Lakes & Wetlands of the Great Plains

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Introduction

The Great Plains of North America is characterized by cropland interspersed with a variety of prairie ecosystems and with few lakes and wetlands. The paucity of lakes in the Great Plains is due to a west-to-east precipitation gradient and a north-to-south temperature gradient, which creates warm, dry, semi-arid grasslands, particularly in the southern and western Great Plains. This dry, vast landscape has been called the "Horizontal Yellow" by ancient Native American plains tribes and the "Great American Desert" by European settlers (Figure 1). Some sub-regions support larger numbers of lakes and wetlands, but, in general, standing water is limited. In fact, most lakes in the Great Plains are impoundments and reservoirs that have been constructed starting after the "Dust Bowl" era of the 1930s to accommodate the expanding agricultural land use and growing human population. Thousands of artificial waterbodies were created to temper the effects of droughts and floods, and to capture and utilize water from the limited precipitation that characterizes most of the Great Plains.

The Great Plains extends from southwestern Canada through the central U.S. and into the northeastern corner of Mexico in southern Coahuila, Nuevo Leon and Tamaulipas (Figure 2). Lakes within the Great Plains were formed by different geologic and geomorphic processes and retain their physical and water quality characteristics, in part, from the differing patterns of precipitation and temperature that change along their respective gradients (Figure 3). The intensity of agricultural land use that now characterizes much of the Great Plains has played a great part in the changing nature of these water bodies (Figure 4).

Figure 1. Looking west across the South Dakota prairie at Oahe Lake, an impoundment of the middle Missouri River. Photograph courtesy of Don Huggins

Many lakes and impoundments suffer from nutrient enrichment, sedimentation, hydrological alterations and contamination from man-made pollutants. Herein, we synthesize information on major regions of natural lakes and man-made waterbodies of the Great Plans.

Prairie Pothole Lakes and Wetlands

The Prairie Pothole Region (PPR) makes up the northern portion of the Great Plains and includes most of the Great Plains region occurring in Canada (i.e., southern Alberta, Saskatchewan and Manitoba provinces). The physiography of the region consists of a vast glaciated area of flat to rolling plains with a cold, semi-arid climate. Despite low mean annual temperatures (~3° C), this area is characterized by high evaporation rates due to high winds, low humidity, and warm summers. High evaporation rates combined with limited precipitation and the mostly closed drainage topography has lead to the creation of many saline lakes and wetlands that have come to characterize much of this region (see Mushet article in this *LakeLine* issue). This largely semi-arid steppe region in Western Canada was known as "Palliser's Triangle," after John Palliser, an early explorer who thought this area to be

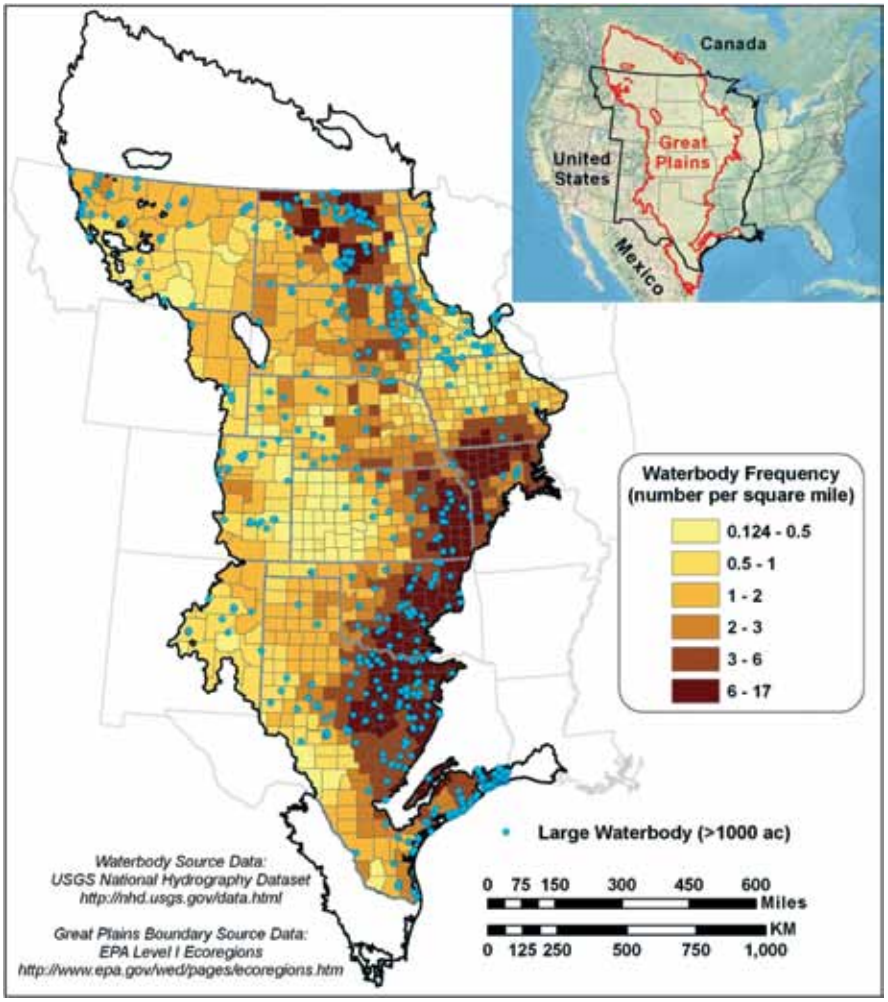

Figure 2. Lake and impoundment density map for the Great Plains in the U.S. showing waterbodies greater than 1,000 surface acres (blue dots).

unsuitable for agriculture because of its harsh climate and treeless landscape. Irrigation and modern farming techniques have turned this area into a highly productive small grains region, which has had some effects on local lake quality. The southern portion of the PPR includes the northeastern edge of Montana running south into eastern North and South Dakota, then over into south-central Minnesota and north central Iowa. While the waterbody population of the PPR is numerically dominated by relatively small, glacially created waterbodies (Figure 5), larger lakes occur throughout parts of the northern Plains and provide many fishing and other recreational opportunities. To learn more about the PPR, visit the Prairie Pothole Joint Venture website (http://www.ppjv.org/). One of the primary ecological functions of the many small lakes and wetlands in the PPR is providing critical habitat that helps sustain important populations of waterfowl, shorebirds, waterbirds, and prairie land birds.

Nebraska Sandhills Lakes

The Nebraska Sandhills covers nearly 20,000 square miles of central and north central Nebraska (Figure 6). The Sandhills region is the largest sand dune area in the western hemisphere and one of the

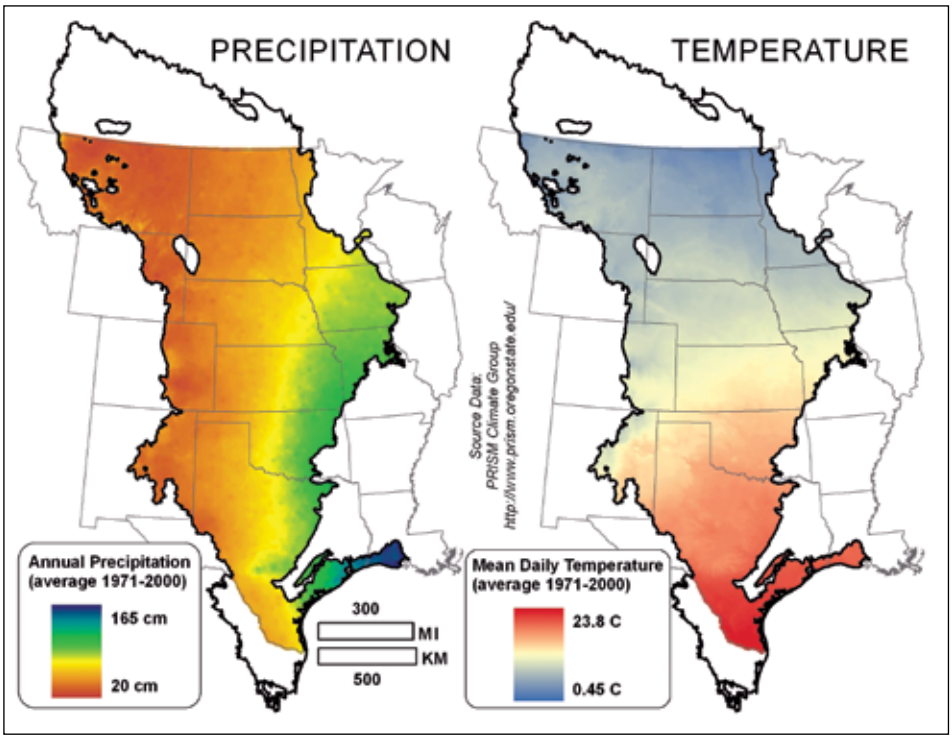

Figure 3. Precipitation and temperature gradients across the Great Plains in the U.S.

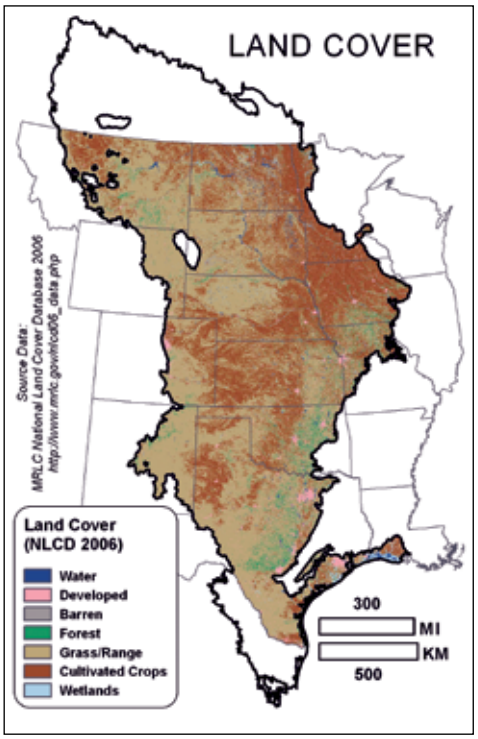

Figure 4. Major land use categories from 2006 National Land Cover Data (NLCD.

Figure 5. Osceola Lake a moderate-sized prairie pothole lake in Kingsburg County, South Dakota. Photograph courtesy of Don Huggins.

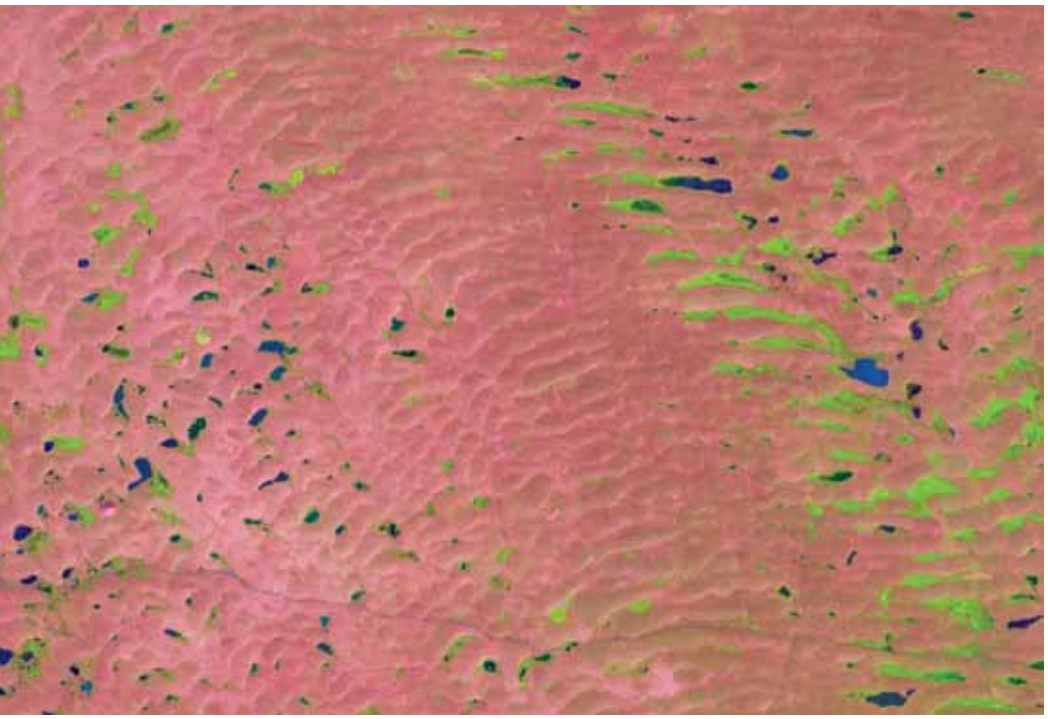

Figure 6. Landsat image of Nebraska Sandhills showing dune waves with lakes and wetlands occurring within the inter-dune troughs. These lakes, many of which are saline, are in located southwestern Cherry and southeastern Sheridan Counties.

largest grass-stabilized dune areas in the world. The region is the recharge zone for the High Plains (Ogallala) aquifer. High filtration rates in the sand create a thick saturated zone that provides source water for lakes in this semi-arid landscape. Fluctuations in lake level dependant on input from groundwater cause rapid changes in lake area. Consequently, the proportion of lake area covered by emergent plants increases with decreased lake level and vice versa. Changes in lake area and shape result in lakes grading into wetlands or wetlands grading into lakes. Thus, it has been difficult for natural resource managers to count the number of lakes in the region, with estimates ranging from 1,500 to 2,500 lakes. Lakes of the Sandhills are shallow, do not stratify in the summer, and are highly productive with high concentrations of total phosphorus, total nitrogen, and chlorophyll-*a.* The lakes also are alkaline, exhibiting an alkalinity gradient ranging from 0.00 mg/L to 90,000 mg/L. Some of the closed-basin hyperalkaline and hypersaline lakes support unique communities of salt-tolerant plants and macroinvertebrates. Two National Wildlife Refuges and two Biologically Unique Landscapes have been designated in the Sandhills for conservation of the region's biological diversity. Overall, the Sandhills are characterized by one of the best remaining mixed grass prairies in North America, but a warming climate combined with increased draw down of ground water sources and possible changes in range management threaten the condition of the Sandhills lakes. (See Hayford and Baker's article in this *LakeLine* issue to learn more about the Sandhills lakes.)

Reservoirs and Impoundments

Today, the need for water infuses and permeates every aspect of life in the Great Plains, from the irrigation that supports agriculture, to the drinking water that citizens use every day in their homes and places of work. While historically lakes and other lentic features were uncommon to the Central and Southern Great Plains, today's landscape is dominated by man-made impoundments of all sizes that provide a multitude of services to the people living within this water-limited region. Lacking the natural lakes of the Northern Great Plains, and spurred by generous federal funding for both small watershed dams to benefit the individual farmer and large reservoirs for flood control, water supply, and irrigation, a flurry of dam construction in the mid-20th century spawned hundreds of thousands of reservoirs in this region. Construction of impoundments in the Southern Great Plains over the last 60 years has resulted in so many impoundments that few unimpacted stream flows remain, as watersheds and basins are replete with hierarchically nested impoundments occurring on both intermittent and perennial stream channels.

Small- to moderate-sized impoundments have a long history of use within the Great Plains, beginning with

the construction of stock watering and farm ponds. These small impoundments typically serve a single farm or livestock pasture, and are essential to successful farm and ranch operations (Figure 7). By 1947 it was estimated that 188 artificial lakes and 71,000 impounded stock ponds had been constructed in Oklahoma, most with aid from the USDA. The number of small impoundments has continued to grow throughout the Great Plains region. Presently, Kansas has more than 135,000 ponds one-half acre in size or smaller, Oklahoma more than 265,000, and Texas more than 675,000. For the most part, these waterbodies create the density pattern observed in Figure 1 for the Central and Southern Great Plains. Like small- to moderate-sized impoundments, federally funded construction of large reservoirs began in the late 1940s.

The most intense construction period occurred during the 1960s. Typically, the U.S. Army Corps of Engineers focused on larger main channel dams for flood control and hydroelectric power, while the Bureau of Reclamation developed smaller projects on tributaries principally for irrigation (Figures 8 and 9). Large federal dams were authorized by a series of key Congressional acts, principally the Pick-Sloan Flood Control Act of 1944 (P.L. 78-534) or one of the Flood Control Acts or River and Harbor Acts passed by Congress in the mid-20th century (e.g., the Flood Control Act of 1954 [P.L. 83-780]).

Now the Great Plains states are facing enormous challenges as they attempt to respond to increasing needs for water, coupled with an increasing occurrence of water quality problems affecting reservoirs. For example, the Texas Water Development Board (TWDB) predicts that between the years 2010 and 2060, water demand in the state will increase by 22 percent. Combined with the expected 10 percent decline from existing water sources, this amounts to a need for 8.3 million additional acre-feet of water per year by 2060. The TWDB recommends that just over half of this new demand be offset by new surface water diversions (33.8 percent) and new major reservoirs (16.7 percent). Water plans from other southern Great Plains states are similarly dire in their estimates of future demand and their ability to deal with severe drought conditions that often leave western reservoirs dry or nearly so (Figure 10). In addition, most reservoirs in the region are gradually filling with sediment washed down from their watersheds. As reservoirs silt in, less water is available for irrigation, industry, recreation, and as drinking water for human use. Furthermore, sediment accumulation continues to create water quality problems and promote algal outbreaks that kill fish, pollute the water, and lead to foul tasting drinking water.

Figure 7. Small farm pond in southern Jefferson County Kansas. These small ponds serve multiple purposes, including livestock watering and waterfowl stop-over sites. Photograph courtesy of Don Huggins.

Figure 8. Canyon Lake, a U.S. Army Corps of Engineers reservoir, is located in south-central Texas and provides flood damage reductions associated with flood events in the Guadalupe River Basin. This reservoir also supplies water to local municipalities and provides various regional recreational opportunities. Photograph courtesy of the U.S. Army Corps of Engineers.

Algal blooms, toxic algae events, and taste and odor problems are recurring and serious problems in many Great Plains reservoirs. Taste and odor problems have been linked to blooms of blue-green algae (cyanobacteria), which in turn are linked to several potential causative factors, including elevated levels of nutrients, warm water temperatures, adequate sunlight, and stable water conditions/long residence times. Nutrient enrichment is a major issue for nearly all water resources in the Great Plains and many states have begun to move toward establishing more protective criteria to sustain these valuable resources. The USEPA has supported Regional Technical Assistance Groups (RTAGs) to take the lead in establishing benchmark values for key nutrient factors that might help states determine appropriate criteria (see www.cpcb.ku.edu for one such nutrient document focused on the Central Plains and surrounding area).

Figure 9. Lovewell Reservoir was built and is managed by the United States Bureau of Reclamation (USBR). Lovewell is located in north-central Kansas near the Nebraska border and has a surface area of 2,980 acres. Photograph courtesy of Bill Johnson.

Figure 10. Lake McKinney, a western Kansas impoundment built in 1948 and located east of Lakin, Finney Co., Kansas. Limited precipitation in the Western High Plains often leaves lakes and impoundments in the region short on water or dry. Photograph courtesy of Bill Johnson.

Playa Lakes and Wetlands

Playa lake basins may originate wherever water periodically can collect in a surficial depression and then expand by hydrologic and geomorphic processes. Thus, playas often occur in parts of the world where the topography is flat, climate is semi-arid, and evaporation rates are high, all of which contribute to the playa wet/dry cycle (Figure 11). While playas can be found throughout the Great Plains, they are most numerous on Southern High Plains. The Southern Plains region is also one of the most intensively cultivated areas of North America. Consequently, playa lakes within this region are embedded in a highly altered landscape resulting in the loss or ecological and hydrological impairment of many playas. Like the Prairie Pothole Joint Venture, the Playa Lakes Joint Venture (PLJV; www.pljv.org/) was established to promote the protection and management of birds and game associated with these waterbodies, and in doing so has led to better understanding and management of these lakes and wetlands. One of the services provided by the PLJV is the development and maintenance of the "Probable Playas" spatial data layer, which includes information used to identify where playa lakes likely exist throughout most of the Southern Plains region. The PLJV map coverage (see website) suggests that as many as 75,000 playas may exist in this southern region (Figures 12 and 13). Unfortunately, it is highly likely that some of these mapped features no longer function as playas, having been plowed, drained, filled with sediment, or otherwise converted to a land-based use such as cropland. Healthy playa lakes and wetlands are biological "hot spots" within the Plains region that support a high diversity of plants, birds, mammals, and invertebrates upon which many vertebrate species feed. Less is known about the use of playas by amphibians and reptiles, and

Figure 11. Dry Lake in southeastern Scott County Kansas, like all playas is devoid of water a greater part of the time and many tend to concentrate salts as a result of evaporation within these typically closed basin and depressions. These salt accumulations are clearly visible in this photograph of the dry bed. Photograph courtesy of Bill Johnson.

Figure 12. Large playa in eastern Colorado near Afton Colorado. Many playas are embedded in agricultural land; in this case the playa is buffered by hay pasture yet surrounded by cultivated cropland such as wheat. Photograph courtesy of Bill Johnson.

Figure 13. Small playa located in the Pawnee National Grasslands of northern Colorado. Photograph courtesy of D. Christopher Rogers

even less is known about their water and sediment quality.

Other Lakes and Wetlands

Oxbow lakes, sink lakes, and borrow and sand pit lakes are also found in the Great Plains. The typically crescent-shaped oxbow lakes are found in abandoned channels (oxbows) of a meandering stream and occur mainly within the floodplains of the major rivers such as the Missouri, Platte, Kansas, Arkansas, Washita, Guadalupe, Brazos, and Colorado Rivers (Figures 14 and 15). Despite being few in number, oxbow lakes of the Great Plains support a diverse fish fauna as well as other vertebrate and invertebrate species. Along some of the large, sand-bottom rivers of the Great Plains, sand pit lakes and ponds have appeared as a result of aggregate mining for the construction industry. This is especially true along the Platte River in central and eastern Nebraska where these waterbodies have become popular recreational areas (Figure 16). Borrow pit lakes also dot the eastern portion of the plains landscape where road construction requires additional soils to build up the road bed. These lakes often remain the property of the land owner and provide fishing and recreation opportunities. Last, there are a few lakes that have been formed as a result of geological subsidence. These sinkholes, swales, or lagoons typically are small and often do not retain water throughout the year, but a few are large and deep enough to be permanent waterbodies. Lake Inman south of Groveland, Kansas, is one such sinkhole (Figure 17).

Historically it can be said that much of the Great Plains had few permanent surface waterbodies, which, in part, limited both agriculture and human settlement. Today, with the development of an extensive reservoir and impoundment system, this has changed, and the Great Plains is home to one of the largest agricultural enterprises in the world. Collectively, Great Plains lakes and impoundments provide for recreation, ecological services and infrastructure support for people and industry. Water remains a fundamental issue in this region, and only good planning and time will tell if the Great Plains will continue to prosper.

Figure 14. Silver Lake, the oxbow lake and town, lay within the Kansas River floodplain northeast of Topeka, Kansas. This oxbow was created as recently as 1891 and like many oxbows in this region is nearly filled with sediment washed in from the surrounding agricultural landscape. From Landsat imagery.

Figure 15. Lake View Lake was formed sometime after 1873 and lies within the Kansas River floodplain just west of Lawrence, Kansas. The oxbow is the site of a housing association that uses the oxbow for boating, fishing, and other water-related activities. An east/west county road has separated the northern tips of the oxbow that are now wetland/crop complexes. From Landsat imagery.

Figure 16. A series of sand pit lakes west of Omaha, Nebraska, along the Platte River, which runs north to south along the right side of the image. These sand pit lakes are often well-developed residential areas composed of primary residential housing or vacation dwellings. From Landsat imagery.

Figure 17. Inman Lake located south of Goveland, Kansas (McPherson Co.) occupies an undrained depression covering about 160 acres. This depression or sinkhole was caused by salt dissolution and resulting subsidence of the land surface. Photograph courtesy of Bill Johnson.

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