well. It is hoped that the management recommendations below will prove useful to water managers within the UKB but should be noted that local buy-in is of the utmost importance as well as edits to each management recommendation that reflect the nuances of the UKB.

*Planning for Climate Change*

In 2010, the National Center for Conservation Science and Policy completed a report on climate change in the Klamath Basin (National Center for Conservation Science and Policy 2010). The recommendations within the report range from broad and general to fairly specific. An update on this report would be a great resource for water managers as they continue to develop and implement water management plans. It became clear in content analysis, by its limited usage in management texts, that climate change planning is one area that needs development in the UKB. A possible explanation of this is the political tendencies of the region, which tend to be fairly conservative leaning (Doremus and Tarlock 2003; Dunlap 2013). Many of the panel analysis matrices resulted in no significant relationships for "climate information and scenarios", "long-term drought planning", or "thinking outside of the box or experimentation", all of which could be viewed as planning for climate change. Regional and state stakeholder resulted in positive relationships for these strategies, while the federal stakeholder group resulted in a negative relationship between occurrences of drought and "thinking outside of the box or experimentation". This may suggest that state and regional agencies organizations are beginning to incorporate climate change planning more effectively than federal agencies in the UKB. Climate change has, in recent years, become a highly-politicized term that evokes emotion. It may be that the best approach for water management specifically is to couch these changes in terms of water availability and drought.

*Surface-Groundwater Interaction*

One area of water management that much of the American West struggles with is surface-groundwater interaction. In part, this is due to the fact that in many western basins, surface water and groundwater are managed independently. In the UKB, effort has been put into monitoring and modeling groundwater. Oregon Water Resources Department (OWRD) manages both surface and groundwater. However, this research indicates the scientific information published in related reports has not always been incorporated into management documents. Groundwater plays an important role in the UKB, particularly for off-project irrigators in the upper portions of the basin. Groundwater has been regulated, following the negotiation of the UKBCA, by Oregon Water Resources Department's Division 25 rules. With the termination of the UKBCA, that shifted to Division 9 rules (Oregon Water Resources Department 2018). This change increased regulated wells in the 2018 water year by approximately 100 wells (Plaven 2018). Oregon also allows exemptions from groundwater monitoring for the following purposes: domestic use (up to 15,000 gallons/day), irrigation of <1/2 acre lawn or non-commercial garden, single industrial or commercial use <5,000 gallons/day, irrigation of school property <10 acres in critical groundwater areas, down-hole heat exchange, and stock water (Oregon Water Resources Department 2018). Better incorporation of groundwater modeling into water management planning may help determine overall water availability.

*Proper Functioning Conditions and Riparian Zones*

Proper Functioning Conditions (PFC) is a qualitative method that is utilized for assessing riparian zone and other lentic areas. Healthy riparian zones are important for a number of reasons including providing groundwater recharge, improving water quality, vegetation can help to cool water, and woody vegetation provides materials that improve instream complexity. The UKBCA incorporated PFC into its riparian management plan. The incorporation of this methodology was important for a number of reasons: 1) it included technical representatives from multiple stakeholder groups, one named by the Landowner Entity (landowners within the off-project area), one named by the Klamath Tribes, and other representatives from state and federal agencies, if they wished to be included. 2) It helped to establish a common language. Often, a difficulty in getting various entities to collaborate effectively is the different language used by each agency/organization. This becomes particularly true when you incorporate landowners who may use a completely different language. By establishing a set of terms and identifying what success looks like, it can help in future management conversations. A PFC monitoring team, like that described in the UKBCA, and funding for PFC assessments should be included in any future agreements or as a separate program, should state or regional funding be available.

*Long-term Drought Planning and Response*

Occurrences of drought were key to the completion of this research. Drought and the Klamath are intrinsically linked, however, not all management strategies and plans incorporate long-term drought planning and few incorporate specific response measures. Both the drought/scarcity planning and drought/scarcity response themes resulted in few key words or terms found in the management texts analyzed. Long-term drought planning only resulted in significant results for one of the state stakeholder matrices tested. In this case, it was positively associated with occurrences of drought, meaning it increases as drought it occurring. Utilizing lessons learned and incorporating these into long-term drought planning is an important part of developing an adaptive drought management plan (Wilhite, Sivakumar, and Pulwarty 2014). Developing a long-term drought plan could be incorporated as part of climate change planning. Responses to specific water availability were also components of now defunct agreements. Planning for drought, including long-term, has largely been done on a state level in Oregon (National Drought Mitigation Center 2018). It may be that these planning efforts have not been properly incorporated into local or specific to the UKB management documents. It is recommended that not only immediate responses but also drought planning over a large time-span (e.g. 20 years) are included in future agreements and other UKB-specific management documents work to include those responses that are more immediate and specific to the water year at hand. The National Drought Mitigation Center (2018) includes a large section on drought planning, including a 10-set drought planning process that should be utilized when preparing a drought plan. It also includes lessons learned from pilot programs on community drought planning as well as detailed information for individual landowners on how to develop their own drought plans (National Drought Mitigation Center 2018). One of the foundational tenets of any drought plan is: the more accurate information incorporated, the better (National Drought Mitigation Center 2018). This highlights the need to incorporate the large amount of research completed in the Upper Klamath on both water resources, as well as research on social networking that identifies relationships between management agencies.

*Human Resources*

A limitation of this study is staff turnover. Particularly in the case of federal and state agencies, compensation is generally comparable to other parts of the state with the same cost-of-living. However, the UKB is a complicated basin and success in water management hinges on the relationships built between stakeholders. With each new staff turnover, comes complications in getting a new person up to speed and work to re-build trust between entities. Encouraging longevity, particularly on the part of state and federal agencies, is incredibly importation in this basin and it is recommended that recruitment strategies be modified to reflect this.

*Dispute Resolution Model*

The KBRA was an exercise in Coordinated Resource Management (CRM). CRM is a highly local, collaborative process that brings stakeholders together to reach an agreement. One problem with the CRM process and the KBRA may have been who was at the table, by excluding certain stakeholders, opposition to the agreement was fostered. An agreement as large as the KBRA must not only have public buy-in but also strong federal support, a component that was clearly missing for the KBRA. Although the KBRA eventually sunset, it still appears that CRM is the best mode for garnering a lasting agreement on water in the UKB between conflicting, and often divisive, interests. However, tensions have escalated to such an extent that going back a few steps and utilizing the eight steps of the Dispute Resolution Model, which utilizes a mediator and incorporates back and forth to reach consensus, may be necessary.

### Study Limitations and Opportunities for Future Research

The inherent limitation in this study is its scope. It is difficult to pinpoint the adaptive capacity of the UKB, separate from the entirety of the Klamath Basin. However, the geographic area alone in a study like that presents a problem when undertaking a Master's thesis. This research can serve as a stepping stone to understanding the adaptive capacity within the UKB and help to highlight some of the struggles and potential solutions that may be transferable to other basins. Another potential limitation was the HRSC form, which was not completed in a way that would allow quotations to be used for this research. Use of quotes would strengthen arguments and are commonly used in research utilizing interviews. However, it is uncertain the level of candor, or even acceptance of interviews, that respondents would have used had portions of their interview been quoted in this work. One limitation of the EHC is the time-frame chosen and availability of qualified respondents. In discussing the 2011-2015 drought in terms of the 2001 drought and 2002 fish kills, it becomes difficult to find respondents who have remained in the basin over that time frame and have the ability to discuss with accuracy both the 2001 drought/2002 fish kills and the 2011-2015 drought and management strategies.

Opportunities for future research include expanding the study to the entire Klamath Basin. For the event history calendar in particular this could be particularly informative. The energy-water-food nexus in the Klamath also presents intriguing possibilities for future research. One reason for resistance to dam removal in the region is their ties to lower energy rates. Negotiations when the dams were built ensured that they would be turned over for management by BOR, while PacifiCorp, the energy company that owns the dams, would commit to low energy costs for farmers (Jaeger 2004). PacifiCorp would retain the right to generate hydropower on the Klamath River. In 2006, PacifiCorp did not renew this contract that, at the time, had been in place for 100 years (Souza 2006; Doremus and Tarlock 2008). This represented a massive increase for irrigators who had been paying $1/10^{th}$ of the cost of what other irrigators pay (Jaeger 2004). These shifts in prices and, more specifically, the impact of irrigators directly related to the rate of price increases, and how these prices have affected the rate at which irrigators pump groundwater. Further research on this could include an economic analysis, more technical surface-groundwater exploration, and/or further social research as to how energy rates have effected collaboration, water management, and adaptive capacity in the UKB.

## Conclusion

Adaptive capacity in the UKB has not been stagnant. This research set out to uncover the relationship, if any, between approaches water managers use to prepare for and mitigate water scarcity and occurrences of drought. It was hypothesized that if these approaches had a negative relationship, meaning emphasis on the approach decreases when drought increases, and/or these approaches were related in a statistically significant way to independent variables (SPI data, streamflow discharge, lake levels) with a built-in lag, it would suggest a decrease in, or low, adaptive capacity. However, the results from content analysis, semi-structured interviews, and the event history calendar suggest that adaptive capacity was on the rise following the 2001 drought and 2002 fish kills but has begun to decrease again following the sunset of the KBRA. It remains to be seen whether that decrease will continue until another occurrence of drought or event on the socio-political landscape pushes it back or if the relationships forged during negotiations of the KBRA, UKBCA, KHSA, and other agreements will help to limit that decrease.

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## APPENDIX A: Consent Form

**<u>Central Washington University</u>**

Cultural and Environmental Resource Management

Water demands, adaptive capacity, and drought: An analysis of the Upper Klamath Basin, Oregon and California

**Introduction**

The objective of this study is to assess the adaptive capacity of the Upper Klamath Basin in terms of water resources and to assess the effectiveness of policies put into place following the 2001 drought in terms of the 2011-2015 drought.

The anticipated outcome of this study will be a published thesis and a published journal article.

**Procedures**

Meetings will take place over the summer of 2016 at a time and place that is convenient for you and you will be asked questions based on your knowledge of water supply, demand, and management in the Upper Klamath Basin.

<u>During the first visit</u>

Interviews will take place at a time and place that is convenient to you and will last 30 minutes to an hour, based upon your availability. Interviews will be audio-recorded

<u>During the second visit</u>

You may be asked, based on your answers during the first visit, for a second interview. This will be entirely voluntary, will occur at a time and place that is convenient for you, and the length of any second interview will be solely determined upon your availability.

**Risks**

The risks associated with this research study are comparable to those encountered during normal daily conversation. You may experience some mild discomfort being audio-recorded.

**Benefits**

There are no direct benefits to participating in this research.

This research will contribute to the body of knowledge on water resource management and demand conflicts in areas facing water scarcity. Findings from this study will add to the current research and further the understanding of water resource management, particularly as it relates to drought.

**Voluntary Participation and Withdrawal**

Participation in research is voluntary. You have the right to refuse to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You may skip questions or discontinue participation at any time.

If you decide to end your participation, you may also choose to have all data collected on you removed from the study and destroyed.

Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

| | |
|---|---|
| CWU Human Subjects Review Approval: | June 15, 2016 |
| Do not use after this date: | June 14, 2017 |

Figure 1. Consent Form Signed by all Respondents, Page 1.

**Confidentiality**

We will keep your records private to the extent allowed by law. With the exception of Informed Consent and Contact Information forms, all data collection sheets will be distinguishable solely by a randomly assigned subject number. The Informed Consent and Contact Information forms, as well as the subject number key, will be retained in a locked filing cabinet, separate from data collection forms with subject's identification numbers. With permission, audio recordings and transcripts will be retained indefinitely. Research data files will be stored electronically on a password protected external hard drive. These files will only be accessible to Patricia Snyder and Dr. Anthony Gabriel. Your name and other facts that might point to you will not appear when we present or publish the results of this study. You may opt to be provided with a copy of the final product of this research, if you so choose.

**Contact persons**

If you have any questions about this study, e-mail Dr. Anthony Gabriel or Patricia Snyder at gabriela@cwu.edu or snydertr@cwu.edu.

This research has been reviewed and approved by Central Washington University Human Subjects Review Committee. If you have any questions about your rights as a participant or if you think you have not been treated fairly, contact the Human Protections Administrator at 509-963-3115.

**Consent to participate**

By singing this consent form, you are not giving up any legal rights. Your signature means that you understand the study plan, have been able to ask questions about the information given to you in this form, and you agree to join the study.

We will give you a copy of this consent form to keep for your personal records.

____ Yes, you have permission to retain the audio recordings and transcripts at the conclusion of the study.

_____ No, please destroy the audio recordings and transcripts at the conclusion of the study.

| | | |
|---|---|---|
| ______________________ | ______________________ | __________ |
| Printed Name | Signature | Date |
| ______________________ | ______________________ | __________ |
| Principal Investigator | Signature | Date |

CWU Human Subjects Review Approval: June 15, 2016
Do not use after this date: June 14, 2017

Figure 2. Consent Form Signed by All Respondents, Page 2.

APPENDIX B: All Texts Analyzed

Table 1. Full Content Analysis Results of Management Texts.

| Key word or term | Percentage Found | Texts found |
|---|---|---|
| Water rights | 1.89 | • Draft Business Plan for the Upper Klamath Basin (0.03%)<br>• KBRA (0.1%)<br>• 2013 KP Ops Plan (0.35%)<br>• UKBCA (0.2%)<br>• 2014 KP Ops Plan (0.38%)<br>• 2015 KP Ops Plan (0.32%)<br>• Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River (0.02%)<br>• 2016 KP Ops Plan (0.39%)<br>• KHSA (0.1%) |
| Water law/legislation | 0.07 | • UKBCA (0.01%)<br>• 2015 KP Ops Plan (0.02%)<br>• 2016 KP Ops Plan (0.02%)<br>• KBRA (.01%)<br>• Evaluation of Alternative Groundwater-Managements Strategies for the Bureau of Reclamation Klamath Project, Oregon and California (0.01%) |
| Banking and transfers | 0.43 | • UKBCA (0.01%) |

| **Key word or term** | **Percentage Found** | **Texts found** |
|---|---|---|
| | | • 2014 KP Ops Plan (0.08%)<br>• 2015 KP Ops Plan (0.13%)<br>• 2016 KP Ops Plan (0.2%)<br>• KBRA (0.01%) |
| Water availability | 0.18 | • 2012 KP Ops Plan (0.15%)<br>• KBRA (0.1%)<br>• Draft Business Plan for the Upper Klamath Basin (0.1%)<br>• Evaluation of Alternative Groundwater-Managements Strategies for the Bureau of Reclamation Klamath Project, Oregon and California (0.01%) |
| Monitoring and metering | .03 | • Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.02%)<br>• UKBCA (0.01%) |
| Reservoirs and storage | 3.04 | • 2011 KP Ops Plan (0.38%)<br>• 2012 KP Ops Plan (0.54%)<br>• 2013 KP Ops Plan (0.55%)<br>• 2014 KP Ops Plan (0.47%)<br>• 2015 KP Ops Plan (0.36%) |

| Key word or term | Percentage Found | Texts found |
| --- | --- | --- |
| | | • 2016 KP Ops Plan (0.36%0<br>• Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River (0.25%)<br>• KBRA (0.02%)<br>• KHSA (0.04%)<br>• Evaluation of Alternative Groundwater-Managements Strategies for the Bureau of Reclamation Klamath Project, Oregon and California (0.03%)<br>• Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.04%) |
| Conservation, efficiency, and consumption | 0.14 | • UKBCA (0.01%)<br>• 2015 KP Ops Plan (0.1%)<br>• KBRA (0.02%)<br>• Draft Business Plan for the Upper Klamath Basin (0.1%)<br>• Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.07%) |
| Fish health | 0.13 | • Draft Long-Term Plan for Protecting |

| Key word or term | Percentage Found | Texts found |
| --- | --- | --- |
| | | Late Summer Adult Salmon in the Lower Klamath River (0.12%)<br>• KHSA (0.1%) |
| Water quality | 0.43 | • UKBCA (0.01%)<br>• Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River (0.02%)<br>• KBRA (0.02%)<br>• KHSA (0.06%)<br>• Draft Business Plan for the Upper Klamath Basin (0.16%)<br>• Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.16%) |
| Cultural | 0.15 | • 2014 KP Ops Plan (0.02%)<br>• 2015 KP Ops Plan (0.02%)<br>• 2016 KP Ops Plan (0.02%)<br>• Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River (0.01%)<br>• KBRA (0.01%)<br>• KHSA (0.01%)<br>• Draft Business Plan for the Upper |

| Key word or term | Percentage Found | Texts found |
|---|---|---|
| | | Klamath Basin (0.02%)<br>• Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.04%) |
| Declarations, triggers, warning systems | 0.07 | • UKBCA (0.01%)<br>• 2014 KP Ops Plan (0.05%)<br>• KBRA (0.01%) |
| Mitigation and planning | 0.55 | • 2012 KP Ops Plan (0.04%)<br>• 2013 KP Ops Plan (0.07%)<br>• 2014 KP Ops Plan (0.13%)<br>• UKBCA (0.01%)<br>• 2015 KP Ops Plan (0.16%)<br>• Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River (0.03%)<br>• KBRA (0.02%)<br>• KHSA (0.04%)<br>• Evaluation of Alternative Groundwater-Managements Strategies for the Bureau of Reclamation Klamath Project, Oregon and California (0.03%)<br>• Work Plan for Adaptive |

| Key word or term | Percentage Found | Texts found |
|---|---|---|
| | | Management Klamath River Basin Oregon and California (0.02%) |
| General response and emergency management | .01 | • KBRA (0.01%) |
| Previous drought events and experiences | 0.07 | • Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.07%) |
| Conflict between stakeholders | 0.11 | • UKBCA (<0.01%)<br>• KBRA (0.01%)<br>• KHSA (0.01%)<br>• Draft Business Plan for the Upper Klamath Basin (0.04%)<br>• Work Plan for Adaptive Management Klamath River Basin Oregon and California (0.04%) |
| Coordination between stakeholders | 0.85 | • 2012 KP Ops Plan (0.07%)<br>• 2013 KP Ops Plan (0.13%)<br>• UKBCA (0.02%)<br>• 2014 KP Ops Plan (0.14%)<br>• 2015 KP Ops Plan (0.14%)<br>• 2016 KP Ops Plan (0.19%)<br>• Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the |

| Key word or term | Percentage Found | Texts found |
|---|---|---|
| | | Lower Klamath River (0.07%)<br>• KBRA (0.09%) |