

5-1-2010

Keeping Wetlands Wet: The Human Hydrology of Wetlands in the Bear River Basin

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KEEPING WETLANDS WET: THE HUMAN HYDROLOGY OF
WETLANDS IN THE BEAR RIVER BASIN

by

Rebekah Downard

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Human Dimensions of Ecosystem Science and Management

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2010

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ABSTRACT

Keeping Wetlands Wet: The Human Hydrology
of Wetlands in the Bear River Basin

by

Rebekah Downard, Master of Science

Utah State University, 2010

Major Professor: Dr. Joanna Endter-Wada
Department: Environment and Society

This research seeks to understand how wetlands maintain a water supply in the Bear River Basin, where water is generally scarce. Research was conducted through semi-structured interviews with wetland and water experts in the basin and archival research of historical documents and water rights.

The U. S. Fish and Wildlife Service manages three refuges on the Bear River, and has obtained water rights portfolios for each. Holding water rights does not ensure that there will be water available for refuge wetlands. Instead, position in relation to other powerful water users is the most important factor in determining the security of a refuge's water supply and the threats faced from drought. All refuges must manage their water because the human-hydrology of the river is complex and variable; this requires a combination of infrastructure and planning. Maintaining relationships with other water users is another important adaptation to the human-hydrology of the river, because all water users along the river are interconnected. Recognizing that they face the same

threats to their water supply allows wetland managers and irrigators to cooperate in order to maintain the water supply for their region of the river and increases adaptability as the region faces climate change.

The Bear River Migratory Bird Refuge is the oldest refuge on the river and has the least secure water supply, despite having the largest water rights portfolio. Because it is chronically short of water during the summer, refuge staff have developed an adaptive management strategy to effectively utilize the water they do receive. Management involves predicting water supplies each year, **setting water level targets accordingly**, actively diverting water to priority wetlands, and allowing non-priority wetland to dry. This is followed by extensive monitoring of habitat conditions and bird use, the results of which are shared in annual management plans. This strategy maintains the most wildlife habitat possible and offers important institutional adaptations. Most importantly, it demonstrates the refuge's water rights are being put to beneficial use. Sharing knowledge gained through management also builds trust and adaptive capacity among water users facing the complex human-hydrology at the end of the Bear River.

(129 pages)

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Joanna Endter-Wada, for her extensive help in developing and completing my research project, for helping me refine my research, and for all the support she's offered over the past three years. I would also like to thank my committee members, Dr. Karin Kettenring and Judy Kurtzman, for all the feedback and help they've given me with my research and coursework. I would also like to thank my family for all their support and encouragement.

Rebekah Downard

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CHAPTER 1

INTRODUCTION

Wetland habitat is rare in the arid Intermountain West of the United States, a function of both the natural aridity of the region and historic destruction of wetlands. Despite being quite rare, western wetlands provide many ecosystem services, including water disturbance regulation, nutrient cycling, and habitat for significant portions of the North American continent's bird populations, making wetland conservation especially important (Kadlec and Knight 1996, Costanza et al. 1997, Haig et al. 1998, Batzer and Sharitz 2006, Ivey and Herziger 2006). Conserving wetlands in this region requires not only protecting the land within wetland complexes, but also the water supply that feeds them. This is no easy task in a region where water is scarce and heavily appropriated for diversion and use.

Wetlands are complex ecological systems that are potentially affected not only by changing natural environments, but by various policy systems, management institutions, and individual actors. Understanding how wetlands in this region have stayed wet, despite significant changes in land and water use, requires understanding the physical and social contexts within which wetlands exist. Aspects of that context pertinent to this study include wetland, water and wildlife policies; wetland ecology, human hydrology and water security; and adaptive management and collaborative learning applied to wetland issues.

Several federal policies were enacted during the 20th century to protect wetland habitat. Such legislation generally employs one of two mechanisms: 1) preservation of

important wildlife habitat through protection under federal or state agencies; or 2) regulation of activities that could destroy wetlands through permitting, fines or subsidies. These policies have been effective in slowing the pace of wetland destruction nationwide, however, none of these policies specifically addresses protecting a water supply for wetlands (Vileisis 1997, Somerville and Pruitt 2006). Today, wetlands continue to be threatened or destroyed by activities in watersheds that disrupt their hydrology (Dahl 2006). In the Intermountain West, this is most often manifested in wetlands drying up as their water source is diverted for use elsewhere.

Periodic drying is not usually bad for wetlands; in fact, it is part of the natural hydrologic cycle of wetlands and is often necessary for maintaining the ecosystem services wetlands provide. However, lack of flooded wetland habitat can leave migratory birds on the Pacific Flyway without a critical stopover point in arid regions that has enough vegetation to meet their food or reproductive needs (Haig et al. 1998, Ivey and Herziger 2006, Denton 2007). And if water fails to return in a timely manner (between a few months and a few years, depending on the type of wetland), it may result in long-term damage to wetland flora and fauna (Christiansen and Low 1970, Kadlec and Adair 1994). Chronic water shortages have led to serious wetland depletions across the West (MacDonnell 1991).

Water policy in the West has legally allocated most of the water in Western rivers to agricultural or municipal uses, leaving environmental uses of water, like wetlands, dry during times of shortage (MacDonnell 1991). Under the rules of prior appropriation water law, the primary means for allocating water in the western United States, all users must obtain a legal water right from the state within which the water is diverted. Each

water right includes a priority date, corresponding to when an application to use water was filed and designates the beneficial use the water will be put to, most often irrigation, industry, municipal use or wildlife propagation. When water supplies are insufficient to meet all users' needs, those water users who have acquired their water rights most recently, referred to as junior appropriators, will have their water rights cut off first. Beneficial use requirements are embedded into water law to help ensure that states are allocating water in the public's interest, by producing goods or services deemed to be of benefit to the public (MacDonnell 1991, Getches 2009).

In order to have a secure water supply, wetlands generally must be managed by an entity capable of obtaining water rights, like the U. S. Fish and Wildlife Service, which manages millions of acres of wetland habitat in their National Wildlife Refuge System. However, because of the "first in time, first in right" nature of water rights in the West, and the current shifts in water distribution due to growing urban and suburban populations and climate change, holding a water right does not constitute water security. Water security is the availability of enough water, on a dependable basis and of acceptable quality, to sustain ecosystem function and human health and livelihoods, along with acceptable levels of water-related risks, like drought and flooding (Grey and Sadoff 2007). Water security is affected by the historical trajectories and future prospects of the human-hydrological environments that affect wetlands, and requires wetland managers to be able to adapt to uncertain water conditions and changes over time.

Enhancing water security often requires active water management and networking with other interests that use the water sources upon which wetlands depend. Having the ability to manage water in wetlands maximizes the productive potential of a limited

supply while minimizing its destructive potentials. In order to be effective, water management infrastructure must be balanced by institutional developments like planning procedures that ensure the optimal use of water and the sustainability of water management (Grey and Sadoff 2007).

Agriculture utilizes about 80% of diverted water in the western United States and is commonly cited as a threat to wetlands, due to the historical conversion of wetlands for agricultural cultivation and diversions of water for irrigation (Vileisis 1997, Lemly et al. 2000, Langston 2003). However, emerging research shows that many wetlands in the Intermountain West region are actually irrigation dependant because they receive significant amounts of water from irrigation return flow (Lovvorn and Hart 2004, Peck et al. 2005). Successful efforts to increase water security must recognize the human-hydrologic interdependencies of all water uses, agricultural, municipal and environmental, in order to enhance security for all users (Dimitrov 2002, Endter-Wada et al. 2009).

While it may be easiest and even most natural to let wetlands dry during times of water shortage, such a strategy would not meet the mandates of agencies that have been directed to protect wetlands or wildlife. Instead, wetlands managers are often advised to respond to uncertainty or changes in environmental conditions, like decreased water availability, through adaptive management, a management paradigm that promotes a scientific approach to natural resource management in the face of uncertainty (Holling 1978). The goal of adaptive management is to formulate future policies based on what is learned from effects of previous management efforts and to protect the resilience of ecosystems (Gunderson et al. 2006, Hahn et al. 2006).

Adaptive management holds a lot of potential for wetland management in the West because it provides a proactive means to confront uncertainty in water management. Adaptive management also provides a way to meet the requirements of the multiple state, federal and international policies related to wetlands, wildlife and water management (Gunderson 1999). One of the key requirements of adaptive management is monitoring the effects of management strategies and integrating what is learned into subsequent approaches (Gunderson et al. 2006). Analyzing the effects of policies and management strategies is also an important part of collaborative learning, an emerging paradigm in natural resource management that involves linking government agencies, communities, and individuals together to deal with common problems and solve regional issues. (Wondelleck and Yaffee 2000, Euliss et al. 2008). Sustainable wetland management requires linking adaptive management with the social component of ecosystems through collaborative learning (Smith et al. 2008). Building such links often falls to individual wetland or water managers, who can build relationships with other water users in the area and foster cooperation in water use, rather than conflict (Wondelleck and Yaffee 2000, Weber and Khademian 2008).

The U. S. Fish and Wildlife Service manages three wetland complexes within the Bear River Basin, which occupies portions of Utah, Idaho and Wyoming, as national wildlife refuges. Each of these refuges has a unique history and geopolitical position along the river and comparing them provides an opportunity to study the ways wetlands in arid regions have secured and managed water supplies. Chapter 2 of this research presents a comparative analysis of water security at the wildlife refuges through addressing three general questions. First, how was the refuge's water supply obtained?

Second, how secure is that water supply? Third, how have refuge managers adapted to uncertain water availability conditions?

Chapter 3 investigates one refuge in particular, the Bear River Migratory Bird Refuge (BRMBR), located in Utah. BRMBR is the oldest refuge on the Bear River and faces the most significant threats to its water security. As such, it provides an interesting case study in which to examine how adaptive management is applied to a wetland complex with an uncertain and dynamic water supply. The first research objective of Chapter Three is to compare physical water availability, legal water rights and wetland water needs at BRMBR. The second research objective is to explore how the refuge has adapted to the physical and social realities of the Bear River. This case study illustrates one means of meeting national wildlife habitat goals while complying with state water law and maintaining relationships with local interests.

The questions addressed in this research require an in-depth contextualized study of the politics, history, and ecology of the Bear River Basin, and of the organizations and people who currently make decisions about water and wildlife. The specific ecological and political dimensions of the Basin are particular to that region, but dealing with scarce water supplies and changing water uses is an issue common across the Western United States. The means by which the federal refuges in these case studies have secured water supplies provide insights that can be utilized in other managed wetland cases, particularly in other heavily allocated river basins where people are trying to balance the needs of traditional water uses, new water demands and ecological values.

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CHAPTER 2

KEEPING WETLANDS WET: HUMAN HYDROLOGY AND WATER SECURITY AT FEDERALLY MANAGED WETLANDS IN THE BEAR RIVER BASIN¹

ABSTRACT

The water requirements of wetlands make them rare in the arid West. However, in the Bear River Basin (which covers parts of Utah, Idaho, and Wyoming), there are several large wetland complexes, including three federal wildlife refuges. Each refuge occupies a different geopolitical position along the river and faces different threats to its water supply due to drought and future developments. This research seeks to understand how each refuge has obtained a water supply and the security of that supply by analyzing the human-hydrologic contexts within which these wetlands are located. Researchers conducted semi-structured interviews with wetland and water rights experts involved in policy and management of the Bear River. Interviews were complimented by archival research of historical documents, water rights and field research on the river environment.

Refuges with the most secure water supply hold senior water rights or have agreements to utilize other users' senior water rights. Beyond holding legal rights, it is best to hold an advantageous geographic position in relation to other water users whose diversions affect the quantity and quality of water in the river. **No matter how legally secure a refuge's water supply is, refuge managers must practically manage this water to make those rights effective, which requires infrastructure and planning.**

¹ Co-authored by Rebekah Downard and Dr. Joanna Endter-Wada

To adapt to the water related risks and demands of refuge management, managers at each refuge actively manipulate their refuge's water supplies and works to maintain good relationships with other water users, especially ones whose use is hydrologically interconnected with their wetlands. Active management and collaborative problem solving will be critical for all refuges as they face the challenges of future water development in the Bear River Basin and the uncertain consequences of climate change in the region.

INTRODUCTION

Wetlands are rare in the Intermountain West of the United States, primarily because of the general aridity of the region. Conserving wetlands in this region requires not only protecting the land within wetland complexes, but also the **water supply that feeds them**. This is no easy task in regions where water is scarce and heavily appropriated for diversion and use. Holding **legal rights** to water is an important step in securing water for wetlands, but **does not necessarily constitute water security**. Water security is affected by the historical trajectories and future prospects of the human-hydrological environments that affect wetlands, and requires wetland managers to be able to adapt to uncertain water conditions and changes over time. Enhancing water security often requires active water management and networking with other interests that use the water sources upon which wetlands depend.

Wetlands have three identifying characteristics: water, hydric soils and hydrophytic vegetation (Cowardin *et al.*, 1979). Water is the key ingredient in a wetland and water depth and flood duration, which make up the wetland's hydroperiod, drive

most other characteristics of a wetland (Jackson, 2006). Wetlands are one of the most biologically productive ecosystems in the world and provide ecosystem services that include wildlife habitat, wastewater treatment, nutrient cycling, and water disturbance regulation (Batzner & Sharitz, 2006; Costanza *et al.*, 1997; Kadlec & Knight, 1996). To perform these services, freshwater wetlands need dynamic pulses of water (Christiansen & Low, 1970; Smith *et al.*, 2008).

Despite the important role wetlands play in maintaining healthy watersheds and wildlife populations, wetlands have been maligned as wasteful places for much of the United States' history and a great deal of effort has gone into converting them to other land uses (Badger, 2007; Cronon, 2003; Giblett, 1996; Vileisis, 1997). This began to change in the 20th century when key pieces of legislation were enacted to protect wetlands. This legislation generally employs one of two mechanisms: 1) preservation of important wildlife habitat; or, 2) regulations that prevented destruction of wetlands. The Fish and Wildlife Coordination Act (1934) follows the first wetland protection strategy. The Act requires consultation with the U. S. Fish and Wildlife Service (FWS) before beginning construction activities that could negatively affect wildlife habitat and provides a means for the government to acquire land and water for wildlife conservation. Many states also have similar policies to protect their own wildlife habitat. Most other federal wetland legislation follows the second route by seeking to prevent wetland destruction through permitting (e.g., the 1972 Clean Water Act), agency policy (e.g., Executive Order 11990 signed in 1977) or withholding federal subsidies (e.g., the Swamp Buster provisions of the 1985 Food Security Act) (National Research Council, 2001; Somerville & Pruitt, 2006; Vileisis, 1997).

This federal legislation has been effective in slowing the pace of wetland destruction nationwide. However, none of these policies specifically addresses protecting the water supply for wetlands. Rather, they focus on protecting land that has been designated as wetlands or the wildlife that utilizes wetland habitat. Today, wetlands continue to be threatened or destroyed by activities in watersheds that disrupt their hydrology by decreasing or increasing flood pulses or altering patterns of sedimentation (Dahl, 2006). These activities are often regulated or mandated by policies related to water allocation and management, which are much older than those designed to protect wetlands and have only recently been amended to incorporate environmental values of water, like wetlands.

Under the rules of prior appropriation water law, the primary means for allocating water in the western United States, all users must obtain a legal water right from the state within which the water is diverted. Each water right includes a priority date, corresponding to when application to use water was filed and designates the beneficial use the water will be put to, most often irrigation, industry, municipal use or wildlife propagation. Every water user's rights are affected by the water available in the source of supply and the seniority of other user's water rights relative to their own. When water supplies are insufficient to meet all users' needs, those water users who have acquired their water rights most recently, referred to as junior appropriators, will have their water rights cut off first (Getches, 2009). In order to secure water, wetlands generally must be managed by an entity capable of obtaining water rights, like the U. S. Fish and Wildlife Service which manages millions of acres of wetland habitat in their National Wildlife Refuge System.

Water is primarily allocated by individual states, but there are a few cases whereby the federal government plays a role in water allocation, one of these being through the federal reserved right claim. Under this doctrine, established in 1908 during the case of *Winters v. United States*, the federal government has right to enough water to serve the purposes federal land was set aside for, be it Indian reservations, national parks or wildlife refuges. Water rights claimed as federal reserved rights hold a priority date of when the land reservation was established. The doctrine also comes into play with efforts to protect endangered species (Getches, 2001).

Having legal access to water does not guarantee water will always be available to wetlands, especially in the arid Intermountain West. After the establishment of western states, water was generally allocated to agricultural first and is now being redistributed, often through market mechanisms, from agricultural to municipal use. Meanwhile, climate change threatens to disrupt water supplies by altering patterns of precipitation and evaporation. Thus, water supplies for wetlands in this region are best described in terms of their water security. Water security is defined as the availability of enough water, of acceptable quality, to sustain ecosystem function and human health and livelihoods, along with acceptable levels of water-related risks, like drought and flooding (Grey & Sadoff, 2007). Most research on water security has focused on the security of water for food production and sanitation and the risk of violent conflict due to lack of security (Dimitrov, 2002; Gleick, 1993; Postel, 1996). Water security can be assessed for different water uses, including personal use, agricultural use and environmental use. Efforts to maintain or increase security for just one of these three uses can cause conflict, and security for all uses is decreasing globally (Bruins, 2000; Vaux, 1993). However,

efforts to increase water security that recognize the human-hydrologic interdependencies of all water uses are more likely to enhance security for all users, but are also more difficult to achieve (Dimitrov, 2002; Endter-Wada *et al.*, 2009).

Agriculture utilizes about 80% of diverted water in the western United States and is commonly cited as a threat to wetlands, due to the **historical conversion of wetlands for agricultural cultivation and diversions of water for irrigation** (Langston, 2003; Lemly *et al.*, 2000; Vileisis, 1997). Historical and globally focused research suggests the two interests continue to compete for water, and that improvements in agricultural water use efficiency will mean increased security for environmental uses (Gleick, 1993; Grey & Sadoff, 2007; Jury & Vaux, 2005; Postel, 1996; Vaux, 2008). However, emerging research shows that many wetlands in the Intermountain West region are actually irrigation dependant because they **receive significant amounts of water from irrigation return flow** (Lovvorn & Hart, 2004; Peck *et al.*, 2005). Population growth increases the demand for water, and municipal water managers are also promoting increased agricultural water use efficiency and transfers of water from agricultural to municipal use as a way to increase water security in urban areas (Utah Division of Water Resources, 2000). This poses a **threat to wetlands that receive water from irrigation return flows** or that have adapted to the current water distribution system.

Historically, **the most commonly applied means of increasing water security under highly variable hydrologic conditions have been water storage and delivery facilities.** ~~More recently water managers have begun seeking agreements with other waters and other non-structural adaptations to better manage rivers and integrate multiple uses~~ (Dimitrov, 2002; Grey & Sadoff, 2007; Jury & Vaux, 2005). The ability to manage

water maximizes the productive potential of a limited supply while minimizing its destructive potentials (e.g., the risks of droughts and floods). In order to be effective, water management infrastructure must be balanced by institutional developments like planning procedures that ensure the optimal use of water and the sustainability of water management (Grey & Sadoff, 2007). As water security becomes a more pressing issue, due to population growth and climate change, collaborative institutions that manage water across state and agency boundaries will become necessary to address regional and local water needs (Dimitrov, 2002; Kamieniecki & Kraft, 2008; Wondelleck & Yaffee, 2000).

Human interaction is important in river basins where water supplies are variable and heavily managed, especially where they constitute interstate water bodies. A common source of conflict and water insecurity is the compartmentalization of water management within agencies or states. Conflict arises when multiple groups or agencies manage different aspects of the same supply (e.g., quality or quantity) or when states have different rules for allocating an interstate river (Dimitrov, 2002; Grey & Sadoff, 2007; Wondelleck & Yaffee, 2000). Individual water and wetland managers can be key actors in building collaborative capacity in an area, especially when they can find the flexibility to work outside the bounds of organizational structures and when they are willing to communicate and work with personnel in other institutions (Ashe, 2003; Hahn *et al.*, 2006).ⁱ

Wetlands in the Intermountain West only cover about 1% of the region's land area, compared to 5% nationwide (Dahl, 2006). However, these rare pieces of wetland habitat are critical stopover points for millions of birds on the Pacific Flyway, supporting

30-60% of North America's bird diversity at some point during the year (Haig *et al.*, 1998; Wilson & Carson, 1950). Periodic drought is not usually bad for wetlands; in fact, it is part of the natural hydrologic cycle of wetlands and is often necessary for maintaining the ecosystem services wetlands provide. However, lack of flooded wetland habitat can leave migratory birds without a critical stopover point in arid regions that has enough vegetation to meet their food or reproductive needs (Denton, 2007; Ivey & Herziger, 2006). Low water can decrease plant growth and food production and concentrates more birds in smaller areas, making outbreaks of bird diseases more likely and potentially more devastating (Al Trout, personal communication). Furthermore, drought's positive effects are contingent upon the rate of water drawdown and on sufficient water returning in a timely manner to maintain wetland plant communities (Christiansen & Low, 1970; Kadlec, 1962; Taft *et al.*, 2002).

Wetlands in the Intermountain West are adapted to periodic drying, but natural hydrologic cycles and water sources have been disrupted and manipulated for human uses. As waterways across the Western United States were developed, primarily for agricultural use, many wetlands were intentionally drained or accidentally dried up. Other wetlands have developed in low lying areas where water has been redistributed due to hydrologic manipulations of rivers for other, out-of-stream uses (Lemly *et al.*, 2000; MacDonnell, 1991; Peck *et al.*, 2005). Predicted changes in precipitation and temperature due to climate change will also have a significant impact on wetlands and water distribution in the West. Over a 50-year period, there has been a 15-60% decrease in snowpack at measurement points across the Interior West, though the highest mountain points have seen an increase in snowpack (Mote *et al.*, 2009). Changes in the timing of

spring runoff (the annual peak of stream discharge) have been increasing over the last few decades, with runoff peaking earlier and less water coming downstream naturally during the late spring and summer (Lundquist *et al.*, 2009). Climate models also suggest increased variability in inter-annual precipitation and rises in temperature that will increase the evapotranspiration demands of wetland and agricultural plants (Wagner, 2009). All of these factors combine to produce a great deal of uncertainty globally and locally about how much water will be available in rivers and aquifers and how users will have to adapt to changes in water supplies (Jackson *et al.*, 2001).

Within the Bear River Basin, located in the states of Utah, Idaho, and Wyoming, three wetland complexes are managed as part of the National Wildlife Refuge System. Hydrologic conditions on the river vary considerably, both temporally and spatially, and each refuge has had different opportunities to obtain a water supply and faces different threats to that water supply. This chapter presents a comparative analysis of these water supplies through three addressing general questions. First, how was the refuge's water supply obtained? Second, how secure is that water supply? Third, how have refuge managers adapted to uncertain water availability conditions?

Answering the first question requires an understanding of the legal and physical rules of water allocation in the region. An initial policy review revealed that there are five main mechanisms for obtaining a water supply at federal refuges in the Intermountain West: 1) securing state certificated water rights; 2) securing a federal reserved water right; 3) making agreements with other water users for access to water; 4) purchasing or leasing water rights from other entities; or, 5) having an advantageous geographic position that requires no legal or agreed upon water supply delivery.

The second question this research sought to answer was how secure each refuge's water supply is, which requires a modification of the traditional definition of water security. Water security for wetlands is different than water security for human consumption or agriculture use because wetlands are adapted to dynamic hydroperiods. For the purpose of this research, water security is defined as the availability of a quantity of water, during most years, sufficient to support enough flooded or periodically flooded wetlands to meet habitat needs established by each refuge. Three factors determine water security: the hydrologic environment, the human environment, and the interactive effects of future changes to those environments.

The three federal wetlands we studied are all located in contexts where, since the end of the 19th and beginning of the 20th centuries, significant hydrologic manipulations of the Bear River occurred to support irrigated agriculture. More recent changes have involved increasing agricultural irrigation efficiency, transfers of water rights among various uses, and developing water supply infrastructure to support growing urban areas. Thus, our third question was: How have wetland managers adapted to the uncertain water conditions on the Bear River?

Researching these questions requires an in-depth contextualized study of the politics, history, and ecology of the Bear River Basin, and of the organizations and people who currently make decisions about water and wildlife. The specific ecological and political dimensions of the Basin are particular to this region, but dealing with scarce water supplies and changing water uses is an issue common across the Western United States. The means by which the refuges in this case study have secured water supplies provide insights that can be utilized in other managed wetland cases, particularly in other

heavily allocated river basins where people are trying to balance the needs of traditional water uses, new water demands and ecological values.

METHODS

Research Approach

The general research approach followed a retroductive methodology to explain an interesting phenomenon through a combination of research approaches, including semi-structured interviews and archival document research (Creswell, 2009; Romesburg, 2009).

A literature review and preliminary search of water rights yielded a ten-question interview protocol and list of interview participants. Interview participants included current and former managers and biologists at federal wildlife refuges, water right administrators of states in the region, and state wildlife managers and biologists (see Appendix A). Interview participants identified additional sources of data, secondary literature, and potential interviewees that provided further insights about the case studies. Interview questions addressed the source, quantity and legal nature of refuge water supplies, the nature and effects of drought, constraints and opportunities for acquiring water supplies, controversies associated with water allocation on the Bear River, the effectiveness of wetland policies and interagency and inter-basin politics (see Appendix B for interview protocol). Interviews were recorded and transcribed when possible (see Appendix C for informed consent letter approved by Utah State University's Institutional Review Board).

Data from interviews were triangulated with other sources of information, including water rights, stream flow data and refuge management plans. Interviews produced themes about differential water security along the Bear River and the importance of relationships and knowledge sharing which were verified through additional literature searches. The results of this research are presented here as a comparative case study of three wildlife refuges in the Bear River Basin, detailing water security and adaptations at each refuge.

The Bear River Basin: Context for the Case Studies

The Bear River Basin is geographically and politically complex (Jibson, 1991). The Bear River flows for 500 miles through three states, beginning in the montane forests of the High Uinta Mountains in Utah, passing through sagebrush rangelands and agricultural valleys of Wyoming, Idaho and Utah, and crossing state lines five times before emptying into the Great Salt Lake (see Figure 2-1).ⁱⁱ The Bear River Basin receives most precipitation in the form of snow, which falls on high elevation forests during the winter. Because of this, flow in the Bear River varies significantly seasonally and between years depending on annual accumulated snow pack, often seen in cycles of drought and flooding (Utah Water Research Laboratory, 2010). Discharge at the end of the river can vary from 23 cubic feet per second (cfs) during July of a dry year, to 14,700 cfs in April of a wet year (U. S. Geological Survey, 2009a). Figure 2-2 shows the hydrograph of average monthly discharge in the Bear River over the last 45 years, indicating the changes in stream flow within and between years. The cycles of drought

and flood have been the impetus for the formation of important water policies along the river (Endter-Wada *et al.*, 2009; Utah Division of Water Resources, 2000).

The Bear River Basin contains two natural, ecologically unique lakes, Bear Lake and the Great Salt Lake. The ecological differences between the two lakes have important political consequences for their associated wetlands. The Great Salt Lake (GSL) is a shallow, hyper-saline, terminal lake at the end of the Bear River. Changes in lake elevation, due to changes in winter snow pack, result in large changes in surface area (U. S. Geological Survey, 2009b).ⁱⁱⁱ The north and east sides of the lake support exceptionally productive wetlands that fluctuate in size along with the shoreline of the lake. The GSL is often described as desolate because it supports no fisheries; however, it has a very productive food web based on brine shrimp and brine flies that support huge populations of birds and a large brine shrimp harvesting industry (Wurtsbaugh & Gliwicz, 2001).

Bear Lake, which straddles the Utah-Idaho border, is a natural lake that has been augmented to store high spring runoff flows for delivery during the irrigation season.

The Bear River was not historically connected with the lake until 1918, when a canal was completed to divert the river into Mud Lake, then into Bear Lake, followed by a canal and pumping station to bring stored water back out of the lake and into the river. This allows the top 21.65 feet of the lake to be used as a storage reservoir (Jibson, 1991).^{iv}

PacifiCorp, a power company, manages the canals within the stipulations in the Dietrich and Kimball Decrees, the Bear River Compact, and the Bear Lake Settlement Agreement, described in Table 2-1.

The natural geography of the river basin limited where and how the first settlers could manipulate the river, so settlement began first along tributaries and on mountain benches, where water was most easily impounded and diverted. The oldest legal rights on the Bear River date back to the 1860s, when the river was first allocated for irrigation according to the rules of prior appropriation. These rules were codified into state constitutions when the territories achieved statehood in 1890 and 1896 (Jibson, 1991).^v However, in the past 150 years, technological advancements have allowed users to exercise greater control of the river, building larger dams and putting large river valleys into agricultural production. The Bear River and its tributaries are now impounded by numerous dams and diverted by several canals, which capture snowmelt during spring runoff and distribute it later when natural flow and precipitation are low. The construction of so much infrastructure has had significant ecological and political consequences.

Management of the Bear River is difficult because it is an interstate river and because it is prone to cycles of drought and flooding. However, negotiations over water on the Bear River have been marked by “cooperation and iron-clad decree” rather than protracted conflict common in other river basins in the West, even in times of drought (Endter-Wada *et al.*, 2009).^{vi} Cooperation is possible because of the Bear River Compact, which allocates water equitably between states, and the Bear River Commission, a transboundary organization that administers the Compact and connects users from all three states (Boyce, 1996; Jibson, 1991). There are several other water policies unique to the Basin that impact wetlands and their water supply, summarized in Table 2-1. These form the “law of the river,” adding to the framework of prior

appropriation by including provisions that fit regional water needs and historical water use. The law of the river includes compacts, court decrees, agreements between powerful water users and management plans.

The human hydrology that results from the hydrological, ecological and political aspects of the Bear River is presented below as a case study of the three federal wildlife refuges in the Bear River Basin.

RESULTS

Each federal refuge on the Bear River holds a different geopolitical position, but they all have the same general options for securing a water supply. Based on their particular histories and the various pressures refuge wetlands face from drought, managers at each refuge have chosen different means for securing a water supply, yet all have adapted in similar ways to the water insecurities they face. There are three factors that determine water security at each refuge: the hydrologic environment, the human environment, and the interactive effects of future changes to those environments. These factors together form a unique human-hydrologic environment at each Refuge.

Aspects of the hydrologic environment that affect wetlands are the absolute level of resource availability, the inter- and intra-annual variability of water, and the spatial distribution of the water (Grey & Sadoff, 2007). Given the region's general aridity and the temporal and spatial variability of river flow, the Bear River provides a dynamic and uncertain water supply; however, the uncertainty and dynamism of the river's hydrology varies by location (Utah Division of Water Resources, 2004). The average monthly stream flow in the Bear River in the vicinity of each refuge was analyzed to determine

how similar stream flows were at each refuge from year to year, particularly during the irrigation season.

The human environment of the Bear River has two components: institutions (the organizations, policies, laws, regulations, and incentives related to water management) and infrastructure (dams, canals, and other water conveyance structures) (Grey & Sadoff, 2007). Prior appropriation is the primary water allocation institution on the river, and is discussed here as the legal rights held or utilized for the wetland habitat at each refuge. Once institutional access to water is secured, water must be managed within refuges through a combination of infrastructure and planning. Refuge infrastructure is most often in the form of a series of dikes that subdivide a wetland complex into discrete units where water depth can be manipulated by canals that deliver water to these units. Information on water needs, water rights, and physical supply are necessary to utilize infrastructure properly.

The third factor in determining water security is the future environment of the river. Among the future challenges facing Bear River Basin wildlife refuges are changes in water use throughout the basin, climate change and emerging problems with water quality. These changes will affect both the hydrological environment, through alteration of the quantity and timing of water in the Bear River, and the human environment of the river through the necessary changes to river management policy. Adapting to those changes will also increase the cost of maintaining water security. The discussion below describes the environmental factors at each case study refuge and corresponding water security and adaptations.

Cokeville Meadows National Wildlife Refuge, Wyoming

One of the most recent additions to the national wildlife refuge system is Cokeville Meadows National Wildlife Refuge (CMNWR), located in the upper region of the Bear River, where it flows through western Wyoming. The refuge was established in 1993 after it was identified as prime waterfowl habitat that should be protected. The wetlands and attendant wildlife found at CMNWR are rare in Wyoming, which consists of more rangelands and mountains than wetlands. Thus far, the U. S. Fish and Wildlife Service (FWS) has acquired 8,000 acres of land for the refuge and hopes to obtain up to 26,000 acres of land in order to protect 20 miles of the Bear River and its tributaries in the vicinity of the refuge (Kate Kirk, personal communication) (see Figure 2-3).

The hydrologic environment at CMNWR follows a fairly predictable pattern, river flow peaks in June and decreases through the summer. Differences between minimum and maximum flows over the course of the year and between years are not extreme, though seasonal variation and inter-annual changes in discharge are apparent (see Figure 2-4). There are also smaller tributaries and groundwater sources that supply water to CMNWR and moderate some of the effects of the variability in the Bear River.

The FWS has a diverse portfolio of water rights acquired with lands purchased for CMNWR, including shares in eight ditches, 16 ground water rights and rights to storage water (see Table 2-2). Many of the surface rights have natural flow priorities dating back to the 1800s.^{vii} The foundation of the refuge's water supply is a number of rights on the B. Q. (Beckwith-Quinn) Dam East and Pixley Irrigation Ditches that date back to the 1870s and 1880s. These are the oldest rights on the refuge and are used to irrigate the largest contiguous portions of the CMNWR. The refuge is entitled to 44% of the flow in

the B.Q. Canal (which can carry up to 150 cfs) and 33% of the flow in the Pixley Canal (which on average carries 40-60 cfs) (Kate Kirk, personal communication).

Groundwater forms the second major piece of CMNWR's water supply; these rights have lower priority, but some are quite large. Most of the rights are for irrigation to be used during the late spring and summer; however there are some designated for stock water or domestic use. Much of the current work on the refuge involves cataloging their rights and working to fully utilize them. Utilizing these rights, especially groundwater rights, requires significant infrastructure, including pumps and sprinklers. Some of this infrastructure, which was acquired with the land purchased for the refuge, has not been used in recent years and the refuge's staff is currently trying to get groundwater pumps refurbished so they can use all water sources available to the refuge (Kate Kirk, personal communication).

CMNWR managers are unable to fully manage their water because the refuge is relatively new and is only just beginning the process of developing a management plan to guide their efforts. However, the physical infrastructure for water management (dikes and board-stop structures) is in place and as they gather data and complete a water management plan, managers hope to be able to actively manage their water to better meet the requirements of wildlife. According to a refuge manager, "The water management plan is extremely important.... We just know we need water in wetlands for the birds, and then we get rid of it for agricultural ends" (Kate Kirk, personal communication). This is not to suggest that there is no water management taking place. Most of the time managers spend on the refuge they are adjusting water levels in different wetland units and following a general strategy of filling wetlands during the spring and drying units in

the late summer. To meet agreements with nearby landowners negotiated when the refuge was established, the staff purposely draws down some wetland units during the late summer to allow those landowners to cut and dry wetland vegetation from the refuge for hay to feed cattle (Kate Kirk, personal communication).

In order to develop a water management plan and eventually open the refuge to the public, managers will develop a Comprehensive Conservation Plan (CCP). This document is a requirement of the 1997 National Wildlife Refuge System Improvement Act and should act as a tool to guide long-term management decisions at the refuge. The CCP process involves identifying the purpose of each refuge, distribution of wildlife, habitat and archeological values, areas with recreation potential, and significant problems that would adversely affect refuge values. With this information, and with input from the public, refuges managers are then required to put together a comprehensive management plan (U. S. Code, 1997). Gathering the necessary information and developing a long-term management plan is a large task for a new refuge with limited staff.

At CMNWR, managers feel comfortable with their current water supply: “In dry years the refuge [isn’t] affected because we have a lot of senior rights.... What we’re entitled to can pretty much maintain [the habitat] we have” (Kate Kirk, personal communication). Furthermore, they foresee no major threats to the water supply, because of the refuge’s advantageous position high in the watershed where upstream water development is unlikely. It would have to be a year without snow in order for the refuge to not have enough water. However, because no one has been staffing and monitoring the refuge for long periods of time (because it is new), it is unclear exactly how drought would affect the wetlands (Kate Kirk, personal communication). History has shown that

drought can hit the agricultural interests in that area hard because there is insufficient storage to carry the area through several years of diminished snowpack (Jibson, 1991). This history is applicable to CMNWR because these wetlands were agricultural fields until the refuge was established. Climate change could also pose a serious threat to CMNWR water supply, because various models predict it will likely decrease the snowpack that feeds the Bear River.

As the staff determines the refuge's water supply and needs, managers will have the flexibility to adapt their future management plans to the contextual realities of water and land management in the area (Kate Kirk, personal communication). One such adaptation already in place is allowing landowners to harvest hay on refuge lands. Because of this arrangement, the refuge does not need to keep as many of their wetland units flooded, thus demanding less water during the late summer than they would if units were scheduled to be flooded.

CMNWR managers have built good working relationships with the Wyoming State Engineer's Office and the Wyoming Division of Wildlife Resources. These relationships are important because they help managers get to know their water supply and wildlife resources and build collaborative capacity to adapt to water changes in the area. CMNWR managers cooperate with neighboring water users on a regular basis; currently they send FWS water down canals when other water users ask for it. This will likely change as the refuge develops a water management plan, but the current practice has built lines of communication between water users in the area. Managers also hope to develop more relationships with the local community through the CCP Process (Kate Kirk, personal communication).

Bear Lake National Wildlife Refuge, Idaho

The Bear Lake National Wildlife Refuge (BLNWR) was established in 1968 to aid the recovery of declining Canada goose populations because the Mud Lake and Dingle Marsh area of the Bear River was identified as prime goose nesting habitat (Annette deKnijf, personal communication). The refuge encompasses 19,000 acres, including 17,000 acres of wetland habitat. The marshes, along with grasslands, grain fields and open water habitat, support many species of waterfowl and colonial nesting birds (U. S. Fish and Wildlife Service, 2009). Mud Lake forms the southern portion of BLNWR, and connects to Bear Lake through a large culvert. Despite all of the hydrologic changes associated with development of Bear Lake for hydropower and irrigation, the BLNWR wetlands persisted and after the area was established as a wildlife refuge efforts have proceeded to improve the quality of the habitat (see Figure 2-5).

The hydrologic environment at BLNWR is primarily determined by the Rainbow Canal, which diverts the Bear River from its natural channel through BLNWR and into Bear Lake. Flow in the canal does diminish during the late summer, but not drastically, and discharge remains fairly predictable between years (see Figure 2-4). Bloomington, Paris, and St. Charles Creeks all terminate at this refuge, as do the Dingle and Ream Crockett irrigation canals. Most years, these canals will carry water for the entire irrigation season (April through October), thus increasing the reliability of water at BLNWR.

FWS does not own any water rights for BLNWR. Instead, it has entered into agreements with the entities that do hold rights either through holding shares in irrigation

companies or negotiating agreements for water use with powerful nearby water users.

PacifiCorp, a power company, manages the Rainbow Canal and other facilities associated with Bear Lake water storage, and holds rights to divert 5,500 cfs of the Bear River through this canal with priority dates of 1911 and 1912.^{viii} Through an agreement with PacifiCorp, refuge managers can draw the canal up or down six inches, according to wetland habitat needs (Annette deKnijf, personal communication). Before this agreement was made the water level in Dingle Marsh would fluctuate widely according to the water being brought into and released from Bear Lake for hydropower generation or irrigation needs, to the detriment of nesting birds (U. S. Fish and Wildlife Service, 2008). While PacifiCorp's rights are not as senior as the canal companies' rights, through several agreements and decrees (mentioned in Table 2-1), the water is actually diverted and stored for downstream irrigators who have priorities dating back to the 1880s.

The FWS also holds shares in five of the canal companies that irrigate lands around the refuge. The canal companies' rights are primarily for irrigation, but there are some wildlife or stock watering rights that can be used year round. The combination of PacifiCorp and irrigation company water rights ensures there will be water for BLNWR because of its proximity to the canals and to Bear Lake. Table 2-3 lists the rights relevant to BLNWR.

BLNWR does have a management plan but it has less physical infrastructure than other refuges, which limits the ability to manage habitat to some degree. However, there are plans to add more wetland units in the near future in order to better implement management efforts. Current management practice involves filling wetland units during the spring, when water is plentiful, and intentionally allowing units to draw down in the

fall, when water is scarcer. As refuge personnel build more water control structures, they may be able to restore some of the natural wetland hydrology to the area that was disrupted by construction of the Rainbow Canal and a causeway between Bear Lake and Mud Lake. This would help recreate the slow flow across BLNWR land from north to south. Through this measure, they will also create diverse habitat types and control some of their water quality problems (Annette deKnijf, personal communication).

BLNWR sits in a good place geopolitically currently and for the foreseeable future. The Bear River Compact designates that there should be no net legal loss of water into Bear Lake. Thus, water developments upstream of the refuge cannot legally diminish PacifiCorp's storage rights in Bear Lake (the source of the refuge's supply). Managers at BLNWR note that there seems to be enough water most years and do not feel the refuge needs more. But they feel certain that if a really serious drought were to affect the area, irrigators' needs would come before the wetlands. However, that prospect seems unlikely. A more pressing concern is the quality of water entering the refuge; currently managers are seeing problems with phosphorous, pesticides and sediments (Annette deKnijf, personal communication).

BLNWR has not had to focus as much on maintaining a water supply because of its geographic position on the river, so managers are able to focus on trying to restore the natural hydrology and enhance water quality (Annette deKnijf, personal communication). Enhancing water quality is an option only available to refuges with secure water supplies, both because of the water quantity required to manage water quality problems, and because of the time it takes to manage major water quantity issues. Climate change does

pose a threat to BLNWR, as it could change the amount of water entering Bear Lake through changes in snowpack and potentially change the way the lake is operated.

One of the most important aspects of water management at Bear Lake NWR is the good relationship managers have had with PacifiCorp, which provides the primary source of water to the refuge. BLNWR will be starting the CCP process shortly, which presents an opportunity to involve nearby communities in developing management goals for the refuge (Annette deKnijf, personal communication). Having those lines of communication with the local communities will allow for future adaptations to river conditions.

Bear River Migratory Bird Refuge, Utah

Bear River Migratory Bird Refuge (BRMBR) sits within the 112,000 acre Bear River Delta in the northeast arm of the Great Salt Lake (GSL) and encompasses 74,000 acres, about 30,000 acres of which are managed as freshwater wetlands (Olson, 2009; Olson *et al.*, 2004) (see Figure 2-6). Every year more than 260 species of birds utilize BRMBR for feeding, breeding or staging; these birds account for about 30% of the birds on the Pacific Flyway and some from the Central Flyway. Many of these bird populations are internationally significant but none of them are threatened or endangered (Haig *et al.*, 1998; Ivey & Herziger, 2006; Wilson & Carson, 1950).

When the early explorers of the West first saw the Bear River delta they were astonished by the flocks of ducks and shorebirds feeding on the marshes (Fremont, 1845).^{ix} But by the 1920s, the delta had been depleted to about 2,000 scattered wetland acres, down from 45,000 acres, due to upstream irrigation diversions. Changes in the

hydrology of the river exacerbated outbreaks of avian botulism that killed up to 500,000 birds a year (Olson *et al.*, 2004; Wilson & Carson, 1950). Congress reacted by establishing the Bear River Migratory Bird Refuge in 1928 with the mission to create suitable feeding and breeding habitat for migratory birds and to comply with the Migratory Bird Treat Act of 1918 (U. S. Code, 1928).

Of the water in the Bear River, 60% comes from the Bear River Mountain Range, which lies between Bear Lake and BRMBR. The river flows through this region gaining significant volume (Will Atkin, personal communication; Bob Fotheringham, personal communication). Despite this increase in water volume in the river, **BRMBR has the least dependable stream flows of the three Bear River Basin refuges studied because it lies downstream of all water users, a poor geographic position to hold.** The physical hydrologic environment here shows the most variability, a result of the human hydrology of the Bear River. Stream discharge can vary between 50 cfs and 3,500 cfs within the same year, and drought or flood years amplify this variability (see Figure 2-4). Very little of the refuge's water supply comes from sources other than the Bear River, leaving it vulnerable to the variability of that source (Kadlec & Adair, 1994).

People managing water at BRMBR are very aware of how insecure their water supply is. They view drought as a yearly phenomenon, rather than something that may happen every few years. **The refuge's primary source of water runs extremely low during the irrigation season,** "...so that leads to drought conditions for us during some pretty critical habitat periods.... There's always going to be a shortage, we're not going to be able to fill up everything every year" (Bridget Olson, personal communication). Every

year, refuge managers plan to see up to 75% of their wetland units dry up because of summer river conditions (Al Trout, personal communication).

When BRMBR was established, managers applied for a foundational water right to 1,000 cfs from the Bear River for wildlife propagation, a beneficial use that allows a right to be used all year long. In addition to this foundational right, FWS holds 28 other rights for use at the refuge that fall into four categories: applications to appropriate, diligence claims, underground water rights and decreed rights (see Table 2-4).^x

Applications to appropriate have priority dates established when the right was applied for while the other three types of rights are claims that are declared after use has been initiated, either by users or the courts, and hold dates prior to the declaration of use (Utah Division of Water Rights, 2009). Most of the rights for the refuge, and their most senior rights, are diligence and underground water claims; however, these are limited to use on a small portion of the refuge that is composed primarily of lands purchased since the 1990s.

BRMBR managers have the greatest ability to manage water. Upon establishment, refuge staff began aggressive development of a system of dikes and canals to impound freshwater from the Bear River on the refuge longer and exclude the saline water of the GSL (Olson *et al.*, 2004). This effort produced visible improvements in wildlife populations and habitat by the 1930s and continues to be used today there and at other wildlife refuges (Wilson & Carson, 1950). The current system involves 96 miles of dikes that divide the complex into 26 units; this creates more habitat diversity and gives managers the ability to better manage water depths within units (Olson *et al.*, 2004).^{xi}

BRMBR biologists have established wetland habitat water requirements and management goals based on migratory bird needs. Achieving these habitat goals requires intensive water management. To maximize management goals within wetland units, biologists complete ~~an annual water management plan~~, based on snow pack forecasts, that determines how much water they expect to see and how they will use it. The plan establishes water depth targets for individual wetland units and prioritizes units based on their importance to wildlife. Non-priority units are allowed to dry first as stream flow decreases while others are actively kept flooded as long as possible, with an effort to make sure units don't go dry for too many years in a row. When water becomes available again, units are refilled on the same priority basis. A wetland unit priority system allows for adaptations when water supply predictions are inaccurate, which can happen when rates of snowmelt are faster or slower than predicted or when there is more spring and summer precipitation than average. In addition to providing habitat, water is also required for botulism control, which requires emptying and flushing wetland units during the late summer to prevent disease outbreaks (Olson, 2009, Olson *et al.*, 2004).

The future environment of the river at BRMBR is less clear and more threatening than at the other refuges. According to biologists at BRMBR, "There are always threats to our water supply" (Bridget Olson, personal communication). Foremost among those threats are transfers of water uses upstream from agricultural to municipal or industrial uses, which could decrease the return flow the refuge receives during irrigation season. Because of water agreements involving Bear Lake, water saved due to increased agricultural irrigation efficiency or other changes in use is stored in Bear Lake, rather than making its way down the Bear River. The FWS also watches new water

appropriations on the river that could decrease the water available at BRMBR even more (Bob Barrett, personal communication). While many water users on the river believe the system is fully allocated, the Utah Division of Water Resources (2000) has been directed to develop 275,000 acre feet of Bear River water from to support the rapid population growth within and outside of the Bear River Basin. This will require new water storage facilities and transfers of water from agricultural to municipal use because extra water is only available during the spring runoff (Boyce, 1996).^{xii} New water storage facilities can present a threat or an opportunity to increase water security for the refuge. If FWS could obtain storage rights for the refuge that water could potentially be used during the summer when there is little water left in the Bear River. However, if they do not secure storage rights, there will simply be less water flowing through the delta, thus less water for BRMBR (Kadlec & Adair, 1994; Al Trout, personal communication).

BRMBR is the leader in adapting to the human-hydrologic context of the Bear River through intensive water management. BRMBR has the best documentation of their water needs, based on the habitat requirements of ten priority bird species, and well established goals for water management that are incorporated in published annual and long-term management plans that adapt to yearly changes in water supply (Bridget Olson, personal communication). For further discussion of these adaptations see Chapter Three.

Maintaining good relationships with other water users is very important for BRMBR. Most of the water the refuge receives in the late summer is return flow from upstream irrigation that would not be in the river without irrigators having it delivered from storage in Bear Lake. If more water is stored in the upper reaches of the river, less

water will make it downstream to where BRMBR is located. Water use in the lower Bear River is carefully planned and monitored, but after a storm event there may be extra water in irrigation canals that must be spilled from overflowing canals rather than utilized on fields. BRMBR managers work with a canal company and hunting clubs nearby to manage unexpected spills and return flows so they can be of the most benefit to the lower Bear River region as a whole (Al Trout, personal communication).

Managers at the BRMBR have done a lot of relational work with other agencies in the Bear River delta, especially in the last 20 years. The most important work may have been during the adjudication of the lower Bear River in the 1990s. Under the adjudication process, the FWS presented all the water rights for the refuge to the State Engineer, which required extensive consultation with the State Division of Water Rights. Through this consultation and negotiation the refuge received a higher duty of water for their rights, which allows them to use seven ac/ft of water per acre on their wetlands, rather than the standard decreed four ac/ft of water per acre. This allows the refuge to legally apply more water per acre to their wetlands than agricultural users do to their crops, when that water is available. It also allows for a more accurate legal quantification of the refuge's water needs. The manager of the refuge also sits on the water board in the region and attends meetings with other water users (Will Atkin, personal communication; Al Trout, personal communication).


Unfortunately, there have been less positive developments in the relationship building process as well. The most notable of these events happened in the early 1990s when BRMBR began the process of filing a federal reserved water right claim, which a former refuge manager likened to “dropping a bomb.” The FWS dropped their claim

after it was determined that the Service did not own all the land for which they were claiming a federal reserved right, and that the date of such a claim would not have a high enough priority for it to actually get more water for the refuge. Not only did the process cause negative feelings among other water users, but it also exacerbated tensions with the state over management of state sovereign lands in the bed of the Great Salt Lake (Bob Fotheringham, personal communication; Al Trout, personal communication). Before that, in the 1970s, during negotiations over amendments to the Bear River Compact, the Refuge had 120,000 ac/ft of the Bear River reserved for its future development in the Compact, but this was removed, as was any further discussion of refuge development (Boyce, 1996; Jibson, 1991). BRMBR has also pursued storage facilities with state agencies, which fell through and strained relationships between the organizations (Al Trout, personal communication). Currently the refuge managers focus on maintaining the water supply they have and becoming more integrated with the local water user community, rather than acquiring more legal rights to water (Bob Barrett, personal communication).

DISCUSSION

It is difficult to compare factors that determine water security in this study because not all are equally important and much depends on future development in the Bear River Basin. However, based on the factors discussed above, water security at each refuge within the Bear River Basin can be characterized and some preliminary comparisons can be suggested (see Table 2-5).

First, a refuge's geographic position in the human-hydrologic context of the river appears to be the most important factor in determining the security of its water supply. A refuge located upstream of, or adjacent to large, powerful water users has a more secure supply than one located downstream of powerful users in a heavily appropriated system. Geographic position matters because it determines how much water will actually be in the river during the growing season. However, refuges must still obtain legal rights to that water.



The primary mechanism for obtaining a water supply at wildlife refuges in the Bear River Basin has been to apply for state certificated water rights, though one refuge (BLNWR) owns no water rights of its own, and has instead entered into agreements to use other water users' water rights. Water rights are acquired primarily through state applications to appropriate or accompany lands purchased for refuge use. All refuges have a portfolio of rights from several sources and of varying priority. This plays an important function in determining water security at each refuge.

Paradoxically, BLNWR has the most secure water supply on the river, although it holds no rights of its own. Its security is based primarily on its relationship to the power company that manages a major canal running through BLNWR and allows the refuge to draw that canal up or down. As long as the major structure of the current law of the Bear River remains in place, there will likely always be water flowing to and from the refuge because of the seniority and quantity of the water rights managed by the power company under contract with downstream irrigators. CMNWR has similar water security, but it is because the FWS holds several senior water rights and the refuge lies upstream of major water diversion and uses. Agricultural, municipal and industrial water users dewater the

river as it flows to BRMBR, leaving it with the least secure water supply. Not only is there little water left in the Bear River when it reaches that refuge, but water rights held there by the FWS have junior priority, leaving them with no legal recourse for calling for more water to flow downstream.

In facing threats to water security, it may be necessary to reconsider what constitutes security (Dimitrov, 2002). In the Bear River Basin water managers have long come to expect drought (Endter-Wada *et al.*, 2009). So in this context, water security is the ability to deal with droughts without compromising the functionality of wetlands. Because BRMBR has the least secure water supply, they have been the leader in adapting to the conditions of the Bear River and the other refuges have followed its example to some extent. Adaptations to the human hydrology of the Bear River fall into two categories: water management and maintaining relationships with other water users. These adaptations help to minimize conflict between water users and help users recognize opportunities for cooperation.

All refuge managers emphasize how important it is to manage the water they receive (Bob Barrett, personal communication; Annette deKnijf, personal communication; Kate Kirk, personal communication; Bridget Olson, personal communication; Al Trout, personal communication). Regional water managers have pointed out that wetland managers manipulate their water just as much, if not more, than any other irrigator on the river (Will Atkin, personal communication; Bob Fotheringham, personal communication). In order to maintain water at the end of a heavily dammed and utilized river, BRMBR has responded by impounding and diverting their water and formulating plans for maintaining various water depths (in inches) in their different

wetland units on a month by month basis. Outside observers have called this seemingly unnatural water management scheme at BRMBR, "...an engineered system, relying on an engineered system" (Rich Sumner, personal communication). Being able to predict and plan also gives refuges' staffs some flexibility to manage wildlife habitat with a limited water supply. This type of intense water management does not often try to mimic the natural hydrology of the river, because the river has been too heavily altered. Instead, it seeks to restore enough wetland hydrology to keep the maximum possible amount of flooded wetland habitat available to birds (Bob Barrett, personal communication; Kadlec & Adair, 1994; Bridget Olson, personal communication).

The second part of adapting to human hydrology at federal wildlife refuges involves building relationships with other agencies, especially water rights agencies, and local water users. In order to be most effective in gathering information, refuge managers need to know about the community of water users within which they operate in and also about the water uses and needs of other communities they are connected to through shared water sources. This is most often done through consultation with other agencies or attending and participating in meetings related to water allocation and management. Some refuge managers have gone further in building relationships with other water users in their area. Such networking promotes discussion and action on water threats to the area as a whole, reducing the need for area water users to face these threats individually. These relationships do not necessarily secure additional water for refuges, but they do give refuge managers a seat at the negotiating table and facilitate knowledge sharing in a non-hierarchical, transboundary way (Al Trout, personal communication; Iza, 2004; Weber & Khademian, 2008).^{xiii}

In the Bear River Basin, knowing each other is as important for water users as knowing river conditions (Endter-Wada *et al.*, 2009). Communication with other water users can enhance the human environment at the refuges by promoting collaborative learning about the river among all users, including refuge managers. However building relationships is time consuming and potentially subject to pitfalls. In the Bear River Basin, individual refuge managers, canal company managers, university researchers and water rights managers have built collaborative capacity as they have interacted with one another and built links between their organizations to make the most of scarce water supplies in the Basin (Bob Barrett, personal communication; Bob Fotheringham, personal communication; Hahn *et al.*, 2006; Al Trout, personal communication).

People with both agricultural and wetland interests on the Bear River recognize their water supplies are interdependent and that they face similar threats to that supply. Portions of some refuges, especially BRMBR, are irrigation dependent. Because of this hydrological connection, less water used for agriculture means less water for wetlands (Kate Kirk, personal communication; Peck *et al.*, 2005). Recognizing that they face a common problem allows both water use groups to focus on public involvement and collaboration to develop innovative strategies that focus on local water problems and fosters cooperative attempts to increase overall water security (Dimitrov, 2002; Endter-Wada *et al.*, 2009; Kamieniecki & Kraft, 2008; Weber & Khademian, 2006; Wondelleck & Yaffee, 2000).

CONCLUSIONS

Many wetland managers must maintain habitat within complex human-hydrologic systems. Holding water rights is a necessary step toward gaining water security for wetlands, but does not ensure there will be water available during times of scarcity. The most important factor in determining water security is a wetlands' geographic position in relation to powerful water users. Regardless of the legal security of a wetland's water supply, staff must actively manage their water because the hydrology of Western rivers has been altered so much. This management requires both infrastructure and planning.

In addition to managing water, wetland managers must also maintain relationships with other water users in the area, because all water uses within the watershed are interconnected, and many wetlands are irrigation dependant to some degree. Recognizing that they face similar threats allows agricultural and wetland water users to cooperate in adapting to uncertain water supplies and in facing future threats.

Many Western rivers are facing changes similar to those on the Bear River, namely growing demands on water, transfer of water from agricultural to municipal uses, and future supply uncertainties related to climate change. The lessons learned by wetland managers along this river can help others facing changes to the human hydrology of their region as they seek to enhance the security of their own water supplies.

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Table 2-1. Important Water Policies in the Bear River Basin

Policy	Date	Substance
Prior Appropriation	1862	States allocate waters, rights are based on priority, and shortages are not shared. Rights designate a quantity, date (priority and time of use), place of use, beneficial use and point of diversion. Rights not used are considered forfeited. *
Winter's Doctrine	1908	Assures that lands set aside by the federal government have enough water for their designated purpose. Priority for that water set at date of refuge/reservation/park establishment. *
UP&L – U-I Sugar Company Agreement	1912	Bear Lake will be run by Utah Power and Light (UP&L) as a storage facility; Utah-Idaho Sugar Company (U-I) water rights will be stored there and delivered by UP&L during the irrigation season. †
Dietrich Decree	1920	Decreed UP&L's right to store water in Bear Lake. Established a schedule of rights for use of the Bear River and its tributaries that specified the rights of the plaintiff (UP&L) and defendants (mostly canal companies) in Idaho.
Kimball Decree	1922	Added more defendants from Utah to Schedule of Rights from the Dietrich Decree
The Bear River Compact	1958	Establishes the rights and obligations of Idaho, Utah, and Wyoming with respect to the waters of the Bear River. Divided the river to three divisions, assigned river flow and diversions within each division. Allocated storage water between states. Set minimum elevation for Bear Lake. Established the Bear River Commission to administer the provisions of the Compact. ‡
Bear River Development Act	1991	Passed by the Utah State Legislature in 1991. Directs the Utah Division of Water Resources to develop the Bear River and its tributaries. Allocates 1.2 million acre-feet of water between the Utah and Idaho portions of the Bear River Basin. Further divides Utah's portion between four counties and conservancy districts. †
Lower Bear River Adjudication	1993	Judicial proceeding that establishes the rights of all users on a river. Began in 1940s, preliminary findings for the Lower Bear River Basin published in 2005.
Bear Lake Settlement Agreement	1995	Agreement between PacifiCorp and water users (not states) to settle disputes concerning the operation and management of Bear Lake. Protects the elevation of Bear Lake during drought through decreases in irrigation allocations.

(Sources: * Getches, 2009; † Denton, 2007; ‡ Jibson, 1991)

Table 2-2. Water Rights Held by the FWS for Cokeville Meadows National Wildlife Refuge.²

Priority	Quantity	Source	Beneficial Use
1878	1435 shares	B.Q. Dam East/Bear River	Irrigation
1878	9.61 cfs	B.Q. Dam East/Bear River	Irrigation
1879	2.3 cfs	Bear River	Irrigation
1880	17.0 2 cfs	Pixley Ditch/Bear River	Irrigation
1881	0.29 cfs	North Lake Spring	Irrigation
1888	0.14 cfs	Leeds Creek	Irrigation
1897	10.0 5 cfs	Smith's Fork	Irrigation, Domestic
1901	1.14 cfs	Bear River	Irrigation
1907	0.08 cfs	Pixley Enlargement/Bear River	Irrigation
1908	Unspecified	Succor Spring Ditch/Succor Springs	Irrigation, Stock, Domestic
1909	16.64 cfs	Covey Canal/Smith's Fork	Irrigation, Domestic
1914	1.22 cfs	Antelope Creek	Irrigation (storage)
1925	0.38 cfs	Antelope Creek	Irrigation
1959	900 gpm	Groundwater	Irrigation
1959	1900 gpm	Groundwater	Irrigation
1972	25 gpm	Groundwater	Stock, Miscellaneous, Domestic
1972	25 gpm	Groundwater	Domestic, Stock
1977	1300 gpm	Groundwater	Stock, Irrigation
1977	1140 gpm	Groundwater	Irrigation
1981	1200 gpm	Groundwater	Irrigation, Stock
1982	200 gpm	Groundwater	Irrigation
1982	25 gpm	Groundwater	Domestic, Stock
1982	1000 gpm	Groundwater	Irrigation
1984	450 gpm	Groundwater	Irrigation
1993	400 gpm	Groundwater	Irrigation
1998	0 gpm	Groundwater	Irrigation

² Rights gathered from information provided by Kate Kirk and the Wyoming State Engineer's (2010) Water Rights Database.

Table 2-3. Water Rights with Service Areas in Bear Lake National Wildlife Refuge.³

Owner	Priority	Quantity	Source	Beneficial Use
Irrigation Company Rights				
Dry Lake Canal Co	1864	5.0 cfs	Paris Creek	Irrigation
Grimmett Black Otter Irrigation Co	1877	20.0 cfs	Bear River	Stock water, Wildlife
Grimmett Black Otter Irrigation Co	1877	133.5 cfs	Bear River	Irrigation
Ream Crockett Irrigation Co	1877	30.0 cfs	Bear River	Irrigation
Ream Crockett Irrigation Co	1877	10.0 cfs	Bear River	Stock water
Dingle Irrigation Co	1884	6.0 cfs	Bear River	Irrigation
Ream Crockett Irrigation Co	1884	19.5 cfs	Bear River	Irrigation
Ream Crockett Irrigation Co	1885	12.8 cfs	Bear River	Irrigation
Hemmert Hot Spring	1898	0.3 cfs	Springs	Stock, Domestic, Recreation
Dry Lake Canal Co	1905	5.0 cfs	Paris Creek	Irrigation
Dingle Irrigation Co	1969	7.5 cfs	Bear River	Irrigation
Storage Rights to Bear Lake				
PacifiCorp	1890	0.9 cfs	Bloomington Creek	Irrigation
PacifiCorp	1894	0.5 cfs	St. Charles Creek	Irrigation
PacifiCorp	1902	0.5 cfs	Bloomington Creek	Unspecified
PacifiCorp	1911	3000.0 cfs	Bear River	Irrigation, Power from Storage
PacifiCorp	1912	2500.0 cfs	Bear River	Irrigation, Power from Storage
PacifiCorp	1912	300.0 cfs	Bear River	Irrigation, Power from Storage
PacifiCorp	1912	200.0 cfs	Bear River	Power from Storage

³ Rights gathered from information provided by Annette deKnijf and located in the Idaho Division of Water Rights (2010) Water Rights Database.

Table 2-4. **Water Rights Held by the FWS for Bear River Migratory Bird Refuge.**⁴

Priority	Quantity	Source	Beneficial Use	Type
1860	1.04 cfs	Stauffer-Packer Spring	Irrigation	Diligence
1869	2.4 cfs	Unnamed Stream	Irrigation, Incidental Habitat Creation	Diligence
1869	1.0 cfs	Perry Spring Stream	Irrigation, Stock	Underground Claim
1870	0.002 cfs 7.0 acft	Underground Water Well	Stock	Underground Claim
1870	0.56 cfs	Perry Spring Stream	Irrigation	Diligence
1870	3.06 cfs	Dan Walker Spring	Irrigation	Diligence
1880	1.0, cfs 49.2 acft	Unnamed Spring Stream	Irrigation, Stock	Diligence
1880	0.015 cfs	Unnamed Spring Stream	Stock	Diligence
1881	1.0 cfs 17.2 acft	Unnamed Spring	Irrigation	Diligence
1885	1.5 cfs	Underground Water Drain	Irrigation, Stock	Underground Claim
1885	2.0 cfs	Underground Water Drain	Irrigation	Underground Claim
1887	3.0 cfs	Underground Water Drain	Irrigation	Underground Claim
1896	2.4 cfs	Unnamed Stream	Irrigation, Stock, Incidental Habitat	Diligence
1896	7.37 cfs	East Slough	Irrigation, Stock, Other	Decree
1896	45.0 cfs	Black Slough	Irrigation, Other	Decree
1900	1.59 cfs	Underground Water Drain	Irrigation	Underground Claim
1900	1.114 cfs	Underground Water Drain	Irrigation, Stock	Underground Claim
1902	15.9 11,51 cfs 1 acft	Bear River	Waterfowl Habitat	Diligence
1902	0.002 cfs 7.0 acft	Unnamed Stream	Stock	Diligence
1902	2000. 0 acft	Bear River	Irrigation	Diligence
1907	0.5 cfs	Surface Drains	Irrigation, Stock	Application

⁴ Water Rights data gathered from **Utah Division of Water Rights (2009) Water Rights Database.**

	20.42 acft			
1920	0.01 cfs 7 acft	Underground Water Well	Stock	Underground Claim
1928	1000 425,7 cfs 71 acft	Bear River	Waterfowl Habitat	Application
1955	0.011 cfs 0.42 acft	Underground Well	Stock	Application
1961	0.134 cfs /0.14 acft	Underground Well	Stock	Application
1991	2666. 65 acft	Salt Creek	Wildlife, Fish, Irrigation	Application
1995	1 cfs 40 acft	Underground Drain	Wildlife	Application
1995	1.04 cfs 4 acft	Stauffer-Packer Spring	Wildlife	Application
1997	2.0 cfs	Surface Water and Underground Drains	Irrigation, Stock	Application

Table 2-5. Assessment of water security at federal wildlife refuges.

	Hydrologic Environment	Socio-economic Environment			Future Environment	Assessment
		Legal Rights	Manager Perception	Ability to Manage		
Cokeville Meadows NWR	Moderate: moderate seasonal and inter-annual variation	High: senior, various sources	High: risk of upstream water development is low	Low: infrastructure in place, but no management plan	Moderately High: Loss of winter snowpack is only foreseeable way water would decline;	Moderate - High
Bear Lake NWR	Moderate-High: season variability, relatively low inter-annually	Moderate - High: agreements and leases to use water with senior rights	High: legally; development cannot diminish flow in Bear L.	Moderate: minimal infrastructure, has water management plan	High: No snowpack only way to diminish supply that is legally protected	High
Bear River MBR	Low: high variability between seasons and year: risk from drought and flood	Moderately Low: primary water rights are junior, reliant on one source	Low: water is almost always unavailable during critical growing season	High: well established management plan and extensive infrastructure	Low: almost any upstream development could negatively affect water supply	Low

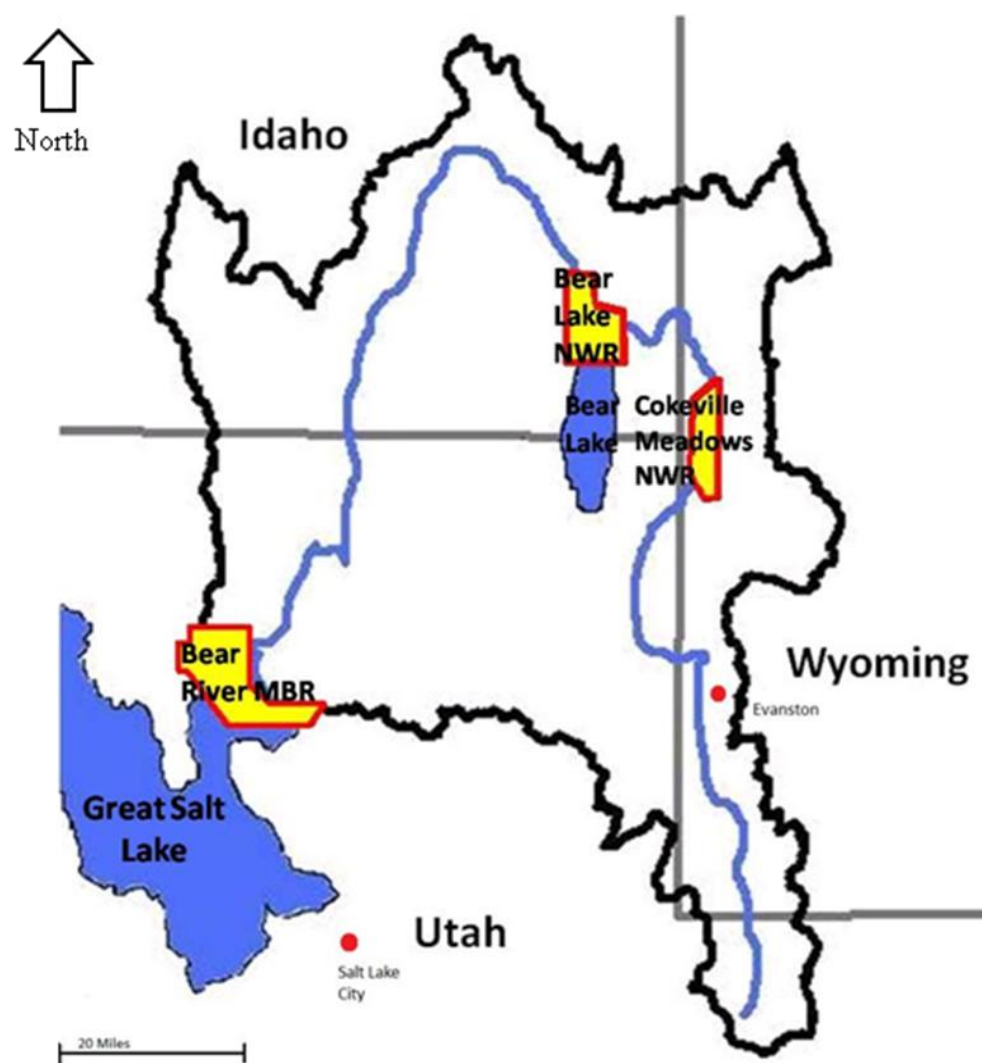


Figure 2-1. The Bear River Basin.

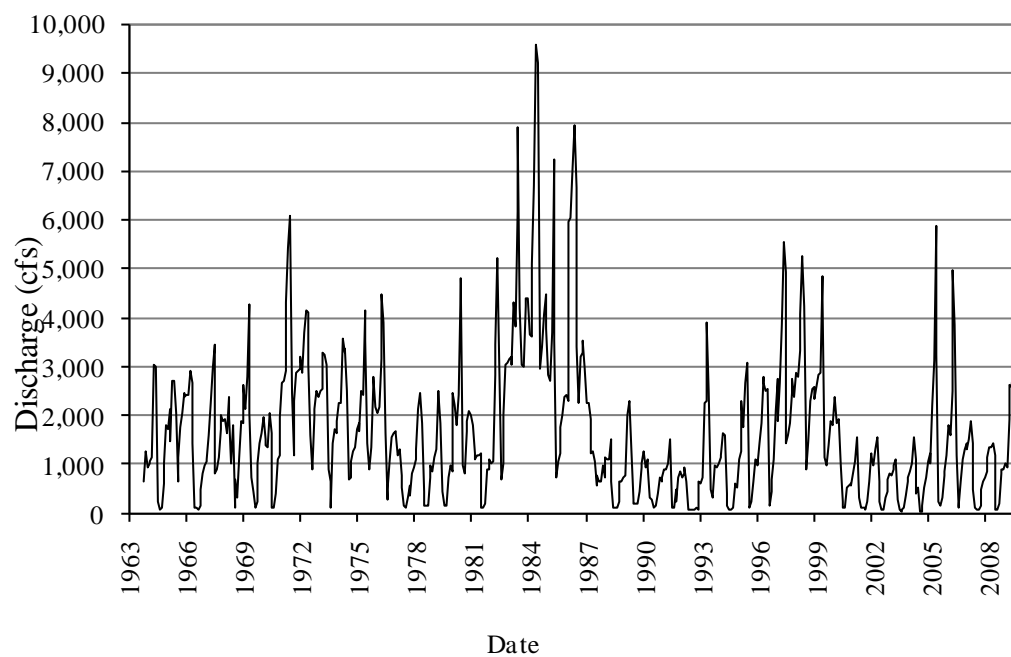


Figure 2-2. Average monthly discharge in the Bear River at the Corinne gaging station 1963-2009.⁵

⁵ Data gathered from U. S. Geological Survey (2010) online water information database.

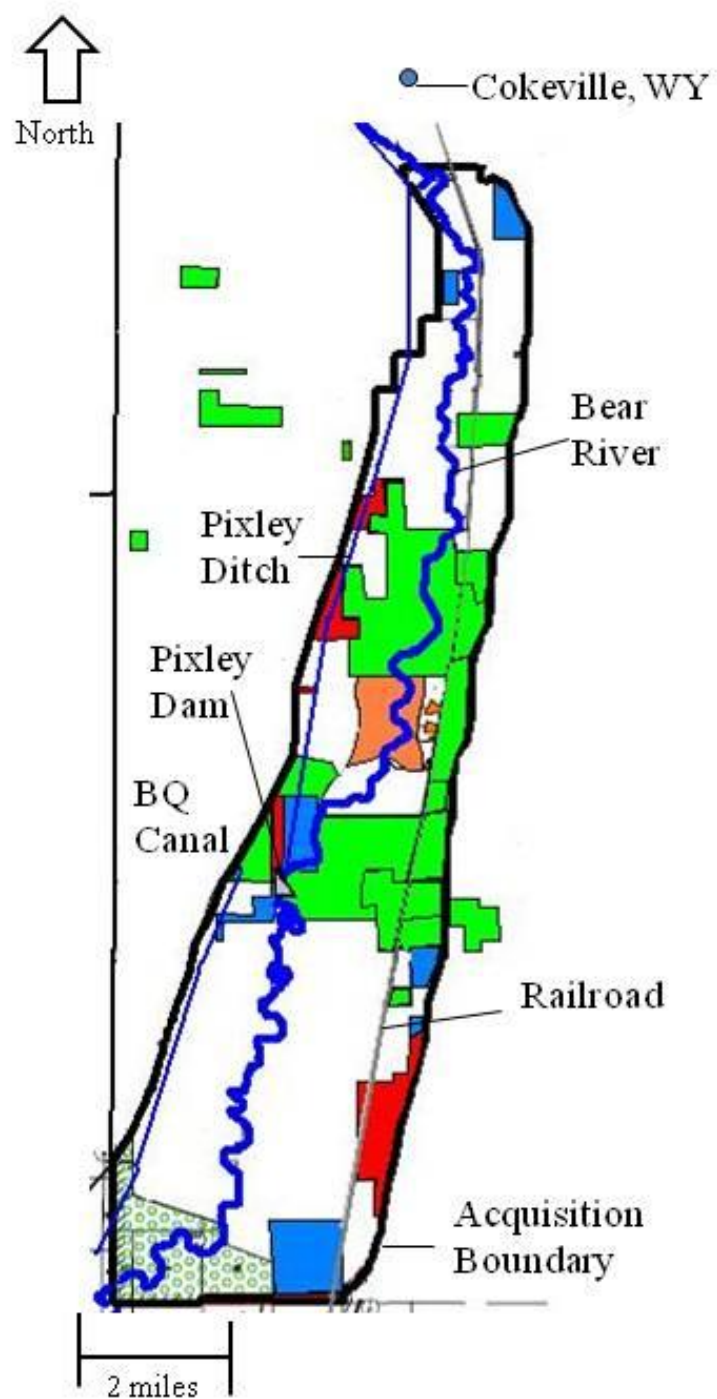


Figure 2-3. Cokeville Meadows National Wildlife Refuge. Shaded parcels indicate land owned or managed by FWS.

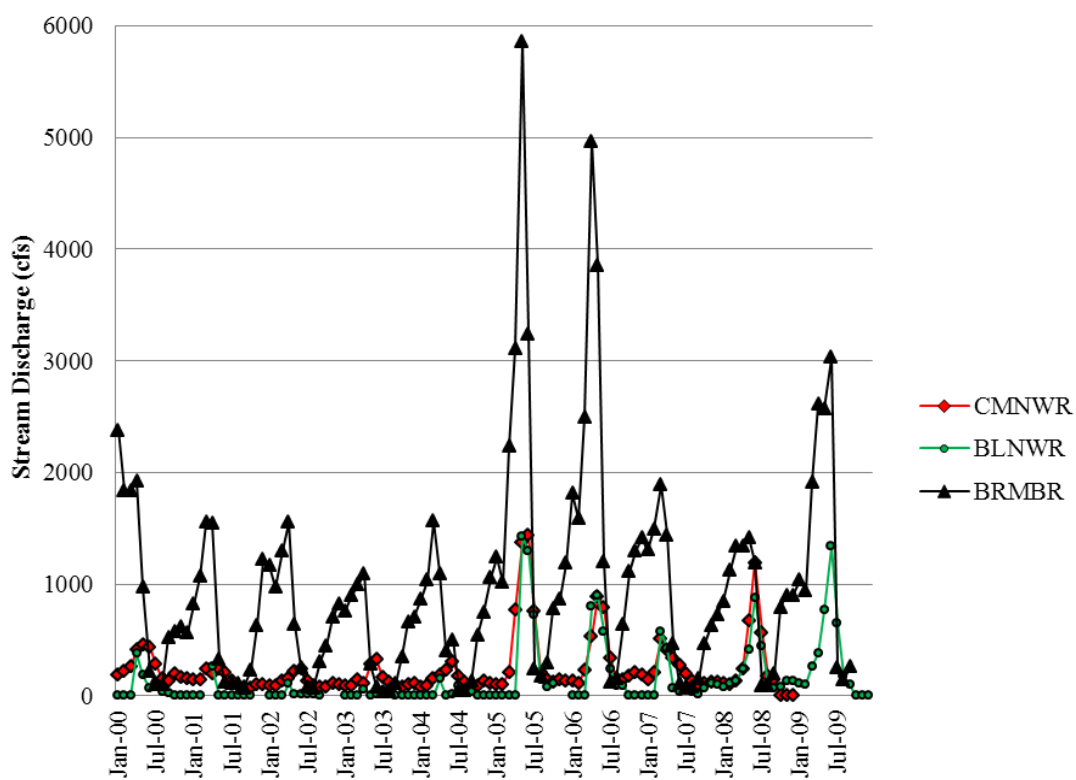


Figure 2-4. Average monthly discharge at federal wildlife refuges in the Bear River Basin 1999-2009 (U. S. Geological Survey, 2010).

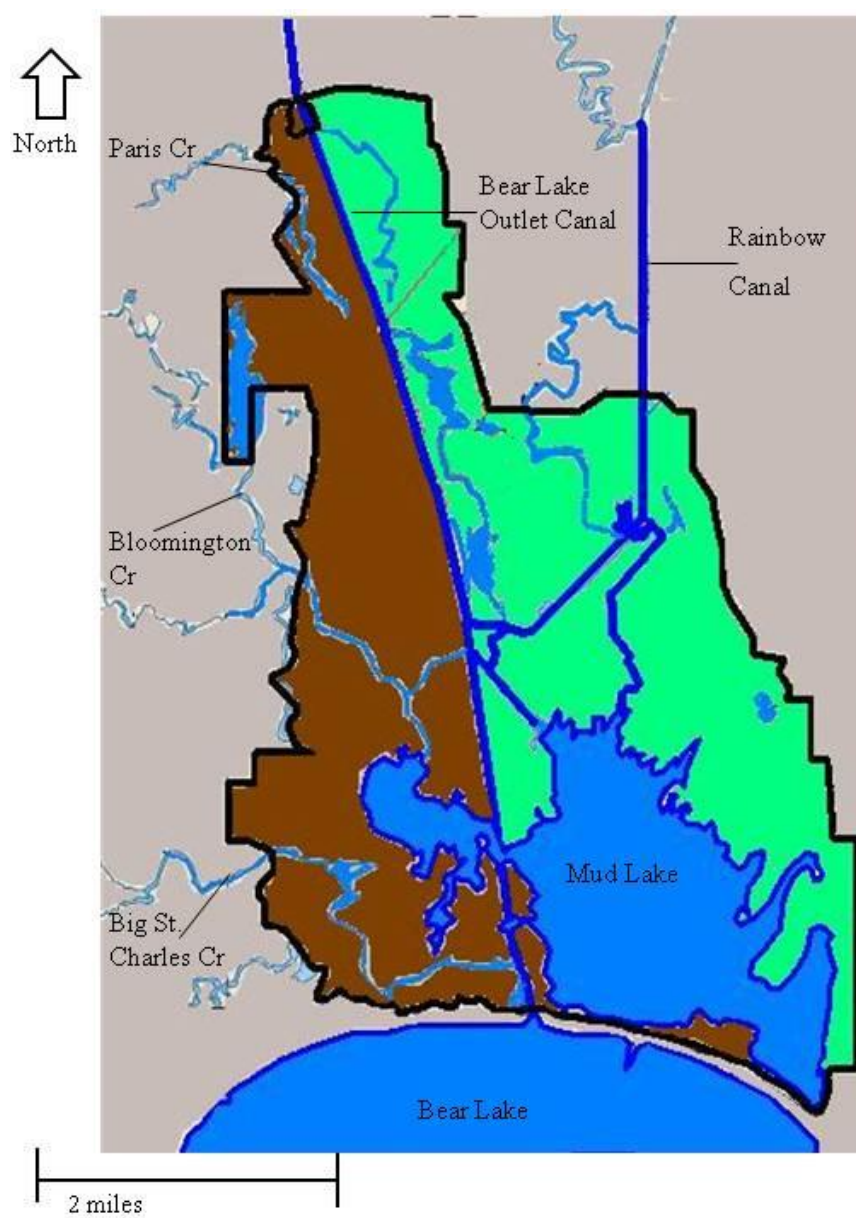


Figure 2-5. Bear Lake National Wildlife Refuge.

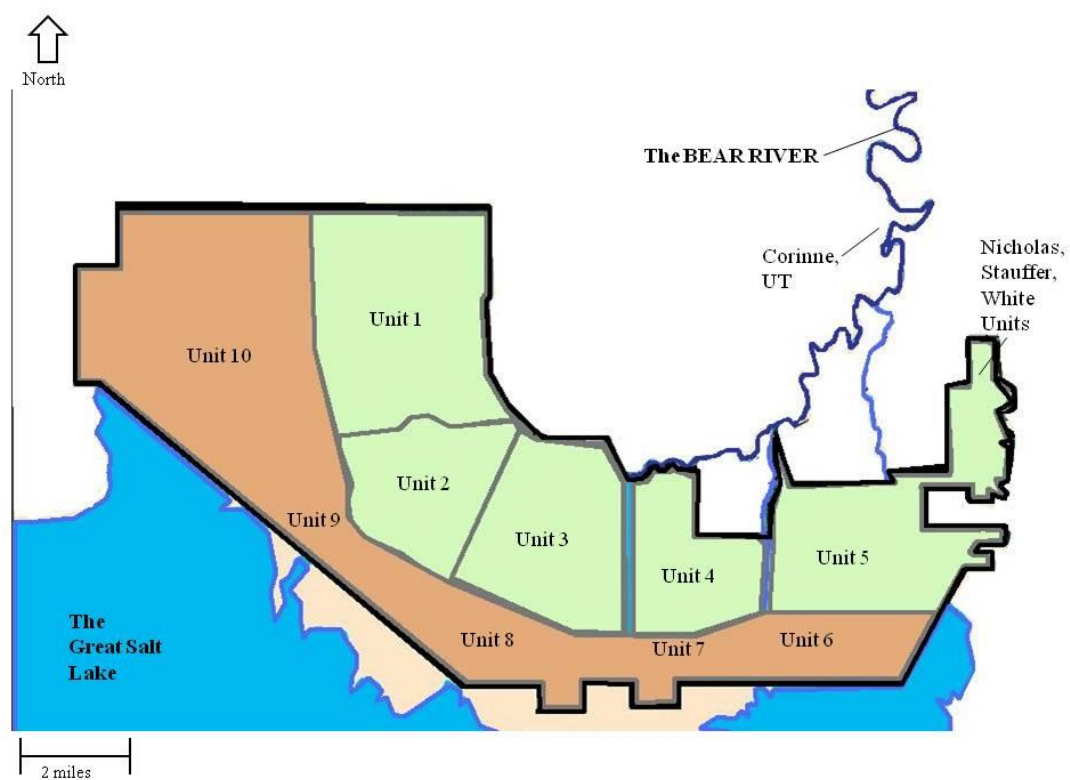


Figure 2-6. Bear River Migratory Bird Refuge.

Outdated figure?

CHAPTER 3:
KEEPING WETLANDS WET: ADAPTING TO UNCERTAIN
WATER CONDITIONS AT BEAR RIVER
MIGRATORY BIRD REFUGE⁶

ABSTRACT

Many wetlands in the western United States have been diminished or destroyed by changes to their water supply, primarily due to extensive stream diversions for agriculture and other human uses. However, several large wetland complexes remain, despite major changes to their water sources. This study looks at the Bear River Migratory Bird Refuge (BRMBR), a large, heavily managed wetland complex that lies at the end of the Bear River on the northern shores of the Great Salt Lake in Utah. This research explores how BRMBR has adapted to the physical and institutional realities of wetland management under uncertain river conditions.

Research was conducted using semi-structured interviews with wetland and water rights experts in the Bear River Basin and archival research of water rights and river conditions. This research shows that over the last 10 years BRMBR received about 15%



of the water needed to maintain its wetland habitat during July through September, while receiving more than it needs most other months. The magnitude of this difference varies

according to year, depending on accumulated snowpack. Because of this poorly timed and uncertain water supply, BRMBR uses an adaptive management approach to predict

⁶ This chapter is co-authored by Rebekah Downard, Dr. Joanna Endter-Wada, and Dr. Karin Kettenring

their annual water supply, prioritize wetland units to keep flooded and monitor the effects of management decisions.

Adaptive wetland management at BRMBR does not pretend to recreate the natural hydrology of the river, but it seeks to maximize migratory bird habitat, creates a means for sharing information about the river, and puts the water rights of the BRMBR to beneficial use. These actions are important steps in meeting refuge goals and maintaining good relationships with other water users in the watershed. Adaptations at BRMBR provide a useful example for other wetland managers striving to conserve wetland habitat under the physical and institutional realities of river management in the Western United States. These adaptations also provide experience for confronting future water uncertainties related to climate change.

INTRODUCTION

Wetlands have always been rare in the Intermountain West of the United States, in part due to topography, but primarily due the general aridity of the region. Wetlands became more scarce after conversion of wetlands to cultivated fields and diversion of waters that once fed wetlands related to European settlement and agricultural irrigation beginning in the mid-1800s. However, a few large wetland complexes remain, though often to a lesser extent than they existed historically. Wetland complexes are usually managed by state or federal wildlife agencies to provide habitat for birds migrating on the Pacific and Central flyways in compliance with the Migratory Bird Treaty Act and other wildlife policies. In order to maintain these wetlands managers must engage in intensive water management because of the highly variable nature of many western rivers (often

the major source of water for wetlands) and because of general decreases over time in the available water supply.

Beyond these physical water limitations, there are institutional arrangements that constrain water management on wetlands. Water policy in the West has legally allocated most of the water in Western rivers to agricultural or municipal uses, leaving environmental uses that appropriated water later in time, like wetlands, dry during times of shortage. Wetland management activities often must follow the requirements of multiple state, federal and international wildlife, water or wetland policies while also following the tenants of adaptive management. It is under these physical and institutional water challenges that wetlands must be managed in the region. This requires finding a way to manage under conditions of uncertainty and cultivating the capacity to adapt to changing water conditions.

Water is the key ingredient in creating and maintaining wetlands. The presence of water at or near the soil surface creates anaerobic conditions that conditions that lead to the formation of hydric soils and selects for plants and animals adapted to flooded and low oxygen conditions (Cowardin et al. 1979). Water may be present in a wetland all year, or only seasonally; it can be a few feet deep, or present only at the soil surface. These differences in water depth and duration constitute a wetland's hydroperiod. Changes to the hydroperiod change the character of a wetland (Jackson 2006). In the United States Intermountain West, freshwater wetlands not only need adequate supplies of fresh water during the growing season (April through September), but they also need dynamic hydroperiods to function optimally (Christiansen and Low 1970, Euliss et al. 2008, Smith et al. 2008). Meeting these wetland water needs can be difficult because the

wetland growing season is also the agricultural irrigation season, when other water demands on water supplies are highest.

Wetlands are one of the most biologically productive ecosystems in the world and they perform a number of important ecosystem services, including providing wildlife habitat and buffering against hydrological disturbances (Mitsch and Gosselink 1993, Kadlec and Knight 1996, Batzer and Sharitz 2006, Ivey and Herziger 2006). Because they are so rare in the West, accounting for only 1% of land cover, wetlands in arid regions become vital habitat for both resident and migratory birds on the Pacific Flyway, and addressing threats to what is left of their water supply is critical for maintaining international wildlife populations (Lemly et al. 2000, Tiner 2003, Dahl 2006). The wetlands of the Great Basin, primarily those associated with the Great Salt Lake, support 38% of North America's waterbird diversity and 63% of its shorebird diversity (Haig et al. 1998).

Several federal policies are designed to protect wetlands by preventing their destruction or by protecting wildlife habitat, including the Migratory Bird Treaty Act, the Fish and Wildlife Coordination Act, the Clean Water Act, the Endangered Species Act and the National Food Security Act (National Research Council 2001, Somerville and Pruitt 2006). These policies helped slow the upward trajectory of wetland destruction, whereby more than half of the nation's wetlands were converted into other uses by the 1950s. However, none of these policies specifically protect the water for wetlands and actions that disrupt wetland hydrology continue to alter or destroy wetlands today (Vileisis 1997, Dahl 2006). Currently wetlands in the arid West exist in contexts where

natural river hydrology has been so heavily manipulated that it can best be understood as “human hydrology” (Endter-Wada et al. 2009).

Wetlands are not often resistant to hydrologic disruptions, however, they do show resilience in recovering from the effects of hydrologic changes like drought, flooding, and increased sedimentation (Gunderson et al. 2006). Wetlands in the West have adapted to periodic drought and, in fact, rely on drying to maintain healthy vegetation and invertebrate populations (Kaminiski et al. 2006). However, there are limits to the extent wetlands can be disturbed while retaining the ability to recover. Human intervention can undermine the resilience of these ecosystems (Holling 1973, Gunderson et al. 2006). Chronic water shortage or constant inundation both decrease wetland health and diversity and can make invasion by non-native vegetative species more likely (Smith et al. 2008, Euliss et al. 2008). Understanding the ways in which wetlands respond to human-hydrologic manipulations that alter their natural hydrologic variability is an important issue in wetland management.

Drawdown, a common wetland management practice that involves intentionally lowering water depth in wetlands, is often used to restore a more natural hydroperiod in wetlands where the hydrology has been disrupted. The benefits of wetland drawdown (managed or natural) are contingent upon when flooding conditions will return and the time of year when drying occurs. When drying occurs at the right time and rate, it can trigger plant reproduction, exclude undesirable plant species and rejuvenate desirable vegetation (Bowyer et al. 2005). Drying also stimulates reproductive cycles in invertebrates and keeps those communities diverse and resilient (Tronstad et al. 2005). The appropriate water regime of a wetland (the cycle of flooding and drying) differs,

depending on the region and plants or invertebrates present or desired in wetlands. Generally, rapid wetland drawdown, drying out a wetland too early in the growing season, or drying a wetland for too long can cause habitat damage through soil compaction, increased salinity, decreased invertebrate density, and establishment of undesirable plant species (Kadlec 1962, Christiansen and Low 1970, Welling et al. 1988, Kadlec and Adair 1994, Bolduc and Afton 2003, deSzalay et al. 2003).

When temperatures are higher, generally during the growing season, wetland plants need more water to meet their evapotranspiration needs. Increased evaporation and the natural decrease in stream flow during the summer months cause wetlands to dry out naturally. Drying causes water and salt stress to plants as evaporation can leave salts behind on the surface of wetlands and draw salts into plant root zones through capillary action (Kadlec 1982). Too much salt in wetland soils can delay germination and slow plant growth because it prevents plants from taking up water (Christiansen and Low 1970). Sago pondweed (*Potamogeton pectinatus*), one of the most important wetland plants for waterfowl, grows well under low to moderate salinity, as do hardstem (*Schoenoplectus acutus*) and alkali bulrush (*Schoenoplectus maritimus*), but productivity decreases sharply when salinity passes a certain threshold (Williams and Marshall 1938, Kadlec 1982, Kadlec and Smith 1984, Olson et al. 2004).

Understanding these plant water needs is critical for maintaining wetland habitat under conditions of water uncertainty. The effects of drying and increased salinity may not be detrimental to wetlands if water returns in time to rejuvenate vegetation and flush salts from soils. However, if water does not return in a timely manner (between a few months and a few years, depending on the type of wetland), long-term damage to wetland

vegetation, invertebrates, and seed banks can occur (Christiansen and Low 1970, Kadlec and Adair 1994). Chronic water shortages have lead to serious wetland depletions across the West (MacDonnell 1991).^{xiv}

Irrigated agriculture is the primary use of water diverted from Western rivers, and irrigators often have the longest historical use and most senior legal rights to use water under Western prior appropriation laws (Utah Division of Water Resources 2004).^{xv} The hydrology of Western rivers has been altered through the construction of water infrastructure designed to deliver water to meet the water needs of irrigated agricultural crops. Delivering water to sustain wetlands was not specifically designed into this infrastructure, as water for wetlands was considered wasteful until waterfowl production became recognized as a beneficial use of water in the 1900s. As environmental uses of water have become legally recognized, it has been difficult to secure water for these uses in heavily allocated and managed river basins (MacDonnell 1991, Getches 2009).

Beneficial use is the measure of a water right. The purpose of water use determines how much water a user can obtain and water right holders must prove they are meeting the beneficial use of their water right within a few years of diverting water. Beneficial uses of water in most states include irrigation, domestic use, stock watering, industrial use, and wildlife propagation (Getches 2009). Maintaining a wetland itself is only a beneficial use in Nevada, but other states do recognize waterfowl and fisheries production as beneficial uses, and they are often associated with wetlands (MacDonnell 1991). States impose limits on who can hold water rights for wildlife, generally restricting it to state and federal wildlife management agencies. The amount of water that can be reasonably diverted to a wetland is determined by a duty of water (Getches 2009).

Beneficial use requirements ensure that states are allocating water in the public's interest, as beneficial use of water is supposed to produce goods or services deemed to be of benefit to the public.

This requirement [beneficial use] is intended to ensure that appropriations meet evolving standards of public acceptability.... Thus any applicant for a wetland water right may be required to demonstrate that the quantity of water claimed bears some reasonable relationship to the public and private values derived from the wetland. (MacDonnell 1991, p. 282).

Ecological uses of water, like instream flows, were not recognized by most states until the 1970s, when most western rivers had already been fully appropriated and had been extensively dammed and diverted (Getches 2009).

Once water rights are obtained, wetlands managers in the West must manage water to meet habitat goals within the policies of the river basins they are located in, which include state water laws, interstate compacts and other rules determining water use within watersheds. Management goals must also fit within the policies implemented by the agency managing wetlands. The U. S. Fish and Wildlife Service (FWS) oversees the National Wildlife Refuge System (NWRS) with the goals of conserving, protecting and enhancing wildlife habitat for the benefit of the public (Dahl 2006). The specific goal of the NWRS, as of 1997, is to manage a system of land and water specifically to conserve wildlife and maintain the biological integrity of ecosystems (U. S. Code 1997, U. S. Fish and Wildlife Service 1999). Wetlands have almost always been “working landscapes,” manipulated to produce as much of a “waterfowl product” as possible (Purseglove 1989, Langston 2003). While it may be easiest and even most natural to let wetlands dry during times of water shortage, that may not preserve enough wildlife habitat to meet the goals

of wildlife management. Maximizing wildlife habitat under water scarcity often requires extensive infrastructure and planning.

In the Intermountain West, one of the most difficult aspects of the environment to adapt to is the uncertainty of water supplies, because rivers are often highly variable. Uncertainty in wetland management comes from two sources: incomplete or imperfect knowledge of a system and the variability or unpredictability of a system (Brugnach et al. 2008). Water supplies in this region present a great deal of variability and unpredictably. Managers can respond to uncertainty or changes in environmental conditions, like decreased water availability, in three basic ways: they can wait to see if the previous conditions will return; they can try to return the system to its original state; or, they can adapt to the new altered situation (Gunderson 1999). The third option is adaptive management, a management paradigm that promotes a scientific approach to natural resource management (Holling 1978).

Under adaptive management, potential resource management policies are chosen based on the best available scientific information. Before a policy is applied, environmental feedback variables affected by a policy are identified, and then results of policy decisions on those variables are monitored to determine the success of the policy (Holling 1978). The goal of adaptive management is to formulate future policies based on what is learned from effects of previous management efforts and to protect the resilience to ecosystems (Holling 1978, Gunderson et al. 2006, Hahn et al. 2006). Adaptive management holds a lot of potential for wetland management in the West, because it provides a means to confront uncertainty in water management through monitoring and learning how ecosystems react to management and environmental

variability. It also acknowledges that resources will change as a result of human interventions and that there will always be new uncertainties to address through management. Adaptive management recognizes that habitats operate within an institutional framework and that natural resource agencies also have non-ecological management objectives for the land they manage (Gunderson 1999).

Learning from past management strategies is perhaps the most important component of adaptive management, but the step most often missed in practice. This is usually because of incentives built in to short-term goals and funding structures that promote accumulating knowledge (monitoring) over actually developing understanding (learning) (Gunderson 1999, Gunderson et al. 2006). Effective application of adaptive management is also difficult because it requires governance agencies to be both strong (in order to build understanding into new policies) and flexible (to be able to deal with change) (Dietz et al. 2003, Folke et al. 2005). Lack of true understanding and the strength and flexibility to apply it often leads to situations where learning is only emphasized when a policy is clearly failing (Gunderson 1999).

Despite these difficulties, following the principles of adaptive management is important for large wetland complexes in arid regions, because those wetlands are often the only wetland habitat available to large migratory wildlife populations for hundreds of miles. Thus, the effects of management decisions are felt beyond the boundaries of the wetland complex. It is also important because generalizable recommendations for wetland management are rare. Though there are extensive, place-specific recommendations in the scientific literature about how to manage wetlands for wildlife, recommendations are less often focused on regional limitations to wetland management,

like water shortages (Taft et al. 2002). Consequently, wetland managers are often put in positions of making decisions for wetlands based on their own knowledge and set of environmental or institutional constraints and learning from those decisions becomes critical.

Historical examples of wetland management in the Great Basin that have proceeded without careful planning, monitoring and learning have often been to the detriment of wildlife and habitat. One such example is the Malheur National Wildlife Refuge in Oregon. Before the area was established as a refuge, wetlands located there were first overgrazed by cattle, and then drained for agricultural cultivation. After refuge establishment, habitat was treated with numerous pesticides, mowed, disked, and generally treated based on management trends common at that time. Each management strategy had a different goal, but the results of management actions were not often monitored and had significant negative impacts, including soil erosion, toxin accumulation, and intense flooding that were not addressed, even under newer management practices (Langston 2003).

Analyzing the effects of policies and management strategies is also an important part of collaborative learning, an emerging paradigm in natural resource management that involves linking government agencies, communities, and individuals together to deal with common problems and solve regional issues. As a part of adaptive management, collaborative learning helps agencies deal with complexity, uncertainty, and change by encouraging them to incorporate different types of knowledge into planning and share that knowledge with more entities (Wondelleck and Yaffee 2000, Euliss et al. 2008). Sharing the results of learning also helps build trust and increases the ability to manage

natural resources, particularly migratory ones like water or wildlife (Dietz et al. 2003, Weber and Khademian 2008).

Sustainable wetland management requires linking adaptive management with the social component of ecosystems, including other management institutions and property rights structures. Good management policies should have an “ecological fit” within the ecosystem processes and social and political realities of a region (Euliss et al. 2008, Smith et al. 2008). This involves thinking of the environment as a social-ecological system, a system that explicitly includes humans (Berkes and Folke 1998). Ideal social-ecological networks promote openness so information is passed around easily, while maintaining a degree of formality that produces connectedness. The ability to integrate both qualities gives a network the ability to adapt and transform (Gunderson et al. 2006).

The last 30 years has produced a great deal of literature on adaptive management, but it has been introduced into practice with varying degrees of success. The Bear River Migratory Bird Refuge (BRMBR) provides an interesting case study in which to examine how adaptive management is applied to a wetland complex with an uncertain and dynamic water supply. It illustrates one means of meeting national wildlife habitat goals while complying with state water law and maintaining relationships with local interests.

This research has two objectives in exploring the environmental and social realities of this case study. The first objective of this research is to compare physical water availability, legal water rights and wetland water needs at BRMBR. The second research objective is to explore how the refuge has adapted to the physical and social realities of the Bear River.

METHODS

Research Approach

The Bear River Migratory Bird Refuge lies at the end of the Bear River, a heavily managed river system. Changes far upstream can have significant effects downstream. The causes of these changes may not be identifiable through strict quantitative analysis of water supply, and neither are the adaptations to such disturbances (Holling 1973). Thus, this research takes a qualitative approach to explaining how BRMBR has adapted to the uncertain human-hydrological conditions it faces (Creswell 2009, Romesburg 2009).

A literature review, preliminary search of water rights, and inventory of water institutions yielded a ten-question interview protocol and list of potential interview participants. Interview participants included current and former managers and biologists at BRMBR and other refuges, water right administrators of states in the region and state wildlife managers and biologists (see Appendix A). Interview participants identified additional sources of data, secondary literature, and potential interviewees that provided insights about the case study.

Interview questions addressed the source, quantity, and legal nature of refuge water supplies, the nature and effects of drought, constraints and opportunities for acquiring water supplies, controversies associated with water allocation and wetland management on the Bear River, the effectiveness of wetland policies, and interagency and intra-basin politics (see Appendix B for interview protocol). Interviews were recorded and transcribed when possible (see Appendix C for informed consent letter approved by Utah State University's Institutional Review Board).

Data from interviews were triangulated with other sources of information, including water rights, stream flow data, refuge management plans, historical documents, and observations from meetings. Interviews produced themes about social-ecological systems and the importance of adaptive management in the face of uncertainty that were explored in further literature searches. This pointed to the Bear River Migratory Bird Refuge as a telling case study of adaptive management.

Study Area: The Bear River Watershed and Bear River Migratory Bird Refuge

The Bear River flows for 500 miles through the states of Utah, Idaho, and Wyoming. The watershed covers 19,425 square kilometers and includes about 50 tributaries to the main stem Bear River (Utah Water Research Laboratory 2010). The Bear River Basin contributes most of the water to the larger Great Salt Lake Watershed, which is nested within the Great Basin Watershed. This forms a significant piece of the region known as the Intermountain West (Ivey and Herziger 2006). Figure 3-1 shows the major water features of the Bear River Watershed.

The natural flow in the Bear River is highly variable and driven by snowpack. Snowpack conditions vary year to year and can change within any one year based on climatic conditions in the month of April (Utah Division of Water Resources 2004, Olson 2009). Discharge at the end of the river can vary from 23 cubic feet per second (cfs) in an extremely dry year, to 14,700 cfs during an intense flood year. In 2009, the river peaked at 3,970 cfs in June, and by August it reached a minimum flow of 87 cfs (U. S. Geological Survey 2009a). It is difficult to find an “average” water year on the Bear

River because stream flow is so variable. However, this variability does tend to follow a cycle involving a few years of drought followed by a few years of flooding that seems to be correlated with the Pacific Ocean El Nino phenomenon (B. Fotheringham, *pers. comm.*). Figure 3-2 illustrates the average hydrograph of the Bear River at the Corinne, Utah gauging station from 1963-2009, indicating spring runoff peak in June, a sharp decline in flows beginning in July, and then a more gradual increase in flow during September and October.^{xvi} Figure 3-2 also shows some of the inter-annual variability of the river, depicting flow during the highest flood year on record (1984) and the worst drought year during time with stream gauge data (2004).

The Bear River is extensively dammed and diverted to capture high early spring river flows and release them during the late spring and summer when river conditions are too low to meet irrigation needs. These modifications have changed the hydrology of the river significantly.^{xvii} One of these changes is a redistribution of wetland coverage in the basin. Significant wetland acreage was dried or converted to agricultural cultivation, but there has also been an increase in wetlands in other places created by irrigation return flows and along the edges of reservoirs (Dahl 2006; K. Kirk, *pers. comm.*). This pattern has been seen in other areas throughout the West (Lemly et al. 2000, Tiner 2003).

The basic rules of prior appropriation have been modified to meet the needs of the Bear River Basin through court decrees, interstate water compacts, legislation, and agreements between powerful water users. Additions to the law of the river have most often been the result of severe droughts or floods (Jibson 1991, Endter-Wada et al. 2009). These policies and historical developments in the Bear River Basin are described in Table

3-1. These policies have been accompanied by governance adaptations that promote enhanced communication between water users (Endter-Wada et al. 2009).

The central feature of the Great Basin is the Great Salt Lake, a large, shallow, hyper-saline lake that lies at the end of the Bear, Weber, and Jordan Rivers. Because the lake is shallow and the rivers that feed it are driven by snowpack, the shoreline of the lake is very dynamic (U. S. Geological Survey 2009b).^{xviii} While it appears desolate because it is too saline to support fish, it is one of the world's richest ecosystems and depends on the Bear River for most of its inflow (about 60%). At the base of this ecosystem are the brine shrimp and brine fly (Wurtsbaugh and Gliwicz 2001). The wetlands along the north and east shorelines of Great Salt Lake comprise 75% of all the wetlands found in the state of Utah. The salinity gradient of Great Salt Lake marshes makes them very productive. The lake and its wetlands support about 30% of the birds migrating along the Pacific Flyway at some point during the year (Haig et al. 1998, Ivey and Herziger 2006).^{xix}

The Bear River Migratory Bird Refuge

The Bear River Migratory Bird Refuge sits within this highly modified political and hydrological landscape at the terminus of the Bear River, where it flows into the northeast arm of the Great Salt Lake, about 60 miles north of Salt Lake City, Utah. As the Bear River flows into the lake, it forms a delta of about 112,000 acres, much of which is managed as freshwater wetlands by the United States government, the state of Utah, and private landowners (Olson et al. 2004). The refuge itself is managed by the U. S. Fish and Wildlife Service (FWS) and encompasses about 74,000 acres, of which 29,259

acres are managed as freshwater wildlife habitat (see Figure 3-3). The refuge provides feeding, breeding, and resting habitat for more than 260 species of migratory birds by maintaining diverse wetland and grassland types within their boundary (Paton and Bachman 1996, Olson et al. 2004).

The wetland complex of the Bear River delta was likely always a dynamic system that expanded and contracted in size based on flow in the Bear River (Kadlec and Adair 1994). But beginning in the 1800s with intensified land and water use in the region, the delta wetlands began shrinking very rapidly without corresponding rebounds. By the 1920s, extensive irrigation diversions on the Bear River had depleted the delta's wetlands to less than 2,000 acres. Wetland loss and outbreaks of avian botulism lead citizens in the area to petition Congress, which established the refuge in 1928 as habitat for migratory birds (U. S. Code 1928, Wilson and Carson 1950).

The refuge is currently divided into 26 wetland units by 96 miles of dikes.^{xx} The goal of this system is to manage water depth in individual units to maintain a variety of flooded freshwater wetland habitat by impounding fresh water from the Bear River and excluding the saline waters of the Great Salt Lake. This infrastructure is managed through an adaptive process laid out in long-term and **annual habitat management plans** (Olson et al. 2004).

Analysis of how the Bear River Migratory Bird Refuge managers have adapted to the challenges of managing wetlands in the West requires linking the human and hydrological components of the region and understanding the Bear River Migratory Bird Refuge within the larger context of the Bear River Watershed. The water supply

available to the refuge, the legal rights FWS holds for the refuge and the established water needs of wetlands are described in the next section.

RESULTS

Wet Water: the Bear River Migratory Bird Refuge's Historical Water Supply

As discussed earlier, stream flow in the Bear River varies a great deal among and within years and shows the most variability at its terminus, where it enters BRMBR. The river's hydrology is driven by inflow that comes primarily from snowpack (both annual accumulation and rate of melting) and outflow that occurs primarily from human water diversions. Figure 3-4 shows stream flow in the Bear River at the Corinne, Utah gauging station (a few river miles upstream of BRMBR) over the last 45 years. This graph indicates the general cyclic nature of the river's drought and flood years. The refuge often experiences several dry years in a row or several wet years in a row. During 2004, the driest year with gauge data, the Bear River discharged 482,714 acre-feet (acft) over the course of the year. During a major flood, 20 years earlier, the river discharged 3,613,926 acft of water (U. S. Geological Survey 2009a).

Figure 3-5 illustrates the variability introduced through human modification of the river through the hydrograph of the Bear River in 2009, a year where stream flow was predicted to be about 90% of normal (Olson 2009). Total discharge from the river in 2009 was 917,250 acft, but there are distinct differences in stream flow during the spring, when the river was running at 3,000-4,000 cfs, and the summer, when the river flowed at

less than 200 cfs.^{xxi} Such a steep decline in stream flow is due to extensive diversion of water out of the river to irrigate agricultural crops.

Paper Water: the Refuge's Rights and Needs for Water

Upon establishment in 1928, the FWS applied for the refuge's foundational water right to 1,000 cfs from the Bear River. The FWS holds 28 other water rights for the refuge of various sizes and priorities from several sources (see Table 3-1). These rights total up to 438,785.12 acft of water per year, primarily for use during the irrigation season. Irrigation rights in Utah are for use between April 1 and October 31 (unless otherwise stated), while water rights for stock and wildlife may be used year round.^{xxii} About 431,600 acft of this supply comes solely from the Bear River.

Rights held by other water users on the Bear River are important in determining the water supply at BRMBR. Because it was established in 1928 and most Bear River water development had occurred prior to that time, the refuge's foundational right is junior to all of the large senior agricultural rights on the river during the irrigation season. The most relevant of these water rights are held by the Bear River Canal Company (BRCC), which diverts water from Cutler Dam with an 1889 priority, and irrigates most of the valley upstream of the refuge.

BRMBR water rights from the Bear River have some unique stipulations. The 1928 foundation right to 1,000 cfs is limited to 425,771 acft per year, and within that limit the diversion is also allocated by month, according to the water needs established by researchers from Utah Division of Natural Resources (Christiansen and Low 1970). The right allocates some water within the overall right specifically for flushing units during

the summer to prevent botulism outbreaks. The other two rights the refuge holds to use water from the Bear River (with 1902 priorities) are unique in that they are only recognized in the priority system during periods of high flow, May 1 - June 15 and September 15 - November 30, because that is when the water covered under the right was historically available.

Water rights have a place of use or service area specified on the right. The service area of the refuge's foundational Bear River water right covers most of the refuge's managed habitat (Units 1 - 5), while most of the rights to water from tributaries and drains (those with priority before 1900) service a small, relatively new portion of the refuge (refer to Figure 3-3). Thus, despite holding many water rights, only one right is actually used on most of the refuge, and that right has a junior priority.

One of the key features of water rights is the duty of water, which is a determination of the amount of water needed to grow particular crops or satisfy a use in particular locations. In the Bear River delta, wetland habitat has a higher adjudicated duty of water than agriculture in that area. Wetland habitat may use seven acft of water per acre, as opposed to the four acre feet of water per acre adjudicated for agriculture (W. Atkin, B. Fotheringham, A. Trout, *pers. comms.*). This was based in part on research done by state and university researchers on the needs of Bear River delta wetlands (Christiansen and Low 1970, Kadlec and Adair 1994).^{xxiii} While noting that wetlands require more water than many other water uses, researchers kept the limits of prior appropriation in mind when they conducted their research. Wetland water requirement was defined as

[T]he amount of water required by marshlands (state and federal refuges and private hunting areas having valid water rights) to maintain them in a productive state for the raising of waterfowl and for hunting purposes. This requirement is considered the minimum amount that will satisfy the needs and which can, therefore, be beneficially used (Christiansen and Low 1970, p. 9).”

Most generally, the refuge wetlands require 1.09 cfs per 100 acres of wetted habitat (Christiansen and Low 1970). So if the refuge is trying to keep all 29,295 acres of wetland habitat wet, it needs a minimum flow of 319.32 cfs in the Bear River or 632.24 acft of water per day (or 18,967 acft per month).⁷ This is misleading, though, because the water demand in marshes changes throughout the year based on the stages of plant growth, with larger, growing plants requiring more water than small or senescent plants. Over the course of the year, wetlands of the Bear River Bay require 62.91 inches of water; however, they require 48.44 inches of that water during the months of April through August, when water demand is highest throughout the Basin (Christiansen and Low 1970, Kadlec and Adair 1994). Based on this, BRMBR could use about 56,000 acft of water, or 957.77 cfs of inflow during the month of July.

Water needs are provided primarily by surface water, mainly out of the Bear River, because summer precipitation is rare and the sediments of BRMBR are naturally saline, making groundwater a poor choice (Kadlec and Adair 1994). When wetland water demands reach their peak, water supplies are at their lowest, which prevents flushing of saline sediments, leaving wetland units dry and dusted with a layer of salt left behind by evaporation (Kadlec and Smith 1984). Drying also brings salt to the surface of wetland soils through capillary action, increasing the salinity around plant roots (Kadlec

⁷ x cfs * 1.983 = acre feet of water per day

1982). Fortunately, the wetland plants that managers would like to be present in wetland units at BRMBR, like alkali bulrush and sago pondweed, have moderate salinity tolerances while less desirable species, including hardstem bulrush and cattail (*Typha latifolia*) have lower salinity tolerances (Christiansen and Low 1970, Kadlec and Adair 1994, Olson et al. 2004).


Late summer wetland management at BRMBR also calls for flushing wetland units to control outbreaks of avian botulism. This requires draining units during August and refilling them to target levels as soon as water is available (Kadlec and Adair 1994). BRMBR's foundational water right sets aside 120,000 acft of water for this purpose, which raises their September water needs to 60,000 acft.

Comparison of Water Supply and Water Needs

To understand whether BRMBR is receiving its entire supply requires analysis at of water supply by month, rather than by year, because water availability changes seasonally. Figure 3-6 charts the legal rights BRMBR holds and the physical supply it has received over the last ten years on a monthly basis. The water demands of plants due to growth, salt, and evapotranspiration factors, as well as water requirements for botulism control, reach a peak just as water in the river is plummeting to its lowest point. While this critical water demand point does not coincide with peak bird use times (March and October), vegetation needs to remain healthy throughout the year in order to meet bird needs during the fall migration and to reproduce the next spring.

Over the course of an entire year, the refuge does receive the 431,611.8 acre feet it is entitled to from the Bear River (often more than that); however, during the summer

months, particularly July through September, BRMBR receives much less water than it needs to maintain its wetland habitat. During the rest of the year, the refuge is receiving far more water than it can use. Table 3-3 quantitatively compares the refuge's rights and average monthly river flow during the last ten years (2000 - 2009), and the wettest and driest years with complete stream gauge data.⁸ A ratio value of one or higher indicates the Bear River is able to satisfy the refuge's full legal rights, a ratio of less than one indicates the river is flowing too low to satisfy the refuge's rights. Because the refuge's monthly rights were calculated based on wetland needs, this ratio can also be used to illustrate the refuge's water need surplus or deficit.

The need calculated by Christiansen and Low (1970) and used in BRMBR's foundational water right was based on two assumptions: first, that there is enough water available to marshes during the months of maximum use to meet evapotranspiration requirements; second, that there is enough water on an annual basis to provide outflow sufficient to manage a tolerable salinity level. From this data, it seems clear that the first assumption is not being met most years. During July and August, the river is only supplying about 15% of the refuge's needs on average, and during a dry year it may provide as little as 4.6% of the refuge's needs. The water in the river at this time is almost exclusively return flow from irrigation, so quality is also a concern (B. Olson  pers. comm.).

Given the disparity between wetland water needs and physical supply in the Bear River, the wetlands of BRMBR have fluctuated in size a great deal within a year's time.

⁸ This ratio was calculated for every month by dividing BRMBR legal right by the hydrologic supply in the Bear River.

Over the past few years the refuge has been able to maintain between 2,803 and 27,500 acres of wetlands (Olson 2009). Ideally, the refuge could use 100,000 more acft of water during July and August;^{xxiv} however, that much water is not available for allocation, so managers try to make the most of the water the refuge receives through adaptive management (A. Trout, *pers. comm.*). Fortunately, these severe water shortages occur outside of peak bird use, which is in April and October. However, birds utilize the refuge year round and water is needed to meet bird habitat demands for accessible foraging, safe nesting and cover, in addition to keeping vegetation viable throughout the year (Olson 2009).

Adaptive Water Management

The general management strategy at BRMBR follows an adaptive management approach and contains both structural and operational components. This strategy involves impounding and managing the water that comes into the refuge during the spring so that it will last as far into the summer as possible (B. Olson, *pers. comm.*). Managers recognize that it is impossible to restore the natural river hydrology at the lower end of the river to pre-settlement conditions or obtain new large water appropriations, so they anticipate yearly water shortages and manage their wetlands to buffer the effects of variable water conditions in order to maintain as much healthy wetland habitat as possible (B. Olson, *pers. comm.*).

The structural component of this adaptive management is the water control system that diverts the Bear River through various canals and into diked wetland units. The original water control system at BRMBR blocked the Bear River when it reached the

refuge then diverted that water into five large wetland units. Water moved through units sequentially, rather than being delivered to each unit through canals. This system was destroyed by floodwaters from the Great Salt Lake during the 1980s. A new water control system was built in the 1990s that subdivided the original units into 26 smaller units and contained several miles of canals that could divert water to individual units or bypass water into the Great Salt Lake. Smaller wetland units mean water levels can be more easily manipulated and controlled to provide more habitat variety within the refuge boundaries while the potential for flood and ice damage is diminished (Olson et al. 2004).

The operational component of adaptive management at BRMBR is laid out in the long-term and annual Habitat Management Plans written by refuge biologists to determine how water will be managed within wetland units. Every ten years a long-term habitat management plan is established, which lays out several management strategies that seek to maintain the most freshwater wetland habitat possible. Strategies for each unit are chosen annually, based on anticipated water supply and bird responses to previous water and vegetation management strategies (Olson et al. 2004, Olson 2009).

The 2009 BRMBR Habitat Management Plan called for wetland units to be filled after ice melts at the refuge and before the peak of spring runoff. As stream discharge decreases, managers let non-priority units dry naturally, and divert any inflow into higher priority units. Units are refilled based on priority when water becomes available again during the fall (Olson 2009). Under this system, about 75% of wetland habitat still goes dry during the summer months, but the systems maintains as much wet habitat as possible, and works to ensure that units do not stay dry for too long (A. Trout, *pers. comm.*).

In accordance with the principles of adaptive management, the refuge staff does extensive monitoring of the effects of management activities. They monitor ratios of open water to emergent vegetation, sago pondweed flowering, and water depth. They also conduct bi-weekly bird surveys and monitor the effectiveness of predator control programs and avian influenza (Olson et al. 2004).^{xxv} This monitoring allows for changes in management strategy over the years and sometimes within a year if water supplies do not meet predictions or there are large changes in bird use (Olson 2009).^{xxvi} However, it is difficult to know the full impact of habitat changes at BRMBR on populations of birds that migrate across the entire continent and beyond (A. Trout, *pers. comm.*). By trying to monitor the impact of their management, the staff is meeting the goals of the refuge, the refuge system and federal wildlife policies. However, if the Endangered Species Act were to apply to the refuge (currently there are no threatened or endangered species with critical habitat at BRMBR) the refuge may have to re-evaluate their management strategy to incorporate the requirements of that policy.

DISCUSSION

BRMBR was established to support migratory birds, so refuge management focuses primarily on the responses of birds to the provision of important bird food, nesting areas and stopover habitat (Olson et al. 2004). Maintaining all of the refuge's 29,000 acres of potentially flooded freshwater wetland habitat would require more water than is generally available to the refuge, based on its geographic position and water right priorities. Allowing all wetlands units to go dry naturally according to the conditions of the river would fail to meet the goals of the refuge, but seeking additional water rights to

completely meet established habitat needs has proven to be unfruitful. So rather than follow either of those strategies, refuge managers have chosen to adapt to an uncertain and generally scarce water supply on an annual basis. The intensive, adaptive water management plan implemented at BRMBR also has the benefit of adapting to the institutional context of the Bear River.

Management at BRMBR must meet the goals of the refuge (to provide habitat for migratory birds) and the requirements of prior appropriation and the law of the Bear River (to put water to a beneficial use). Monitoring habitat response to management strategies, sharing that information with the public, and maintaining relationships with other water users are important institutional adaptations to the human-hydrology of the Bear River (see Chapter Two for more discussion of human hydrology).

In the Bear River Basin, there are no wetlands for wetlands' sake (W. Atkin, *pers. comm.*). At the BRMBR, wetlands are maintained for wildlife, specifically migratory birds. The wildlife production goals of the refuge cannot work within the physical realities of the Bear River Basin without intensive water management and that water management cannot work within the institutional environment of the Bear River without monitoring. Monitoring how wildlife utilize refuge habitat, through bird counts and nesting surveys, after water management plans have been established meets the beneficial use requirements of prior appropriation by demonstrating that water is being consistently put to beneficial use (for wildlife propagation). Meanwhile, the requirements governing the FWS, the National Wildlife Refuge System and federal wildlife policies to provide habitat for wildlife populations are also being met, thus satisfying the refuge's water and wildlife obligations to the U. S. public and international community (U. S. Code 1928, U.

S. Fish and Wildlife Service 1999). Monitoring also gathers data that will be incorporated into adaptive management practices.

Refuge managers publish the Habitat Management Plans (HMPs) on the refuge website every spring, which serves a role in gaining the trust of other water users. Sharing knowledge gained through the adaptive management process, which is included in HMPs, is an important part of the relationship building process, not only between natural resource management agencies, but also between agencies and the public (Weber and Khademian 2008, Gunderson 1999, Wondelleck and Yaffee 2000, Dietz et al. 2003, Hahn et al. 2006). The FWS has increasingly recognized a need for more wildlife refuges to involve the public in planning, and recognized that this requires a shift in refuge management from previous paradigms that do not integrate public values into management (Boylan 2003, Langston 2003). BRMBR is a leader in this aspect, as community support is already an important component of management (B. Barrett, A. Trout, *pers. comm.*).

Within the context of the Bear River Basin, sharing knowledge gained about the river with other water users helps promote transparency and trust (Endter-Wada et al. 2009). Maintaining relationships with other water users in the Bear River Basin is an important piece of water management at BRMBR because all water uses in the area are connected to each other through the Bear River and all uses ultimately affect the wetlands downstream (Euliss et al. 2008). During July and August, water in the Bear River is almost exclusively return flow from Bear River Canal Company (BRCC) (Olson 2009, A. Trout, *pers. comm.*). While most irrigation rights in Utah end October 31, BRCC rights end September 30. This gives BRMBR the right to call on the water BRCC may be using

in the month of October, if they think it will help them refill refuge wetland units in a timely and effective manner. However, making a call on the river would likely prove to be futile because water would not realistically reach the refuge in time to benefit wetland habitat. Furthermore, calling on the right of another user causes negative feelings between water users and that has prevented cooperation between irrigators and the refuge in the past (A. Trout, *pers. comm.*).

Refuge managers have sought other means of obtaining additional water for their refuge, including attempting to file for a federal reserved water right, asking for allocations under the amended Bear River Compact, and pursuing shares in a water storage facility. However, these efforts were viewed as giving too much power to the state of Utah (in interstate negotiations) or too much power to the federal government (in negotiations with the state), and thus failed to secure more water for the refuge (Jibson 1991, Boyce 1996, A. Trout, *pers. comm.*).

Rather than seeking more water by calling on the river or making federal reserved rights claims, BRMBR maintains open communication with other water users. This includes BRCC, which can occasionally spill unanticipated excess water to the refuge when all users are on good terms with one another. Refuge managers remain active in water management discussions on the Bear River and actively monitor new, large appropriation applications on the river. Individual wetland, water, and canal managers have been critical in forging relationships between water users and management agencies (B. Barrett, B. Fotheringham, A. Trout, *pers. comms.*). Attending meetings and talking with other water users might not put more water in the Bear River on a guaranteed basis, but it does keep the refuge with a seat at the negotiating table to seek occasional and

future opportunities to improve its abilities to secure water through informal as well as formal means (A. Trout, *pers. comm.*). This facilitates sharing knowledge gained about the Bear River and discovery of any opportunities to access additional water. It also encourages face-to-face communication that helps increase trust and the ability to govern scarce resources (Dietz et al. 2003, Gunderson et al. 2006).

CONCLUSIONS

The Bear River Migratory Bird Refuge faces serious management challenges during the summer, when stream flow in the Bear River falls far below the needs of wetlands on the refuge. The refuge staff has adapted to this by obtaining water rights through the state of Utah and building a complex system of dikes and canals to manage its water supply. To compliment this infrastructure, refuge biologists complete long-term and annual habitat management plans based on predictions of summer water supplies and bird response to previous treatments. This follows the tenants of adaptive management and produces the most wet freshwater wetland habitat possible under extremely variable and often low water circumstances. Managers at the refuge have developed important relationships with other water users that facilitate sharing information about what they have learned about the Bear River and ways they can cooperate to benefit the area.

Beyond adapting to the physical realities of scarce water supplies, the water management strategy at BRMBR also conforms to the institutional realities of the area, where water rights must be put to beneficial uses and users must prove they are using their water in such a manner. It also helps the refuge managers meet the goals of the refuge within the larger National Wildlife Refuge System.

This combination of adaptive management strategies and relationship building is critical to successful wetland management in arid river basins. BRMBR demonstrates how wetlands can be managed successfully within the constraints of low water supply and multiple institutional expectations.

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Table 3-1. Important Events and Policies on the Bear River

Date	Event	Implication
1862	First allocation on the Bear River	Establishes Prior Appropriation as means for allocating water. † States allocate waters, rights are based on priority, and shortages are not shared. Rights designate a quantity, date (priority and time of use), place of use, beneficial use and point of diversion. Rights not used are considered forfeited. *
1889	Utah-Idaho Sugar Company applies for water	Right is to 333 cfs of the Bear River, which is distributed throughout the valley above BRMBR. Company sells land with water rights to encourage agriculture in the area. Later changes name to Bear River Canal Company. †
1908	Winter's Doctrine	Assures that lands set aside by the federal government have enough water for their designated purpose. Priority for that water is set at date of refuge/reservation/park establishment.*
1912	UP&L – U-I Sugar Company agreement of Bear Lake Use	Bear Lake will be run by Utah Power and Light (UP&L) as a storage facility; Utah Idaho Sugar Company (U-I Sugar) water rights will be stored there and delivered by UP&L during the irrigation season. †
1920	Dietrich Decree Botulism outbreak in GSL Delta	Decreed Utah Power and Light's right to store water in Bear Lake. Established a schedule of rights for use of the Bear River and its tributaries that specified the rights of the plaintiff (UP&L) and defendants (mostly canal companies). Public outcry results from bird die-offs
1922	Kimball Decree	Added more defendants to Schedule of Rights from the Dietrich Decree
1928	Bear River Migratory Bird Refuge established	Apply for foundational water right, infrastructure and management put in place to rehabilitate the diminished marshes of the Bear River Delta.
1958	The Bear River Compact	Establishes the rights and obligations of Idaho, Utah, and Wyoming with respect to the waters of the Bear River. Divided the river into 3 divisions, and assigned river flow and diversions within each division. Allocated storage water between states. Set minimum elevation for Bear Lake. ‡
1983	Great Salt Lake Flooding	Flood waters destroy BRMBR buildings and dikes, refuge closed until 1989
1989	GSL Waters recede	Refuge begins construction on more elaborate systems of dikes and canals to more fully manage water (including a bypass option)
1991	Bear River	Passed by the Utah State Legislature in 1991. Directs the

	Development Act	Utah Division of Water Resources to develop “excess water” in the Bear River and its tributaries. Allocates 1.2 million acre-feet of water between the Utah and Idaho portions of the Bear River Basin. Further divides Utah’s portion between four counties and conservancy districts. †
1993	Lower Bear River Adjudication	Judicial proceeding that establishes the rights of all users on a river. Began in 1940s, preliminary findings for the Lower Bear River Basin published in 2005.
1995	Bear Lake Settlement Agreement Cutler Relicensing	Voluntary agreement between PacifiCorp (formerly UP&L) and water users (not states) to settle disputes concerning the operation and management of Bear Lake. PacifiCorp made contracts with downstream irrigators for the use of their storage water in Bear Lake. Protects the elevation of Bear Lake during drought. Cutler Dam now managed as run-of-the-river facility, ending large fluctuations in river levels below dam due to power generation.
2004	BRMBR Long Term Habitat Management Plan Completed	Lays out management strategies for BRMBR based on habitat use and water supply.

(Sources: * Getches 2009, † Denton 2007, ‡ Jibson 1991)

Table 3-2. Water Rights held by Bear River Migratory Bird Refuge. Bear River Water Rights are Highlighted.⁹

Source	Priority	Quantity (acre-feet)	Flow Right (cfs)	Right Number	Beneficial Use	Type
Stauffer-Packer Spring	1860	149.19	1.04	29-3172	Irrigation	Diligence
Perry Spring Stream	1869	57.21	1.00	29-951	Irrigation	Underground claim
Unnamed Stream	1896	326.38		29-1919	Irrigation, Incidental Wildlife	Diligence
Unnamed Spring	1869	283.78; (0.03)		29-973	Irrigation (Stock, Incidental Wildlife)	Diligence
Dan Walker Spring	1870	192.68; (0.64)	3.06	29-936	Irrigation; (Stock)	Diligence
Perry Spring Stream	1870	27.84 (0.56)	0.56	29-937	Irrigation (Stock)	Diligence
Underground Drains	1870	0.22	0.002	29-3061	Stock	Underground claim
Unnamed Spring Stream	1880	10.86	0.02	29-2622	Stock	Diligence
Unnamed Spring Stream	1880	49.2 (0.91)	1.00	29-1697	Irrigation (Stock)	Diligence
Unnamed Spring	1881	328.62	1.00	29-3060	Irrigation	Diligence
Underground Drains	1885	164.40 (0.86)	1.50	29-1915	Irrigation (Stock)	Underground Claim
Underground Drains	1885	329.73 (0.86)	2.00	29-1916	Irrigation (Stock)	Underground Claim
Underground Drains	1887	147.64 (0.86)	3.00	29-1914	Irrigation (Stock)	Underground Claim
East Slough	1896	403.60	7.37	29-1450	Irrigation	Decree
Black Slough	1896	940.4	45.00	29-3484	Irrigation	Decree
Underground Drains	1900	231.96 (0.84)	1.59	29-768	Irrigation (Stock)	Underground Claim
Underground Drains	1900	189.08 (0.64)	1.11	29-769	Irrigation (Stock)	Underground Claim
Bear River	1902	3840.80	15.90	29-3485	Wildlife	Diligence
Bear River	1902	2000.00	-	29-3698	Irrigation	Diligence
Unnamed Stream	1902	0.28	0.002	29-3157	Stock	Diligence
Underground Drains	1920	0.86	0.01	29-770	Stock	Underground claim
Surface Drains	1907	20.52 (0.03)	0.50	29-980	Irrigation (Stock)	Application
Bear River	1928	425,771.00	1,000.00	20-1014	Wildlife	Application
Underground Well	1955	0.42	0.01	29-1165	Stock	Application

⁹ Data gathered from Utah Division of Water Rights (2009) online database.



Underground Well	1961	0.002	0.13	29-1330	Stock	Application
Salt Creek	1991	666.25 (666.25) [1337.75]	-	29-3668	Waterfowl (Fisheries) [Irrigation]	Application
Stauffer-Packer Spring	1995	4.00	1.04	29-3825	Wildlife	Application
Underground Drains	1995	40.00	1.0	29-3824	Wildlife	Application
Surface and Underground Drains	1997	1447.59	2.0	29-1637	Stock	Application
Total BRMBR Rights		438785.12				

Table 3-3. Bear River Migratory Bird Refuge Water Rights vs. Bear River Stream Discharge, by Month Over the Last Decade, the Last Major Drought Year (2004) and Last Major Flood Year (1984).

Month	BRMBR Water Rights (acft)	Average discharge '00-'09 (acft)	Ratio	Average discharge 2004	Ratio	Average discharge 1984	Ratio
Jan	5,938	75,843	12.77	53,445	9.00	223,700	37.67
Feb	8,202	66,456	8.10	57,400	7.00	199,609	24.34
Mar	61,380	105,235	1.71	96,021	1.56	313,574	5.11
Apr	59,400	123,121	2.07	65,261	1.10	397,988	6.70
May	61,733	103,238	1.67	24,890	0.40	590,018	9.56
June	35,842	59,121	1.65	29,906	0.83	547,367	15.27
July	56,978	7,134	0.13	2,643	0.05	207,410	3.64
Aug	40,868	5,958	0.15	2,871	0.07	181,038	4.43
Sept	60,072	15,996	0.27	7,823	0.13	203,634	3.39
Oct	28,800	36,198	1.26	33,195	1.15	250,257	8.69
Nov	10,331	46,622	4.51	44,344	4.29	265,980	25.74
Dec	1,997	58,703	29.40	64,915	32.51	233,352	116.85
Total	431,542	703,624	1.63	482,714	1.12	3,613,926	8.37

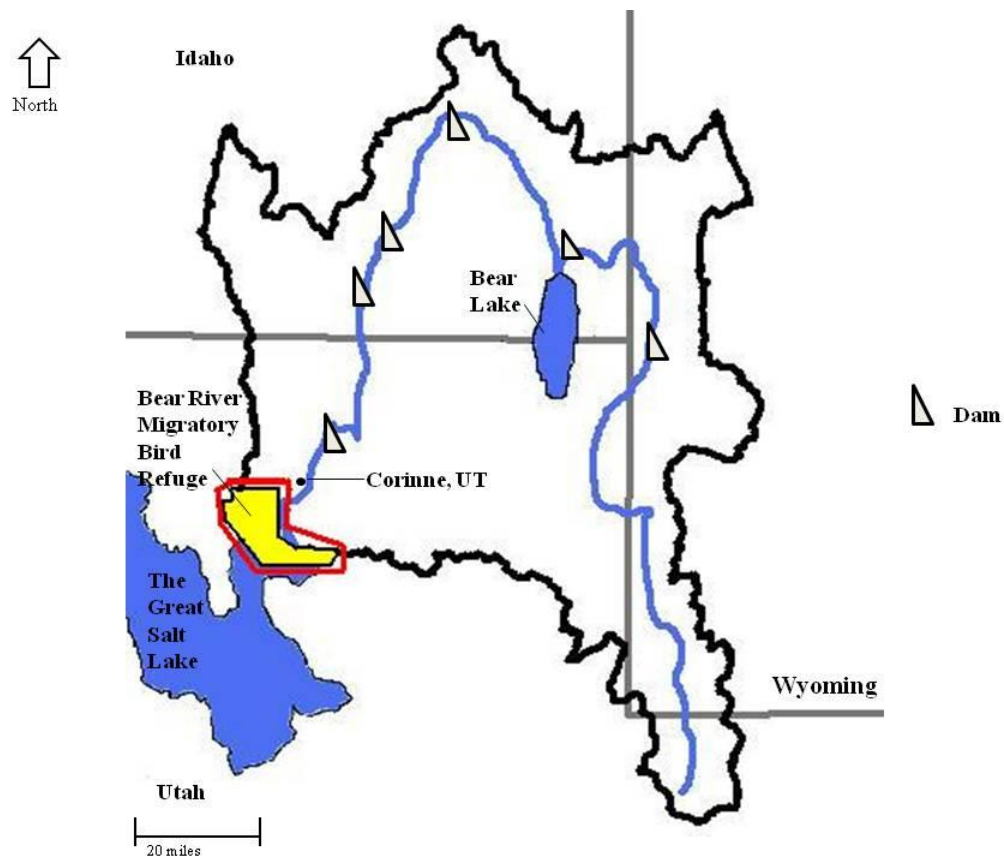


Figure 3-1. The Bear River Basin

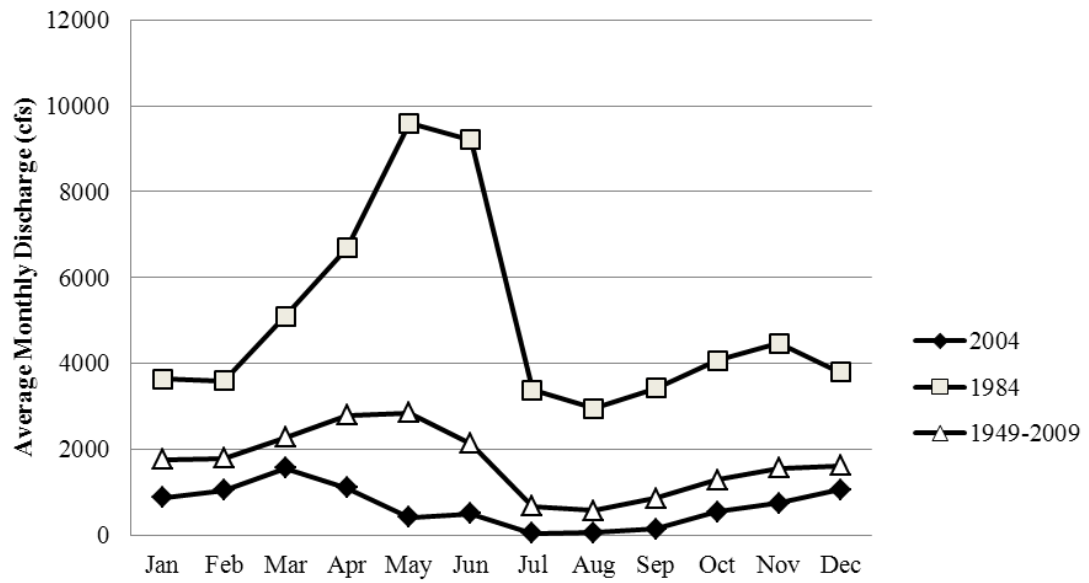


Figure 3-2. Average monthly discharge in the Bear River at Corinne, Utah during a flood year, drought year, and 60-year average (U. S. Geological Survey 2010).

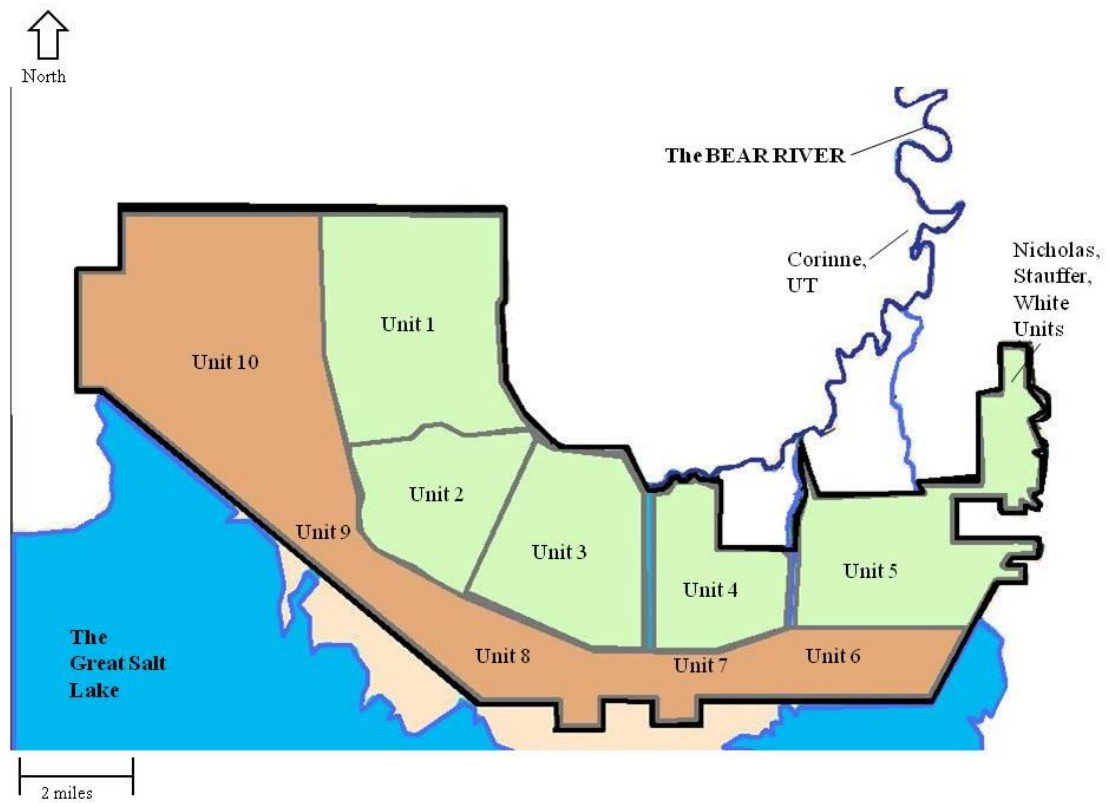


Figure 3-3. The Bear River Migratory Bird Refuge

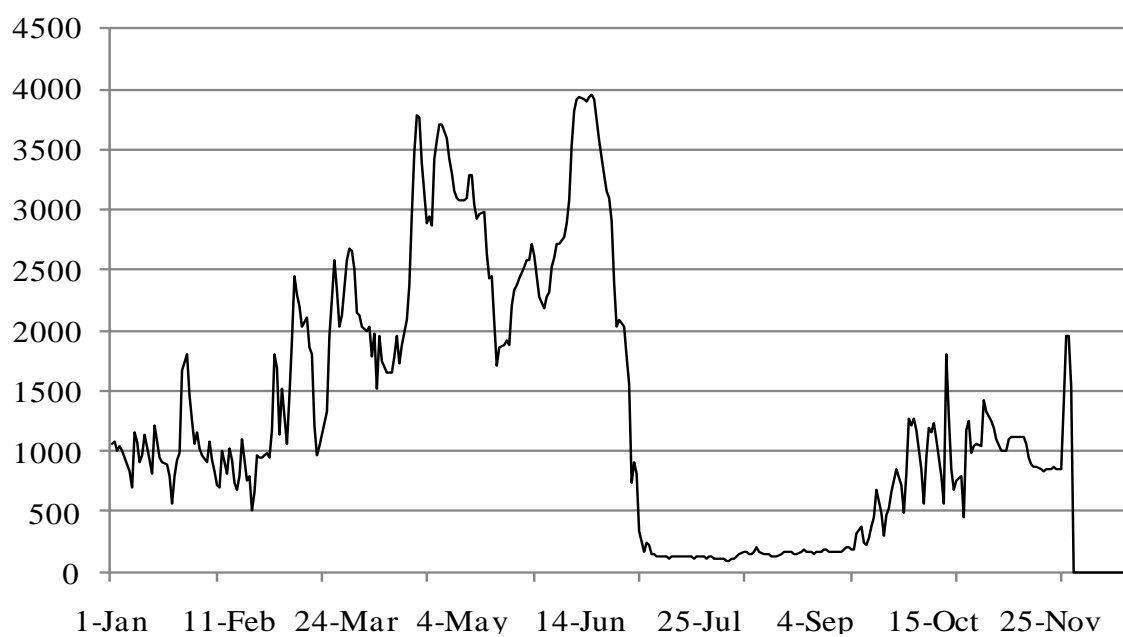


Figure 3-4. Average daily discharge in the Bear River at Corinne, Utah, 2009.¹⁰

¹⁰ Data gathered from U. S. Geological Survey (2010).

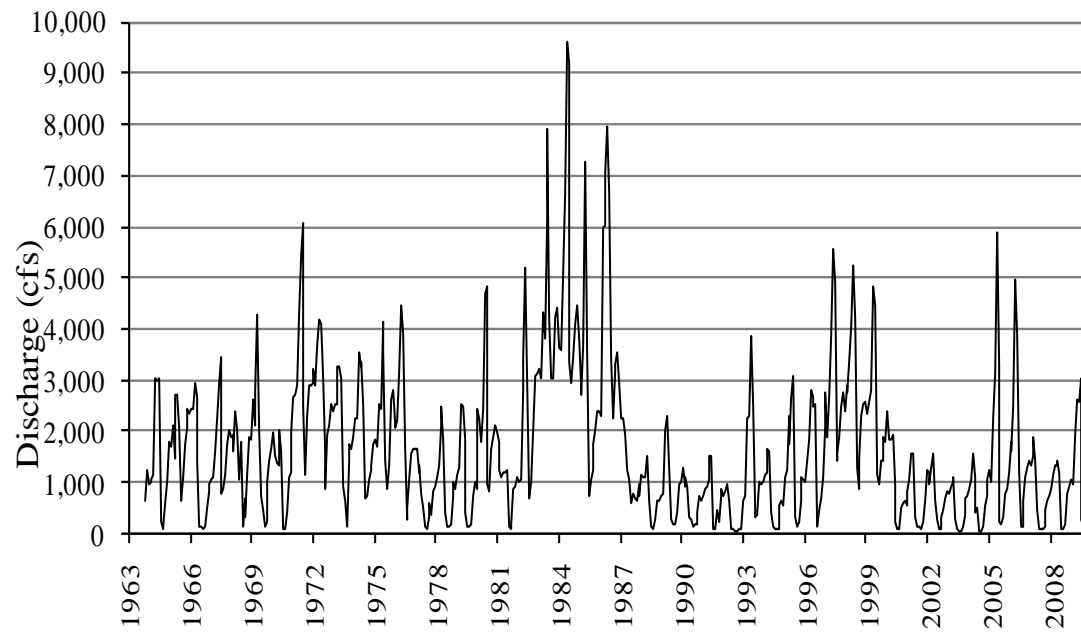


Figure 3-5. Average monthly discharge of the Bear River at Corinne, Utah, 1963-2009 (U. S. Geological Survey 2010).

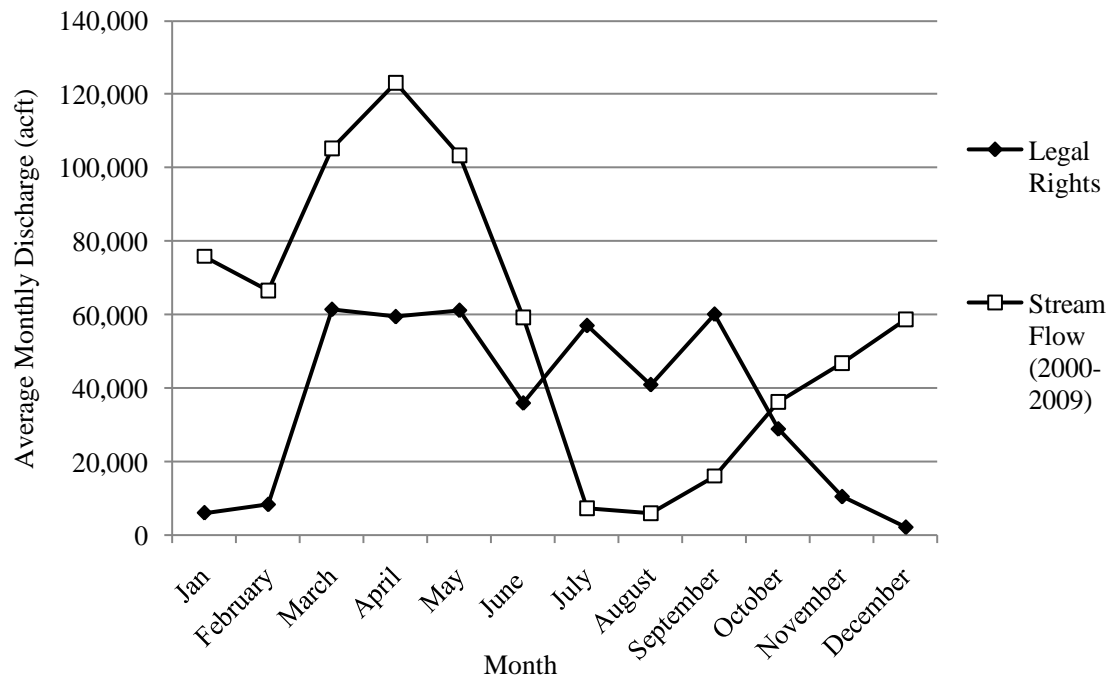


Figure 3-6. Bear River Migratory Bird Refuge legal water rights and average monthly stream discharge 2000-2009.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Wetland protection in the Western United States is difficult for many reasons, but water scarcity is foremost among those difficulties. While many federal policies exist to protect land that has been designated as wetlands from being converted to other uses, state water policies continue to develop potential wetland water supplies for other uses. The research reported on in this thesis focused on case studies in the Bear River Basin, but the issues examine here are common across the West. Thus, conclusions from this research have potential applications for other wetlands in the region where managers are trying to secure and maintain water supplies and adapt to uncertain future hydrologic conditions.

One conclusion from this study is that a wetland's geographic position within the human-hydrologic system where it is located is the most important factor in determining the security of its water supply. A wetland located upstream of, or adjacent to large, powerful water users will likely have a more secure supply than one located downstream of powerful users. This is especially true in heavily appropriated watersheds. Geographic position in relation to water sources as well as other water users matters because it determines how much water will actually be available at critical points during the growing season.

Regardless of the water security bestowed by favorable climatic and hydrologic conditions, under western water law, wetland managers must still obtain legal rights or secure agreements to use the water that supplies their wetlands. The primary mechanism

for obtaining a water supply at wildlife refuges in the Bear River Basin has been to apply for state certificated water rights, though agreements to access other water users' water rights have also played a role. Water rights can be obtained through applications to appropriate, now that most states recognize ecological uses of water as beneficial uses. However, many river systems are already heavily appropriated for other uses and rights obtained through new applications would not have high enough seniority to get water when it is most needed by plants either seasonally or during periods of severe drought. Often, it is better to acquire senior water rights in connection land acquisitions.

Once managers have the right or permission to use water, it must be actively managed to meet the requirements of wetland, wildlife and water policies. Water management does not pretend to recreate natural wetland hydrology, because often that is not possible within the altered human-hydrologic contexts of most wetlands in the West. Instead, wetland water management tries to provide a buffer against extremes in water availability by decreasing the rate of drying or flooding. It also helps provide the most wildlife habitat possible, which is often the purpose for which wetland water rights are obtained.

Having an insecure and uncertain water supply does not mean that wetlands are allowed to dry or flood according to water conditions. While that may be a more natural way for wetlands to function, it fails to meet the requirements of wetland and water policies. Instead, as is the case with Bear River Migratory Bird Refuge (BRMBR), uncertainty can prompt wetland managers to adapt in innovative ways. Such adaptations have both a structural and a social dimension, and BRMBR has been a leader in this. Not only have managers built an extensive water management system, but they also integrate

forecasting and monitoring into their planning process, in order to adapt to seasonal and annual changes in water availability. Such adaptations are enhanced by relationships within the local water users' community that help refuge staff recognize opportunities for cooperation and collaboration and minimize conflict.

The monitoring and knowledge sharing components of the adaptive management strategy followed by BRMBR plays an important role in adapting to the institutional contexts wetlands operate in, foremost by increasing trust and facilitating networking among water users. In this region, water users understand the refuge is meeting the beneficial use requirements of their water rights when they report on their management decisions and the results of those decisions. Having good relationships with other water users is important, not so much for gaining additional water supplies, but for having a place at the negotiating table that could provide opportunities in the future for enhancing wetland water security. Being involved with other water users also fosters cooperation through the recognition that agricultural and wetland uses of water are interdependent, especially in areas where many wetlands are actually dependent on irrigation return flow, and that both types of users face similar threats to their supplies.

Other wetlands in the Western United States are facing changes similar to those along the Bear River, namely growing demands on limited supplies due to population growth and future supply uncertainties related to climate change. The lessons learned by wetland managers along this river can help others facing changes to the human hydrology of their own region as they seek to enhance the security of their water supplies.

APPENDICES

APPENDIX A

Interview Participants

- Atkin, Will. 2009. State Engineer's Office, Northern Division Manager. Interview 12 January 2009.
- Barrett, Bob. 2009. Refuge Manager, Bear River Migratory Bird Refuge. U. S. Fish and Wildlife Service. Interview 7 January 2009.
- deKnijf, Annette. 2009. Refuge Manager, Bear Lake National Wildlife Refuge. U. S. Fish and Wildlife Service. Interview 23 March 2009.
- Fotheringham, Bob. 2009. Water Director, Water Department, Cache County (former northern region State Engineer). Interview 22 June 2009.
- Kirk, Kate. 2009. Interview. Biological Technician, U. S. Fish and Wildlife Service. Interview 9 April 2009.
- Olson, Bridget. 2009b. Biologist, Bear River Migratory Bird Refuge. U. S. Fish and Wildlife Service. Interview. 7 January 2009.
- Sumner, Rich. 2009. Environmental Protection Agency Wetlands Liaison. Interview 9 July 2009.
- Trout, Al. 2009. Interview. U. S. Fish and Wildlife Service, Former Refuge Manager. Interview 20 March 2009.

APPENDIX B

Interview Protocol

1. Where does the water come from that maintains (“Bear River” or specific reference) wetlands?

Probes: Do (these) wetlands have certificated water rights?

If so, what is the nature of those rights?

If not, how is the water secured?

2. How much water (amount, frequency) do these wetlands need?
3. What happens to (“Bear River” or specific reference) wetlands in times of drought?
4. Are maintenance of (Bear River; these) wetlands controversial? Can you explain?

Probes: What groups or individuals are involved in this controversy?

5. What are the constraints to obtaining enough water to maintain these wetlands?

Probes: What constraints operate on an annual basis?

What constraints pertain in times of scarcity?

6. What are the opportunities for obtaining enough water to maintain these wetlands?

Probes: What is the role of formal water rights applications?

What is the role of informal agreements?

7. How do natural resource agencies take wetlands into account in their planning processes?

8. How does your state division of water rights take wetlands into account when reviewing water use applications (new appropriations, changes of use)?

9. I would be interested in hearing your opinions about wetland policies.

Probes: What do you think are the strengths and weaknesses of those policies?

10. Do the policies and politics differ depending upon the geographic location of the wetland involved?

APPENDIX C



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Date Created: September 19, 2008; Page 1 of 2
 USU IRB Approved: 09/25/2008
 Approval terminates: 09/24/2009
 Protocol Number: 2136
 IRB Password Protected per IRB Administrator

INFORMED CONSENT

**Keeping Wetlands Wet: Wetland Policies and Politics in the Bear River Basin
 2008**

We are conducting research in the Bear River Basin on the water needs of wetlands and the effectiveness of water law and environmental policies in protecting wetlands. The overall objective of this research is to investigate the various ways in which wetland areas obtain and maintain a water supply. We are particularly interested in what happens to wetlands during periods of drought when water supplies are scarce. This research also involves policy analysis of wetland issues more generally.

This research project involves conducting in-depth interviews with professionals involved with water rights and wetlands along the Bear River. These 1-2 hour interviews are designed to obtain information on the water supply issues in wetland areas and the local politics involved in protecting wetlands. Interviewees have been selected to represent the various government agencies involved in wetlands management and local non-governmental organizations concerned with wetlands protection.

You have been asked to be interviewed because of your involvement in wetlands management or protection in the Bear River Basin. Your participation is completely voluntary and you may withdraw at any time without consequence. We would like to recognize your participation in the research by listing you in publication and report acknowledgements because the research validity rests on the knowledge and reputation of those interviewed. However, if at any time during the interview you indicate that certain information is "off the record," those comments will be kept completely confidential and will be deleted from the interview transcriptions. If there are any questions you would be uncomfortable answering, you may choose not to answer them without consequences. If you would prefer that your participation in this study remain confidential, we will honor that request as well. If you decide to withdraw from the study after the interview has begun, any information obtained from you prior to that point will be destroyed.

We would like to ask your permission to tape record the interview and then to transcribe the tape recording. This is to ensure that we have correctly heard and understood the information you provide. The tapes and transcriptions will be kept secure in a locked file cabinet in a research laboratory at Utah State University. The information will be used for research purposes only, and access to the information will be limited to those people directly involved in the research work. The audiotapes will be destroyed within two years from the date of the interview; transcriptions of the interviews will be kept in the research laboratory until research findings have been published and then they will be destroyed.

The Institutional Review Board (IRB) for the protection of human participants at USU has reviewed and approved this research study. If you have any pertinent questions about your rights, want to obtain information from someone other than the researchers, or are concerned about potential harm from participation, you may contact the IRB Administrator, True Fox, at (435) 797-0567. Obtaining the informed consent of participants in research projects is an important and required part of university procedures. We will retain a copy of this consent form for our records, and are providing you with a



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INFORMED CONSENT

Keeping Wetlands Wet: Wetland Policies and Politics in the Bear River Basin 2008

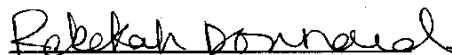
copy for your reference (note that it includes information so you can contact us after the interview session if you choose to do so).

We very much appreciate your time and want to thank you in advance for your participation in this study. If you have any questions or concerns about the research itself, please contact Joanna Endter-Wada, the Principal Investigator, at (435) 757-2781 or 435-797-2487. She would be more than happy to answer them.

I certify that the research study has been explained to the individual, by one of us, and that the individual understands the nature and purpose, and the possible risks and benefits associated with taking part in this research study. Any questions that were raised have been answered.



Joanna Endter-Wada, Ph.D.
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Associate Professor
Department of Environment and Society
College of Natural Resources
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Rebekah Downard
Graduate Student Researcher
Phone: 801-643-0076
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Interviewee Consent (check all that apply):

- ☐ I agree to be interviewed and understand that my participation is voluntary
☐ I agree to have the interview taped and transcribed
☐ I prefer that my participation in this study remain confidential
 (my name will not be listed as one of the people interviewed)

Name of Interviewee (printed)

Signature of Interviewee

Date

APPENDIX D

ENDNOTES

ⁱ Natural resource agencies like the FWS have come to recognize the importance of forging ties between the land they hold and communities and are trying to promote building these ties at wildlife refuges that have not yet done so (Ashe, 2003).

ⁱⁱ The Bear River is unique in being the longest river in North America that does not reach the ocean (Jibson, 1991).

ⁱⁱⁱ During the past 100 years the lake has occupied between 3,300 and 950 square miles of surface area (U. S. Geological Survey, 2009b)

^{iv} Historians have called this the single most important development affecting Bear River water allocation (Jibson, 1991).

^v Agricultural development in the Bear River Basin was encouraged by canal companies that sold parcels of land with shares of water in their companies. Irrigation is the dominant water interest on the Bear River, followed closely by PacifiCorp, formerly Utah Power and Light (UP&L). Together they determine how most of the water in the river is used. However, as the basin has developed, a more diverse set of interests call on the river, including municipal uses, manufacturing, and recreational and environmental interests, while hydropower has fallen in importance (Jibson, 1991). Water policy on the river has developed to address these newer uses and will continue to evolve to address changes in water use in the basin (Boyce, 1996).

^{vi} This could be due to the Mormon traditions in the Basin or because the complexities of the Bear River require creative approaches to water allocation (Boyce, 1996).

^{vii} Every water right has a beneficial use with corresponding period of use; irrigation rights are generally in priority from April through October, but this varies by state and legal decree; while stock water, wildlife and domestic rights are in priority year round. Within this period of use, many flow rights, measured in cfs or gpm (gallons per minute) are limited to a discharge amount in acre-feet that constitutes the maximum volume of water that can be used per year.

^{viii} However, the river has never exceeded 5,000 cfs above Bear Lake (Jibson, 1991)

^{ix} Birds of the delta were so numerous, John C. Fremont described the noise from the movement of huge flocks of birds as thunderous (Fremont, 1845; Wilson & Carson, 1950).

^x In Utah, diligence claims are rights to waters that had been used prior to 1903 and underground water claims are rights to underground water that had been used prior to 1935 (Utah Division of Water Rights, 2009).

^{xi} A simple water management system was built when the Refuge was established and rebuilt with more units and control in the 1980s after the refuge was destroyed by flooding of the Great Salt Lake (Al Trout, personal communication).

^{xii} Under the law, Utah Division of Water Resources (2000) is to develop 120,000 acft of water in Cache and Box Elder Counties, within the Bear River Basin, and 100,000 acft in Davis and Jordan Valley Water Conservancy Districts, south of the basin.

^{xiii} It also follows the recommendations of social scientists who study collaboration and the RAMSAR Convention (a convention to protect global wetlands for birds) to participate in watershed-wide water planning, foster cooperation, and get wetland/environmental water use recognized by more water users (Iza 2004).

^{xiv} Including in some high profile cases such as the Lahontan Valley in Nevada and the Central Valley of California (MacDonnell 1991).

^{xv} Most western states follow the Doctrine of Prior Appropriation, generally summarized as “First in Time, First in Right,” but allocation rules specify far more requirements than simply having priority. Users obtain water rights with a priority date and senior users are guaranteed their full water right in times of shortage, while junior users may be cut off, because water shortages are not shared between users. A water right gives the user the right to divert a specific quantity of water, at a specific time during the year, with a specified priority date, for a designated, beneficial use at a specific location. Prior Appropriation also contains a “use it or lose it” clause; water that is not continually put to a beneficial use may be lost (Getches 2009).

^{xvi} There is some disagreement between water users over whether the Bear River is fully allocated, most water users, and even historians believe there is no longer water available in the river for major appropriations (Jibson 1991, Al Trout personal communication, Bob Barrett personal communication). However, the state of Utah has been directed to develop 220,000 additional acre-feet of water, through the Bear River Development Act (Utah Department of Water Resources 2000). What is clear to everyone on the river is that there are times of the year, namely July through September, when the Bear River is fully allocated.

^{xvii} Little is known about the historical conditions of the river, but researchers hypothesize that before the impoundments and diversions were in place, the hydrograph of the Bear River had two peaks associated with snowmelt, one in March or April, and a higher spring runoff peak in May or June. This would have been followed by a gradual decrease in discharge through September, when precipitation events increased flow in the river again (Olson et al. 2004).

^{xviii} On average it covers 1,700 square miles (mi²) but in the last 40 years alone the lake has fluctuated between 3,300 mi² and 950 mi² in surface area (U. S. Geological Survey, 2009b).

^{xix} The delta where the Bear River flows into the Great Salt Lake itself hosts significant portions of the world’s populations of California gulls, Eared grebes, White-faced ibis, and American white pelicans (Ivey and Herziger 2006).

^{xx} Refuge staff began aggressive construction of a water management system when the refuge was first established. This active management produced significant, visible improvements in wildlife populations within a few years (Wilson and Carson 1950). After flooding in the 1980s destroyed the refuge, the water control system was rebuilt more wetland units to produce greater control of water.

^{xxi} The pre-settlement hydrology of the Bear River likely had a dry phase at the same time of year, but not nearly as extreme as current conditions.

^{xxii} The Dietrich and Kimball Decrees establish the irrigation season for Bear River Canal Company (and several other water users) as April 1 – September 30.

^{xxiii} Work in the 1960s was done to determine the needs of wetlands in order to ensure the state's wildlife management areas had the water rights they needed.

^{xxiv} If this water were equally distributed between the months it is most needed, the refuge's demand:supply ratio would be just over 1.

^{xxv} However, these are constrained by time and staff (Olson 2009).

^{xxvi} For instance, 2008 was predicted to be a close-to-normal water year, however, water in the river ended up much lower than expected, closer to 36% of normal. Nevertheless, BRMBR was still able to maintain 11,000 acres of wetland habitat (Olson 2009). Managers have also been able to divert water from wetland units that used to host nesting birds, to other units, should birds decide to move.