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ENVIRONMENTAL CONDITIONS, IRRIGATION REUSE PITS, AND THE NEED FOR RESTORATION IN THE RAINWATER BASIN WETLAND COMPLEX, NEBRASKA

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1. INTRODUCTION

Many of the processes of social and economic change in rural areas of America in the last century have had significant negative environmental impacts (Woods, 2005). The conversion of native grasslands and woodlands to farmland is a phenomenon that has been observed the world over (Foley *et al*., 2005). The growing demands of agriculture have transformed land cover at a global scale (Goudie, 2006). It is estimated that, globally, grasslands have lost approximately 19.4 million sq km from their pre-agricultural extent. According to Goldewijk (2001), in the past 300 years, areas of cropland and pasture have increased by around five to six fold. The loss of wetlands on a global scale is cause for serious concern. Wetlands cover about 6 percent of the earth's surface, even though they tend to occur in relatively small and often geographically isolated patches. However they also are responsible for about one quarter of the Earth's net primary productivity, and provide crucial wintering, breeding, and refuge areas for wildlife (Goudie, 2006). With these facts in mind, it becomes even more alarming that the world has lost up to 50 percent of its wetlands since 1900; the United States alone has lost approximately 54 percent of its native wetland habitat, mostly through the conversion to farmland (Goudie, 2006).

Wetlands within the Rainwater Basin region of south-central Nebraska exemplify agricultural conversion of natural areas. This region once contained over 11,000 individual permanent/semipermanent playas, covering approximately 80,900 to 121,400 ha (Bishop and Vrtiska, 2008). Those numbers have been reduced over 90 percent from their original extent, with about 400 remaining wetland basins (Gersib, 1992).

The Rainwater Basin serves as crucial habitat and is recognized as the focal point of the Central Flyway during spring waterfowl migration. Annually, an estimated 12.4 million waterfowl use this region during spring/fall migrations. This includes approximately 90 percent of the continental population of greater white-fronted geese, 50 percent of mid-continent mallards, and approximately 30 percent of the breeding population of northern pintails. Increasing numbers of snow geese also are utilizing wetlands in the region each year (NRCS, 2008). In addition to providing critical migratory waterfowl habitat, the wetlands contribute to improving water quality, and recharge of the Ogallala Aquifer (Wood and Osterkamp, 1984; Mullican *et al.*, 1994; and Smith, 2003).

In 1992, the Rainwater Basin Joint Venture (RWBJV) was formed to address habitat loss in the region. The RWBJV is a partnership of federal, state, local, and private entities dedicated to the enhancement and restoration of wetlands. Partner organizations include the Nebraska Game and Parks Commission, US Fish and Wildlife Service, Natural Resources Conservation Service, Ducks Unlimited, Pheasants Forever, the Nature Conservancy, local governments, landowners, and others. The purpose of this paper is to review the importance of the Rainwater Basin, historic landscape alterations that have occurred there, and actions that may improve the quality and extent of playa wetland habitat.

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2. STUDY AREA

The Rainwater Basin Wetland Complex covers approximately 15928 km^2 adjacent to and south of the Platte River (Figure 1) covering parts, or all of 21 counties in south-central Nebraska (Bishop *et al.,* 2008). Due to the large size and geographic location of the study area, a typical central US east-to-west precipitation gradient is present, with the eastern portion approaching almost 762 mm of annual precipitation, and the western portion averaging approximately 508 mm of precipitation (Bishop *et al*., 2004). The area was identified by Condra (1939) as the Loess Plains Region of Nebraska based on the prominence of loess soils. Due to the thick, highly impervious clay pan in these soils, the Rainwater Basin wetlands pond water, in large part isolating the pooled seasonal surface water in the wetlands from the underlying aquifer. The region is characterized by gradually rolling topography. Wetlands are most commonly found in depressions occupying the higher portions of the landscape, typically between drainages. These wetland depressions fill seasonally in response to heavy precipitation events or late winter/early spring snowmelt.

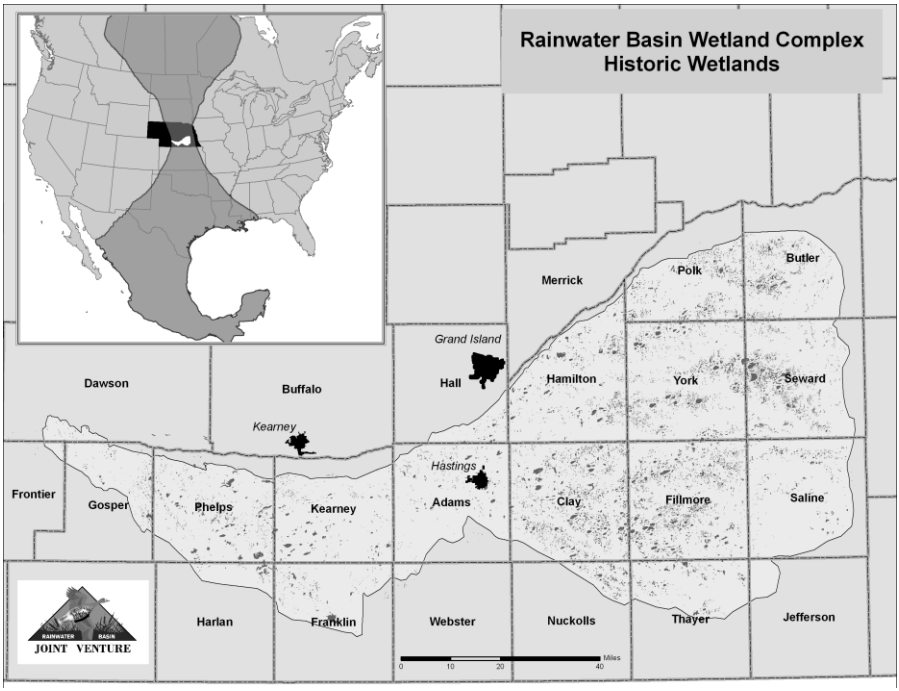

FIGURE 1
NEBRASKA'S RAINWATER BASIN
Source: Rainwater Basin Joint Venture

Agriculture constitutes the predominant land use throughout the area. This has had a variety of effects upon the landscape, including considerable drainage of wetlands. The once native grassland has, in large part, been extensively transformed to production of crops such as corn, and soybeans. Within the Rainwater Basin itself, more than 80 percent is cropland, and more than 60 percent of that cropland is irrigated (Bishop, 2004). The drainage of the basins has occurred in two primary phases. The first took place around the time of first settlement, and was marked by road construction, and the installation of ditches, drains, and drainage tunnels.

The second major period of drainage occurred in the 1970s and was characterized by the large scale loss of wetlands due to land leveling and the continued installation of drainage pits.

3. ENVIRONMENTAL MODIFICATIONS

The most dramatic alteration of the wetlands was the large scale drainage of basins around the time of first settlement, thus enabling the development of farming, and eventually large scale agricultural operations. Related infrastructure, including roads, utilities, irrigation networks, and irrigation reuse pits (tailwater recovery pits) have all had profound negative impacts on the functioning of the wetlands, as well as the surrounding landscape and hydrologic conditions. Bishop *et al.* (2008) noted that the large number of hydrologic modifications, including irrigation reuse pits, have had the single largest negative influence upon the functioning of wetlands. Figure 2 shows an irrigation reuse pit adjacent to a wetland; Figure 3 depicts an unaltered playa wetland within the Rainwater Basin region (center pivot irrigation in the background).

FIGURE 2
MAN-MADE IRRIGATION REUSE PIT
(Photo: J. Harrington, Jr., March 2009)

FIGURE 3
FUNCTIONING WETLAND
(Photo: J. Harrington, Jr., March 2009)

Nebraska has more irrigated area than any other state (Johnson, 2009). Agriculture, particularly irrigated crop farming, is the predominant land use throughout the Rainwater Basin of south-central Nebraska; the regional dependency on irrigation is evident in Figure 4. The human-altered agricultural landscape affects migratory waterfowl populations that rely upon this critical habitat.

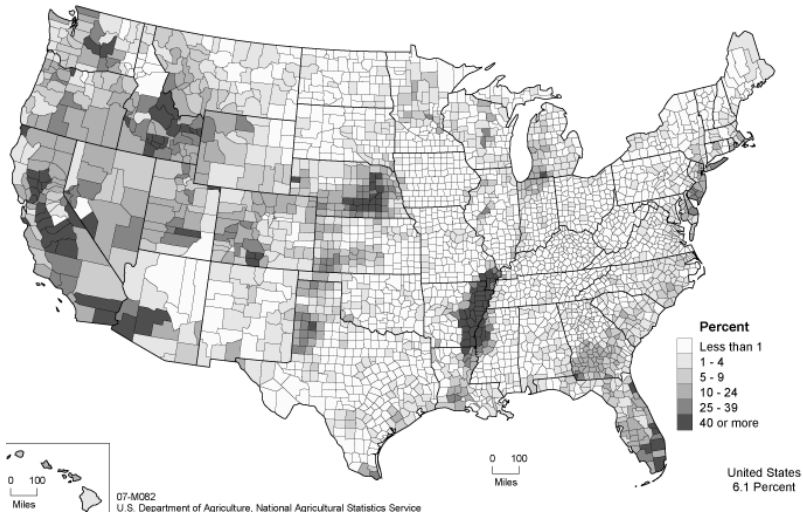

FIGURE 4
IRRIGATED AREA AS PERCENT OF TOTAL FARMLAND (49 STATES)
Source: Excerpt from Census of Agriculture 2007

A recent RWBJV analysis found that over 70 percent, or almost 1.1 million ha, of the Rainwater Basin was under cultivated agriculture, with 65 percent being irrigated (22.5 percent gravity, 77.5 percent center pivot) (Bishop and Vrtiska, 2008). Before the advent of center pivot irrigation, nearly all of the land in the region was watered via gravity irrigation. The construction of irrigation reuse pits in the lowest lying areas of each field greatly improved the efficiency of water use, but also caused unforeseen consequences. Most importantly, the irrigation reuse pits interrupt the hydrology of watersheds by intercepting natural runoff that originally drained to the nearest wetland. This interruption has caused a dramatic reduction of water supplied to the wetlands.

According to current RWBJV data, there are approximately 5,700 farm operations in the region. Of those, 3,800 possess or are within close proximity of an irrigation reuse pit. Additionally, there are approximately 11,200 land owners in the Rainwater Basin region. Of those, 4,450 own land with an irrigation reuse pit on their property (Bishop *et al.*, 2008); a recent RWBJV inventory counted approximately 10,217 pits within the Rainwater Basin (Bishop and Vrtiska, 2008). Irrigation reuse pits may be located either within the historic hydric soil footprints of existing watersheds or in the surrounding wetland watershed. These two categories of pits have very different hydrological impacts upon the local wetland. Pits located in the upland watersheds tend to intercept water that would have flowed down to the wetland in historic conditions, while pits within the wetland footprint tend to remove shallow wetland water storage and concentrate existing water into the deeper pit. Moreover, the material removed to create the pits within wetlands has often been used to fill parts of the neighboring wetland; further reducing its extent and functioning capability. Bishop and Vrtiska (2008) estimated that the pits within the Rainwater Basin capture up to 42.6 million m^3 of water at full pool, and since they are embedded in the watershed they must completely fill before any water makes it to down-slope wetlands.

Due to conversion to center pivot irrigation, the majority of the reuse pits are no longer needed. Restoration practices, particularly earthen filling of irrigation reuse pits back to original grade, can help to restore functional watersheds and habitats.

4. RESTORATION NEED

Approximately 12.4 million birds migrate through the Rainwater Basin complex each year during their journey to wintering and breeding ground. During spring migration alone, 9.8 million birds pass through the RWB on their way to breeding grounds expanding from the prairie pothole region to the arctic tundra. Migrations of such long distances require immense expenditures of energy and migration habitats such as the RWB provide necessary resting and foraging resources to help replenish energy reserves and improve body condition. The RWB has lost nearly 85 percent (RWBJV Annual Habitat Survey, 2009 unpublished) of its wetland habitat base but still hosts millions of waterfowl each spring resulting in increased competition for limited food resources. Bishop and Vrtiska (2008) calculated the 12.4 million migrants require approximately 24.1 billion kilocalories (kcal) annually to fulfill their energetic needs. It was originally believed waste grain from the area's agricultural production was enough to meet the waterfowl's energetic requirements. However, research by Loesch and Kaminski (1989) and Baldassarre and Bolen (1994) indicate that waste grain alone cannot meet the nutritional needs of the birds: they also need the inorganic elements, vitamins, and amino acids found only in early successional wetland plant seeds. Bishop and Vrtiska (2008) found that approximately 39 percent, or 9.5 billion kcal, of the total 24.1 billion kcal should be provided from wetland habitats within the Rainwater Basin. Further, 22.1 billion kcal need to be available for the spring migration period (Bishop 2008). A total of 15,317 ha of wetlands with early succession vegetation would be required to meet such caloric needs.

LaGrange and Dinsmore (1988) concluded that stopover locations closer to the breeding grounds were critical to ensuring dabbling ducks would acquire sufficient nutrient resources to positively influence recruitment. Wetland condition directly affects food quality and quantity available to waterfowl, which in turn impacts survival and recruitment of waterfowl populations. Furthermore**,** survival and recruitment are thought to be the driving factors that influence a population's dynamics (stable, declining, or increasing populations) (Bishop, 2008). Beyond nutritional requirements, migratory waterfowl have additional needs that are met by wetlands. Resting habitat is equally important to population sustainability. Currently, an additional 2,700 ha of semi-permanent wetlands should be flooded in order to adequately meet resting needs (Bishop 2008).

Habitat along the entire flyway has been lost or degraded to some extent, and the habitat modifications that have been made in the Rainwater Basin are not an isolated phenomenon. From the wintering grounds in the southern United States to the breeding areas in central Canada, habitat has decreased, largely due to conversion of grasslands and wetlands for agricultural production. Runge and Boomer (2005) have noted since 1975, northern pintails have continued to gradually migrate further northward over time, thus expending greater amounts of energy to reaching breeding grounds and possibly resulting in poorer body condition at nest initiation. Finally, Eldridge and Krapu (1998), and Dubovsky and Kaminski (1994) hypothesized the increase in migration distance probably has a negative impact on the physical attributes of birds such as body condition, resulting in a reduced clutch size, later nest initiation, and a reduced propensity to re-nest if the initial nest is lost. This information has indicated the importance migration habitats have on waterfowl populations, and the necessity to provide adequate habitat for all lifecycle stages throughout the flyways**.**

5. HABITAT IMPROVEMENT AND RESTORATION ACTIONS

Over time, the Rainwater Basin wetland complex has undergone a series of changes that have had negative ramifications on the wetlands and the species that use these aquatic

resources. With recognition of these changes and of the importance of the habitat to migratory waterfowl, work to determine what can be done to restore at least a portion of the area to a more natural functioning wetland system has been undertaken. Bishop (2008) found that between the years of 2004-2007, flooded wetlands provided 4 million to 1.9 billion kcal of available forage, which is significantly less than the required 9.5 billion kcal needed for spring migration. He concluded that conservation strategies such as wetland restoration, land acquisition, establishment of conservation easements, removal of off-site hydrologic modifications (reuse pits), and vegetation monitoring and management are required to offset the current habitat deficiencies.

The RWBJV aims to preserve, restore, and enhance at least one third, or 4,530 ha, of the wetland habitat for the foraging requirements of waterfowl. In many cases, private lands must first be acquired before restorative actions may commence. This is being done through the use of easements on private lands, fee title acquisition of wetlands, and habitat restoration. Additionally, since the 1960s the Nebraska Game and Parks Commission (NGPC) and the U.S. Fish and Wildlife Service (USFWS) have acquired nearly 12,950 ha of wetlands and their associated uplands for habitat conservation (Bishop *et al*., 2008). Over 1,200 ha of wetlands have been restored in the Rainwater Basin under the Wetlands Reserve Program (WRP) (NRCS, 2008). As of December 2007, there were 71 WRP easements (2005 ha) on playa wetlands in the Rainwater Basin. One method that has been utilized successfully is pumping groundwater into wetlands in drought years to supplement hydrology. However, pumping is expensive. In the spring of 2006, the USFWS spent over $23,000 to pump groundwater. (Bishop, 2008).

The restoration method that has the most profound impact on improved wetland hydrology is the filling of irrigation reuse pits that are no longer needed by the landowner. Natural runoff would no longer be captured in these pits and would instead be allowed to reach the wetland. A project is currently underway to fill ⅓ of the reuse pits found in the Rainwater Basin region. It is thought that once the approximately 450 reuse pits have been filled, dramatic improvements to the hydrology of affected wetlands will occur. Figure 5 provides an example of two filled irrigation reuse pits (rectangular shapes), as well as some creative wetland restoration work inside the wetland itself. Remaining reuse pits can be seen on adjacent properties along the left-hand edge of the photo. Once the aforementioned project has been completed, it will be essential to monitor the level of hydrologic functioning occurring annually, and compare the results with data from previous years to gain insight on the level of habitat improvement that has occurred. At this time, it would be beneficial for a specific case study to be performed on the positive impacts of filling reuse pits. Currently no such study exists.

6. CONCLUSIONS

Throughout recent history, the expansion, intensification, and specialization of agriculture have transformed natural land more than any other human activity (Foley *et al*., 2005). The extent of this modification is subject to some debate, but it is now uncertain if there are any truly ‘natural’ places remaining in the world today (McKibben 1989). The Rainwater Basin wetland complex of south-central Nebraska is no exception to this trend in land use. Currently, only a very small percentage of the native wetland acreage still functions in a relatively natural way on an annual basis, and recent studies have found that this area (12,140 ha) is not sufficient to supply appropriate quantities of nutrients, vitamins, and amino acids to the large populations of waterfowl that migrate through this region. Additionally, the wetland area has been found lacking in terms of supplying enough habitat for resting and loafing.

FIGURE 5
CREATIVE WETLAND RESTORATION
AND REUSE PIT FILLING (TO TOP AND RIGHT OF WETLAND)
Courtesy of Rainwater Basin Joint Venture

Field investigation, conversations with key stakeholders, and a review of the relevant literature indicate that several physical modifications such as roads, ditches, utility lines, and irrigation reuse pits, have had direct negative impacts upon the hydrologic function of the Rainwater Basin. Often this is in the form of reduced surface runoff to the down-slope wetlands, resulting in less useable habitat for waterfowl. In recent years, a variety of agencies have recognized the region's biological worth, and conservation practices are currently being implemented in an attempt to restore the wetlands to a condition closer to their original extent and quality.

Means of conservation and wetland enhancement include the supplemental pumping of groundwater in drought years, as well as the purchase of easements on private lands for conversion from farmland back to functioning wetlands. Irrigation reuse pits represent one of the easiest problems to identify, as well as to solve (with adequate funding), in the Rainwater Basin.

The Rainwater Basin wetland complex of south-central Nebraska is at the focal point of the central flyway migratory bird migration route and thus is of critical ecological importance. Due to the highly modified nature of the landscape, it is crucial that further research on the social, economic, and environmental factors influencing the area be conducted, and conservation practices continue to be a top priority throughout the region. Few geographical areas within the US serve such important ecological roles as the Rainwater Basin and, based on the ecological importance of these wetlands to migratory bird populations, there is a continuing need for research and development of appropriate conservation practices for the preservation of this resource.

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