Journal of Environmental Management 131 (2013) 394–406

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Keeping wetlands wet in the western United States: Adaptations to drought in agriculture-dominated human-natural systems

Rebekah Downard [a,b,*], Joanna Endter-Wada [c,b,1]

[a] Department of Watershed Sciences, Utah State University, 5210 Old Main Hill, Logan, UT 84322-5210, USA
[b] Ecology Center, Utah State University, 5205 Old Main Hill, Logan, UT 84322-5205, USA
[c] Department of Environment and Society, Utah State University, 5215 Old Main Hill, Logan, UT 84322-5215, USA

ARTICLE INFO

Article history:
Received 19 February 2013
Received in revised form
19 July 2013
Accepted 11 October 2013
Available online 8 November 2013

Keywords:
Wetlands
Water policy
Irrigation systems
Wetland management
Drought adaptation
Coupled human-natural systems

ABSTRACT

Water is critical to protecting wetlands in arid regions, especially in agriculture-dominated watersheds. This comparative case study analyzes three federal wildlife refuges in the Bear River Basin of the U.S. West where refuge managers secured water supplies by adapting to their local environmental context and their refuge's relationship to agriculture in being either irrigation-dependent, reservoir-adjacent or diked-delta wetlands. We found that each refuge's position confers different opportunities for securing a water supply and entails unique management challenges linked to agricultural water uses. Acquiring contextually-appropriate water rights portfolios was important for protecting these arid region wetlands and was accomplished through various strategies. Once acquired, water is managed to buffer wetlands against fluctuations caused by a dynamic climate and agricultural demands, especially during droughts. Management plans are responsive to needs of neighboring water users and values of the public at large. Such context-specific adaptations will be critical as the West faces climate change and population growth that threaten wetlands and agricultural systems to which they are linked.

1. Introduction

1.1. Water supplies are critical for wetland health and function

Water is the driving force in wetlands, responsible for their structure and function (Faulkner et al., 2011; Keddy et al., 2009). Water also links wetland managers to other water users across ownership boundaries in coupled human-natural systems (Falkenmark, 2004; Liu et al., 2007a). These linkages are evident in the ways hydrologic manipulation through impoundment and diversion of rivers has destroyed wetlands in some places and created wetlands in other locations. Early wetland policies in the U.S. encouraged wetland destruction in favor of other land uses, but more recently policies like the Clean Water Act have been established to protect wetlands (Eckles, 2011; Vileisis, 1997). Conservation policies have successfully slowed wetland loss; however, the focus of these policies has been to protect land designated as wetlands rather than the water supplies crucial to wetland function (Brinson and Eckles, 2011; Iza, 2004; MacDonnell, 1991).

In the West, water is scarce, highly contested, and heavily managed while wetlands are rare and ecologically valuable (Barnett et al., 2008; Dahl, 2011). As rivers in this region were allocated and diverted for human use, the timing and distribution of flooding changed, as did wetland distribution, which generally decreased (Langston, 2003; Reisner, 1989). Wildlife refuges were established to protect remaining wetland habitat and managers made additional changes as they began manipulating water within refuge boundaries to actively manage for wildlife (Downard, 2010; Welsh et al., 2013). Periodic drought is a natural part of wetland hydrology; however, extended drought or increased hydrologic variability, which climate change models suggest will increase, can severely impair ecosystem functions (Burkett and Kusler, 2000; Zedler, 2009).

1.2. Managing wetlands in the context of agriculture and western water law

The geographic and socio-political position of wetlands in relation to other water uses determines the frequency and magnitude of drought in wetlands and presents varying opportunities for securing and managing water. Wetland water

* Corresponding author. Department of Watershed Sciences, Utah State University, 5210 Old Main Hill, Logan, UT 84322-5210, USA. Tel.: +1 801 643 0076.
E-mail addresses: rdownard8@gmail.com (R. Downard), Joanna.Endter-Wada@usu.edu (J. Endter-Wada).
[1] Tel.: +1 435 797 2487.

0301-4797/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jenvman.2013.10.008

management in agriculture-dominated watersheds requires recognizing and adapting to 1) hydrologic connections between water users, where one user's return flow may be another's water source; 2) shifting wetland distribution away from deltas and toward reservoirs and canals; and, 3) human linkages built at various scales as users adapt water allocation institutions to drought and changing uses of water.

Under the prior appropriation system dominant in the West, water rights are allocated by states on a "first in time, first in right" basis. Water shortages are not shared during droughts; thus, water users with older, "senior" water rights have greater security and experience drought differently than those with "junior" water rights (Getches, 2009). Environmental uses of water (including wetlands) were not legally recognized by most states until the 1970s, resulting in appropriations for these uses generally having junior priorities or "paper water" rights without actual practical access to "wet water" (Hillman et al., 2012). However, there are other means to secure a water supply, outside of applying for state water rights, and the security of a water supply does not necessarily depend upon the seniority of a water right (Baron et al., 2002; Grey and Sadoff, 2007). During times of drought, cooperation between neighboring land owners, outside the formal requirements of water law, can alleviate negative impacts of water scarcity (Endter-Wada et al., 2009).

In agricultural-dominated human-natural systems, wetlands can be characterized in terms of three relationships they commonly have to their water supply: diked-delta, reservoir-adjacent, and irrigation dependent. Diking wetlands to buffer against drought or extreme hydrologic fluctuations is a common management adaptation to upstream hydrologic change, particularly in deltaic wetlands in lower reaches of rivers (Haig et al., 1998; Zedler and Kercher, 2005). The regulation of western rivers was facilitated by construction of reservoirs for water storage, hydropower production, and flood regulation, which created wetlands near these new, more permanent water sources (Doll et al., 2009; Volz, 1995). Wetlands created by and dependent on flood irrigation, agricultural return flows, and canal seepage are especially ecologically valuable because they often exist in regions where natural wetlands are rare and/or impaired (Copeland et al., 2010; Peck and Lovvorn, 2001).

1.3. Significance of this comparative case study of wetlands in the Bear River Basin

The Bear River Basin is characteristic of most river basins in arid regions: heavily-managed, dominated by agriculture, and structured by histories of human adaptations to droughts (Endter-Wada et al., 2009). However, the Basin is unique in having many large wetland complexes that provide critical migratory bird habitat (Aldrich and Paul, 2002; Tiner, 2003). In this comparative case study of Bear River Basin wetlands, we examine how the locations of three U.S. Fish and Wildlife Service (USFWS) refuges impacts the way they experience droughts and the water management adaptations managers have made. While being managed by the same agency and located within the same watershed, the contextualized position at each refuge in relation to available stream flow, adjacent land uses, and water rights seniorities has led managers to pursue different means of securing wetland water supplies. Understanding how wetland managers have adapted to drought in the U.S. West requires qualitative, multi-method research of context at multiple scales with a focus on historical trajectories, hydrologic realities, and local institutions and legislation. Lessons learned by refuge managers in adapting to the challenges and opportunities of their location along the river can be applied in other arid, agriculture-dominated watersheds.

2. Context – the Bear River Basin

2.1. Hydrology of a dynamic, agriculture-dominated river

The Bear River runs for 800 km through the states of Utah, Wyoming and Idaho (Fig. 1) in a semi-arid climate that only receives 54 cm of annual precipitation. Stream flow is driven by snowpack that accumulates in the mountains and is stored in reservoirs during spring runoff for release during the irrigation season. Annual stream flow is naturally highly variable and difficult to predict, and the Bear River is usually experiencing either drought or flooding. Since European settlement, the river's natural hydrology has been altered by reservoirs, canals and other infrastructure needed to support agriculture and hydropower operations. Regional climate models predict higher rates of evapotranspiration, more frequent and severe droughts and floods, and a shift in precipitation from snow to rain, creating challenges for a water management system engineered to capture snowmelt (Lundquist et al., 2009; Mote, 2009).

2.2. Policy adaptations to unpredictable, drought-prone hydrology

Historically, severe droughts have led to important policy developments in order to decrease conflict between water users. Senior rights to the Bear River under the rules of prior appropriation were first claimed in 1862. The basic tenants of prior appropriation were subsequently modified by other policies that together form the Law of the Bear River, the most prominent of which is the Bear River Compact that divides the river into three divisions (Upper, Central, and Lower), allocates storage rights and delivery obligations between the divisions, and establishes protocols for drought mitigation (Jibson, 1991). Other additions to the Law of the Bear River include court decrees and adjudications, state constitutions and water development plans, and reservoir operation agreements. Agriculture is the primary use of Bear River water, but PacifiCorp, a power company, is responsible for management of six large reservoirs on the river and is influential in river management decisions. Despite a long history of water development, the Bear River remains one of the few basins open to new appropriations in the West (UDWRe, 2004).

2.3. Shifting wetland distribution in response to hydrologic changes

The impoundment, diversion, and delivery of Bear River water has changed the spatial and temporal availability of water and led to shifts in wetland distribution from lower reaches of the river to areas upstream. Migratory birds followed this shifting distribution of wetlands, providing the rationale for refuge designations. The Bear River terminates in a delta with the Great Salt Lake (GSL), a hyper-saline, terminal lake located in Utah. Water that flows into GSL is considered wasted under western water law, and little water reaches the lake during the irrigation season, extensively dewatering the delta; however, millions of migratory birds on the Central and Pacific flyways utilize these wetlands (Ivey and Herziger, 2006). Bear River Migratory Bird Refuge was established to protect the remaining delta from further degradation. The same diversions that dewatered the delta expanded a smaller complex of wetlands in Idaho associated with Bear Lake when the lake was augmented to act as a storage reservoir, and these expanded wetlands became the Bear Lake National Wildlife Refuge. Application of diverted Bear River water in the upstream mountain valleys of Wyoming created large wetland complexes amongst vast expanses of rangeland, as is the case with Cokeville Meadows National Wildlife Refuge.