Appeal for a Comprehensive Assessment of the Potential Ecological Impacts of the Proposed Platte-Republican Diversion Project

Andrew J. Caven, Emma M. Brinley Buckley, Joshua D. Wiese, Bill Taddicken,
Brice Krohn, Timothy J. Smith, and Andrew Pierson

ABSTRACT—To adhere to the Kansas-Nebraska-Colorado Republican River Compact, the Central Nebraska Public Power and Irrigation District, the Lower Republican Natural Resources District (NRD), and the Tri-Basin NRD proposed the first transbasin diversion in Nebraska history. The Central Platte River Valley supports diverse wildlife, including four federally listed and eleven state-listed species, as well as robust agricultural production. Periods of high flow in the Central Platte River Valley are necessary to maintain the basin's ecological structure, function, and groundwater recharge. Recent decades demonstrate that current water demands placed on the Platte River are not sustainable, and large portions are designated as "overappropriated." Over 90% of active river channel has been lost in some areas of the Platte. The project proposal fails to account for the ecological dynamics of the Central Platte River Valley when estimating the potential costs and benefits. Moreover, not all alternatives for water acquisition and/or conservation appear to have been fully investigated, nor were stakeholders in the Platte River Basin involved in the decision-making process to pursue the current transbasin diversion. We recommend a more critical public and scientific evaluation of the current proposal before it moves forward, as well as the addition of a robust ecological impacts monitoring plan.

Key Words: Central Platte River, groundwater, interbasin diversion, landscape ecology, transbasin diversion, water development, water management

Project Overview

Rivers do not recognize political boundaries. Many upstream and downstream interests have competed for the right to utilize more of the Platte River's water, resulting in several legal battles in the 20th century (Eisel and Aiken 1997). For example, in 1978 the Crane Trust was established to "protect and maintain the . . . hydrological and biological integrity" of the Central Platte River Valley as a legal mitigation to the negative impacts of constructing the Grayrocks Dam in Wyoming (VanDerwalker 1982). Today we are still having similar battles over this highly valuable resource. On February 24, 2015, the Supreme Court of the United States ordered Nebraska to pay 5.5 million dollars to Kansas for consuming more than its share of the water resources of the Republican River, violating the Republication River Compact of 1943 (Case No. 574; US Supreme Court 2015). To meet the needs of the Kansas-Nebraska-Colorado Republican River Compact, the Central Nebraska Public Power and Irrigation District (CNPPD), the Lower Republican Natural Resources District (NRD), and the Tri-Basin NRD recently proposed what could become the first transbasin water diversion in Nebraska history (Fig. 1; Olsson Associates 2017).

We reviewed the "Platte River Diversion Application for Variance" (Olsson Associates 2018), which includes a copy of the "Interbasin Transfer Permit Application," as well as the "Platte Republican Diversion Project Feasibility Review," prepared by Olsson Associates (2017) for the CNPPD and the Lower Republican and the Tri-Basin NRDs, respectively. We also reviewed "Application A-19594" and its required forms submitted by the CNPPD to the Nebraska Department of Natural Resources (CNPPD 2018). The proposal would divert 275 cubic feet per second (cfs) from the Platte River

Great Plains Research 29 (Fall 2019):123–135. Copyright © 2019 by the Center for Great Plains Studies, University of Nebraska–Lincoln

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

whenever "there is unappropriated water available" into the E-65 supply canal and eventually the headwaters of Turkey Creek, a tributary of the Republican River, through an underground pipeline (CNPPD 2018, Olsson Associates 2017, 2018; Fig. 1). Flows exceeding the capacity of Turkey Creek (100 cfs) would be regulated in Elwood Reservoir for future transportation to the Republican River (CNPPD 2018; Olsson Associates 2018). The following represents our professional assessment of the reports, the potential ecological impacts of the transbasin diversion on the Central Platte River Valley ecosystem, and the precedent it sets forth in Nebraska for water management in the future.

Water in a Valuable Agricultural and Biological Landscape

The Platte River watershed is in a semiarid landscape with a limited water supply compared to the demands of the communities, industries, agricultural production, and fish and wildlife populations it sustains (Thormodsgard 2009; Vörösmarty 2010). An agricultural powerhouse, Nebraska produces about 9 million acres of corn each year. The Central Platte River Valley is one of the state's most productive regions (Dappen et al. 2008; Nebraska Department of Agriculture 2015), as well as a biologically unique and important ecosystem (LaGrange 2005; Schneider et al. 2011; Fig. 1). As the Central Platte River Valley is the "pinch in the hourglass" for the central flyway, the river, wetlands, and subirrigated grasslands are invaluable habitat for migratory birdlife (Currier and Henszey 1996; Krapu et al. 2005; LaGrange 2005). The region also has a unique geomorphology and hydrology, including shallow groundwater that permeates through coarse alluvial sediments below agricultural fields and grasslands, fluctuating in depth along with changes in river flows (Wesche et al. 1994; Chen 2007; Scanlon et al. 2012). This shallow dynamic groundwater supply sustains a unique and diverse biota as well as one of the most productive agriculture regions in the world (Henszey et al. 2004; Davis et al. 2006; Dappen et al. 2008; Scanlon et al. 2012; Vivian et al. 2013; Thormodsgard 2009; Guanter et al. 2014). However, in recent decades it has become clear that the demands placed on this important ecoregion are not sustainable and that efforts must be made to protect it for future generations (Williams 1978; Currier 1997; Zuerlein et al. 2001; LaGrange 2005; National Research Council 2005; Davis et al. 2006; Schneider et al. 2011; Nebraska Department of Natural Resources 2017; Birgé et al. 2018).

The project feasibility review (Olsson Associates 2017, ii) suggests that the Platte River has had "incredible" flows in recent years. Nonetheless, the same report noted that during drought conditions from 2002 to 2005, there would be no water available to divert from the Platte River to the Republican River. Moreover, the Platte River in central Nebraska, directly downstream from where the project is proposed, is officially designated as "overappropriated," considering the availability of surface water and hydrologically connected groundwater in relation to the water rights allocated to users (Central Platte NRD and NE DNR 2012; NE DNR 2017). In summary, the current demand for water is greater than the supply in the average year. Multiple-year droughts are an inherent component of Nebraska's dynamic climate (Hayes et al. 2005). The whole Great Plains ecosystem including the grasslands, rivers, wetlands, and biota they support evolved under sustained periods of both flooding and drought (Anderson 2006). Weakly (1965) documented droughts lasting up to 38 years in west-central Nebraska by utilizing tree rings to gather data on drought cycles going back to the year 1220 AD. As Hayes et al. (2005) note, drought will play an increasingly important role in our collective decision-making processes as demand continues to grow for our finite water resources. Additionally, evidence strongly suggests that snowpack in the Rocky Mountains is declining as a result of climate change, reducing snowmelt feeding the Platte River, and further limiting future water resources in Nebraska (Fassnacht et al. 2018).

The Central Platte NRD and Nebraska Department of Natural Resources (NE DNR) (2012) developed an Integrated Management Plan to create and preserve equilibrium between water use and supply to ensure the long-term "economic viability" and "environmental health" of the Central Platte River Valley, which includes reaches designated as "fully appropriated" and "overappropriated." The Integrated Management Plan is designed to comply with the Platte River Recovery Implementation Program (PRRIP), a cooperative effort including the US Department of Interior, the states of Colorado, Wyoming, and Nebraska, water users, and conservation organizations, to address habitat losses in the Central Platte River Valley impacting species listed under the Endangered Species Act (Smith 2011; Central Platte NRD and NE DNR 2012). The Integrated

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

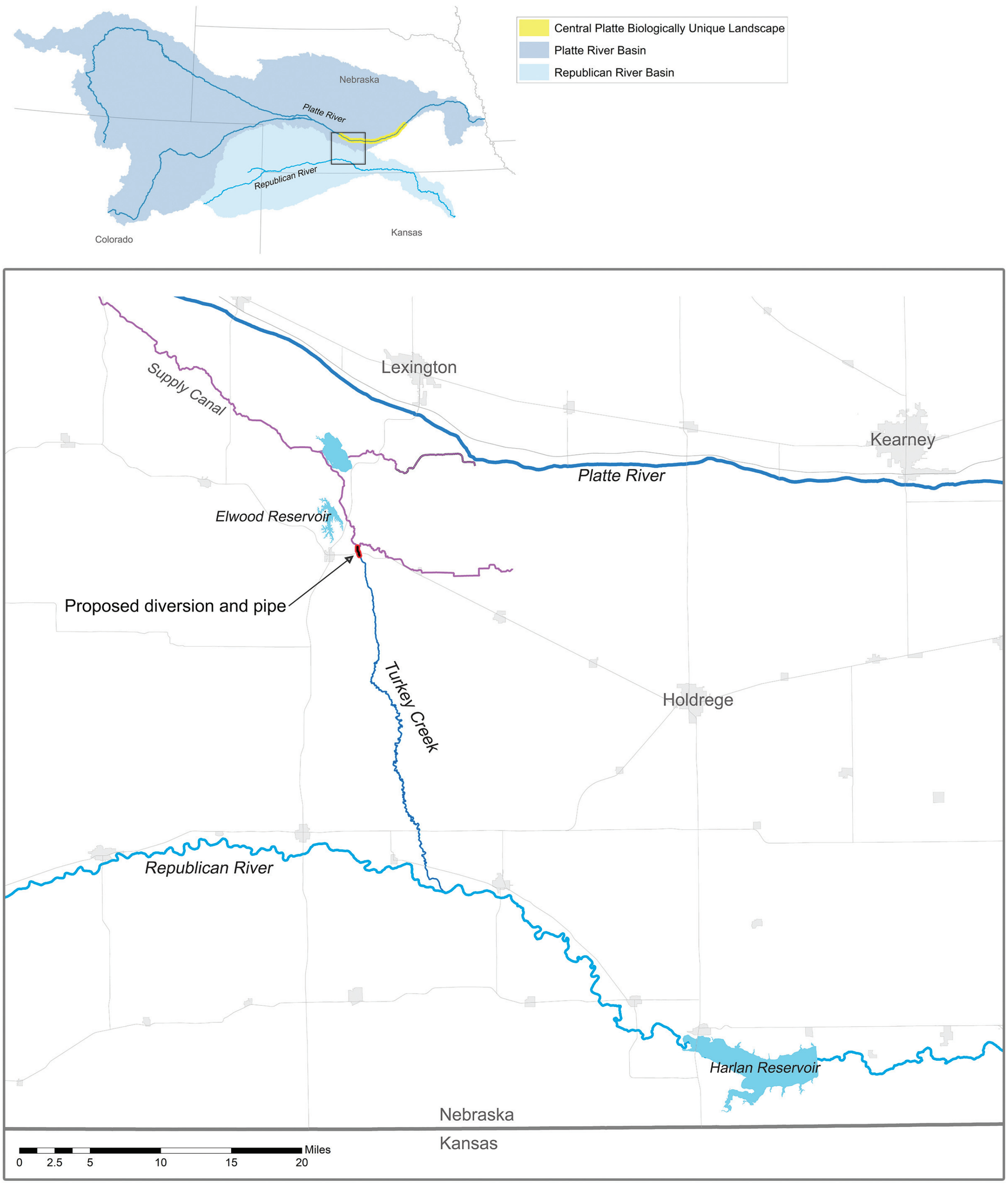

Fig. 1. Map of the Platte River Basin, Republican River Basin, the E-65 supply canal, Elwood Reservoir, the proposed diversion site, Turkey Creek, and Harlan County Reservoir. Image courtesy of the authors.

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

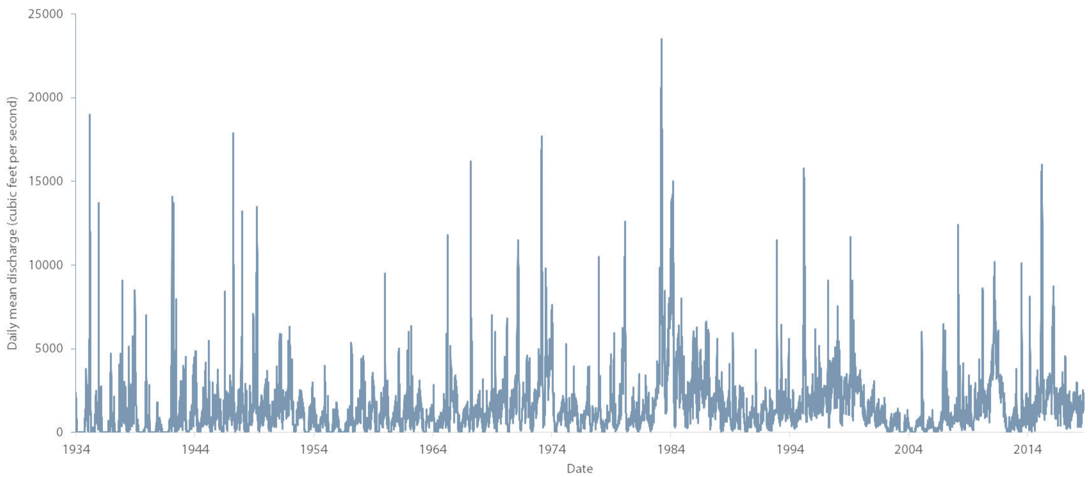

Fig. 2. Hydrograph of streamflow in cubic feet per second (cfs) from 1937 to 2018 at the US Geological Survey stream gage at Grand Island, NE (gage no. 06770500). Image courtesy of the authors.

Management Plan does not allow for further water appropriations in the Central Platte River Valley without a "variance petition," which ensures there would be no adverse impacts to water users or breach of compliance with the PRRIP (Central Platte NRD and NE DNR 2012). The Platte River Valley is home to four federally threatened and endangered species including the whooping crane (*Grus americana*), the pallid sturgeon (*Scaphirhynchus albus*), the piping plover (*Charadrius melodus*), and the interior least tern (*Sternula antillarum*) (National Research Council 2005; Smith 2011). PRRIP (2006) aims to improve habitat for these species by protecting land and increasing river flows when they are inadequate to meet species' needs or long-term ecosystem maintenance needs (PRRIP 2006). PRRIP (2006) seeks to reduce deficits to "target flows by an average of 130,000 to 150,000 acre-feet per year" to sustain and enhance endangered species habitat in the Central Platte River Valley. Despite significant effort and $150 million in expenditure to date ($120 million of water contributed from signatories and $30 million spent on water supply projects), the PRRIP has not yet reached its goal of reducing target flow deficits (J. Farnsworth, PRRIP executive director, pers. comm. 2018). PRRIP currently has water projects in place capable of reducing deficits to target flows by an average of 110,000 acre-feet per year, which is enough to increase mean annual streamflow by almost 10% (J. Farnsworth, PRRIP executive director, pers. comm. 2018). If unappropriated flows of 275 cfs were available for diversion to the Republican River Basin for eight months in a particular year, it would equal a reduction of nearly 133,000 acre-feet per year in Platte River flows.

Potential Impacts on the Platte River
Flows and Habitat Maintenance

According to Olsson Associates reports (2017, 2018), "excess flows" are defined in narrow legal terms, referring to "excess" as water simply not appropriated for human use. Olsson Associates (2017, appendix D, 35) states that "No losses are expected in the Platte River Basin because the diversion project would only be utilized in years when there were excess flows. . . . [A]bsent the Platte Republican Diversion project, this water otherwise would have flowed through the Platte River Basin and left the State of Nebraska." This sentiment has been reiterated by the general manager of the Tri-Basin NRD, who publicly stated that "We'd be taking otherwise 'wasted' water to be put to good use for a beneficial purpose" (*Omaha World-Herald* 2018). This attitude ignores the vital contribution of high flows to river habitat and groundwater recharge. Although peak flows in 2015 were notable within the last decade, historically they were not aberrant, and helped structure the fluvial geomorphology and ecology of the Platte River (Fig. 2; Henszey and Wesche 1993; Johnson 1994; Ward and Stanford 1995). For example, braided rivers with submerged and exposed sandbars, on which the federally threatened piping plover, and the endangered interior least terns nest, result from these wide hydrological

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

fluctuations (Smith 1971; Alexander et al. 2018). Hydrologic variability is a primary driver of riverine ecosystems because it structures biotic diversity and chemical composition, determines temperature regimes, mediates the exchange of organic and inorganic material, transports energy, and dictates habitat conditions in the river and floodplain (Poff and Ward 1989; Ward and Stanford 1995; Strange et al. 1999). Flood events increase biological productivity, including improving fisheries (Junk et al. 1989). The importance of flooding events and streamflow variation is recognized globally, with some restoration efforts focusing on recreating flood pulse events to restore ecological processes to degraded river systems (Robinson 2012; Wohl et al. 2015).

Historically, the Platte River's natural hydrograph was characterized by robust spring flows followed by a natural decline in the summer (Fig. 2; Williams 1978). Retaining water for use in summer months when water availability is naturally limited was one of the primary historic reasons for dam construction on the Platte. During high water events, such as in 2015, the riverbanks are scoured of vegetation and eroded, and sandbars accumulate within the channels of the Platte River. Retaining the ability for the Platte River to produce large scouring floods is important, because large late winter and early spring floods are the most effective at removing woody vegetation from river sandbars (Williams 1978; Johnson 1994; Poff et al. 1997). Prolonged periods of low flow without high water events can result in sandbar stabilization via the establishment of early successional woody vegetation, an increasingly common occurrence resultant from greater water appropriation and reduced river flows in recent decades (Williams 1978; Currier 1982, 1997; Johnson 1994). Widespread sandbar stabilization has changed the character of the Platte River, transforming the iconic and characteristically wide and shallow braided prairie river into a more sinuous, incised, and narrow wooded river with deeper channels during periods of high flow (Williams 1978; Eschner et al. 1981; Johnson 1994; Currier 1997; Horn et al. 2012). In the last century, concurrent with reductions in Platte River flows, active channel area has been reduced by over 90% in portions of the Central Platte River Valley (Williams 1978; Sidle et al. 1989). This has consequential impacts for wildlife including whooping cranes, interior least terns, and sandhill cranes (*Antigone canadensis*), which prefer wide shallow-river channels with long unobstructed view widths and sandbar habitats free of vegetation (Lingle et al. 1991; Faanes et al. 1992; Faanes and Le Valley 1993; Kirsch 1996; Currier 1997; Kinzel et al. 2009; Pearse et al. 2017). As Faanes and Bowman (1992) note, periodic high flows exceeding 8,000 cfs are essential for the maintenance of whooping crane roosting habitat in the Central Platte River Valley. Farnsworth et al. (2018) found that the mean daily volume of the 40-day peak flow was the best hydrological predictor of annual total unobstructed channel width in the Central Platte River Valley.

Rivers with relatively natural flow regimes provide a number of "ecological services" that benefit human communities, which can be valuated economically, such as sustainable fisheries and clean drinking water (Wilson and Carpenter 1999; Parker and Oates 2016). However, some of these benefits are more indirect and less obvious to the general public. As we have noted, early spring floods and sustained summer river flows are essential to maintaining sandhill crane habitat. Dority et al. (2017) estimated the spring sandhill crane migration produces a regional economic impact of 14.3 million dollars annually in the Central Platte River Valley. Large scouring floods also help control invasive species such as common reed (*Phragmites australis*) which cost over 3.5 million dollars to manage within the Central Platte River Valley from 2007 to 2011 (Rapp et al. 2012; Platte Valley Weed Management Area and West Central Weed Management Area 2013; Galatowitsch et al. 2016). Additionally, conservation organizations have dedicated substantial financial and human resources (estimated at over $300,000 USD [adjusted for 2017] annually, with low water years costing nearly $1,000,000 USD) toward disking the river channel to prevent vegetation encroachment and establishment within key sandhill crane and whooping crane roosting habitats, particularly during low flow years (Currier 1991; Pfeiffer and Currier 2005; Crane Trust and Rowe Sanctuary unpublished internal management records). Maintaining adequate flows throughout the growing season prevents the establishment of early successional vegetation within the riverbed, reducing the need for widespread intensive disking campaigns (Johnson 1994; Currier 1997).

Nebraska has always been subject to pronounced and cyclical drought (Hayes et al. 2005) and the overappropriation of the Platte River can have serious long-term consequences for the ecosystem during sustained dry periods. For example, fish kills resulted from portions of the Platte River drying during 13 years from 1974 to 1996 (Zuerlein et al. 2001). Median "active" channel

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

area decreased by 26% in the Central Platte River Valley during a sustained period of low flow between 1988 and 1994, reducing appropriate available roosting habitat for sandhill cranes and whooping cranes (Currier 1997). As canal diversions within the Platte River Basin have taken increasingly more water out of the river, the groundwater flow gradient has changed, so that the modern Platte River depends on groundwater in-flow during dry periods (Fig. 3). As a result of existing intrabasin diversions, the Platte River in the region of the proposed diversion has changed from a predominantly "flow-through" stream (little *net* transfer between groundwater and surface water) to a predominantly "gaining" stream (pers. comm., Erin M. K. Haacker, University of Nebraska–Lincoln). However, this phenomenon is seasonally variable; high flows provide recharge to groundwater, which then gradually flows back to the channel during drier periods. In summary, recurrent high spring flows are essential to maintaining the function and dynamism of the Central Platte River Valley ecosystem (Wesche et al. 1994; Zuerlein et al. 2001), especially given the already highly altered hydrological conditions (Williams 1978). Considering the in-stream flow requirements of the PRRIP and the US Fish and Wildlife Service, on 9 of 17 years (~53%) from 2000 to 2016 the Platte River would yield less than 2,000 acre-feet of water to the Republican River (Olsson Associates 2018, 4–5). More disconcerting is that recent decades represent a relatively wet period when considering the long history of the Great Plains and central Nebraska (Weakly 1965; Hayes et al. 2005). The Platte-Republican diversion project could potentially impact the water-vulnerable and already overburdened Platte River ecosystem while yielding limited water to the Republican Basin in most years. It appears clear to us that the ecological needs of the Platte River ecosystem, and the endangered species therein, have not been adequately addressed by the Platte-Republican diversion planning process.

The Olsson Associates (2018) report broadly fails to address issues of maintaining in-stream flows for endangered species habitat and ecosystem maintenance. If 275 cfs were regularly removed from the river system in the spring months from March through May, it would impact soil saturation, shallow groundwater levels, and therefore river flows in the summer months. Our calculations suggest that removing 275 cfs from the Platte River is equivalent to initiating over 150 wells pumping 800 gallons/minute. The application for variance (Olsson Associates 2017) addresses the timing of instream

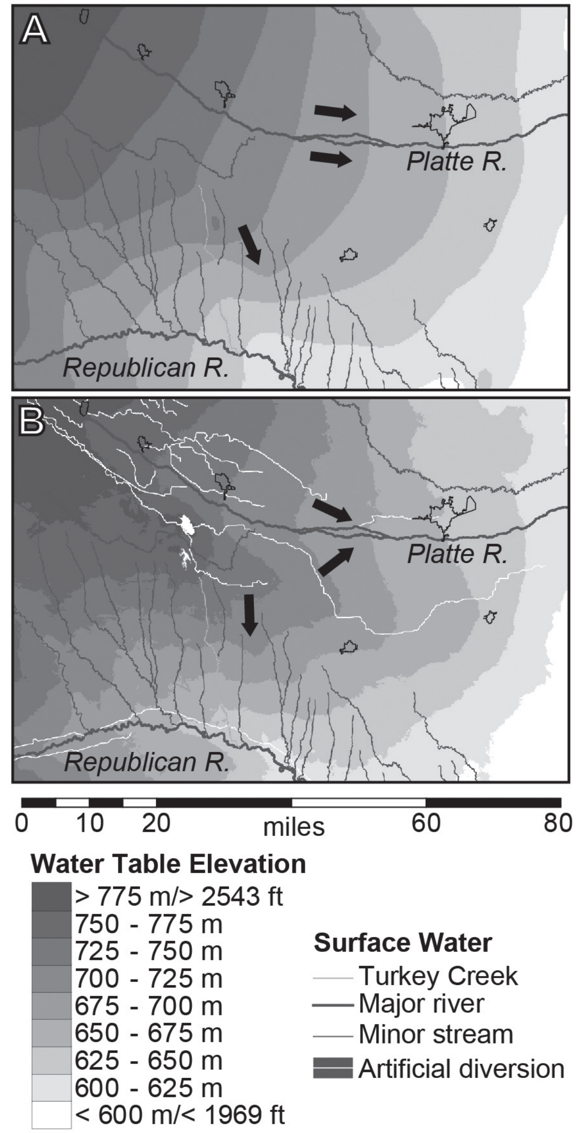

Fig. 3. Map of water table elevation in the portions of the Platte and Republican basins depicted in Figure 1. **A**. Estimated water table prior to significant intrabasin groundwater and surface-water diversions. **B**. Estimated water table in 2016. Water table elevation generated using methods from Haacker et al. (2016). Image courtesy of Erin M. K. Haacker.

flow removal to some degree by stating that water would not be removed from the Platte River between June and August. However, spring flows and summer flows are not independent of each other. The Platte River Valley is composed of relatively course alluvial sediments. Due to the permeable composition and lack of a hard clay layer, a large quantity of water flows through the hyporheic zone, where shallow groundwater freely mixes with channel water (i.e., much of the river's flow is technically below ground; Boulton et al. 1998). Early spring floods

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

replenish shallow groundwater (Ekstein and Hygnstrom 1996; Brunke and Gonser 1997; Chen 2007), which is vital for agricultural production in the Central Platte River Valley and sustains wet meadow habitats vital for a diversity of flora and fauna including a number of species of concern such as the whooping crane (Currier 1989; Wesche et al. 1994; Currier and Henszey 1996; Henszey et al. 2004; Thormodsgard 2009; Chávez-Ramírez and Weir 2010; Baasch et al. 2019). In-stream flows determine the saturation of shallow groundwater, contributing to groundwater stores during sustained periods of high flow (Brunke and Gonser 1997; Boulton et al. 1998).

Adverse Impacts

Olsson Associates 2018 (11) asserts that the potential "adverse impacts" for downstream ecosystems are "none"—a finding that does not consider the unique biology and hydrology of the Platte River ecosystem. Meeting the target flows of the Platte River Recovery Implementation Program is listed as the only known use of "unappropriated water." From an ecological perspective founded on scientific research, these in-stream flows represent an appropriation of water to meet the basic needs of wildlife, in particular, the needs of the whooping crane (Faanes and Bowman 1992; Pearse et al. 2017; Farnsworth et al. 2018). Strikingly, the only time wildlife is substantively discussed in the report is to describe the potential benefits to Turkey Creek, the Republican River, and Harlan County Reservoir, and in particular, the positive impact to fisheries (none of which contain federally threatened or endangered species). The Central Platte River, by contrast, is designated as a biologically unique landscape by the Nebraska Game and Parks Commission and sustains habitat for four federally listed species (Schneider et al. 2011). It is also home to 11 species considered "Tier-1 At-risk" by the Nebraska Game and Parks Commission, including several species dependent on quality riverine and wetland habitat such as the Platte River caddisfly (*Ironoquia plattensis*), the plains topminnow (*Fundulus sciadicus*), and the North American river otter (*Lontra canadensis*) (Schneider et al. 2011). New water is not created through a diversion and a large amount can be lost through inefficient artificial transportation systems such as canals, which also provide much less valuable wildlife habitat than natural rivers (Davies et al. 1992; Gupta and Van der Zaag 2008; Pittock et al. 2009). The Olsson Associates (2017, 2018) reports do not include an estimation of the amount of diverted water resources that would be lost in transport through evaporation or infiltration along the E-65 canal, while being stored in Elwood Reservoir, or while moving down Turkey Creek. It defies logic that a transfer of water from one basin to another will have a strong positive impact on the recipient without having any measurable negative impact on the donor basin.

Groundwater–Surface Water Connections

In response to the Colorado-Kansas-Nebraska Republican River Compact of 1943, the states of Colorado and Kansas had already begun regulating groundwater development along with surface water in the Republican River Basin (Popelka 2004). By contrast, Nebraska did not impose statewide regulations on groundwater well development until decades later, leaving regulation to the local Natural Resources Districts (Popelka 2004). From 1949 to 1992 the number of irrigated acres within the Nebraska portion of the Republican River Basin increased by an order of magnitude, from just over 90,000 to over 1 million, with the installation of over 10,000 individual groundwater wells (Popelka 2004). It was not until 1996 that Nebraska recognized the inherent connection between surface and groundwater for regulatory purposes with the passage of LB 108 and not until 2004 with the passage of LB 962 that groundwater development was restricted within watersheds designated as fully or over-appropriated (Popelka 2004; Ostdiek 2010). Despite improvements in the efficiency of water use via technological advancement, agricultural demand for groundwater in the Great Plains remains unsustainable (Smidt et al. 2016). New water management programs need to provide economic benefits for farmers to conserve water if we are to achieve a more sustainable future (Smidt et al. 2016). Hornbeck and Keskin (2014) note that farmers without access to groundwater have maintained agricultural practices that mitigate the impacts of drought that are not utilized in areas with long histories of groundwater access.

Though groundwater levels are relatively stable in the Northern High Plains, particularly in the Sandhills of Nebraska, at current rates of groundwater extraction the Central and Southern Plains may not be able to irrigate in as few as 20 to 30 years (Haacker et al. 2016). Fenichel et al. (2016) value the losses in natural capital associat-

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

ed with groundwater and aquifer depletion in Kansas from 1996 to 2005 at about $110 million USD. However, Butler et al. (2016) indicate that moderate reductions in groundwater extraction can markedly improve resource sustainability, which can contribute toward long-term economic growth (Golden and Guerrero 2017). The Republican River Basin is at risk of depleting its groundwater stores and the basin's NRDs could extend the life of their resources and improve their communities' long-term economic outlooks through targeted water conservation measures (Butler et al. 2016; Golden and Guerrero 2017). The Olsson Associates (2017, 2018) analyses do not place any economic value on long-term water storage and therefore critically overestimate the short-term cost of reducing surface water and groundwater appropriations in the Republican River Basin relative to potential the long-term benefits.

Transbasin Diversions

As Davies et al. (1992) notes, transbasin water transfers can have serious ecological consequences when not implemented thoughtfully, including exotic species invasions and altered hydrological regimes that negatively impact endemic biota while delivering limited water supplies. Davies et al. (1992) argues that transbasin diversion plans should include ecological impact monitoring plans to continually assess the influence of diversions on important biological resources, enabling rapid responses when significant impacts are detected. Gupta and Van der Zaag (2008) suggest five criteria to evaluate the plausibility of transbasin transfers: (1) there is an "objectively verifiable surplus in the donor basin" and "deficit in the receiving basin" in addition to an efficient mode of transfer for water resources; (2) the transfer scheme is sustainable economically, socially, and environmentally while being resilient to ecological and social stressors; (3) the proposal relies on "good governance" with inclusive, "participatory decision-making" and public accountability; (4) the design balances "rights" and "needs" at multiple relevant spatial scales, where no entity "will be worse off because of the project" and mechanisms exist to make compensation if negative impacts arise; (5) the plan is based on sound "hydrological, ecological, and socioeconomic research" that effectively considers risk, gaps in knowledge, uncertainty, and "has considered all possible alternative measures" to meet water needs.

We contend that the proposed Platte-Republican diversion project fails to satisfy the above criterion in almost every respect. First, the basin of origin is designated overappropriated. Secondly, it is unclear if the transfer scheme is resilient to environmental stressors. Third, the decision-making process did not actively engage major environmental and agricultural interests in the Central Platte River Valley. Fourth, there is no scheme to compensate downstream interests in the case that negative impacts arise. Fifth, the project plan does not adequately address the dynamic needs of the biologically important and ecologically fragile Platte River Basin. The plan also fails to include any ecological impact monitoring or fully consider all alternatives. The Olsson Associates (2017) "feasibility review" only considered the economic implications of two alternative means to comply with the Republican River Compact. These include leasing surface water from irrigation districts in the Republican River Basin and pumping water through the Nebraska Cooperative Republican Platte Enhancement (N-CORPE) project, both of which demonstrate a higher cost per acre-foot than the proposed Platte-Republican diversion project by Olsson Associates (2017) estimate (see N-COPRE 2013 for project description). Although not designated as such, significant evidence exists that the Republican River Basin may be overappropriated in part as a result of Nebraska's tardy recognition of the interconnectedness of surface water and groundwater (Popelka 2004). The Olsson Associates (2017, 2018) reports fail to include strategically retiring a portion of junior groundwater wells in the least productive irrigated regions of the Republican River Basin through collaborative approaches with landowners, or providing incentives for and in cooperation with water users to reduce consumption, as available options. Water augmentation from the Platte to the Republican is a temporary solution to a more substantive issue of water security, and the Platte-Republican diversion project is likely treating the symptoms rather than the cause. Emanuel et al. (2015) suggests that donor basins often suffer from the same hydroclimatological pressures limiting water availability in receiving basins, thereby limiting their effectiveness in offsetting water shortages.

Conclusions

Benjamin Franklin said, "When the well is dry we know the value of water" (Franklin 1773 as cited in Hayes et

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

al. 2005). Potentially a precedent-setting event, this project would be the first formal transbasin diversion in Nebraska history. An apple is eaten one bite at a time; it can appear as though we are taking a moderate portion, but the Platte River has already been predominantly consumed and overappropriated. Additional diversions to the Platte River, or other river systems in the state, could increase stress on already highly manipulated river systems and floodplains, further reducing their natural dynamism and ecological integrity (Poff et al. 1997). Scientist and explorer John Wesley Powell once suggested that the political boundaries of the western United States should be organized by watersheds, because these boundaries delineated the most critical natural resources for communities in the arid west (*NPR News* 2003). Beyond the implications of this specific project, our stance on this issue is that the precedent set by the proposed transbasin diversion could have far-reaching consequences for the Platte River ecosystem and other river systems in Nebraska for years to come. In this era of drastic human-driven environmental change, decision-making frameworks that consider the resilience of our integrated social and ecological communities may improve outcomes for all (Birgé et al. 2018). We recognize the necessity to adhere to the compact and understand the complexity of finding solutions, but we argue that this proposed project and its associated planning reports do not address or consider the hydrological, biological, or water-management repercussions of such an undertaking. We also contend that if this plan is to move forward, the Platte-Republican diversion project needs a serious ecological impact monitoring plan to allow for a rapid response to the needs of species of concern in the basin of origin. We argue that any proposed transbasin diversion project in Nebraska should undergo a comprehensive and public assessment considering the complexities and vulnerabilities of the ecosystem, the long-term sustainability of our water-use practices, and the needs of our communities.

Andrew J. Caven (acaven@cranetrust.org, 605-252-8007), Platte River Whooping Crane Maintenance Trust (Crane Trust), 6611 West Whooping Crane Drive, Wood River, NE 68883

Emma M. Brinley Buckley, Department of Communication, 2504 9th Avenue, University of Nebraska at Kearney, Kearney, NE 68849

Joshua D. Wiese, Platte River Whooping Crane Maintenance Trust (Crane Trust), 6611 West Whooping Crane Drive, Wood River, NE 68883

Bill Taddicken, Audubon Rowe Sanctuary, 44450 Elm Island Road, Gibbon, NE 68440

Brice Krohn, Platte River Whooping Crane Maintenance Trust (Crane Trust), 6611 West Whooping Crane Drive, Wood River, NE 68883

Timothy J. Smith, Platte River Whooping Crane Maintenance Trust (Crane Trust), 6611 West Whooping Crane Drive, Wood River, NE 68883

Andrew Pierson, Audubon Rowe Sanctuary, 44450 Elm Island Road, Gibbon, NE 68440

Acknowledgments

Thank you to Dr. Erin M. K. Hacker and Chuck Cooper for providing friendly reviews of this manuscript as well as Jason M. Farnsworth for providing up-to-date information regarding the Platte River Recovery Implementation Program's water conservation efforts. Thank you also to the readers for taking the time to consider our reflections on the proposed Platte-Republican transbasin diversion plan. Your participation in the stewardship of our natural resources is invaluable.

References

Alexander, J. S., J. G. Jorgensen, and M. B. Brown. 2018. "Reproductive Ecology of Interior Least Tern and Piping Plover in Relation to Platte River Hydrology and Sandbar Dynamics." *Ecology and Evolution* 8 (11): 5674–79.

Anderson, R. C. 2006. "Evolution and Origin of the Central Grassland of North America: Climate, Fire, and Mammalian Grazers." *Journal of the Torrey Botanical Society* 133 (4): 626–47.

Baasch, D. M., P. D. Farrell, A. T. Pearse, D. A. Brandt, A. J. Caven, M. J. Harner, G. D. Wright, and K. L. Metzger. 2019. "Diurnal Habitat Selection of Migrating Whooping Cranes in the Great Plains." *Avian Conservation and Ecology* 14 (1): 6.

Birgé, H. E., C. R. Allen, R. K. Craig, and D. Twidwell. 2018. "Resilience and Law in the Platte River Basin Social-Ecological System: Past, Present, and Future." In *Practical Panarchy for Adaptive Water Governance*, ed. B. Consens and L. Gunderson, 115–30. Basel, Switzerland: Springer International Publishing.

Boulton, A. J., S. Findlay, P. Marmonier, E. H. Stanley, and H. M. Valett. 1998. "The Functional Significance of the Hyporheic Zone in Streams and Rivers." *Annual Review of Ecology and Systematics* 29 (1): 59–81

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

Brunke, M., and T. Gonser. 1997. "The Ecological Significance of Exchange Processes between Rivers and Groundwater." *Freshwater Biology* 37 (1): 1–33.

Butler, J. J., D. O. Whittemore, B. B. Wilson, and G. C. Bohling. 2016. "A New Approach for Assessing the Future of Aquifers Supporting Irrigated Agriculture." *Geophysical Research Letters* 43 (5): 2004–10.

Central Platte NRD (Natural Resources District) and NE DNR (Nebraska Department of Natural Resources). 2012. "Integrated Management Plan." Grand Island and Lincoln, NE, May 21.

Chávez-Ramírez, F., and E. Weir. 2010. "Wet Meadow Literature and Information Review." Technical Report, Platte River Recovery Implementation Program, Kearney, NE, 42 pp.

Chen, X. 2007. "Hydrologic Connections of a Stream-Aquifer-Vegetation Zone in South-Central Platte River Valley, Nebraska." *Journal of Hydrology* 333 (2–4): 554–68.

CNPPD (Central Nebraska Public Power and Irrigation District). 2018. "Application A-19594; NE DNR Form APA-001. Updated 2008. Application for a Permit to Appropriate Water; NE DNR SW Form 400. Updated 2011. Interbasin Transfer of Water Addendum to Application for a Permit to Appropriate Water." Holdrege, NE, July 3.

Currier, P. J. 1982. "The Floodplain Vegetation of the Platte River: Phytosociology, Forest Development, and Seedling Establishment." PhD diss., Iowa State University, Ames.

Currier, P. J. 1989. "Plant Species Composition and Groundwater Levels in a Platte River Wet Meadow." *Proceedings of the North American Prairie Conference* 11:19–24.

Currier, P. J. 1991. "Reclamation of Crane Roosting Habitat on the Platte River and Restoration of Riverine Wetlands." In *Proceedings of the 1987 International Crane Workshop, Qiqihar, Heilongjiang Province, China*, ed. J. T. Harris, 403–7. Baraboo, WI: International Crane Foundation.

Currier, P. J. 1997. "Woody Vegetation Expansion and Continuing Declines in Open Channel Habitat on the Platte River in Nebraska." *Proceedings of the North American Crane Workshop* 7:141–52.

Currier, P. J., and R. J. Henszey. 1996. "Platte River Wet Meadows: A Primer on their Flora, Fauna, Hydrology, Management, and Restoration." Technical Report, US Fish and Wildlife Service (Project No. 14-16-0006-90-917), Grand Island, NE.

Dappen, P. R., I. C. Ratcliffe, C. R. Robbins, and J. W. Merchant. 2008. "Mapping Agricultural Land Cover for Hydrologic Modeling in the Platte River Watershed of Nebraska." *Great Plains Research* 18 (1): 39–52.

Davies, B. R., M. Thoms, and M. Meador. 1992. "An Assessment of the Ecological Impacts of Inter-Basin Water Transfers, and their Threats to River Basin Integrity and Conservation." *Aquatic Conservation: Marine and Freshwater Ecosystems* 2 (4): 325–49.

Davis, C. A., J. E. Austin, and D. A. Buhl. 2006. "Factors Influencing Soil Invertebrate Communities in Riparian Grasslands of the Central Platte River Floodplain." *Wetlands* 26: 438–54.

Dority, B. R., R. Thompson, S. Kaskie, and L. Tschauner. 2017. "The Economic Impact of the Annual Crane Migration on Central Nebraska." Technical Report, College of Business and Technology, University of Nebraska–Kearney, Kearney, NE.

Eschner, T. R., Hadley, R. F. and Crowley, K. D. 1981. "Hydrologic and Morphologic Changes in Channels of the Platte River Basin; A Historical Perspective." US Geological Survey Open-File Report No. 81-1125.

Eisel, L., and D. Aiken. 1997. "Platte River Basin Study, Report to the Western Water Policy Review Advisory Committee." University of Nebraska–Lincoln Faculty Publications: Agricultural Economics, No. 25.

Ekstein, J. D., and S. E. Hygnstrom. 1996. "Fate of Wetlands Associated with the Central Nebraska Irrigation Canal System." *Great Plains Research* 6 (1): 41–60.

Emanuel, R. E., J. J. Buckley, P. V. Caldwell, S. G. McNulty, and G. Sun. 2015. "Influence of Basin Characteristics on the Effectiveness and Downstream Reach of Interbasin Water Transfers: Displacing a Problem." *Environmental Research Letters* 10 (12): 124005.

Faanes, C. A., and D. B. Bowman. 1992. "Relationship of Channel Maintenance Flows to Whooping Crane Use of the Platte River." *Proceedings of the North American Crane Workshop* 6:111–16.

Faanes, C. A., and M. J. Le Valley. 1993. "Is the distribution of Sandhill Cranes on the Platte River Changing?" *Great Plains Research* 3(2): 297–304.

Faanes, C. A., G. R. Lingle, and D. H. Johnson. 1992. "Characteristics of Whooping Crane Roost Sites in the Platte River." *Proceedings of the North American Crane Workshop* 6:90–94.

Farnsworth, J. M., D. M. Baasch, P. D. Farrell, C. B. Smith, and K. L. Werbylo. 2018. "Investigating Whooping Crane Habitat in Relation to Hydrology, Channel Morphology and a Water-Centric Management Strategy on the Central Platte River, Nebraska." *Heliyon* 4(10): e00851.

Fassnacht, S. R., N. B. Venable, D. McGrath, and G. G. Patterson. 2018. "Sub-Seasonal Snowpack Trends in the Rocky Mountain National Park Area, Colorado, USA." *Water* 10 (5): 562.

Fenichel, E. P., J. K. Abbott, J. Bayham, W. Boone, E. M. Haacker, and L. Pfeiffer. 2016. "Measuring the Value of Groundwater and Other Forms of Natural Capital." *Proceedings of the National Academy of Sciences* 113 (9): 2382–87.

Franklin, B. 1773. *The Autobiography of Benjamin Franklin*. London: J. Parsons.

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

Galatowitsch, S. M., D. L. Larson, and J. L. Larson. 2016. "Factors Affecting Post-Control Reinvasion by Seed of an Invasive Species, *Phragmites australis*, in the Central Platte River, Nebraska." *Biological Invasions* 18 (9): 2505–16.

Golden, B., and B. Guerrero. 2017. "The Economics of Local Enhanced Management Areas in Southwest Kansas." *Journal of Contemporary Water Research and Education* 162 (1): 100–111.

Guanter, L., Y. Zhang, M. Jung, J. Joiner, M. Voigt, M., J. A. Berry, C. Frankenberg, A. R. Huete, P. Zarco-Tejada, J. Lee, M. S. Moran, G. Ponce-Campos, C. Beer, G. Camps-Valls, N. Buchmann, D. Gianelle, K. Klumpp, A Cescatti, J. M. Baker, and T. J. Griffis. 2014. "Global and Time-Resolved Monitoring of Crop Photosynthesis with Chlorophyll Fluorescence." *Proceedings of the National Academy of Sciences* 111: e1327–e1333.

Gupta, J., and P. Van der Zaag. 2008. "Interbasin Water Transfers and Integrated Water Resources Management: Where Engineering, Science and Politics Interlock." *Physics and Chemistry of the Earth* 33 (1): 28–40.

Haacker, E. M., A. D. Kendall, and D. W. Hyndman. 2016. "Water Level Declines in the High Plains Aquifer: Predevelopment to Resource Senescence." *Groundwater* 54(2):231–242.

Hayes, M. J., C. L. Knutson, and Q. S. Hu. 2005. "Multiple-Year Droughts in Nebraska." University of Nebraska–Lincoln, Drought Mitigation Center Faculty Publications, No. 3.

Henszey, R. J., and T. A. Wesche. 1993. "Hydrologic Components Influencing the Condition of Wet Meadows along the Central Platte River, Nebraska." Technical Report, Nebraska Game and Parks Commission, Lincoln, NE.

Henszey, R. J., K. Pfeiffer, and J. R. Keough. 2004. "Linking Surface- and Ground-Water Levels to Riparian Grassland Species along the Platte River in Central Nebraska, USA." *Wetlands* 24 (3): 665–87.

Horn, J. D., R. M. Joeckel, and C. R. Fielding. 2012. "Progressive Abandonment and Planform Changes of the Central Platte River in Nebraska, Central USA, Over Historical Timeframes." *Geomorphology* 139:372–83.

Hornbeck, R., and P. Keskin. 2014. "The Historically Evolving Impact of the Ogallala Aquifer: Agricultural Adaptation to Groundwater and Drought." *American Economic Journal: Applied Economics* 6 (1): 190–219.

Johnson, W. C. 1994. "Woodland Expansions in the Platte River, Nebraska: Patterns and Causes." *Ecological Monographs* 64 (1): 45–84.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. "The Flood Pulse Concept in River-Floodplain Systems." *Canadian Special Publication of Fisheries and Aquatic Sciences* 106 (1): 110–27.

Kinzel, P. J., J. M. Nelson, and A. K. Heckman. 2009. "Response of Sandhill Crane (*Grus canadensis*) Riverine Roosting Habitat to Changes in Stage and Sandbar Morphology." *River Research and Applications* 25 (2): 135–52.

Kirsch, E. M. 1996. "Habitat Selection and Productivity of Least Terns on the Lower Platte River, Nebraska." *Wildlife Monographs* 132:3–48.

Krapu, G. L., D. A. Brandt, and R. R. Cox Jr. 2005. "Do Arctic-Nesting Geese Compete with Sandhill Cranes for Waste Corn in the Central Platte River Valley, Nebraska?" *Proceedings of the North American Crane Workshop* 9:185–91.

LaGrange, T. G. 2005. "A Guide to Nebraska's Wetlands and their Conservation Needs." Nebraska Game and Parks Commission, Lincoln.

Lingle, G. R., G. A. Wingfield, and J. W. Ziewitz. 1991. "The Migration Ecology of Whooping Cranes in Nebraska, USA." In *Proceedings of the 1987 International Crane Workshop, Qiqihar, Heilongjiang Province, China*, ed. J. T. Harris, 395–401. Baraboo, WI: International Crane Foundation.

National Research Council. 2005. *Endangered and Threatened Species of the Platte River*. Washington DC: National Academies Press.

N-CORPE (Nebraska Cooperative Republican Platte Enhancement Project). 2013. "Interlocal Cooperation Agreement." Upper Republican, Middle Republican, Lower Republican, and Twin Platte Natural Resources Districts. Imperial, Curtis, Alma, and North Platte, NE, December 17.

Nebraska Department of Agriculture. 2015. Nebraska Ag Facts Brochure. Nebraska Department of Agriculture, Lincoln. http://www.nda.nebraska.gov/publications/ne_ag_facts_brochure.pdf.

NE DNR (Nebraska Department of Natural Resources). 2017. 2018 Annual Review of Availability of Hydrologically Connected Water Supplies. Lincoln, NE, December 29. https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/statewide/FAB/2018AnnualReport/20171229_FAB_Final.pdf.

NPR News. 2003. "The Vision of John Wesley Powell: Explorer Foresaw the Water Issues that would Plague the West." National Public Radio, August 26. https://www.npr.org/programs/atc/features/2003/aug/water/part1.html.

Olsson Associates. 2018. "Platte Republican Diversion: Application for Variance and a Copy of the Interbasin Transfer Permit Application." Prepared for Central Nebraska Public Power and Irrigation District, Holdrege, NE, March 1.

Olsson Associates. 2017. "Platte Republican Diversion Project Feasibility Review." Prepared for the Lower Republican and Tri-Basin Natural Resources Districts, Alma and Holdrege, NE, February. Olsson Project No. 016-1500.

Omaha World-Herald. 2018. "Platte River Diversions to Republican River Would Be Nebraska's First." March 7. https://www.omaha.com/news/nebraska/platte-river-diversion- to-republican-river-would-be-nebraska-s/article_6a64d1d3-efa5-5520-b463-23c96f7b2e2f.html.

Ostdiek, A. 2010. "Stream Depletion and Groundwater Pumping, pt. 1: The Groundwater Balance." *Water Matters*, Nebraska Department of Natural Resources, No. 4. https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/water-matters/WaterMatters_No4.pdf.

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

Parker, H., and N. Oates. 2016. "How Do Healthy Rivers Benefit Society? A Review of the Evidence." London: Overseas Development Institute and World Wildlife Fund.

Pearse, A. T., M. J. Harner, D. M. Baasch, G. D. Wright, A. J. Caven, and K. L. Metzger. 2017. "Evaluation of Nocturnal Roost and Diurnal Sites Used by Whooping Cranes in the Great Plains, USA." US Geological Survey Open-File Report 2016-1209.

Pfeiffer, K., and P. J. Currier. 2005. "An Adaptive Approach to River Channel Management on the Platte River in Central Nebraska." *Proceedings of the North American Crane Workshop* 9:151–54.

Pittock, J., J. Meng, M. Geiger, and A. K. Chapagain. 2009. "Interbasin Water Transfers and Water Scarcity in a Changing World—A Solution or a Pipedream?" Frankfurt, Germany: World Wildlife Fund.

Platte Valley Weed Management Area and West Central Weed Management Area. 2013. "Platte Valley and West Central Weed Management Area's Invasive Species Control in the Central Platte River 2008–2013 Summary." Kearney and North Platte, NE, http://www.plattevalleywma.org/Documents/08-11summary.pdf.

Poff, N. L., and J. V. Ward. 1989. "Implications of Streamflow Variability and Predictability for Lotic Community Structure: A Regional Analysis of Streamflow Patterns." *Canadian Journal of Fisheries and Aquatic Sciences* 46 (10): 1805–18.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. "The Natural Flow Regime." *BioScience* 47 (11): 769–84.

Popelka, A. M. 2004. "The Republican River Dispute: An Analysis of the Parties' Compact Interpretation and Final Settlement Stipulation." *Nebraska Law Review* 83:596.

PRRIP (Platte River Recovery and Implementation Program). 2006. "Final Platte River Recovery Implementation Program." Nebraska Department of Natural Resources, Lincoln, October 24. https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/upper-platte/platte-river-recovery-implementation-program/implementation-program.pdf.

Rapp, R. E., A. Datta, S. Irmak, T. J. Arkebauer, and S. Z. Knezevic. 2012. "Integrated Management of Common Reed (*Phragmites australis*) along the Platte River in Nebraska." *Weed Technology* 26 (2): 326–33.

Robinson, C. T. 2012. "Long-Term Changes in Community Assembly, Resistance, and Resilience Following Experimental Floods." *Ecological Applications* 22:1949–61.

Scanlon, B. R., C. C. Faunt, L. Longuevergne, R. C. Reedy, W. M. Alley, V. L. McGuire, and P. B. McMahon. 2012. "Groundwater Depletion and Sustainability of Irrigation in the US High Plains and Central Valley." *Proceedings of the National Academy of Sciences* 109 (24): 9320–25.

Schneider, R., K. Stoner, G. Steinauer, M. Panella, and M. Humpert, eds. 2011. "The Nebraska Natural Legacy Project: State Wildlife Action Plan," 2nd ed. Lincoln: Nebraska Game and Parks Commission.

Sidle, J. G., E. D. Miller, and P. J. Currier. 1989. "Changing Habitats in the Platte River Valley of Nebraska." *Prairie Naturalist* 21 (2): 91–104.

Smidt, S. J., E. M. K. Haacker, D. A. Kendall, J. M. Deines, L. Pei, K. A. Cotterman, H. Li, X. Liu, B. Basso, and D.W. Hyndman. 2016. "Complex Water Management in Modern Agriculture: Trends in the Water-Energy-Food Nexus over the High Plains Aquifer." *Science of the Total Environment* 566:988–1001.

Smith, C. B. 2011. "Adaptive Management on the Central Platte River—Science, Engineering, and Decision Analysis to Assist in the Recovery of Four Species." *Journal of Environmental Management* 92 (5): 1414–19.

Smith, N. D. 1971. "Transverse Bars and Braiding in the Lower Platte River, Nebraska." *Geological Society of America Bulletin* 82(12):3407–3420.

Strange, E. M., K. D. Fausch, and A. P. Covich. 1999. "Sustaining Ecosystem Services in Human-Dominated Watersheds: Biohydrology and Ecosystem Processes in the South Platte River Basin." *Environmental Management* 24 (1): 39–54.

Thormodsgard, J. M. 2009. "Greater Platte River Basins—Science to Sustain Ecosystems and Communities." US Geological Survey Fact Sheet 2009–3097.

US Supreme Court. 2015. State of Kansas v. States of Nebraska and Colorado on Exceptions to Report to Special Master. Case No. 574.

VanDerwalker, J. G. 1982. "The Platte River Whooping Crane Critical Habitat Maintenance Trust." In *Proceedings of the 1981 Crane Workshop, Grand Tetons National Park, WY*, ed. J. C. Lewis, 4–6. Tavernier, FL: National Audubon Society.

Vivian, L. A., M. Cavallaro, K. Kneeland, E. Lindroth, W. W. Hoback, K. M. Farnsworth-Hoback, R. R. Harms, and J. E. Foster. 2013. "Current Known Range of the Platte River Caddisfly, *Ironoquia plattensis*, and Genetic Variability among Populations from Three Nebraska Rivers." *Journal of Insect Conservation* 17 (5): 885–95.

Vörösmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich., P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. R. Liermann, and P. M. Davies. 2010. "Global Threats to Human Water Security and River Biodiversity." *Nature* 467 (7315): 555.

Ward, J. V., and J. A. Stanford. 1995. "Ecological Connectivity in Alluvial River Ecosystems and Its Disruption by Flow Regulation." *Regulated Rivers: Research and Management* 11 (1): 105–19.

Weakly, H. E. 1965. "Recurrence of Drought in the Great Plains during the Last 700 Years." *Agricultural Engineering* 46:85.

Wesche, T. A., O. D. Skinner, and R. J. Henszey. 1994. "Platte River Wetland Hydrology Study." Final report, US Bureau of Reclamation and Wyoming Water Resources Center, University of Wyoming, Laramie.

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln

Williams, G. P. 1978. "The Case of the Shrinking Channels: The North Platte and Platte Rivers in Nebraska." Circulars of the United States Geological Survey. No. 781.

Wilson, M. A., and S. R. Carpenter. 1999. "Economic Valuation of Freshwater Ecosystem Services in the United States: 1971–1997." *Ecological Applications* 9 (3): 772–83.

Wohl, E., S. N. Lane, and, A. C. Wilcox. 2015. "The Science and Practice of River Restoration." *Water Resources Research* 51:5974–97.

Zuerlein, E. J., J. L. Hutchinson, S. Schainost, and R. Lock, R. 2001. "Instream Flow Rights for the Platte River—A Major Tributary of the Missouri River." In *Proceedings of the 11th Platte River Basin Ecosystem Symposium, Kearney, NE*, ed. G. Lingle. Lincoln: University of Nebraska–Lincoln.

© 2019 Center for Great Plains Studies, University of Nebraska– Lincoln