2022

Guide to Nebraska's Wetlands and their Conservation Needs

Ted LaGrange

NEBRASKA GAME PARKS

GUIDE TO NEBRASKA'S WETLANDS

and their conservation needs

GUIDE TO NEBRASKA'S WETLANDS

and their conservation needs

Third Edition, 2022

By: Ted LaGrange, Wetland Program Manager

Design by: Tim Reigert

Nebraska Game and Parks Commission
Tim McCoy, Director

Funding provided by:

NEBRASKA GAME PARKS

PLATTE BASIN TIMELAPSE

DUCKS UNLIMITED

NEBRASKA COOPERATIVE FISH & WILDLIFE RESEARCH UNIT

U.S. Environmental Protection Agency

Acknowledgments

The following individuals served on the Core Team for the Wetlands of Nebraska Outreach and Education project and were instrumental in the planning and implementation: Grace Gaard and Lindsay Rogers (Nebraska Game and Parks Commission (NGPC) Fish and Wildlife Education Division); Shawna Richter-Ryerson, Nick Sauvageau, and Jeff Kurrus (NGPC Communications Division); Randy Stutheit, Molly Haas Wavada, and Ted LaGrange (NGPC Wildlife Division); Kevin Pope (U.S. Geological Survey — Nebraska Cooperative Fish and Wildlife Research Unit); and Mike Forsberg, Mike Farrell, Mariah Lundgren, Brooke Talbott, Ethan Freese, Grant Reiner, and Dakota Altman (University of Nebraska-Lincoln Platte Basin Timelapse).

The following individuals served on the Advisory Committee and provided invaluable oversight for this project: Hanna Pinneo (Nebraska Statewide Arboretum), Eliodora Chamberlain, Jeannette Schafer and Justin Kensinger (U.S. Environmental Protection Agency), Audrey Webb (Nebraska Department of Education), John Denton and Ele Nugent (Ducks Unlimited), Josh Wilhelm (Nebraska Department of Environment and Energy), Melissa Panella (NGPC), Judi gaiashkibos (Nebraska Commission on Indian Affairs), Rochelle Settles and Betsy Barent (Lincoln Public Schools), Dayna Derichs (Millard Public Schools), Jocelyn Harrison (Henry Doorly Zoo), Joey Hajda (Thedford Schools), Lisa Cotter (Lexington Middle School), and Arlys Cupp (Chase County Schools), and Susan Pope, (Educator).

Much of the content of this document was built on information compiled by Dick Gersib and Randy Stutheit of the Nebraska Game and Parks Commission. Gordon Coke (The Flatwater Group) helped with writing the section that defines saline and alkaline wetlands. Additional subject matter experts providing input included: Andy Caven (Crane Trust); Tom Peterson (Ducks Unlimited); Chris Landland (National Park Service); Tatiana Davila (Nebraska Department of Environment and Energy), Gerry Steinauer, Hannah Jones, Joel Jorgensen, John Laux, Kirk Steffensen, Scott Luedtke, Joe Cassidy, Matthew Garrick, Olivia DaRugna, Rachel Simpson, Thad Huenemann and Zac Brashears (NGPC); Andy Bishop, Dana Varner, Roger Grosse and Greg Brinkman (Rainwater Basin Joint Venture); Chris Helzer and Rich Walters (The Nature Conservancy), and Crystal Powers and Mark Vrtiska (University of Nebraska-Lincoln). Mark Vrtiska coordinated having the following UNL students help format the citations in the reference section: Caitlin Copenhaver, Cole Demuth, Katie Krager, Sean Kruse, and Megan Soldatke.

Staff from the following agencies/organizations helped to review this document: Audubon Nebraska, Ducks Unlimited, Nebraska Cattlemen, Pheasants Forever, Crane Trust, Sandhills Task Force, Saline Wetlands Conservation Partnership, Rainwater Basin Joint Venture, The Nature Conservancy, Nebraska Department of Environment and Energy, Nebraska Department of Natural Resources, Nebraska Department of Transportation, Nebraska Game and Parks Commission, National Park Service, Natural Resources Conservation Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service.

This was printed as a part of the Wetlands of Nebraska Outreach and Education project. Funding for this project was provided by the following: U.S. Environmental Protection Agency (grant CD# 97770101), Ducks Unlimited, the University of Nebraska-Lincoln, and the Nebraska Game and Parks Commission. Printed as a component of Nebraska's 2021-2025 State Comprehensive Outdoor Recreation Plan (SCORP): Guiding Success in Nebraska's Outdoor Recreation.

For additional information please contact:
Ted LaGrange, Wetland Program Manager
Nebraska Game and Parks Commission
P.O. Box 30370
Lincoln, NE 68503
Phone: (402) 471-5436
Email: ted.lagrange@nebraska.gov

or visit the Nebraska Game and Parks Commission's wetland website at: NebraskaWetlands.com. This site houses all the products created by this project.

A great blue heron is an iconic wetland bird. Here it hunts for food in an eastern saline wetland at Shoemaker Marsh near Lincoln. DAKOTA ALTMANN, PLATTE BASIN TIMELAPSE

Table of Contents

Wetlands in the Sandhills are home to many species of shorebirds, including this American avocet. MARIAH LUNDGREN, PLATTE BASIN TIMELAPSE

Wetlands: a source of great interest, and at times conflict. Wetlands represent different things to different people. To some people they may be considered shallow, muddy nuisances whereas to others they are considered to be wonderful, varied, and productive assets. This is because wetlands take on many roles as part of an elaborate and dynamic system. Understanding wetlands requires understanding the complex and varying roles they can play. To aid in this understanding, this guide defines wetlands, discusses their importance and dynamics, identifies threats and losses, describes conservation programs, and takes an in-depth look at Nebraska's regional wetland complexes.

NEBRASKA'S WETLANDS

Nebraska's wetland resources are surprisingly diverse and dynamic. They include marshes, lake edges, river and stream edges, backwaters, oxbows, wet meadows, fens, forested floodplains, and seep areas. These wetlands vary greatly in nature and appearance due to physical features, such as geographic location, water source and permanence, and chemical properties. Some wetlands hold water for only a few weeks or less during the spring, whereas others rarely go completely dry. Many wetlands receive their water from groundwater aquifers, and others are totally dependent on precipitation and runoff. Finally, the water chemistry of wetlands ranges from fresh to saline, and from acidic to basic. These descriptions identify the extremes of wetland characteristics. Nebraska's wetland resources possess these extremes and virtually every combination in between.

What is a Wetland?

There has been controversy about how to define wetlands, because wetlands are regulated by several laws. The application of these laws requires the wetland boundary be determined, a process termed wetland delineation. Delineation of wetlands can be difficult because they occupy a transitional zone on the landscape, and frequently become dry.

The State of Nebraska has adopted the federal definition that wetlands are "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (USACE 1987).

Wetland delineation in Nebraska is based on the 1987 Corps of Engineers Wetlands Delineation Manual (USACE 1987) and the Regional Supplemental Manuals for the Great Plains (USACE 2010a) and Midwest (USACE 2010b). These manuals use *three diagnostic environmental characteristics* to delineate wetlands. The three characteristics are:

1) Hydric vegetation — a prevalence of hydric, or water-loving, plants adapted to growing in inundated or saturated conditions.

2) Hydric soils — the presence of soils that developed within inundated or saturated conditions that limit oxygen, known as anaerobic conditions.

3) Hydrology — inundation or saturation by water at some time during the growing season, or the time when plants are actively growing.

All three of these characteristics must be present for an area to be considered a wetland. Note that these characteristics apply to both natural and artificial wetlands, such as constructed ponds.

NEBRASKA'S WETLANDS

Nebraska's wetland resources are as diverse and dynamic as those of any state in the nation. They include marshes, lakes, river and stream backwaters, oxbows, wet meadows, fens, forested swamps, and seep areas.

Wetlands line the edges (fringe) of most streams and rivers, including East Ninemile Creek, a cold-water trout stream in Scotts Bluff County. TED LAGRANGE, NEBRASKA GAME AND PARKS COMMISSION

Some wetlands, especially in eastern Nebraska, are naturally wooded, like the edge of this wetland on the Missouri River floodplain at Fontenelle Forest. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Playa wetlands generally occur on flat landscapes with good quality soils, and many are farmed in drier years. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Many wetlands are connected to groundwater, including fens in the Sandhills. Two boiling springs push cold groundwater to the surface. The "boiling" is not caused by heat but by groundwater that reaches the surface with enough power to suspend the sand grains. DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

Waterfowl using a Rainwater Basin playa wetland near Utica. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Wetlands are associated with the edge of most lakes and ponds across the state. DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

Wetlands can be found within most of our communities. Some are natural, and some are constructed, such as this rain garden area in downtown Lincoln. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Wet meadow wetlands are abundant in the Sandhills and along many of our rivers, including here along the Platte River in Lincoln County. They are important for hay production. MIKE FORSBERG, NEBRASKALAND

Alkaline wetlands have concentrations of salts (the white crust) that form through evaporation. ETHAN FREESE, PLATTE BASIN TIMELAPSE

The Central Platte River and its floodplain has a variety of wetland types, including fringe and wet meadow wetlands shown here.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

Benefits: Why Wetlands are Important

There are good reasons why we should care that Nebraska has lost some of its wetland resources and to understand why some agencies are now trying to protect wetlands when not long ago they were paying to drain them. Two main factors have contributed to this change in approach and attitude. The first is that our knowledge of how wetlands function has increased dramatically in the past few decades. Wetlands now are known to serve numerous functions, many of which have benefits to society. These benefits have long been recognized by the Native Americans who relied on wetlands for many of their needs. Secondly, as wetland losses increased, the benefits they provided were reduced or eliminated. The loss of a small percentage of a region's wetlands probably had little effect, but as losses increased, a threshold was crossed, and negative affects began to occur. Examples include declining wildlife diversity and abundance, increased flooding in some watersheds, and deteriorating water quality in many regions. These are just some of the reasons why wetland conservation in Nebraska now is recognized as a need.

We all need a good supply of clean water. One of the many benefits of wetlands is they help to recharge our groundwater and filter out pollutants. GETTY IMAGES

The terms "functions" and "values" have often been used when talking about the importance of wetlands. Functions are the things a wetland does, and the worth of those functions to an individual or society is its value. Based on these definitions, functions can be measured and documented, while values may vary from person to person. For example, we can measure the function a wetland serves by holding water and reducing downstream flooding. This may have no value to a person living outside of the watershed where the downstream flooding is being reduced, but a great deal of value to a downstream landowner or society that pays indirectly for the costs of flooding. Ascribing and quantifying values is extremely complex (Hubbard 1989, Leitch and Hovde 1996, Smith et al. 2011) and is beyond the scope of this guide.

It is important to note not all wetlands provide the benefits listed below. Nor will a given wetland necessarily provide these benefits equally within a year or over a series of years.

Some of the recognized benefits of wetlands include:

Improving Water Quality — When many people consider wetlands, the last thing they think about is clean water. Wetlands can produce gas with a rotten egg odor and contain numerous floating plants, algae, bacteria, bugs, and other animals that hardly make you want to drink the water. However, due to these plants and animals, as well as the chemical processes that produce the smelly gas, wetlands are a great

By the Numbers

Number of species that use Nebraska wetlands[1]

Plants	Amphibians	Reptiles	Birds	Mammals
990	13	18	176	29

Number of species occurring in Nebraska

Plants	Amphibians	Reptiles	Birds	Mammals
2,000	13	47	352	80

Percent of all Nebraska species that use wetlands

Plants	Amphibians	Reptiles	Birds	Mammals
50%	100%	38%	50%	36%

[1] Estimate based on use of wetlands as important habitat at some point in the species life cycle.

The setting sun silhouettes Chimney Rock across an alkaline wetland along the North Platte River in Morrill County.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

natural cleanser of many common water pollutants. Wetlands act as a filter, slowing water down and allowing sediment and many pollutants to settle out. As the water slowly moves through the wetland, a series of chemical transformations take place that tie-up or alter a variety of pollutants. The result is the water leaving a wetland is of higher quality than the water entering the wetland. In fact, studies have shown that up to 80% of the nitrate pollution entering wetlands is converted to harmless nitrogen gas by the time the water exits the wetland. Wetlands increasingly are being used for water pollution control and wastewater treatment due to their water cleansing functions.

Providing Habitat for Wildlife, Fish, and Unusual Plants — Wetlands are among the most productive biological systems known. They produce more plant and animal life per acre than cropland, prairies, or forests. This high level of productivity makes wetlands important habitat for an abundance of wildlife and fish. Wetlands provide migration, breeding, nesting, and feeding habitat for millions of waterfowl, shorebirds, songbirds, and other wildlife. Wetlands are home to thousands of plant and animal species, including many that are threatened or endangered. Eleven of Nebraska's 15 federal endangered and threatened species use wetland areas, as do 22 of Nebraska's 32 state-listed endangered and threatened species. Many wetlands provide important feeding and rearing habitat for fish. All the state's amphibian species, as well as many reptile and invertebrate species, use wetlands. Wetlands also provide important winter cover for pheasants, deer, and other resident wildlife.

Nebraska has three major wetland complexes of international importance to wildlife. The Rainwater Basin area in south-central Nebraska provides critical spring staging and migration habitat for waterfowl, shorebirds, wading birds, and endangered species. Immediately north of this area is the Central Platte River, which provides critical migration habitat for the endangered whooping crane, spring staging habitat for 80-85% of the mid-continent population of sandhill cranes, breeding habitat for threatened

and endangered species, and migration habitat for waterfowl and other waterbirds. Finally, the Sandhills wetland complex in north-central Nebraska is recognized as providing important breeding and migration habitat for waterfowl, shorebirds and several endangered species.

Reducing Flooding and Soil Erosion — Many wetlands act as a sponge by storing water temporarily and then allowing the water to percolate into the ground, evaporate, or be slowly released back into a stream or river. This temporary storage reduces downstream flooding after a storm and can provide tremendous economic benefits. Wetlands also slow the overland flow of water, reducing downstream soil erosion.

Supplying Water — Many wetlands slowly release water into the ground, adding water to the underlying aquifers; this is called groundwater recharge. Some wetlands also slowly release water to streams and rivers, helping to maintain stream flows. These water-supply functions can benefit municipal and agricultural water users, and provide water for livestock.

Wetlands along the edges of lakes and ponds provide important habitat for fish. Here Lexus Erickson shows off the large bluegill she caught. JULIE GEISER, NEBRASKALAND

Cattle grazing along the edge of a Sandhills wetland benefit from the abundant and nutritious forage provided.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

Producing Food and Sequestering Carbon — The soils formed by wetlands can be very productive. These fertile soils benefit many farmers and ranchers who tap the capability of wetlands to produce hay and forage for livestock. Less conventional uses also are possible, such as raising fish, crayfish and frogs, or growing alternative crops, such as wild rice, new strains of crops adapted to wetlands, and the use of wetland plants for biomass or ethanol production (USEPA 1991).

Wetlands are increasingly recognized for their important role in carbon capture and in helping to address climate change. Temperate freshwater wetlands, such as those found in Nebraska, showed some of the highest rates of carbon sequestration recorded due to their high productivity and the buildup of carbon in wetland soils.

Providing Recreation and Education — Wetlands provide numerous recreational opportunities, including hunting, trapping, wildlife watching, kayaking, photography, and enjoyment of the serenity that a wetland can offer. Anglers also benefit from wetlands because many species of fish use these areas for spawning, hiding, or because the foods used by the fish are produced in wetlands. Wetlands provide an excellent setting for environmental education because of the many unusual life forms present and because they are unique features of the landscape. Wetlands also serve a historical function because they represent a landscape much as it once appeared in the past.

Wetland Dynamics

Wetlands are highly dynamic and productive systems. Because wetlands occupy a continuum between wet and dry conditions, they undergo a variety of unique changes both seasonally and from year-to-year. Wetlands become dry and then flood, are burned by prairie fires, and are subjected to other disturbances such as grazing. These are natural processes that do not harm the wetland. In fact, it is the interaction of all these dynamic processes that make wetlands so productive. If some of these processes are altered, for example, by maintaining a constant water level, the wetland will begin to deteriorate.

Wetlands are very dynamic. They change across seasons and years. Here the same wet meadow wetland along the Central Platte River is shown in different seasons. MICHAEL FORSBERG

A late winter prescribed fire mimics prairie fires that occurred naturally in the past and helps keep vegetation healthy.

Sandhill cranes arrive during spring migration and feed in the wetland that now ponds some water.

Wetlands were naturally grazed by bison and elk, and prescribed grazing by cattle is often used to keep wetlands in good condition.

By late summer and early fall in many years, the water has dried up and plants cover the wetland.

Wetland Restoration and Management

Conducting wetland restoration and management activities requires a detailed understanding of site-specific soils, engineering, hydrological, and biological issues that are too extensive to address within this guide.

To obtain more information, visit Appendices C and D in the comprehensive Nebraska Wetland Program Plan (LaGrange 2015) available online, or the publications on restoration and management listed in the General References section near the back of this guide. In addition, prior to undertaking a restoration or management project, contact your local Nebraska Game and Parks district office (see contact information on page 85).

Wetland Classification

Numerous classification systems have been developed for wetlands. The one most used today is the Cowardin system (Cowardin et al. 1979). This is a hierarchical system that classifies wetlands according to system, plant community and substrate, water regime, water chemistry, and numerous special modifiers such as the presence of dikes, drainage, and excavations. In many cases, portions of the same wetland can be classified differently.

Systems — The three wetland systems that occur in Nebraska are palustrine, lacustrine and riverine. Palustrine systems include marshes, wet meadows and the edges of lakes and streams. Lacustrine systems are lakes, usually deeper than 6.6 feet. Riverine systems are rivers and streams that flow in a defined channel.

Water Regime — Water regime describes the duration and timing of inundation or saturation in a wetland. In Nebraska, most palustrine wetlands are of the temporarily, seasonally, or semipermanently flooded water regimes. Temporarily flooded wetlands are flooded for brief periods, often only a few weeks, during the growing season. Seasonally flooded wetlands have water present for extended periods during the growing season, but tend to dry up by the end of the season in most years. Semipermanently flooded wetlands have water in most years and only occasionally dry up.

Wetland Inventories and Maps

Many different techniques have been used to inventory the past and current number and acreage of wetlands and track the conversion or loss of wetlands in Nebraska. Because of this, the numbers derived statewide or within a complex not always are in agreement, and care needs to be taken when interpreting these numbers. Nevertheless, these numbers are useful in examining the major, long-term trends in wetland numbers and acreage.

The most complete wetland inventory for Nebraska was conducted by the National Wetlands Inventory of the U.S. Fish and Wildlife Service. The inventory produced maps that depict wetlands using the Cowardin classification system (Cowardin et al. 1979). They are an excellent tool for inventorying and locating wetlands, but they are not delineation maps. Much of the state was mapped using aerial photographs taken in the early 1980s, so some inaccuracies are present in the mapping due to changes that have happened since then. The Rainwater Basin and Central Platte River areas were updated in 2011, and a large portion of the Sandhills is being updated. Digital maps are available for much of the state and can be accessed at fws.gov/wetlands.

Wetlands Are Everywhere

Even if a wetland is not within one of the complexes in this guide, it does not mean it is unimportant or does not provide benefits.

Wetlands are in every Nebraska county, especially along Nebraska's many streams and rivers, and are important components of the ecosystem. Wetlands also are associated with many of the state's constructed farm ponds and reservoirs.

Wetlands are found in every county, and many are associated with streams, such as this fringe and seepage wetland along Spring Creek in Lancaster County.

ETHAN FREESE, PLATTE BASIN TIMELAPSE

Statewide Wetland Resources

At the time of statehood in 1867, Nebraska contained an estimated 2,910,000 acres of wetlands covering about 6% of the state (Dahl 1990). Through much of the state's history, wetlands were viewed as an impediment to transportation, agriculture and development. The federal government actively encouraged the conversion of wetland areas to other uses through land giveaways, direct financial assistance, technical assistance, crop subsidies and tax incentives. Wetlands have been affected directly by filling, ditching, tiling, digging concentration pits, channelization, water pollution and declining water tables, and indirectly by changes in the surrounding uplands that caused increased sedimentation into wetlands or the diversion of surface runoff away from wetlands. Wetlands and deeper water areas also were created in some regions due to the construction of farm and livestock ponds, and locally rising water tables due to irrigation canal and reservoir seepage.

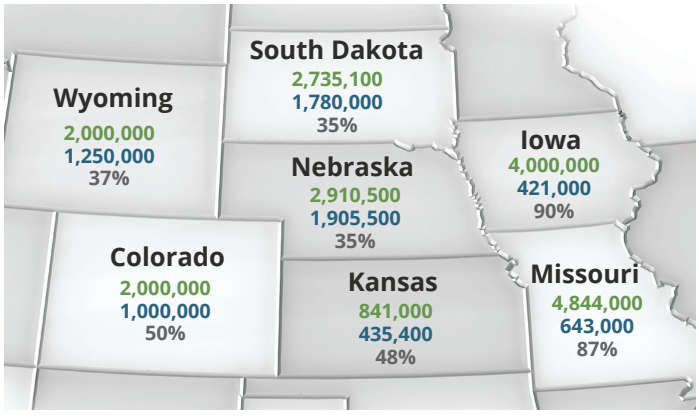
Nebraska has more acres of wetlands than any surrounding state, due in large part to the extensive wetlands remaining in the Sandhills. However, in many parts of the state, wetlands have been destroyed or highly altered. Pictured here is the location of a historic Rainwater Basin wetland. The once shallow and productive wetland has been drained into deep pits that were excavated to concentrate the water and to allow for the passage of a center-pivot irrigation system. JON FARRAR, NEBRASKALAND

The net result of all these activities statewide was a reduction in wetlands from the 1780s to the 1980s by an estimated 35%, to 1,905,000 acres covering only 4% of the state (Dahl 1990). The destruction of wetlands was much higher in some regions of the state, but the statewide figure is buffered by the large wetland resources remaining in the Sandhills. Most states surrounding Nebraska have lost a greater percentage of their wetlands (Dahl 1990).

Wetland status and trends over time have not been quantified statewide in Nebraska, but have been nationally and regionally. The status and trends reports completed by the U.S. Fish and Wildlife Service show a high loss of wetlands prior to the mid-1980s, but in the ensuing 20 years, the loss of wetlands slowed and, in some places, reversed. Palustrine temporarily flooded and seasonally flooded wetlands still were being lost, but that was offset by the addition of ponds and deeper water habitats (Dahl 2006, Dahl 2011).

Many organizations and agencies have put much effort into conserving and managing some outstanding examples of Nebraska's wetland resources. These entities have acquired or protected approximately 50,000 acres of wetlands in Nebraska; however, this represents less than 3% of the remaining wetlands in the state. Examples of some public areas to visit are provided in the Nebraska's Regional Wetland Complexes section of this guide. A statewide list of public wildlife management areas, many of which contain wetlands, is available from Nebraska Game and Parks.

Wetland Acreage Comparison



SOURCE – DAHL 1990

Wetland Conservation Efforts

It is beyond the scope of this publication to deal in-depth with all the wetland conservation efforts underway in Nebraska. Listed below are statewide initiatives, and regional initiatives are covered in the respective sections under Nebraska's Regional Wetland Complexes.

Wetland Restoration, Enhancement, and Management Assistance — Private landowners are a key partner in doing any wetland conservation work as most wetlands are located on private lands. Programs are available to assist these land stewards with the restoration, enhancement and management of their wetland areas. These programs provide up to 100% cost-share and are flexible enough to meet the needs of most landowners. For farmers and ranchers, these programs can provide options that benefit wetlands and keep their land in production. For assistance or additional information, contact your nearest Nebraska Game and Parks Commission office or the headquarters office at P.O. Box 30370, Lincoln, NE 68503, (402) 471-5436. The U.S. Fish and Wildlife Service (308-382-6468) or your local Natural Resources Conservation Service office can also provide assistance as can many conservation organizations, such as Ducks Unlimited (517-242-6207).

Acquisition — Several agencies have programs to acquire wetlands, on a willing seller basis, by fee title (e.g., state wildlife management areas) or by easement (e.g., the USDA Wetland Reserve Easements program). Contact your nearest Nebraska Game and Parks Commission office, or the headquarters office, P.O. Box 30370, Lincoln, NE 68503, (402) 471-5436 or 5535. The U.S. Fish and Wildlife Service, your local Natural Resources Conservation Service office, Ducks Unlimited or other conservation organizations also may be able to help.

River otters are one of many types of wildlife that benefit from the conservation of wetlands in Nebraska. MICHAEL FORSBERG

Water Quality Programs — Wetlands are incorporated into several water quality improvement programs and the state water quality standards. Contact the Nebraska Department of Environment and Energy, P.O. Box 98922, Lincoln, NE 68509, (402) 471-2186.

Legal Protection — Several laws are in place to protect existing wetland areas and the benefits that they provide. The federal Clean Water Act may require that a Section 404 permit be obtained from the U.S. Army Corps of Engineers prior to draining, filling, placing objects, or digging in a wetland or other water area. Contact the U.S. Army Corps of Engineers, 8901 South 154th St., Suite 1, Omaha, NE 68138, (402) 896-0723. The Nebraska Department of Environment and Energy considers wetlands to be waters of the state and protects them from degradation (Nebraska Surface Water Quality Standards, Title 117). Contact the Nebraska Department of Environment and Energy, P.O. Box 98922, Lincoln, NE 68509, (402) 471-2186.

Landowners who receive federal farm program benefits need to follow the wetland rules contained in the Swampbuster provision of the federal Farm Bill to maintain their eligibility for benefits. This program is administered by the Natural Resources Conservation Service.

Outreach, Education, and Planning — A variety of outreach, education and planning efforts address wetlands. Project Aquatic WILD and Project WET provide teachers and school children with wildlife and wetland curricula materials that may be used in formal and informal education settings. For Project WILD, contact the Nebraska Game and Parks Commission, P.O. Box 30370, Lincoln, NE 68503, (402) 471-5363. For Project Wet, contact the Nebraska Forest Service Conservation Education Program, P.O. Box 830965, Lincoln, NE 68583, (402) 472-2944, nfs.unl.edu/education. Additional outreach materials are available from the Wetland Program Manager, Nebraska Game and Parks Commission, P.O. Box 30370, Lincoln, NE 68503, (402) 471-5436. Visit NebraskaWetlands.com to find links to a variety of wetland educational materials.

What You Can Do

If you are interested in helping to conserve wetland resources, there are many ways to help:

• Purchase a Federal Migratory Bird Hunting and Conservation Stamp, otherwise known as the duck stamp, and a Nebraska Habitat Stamp and Waterfowl Stamp. Wetland conservation is a high priority of the Nebraska Game and Parks Commission, and these efforts are funded through the sale of habitat and waterfowl stamps, and hunting, big game, fishing, and fur harvest permits. Revenue received through the sale of waterfowl and habitat stamps all go into wildlife habitat projects. Some contributions to the Nebraska Game and Parks Commission's Nongame and Endangered Species Fund also go toward wetland projects.

• Join and support conservation organizations that work with wetlands.

• Volunteer to adopt a wetland area. There are many projects that could use your help.

• Participate in wetland restoration and management. If you own land, there are numerous programs available to help you with your wetland. If you do not own land, inform your friends and neighbors who do about these opportunities and encourage them to participate.

• Learn more about wetlands and share your knowledge with others including school classes and youth groups.

• Support wetland conservation legislation, programs and proposals. Be active in policy decisions – your voice counts.

• Seek to incorporate wetland conservation into city, county, and natural resources district planning.

• Report potentially illegal wetland drainage. Many activities are allowed in wetlands; however, if you are uncertain, contact the U.S. Army Corps of Engineers at (402) 896-0723 and/or your local Natural Resources Conservation Service office.

Get out to explore and learn about the amazing wetlands Nebraska has to offer. GRANT REINER , PLATTE BASIN TIMELAPSE

Wetland Conservation Approaches

Due to the benefits provided by wetlands, there is a need for continued conservation. This is especially important for some areas due to past wetland losses and continued threats to the wetlands. The following list provides some general statewide recommendations for wetland conservation. These approaches should be tailored to meet the unique needs of each regional wetland complex.

Most wetlands in Nebraska are on private land. There are many options available to help landowners retain, restore or manage their wetlands. Contact the Nebraska Game and Parks Commission or one of our partners like the Natural Resources Conservation Service, to learn more.
JOANNA POPE, USDA, NATURAL RESOURCES CONSERVATION SERVICE

Retain — Because a vast majority of Nebraska's wetlands are in private ownership, the conservation of these areas requires understanding and meeting the unique needs of landowners. A variety of tools already are available to allow this to happen, but new ones also need to be developed.

Alternative ways to retain our remaining wetlands also need to develop. These could include the use of easements to retain areas while allowing them to remain in private ownership, changes in the tax code that favor wetland retention, and seeking ways to help landowners generate more income from their wetland areas.

In addition, efforts to acquire important wetland areas need to be continued. Several conservation partners have programs to help.

Finally, laws that retain existing wetlands, such as the Clean Water Act, Nebraska Environmental Protection Act and Title 117 – Nebraska Water Quality Standards, and Farm Bill, need to be maintained. It is important that these laws continue to recognize the complex dynamics of wetlands and the fact that not all wetlands serve the same functions. It also is important to continue to work with landowners in finding ways to make wetland retention compatible with their interests and needs.

Restore — Simply retaining our remaining wetland areas will not be adequate to ensure the conservation of our wetland systems and the benefits they provide. This is especially true for some wetland complexes where more than 90% of the wetlands have been eliminated or severely degraded. Efforts to restore wetlands, both on public and private land, need to be increased.

Manage — Given that wetlands are dynamic systems historically disturbed frequently, it may not be adequate to simply put a fence around a wetland and "walk away" from it. In the absence of natural processes and disturbances, wetlands need some

There is still a lot to learn about wetlands and the wildlife that use them. Here researchers capture and place radio transmitters on Trumpeter Swans in the Sandhills to learn more about their habits and movements. MICHAEL FORSBERG

management. Management might include water-level changes, tree removal, burning, prescribed grazing and haying, and sediment removal. There is a need to increase management assistance, especially to private landowners.

Inventory — For many of Nebraska's wetland complexes, our knowledge of the number and distribution of wetlands is very limited. This is especially true for many of our riparian, or streamside, wetlands. Inventories need to be completed and/or analyzed for these areas. National Wetland Inventory maps for parts of Nebraska are based on aerial photography from the early 1980s, and maps in these areas need updating.

Research — There is a need to obtain better information on how wetlands function. This is especially true for some of the lesser-known wetland complexes.

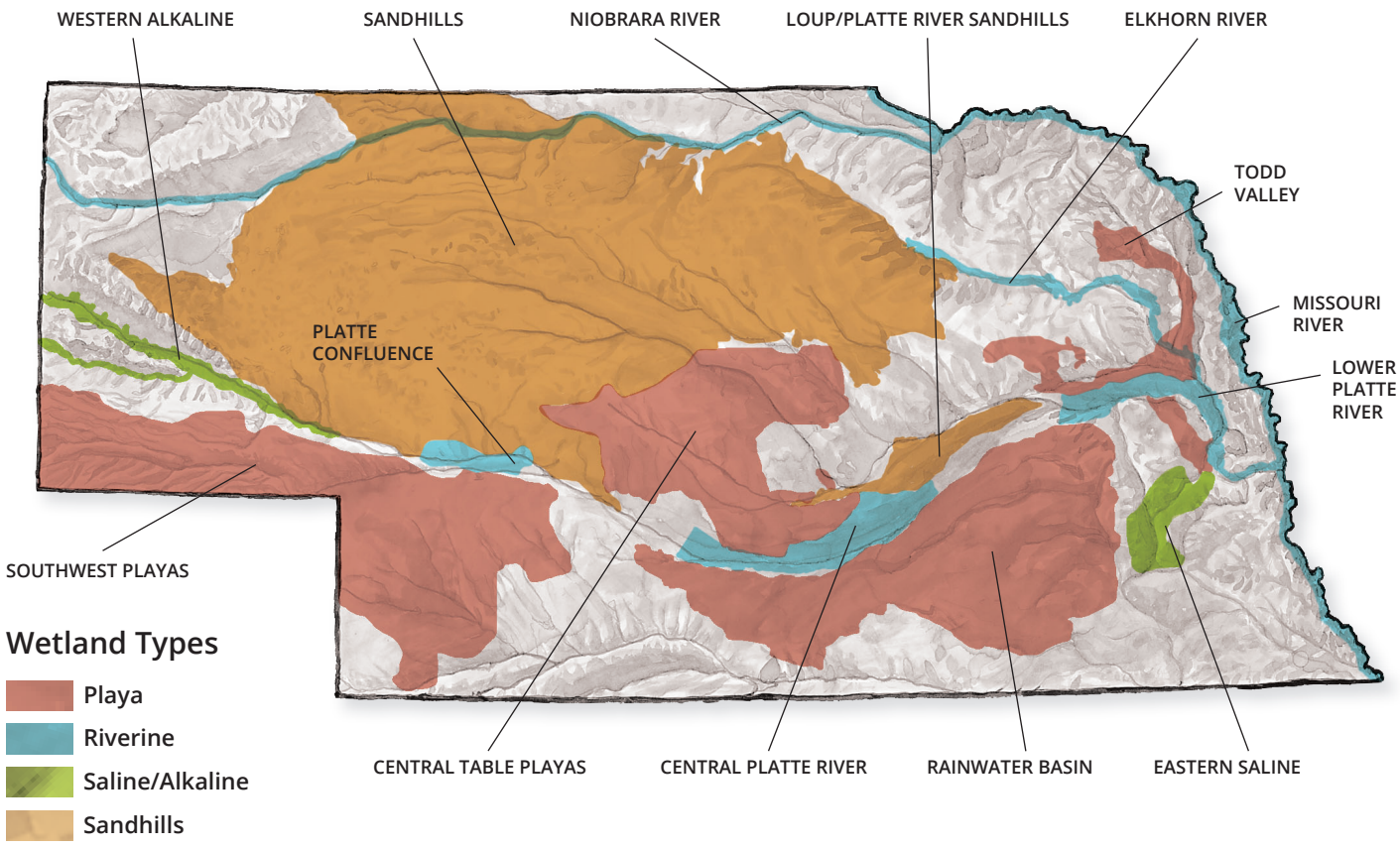
Education — Wetlands will be conserved only if we all understand the benefits provided by wetlands. Emphasis on, and support for, wetland education needs to continue.

Participants in Girls, Inc., from Omaha, discover the wonder of wetlands, including this freshwater mussel, at Two Rivers State Recreation Area in Douglas County. Wetlands are great places to explore and learn. AMBER SCHILTZ, NEBRASKA GAME AND PARKS COMMISSION

NEBRASKA'S REGIONAL WETLAND COMPLEXES

Wetlands occur throughout Nebraska, but for many purposes it is useful to identify some of the larger wetland complexes. A complex is considered a geographically definable concentration of wetlands similar in form and function. The basis for these complexes and much of the information was adapted from the Nebraska Game and Parks Commission's Nebraska Wetlands Priority Plan (Gersib 1991). These boundaries were refined, new boundaries added, and wetland acreage and number statistics generated following procedures described by LaGrange et al. (2005).

The wetland complexes are grouped into four categories: playas, sandhills, saline/alkaline and riverine. Six of the complexes were ranked by Gersib (1991) in the Nebraska Wetlands Priority Plan, and the rankings received were based on wetland functions, losses, and threats. The remaining eight complexes were not discussed or scored by Gersib (1991), and the information available for these complexes is considerably less.



Nebraska's regional wetland complexes consist of four types of wetlands: Playa, Riverine, Saline/Alkaline and Sandhills. Even if a wetland is not located within one of these four complexes, it still is an important component of our ecosystem. TIM REIGERT, NEBRASKALAND

Acres of Wetlands by Complex

COMPLEX NAME	ESTIMATED WETLAND ACRES REMAINING[1]	STATUS[2]
Rainwater Basin	34,103	Endangered
Central Table Playas	7,317	
Southwest Playas	21,680	
Todd Valley	2,662	Endangered
Sandhills	369,606	
Loup/Platte River Sandhills	8,174	
Eastern Saline	3,244	Endangered
Western Alkaline	10,703	
Central Platte	40,761	Endangered
Platte Confluence	14,280	Endangered
Lower Platte	33,422	Endangered
Missouri River	61,430	Endangered
Elkhorn	26,396	
Niobrara	30,633	

[1] Based on analysis of National Wetland Inventory (NWI) Data (LaGrange et al. 2005).

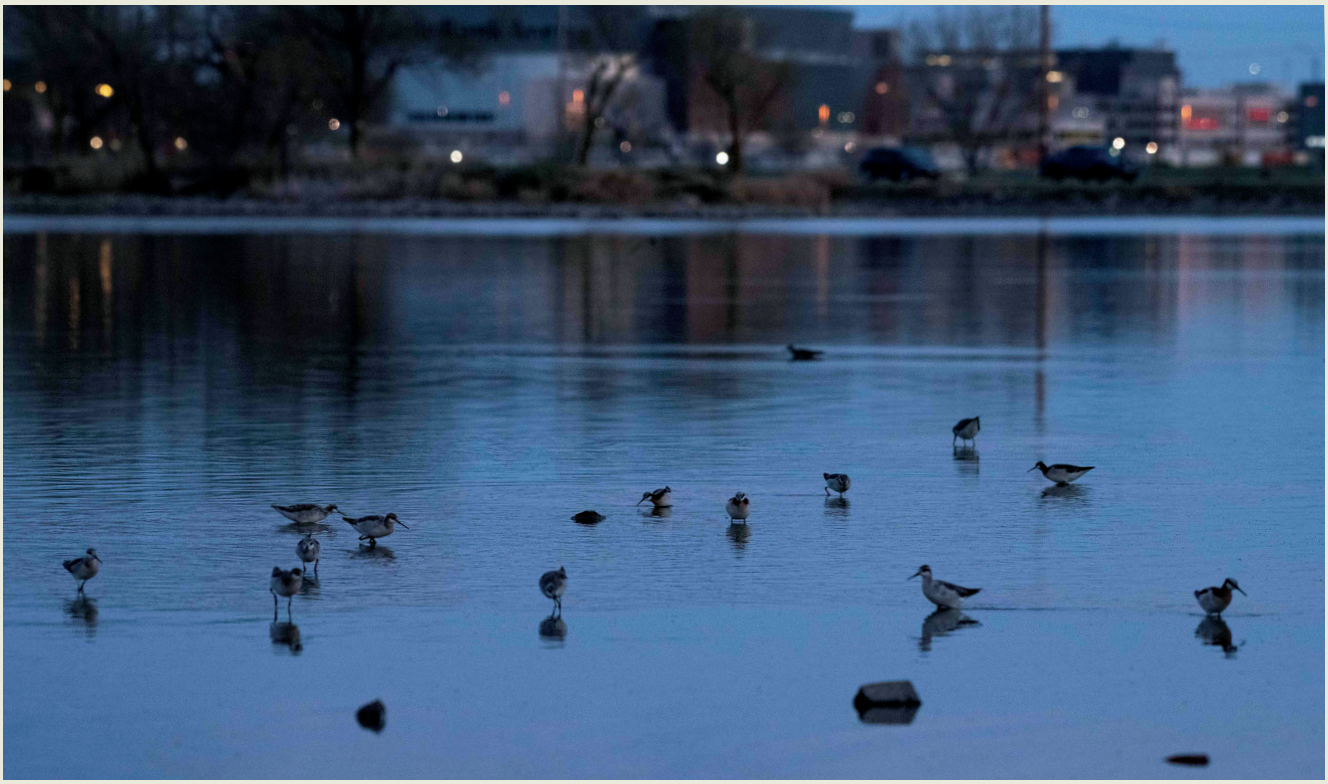
[2] Based on past losses and projected future threats. The other complexes face threats but are not considered endangered.

A pied-billed grebe floats on a wetland at the edge of a lake in the Sandhills. GRANT REINER, PLATTE BASIN TIMELAPSE

Urban Wetlands

Wetlands are in and around our towns and cities, or urban areas, and they help improve and enrich the lives of the people living there. Some of these wetlands are natural, and others have been highly modified or created. Not only can these wetlands provide habitat for fish and wildlife, but they also filter and improve water quality and reduce downstream flooding by storing stormwater runoff. These wetlands also provide important green spaces that offer a place to relax and unwind or a place to recreate for those looking to walk, bike, fish, observe wildlife, or explore nature.

The North Platte River has wetlands all along the channel, including here at Riverside Park in Scottsbluff, with Scotts Bluff National Monument pictured in the upper left.
DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE



Spring migrating shorebirds stop to rest and feed at Oak Lake, an urban wetland in Lincoln, giving people an opportunity to observe a small step in the incredible journey these birds are on. DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

Playa Wetlands

Playa wetlands are wind-formed depressions located in semi-arid areas. Many are nearly circular or oval, but others have more irregular boundaries. They have a clay layer in the soil under the wetland that when wet, ponds water on the surface and slows the movement of the water into the ground. This clay layer was formed by water movement over thousands of years. Most playas are not directly connected to groundwater. The major playa complexes in Nebraska include the Rainwater Basins, Central Table Playas, Southwest Playas, and the Todd Valley.

Playa wetlands are wind-formed depressions that pond water over a clay layer in the soil. This Southwest Playa in Chase County is farmed in most years.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

RAINWATER BASIN

Profile

The Rainwater Basin complex was named for the abundant natural wetlands that formed where clay-bottomed depressions catch and hold rain and runoff water. It covers a 6,150-square-mile area across all or parts of 21 counties in south-central Nebraska. The landscape of the complex is characterized by flat to gently rolling plains formed by deep deposits of wind-blown silt-loam soil. The wetlands were formed by wind action and tend to have a northeast to southwest orientation. There frequently is a hill, or lunette, located immediately south or southeast of the wetland where the windblown loess was deposited. Natural surface water drainage in the region is poorly developed, resulting in numerous closed watersheds draining into these wetlands. Most of the wetlands in this region do not receive groundwater inflow. Wetlands range in size from less than 1 to more than 1,000 acres.

Loss and Threats

Analysis of the historic soil surveys (1910-1917), National Wetland Inventory (1980-1982), and Soil Survey Geographic (SSURGO) data (1961-2004) indicated playa wetlands were once a prominent feature of this landscape. Combined, these datasets identified approximately 11,000 individual playa wetlands comprising 204,000 acres that were historically part of the landscape (RWBJV 2013a). It has been estimated more than 1,000 semipermanent and seasonal wetlands covered over 70,000 acres, and more than 10,000 temporary wetlands accounted for an additional 134,000 acres.

A Nebraska Game and Parks Commission breeding waterfowl habitat survey (McMurtrey et al. 1972) used the historic soil surveys as a reference to evaluate the distribution of remaining wetlands. McMurtrey et al. (1972) reported 82% of the major wetlands had been converted to agriculture, removing approximately 63% of the total wetland acres from the landscape. The fast-paced degradation continued, and by 1982, only 10% of the surveyed wetlands remained. The remaining wetlands represented only 22% of the original surveyed acres, and virtually all were hydrologically impaired (Schildman and Hurt 1984).

This trend study did not attempt to estimate the quantity and quality of smaller wetlands that were not identified on early soil surveys. However, because small wetlands are more vulnerable to destruction, it is likely that the proportion of loss documented by Schildman and Hurt for larger wetlands is even greater for the smaller wetlands.

Using National Wetland Inventory digital data and contemporary soil survey maps, a multiagency wetland team in 1990 identified 34,103 acres of

Rainwater Basin wetlands remaining (Raines et al. 1990), and of these only 28,260 acres were naturally occurring palustrine wetlands (Smith and Higgins 1990). Using National Wetland Inventory data updated in 2011, the Rainwater Basin Joint Venture found 44,198 acres of palustrine wetlands (RWBJV 2013a); the increase is likely due to improved aerial imagery and techniques and restoration efforts. These studies indicated that palustrine, or marsh-like, emergent wetlands have decreased over the long-term, and virtually all remaining wetlands have been degraded in some fashion. Given all the various data sources, the current best estimate of wetland loss is: Of the historic average of about 204,000 wetland acres, roughly 40,000 acres, or about 17%, remain (RWBJV 2013a). Playa wetlands in the Rainwater Basin make up less than 1% of the total landscape (Bishop and Vrtiska 2008; Bishop et al. 2011).

Rainwater Basin wetlands were identified by the U.S. Fish and Wildlife Service as one of nine areas in the U.S. of critical concern for wetland losses (Tiner 1984). Rainwater Basin wetlands were given the highest ranking, a Priority 1, in the Nebraska Wetlands Priority Plan (Gersib 1991). The remaining wetland resources of the Rainwater Basin complex continue to face numerous threats, mostly related to conversion to cropland. Rainwater Basin wetlands face the direct threat of elimination by drainage and/or filling. The construction of concentration pits, also called dugouts or reuse pits, was once common, and these pits threaten the functions of wetlands by converting shallow productive water spread over a large area into a smaller, deep, and less productive water pit. Water pollution, especially culturally accelerated sediment washing into the wetlands from surrounding crop fields (LaGrange et al. 2011), can seriously reduce the functions of Rainwater Basins. Additionally, nearly all Rainwater Basin wetlands are threatened by changes to their watershed that divert water away from them or concentrate upland runoff water into concentration pits. Of greatest concern is the cumulative impact of these threats that cause shallow wetlands to lose a few inches of water and then no longer function as wetlands.

Several invasive plant species threaten these wetlands. The spread of an aggressive cultivar of reed canary grass is a major threat. Reed canary grass forms dense, uniform stands in wetlands and provides minimal habitat for water birds. Introduced purple loosestrife and European common reed (also called Phragmites) have been found in some of the wetlands and are additional threats. A hybrid cattail, a cross of native broad-leaf cattail and introduced narrow-leaf cattail, is very aggressive and becoming a major threat. Although a native species, river bulrush can form dense stands, especially in areas with culturally accelerated sediment. Trees were not a native component of Rainwater Basin wetlands and are now

About 30% of the continental population of northern pintails use the Rainwater Basin during spring migration.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

Rainwater Basin playa wetlands are internationally recognized for their importance to migrating waterfowl. ETHAN FREESE, PLATTE BASIN TIMELAPSE

considered to be invasive in these wetlands.

Benefits

Rainwater Basin wetlands are most noted for their importance to waterfowl, especially during the spring migration (Gersib et al. 1989a, Gersib et al. 1992). The North American Waterfowl Management Plan lists the Rainwater Basin as an area of greatest continental significance to North American ducks, geese, and swans (U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries 2012). They host an estimated 8.6 million spring-migrating ducks and geese annually, providing the foods to build nutrient reserves necessary for migration and reproduction further to the north (RWBJV 2013a). Previous studies have suggested that approximately 90% of the mid-continent population of greater white-fronted geese, 50% of the mid-continent population of snow geese, 50% of the mid-continent population of mallards and 30% of the continent population of northern pintails use the Basins during spring migration. The numbers can vary greatly from year to year, and some recent information indicated that the number of greater white-fronted geese using the Basins has declined. During very wet years, ducks will breed in relatively high numbers in the Rainwater Basin and also will produce substantial numbers of ducks (Evans and Wolfe 1967). As of 2012, 358 bird species have been recorded in the Rainwater Basin (Jorgensen 2012). It is estimated that 600,000 shorebirds representing 40 species migrate through the Basins during the spring (Jorgensen 2005, RWBJV 2013a), and the region has been identified as a site of hemispheric importance in 2009 by the Western Hemisphere Shorebird Reserve Network.

Some notable shorebird species include the buff-breasted sandpiper, Hudsonian godwit, American golden plover, and lesser yellowlegs. The Rainwater Basin was historically an important area for the Eskimo curlew, but sadly it is now very likely this species is extinct due to habitat loss and unregulated harvest during the late 1800s and early 1900s. Thirty-four species of waterbirds including herons, egrets, rails, terns and gulls have been observed in the Rainwater Basin. Rainwater Basin wetlands are regularly used by the state and federally endangered whooping crane and the threatened piping plover.

A waterfowl hunter enjoys a morning on the Bluebill Wildlife Management Area in Fillmore County. This restored wetland is one of many conservation successes that were the result of the work of many partners using many different funding sources, including the money that hunters pay to support wildlife conservation. ETHAN FREESE, PLATTE BASIN TIMELAPSE

These wetlands provide breeding habitat for a variety of wetland-dependent birds that nest in Nebraska, especially during years with abundant water. Rainwater Basins also provide important habitat for insect pollinators (Begosh et al. 2020) and for amphibians (Beas and Smith 2014, Smeenk 2019). The Rainwater Basin is considered a Biologically Unique Landscape (see page 65) in the Nebraska Natural Legacy Project's State Wildlife Action Plan (Schneider et al. 2011).

Rainwater Basin wetlands provide benefits in the form of groundwater recharge (Wilson 2010), flood storage, reduction of water pollutants (Foster 2010), and sediment trapping (LaGrange et al. 2011). Nitrate levels in the groundwater under the Rainwater Basin region are high in many locations (clearinghouse.nebraska.gov), and the wetlands can play an important role in helping to reduce nitrate pollution. Groundwater recharge through playa wetlands is significant, and happens through cracks that form in the clay layer during dry times. As water flows into a wetland with cracks, a large volume of it flows downward toward the aquifer (Gurdak and Roe 2009, Wilson 2010). Rainwater Basin playas also provide services of carbon storage and greenhouse gas emission reduction (Daniel et al. 2019).

Nearly all Rainwater Basin wetlands provide opportunities for recreation, particularly hunting and wildlife observation. Waterfowl hunting remains very popular throughout the region (Fontaine et al. 2019), but opportunities tend to vary by location and time due to the dynamic nature of playa wetlands. Consequently, public land managers often pump groundwater into select wetlands to enhance wildlife habitat and waterfowl hunting opportunities, especially during dry years.

The diverse plant communities associated with Rainwater Basin wetlands also provide habitat for many resident wildlife species, including ring-necked pheasants. Pheasant populations thrived in the Rainwater Basins during the 1950s and 1960s, attracting resident and nonresident hunters to the region each fall (Baxter and Wolfe 1973). Over time, agricultural land use intensified, which greatly reduced the availability of suitable cover for pheasants throughout the region. Although today's pheasant populations (and associated hunting opportunities) are much more isolated, pheasant hunting remains very popular. The region's network of publicly accessible lands continues to provide an important resource for upland bird hunters, especially those living in Nebraska's urban population centers (Fontaine et al. 2019).

Conservation Success Stories

Although the Rainwater Basin landscape is highly

altered, the wetlands there still provide many benefits, and the altered ones can be restored. Delivering conservation in this area requires the ability to work in partnership with agriculture and private landowners and numerous agencies and organizations.

A major success story was the development of a partnership called the Rainwater Basin Joint Venture in 1992. The joint venture was established as part of the North American Waterfowl Management Plan, but a unique feature is that it was a homegrown partnership that developed locally. The joint venture has continued to grow and evolve, and current partners on the board include: landowners, Nebraska Natural Resource Districts, Ducks Unlimited, Pheasants Forever, The Nature Conservancy, Lindsay Corporation, Nebraska Game and Parks Commission, Natural Resources Conservation Service, USDA Farm Services Agency, and the U.S. Fish and Wildlife Service. The joint venture's goals, objectives, targets, and strategies are listed in the implementation plan (RWBJV 2013a).

A variety of conservation programs are available from the joint venture partners, and all are voluntary. Improvements have been made to many thousands of acres on public and private lands. Many studies have been done that provide information on how to improve what the joint venture does and to document the responses by wildlife and the other benefits provided. Those responses have been very positive by the wetland wildlife, improvements in water quality and groundwater recharge, and to the people who benefit. Website: rwbjv.org.

Contacts

Rainwater Basin Joint Venture — Contact the Rainwater Basin Joint Venture coordinator, 2550 N. Diers Ave., Suite G, Grand Island, NE 68803, (308) 382-8112.

Other contacts include the Nebraska Game and Parks Commission office in Kearney, (308) 865-531, or in Lincoln, (402) 471-5561; the U.S. Fish and Wildlife Service office in Funk, (308) 263-3000; and the Ducks Unlimited office in Grand Island, (517) 242-6207.

Select Public Use Areas

This is not a complete listing of public areas but instead is a list of representative areas that are geographically dispersed and accessible.

- Eckhardt Waterfowl Production Area (WPA), 4 miles north, 3 miles west of Ong, Clay County
- Harvard WPA, 3 miles west of Harvard, Clay County
- Hultine WPA, 6 miles east of Harvard, Clay County
- Kissinger Wildlife Management Area (WMA), 1 mile north of Fairfield, Clay County
- Massie WPA, 3 miles south of Clay Center, Clay County
- Verona Ducks Unlimited property, 2 miles north, 3 miles east of Clay Center, Clay County
- Mallard Haven WPA, 2 miles north of Shickley, Fillmore County
- Rauscher WPA 1 miles south, 4 miles east of Sutton, Fillmore County
- Pintail WMA, 5 miles south, 2 miles east of Aurora, Hamilton County
- Springer WPA, 2 miles south, 7 mlies west of Aurora, Hamilton County
- Teal View Wetland Education Area owned by Upper Big Blue NRD, 5 miles north of Hampton, Hamilton County
- Gleason WPA, 4 miles south, 4 mlies west of Minden, Kearney County
- Jensen WPA, 6 miles north of Campbell, Kearney County
- Cottonwood WPA, 2 miles west, 1 mile north of Bertrand, Phelps County
- Funk WPA, 1 mile north of Funk, Phelps County
- Lake Seldom, 0.5 miles south of Holdrege, Phelps County
- Sacramento WMA, 2 miles west of Wilcox, Phelps County
- North Lake Basin WMA, 1 mile north of Utica, Seward County
- Straightwater WMA, 1 mile south, 1 mile west of Tamora, Seward County
- Father Hupp WMA, 2 miles west of Bruning, Thayer County
- Kirkpatrick Basin North WMA, 4 miles west, 2 miles south of York, York County
- Marsh Duck WMA, 3 miles west, 2 miles south of Utica, York County
- Sinninger WPA, 2 miles south, 3 miles east of McCool Junction, York County

The Rainwater Basin is designated as a site of hemispheric importance to shorebirds, such as the red-necked phalarope, Wilson's phalarope, dunlins, semipalmated sandpipers, and white-rumped sandpipers pictured here using a Rainwater Basin wetland during spring migration. These birds are long-distance migrants, with some species wintering in South America and nesting in the arctic. JOEL JORGENSEN, NEBRASKA GAME AND PARKS COMMISSION

CENTRAL TABLE PLAYAS

Profile

Central Table Playa wetlands are situated on relatively flat, loess soil tablelands surrounded by a landscape highly dissected by drainages. The largest cluster of wetlands is located near the town of Arnold in Custer County, but similar wetlands are scattered in some of the surrounding counties. A particularly large wetland basin located 11 miles east of Arnold has been the source of much speculation that its formation was caused by meteorite impact. However, investigations suggest it is of wind-formed origin, like other playa wetlands (Flowerday 2001). Central Table Playas receive water from runoff and are small (mostly less than 5 acres), temporarily and seasonally flooded wetlands. The complex may represent an extension of the Southwest Playas east toward the Rainwater Basin and Todd Valley complexes. The wetlands in this complex are possibly remnants of a larger area of wetlands that was naturally eroded, breached and drained by streams. It's unknown why this area has a more developed natural drainage pattern than the other complexes.

Loss and Threats

Based on hydric soil mapping units and depressional wetland points defined in the Soil Survey Geographic Database, as well as the palustrine wetlands delineated in the National Wetlands Inventory, it is estimated over 6,300 playas covered more than 18,000 acres (RWBJV 2013a). Based on an assessment of aerial photography completed in 2010, just over half of these playas, or 3,470 individual wetland footprints, continue to demonstrate some level of function, such as ponding water or growing hydric vegetation (Bishop et al. 2011).

Some of the wetlands have been modified by concentration pits or drained by ditches. In some locations, the hydrology of the watershed has been altered by the placement of terraces and diversions that reduce the amount of water entering the wetlands. Most of the Central Table Playas are farmed as conditions allow. Culturally accelerated sedimentation is an ongoing threat (LaGrange et al. 2011).

Benefits

Our understanding of the benefits of the Central Table Playa wetlands is limited by the lack of information, but they likely provide groundwater recharge and water quality improvement services. The wetlands are often visited by endangered whooping cranes during migration. These wetlands also provide habitat for migrating waterbirds, including waterfowl, shorebirds, and wading birds. The Central Table Playas are mostly within the Central Loess Hills Biologically Unique Landscape (Schneider et al. 2011).

Conservation Success Stories

A coordinating wildlife biologist, along with several partners, has worked in the area to quantify wildlife use of the playas. In addition, this biologist has helped develop conservation programs and make landowners aware of these opportunities. It has been challenging to find the best program fit, but several landowners are participating in USDA wetland conservation programs, and efforts continue to identify what

Endangered whooping cranes use many Nebraska wetlands, including Central Table Playas, during their spring and fall migrations. ERIC FOWLER, NEBRASKALAND

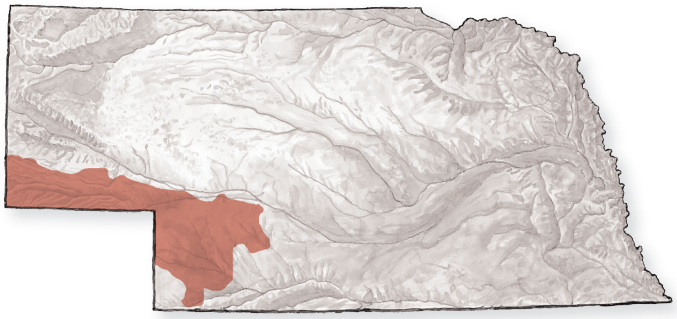
options will be the most successful. Website: NebraskaNaturalLegacy.org.

Contacts

Coordinating wildlife biologist in Ord, (308) 728-3244, or the Nebraska Game and Parks Commission office in North Platte, (308) 535-8025, or Kearney, (308) 865-5310.

Select Public Use Areas

- Berggren-Young WMA, 2 miles east of Merna, Custer County



SOUTHWEST PLAYAS

Profile

The playa wetlands of southwest Nebraska occupy small clay-lined depressions on nearly flat lands of loess soil. These freshwater wetlands receive water from runoff and are small (mostly less than 5 acres), temporarily and seasonally flooded wetlands. Most have no natural outlet for water. In most years, these wetlands dry early enough in the growing season to be farmed. Southwest Playa wetlands are like the Rainwater Basin wetlands farther east, except that the Rainwater Basin complex receives greater rainfall, and the wetlands there tend to be larger.

Loss and Threats

Due to the small amount of annual rainfall received (16-18 inches per year) in the Southwest Playa region, there has been less drainage of these wetlands than has occurred in many other complexes. Some of the wetlands are drained into concentration pits or road ditches, but most simply dry up naturally and are farmed. Wheat is the dominant crop in the area, but corn and soybean acreage has been increasing. In some locations, the hydrology of the watershed has been altered by the placement of terraces that reduce the amount of water entering the wetlands. These terraces also reduce the amount of eroded soil entering the wetlands. Because culturally accelerated sediment filling the wetlands is an added threat to the

Ring-necked pheasants are an important game bird, and they benefit greatly if wetlands are nearby to provide places to nest, feed, and escape winter weather. MIKE FORSBERG, NEBRASKALAND

Playas (LaGrange et al. 2011), soil erosion treatments are needed in the watershed of these wetlands. However, care needs to be taken to ensure erosion treatments do not reduce the wetland's water source.

Benefits

Our understanding of the benefits of the Southwest Playa wetlands is somewhat limited. A study was completed in 2006-2008 that documented their role in providing important habitat for migrating waterfowl and shorebirds (Cariveau and Pavlacky 2009). In addition, these wetlands provide important habitats for ring-necked pheasants. These water areas are especially important to wildlife in the dry High Plains region of the United States of America where wetlands often are scarce. The North American Waterfowl Management Plan lists portions of the Southwest Playa complex as an area of greatest continental significance to North American ducks, geese, and swans (U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries 2012).

Conservation Success Stories

This landscape is predominately located in farmland, and programs have been developed to help landowners with wetland conservation options. There has been a lot of interest in the management and access opportunities through the Open Fields and Waters program administered by the Nebraska Game and Parks Commission. USDA wetland programs also have been used, with eight properties enrolled in the Wetland Reserve Easements Program, and many more

in the Conservation Reserve Program for wetlands. Ducks Unlimited also has worked with landowners to restore several playas. Website: nrcs.usda.gov, search "wetland reserve easements."

Contacts

The Playa Lakes Joint Venture is a multistate partnership for wetland and bird conservation that covers portions of western Nebraska. Contact the Playa Lakes Joint Venture coordinator, 2675 N. Park Drive, Suite 208, LaFayette, CO 80026, (303) 926-0777.

Other contacts include the Nebraska Game and Parks Commission office in North Platte, (308) 535-8025, or Alliance, (308) 763-2940.

Select Public Use Areas

None

TODD VALLEY

Profile

The complex is split into two regions. The region south of the Platte River is in an ancient valley of the Platte River (termed the Todd Valley) that runs northwest to southeast through part of Saunders County (Lueninghoener 1947). The valley has partially filled with sand deposits and fine, windblown loess soils after the river moved to its present location. The region north of the Platte River is located on an ancient floodplain terrace between the Platte River and Shell Creek and along Logan Creek. Todd Valley wetlands occupy small, clay-lined, closed depressions located in loess soils. They are mostly fresh-water, seasonally and temporarily flooded wetlands that receive most of their water from runoff.

Loss and Threats

Losses within this wetland complex have not been quantified. However, examination of soil maps and wetland maps, combined with limited site visits, suggest that many Todd Valley wetlands have been altered or eliminated. These losses have been caused by concentration pits, drainage and road ditches,

A monarch caterpillar feeds on swamp milkweed flowers in a small wetland at Bobcat prairie in Lancaster County.
DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

tile lines, and in some areas by agricultural drainage wells that drain water into the underlying sand layers. The principal threat facing Todd Valley wetlands is continued conversion to agricultural production.

Benefits

Todd Valley wetlands provide benefits like those of Rainwater Basin wetlands. Because the individual wetlands tend to be smaller than Rainwater Basin wetlands, and the total complex size is smaller, overall, they do not attract concentrations of migratory waterbirds as large as the Rainwater Basin wetlands do but may be proportionally similar. A recent study did document use of these wetlands by 26 waterfowl species, 24 shorebird species and 13 waterbird species (Jorgensen and Brenner 2020). Little is known about the hydrologic functions of the Todd Valley wetlands.

Conservation Success Stories

As with our other playa wetland complexes, there are USDA programs available to help restore playas and several landowners have participated in these programs. More work is needed to try and find the best program options for landowners in this area. There were several playa wetlands restored on the east side of Lake Wanahoo. The Wilkinson Wildlife Management Areas is an excellent wetland that was restored through the work of the Todd Valley Wetland Association. Website: nrcs.usda.gov, search "wetland reserve easements."

Contacts

Nebraska Game and Parks Commission office in Lincoln, (402) 471-5561, or Norfolk, (402) 370-3374.

Select Public Use Areas

- Wilkinson WMA, 2 miles south of Platte Center; not a playa wetland, but adjacent to some. Platte County.
- Lake Wanahoo, 2 miles north of Wahoo; has several small playas on the east side. Saunders County.

Sandhills Wetlands

These wetlands are formed in depressions in sandhill areas where groundwater intercepts the surface of the land. The most notable complex is the Sandhills. The other complex is the Loup/Platte River Sandhills. Additionally, sandhill-type wetlands are in southwest Nebraska, in the Sandhills Borders area along the Elkhorn and Niobrara rivers, and in scattered pockets south of the Platte River.

SANDHILLS

Profile

The Sandhills region of north-central Nebraska comprises what has been considered to be the largest contiguous tract of grassland remaining in the United States and the largest stabilized sand dune area in the Western Hemisphere. A recent study suggests the Sandhills is the largest intact temperate grassland in the world (Schlotz and Twidwell 2022). This region encompasses 19,300 square miles and overlies several extensive aquifers of the Ogallala Formation that

A thunderstorm moves across the Sandhills providing water that will help to recharge the Ogallala Aquifer. The aquifer helps to sustain more than a million acres of sandhill wetlands that are embedded in the largest intact temperate grassland in the world. Water is the lifeblood of this landscape and helps to support abundant fish and wildlife, a vibrant ranching community, and supplies water to much of eastern Nebraska. ETHAN FREESE, PLATTE BASIN TIMELAPSE

contains a storage capacity of nearly one billion acre-feet of water. This vast water resource occurs both in the underground aquifer and above ground in the form of wetland areas. Sandhills wetlands are mostly freshwater and include saturated wet meadows, shallow marshes, and the fringes of deeper lakes, rivers and streams.

An analysis of the original National Wetland Inventory digital data (based on aerial images from the 1980s) indicated that 369,606 acres of wetland were mapped in the Sandhills (LaGrange et al. 2005). The inventory maps for the Sandhills are being updated, and about half of the area has been updated using aerial photos, mostly from 2010. Comparing original inventory data to the updated content, about three times as many wetland acres have been mapped (Greg Brinkman, personal communication). The reason for the substantial increase is likely due to higher quality aerial imagery from wetter years and improved mapping technology. The increase in the acres of wetlands does not mean there was a change in the extent of wetlands. The water levels in the Sandhills can change a lot and are mostly related to changes in groundwater levels in response to differing amounts of precipitation. Rundquist (1983) used Landsat satellite generated imagery and mapped larger areas as wet meadow wetlands than did the original National Wetland Inventory. He estimated there were 177,000 acres of open water and marsh and 1,130,000 acres of wet meadows in the Sandhills, and that may be more in line with the updated inventory data. The wetlands in the Sandhills range in size from less than one acre to 2,300 acres; more than 80% of all wetlands are estimated to be 10 acres or less in size (Wolfe 1984). Numerous wetlands are also associated with the streams and rivers within the Sandhills and along the Loup River and its tributaries after they flow out of the Sandhills.

The Sandhills Alkaline Lakes Biologically Unique Landscape is in the western Sandhills. The wetlands here develop a white alkali crust due to high rates of evaporation and little water outflow. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Wetlands and rangelands in the Sandhills are mostly privately owned and benefit from the good stewardship of the region's ranching families. DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

Several unique wetland types are located within the Sandhills. The Nebraska Natural Heritage Program has identified fens within the Sandhills (Steinauer 1995), a rare wetland type both in the Sandhills and throughout the United States of America. Fens are characterized by slightly acidic water and peat or muck soils that form in areas fed with a nearly constant supply of groundwater. Fens harbor several rare plant species such as cotton grass, buckbean and marsh marigold. The current range of these plants is mostly in colder regions north of Nebraska, and the populations in the Sandhills are likely relics from a much cooler period that have survived in these specialized habitats. In the western Sandhills there are numerous highly alkaline wetlands (Steinauer 1994, Gosselin et al. 1994) that harbor unusual plants and invertebrate life. These alkaline wetlands are very attractive to shorebirds because of the invertebrate life they produce.

Loss and Threats

Wetland loss in the Sandhills has occurred primarily through draining by surface ditches, beginning as early as 1900 (McMurtrey et al. 1972, U.S. Fish and Wildlife Service 1960). With the introduction of center-pivot irrigation systems to the Sandhills in the early

Trumpeter swans were once extirpated from Nebraska. They have made a strong comeback thanks to reintroduction efforts and the abundant habitat provided by the Sandhills wetlands. ERIC FOWLER, NEBRASKALAND

Kayaking is a great way to explore wetlands, including this one in the Sandhills. GRANT REINER, PLATTE BASIN TIMELAPSE

1970s, land leveling/shaping and local water table declines resulted in extensive wetland loss in some areas. Though quantifiable data are not available for the Sandhills, estimates of wetland acres drained range from 15% (McMurtrey et al. 1972) to 46% (U.S. Fish and Wildlife Service 1986). Sandhills wetlands were given a Priority 1 ranking due to very extensive past losses in the Nebraska Wetlands Priority Plan (Gersib 1991).

Some Sandhills wetlands still are threatened by drainage to increase hay production. This drainage directly affects the lake or marsh where the project occurs and can lead to cumulative wetland loss downstream and upstream; as the channel becomes entrenched, it lowers the water table and causes lateral drainages to occur, affecting adjacent wetlands. Wetlands also are threatened in some areas by conversion from ranching to irrigated farming. Some non-native invasive species are threatening Sandhills wetlands, including the introduced variety of European common reed, reed canary grass, redtop, garrison creeping foxtail, narrow-leaf and hybrid cattail, purple loosestrife, Eurasian water milfoil, and common carp. These invasives can crowd out native species and alter their habitat. Eastern red cedars are native and do not generally grow in the wetlands. However, they have spread rapidly and are now invasive in the surrounding prairies; this alters the prairie and the hydrologic cycle in the wetlands.

Concentrated, large-scale irrigation development can result in long-term effects on wetland communities by lowering the groundwater table. Groundwater pollution, largely from agricultural chemicals and

Blanding's turtles are endangered in some surrounding states, but the population appears to be thriving in the Sandhills due to the extensive and high-quality wetlands there.
MARIAH LUNDGREN, PLATTE BASIN TIMELAPSE

concentrated livestock waste, is a threat to the historically excellent water quality in the Sandhills. Although nitrate levels in the groundwater under the Sandhills generally are low, they do exceed safe limits (10 mg/L) in some locations, especially in the eastern edge, likely due to fertilizer applications on cropped areas (clearinghouse.nebraska.gov). Poorly sited, large-scale energy development and associated infrastructure, such as roads, as well as similar large-scale developments, can negatively affect large tracts of continuous grasslands and their associated wetlands.

A potentially disastrous future threat is the sale and removal of groundwater to areas away from the Sandhills. With its extensive groundwater resources (Bleed and Flowerday 1990), the Sandhills area is sometimes touted for major water sales. Such a loss of water would greatly affect the region's lakes, marshes, and meadows because they are connected to the groundwater (Winter et al. 2001).

Benefits

Sandhills wetlands are extremely valuable to the region's ranchers and the ranching economy. These wetlands, especially the wet meadows, provide abundant and nutritious forage that is used as winter cattle feed. Wetlands also offer grazing sites and a source of water to livestock.

More than 300 species of birds have been recorded in the Sandhills region. Of these, over 125, including large numbers of waterfowl, shorebirds, and waterbirds, rely on wetland habitats (Bleed and Flowerday 1990). The North American Waterfowl Management Plan lists the Sandhills as an area of greatest continental significance to North American ducks, geese, and swans (U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries 2012). The Sandhills are the most important waterfowl production area in Nebraska and are considered by Bellrose (1980) to be the best duck production area south of the Prairie Pothole Region. Aerial surveys, corrected for visibility, conducted by the Nebraska Game and Parks Commission estimated an average of 94,576 ducks in the Sandhills during the 2003-2005 nesting seasons (Vrtiska and Powell 2011). However, with better wetland conditions, higher estimates (uncorrected for visibility) were observed in 1999-2002 than during the 2003-2005 nesting seasons (Vrtiska and Oldenburger 2002, and Matthew Garrick, pers. comm.). Thus, in years with more abundant precipitation, the actual number of breeding ducks in the Sandhills may exceed the estimates of Vrtiska and Powell (2011). The most common species of breeding ducks included mallard, blue-winged teal, gadwall, northern shoveler, and northern pintails,

Fens are a type of wetland that forms where cold groundwater continues to reach the surface even in dry years. This produces a micro climate that allows for ancient plants, such as this marsh marigold from the last Ice Age, to grow.
DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

with smaller numbers of American wigeon, American green-winged teal, wood duck, ruddy duck, redhead, and canvasback also present (Vrtiska and Powell 2011). Production from the Sandhills Canada goose flock provides a fall flight that exceeds 20,000 birds (M. Vrtiska, pers. comm.). Trumpeter swans likely nested in the Sandhills historically, but were extirpated by the late 1800s. A reintroduction effort occurred at Lacreek National Wildlife Refuge, located in South Dakota north of Merriman, in the early 1960s, and the flock slowly expanded. An aerial survey of a portion of the Sandhills in 2016 and 2017 counted approximately 100 nesting pairs of trumpeter swans (M. Vrtiska, unpublish. data). There were 1,235 trumpeter swans counted in the 2022 mid-winter survey, which are mostly Sandhills-raised birds (M. Garrick, unpublish. data).

Several state and federally listed threatened and endangered species use the Sandhills and associated wetlands. The migration corridor of the state and federally endangered whooping crane encompasses most of the Sandhills. Wet meadows provide habitat for the western prairie fringed orchid, which is a state and federally listed threatened species. Blanding's turtles are in decline across most of their range and are listed as threatened or endangered in adjacent states, but the population in the Sandhills appears to be doing well (Panella and Rothe-Groleau 2021, Haag 2022).

Most of the lakes in the Sandhills are too shallow or

Muskrats are common in many wetlands throughout the state. In marshes, they construct huts or houses like the one pictured. These are built in the fall using wetland plants and provide a place for muskrats to live in the winter. ETHAN FREESE, PLATTE BASIN TIMELAPSE

alkaline to support game fish populations. However, some freshwater lakes, and their associated wetlands, have adequate water depth to overwinter fish and support an exceptional warm-water fishery. These wetlands are very productive with vegetation and invertebrates (Glover 2020), which allow fish species to grow relatively fast due to available prey items. About 60 fish species (including many non-native species) occur within the Sandhills; the most common sportfish species are northern pike, yellow perch, largemouth bass, bluegill, and black crappie. Sandhills streams, including some unique cool-water reaches (Nebraska Game and Parks Commission 2016), and their associated wetlands also provide habitat for two state threatened fish species in Nebraska: northern redbelly dace, and finescale dace; one species on the state endangered list: western blacknose shiner; and one species on both the federal and state list: Topeka shiner. A few of these sandhill streams can support rainbow and brown trout populations. Backwaters of these streams also provide valuable habitat for many other fish species. In addition to fish, the rivers and streams in the Sandhills also provide important habitat for several species of freshwater mussels.

The Sandhills includes all or parts of 11 Biologically Unique Landscapes (Schneider et al. 2011) including: Panhandle Prairies, Upper Niobrara River, Sandhills Alkaline Lakes, Snake River, Dismal River Headwaters, Cherry County Wetlands, Upper Loup Rivers, Platte Confluence, Middle Niobrara River, Elkhorn River Headwaters, and the Lower Niobrara River.

Wetlands in the Sandhills function both as groundwater discharge and recharge sites, though recharge usually occurs only during heavy precipitation events in the spring (Bleed and Flowerday 1990). Although precipitation is low and evaporation rates are high, the large underground reservoir, known as the Ogallala Aquifer, provides a water table at or near the surface for discharge into a vast array of wetlands, even during drought. Agricultural, residential and municipal water supplies within the region, and a sizeable portion of the rest of Nebraska, are dependent upon the Ogallala Aquifer as their sole source of water.

The Sandhills region in general represents one of Nebraska's most popular tourist areas. Visitation data from Valentine and Crescent Lake national wildlife refuges, as well as the presence of many state wildlife management and recreation areas within the Sandhills, reflect well on the recreation benefits

these wetlands provide. Fishing, hunting, and wildlife observation are popular activities (DaRugna 2020), along with camping, kayaking and boating.

Conservation Success Stories

The Sandhills Task Force began in 1992 and is a nonprofit organization and land trust. The goal of the organization is to enhance the Sandhill wetland-grassland ecosystem in a way that sustains profitable private ranching, wildlife and vegetative diversity, and associated water supplies (Sandhills Task Force 2014). The organization is governed by a board that consists of 16 members, and at least nine of these make their primary livelihood from ranching within the Sandhills. The following groups and organizations also have representation on the board: the county commissioner, Ducks Unlimited, Natural Resources Conservation Service, Natural Resources Districts, Nebraska Cattlemen, Nebraska Game and Parks Commission, The Nature Conservancy, and the U.S. Fish and Wildlife Service.

The Task Force has accomplished many wetland projects on ranches over the years. These include: restoring fens, marshes, and wet meadows; addressing stream down-cutting to restore the streams and adjacent wetlands; improving grazing systems; and helping with the renovation of lakes and wetlands by eliminating invasive common carp, so that the water quality and wetland vegetation improve. Website: sandhillstaskforce.org.

Conservation Programs and Contacts

Sandhills Task Force, executive director, P.O. Box 482, Broken Bow, NE 68822, (308) 214-0065.

Other contacts include the Nebraska Game and Parks Commission offices in Norfolk, (308-370-3374);

Blue-winged teal are a common nester in the Sandhills. They also use wetlands across Nebraska during migration, ultimately spending their winters in the southern U.S. or down to South America. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Evening primrose covers the Loup/Platte River Sandhills prairie that surrounds a wetland on the Sunny Hollow Wildlife Management Area in Nance County. Grasslands and wetlands are often intermingled and this provides benefits to a wide variety of wildlife species that use both types of habitats. JON FARRAR, NEBRASKALAND

Alliance, (308-763-2940); or North Platte, (308-535-8025).

Select Public Use Areas

- American Game Marsh WMA, 19 miles south of Johnstown, Brown County
- South Pine WMA, 11 miles south of Long Pine, Brown County
- Ballard's Marsh WMA, 18 miles south of Valentine, Cherry County
- Cottonwood-Steverson Lake WMA, 28 miles north of Hyannis, Cherry County
- McKelvie National Forest, 28 miles southwest of Valentine, Cherry County; there are many Sandhill wetlands along Merritt Dam Road.
- Shell Lake WMA, 8 miles north, 9 miles east of Gordon, Cherry County
- Valentine National Wildlife Refuge, 22 miles south of Valentine, Cherry County
- Crescent Lake National Wildlife Refuge, 23 miles north of Oshkosh, Garden County
- Avocet WMA, 2 miles west of Hyannis, Grant County
- Goose Lake WMA, 6 miles south, 10 miles east of Chambers, Holt County
- Twin Lakes-Rock County WMA, 18 miles south, 3 miles east of Bassett, Rock County

LOUP/PLATTE RIVER SANDHILLS

Profile

The Loup/Platte River Sandhills wetland complex is in a narrow band of wind-deposited sand extending from the confluence of the Platte and Loup rivers at Columbus, west to near the town of Ravenna. Wetlands are most numerous in a 70-square-mile area south of Genoa. Within these sandhills are numerous freshwater wetlands. These wetlands are mostly small (less than 5 acres), and range from temporarily to semipermanently flooded. Some information suggests the groundwater that recharges these wetlands is related to levels in the Platte and Loup rivers, but little quantitative information is available.

Loss and Threats

Some drainage and cropping of these wetlands have occurred, however, losses within this complex appear to be less than in many other complexes in the state. Threats to these wetlands are primarily related to the potential of local groundwater pumping drawing down water tables and causing the wetlands to lose their water source. This complex also may be affected by alterations of flows in the Platte and Loup rivers, but this connection is currently not well understood.

Benefits

Unfortunately, little is known about how this wetland complex functions. The wetlands are known to provide good habitat for nesting waterfowl and likely provide habitat for other water birds. Locally, the area provides recreation for waterfowl hunters. These wetlands provide water and forage production for area livestock. The role that these wetlands play in the water quality and groundwater dynamics of the region needs further investigation.

Conservation Success Stories

More than a dozen landowners in this complex have enrolled their properties into USDA's Wetland Reserve Easements program. This voluntary program pays landowners for the easement, helps restore the wetlands, and then allows the landowner to continue to own the land and to implement approved compatible uses such as livestock grazing that benefits the wetlands. Website: nrcs.usda.gov, search "wetland reserve easements."

Contact

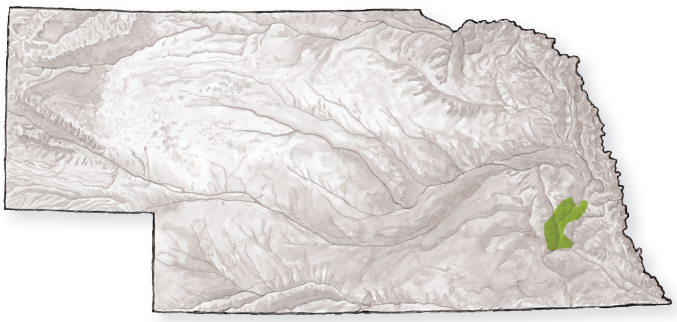
Nebraska Game and Parks Commission office in Kearney, (308) 865-5310, or Norfolk, (308) 370-3374.

Select Public Use Areas

- Sunny Hollow WMA, 4 miles south and 1 mile west of Genoa, Nance County. *Note: Area is on a minimum maintenance road.*

Saline and Alkaline Wetlands

These wetlands have saline (salty) or alkaline (basic) chemical characteristics. The complexes in Nebraska include the Eastern Saline and the Western Alkaline. There also are some highly alkaline wetlands in the western Sandhills that are covered in the Sandhills Complex section. Additionally, moderately saline and alkaline wetlands are found in scattered pockets along much of the Platte River and in a few other regions of the state. Saline wetland soil and water pH ranges from about 7 to 7.5, whereas alkaline wetland pH is typically greater than 8.5. Annual precipitation in saline wetlands is typically 31 inches per year, whereas in western alkaline wetlands it is about 15 to 18 inches per year. Eastern Saline wetlands are comprised primarily of sulfate and/or chloride-based salts. The salinization of these wetlands can occur more quickly than through evaporation alone due to highly saline groundwater discharge into the wetlands. In western Nebraska, alkaline wetlands are sodium carbonate and calcium carbonate based. A combination of low precipitation in the North Platte valley and western Sandhills, along with topography and soil type, limits runoff and decreases the amount of leaching of accumulated salts in the soil. The salinization of alkaline wetlands has occurred over thousands of years through advective accumulation (Ong 2010). In other words, the repeating cycle of evaporation in these semi-arid regions has accumulated salts.



EASTERN SALINE

Profile

For generations the Omaha Tribe collected salt from the wetlands in the vicinity of Lincoln, a place that they called Nithskithe (Welsch 2022). Eastern Saline wetlands are of additional historical significance as their presence spawned a short-lived salt mining industry in the 1860s that led to the establishment of the city of Lincoln (Cunningham 1985). Eastern Saline wetlands occur in lower places, such as swales and depressions, within the floodplains of Salt Creek and its tributaries in Lancaster and southern Saunders counties.

The wetlands receive their salinity from groundwater that is under pressure and rises to the surface in stream valleys of Salt Creek and its tributaries. The groundwater originated along the front range of the Rocky Mountains, and becomes salty

Saline wetlands form where salty groundwater rises to the surface; this can form salt flats. These flats are a place for plants like saltwort and seablite to grow, but also places for animals like this badger to explore. ETHAN FREESE, PLATTE BASIN TIMELAPSE

as it passes through an underground rock formation containing salts deposited by an ancient sea that once inundated what is now Nebraska and Kansas. Eastern Saline wetlands are characterized by saline soils and salt-tolerant vegetation.

Soil salinity varies greatly between, and even within, these wetlands. Highly saline wetlands usually have a central area that is devoid of vegetation, and when dry, exhibit salt encrusted mudflats. Saline wetlands having lower soil salinities are vegetated with salt-tolerant plants.

Loss and Threats

Eastern Saline wetlands are considered critically imperiled in Nebraska (Clausen et al. 1989) and harbor the most limited and endangered vegetation community in the state (Kaul 1975). It has been estimated that there were once 20,000 acres of saline wetlands, and more recent estimates are that only 4,000 acres remain, and many of those are highly degraded.

Extensive wetland losses from expansion of the city of Lincoln and agricultural activities have been noted

(Gersib and Steinauer 1990,Gilbert and Stutheit 1994). They further noted that the remaining saline wetlands identified in their inventory have experienced recognizable degradation through drainage, diking, filling, farming, and overgrazing. Eastern Saline wetlands were given a Priority 1 ranking in the Nebraska Wetlands Priority Plan (Gersib 1991) because of very extensive past losses.

Threats to Eastern Saline wetlands include drainage or filling, streambed degradation, agricultural conversion or use, residential or commercial development, transportation, and water pollution. Of these threats, commercial and residential development are considered the greatest. Commercial and residential development can result in total wetland destruction and the loss of all related benefits. Development also can affect the watersheds of the wetlands. One of the most serious long-term threats is the degradation (deepening) of stream channels that results in erosive lateral headcuts (gullies) that eventually drain wetlands. The stream degradation can lead to lower water tables and a reduction of saline water discharge into the wetlands. An emerging threat to these wetlands is the expansion of invasive plant species, including reed canary grass, European common reed, tall wheatgrass and hybrid cattail.

Benefits

Eastern Saline wetlands provide habitat for a variety of wildlife species, and are particularly important as migration habitat for shorebirds. The exposed saline mudflats provide abundant invertebrate foods. More than 250 species of birds have been reported using the saline wetlands (Farrar and Gersib 1991). Twenty-two species of shorebirds were documented using the saline wetlands during the 1997 spring migration (Poague et al. 1997) and the authors estimated more than 20,000 shorebirds may use these highly vulnerable wetlands during spring migration. The state and federally threatened piping plover occasionally stops over at Eastern Saline wetlands during migration.

The Salt Creek tiger beetle is one of the rarest endangered species in the U.S. The only place in the world that this insect exists is in the saline wetlands near Lincoln. BROOKE TALBOTT

Saltwort is a plant listed as endangered by Nebraska, and the only place in the state it is found is in the saline wetlands.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

The Salt Creek tiger beetle, a very rare insect, is found only on the open salt flat areas of Eastern Saline wetlands. The Salt Creek tiger beetle is a state and federally listed endangered species, and the U.S. Fish and Wildlife Service has designated 1,110 acres as critical habitat for this species.

Eastern Saline wetlands are home to many saline plants that are found nowhere else in Nebraska. Three plant species found growing in Eastern Saline wetlands were considered rare in Nebraska (Clausen et al. 1989), including saltmarsh aster, saltwort, and Texas dropseed. Saltwort is a state listed endangered species. The Eastern Saline Wetlands are within the Saline Wetlands Biologically Unique Landscape (Schneider et al. 2011).

Silty clay soils reduce downward water movement resulting in low to moderate groundwater recharge functions. The location of wetlands within the Salt and Rock Creek floodplains provides important flood-control benefits.

Because of their location in and around the city of Lincoln, as well as their proximity to Omaha, Eastern Saline wetlands are ideally located to provide recreational opportunities for a large portion of the state's population. Bird watching, nature study, hiking, and waterfowl and pheasant hunting are some of the more common outdoor recreational activities. Few wetland areas in Nebraska provide the educational opportunities afforded by the proximity of these unique wetlands to so many people.

Conservation Success Stories

In 2003, the Saline Wetlands Conservation Partnership was formed. This is a partnership among the City of Lincoln, Lower Platte South Natural Resources District, Pheasants Forever, the Nebraska Game and Parks Commission, and others to protect and conserve Eastern Saline wetlands (SWCP 2018). Since its inception, over 2,400 acres of land containing saline wetlands have been conserved through efforts of the partnership. Many of these areas have been restored, and all are open to public use and education. Website: lincoln.ne.gov, search "saline wetlands."

Contacts

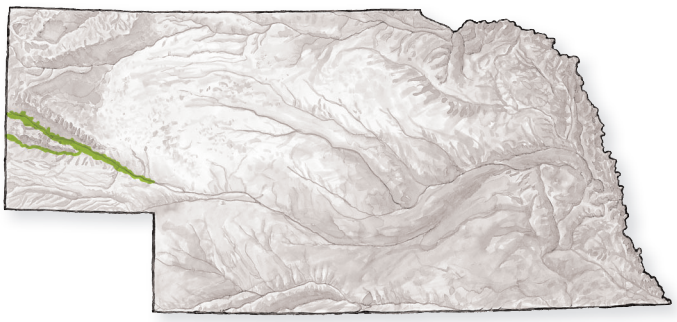
Saline wetland coordinator, 3131 O St., Suite 300, Lincoln, NE 68510, (402) 441-7063.

Other contacts include the Nebraska Game and Parks Commission office in Lincoln, (402) 471-5561.

Select Public Use Areas

- Arbor Lake, 0.5 miles north of Arbor Road on N. 27th St., Lincoln, Lancaster County
- Helmuth Marsh and Little Salt Creek WMA, 3 miles east and 1 mile south of Raymond, Lancaster County
- Jack Sinn WMA, 1 mile south of Ceresco, Lancaster/Saunders counties.
- Lincoln Saline Wetland Nature Center NRD Area, east shore of Capitol Beach Lake in Lincoln, Lancaster County
- Little Salt Fork Marsh Preserve and Little Salt Creek West WMA, 3 miles east of Raymond, Lancaster County
- Marsh Wren, 1 miles south of Arbor Road on 40th St. and then 0.5 miles east, Lincoln, Lancaster County
- Shoemaker Marsh, 1 mile north of Arbor Road on N. 27th St., Lincoln, Lancaster County
- Whitehead Saline Wetlands NRD Area, 27th Street and I-80, Lincoln, Lancaster County
- Zoetis Saline Wetland, First and Cornhusker streets, Lincoln, Lancaster County; owned by Zoetis County and open to public use.

A hiker enjoys spending time on a saline wetland area north of Lincoln. These wetlands provide much needed open space and places to explore. MICHAEL FORSBERG



WESTERN ALKALINE

Profile

Western Alkaline wetlands occur on the floodplain of the North Platte River upstream from Lewellen, and along the upper reaches of Pumpkin Creek. These wetlands receive their water from a combination of overland runoff, flood overflows and springs. The hydrology of these wetlands is complex and influenced by local irrigation runoff. The alkalinity is primarily caused by the salts of sodium carbonate and calcium carbonate becoming concentrated in the soils as a result of high rates of evaporation in this semi-arid region. These wetlands frequently dry up, and a white crust of alkaline salts forms on the exposed soil surface.

Loss and Threats

Wetlands in this complex appear to have experienced fewer losses and to be less threatened than many of the other complexes in Nebraska. Much of this is because of the lack of development in the vicinity of these wetlands and because the soils are poorly suited to crop production. However, some wet meadows on less alkaline sites have been drained and converted to cropland or planted to non-native wheatgrasses. Irrigation projects have affected some sites, and the long-term effect of reduced flows in the North Platte River is unknown. Flows have greatly declined on Pumpkin Creek, likely as a result of groundwater depletions, and this could affect the alkaline wetlands located there.

Benefits

Western Alkaline wetlands provide nesting and migration habitat for a variety of waterfowl, shorebirds, and other waterbirds. This complex is especially attractive to nesting American avocets, Wilson's phalaropes, cinnamon teal, blue-winged teal, mallards, and Canada geese. Much of the shorebird habitat is provided by the open alkaline flats. These wetlands provide important waterfowl hunting and wildlife viewing opportunities in this region of the state. Several plants rare to Nebraska occur in the

alkaline wetlands including the Nevada bulrush, slender plantain, silverweed, eastern cleomella, thelypody, seaside heliotrope, and sea milkwort. The Western Alkaline Wetlands are mostly located within the North Platte River Biologically Unique Landscape (Schneider et al. 2011).

The location of these wetlands near springs and along the Oregon Trail lends to their historical significance.

Conservation Success Stories

Platte River Basin Environments, Inc., is an organization formed by a group of outdoor enthusiasts in western Nebraska concerned about wildlife habitat and the natural areas in the North Platte River

An American avocet nests in the salt grass of a western alkaline wetland in the North Platte River valley. JON FARRAR, NEBRASKALAND

basin. They have worked to conserve, enhance, and restore vital wildlife habitat and natural areas within the North Platte River basin, including the Western Alkaline wetlands. The organization and their partners, including Ducks Unlimited, The Nature Conservancy, and the Nebraska Game and Parks Commission, played an instrumental role in conserving the public use areas listed below. They are committed to providing opportunities for environmental education, and their properties are open to the public. Website: nebwild.org.

Contacts

PRBE lands manager, P.O. Box 2308, Scottsbluff, NE 69363, (308) 641-7515.

Other contacts include the Nebraska Game and Parks Commission office in Alliance, (308) 763-2940.

Select Public Use Areas

- Chet and Jane Fliesbach WMA (Facus Springs), 2 miles south, 3 miles east of Bayard, Morrill County
- Frey Wetlands, 2 miles north, 3 miles west of Bridgeport, Morrill County
- Kiowa WMA, 2 miles south of Morrill, Scotts Bluff County
- Spotted Tail, 1 mile west of Mitchell, Scotts Bluff County

Riverine Wetlands

Wetlands are closely associated with the riparian zones (the interface between land and a river or stream) and associated floodplains (areas formed mainly of river sediments and subject to flooding) of all of Nebraska's rivers and streams. These riparian areas are complex systems with numerous interrelated components (e.g., wetlands, organic matter, sandbars, tree falls, side channels, etc.). Wetlands are an important component of this system by producing invertebrates and other organic matter that provide energy and food to other parts of the streams and rivers. Additionally, these wetlands provide spawning and nursery areas for many types of fish, mussels, amphibians, and reptiles, and a home for numerous wildlife species. Historically, there were extensive wetlands associated with the rivers in southeast Nebraska, such as the Little Blue, Big Blue, Nemaha, and Little Nemaha rivers. However, these rivers were highly altered due to channelization and associated down-cutting, and few wetlands remain today. Although some wetlands still occur along all of Nebraska's rivers, this guide focuses on the wetlands associated with the Platte, Missouri, Niobrara, and Elkhorn rivers. These complexes appear to contain the greatest river-associated wetland acreage remaining in the state. The Platte River contains important wetlands throughout its reach; however, in this guide, three segments are singled out for special consideration (Central Platte River, Platte Confluence and the Lower Platte River).

CENTRAL PLATTE RIVER

Profile

The Central Platte River (also called the Big Bend Reach) extends approximately 90 miles from Lexington to Chapman. Historically the Platte River was a broad open prairie river with a braided channel and numerous saturated wet meadows adjacent to the river. However, the diversion of approximately 70% of the historic annual flows has changed the Central Platte River into a narrower river with a dense band of mixed deciduous woodland and eastern red cedars encroaching on many of the wet meadows. Numerous islands that at one time were open sandbars have

Wetlands are associated with all of Nebraska's streams and rivers. Here the sun sets over the Central Platte River and its associated wetlands located on the sandbars, in the side channel sloughs, and in the wet meadows across the floodplain. ETHAN FREESE, PLATTE BASIN TIMELAPSE

since been overgrown with woody vegetation due to a reduction in high-water scouring flows. The scouring flows came as a result of rapid snowmelt, on either the plains in early spring or in the mountains in early summer, or in response to large rain events. Reductions in flow and the stabilization of sandbars with vegetation has diminished the dynamic interplay between sediment and water that is integral to braided river systems, and increased the disconnection between the river and adjacent wet meadow wetlands.

Loss and Threats

The Central Platte River valley epitomizes the struggle between agricultural and development interests, and wildlife, fish, recreation, and other benefits associated with wetlands. Diminished flows,

Least terns nest on river sandbars. They feed in the nearby river and wetlands capturing small fish to feed their mate and their young.
MICHAEL FORSBERG

increased sediment storage in upstream reservoirs, changes to water quality, invasive species, sand and gravel mining, and agricultural conversion have greatly altered the Central Platte River.

From 1860 to the early 1980s, the Central Platte River lost up to 73% of active channel areas (Sidle et al. 1989), and this affected the associated wetlands. Upstream from the Central Platte, active channel losses on the river have reached 85%. In many areas, channel width has been reduced to 10-20% of its historic size (U.S. Fish and Wildlife Service 1981). Unobstructed channel width at the main channel of the Platte River decreased by 59% from 1938 to 2016 (Caven et al. 2019a). Yet, conditions remain highly variable throughout the Central Platte. For instance, unobstructed channel width at the main channel between Kearney and Odessa decreased by 82% from 1938 to 2016, but only by 15% between Alda and Wood River. This likely is a function of two factors. First, channel width loses have been greater in reaches that were historically one large channel, as areas with multiple channels simply lost functionality in side-channels while largely maintaining it in their main channel (Caven et al. 2019a). Secondly, conservation actions that have been taken improve and maintain functional braided river areas (Farnsworth et al. 2018, Caven et al. 2019a).

Since the mid-1880s, the acreage of wet meadows, a type of wetland, in the Central Platte has declined 73% (Currier et al. 1985). An increase in shrub and forested wetland types has occurred at the expense of riverine, emergent wetlands and wet meadows as a response to decreased scouring flows. The increase in the shrub and forested wetlands has been detrimental to fish and wildlife resources that historically used the river valley (Currier et al. 1985; U.S. Fish and Wildlife Service 1981).

Drainage and conversion to grain crops and sand and gravel mining operations pose the biggest immediate threats to wet meadows adjacent to the Platte River. In fact, Pauley et al. (2018) indicated that from 1957 to 2016, sand and gravel mine site acreage within the Central Platte River Valley floodplain increased by 538%. Loss of instream flows, groundwater depletions, and degradation of the riverbed continue to pose a long-term threat to the source of water for the remaining wet meadows. Once this source of water is lost, the

meadows become drier, allowing tree invasion or agricultural, commercial, and residential development. Impoundment and diversion of river water and water-borne sediment are the main factors that have and continue to cause shifts from a wide, shallow, and open channel to a narrow, deep channel surrounded by upland or wetland with woody vegetation. Failure to address these stream flow issues within the Platte River will continue to threaten the river and the fish and wildlife that depend on it.

The spread of invasive purple loosestrife and European common reed is an additional threat. Both species are introduced plants of little value to wildlife and outcompete desirable native plants.

Wetlands along the Central Platte River were given a Priority 1 ranking (due to very extensive past losses) in the Nebraska Wetlands Priority Plan (Gersib 1991).

Benefits

The Central Platte provides habitat for several state and federally threatened and endangered species. The state and federally endangered whooping crane uses the river during spring and fall migration, and the portion of the Central Platte from Lexington to Shelton has been designated as critical habitat necessary for the survival and recovery of this species. Recently there have been some large numbers of whooping cranes stopping along the Platte during their fall migration, including 46 observed in the fall of 2021. The state endangered least tern and the state and federally threatened piping plover have in the past been found to nest on some of the remaining unvegetated sandbars in the river. Least terns and piping plovers have mostly shifted to nesting around sand and gravel mining areas and off channel habitats created by the Platte River Recovery and Implementation Program, but both species still use the river for foraging habitat. The Central Platte River is a Biologically Unique Landscape (Schneider et al. 2011).

During the spring, over one million sandhill cranes, comprising 80-85% of the mid-continent population, have been counted in this reach of the river (Caven et al. 2020). They converge here to rest and accumulate fat reserves for later migration and nesting (U.S. Fish and Wildlife Service 1981). Seven to 10 million ducks and geese, including snow geese, Ross's geese, greater white-fronted geese, Canada geese, cackling geese, mallards, and northern pintails stop over along the Platte River and in nearby Rainwater Basin wetlands. Average mid-winter waterfowl counts, 1998-2017, were 7,500 mallards and 8,000 Canada Geese in the stretch of river from Gothenburg to Central City (Nebraska Game and Parks Commission, unpubl. data). This reach also provides habitat for migrant wading birds and shorebirds and several nesting colonies of great blue herons.

More than 300 bird species have been observed along the Central Platte River, and 141 species have nested in the area. Over half of the 300 species are neotropical migrants that winter largely south of the Tropic of Cancer, but nest north of the tropics (Lingle 1994). A report issued by the National Audubon Society focused on the importance of the Central Platte as wildlife habitat, especially for migratory birds, and the complexities of managing this severely threatened system (Safina et al. 1989). The North American Waterfowl Management Plan lists the Central Platte River as an area of greatest continental significance to North American ducks, geese, and swans (U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries 2012).

During high flows, the Platte River recharges the underlying Ogallala Aquifer, which provides irrigation water for thousands of acres of cropland (Burns 1981) and municipal water for most of the communities along the river. In portions where the channels are not constricted by structures (e.g., bridges and bank protection) or encroached upon by vegetation, the Platte River has an enormous capacity to carry floodwaters within its own banks (Safina et al. 1989).

The Platte River provides a variety of recreational opportunities. From fall 1986 to fall 1987, Nebraskans spent an estimated $51.3 million on nature-associated recreation in the Platte River Valley (Bureau of

Wildlife observation is a popular activity in and around wetlands due to their abundance and diversity of life. Here a young observer is taking in the world-renowned spectacle of the spring sandhill crane migration. JENNY NGUYEN-WHEATLEY, NEBRASKALAND

During the spring, over one million sandhill cranes, comprising 80-85% of the mid-continent population, have been counted along the Central Platte River. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Sociological Research 1988). Activities from highest to lowest participation rates included picnicking, nature hikes, observing wildlife, swimming, fishing, camping, boating, and hunting. A separate study indicated that up to 80,000 crane watchers flock to the Platte River each spring and benefit the local economy with more than $40 million (Lingle 1992). However, a more recent study suggests that closer to 50,000 crane enthusiasts come to the Central Platte annually and have a resulting economic pact of about $14.3 million regionally (Dority et al. 2017). Estimates vary depending on the techniques used, but regardless, the economic impact is significant.

Conservation Success Stories

Conservation efforts by numerous entities began in the mid-1970s and continue today. These efforts include protecting instream flows, restoring and protecting lowland grasslands and embedded wet meadows, and restoring and maintaining open braided river habitat. The result has been that conditions have improved moderately, and a number of areas have been conserved, including nearly 14,000 acres by the Platte River Recovery and Implementation Program over the past 15 years. As an example, Krapu et al. (2014) documented a 32% increase in lowland grasses between Chapman and Lexington between 1982 and 1998 within 5.6 kilometers of the Platte River, and a lot of additional conservation work has occurred since that study was completed. Caven et al. (2019a) similarly documented a 3% increase in meadow-prairie land cover within 800 meters of the main channel of the Platte River between 1998 to 2016. In both cases, improvements in habitat conditions were concentrated around lands owned and managed by conservation organizations. Many distinctive techniques for habitat restoration have been developed within the region over the past 40 years (e.g., Pfeiffer and Currier 2005). Habitat management actions, such as clearing invasive European common reed and woody vegetation, and disking sandbars to mimic historic scouring, improves and maintains functional braided river area (Farnsworth et al. 2018, Caven et al. 2019a). The efforts of all these partners give hope that the amazing benefits of this reach of the Platte River can be sustained for future generations. Websites: rowe.audubon.org; cranetrust.org; platteriverprogram.org; nature.org, search "nebraska"; ducks.org/nebraska.

Contacts

A number of organizations and agencies have

programs that address wetland conservation issues along the Central Platte, including: Iain Nicolson Audubon Center at Rowe Sanctuary, 44450 Elm Island Road, Gibbon, NE 28840, (308) 468-5282; Crane Trust, 9325 S. Alda Road, Wood River, NE 68883, (308) 382-1820; the Platte River Recovery and Implementation Program 4111 Fourth Ave., Suite 6, Kearney, NE 68845, (308) 237-5728; the U.S. Fish and Wildlife Service, (308) 382-6468; The Nature Conservancy, (402) 342-0282; and Ducks Unlimited, (308)-258-4682.

Other contacts include the Nebraska Game and Parks Commission office in Kearney, (517) 424-6207.

Select Public Use Areas

- Dogwood WMA, 5 miles west, 2 miles south of Overton, Dawson County
- Martin's Reach WMA, 3 miles west, 4 miles south, of Wood River, Hall County
- Fort Kearny State Recreation Area/Bassway Strip WMA, 9 miles north, 2 miles west of Minden, Kearney County
- The Nature Conservancy, Audubon Society, Crane Trust, and Platte River Recovery and Implementation Program each have areas along the Platte River that may be available for public use (with some limitations) and tours or crane observation blinds by reservation.

PLATTE CONFLUENCE

Profile

The Platte Confluence extends approximately 20 river miles, from Sutherland to North Platte and includes portions of both the North Platte River and the South Platte River. This reach had previously been

Muskrat Run WMA on the North Platte River near North Platte in Lincoln County is within the Platte Confluence complex. Partners have worked to restore and manage the wetlands on this area. ERIC FOWLER, NEBRASKALAND

called the Lower North Platte River (LaGrange 2005), but was changed to Platte Confluence to conform with the Nebraska Natural Legacy Project (Schneider et al. 2011). This wetland complex consists of riverine and palustrine wetlands lying within the historically active floodplain and channel of the river. Temporarily and seasonally flooded vegetated wetlands comprise an estimated 80% of all wetlands in the Platte Confluence. There are also extensive wetlands all along the North Platte River upstream of Sutherland. Many of these wetlands are included within the Western Alkaline Wetland complex.

Loss and Threats

Sidle et al. (1989) reported the active river channel width between North Platte and Lake McConaughy has declined 85% since 1860. Wet meadow acreage losses along the North Platte River were estimated to be 23-33% since 1938, though many of the farmable meadows already were converted and under gravity irrigation prior to 1938 (Sidle et al. 1989). Additionally, an increase of scrub-shrub and forested wetland types has occurred at the expense of riverine and emergent wetlands as a response to decreased instream flows and increased sediment storage in upstream reservoirs. This wetland complex was given a Priority 2 ranking in the Nebraska Wetlands Priority Plan (Gersib 1991)because of extensive past losses.

Agricultural conversion, groundwater depletions, and sand and gravel mining operations pose the greatest short-term threats to wet meadows adjacent to the North Platte River. Residential and commercial developments commonly encroach on wet meadows after drainage, filling, or the mining of sand and gravel. Groundwater depletions and degradation of the riverbed will continue to affect the remaining wet meadows in the long-term. Impoundments and the diversion of river water and sediment are the main factors that have caused and will continue to cause the shift from a wide, shallow, open channel to a narrow, deep one bordered by uplands or scrub-shrub/forested wetlands.

The North Platte River provides important habitat for Canada geese during the winter months. JULIE GEISER, NEBRASKALAND

Benefits

During the spring, about 220,000 migrating sandhill cranes spend up to six weeks feeding and resting in the Platte Confluence complex and along the North Platte River upstream of Lake McConaughy to Oshkosh and the lower ends of adjacent tributaries such as Blue Creek and Birdwood Creek (Caven et al. 2020, Varner et al. 2020). Sandhill cranes roost in the river and wet meadows at night and forage in wet meadows, grassland, and cropland during the day. Endangered whooping cranes occasionally use this stretch of river during both spring and fall migrations. Migrating and wintering waterfowl use the river and associated wet meadows (Varner et al. 2020). The entire North Platte River is the most important area in the state for wintering Canada geese and is one of the most important for wintering mallards (Matt Garrick, Nebraska Game and Parks, pers. comm.).

The Platte Confluence and its associated aquifer provide municipal and irrigation water supplies (Missouri River Basin Commission 1976). During high-flow periods, the river recharges the underlying aquifer. Because the Platte River system, including the Platte Confluence, is highly regulated by a series of upstream reservoirs and diversions for irrigation and power district canals, the groundwater discharge and recharge functions of the river and associated wetlands have been significantly altered from natural conditions (Missouri River Basin Commission 1976). Although upstream reservoirs on the North Platte River provide considerable flood protection, the continued loss of wetlands and channel capacity increases the future chances of flood damage.

Waterfowl hunting and fishing occur in the Platte Confluence (Anderson et al. 1989). A survey by the University of Nebraska indicated that Nebraskans have a keen interest in a variety of recreational activities available in this complex and support further efforts to provide these recreational opportunities (Bureau of Sociological Research 1988).

Conservation Success Stories

Over the past 15 years, dense stands of invasive trees, including Russian olive, have been removed from the North River Wildlife Management Area, and grazing and fire management strategies have been implemented. At the nearby Muskrat Run Wildlife Management Area, similar improvements were initiated. These actions have opened up the

Morning light highlights the blooming blazing star on a wet meadow wetland along the Lower Platte River in Saunders County.

ETHAN FREESE, PLATTE BASIN TIMELAPSE

wet meadow and slough wetlands and made them more accessible to sandhill cranes and waterfowl using the area. Further upstream, several private land wetland restoration projects were completed by Ducks Unlimited, the U.S. Fish and Wildlife Service, the Sandhills Task Force, Nebraska Game and Parks Commission, and the wildlife response to the projects has been fun to watch.

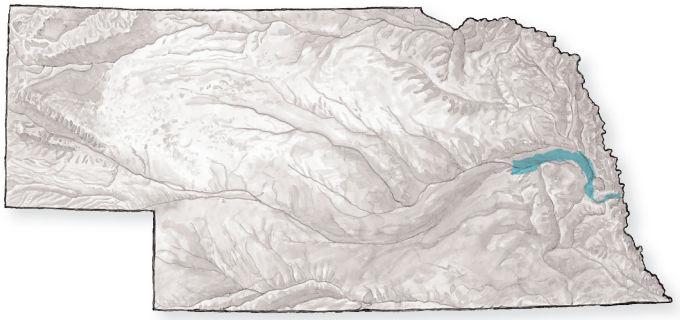
Websites: ducks.org/nebraska, fws.gov/program/partners-fish-and-wildlife.

Contacts

Nebraska Game and Parks Commission office in North Platte, (308) 535-8025.

Select Public Use Areas

- Buffalo Bill Ranch State Historical Park, North Platte, Lincoln County
- Muskrat Run WMA, 6 miles east, 1 mile north of Hershey, Lincoln County
- North River WMA, 3 milies north of Hershey, Lincoln County



LOWER PLATTE RIVER

Profile

The Lower Platte River extends approximately 100 miles from where the Loup River joins the Platte near Columbus to the Platte-Missouri River confluence south of Omaha. The river in this reach begins to flow in a more defined channel, though islands and sandbars are still numerous. The Lower Platte River has fewer acres of wetlands and wet meadows than the Central Platte River. The wetlands along

Damsel flies have a larval stage that swims in the water of wetlands; the adults are winged and feed over the wetlands.
DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

the Lower Platte River are mostly fresh to slightly saline, saturated wet meadows, and seasonally and semipermanently flooded channel remnants and oxbows. These wetlands were likely more forested historically than wetlands further upstream.

Loss and Threats

The wetlands and channel habitat along the Lower Platte River have suffered cumulative losses like those in the Central Platte River (Joeckle and Henebry 2008). Diversion of stream flows and levee construction leading to floodplain development have probably had the greatest impacts. Numerous wetlands also have been altered by drainage and conversion to cropland, sand and gravel mining, and housing and commercial developments. Additional diversion of water poses threats to the wetlands in the future. Levees built along the river eliminate or narrow the river's floodplain and disconnect wetlands from over-bank flows. Wetlands along the Lower Platte River will face continued threats of stream-bank stabilization, sand and gravel mining, and urban expansion and associated disturbances, especially considering their proximity to Omaha, Fremont, Lincoln and Columbus.

Benefits

The wetlands and associated habitats along the Lower Platte River provide important migration habitat for a variety of waterfowl, songbirds, wintering habitat for waterfowl, and nesting habitat for a variety of birds, including wood ducks, bald eagles, and the uncommon Louisiana waterthrush. The state endangered least tern and state and federally threatened piping plover nest on sandbars associated with the river and nearby sand and gravel mines and lakeshore housing developments. These two species have benefited from the actions of the University of Nebraska-Lincoln's Tern and Plover Conservation Partnership. Shorebird surveys conducted on the lower Platte from 2000-2002 have documented 21 species using the Lower Platte River. Several great blue heron rookeries also are located along the Lower Platte River. The state and federally endangered pallid sturgeon, the state endangered sturgeon chub and state threatened lake sturgeon also are found near the mouth of the Platte River. The Lower Platte River is a Biologically Unique Landscape (Schneider et al. 2011).

Wetlands along the river help to attenuate flood flows and filter the water, removing some pollutants. Additionally, numerous towns, including Omaha and Lincoln, pump municipal water from wells that receive recharge from this stretch of river, serving 35% of the population of Nebraska.

The Lower Platte River receives very intensive recreational use due to being within 50 miles of more than 60% of the state's population. Waterfowl and deer hunting, fishing, and boating occur on this reach (Anderson et al. 1989). State parks and recreation areas along the Lower Platte receive a total of 3-4 million visits annually.

Conservation Success Stories

The Nebraska Game and Parks Commission has a Wetlands Initiative Program to help landowners restore and enhance wetlands. Six landowners have had their wetlands improved through this program in the area just north of Yutan. In addition, the Wachiska Chapter of the Audubon Society owns Knott Prairie that is an example of a high-quality wet meadow/tallgrass prairie area that is now almost nonexistent in this area.

Contacts

Nebraska Game and Parks Commission office in Lincoln, (402) 471-5561, or Norfolk, (402) 370-3374.

Select Public Use Areas

- Louisville State Recreation Area, 1 mile west of Louisville, Cass County
- Mahoney State Park, 1 mile south and 2 miles east of Ashland, Cass County
- Platte River State Park, 1 mile south and 2 miles west of Louisville, Cass County
- Whitetail WMA, 1 mile west and 2 miles south of Schuyler, Colfax County
- Fremont Lakes State Recreation Area, 1 mile west of Fremont, Dodge County
- Two Rivers State Recreation Area and Wildlife Management Area, 4 miles south and 3 miles east of Waterloo, Douglas County

- Bramble WMA, 2 miles east and 2.5 miles north of Cedar Bluff, Saunders County
- Schramm Park State Recreation Area, 8 miles south of Gretna, Sarpy County

MISSOURI RIVER

Profile

In Nebraska, the Missouri River floodplain harbors a collection of riverine and marsh-like wetlands that follow the state line from eastern Boyd County downstream to the southeast corner of the state in Richardson County. Prior to the 1930s, the Missouri River was a wild, natural river that supported a tremendous number and diversity of fish and wildlife. The river was described as occupying a sandy channel that flowed between easily erodible banks 1,500 feet to over 1 mile apart with braided, sinuous channels twisting among sheltered backwaters, sloughs, chutes, oxbows, gravel bars, sandbars, mudflats, snags, alluvial islands, deep pools, marshland, and shallow water areas (U.S. Fish and Wildlife Service 1980). The character and natural flow regime of the river was drastically altered between 1930 and 1970 as channelization and mainstem dams were constructed. The unchannelized reaches from eastern Boyd County to the headwaters of Lewis and Clark Lake and from Gavins Point Dam to approximately Ponca State Park remain in a more natural condition, with numerous islands and wetlands, although diminished from pre-dam conditions. Water release management from Fort Randall and Gavins Point Dams altered the connections between the river and the associated backwater and floodplain wetland habitats. Lewis and Clark Lake was created behind Gavins Point Dam and formed a 15-mile lake. Between the riverine section and the headwaters of Lewis and Clark Lake, a 10- to 12-mile transitional section has been created over the past several decades. This transitional section includes an island complex divided by a series of braided channels and extensive wetlands. Channelization

The unchannelized portion of the Missouri River still has sandbars and side channel wetlands, like the ones restored here at Ponca State Park in Dixon County. ERIC FOWLER, NEBRASKALAND

Prothonotary warblers use naturally wooded wetlands such as at Fontenelle Forest along the Missouri River in Bellevue.
JASONONDREICKA

starting just downstream of Ponca State Park caused the river channel to narrow and degrade (deepen) until where the Platte River joins the Missouri near the town of Plattsmouth. The bed is stable or aggrading downstream from Plattsmouth.

Loss and Threats

About 100,300 acres of aquatic habitats (mostly wetlands) and 65,300 acres of islands and sandbars have been converted to dry land or navigation channel between Sioux City, Iowa, and the river's confluence with the Mississippi River (U.S. Fish and Wildlife Service 1980). Within Nebraska, losses were estimated at 18,200 acres of aquatic habitat and 18,700 acres of islands and sandbars. Channelization and measures to reduce the lateral movement of the river, along with the flood reduction efforts provided by mainstem and tributary reservoirs and levees, has fostered agricultural, urban, and industrial encroachment on 95% of the floodplain (Hesse et al. 1989), and this has contributed to the extensive wetland losses. The six huge mainstem dams in the Dakotas and Montana have had measurable influences on water quality, quantity, and timing along the Missouri River. The release of relatively silt-free waters from Gavins Point, the lowermost dam in the system, is contributing to riverbed degradation from below the dam to about Plattsmouth (U.S. Fish and Wildlife Service 1980). Riverbed degradation causes adjacent wetlands to become abnormally dry and isolates backwater areas from the main channel. In addition, control of the release of water from the dams has reduced the flood pulse that helps to maintain floodplain wetlands. Missouri River wetlands were given a Priority 1 ranking (due to very extensive past losses) in the Nebraska Wetlands Priority Plan (Gersib 1991).

Channelization, loss of wetlands, and extensive development of the floodplain have reduced the natural flood-carrying capacity of the Missouri River system. As a result, flood stages have increased as was evidenced by the record floods in 1993, 2011, and 2019. In addition to the large events, due to the loss of the natural flood-carrying capacity, even smaller runoff events can result in moderate flooding.

The Missouri River is a wetland complex where most of the destruction and degradation already has occurred. Categories of greatest threat along the Missouri River appear to be riverbed degradation, residential, agricultural, and commercial development, transportation, navigation maintenance projects, water pollution, water development projects, streambank stabilization, agricultural conversion, and drainage and filling. These factors have had a cumulative effect on river functions by isolating the floodplain from the river and reducing the natural dynamics.

Invasive purple loosestrife has become well-established in the upper reaches of the Missouri River near Niobrara, Nebraska. Purple loosestrife's rapid expansion into the backwater areas of Lewis and Clark Lake is a threat to native plants all along the river. Zebra mussels are an invasive species that also are well established in the Missouri River, including the areas above Gavins Point Dam. Zebra mussels negatively affect several native mussel and fish species.

Benefits

The Missouri River, like many natural systems, is a whole that is greater than the sum of its parts. The interactions between the parts (e.g., wetlands, organic matter, sandbars, tree falls, side channels, etc.) form a complex interrelated system. Wetlands are an important component of this system because they produce invertebrates and other organic matter that provide energy and food to other parts of the river. Additionally, these wetlands provide spawning and nursery areas for many types of fish and are home for numerous wildlife species.

Several state and federally listed threatened and endangered species regularly use the Missouri River in Nebraska. The state endangered least tern and state and federally threatened piping plover nest on unvegetated sandbars in the unchannelized reach of the river, a habitat type that has been eliminated downstream from Sioux City. The recovery plans for the piping plover (U.S. Fish and Wildlife Service 1988) include Missouri River nesting habitat as being essential to the recovery of this species. Several native fish species in the river are in severe decline, including the federally endangered pallid sturgeon, state endangered sturgeon chub, and state threatened lake sturgeon (Galet et al. 2005). Even so, the river still supports a self-sustaining paddlefish fishery and good quality catfish fishery. Other native fishes (e.g.,

walleye and sauger) are more variable depending on water management. Limited commercial fishing currently exists on the Missouri River for rough fish (primarily carp and buffalo). The Missouri River is a Biologically Unique Landscape (Schneider et al. 2011).

Before channelization changed the character of the Missouri River, the area was very important migration habitat for ducks, geese, swans, pelicans, and shorebirds (U.S. Fish and Wildlife Service 1980, U.S. Army Corps of Engineers 1978). Large populations of wood ducks once nested in the river corridor along with smaller numbers of blue-winged teal, gadwall, and mallards. Wood ducks still nest along the river where adequate habitat remains. Although of diminished quality, the Missouri River still provides migration habitat for waterfowl and shorebirds, especially in the unchannelized reach. DeSoto National Wildlife Refuge in Nebraska and Iowa focuses on providing migration habitat for waterfowl. More than 300 species of birds and numerous mammals use the Missouri River and associated habitats. One hundred and sixty-one species of birds likely breed in the region (Mollhoff, 2001). Loss of wetland habitats has caused decreases in populations of wetland mammals such as beaver and muskrat.

In places where the Missouri River floodplain and the associated wetlands remain intact, they help to reduce downstream flood impacts. This provides benefits to farmers and to downstream communities.

The Missouri River in Boyd and Knox counties has been included in the National Park Service's Nationwide Rivers Inventory, in part due to outstanding fish and wildlife benefits (National Park Service 1982). The Missouri River from the Fort Randall Dam in South Dakota to just downstream from Niobrara, Nebraska, and from Gavins Point Dam near Yankton, South Dakota, to Ponca State Park near Ponca, Nebraska, is a Wild and Scenic River identified as the Missouri National Recreational River. Outdoor recreation, from boating and fishing to camping and hunting, is important along the entire Missouri River in Nebraska. However, recreational use likely is much lower than its potential due to the reduction in fish and wildlife habitats in the channelized reach (U.S. Fish and Wildlife Service 1980). Despite this, a 2004 survey by the Missouri Department of Conservation, in cooperation with the Nebraska Game and Parks Commission, and others indicated that the Missouri

American lotus blooms in a wetland along the Missouri River in Fontenelle Forest near Bellevue. MICHAEL FORSBERG

River that year generated 153,470 angler visits, 63,400 hunter visits, and 468,920 wildlife observation visits in Nebraska. The economic impacts realized from recreational use of the Missouri River in Nebraska in 2004 was more than $28 million (Sheriff et al. 2011). Several state parks and recreation areas along the Missouri River, including Indian Cave State Park, Lewis and Clark State Recreation Area, Ponca State Park, and Niobrara State Park, each receive well over 150,000 visitors per year.

Conservation Success Stories

The Missouri River Recovery Program is led by the U.S. Army Corps of Engineers and is addressing past habitat losses. Eighteen projects are underway or have been completed along Nebraska's portion of the river through this program. Some of the partners who helped with these projects included the Nebraska Game and Parks Commission, Winnebago Tribe, Omaha Tribe, Papio-Missouri River NRD, U.S. Fish and Wildlife Service, Fontenelle Forest, and The Nature Conservancy. The projects involved acquiring flood prone lands from willing sellers and then restoring side channels, backwaters, and their associated floodplain wetlands. In addition, many landowners voluntarily enrolled portions of their flood prone properties into the NRCS's Wetlands Reserve Easements program. These two programs have made great strides in improving fish and wildlife habitats along the river while also providing some much-improved recreational opportunities. Websites: nrcs.usda.gov, search "wetland reserve easements;" nwo.usace.army.mil/mrrp/maps-and-sites.

A young wood duck feeds in a wetland covered with duckweed. Wooded wetlands in eastern Nebraska provide important places for these birds to nest and to feed. CHRIS MASADA

Contacts

A variety of programs are in place to help restore wetlands and improve flows and habitat to the Missouri River. Contact the Nebraska Game and Parks Commission office in Lincoln, (402) 471-5561, or Norfolk, (402) 370-3374.

Missouri National Recreational River — The National Park Service manages the National Recreation River, which is a component of the Wild and Scenic River System. The designated areas include the Missouri River from the Fort Randall Dam in South Dakota to just downstream from Niobrara, Nebraska, and from Gavins Point Dam near Yankton, South Dakota, to Ponca State Park near Ponca, Nebraska, the lower 20 miles of the Niobrara River and lower 8 miles of Verdigre Creek. Contact: National Park Service, 508 E. 2nd St., Yankton, SD 57078, (605) 665-0209.

Select Public Use Areas

- Randall W. Shilling WMA, northeast edge of Plattsmouth, Cass County
- William Gilmour Memorial WMA, 1 mile south and 1 mile east of Plattsmouth, Cass County
- Audubon Bend, 2 miles north of Wynot, Cedar County
- Ponca State Park and Elk Point Bend WMA, 2 miles north of Ponca, Dixon County
- Niobrara State Park, Niobrara Confluence WMA and Bazile Creek WMA, adjacent to Niobrara, Knox County
- Langdon Bend, 1 mile east of Nemaha, Nemaha County
- Peru Bottoms WMA, 1 miles north of Peru, Nemaha County
- Hamburg Bend, 3 miles south and 5 miles east of Nebraska City, Otoe County
- Indian Cave State Park, 13 miles north of Falls City, Richardson County
- Fontenelle Forest, Bellevue, Sarpy County; the area is owned by a private organization, but the public can access it for a fee.
- Boyer Chute National Wildlife Refuge, 3 miles east of Fort Calhoun, Washington County
- DeSoto National Wildlife Refuge, 3 miles east of Blair, Washington County

Freshwater mussels are found in places like the Elkhorn River and benefit from nearby wetlands that provide food for them.
GRANT REINER, PLATTE BASIN TIMELAPSE

ELKHORN RIVER

Profile

The Elkhorn River arises out of the eastern Sandhills and joins with the Platte River just west of Omaha. The Elkhorn River contains numerous sandbars and side channels, similar in some ways to the Platte River. Numerous wetlands are associated with the floodplain of the Elkhorn River. Most of these wetlands are oxbows, occurring in former channels of the river that were left isolated as the river changed its course. These wetlands range from permanent lakes to temporarily-flooded meadow areas.

Loss and Threats

The wetlands along the Elkhorn River appear to have been less affected by drainage and diversion than those along the Platte River and many other Nebraska rivers. However, some drainage and filling have occurred, and the remaining wetlands are threatened by continued conversion, sand and gravel mining, potential diversions of river water, sedimentation from surrounding cropland, bank stabilization, and channel straightening.

Benefits

The Elkhorn River and its associated wetlands provide habitat for the state endangered least tern and state and federally threatened piping plover, especially in the vicinity of sandpit sites that provide nesting substrate. Numerous wading birds, shorebirds and waterfowl, especially wood ducks, also use the Elkhorn and its associated wetlands. Parts of the Elkhorn River are in the Elkhorn Confluence and Elkhorn River Headwaters Biologically Unique Landscapes (Schneider et al. 2011).

Freshwater mussels are imperiled across much of their historic range and are a vital part of the aquatic ecosystem. They have declined due to habitat alterations and changes in water quality. The upper stretch of the Elkhorn River from west of Stuart to downriver of O'Neill has one of the few remaining natural populations of plain pocketbook mussels found in Nebraska. Pocketbooks from the Elkhorn River have provided brood stock to assist with native mussel restoration efforts in other parts of the state. Along with pocketbooks, several other species of mussels still can be found in the upper Elkhorn, most commonly the giant floater and heel splitters. Mussels constantly are filtering water, taking in algae, small detritus, and bacteria. The wetlands associated with the river are an important source of these foods needed by the mussels.

Being associated with the river's floodplain, the wetlands of this complex play a valuable role in maintaining the natural functions and dynamics of the river system. These functions include filtering the water, attenuating flood peaks, and providing water to the river during periods of low flows.

The Elkhorn River provides significant recreation because of its proximity to cities such as O'Neill, Norfolk, Fremont and Omaha.

Conservation Success Stories

The Wood Duck Wildlife Management Area provides some outstanding examples of wetlands associated with the Elkhorn River. Many of the wetlands were in good condition, but others had been altered over the years and needed restoration. The restoration of these wetlands required several years to complete and needed the help and input from an array of experts, including soil scientists, biologists, engineers, surveyors, grant managers, contractors, equipment operators, and neighboring landowners.

Partners included private landowners, Ducks Unlimited, The Conservation Fund, First National Bank of Omaha, National Wild Turkey Federation, Pheasants Forever, Izaak Walton League, Todd Valley Wetland Foundation, Nebraska Environmental Trust, Cub Scout Pack 212, U.S. Fish and Wildlife Service (North American Wetland Conservation Act funds), Natural Resources Conservation Service, and the Nebraska Game and Parks Commission. Wetland restoration projects can be complex and take time, but watching how quickly the wildlife respond to the improved conditions makes it all worthwhile. Website: ducks.org/nebraska.

Contacts

Contact the Nebraska Game and Parks Commission

A serene evening scene across an Elkhorn River oxbow wetland at Wood Duck Wildlife Management Area near Norfolk.
TED LAGRANGE, NEBRASKA GAME AND PARKS COMMISSION

office in Norfolk, (402) 370-3374.

Select Public Use Areas

- Hackberry Creek WMA, 2 miles east and 0.5 miles north of Clearwater, Antelope County
- Black Island WMA, 2 miles east of Pilger, Cuming County
- Red Fox WMA, 1 miles south of Pilger, Cuming County
- Powder Horn WMA/Dead Timber SRA, 1 mile west and 3 miles north of Scribner, Dodge County
- Dry Creek WMA, 2 miles southeast of O'Neill, Holt County
- Yellow Banks WMA, 3 miles north and 2 miles west of Battle Creek, Madison County
- Wood Duck WMA, 2 miles south and 4 miles west of Stanton, Stanton County

NIOBRARA RIVER

Profile

The Niobrara River flows across northern Nebraska from Sioux County to Knox County. The portion of the river upstream from Box Butte Reservoir has numerous alkaline wet meadow wetlands on the floodplain. In the central portion of the river, mostly in Cherry County, there are a variety of wetlands that receive water from the river and the numerous springs located along the canyon walls of the river valley. These springs not only support wetlands, but are also the source of over 200 waterfalls along this reach of the river. As the river flows east from Cherry County, it becomes shallower and more braided, with wetlands both along the fringe of the channel and as wet meadows on the floodplain. The Niobrara River is a scenic treasure in Nebraska and provides a unique mix of northern, western, and eastern plant communities. A portion of the river downstream from Valentine has been designated as a National Scenic River, and the lower 20 miles as a National Recreation River under the Wild and Scenic Rivers Act.

Loss and Threats

The wetlands located along the Niobrara have not been greatly altered by human activities. Some small dams have been put in place, but most of the river flows naturally. Invasive purple loosestrife has spread along the Niobrara and constitutes a threat because it is of little value to wildlife, and it out-competes desirable native wetland plants.

Benefits

The Niobrara River and its associated wetlands provide important habitat for over 250 bird species. Endangered whooping cranes stop along the Niobrara River during migration. Least terns and threatened piping plovers nest on unvegetated sandbars on the Niobrara. The region also hosts concentrations of migrating and wintering waterfowl and nesting colonies of wading birds such as great blue herons. The Niobrara River includes the Upper, Middle, and Lower Biologically Unique Landscapes (Schneider et al. 2011).

Being associated with the river's floodplain, the wetlands of this complex play a valuable role in maintaining the natural functions and dynamics of the river system. These functions include filtering the water, attenuating flood peaks, and sustaining the river during periods of low flows.

Since being designated as a Scenic River in 1991,

The Niobrara River by Butte in Boyd County. MICHAEL FORSBERG

tourism related to the river has greatly increased. Use has grown from 25,000-30,000 to an average of 84,000 people per year in 2019-2021.

Conservation Success Stories

An early success that recognized the beauty and importance of the Niobrara River was its designation as a National Scenic River. This designation afforded certain portions of the river some protection, but also recognized the important role private landowners would play in sustaining the beauty of the river. In more recent times, the Nebraska Natural Legacy Project has had coordinating wildlife biologists working with private landowners to help with conservation projects in the Middle and Lower Niobrara River Biological Unique Landscapes and

in the adjacent Verdigris/Bazile Biological Unique Landscape. In the lower portion of the river, many landowners have voluntarily enrolled portions of their property into the NRCS's Wetlands Reserve Easements Program and have restored their wetlands located along the river. Websites: nrcs.usda.gov, search "wetland reserve easements;" nps.gov/niob; NebraskaNaturalLegacy.org.

Contacts

Niobrara National Scenic River — The National Park Service manages a total of 76 miles of the Niobrara as a National Scenic River. Contact: National Park Service, 214 W. Highway 20, Valentine, NE 69201 (402) 376-1901. Other contacts include Fort Niobrara National Wildlife Refuge, U.S. Fish and Wildlife Service, Box 67, Valentine, NE 69201, (402) 376-3789; the Niobrara Valley Preserve, The Nature Conservancy, Box 348, Johnstown, NE 69214, (402) 722-4440; and the Nebraska Game and Parks Commission office in Norfolk, (402) 370-3374.

Springs located along the canyon walls of the river valley form spring branch canyon wetlands, and are also the source of over 200 waterfalls along this reach of the river. MICHAEL FORSBERG

Kayaking, canoeing and tubing are all very popular forms of water recreation along the Niobrara River. JUSTIN HAAG, NEBRASKALAND

Select Public Use Areas

- Borman Bridge WMA, 2 miles southeast of Valentine, Cherry County
- Chat Canyon WMA, 10 miles south and 3 miles east of Nenzel, Cherry County
- Fort Niobrara National Wildlife Refuge, 3 miles east of Valentine, Cherry County
- Smith Falls State Park, 18 miles east of Valentine, Cherry County
- Niobrara State Park, 1 miles west of Niobrara, Knox County
- Fred Thomas WMA, 10 miles north of Bassett, Rock County
- Fossil Bed National Monument, 22 miles south of Harrison, Sioux County

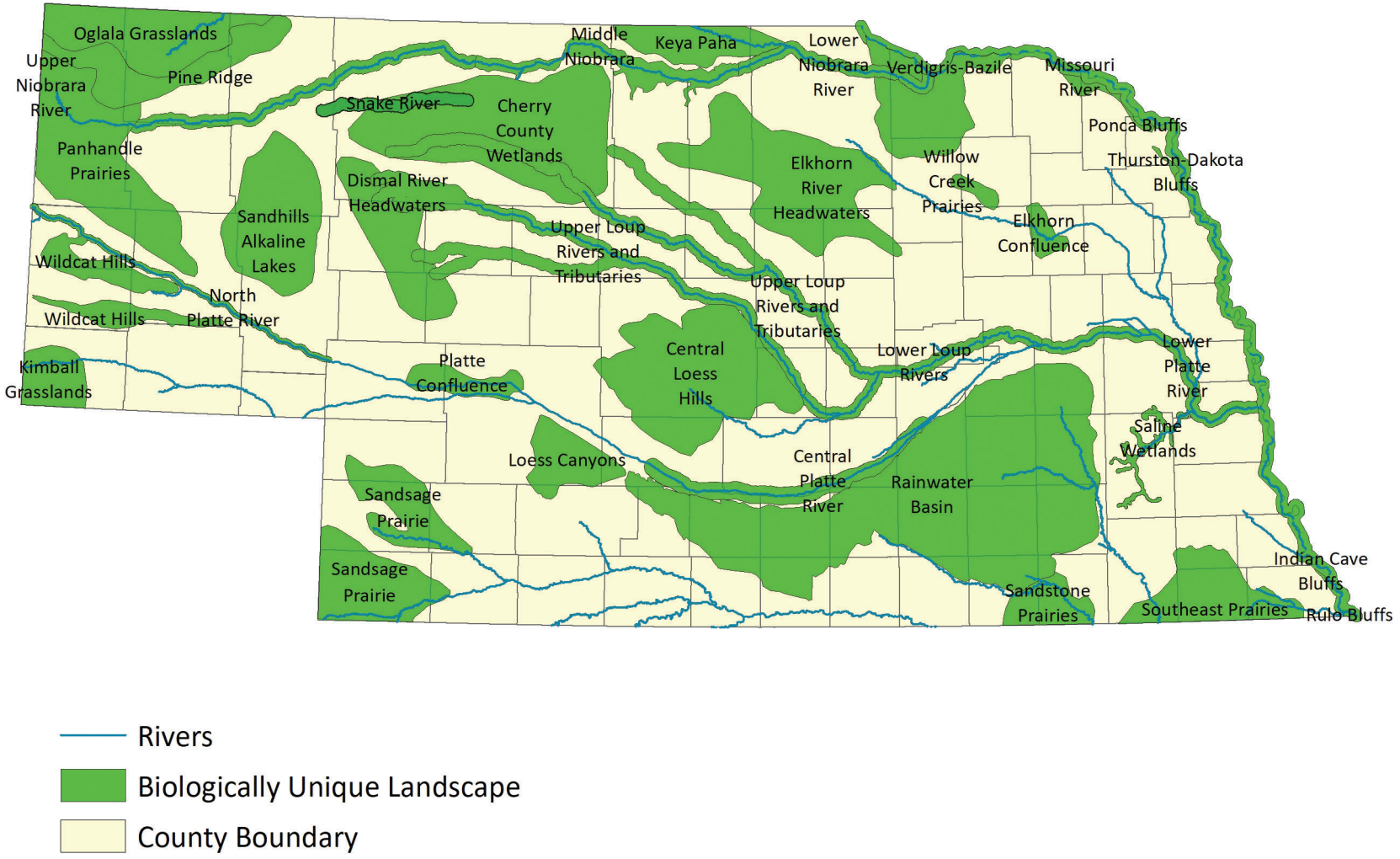
NOMENCLATURE

Table showing common and scientific names of species mentioned in this guide

TAXA	COMMON NAME	SCIENTIFIC NAME
PLANTS	Broad-leaf cattail	*Typha latifolia*
	Buckbean	*Menyanthes trifoliata*
	Eastern cleomella	*Cleomella angustifolia*
	Eastern redcedar	*Juniperus virginiana*
	European common reed	*Phragmites australis* subsp. *australis*
	Garrison creeping foxtail	*Alopecurus arundinaceus*
	Hybrid cattail	*Typha x glauca*
	Marsh marigold	*Caltha palustris*
	Narrow-leaf cattail	*Typha angustifolia*
	Nevada bulrush	*Scirpus nevadensis*
	Purple loosestrife	*Lythrum salicaria*
	Redtop	*Agrostis gigantea*
	Reed canary grass	*Phalaris arundinacea*
	River bulrush	*Bolboschoenus fluviatilis*
	Saltmarsh aster	*Aster subulatus var. ligulatus*
	Saltwort	*Salicornia rubra*
	Sea milkwort	*Glaux maritima*
	Seaside heliotrope	*Heliotropum curassavicum*
	Silverweed	*Potentilla anserina*
	Slender plantain	*Plantago elongata*
	Tall cotton grass	*Eriophorum angustifolium*
	Tall wheatgrass	*Thinopyrum ponticum*
	Texas dropseed	*Sporobolus texanus*
	Thelypody	*Thelypodium integrifolium*
	Western prairie fringed orchid	*Platanthera praeclara*
MOLLUSKS	Giant floater	*Pyganodon grandis*
	White heelsplitter	*Lasmigona complanata*
	Plain pocketbook	*Lampsilis cardium*
	Zebra mussel	*Dreissena polymorpha*
	Giant floater	*Pyganodon grandis*
INSECTS	Salt Creek tiger beetle	*Cicindela nevadica var. lincolniana*
FISH	Black crappie	*Pomoxis nigromaculatus*
	Bluegill	*Lepomis macrochirus*
	Finescale dace	*Chrosomus neogaeus*
	Lake sturgeon	*Acipenser fulvescens*
	Largemouth bass	*Micropterus salmoides*
	Northern pike	*Esox lucius*
	Northern redbelly dace	*Chrosomus eos*
	Paddlefish	*Polyodon spathula*
	Pallid sturgeon	*Scaphirhynchus albus*
	Sauger	*Sander canadensis*
	Sturgeon chub	*Macrhybopsis gelida*
	Topeka shiner	*Notropis topeka*
	Walleye	*Sander vitreus*
	Western blacknose shiner	*Notropis heterolepis*
	Yellow perch	*Perca flavescens*
TURTLES	Blanding's turtle	*Emydoidea blandingii*
MAMMALS	Beaver	*Castor canadensis*
	Muskrat	*Ondatra zibethicus*
	River otter	*Lontra canadensis*

Nebraska Natural Legacy Project: Biologically Unique Landscapes

The Nebraska Natural Legacy Project designated a number of areas as Biologically Unique Landscapes (BULs) (Schneider et al. 2011)



MAP BY COLLEEN ROTHE-GROLEAU, NEBRASKA GAME AND PARKS COMMISSION

SELECT WETLAND SPECIES

PLANTS AND ANIMALS

Select plants and animals that occur in and around Nebraska wetlands. Includes common, unusual, and threatened and endangered species. Underlined species are on the State of Nebraska endangered/threatened list. Bolded species are also on the federal endangered/threatened list.

PLANTS

SALINE

- Saltwort
- Saltgrass

WET MEADOW AND EDGE SPECIES

- Cottongrass
- Marsh marigold
- **Western prairie-fringed orchid**
- Swamp rose mallow
- Spotted touch-me-not
- Swamp milkweed
- Smartweed

Western prairie-fringed orchid. DAKOTA ALTMAN, PLATTE BASIN TIMELAPSE

- Beggar's tick
- Barnyard grass
- Marsh skullcap
- Marsh fern
- Sedges
- Water cress

EMERGENT

- Cattail
- Arrowhead
- Sweet flag
- Bulrush
- Water hemlock
- Wild rice
- Common reed

SUBMERGENT AND FLOATING LEAFED

- Bladderwort

Bladderwort is a carnivorous plant. It has a showy yellow flower above the water, but its underwater leaves have bladders that can capture very small aquatic animals. ETHAN FREESE, PLATTE BASIN TIMELAPSE

- Pondweed
- Water lily

WOODY

- Willow
- Buttonbush
- Dogwood
- Elderberry
- Silver maple
- Cottonwood
- Sycamore

INTRODUCED

- Purple loosestrife
- Reed canary grass

Pond snail. ETHAN FREESE, PLATTE BASIN TIMELAPSE

ANIMALS

NON-INSECT INVERTEBRATES

- Daphnia
- Scud (Amphipod)
- Leech
- Pond snail
- Freshwater mussel
- Crayfish

INSECTS

- Water scorpion
- Damselfly
- Dragonfly
- Water strider
- Water boatman
- Common backswimmer
- Predaceous diving beetle
- Whirligig beetle
- **Salt Creek tiger beetle**
- Midge fly
- Mosquito
- Monarch butterfly
- Western tiger swallowtail butterfly
- Great gray copper butterfly

Crayfish. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Wetlands support many pollinators, such as this monarch feeding on blazing star.
JON FARRAR, NEBRASKALAND

FISH

- **Pallid sturgeon**
- Paddlefish
- Longnose and shortnose gar
- Northern pike
- Grass pickerel
- Largemouth bass
- Bluegill
- Green sunfish
- Western mosquito fish
- Fathead minnow
- Plains topminnow
- Sturgeon chub
- Northern redbelly dace

Northern redbelly dace is listed as a threatened species in Nebraska and lives in cool streams in the Sandhills.
COURTESY OF SOUTH DAKOTA GAME, FISH, AND PARKS

- Finescaled dace
- Northern pearl dace
- Blacknose shiner
- Iowa darter
- Plains killifish
- Stickleback
- Small-mouth buffalo
- Carp

AMPHIBIANS

- Tiger salamander
- Chorus frog
- Bullfrog
- Central Plains toad
- Spadefoot toad
- American toad
- Rocky Mountain toad
- Great Plains toad
- Leopard frog
- Northern cricket frog
- Cope's gray treefrog

Cope's gray treefrogs prefer wooded wetlands, and some are green in color.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

REPTILES

- Snapping turtle
- Blanding's turtle
- Northern painted turtle
- Spiny soft-shelled turtle
- Yellow mud turtle
- Plains garter snake
- Red-sided garter snake
- Massasauga
- Common water snake
- Graham's water snake
- Western fox snake

Birds

- White pelican
- Double-crested cormorant
- Pied-billed grebe
- Eared grebe
- Trumpeter swan
- Canada goose
- Snow goose
- White-fronted goose
- Mallard
- Northern pintail
- Blue-winged teal
- Wood duck
- Redhead
- Great blue heron
- American bittern
- Sandhill crane
- **Whooping crane**
- Bald eagle
- Northern harrier
- Peregrine falcon
- Ring-necked pheasant
- Least tern
- Black tern
- Ring-billed gull
- Sora

Red-winged blackbird.
ETHAN FREESE, PLATTE BASIN TIMELAPSE

- American coot
- **Piping plover**
- Avocet
- Black-necked stilt
- Pectoral sandpiper
- Wilson's phalarope
- Common snipe
- Short-eared owl
- Belted kingfisher
- Willow flycatcher
- Tree swallow
- Yellow warbler
- Common yellowthroat
- Yellow-headed blackbird
- Red-winged blackbird
- Swamp sparrow

MAMMALS

- Short-tailed shrew
- Meadow vole
- Southern bog lemming
- Meadow jumping mouse
- Muskrat
- Beaver
- Raccoon
- Mink
- River otter
- Long-tailed weasel
- White-tailed deer
- Silver-haired bat

A silver-haired bat feeds over a wetland.
ERIC FOWLER, NEBRASKALAND

REFERENCES

GENERAL

Austin, J. E., and A. L. Richert. 2001. A comprehensive review of observational and site evaluation data of migrant Whooping Cranes in the United States, 1943-99. U.S. Geological Survey Report, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Berry, C. R., Jr. and D. G. Buechler. 1993. Wetlands in the Northern Great Plains, a guide to values and management. U.S. Fish and Wildlife Service and Agricultural Extension Service, South Dakota State University, USA.

Bieber, N. R., S. P. Wilson, and C. R. Allen. 2018. River otter distribution in Nebraska. Wildlife Society Bulletin 42:136–143.

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. The U.S. Shorebird Conservation Plan, 2nd edition. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

Collins, J. T. 1993. Amphibians and reptiles in Kansas, 3rd edition, revised. University of Kansas, Natural History Museum, Lawrence, Kansas, USA.

Cowardin, L. M., V. Carter, F. Golet and E. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C., USA.

Cross, D. 1994. Waterfowl Management Handbook. Leaflet 13. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dahl, T. E. 1990. Wetlands – Losses in the United States - 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dahl, T. E. and C. E. Johnson. 1991. Status and trends of wetlands in the conterminous United States, mid-1970s to mid-1980s. First update of the National Wetlands Status Report. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C., USA.

Dahl, T. E. 2000. Status and trends of wetlands in the conterminous United States, 1986 to 1997. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C., USA.

Dahl, T. E. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dahl, T. E. 2011. Status and trends of wetlands in the conterminous United States 2004 to 2009. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dreier, C. A. 2018. Nebraska Wetland Condition Assessment: Intensification of the National Wetland Condition Assessment throughout Nebraska. Thesis. University of Nebraska, Lincoln, USA.

Ducks Unlimited, Inc. 1999. Nebraska Conservation Plan- A strategy for restoring and protecting Nebraska's wetland resources. Ducks Unlimited Inc., Bismarck, North Dakota, USA.

Elliott, C. R. 1991. Mapping Nebraska wetlands. NEBRASKAland, Nebraska Game and Parks Commission. June:36–41.

Farrar, J. 1976. Dabblers and divers, Nebraska's ducks. NEBRASKAland, Nebraska Game and Parks Commission. November:24–33.

Farrar, J. (Coordinator). 1983. Nebraska Rivers – Special Issue. NEBRASKAland, Nebraska Game and Parks Commission. January-February, 146 pp.

Farrar, J. 1983. Ducks and the 404. NEBRASKAland, Nebraska Game and Parks Commission. September:42–43.

Farrar, J. 1985. Birds of the marsh. NEBRASKAland, Nebraska Game and Parks Commission. January:28–41.

Farrar, J. 1989. Blueprint for waterfowl. NEBRASKAland, Nebraska Game and Parks Commission. August:26–35.

Farrar, J. 1990. Field guide to wildflowers of Nebraska and the Great Plains. NEBRASKAland, Nebraska Game and Parks Commission, Nebraska, USA.

Farrar, J. 1991. Marsh birds. NEBRASKAland, Nebraska Game and Parks Commission. May:8–21.

Farrar, J. 1992. Musquash...grazer of the marsh. NEBRASKAland, Nebraska Game and Parks Commission. June:14–23.

Farrar, J. 1998. A wetland reborn. NEBRASKAland, Nebraska Game and Parks Commission. March:28–35.

Farrar, J. 1998. A haven for herons (Omaha's urban wetland). NEBRASKAland, Nebraska Game and Parks Commission. October:40–45.

Farrar, J. 2000. Burning for wildlife. NEBRASKAland, Nebraska Game and Parks Commission. March:20–25.

Farrar, J. 2004. Birding Nebraska. NEBRASKAland, Nebraska Game and Parks Commission. January-February:178.

Forsberg, M. 1997. Purple loosestrife, the rising tide. NEBRASKAland, Nebraska Game and Parks Commission. July:26–33.

Forsberg, M. 2011. The Plains Topminnow. NEBRASKAland, Nebraska Game and Parks Commission. May:20–21.

Forsberg, M. 2015. Seeing a watershed in motion. NEBRASKAland, Nebraska Game and Parks Commission. January-February:24–29.

Fowler, E. 2005. Restoring Nebraska wetlands. NEBRASKAland, Nebraska Game and Parks Commission. March:40–45.

Fowler, E. 2021. One trail – many species use a well-worn path between two waters. NEBRASKAland, Nebraska Game and Parks Commission. November:50–57.

Fowler, E. 2022. Conestoga: a model lake. NEBRASKAland, Nebraska Game and Parks Commission. April:28–35.

Frankforter, J. D. 1996. Nebraska wetland resources. Pages 261–266 in J. D. Fretwell, J. S. Williams, and P. J. Redman, compilers. National water summary of wetland resources, U.S. Geological Survey Water Supply Paper 2425, Reston, Virginia, USA.

Galatowitsch, S. M., and A. van der Valk. 1994. Restoring prairie wetlands: An ecological approach. Iowa State University Press, Ames, Iowa, USA.

Geiser, J. Raising Freshwater mussels in Nebraska. 2017. NEBRASKAland, Nebraska Game and Parks Commission. April:40–47.

Gersib, R. A. 1991. Nebraska Wetlands Priority Plan. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Gersib, R. A. 1985. Wetlands not wastelands. NEBRASKAland, Nebraska Game and Parks Commission. September:20–25.

Great Plains Research. 1998. Freshwater functions and values of prairie wetlands – Special Issue. Great Plains Research 8:208.

Hrabik, R. A., S. C. Schainost, R. H. Stasiak, and E. J. Peters. 2015. The fishes of Nebraska. Mennonite Press, Inc., Newton, Kansas, USA.

Harmon, K. 1980. Economics of wetlands. NEBRASKAland, Nebraska Game and Parks Commission. October:18–19.

Hubbard, D. E. 1989. Wetland values in the Prairie Pothole Region of Minnesota and the Dakotas. U.S. Fish and Wildlife Service,

Cooperative Research Unit, Biological Report 88, Brookings, South Dakota, USA.

Johnsgard, P. A. 2001. The nature of Nebraska: Ecology and biodiversity. University of Nebraska Press, Lincoln, USA.

Johnsgard, P. A. 2012. Nebraska's wetlands: Their wildlife and ecology. University of Nebraska, Nebraska Water Survey Paper No. 78. Lincoln, Nebraska, USA.

Jones, J. K., Jr., D. M. Armstrong, R. S. Hoffman, and C. Jones. 1983. Mammals of the Northern Great Plains. University of Nebraska Press, Lincoln, Nebraska, USA.

Kaul, R. B. 1975. Vegetation of Nebraska (circa 1850). University of Nebraska, Conservation and Survey Division, Lincoln, Nebraska, USA.

Knue, J. 1997. NEBRASKAland: Wildlife Viewing Guide. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. A. Hatch, S. Kress, R. Milko, S. Miller, K. L. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Syderman, J. Trapp, J. Wheeler, and K. D. Wohl. 2002. Waterbird conservation for the Americas: The North American Waterbird Conservation Plan, version 1. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Kusler, J. A., and M. E. Kentula. 1990. Wetland creation and restoration: The status of the science. Island Press, Washington D.C., USA.

Kusler, J. A., and T. Opheim. 1996. Our national wetland heritage, a protection guide. Environmental Law Institute, Washington, D.C., USA.

Kuzelka, R. D., C. A. Flowerday, R. N. Manley, and B. C. Rundquist. 1993. Flat Water: A history of Nebraska and its water. Resource Report No. 12. Conservation and Survey Division, University of Nebraska, Lincoln, USA.

LaGrange, T. G. 1996. The purple problem (purple loosestrife). NEBRASKAland, Nebraska Game and Parks Commission. June:6–7.

LaGrange, T. G. 1997. A guide to Nebraska's wetlands and their conservation needs. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G. 2005. A guide to Nebraska's wetlands and their conservation needs, second edition. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G. 2015. Wetland Program Plan for Nebraska. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G. 2019. Wetland Program Plan for Nebraska, 2019-2023. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G., R. Stutheit, and S. Thomas. 2005. The geographic definitions of Nebraska's wetland complexes and statistics for each generated from digital National Wetland Inventory data. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G., and R. Stutheit. 2011. Wetland management guidelines for Nebraska's wildlife management areas. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Larson, G. E. 1993. Aquatic and wetland vascular plants for the Northern Great Plains. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-238, Fort Collins, Colorado, USA.

Leitch, J. A. and B. Hovde. 1996. Empirical valuation of prairie potholes: Five case studies. Great Plains Research 6:25–39.

Maher, H. D., Jr., G. F. Engelmann, and R. D. Shuster. 2003. Roadside geology of Nebraska. Mountain Press Publication Company, Missoula, Montana, USA.

McMurtrey, M. D., R. Craig, and G. Schildman. 1972. Nebraska wetland survey. Habitat Work Plan K-71. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Mitsch, W. J., and J. G. Gosselink. 2015. Wetlands. Fifth edition. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.

Middleton, B. 1999. Wetland restoration, flood pulsing, and disturbance dynamics. John Wiley & Sons Inc., New York, USA.

Mollhoff, W. J. 2001. The Nebraska Breeding Bird Atlas, 1984-89. Nebraska Ornithologist's Union Occasional Papers No. 7. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Moshiri, G. 1994. Constructed wetlands for water quality improvement. Lewis Publishers, Boca Raton, Florida, USA.

Murkin, H. R., A. G. van der Valk, and W. R. Clark. 2000. Prairie wetland ecology, the contribution of the Marsh Ecology Research Program. Iowa State University Press, Ames, USA.

National Research Council. 1995. Wetlands: Characteristics and boundaries. National Academy Press, Washington, D.C., USA.

Nebraska Department of Environmental Quality, Nebraska Game and Parks Commission, and the Nebraska Natural Resources Commission. 1997. Nebraska wetland resources: A summary of the issues involving conservation of Nebraska's wetlands, Lincoln, Nebraska, USA.

Nebraska Game and Parks Commission. 2016. Cool Water Stream Management Plan. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Nebraska Department of Agriculture. 2000. Purple loosestrife pamphlet. Lincoln, Nebraska, USA.

Payne, N. F. 1992. Techniques for wildlife habitat management of wetlands. McGraw Hill, Inc., New York, New York, USA.

Pennak, R. W. 1978. Fresh-water invertebrates of the United States. John Wiley and Sons, New York, New York, USA.

Rogers, L. 2017. A mammal brief – muskrat. NEBRASKAland, Nebraska Game and Parks Commission. March:8.

Rolfsmeier, S., and G. Steinauer. 2003. Vascular plants of Nebraska, Version I. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Rundquist, D. 1987. Wetlands: A different point of view. NEBRASKAland, Nebraska Game and Parks Commission. April:10–15.

Schainost, S. C. 2016. A Guide to the Freshwater Mussels of Nebraska. Lincoln: Nebraska Game and Parks Commission. 110 pp.

Schmidt, T. L., and T. D. Wardle. 1998. The forest resources of Nebraska. Research Paper NC-332, North Central Research Station, U.S. Forest Service, St. Paul, Minnesota, USA.

Schneider, R., K. Stoner, G. Steinauer, M. Panella, and M. Humpert. 2011. The Nebraska Natural Legacy Project: State Wildlife Action Plan. Second edition. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Sharpe, R. S., W. R. Silcock, and J. G. Jorgensen. 2001. Birds of Nebraska: Their distribution and temporal occurrence. University of Nebraska Press, Lincoln, USA.

Slattery, B. E., and A. S. Kesselheim. 1995. WOW! The wonders of wetlands, an educator's guide. Environmental Concern, St. Michaels, Maryland, USA.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Smith, L. M. 2003. Playas of the Great Plains. University of Texas Press, Austin, USA.

Steinauer, G. 2003. A guide to prairie and wetland restoration in eastern Nebraska. Prairie Plains Resource Institute and the Nebraska Game and Parks Commission, Aurora, Nebraska, USA.

Steinauer, G. 2019. Marshes – A winter refuge for pheasants. NEBRASKAland, Nebraska Game and Parks Commission. December:20–27.

Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska, Version IV. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Thiessen, J. D., K. D. Koupal, and C. W. Schoenebeck. 2019. Factors limiting reintroduced plains topminnow, Fundulus sciadicus, populations in Central Great Plains Streams. Prairie Naturalist 51:68-76.

Tiner, R. W., Jr. 1984. Wetlands of the United States: Current status and recent trends. U.S. Department of the Interior, Fish and Wildlife Service, National Wetlands Inventory, Washington D.C., USA.

U.S. Army Corps of Engineers. 1987. Wetlands delineation manual. Environmental Laboratory. Waterways Experiment Station, Vicksburg, Mississippi, USA.

U.S. Army Corps of Engineers. 2010a. Regional supplement to the Corps of Engineers wetland delineation manual: Great Plains region (Version 2.0), J. S. Wakeley, R. W. Lichvar, and C. V. Noble, editors. ERDC/EL TR-10-1, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi, USA.

U. S. Army Corps of Engineers. 2010b. Regional supplement to the Corps of Engineers wetland delineation manual: Midwest Region (Version 2.0). J. S. Wakeley, R. W. Lichvar, and C. V. Noble, editors. ERDC/EL TR-10-16, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi, USA.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2021. National Engineering Handbook, Part 650. Wetland restoration, enhancement, or creation. Washington, D.C., USA.

U.S. Department of Agriculture, Soil Conservation Service. 1994. Midwestern wetland flora, field office guide to plant species. Midwest National Technical Center, Lincoln, Nebraska, USA.

U.S. Department of Agriculture. County Soil Surveys. Available for each county from the local Natural Resources Conservation Service office. Contains useful soils, geology, landuse, and wetland information.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2002. Field indicators of hydric soils in the United States, Version 5.0. G. W. Hurt, P. M. Whited, and R. F. Pringle, editors. U.S. Department of Agriculture, Natural Resources Conservation Service, Ft. Worth, Texas, USA.

U.S. Environmental Protection Agency. 1991. Wetlands: Their potential for profit, alternative usages of wetlands other than conventional farming in Iowa, Kansas, Missouri and Nebraska.[brochure].

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1986. North American Waterfowl Management Plan. Washington, D.C., USA.

U.S. Fish and Wildlife Service. 1988. National list of plant species that occur in wetlands: Nebraska. Biological Report NERC-88/18.27. U.S. Fish and Wildlife Service, Washington, D.C., USA.

U.S. Fish and Wildlife Service. 1997. A system for mapping riparian areas in the western United States. U.S. Fish and Wildlife Service, National Wetlands Inventory, Denver, USA.

U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries. 1998. North American Waterfowl Management Plan, 1998 Update- Expanding the Vision. Washington, D.C., USA.

U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries. 2012. North American Waterfowl Management Plan, 2012: People Conserving Waterfowl and Wetlands. Washington, D.C., USA.

U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries. 2018. North American Waterfowl Management Plan, 2018 Update - Connecting People, Waterfowl, and Wetlands. Washington, D.C., USA.

van der Valk, A., editor. 1989. Northern prairie wetlands. Iowa State University Press, Ames, USA.

Weller, M. W. 1987. Freshwater marshes, ecology and wildlife management. 2nd edition. University of Minnesota Press, Minneapolis, USA.

RAINWATER BASIN

Anderson, B. E., H. L. Hillhouse, A. A. Bishop, and E. M. Nugent. 2019. Grazing Rainwater Basin wetlands. University of Nebraska-Lincoln, Extension Publication EC3040.

Anteau, M. J., M. H. Sherfy, and A. A. Bishop. 2011. Location and agricultural practices influence spring use of harvested cornfields by crane and geese in Nebraska. Journal of Wildlife Management 75:1004–1011.

Applied Geosciences and Environmental Management Section Environmental Science Division, Argonne National Laboratory. 2011. Five-year summary and evaluation of operations and performance of the Utica Aquifer and North Lake Basin wetlands restoration project in 2004-2009. Department of Energy, Oak Ridge, Tennessee, USA.

Austin, J. E., and A. L. Richert. 2001. A comprehensive review of observational and site evaluation data of migrant whooping cranes in the United States, 1943-99. U.S. Geological Survey Report, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Baxter, W. L., and C. W. Wolfe. 1973. Life history and ecology of the ring-necked pheasant in Nebraska. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Beas, B. J. 2012. The effects of wetland sedimentation and sediment removal on Rainwater Basin vegetation, seed bank, and waterbird communities. Dissertation, Oklahoma State University, Stillwater, USA.

Beas, B. J., L. M. Smith, K. R. Hickman, T. G. LaGrange, and R. Stutheit. 2013. Seed bank responses to wetland restoration: Do restored wetlands resemble reference wetland conditions following sediment removal? Aquatic Botany 108:7–15.

Beas, B. J., L. M. Smith, T. G. LaGrange, and R. Stutheit. 2013. Effects of sediment removal on vegetation communities in Rainwater Basin playa wetlands. Journal of Environmental Management 128:371–379.

Beas, B. J., and L. M. Smith. 2014. Amphibian community responses to playa restoration in the Rainwater Basin. Wetlands 34:1247–1253.

Begosh, A., L. M. Smith, C. N. Park, S. T. McMurry, and T. G. LaGrange. 2020. Effects of wetland presence and upland land use on wild hymenopteran and dipteran pollinators in the Rainwater Basin of Nebraska, USA. Wetlands 40:1017–1031.

Belden, J. B., B. R. Hanson, S. T. McMurry, L. M. Smith, and D. A. Haukos. 2012. Assessment of the effects of farming and conservation programs on pesticide deposition in High Plains wetlands. Environmental Science Technology 46:3424–3432.

Bishop, A. A. 2008. Rainwater Basin wetland complex waterfowl habitat use model, Version 2. U.S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Bishop, A. A., and M. Vrtiska. 2008. Effects of the Wetland Reserve Program on waterfowl carrying capacity in the Rainwater Basin region of south-central Nebraska. A Conservation Effects Assessment Project, Wildlife Component assessment. U.S. Department of Agriculture, Natural Resource Conservation Service Publication. U.S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Bishop, A. A., J. Liske-Clarke, M. Tacha, and R. Reker. 2010. Whooping crane conservation plan for the Rainwater Basin region of south-central Nebraska. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Bishop, A. A., A. Barenberg, N. Volpe, and R. Grosse. 2011. Nebraska land cover development, Rainwater Basin Joint Venture report. Grand Island, Nebraska, USA.

Bishop, A. A., and R. Grosse. 2012. Scoring criteria and ranking for wildlife

habitat incentive program, Rainwater Basin public wetland watershed special initiative. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Blanchong, J. A., M. D. Samuel, and G. Mack. 2006. Multi-species patterns of avian cholera mortality in Nebraska's Rainwater Basin. Journal of Wildlife Diseases. 42:81–91.

Brennan, E. K. 2006. Local and landscape variables influencing migratory bird abundance, behavior, and community structure in Rainwater Basin wetlands. Dissertation, Texas Tech University, Lubbock, USA.

Brennan, E. K., L.M. Smith, D.A. Haukos, and T.G. LaGrange. 2005. Short-term response of wetland birds to prescribed burning in Rainwater Basin wetlands. Wetlands 25:667–674.

Cariveau, A. B., D. C. Pavlacky, A. A. Bishop, and T. G. LaGrange. 2011. Effects of surrounding land use on playa inundation following intense rainfall. Wetlands 31:65–73.

Daniel, D. W. 2015. Greenhouse gas fluxes and carbon storage dynamics in playa wetlands: Restoration potential to mitigate climate change. Dissertation, Oklahoma State University, Stillwater, USA.

Daniel, D. W., L. M. Smith, and S. T. McMurry. 2015. Land use effects on sedimentation and water storage volume in playas of the Rainwater Basin of Nebraska. Land Use Policy 42:426–431.

Daniel, D. W., L. M. Smith, D. A. Haukos, L. A. Johnson, and S. T. McMurry. 2014. Land use and Conservation Reserve Program effects on the persistence of playa wetlands in the High Plains. Environmental Science and Technology 48:4282–4288.

Daniel, D. W., L. M. Smith, and S. T. McMurry. 2016. Greenhouse gas fluxes and carbon storage dynamics in playa wetlands: Restoration potential to mitigate climate change. Natural Resources Conservation Service, Conservation Effects Assessment Project Science Note.

Daniel, D. W., L. M. Smith, and S. T. McMurry. 2017. Effects of sediment removal and surrounding land use on carbon and nitrogen storage in playas and watersheds in the Rainwater Basin region of Nebraska. Soil and Tillage Research 174:169–176.

Daniel, D. W., L. M. Smith, and S. T. McMurry, B. A. Tangen, C. F. Dahl, N. H. Euiliss, Jr., and T. G. LaGrange. 2019. Effects of land use on greenhouse gas flux in playa wetlands and associated watersheds in the High Plains, USA. Agricultural Sciences, Special Issue: Agriculture, Ecosystems and Environment 10:181–201.

Dappen, P., J. Merchant, and M. Tooze. 2001. GIS database development for the Rainwater Basin. Final Report, Conservation and Survey Division, University of Nebraska, Lincoln, USA.

Davis, C. A., and J. R. Bidwell. 2007. Invertebrate response to wetland management practices, land-use practices, and restorations in the Rainwater Basin region. Final Report, State Wildlife Grant T-11, Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Davis, C. A., and J. R. Bidwell. 2008. Response of aquatic invertebrates to vegetation management and agriculture. Wetlands 28:793–805.

Davis, C. A., J. R. Bidwell, and K. R. Hickman. 2009. Effects of hydrological regimes on competitive interactions of Schoenoplectus fluviatilis and two co-occurring wetland plants. Aquatic Botany 91:267–272.

Dinsmore, S. J. 1996a. Snowy plovers in the Rainwater Basin. Nebraska Bird Review 64:71.

Dinsmore, S. J. 1996b. Whimbrel. Nebraska Bird Review 64:131–132.

Drahota, J. 2003. Breeding black-necked stilts at Funk Waterfowl Production Area. Nebraska Bird Review 71:166–167.

Drahota, J. 2012. Rainwater Basin seed availability, depletion, and waterfowl response during spring migration. Thesis, University of Nebraska, Kearney, USA.

Drahota, J., and L. M. Reichart. 2015. Wetland seed availability for waterfowl in annual and perennial emergent plant communities of the Rainwater Basin. Wetlands 35:1105–1116.

Elliott, C R. 1991. Mapping Nebraska wetlands. NEBRASKAland. Nebraska Game and Parks Commission. June:36–41.

Ekstein, J. D., and S. E. Hygnstrom. 1996. Fate of wetlands associated with the central Nebraska irrigation canal system. Great Plains Research 6:41–60.

Erickson, N. E., and D. M. Leslie, Jr. 1987. Soil-vegetation correlations in the Sandhills and Rainwater Basin wetlands of Nebraska. Biological Report 87. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Evans, R. D., and C. W. Wolfe, Jr. 1967. Waterfowl production in the Rainwater Basin area of Nebraska. Journal of Wildlife Management 33:788–794.

Farmer, A. H., and F. Parent. 1997. Effects of landscape on shorebird movements at spring migration stopovers. Condor 99:698–707.

Farmer, A. H., and J. Wiens. 1999. Models and reality: Time-energy trade-offs in pectoral sandpiper migration. Ecology 80:2566–2580.

Farrar, J. 1982. The Rainwater Basin, Nebraska's vanishing wetlands. NEBRASKAland. Nebraska Game and Parks Commission. March:18–34.

Farrar, J. 1995. Grazing for waterfowl. NEBRASKAland. Nebraska Game and Parks Commission. December:8–13.

Farrar, J. 1996. Nebraska's Rainwater Basin. NEBRASKAland. Nebraska Game and Parks Commission. March:18–35.

Farrar, J. 1996. The Troester tunnel. Notes from the field. NEBRASKAland. Nebraska Game and Parks Commission. May:6–7.

Farrar, J. Ducks Unlimited in the Rainwater Basin. 2010. NEBRASKAland. Nebraska Game and Parks Commission. March:22–29.

Fontaine, J. J., A. D. Fedele, L. S. Wzola, L. N. Messinger, E. F. Stuber, C. J. Chizinski, J. J. Lusk, K. L. Decker, and J. S. Taylor. 2019. Hunters and their perceptions of public access: A view from afield. Journal of Fish and Wildlife Management 10:589–601.

Forsberg, M. 1998. Funk Lagoon, yesterday and today. NEBRASKAland. Nebraska Game and Parks Commission. December 24–31.

Foster, S. 2010. Temporal and spatial variations of ions, isotopes and agricultural contaminants in surface and groundwaters of Nebraska's Rainwater Basin wetlands. Thesis, University of Nebraska, Lincoln, USA.

Gabig, P. J. 2000. The Rainwater Basin Joint Venture Evaluation Plan. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Geluso, K., B. T. Krohn, M. J. Harner, and M. J. Assenmacher. 2013. Whooping cranes consume plains leopard frogs at migratory stopover sites in Nebraska. Prairie Naturalist 45:91–93.

Gersib, R. A. 1991. Nebraska Wetlands Priority Plan. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Gersib, R. A., B. Elder, K. F. Dinan, and T. H. Hupf. 1989. Waterfowl values by wetland type within Rainwater Basin wetlands with special emphasis on activity time budget and census data. Nebraska Game and Parks Commission, Lincoln, Nebraska, and U.S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Gersib, R. A., R. R. Raines, W. S. Rosier, and M. C. Gilbert. 1989. A functional assessment of selected wetlands within the Rainwater Basin area of Nebraska. Nebraska Game and Parks Commission. Lincoln, Nebraska, USA.

Gersib, R. A., J. Cornely, A. Trout, J. Hyland, and J. Gabig. 1990. Concept plan for waterfowl habitat protection, Rainwater Basin area of Nebraska. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Gersib, R. A., K. F. Dinan, J. D. Kauffeld, M. D. Onnen, P. J. Gabig, J. E. Cornely, G. E. Jasmer, J. M. Hyland, K. J. Strom. 1992. Looking to the future: An implementation plan for the Rainwater Basin Joint Venture. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Giandinoto, J. M. 1998. Examining spatial and temporal variability in wetlands. Thesis, University of Nebraska, Lincoln., USA.

Gilbert, M. C. 1989. Ordination and mapping of wetland communities in Nebraska's Rainwater Basin region. CEMRO Environmental Report 89-1. Omaha District, U.S. Army Corps of Engineers, Omaha, Nebraska, USA.

Gillespie, C. R. 2015. Shorebird migratory stopover responses to local and regional change: Habitat decisions in a vanishing landscape. Thesis, University of Nebraska, Lincoln, USA.

Gillespie, C. R., and J. J. Fontaine. 2017. Shorebird stopover habitat decisions in a changing landscape. Journal of Wildlife Management 81:1051–1062.

Gordon, C. C., L. D. Flake, and K. F. Higgins. 1990. Aquatic invertebrates in the Rainwater Basin area of Nebraska. Prairie Naturalist 22:191–200.

Gurdak, J. J., and C. D. Roe. 2009. Recharge rates and chemistry beneath playas of the High Plains Aquifer—A literature review and synthesis. Circular 1333, U.S. Geological Survey, Reston, Virginia, USA.

Hillhouse, H. L., S. J. Tunnell, and J. Stubbendieck. 2010. Spring grazing impacts on the vegetation of reed canarygrass invaded wetlands. Rangeland Ecology and Management 63:581–587.

Jones, H. P., K. Schoengold, Z. Tang, Y. Nam, and D. Varner. 2018. An application of economics and environmental planning: The impacts of variable rate irrigation technology on net farm income. University of Nebraska-Lincoln Digital Commons, University of Nebraska, Lincoln, USA.

Jorgensen, C. F. 2012. Assessing local and landscape constraints on habitat management for grassland and upland birds. Thesis, University of Nebraska-Lincoln, Lincoln, USA.

Jorgensen, J. G. 2002. The changing status of the sandhill crane in the eastern Rainwater Basin. Nebraska Bird Review 70:122–127.

Jorgensen, J. G. 2003. Another breeding record of the sandhill crane in the eastern Rainwater Basin. Nebraska Bird Review 71:167–168.

Jorgensen, J. G. 2004. An overview of shorebird migration in the eastern Rainwater Basin, Nebraska. Nebraska Ornithologists' Union Occasional Paper No. 8.

Jorgensen, J. G. 2007. Buff-breasted sandpiper (*Tryngites subruficollis*) abundance, habitat use, and distribution in the Rainwater Basin, Nebraska. Thesis, University of Nebraska, Omaha, USA.

Jorgensen, J. G. 2009. Buff-breasted sandpipers. NEBRASKAland. Nebraska Game and Parks Commission. May:12-19.

Jorgensen, J. G. 2008. Update to an overview of shorebird migration in the eastern Rainwater Basin, Nebraska. Lincoln, Nebraska, USA.

Jorgensen, J. G. 2012. Birds of the Rainwater Basin, Nebraska, Version 1.0. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Jorgensen, J. G. 2016. A summary of 2015 breeding bird surveys of selected Rainwater Basin wetlands. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Jorgensen, J. G., J. P. McCarty, and L. L. Wolfenbarger. 2007. Landscape and habitat variables affecting Buff-breasted sandpiper *Tryngites subruficollis* distribution during migratory stopover in the Rainwater Basin, Nebraska, USA. Wader Study Group Bulletin 112:45–51.

Jorgensen, J. G., J. P. McCarty, and L.L. Wolfenbarger. 2008. Buff-breasted sandpiper density and numbers during migratory stopover in the Rainwater Basin, Nebraska. Condor 110:63–69.

Jorgensen, J. G., J. P. McCarty, and L. L. Wolfenbarger. 2009. Killdeer *Charadrius vociferus* breeding abundance and habitat use in the eastern Rainwater Basin, Nebraska. Wader Study Group Bull 116:65–68.

Jorgensen, J. G., and P. D. Dunbar. 2005. Multiple black-necked stilt nesting records in the Rainwater Basin. Nebraska Bird Review 73:115–118.

Jorgensen, J. G., and W. R. Silcock. 2015. First nesting record and status review of the glossy ibis in Nebraska. Nebraska Bird Review 83:139–149.

Keech, C. F., and V. H. Dreeszen. 1959. Geology and ground-water resources of Clay County, Nebraska. U.S. Geological Survey Water-Supply Paper 1468, Washington, D.C., USA.

Keech, C. F., and V. H. Dreeszen. 1968. Geology and ground-water resources of Fillmore County, Nebraska. U.S. Geological Survey Water-Supply Paper 1839, Washington, D.C., USA.

Krapu, G. L., K. J. Reinecke, D. G. Jorde, and S. G. Simpson. 1995. Spring staging ecology of midcontinent greater white-fronted geese. Journal of Wildlife Management 59:736–746.

Krapu, G. L., D. A. Brandt, and R. R. Cox, Jr. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildlife Society Bulletin 32:127–136.

Krueger, J. P. 1986. Development of oriented lakes in the eastern Rainbasin region of south central Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Kuzila, M. S. 1984. Genesis and morphology of soils in and around large depressions in Clay County, Nebraska. Dissertation, University of Nebraska, Lincoln, USA.

Kuzila, M. S. 1994. Inherited morphologies of two large basins in Clay County, Nebraska. Great Plains Research 4:51–63.

Kuzila, M. S., D. C. Rundquist, and J. A. Green. 1991. Methods for estimating wetland loss: The Rainbasin region of Nebraska, 1927-1981. Journal of Soil and Water Conservation 46:441–446.

Kuzila, M. S., and D. T. Lewis. 1993. Soils in rain basins of south central Nebraska, properties, genesis and classification. Soil Sciences of America Journal 77:155–161.

LaGrange, T. G. 1995. Nebraska's Rainwater Basin Joint Venture. NEBRASKAland. Nebraska Game and Parks Commission. March:24–33.

LaGrange, T. G. 2005. A guide to Nebraska's wetlands and their conservation needs, second edition. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G. 2012. Final report submitted to EPA for the project entitled: Investigation of the role of Rainwater Basin wetlands in contributing to the functions of groundwater quality improvement and wildlife habitat, including an analysis of the impact of sediment on these functions (CD# 98780401), funded by the 2006 and 2007 EPA State, Tribal, and Local Government Wetland Protection Grant Program. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G. 2015. Final report submitted to EPA for the project entitled: Nebraska's Wetland Condition Assessment: An intensification study in support of the 2011 National Survey (CD# 97714601), and the related project entitled: Nebraska's Supplemental Clean Water Act §106 Funds, as related to participation in National Wetland Condition Assessment (I – 97726201). Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G. 2020. Final Report submitted to EPA for the project entitled: Impacts of agricultural toxicants on amphibians in the Rainwater Basin in central Nebraska, USA, 2015-2017 (CD# 97746801), funded by the 2014 EPA Wetland Program Development Grant Program. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G., R. Stutheit, and S. Thomas. 2005. The geographic definitions of Nebraska's wetland complexes and statistics for each generated from digital National Wetland Inventory data. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T. G., R. Stutheit, M. Gilbert, D. Shurtliff, and P. M. Whited. 2011. Sedimentation of Nebraska's playa wetlands:

A review of current knowledge and issues. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Li, R., Z. Tang, X. Li, and J. Winter. 2013. Drainage structure dataset and its effects on LiDAR-derived surface flow modeling. International Journal of Geo-Information 2:1136–1152.

Lotz, A., and C. R. Allen. 2007. Observer bias in anuran call surveys. Journal of Wildlife Management 71: 675–679.

Lueninghoener, G. C. 1947. The post-Kansan geologic history of the Lower Platte Valley area. University of Nebraska-Lincoln Studies No. 2:82.

McCarty, J. P., J. G. Jorgensen, and L. L. Wolfenbarger. 2009. Behavior of buff-breasted sandpipers (*Tryngites subruficollis*) during migratory stopover in agricultural fields. PLoS One 4(11):e8000 1-5.

McCarty, J. P., J. G. Jorgensen, J. M. Michaud, and L. L. Wolfenbarger. 2015. Buff-breasted sandpiper stopover duration in the Rainwater Basin, Nebraska, in relation to the temporal and spatial migration patterns in the Great Plains of North America. Wader Study 122:243–254.

McMurtrey, M. D., R. Craig, and G. Schildman. 1972. Nebraska wetland survey. Habitat Work Plan K-71. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Melcher, C. P., and S. K. Skagen. 2005. Grass buffers for playas in agricultural landscapes: A literature synthesis. U.S. Geological Survey. Biological Resources Discipline, Open-File Report 2005-1220:35. Fort Collins Science Center, Colorado, USA.

Melcher, C. P., and S. K. Skagen. 2005. Grass buffers for playas in agricultural landscapes: An annotated bibliography. U.S. Geological Survey. Biological Resources Discipline, Open-File Report 2005-1221:46. Fort Collins Science Center, Colorado, USA.

Merchant, J. W., and P. R. Dappen. 2010. Employing a geographic information system for wetlands management in Nebraska's Rainwater Basin. Pages 103–118 in N. Hoalst-Pullen and M. W. Patterson, editors. Geospatial Technologies in Environmental Management. Springer, New York, New York, USA.

Mimbs, W. H., J. Patrick, W. Cusaac, L. M. Smith, S. T. McMurry, and J. B. Belden. 2016. Occurrence of current-use fungicides and bifenthrin in Rainwater Basin wetlands. Chemosphere 159:275–281.

Mollhoff, W. J. 2001. The Nebraska Breeding Bird Atlas, 1984-89. Nebraska Ornithologist's Union Occasional Papers No. 7. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Mollhoff, W. J. 2016. The Second Nebraska Breeding Bird Atlas. University of Nebraska State Museum, Lincoln, Nebraska, USA.

Nicolai, N., and J. L. Stubbendieck. 2009. Alternative methods for wetland restoration in the Rainwater Basin, Nebraska. Agronomy and Horticulture – Faculty Publications, University of Nebraska, Lincoln, USA. http://digitalcommons.unl.edu/agronomyfacpub/534.

Nugent, E., A. Bishop, R. Grosse, T. LaGrange, D. Varner, and M. Vrtiska. 2015. An assessment of landscape carrying capacity for waterfowl and shorebirds in Nebraska's Rainwater Basin. A conservation effects assessment project wildlife component assessment report. Rainwater Basin Joint Venture, Wood River, Nebraska, USA.

O'Connell, J. L., L. A. Johnson, L. M. Smith, S. T. McMurry, and D. A. Haukos. 2011. Influence of land-use and conservation programs on wetland plant communities of the semiarid United States Great Plains. Biological Conservation 146:108–115.

O'Connell, J. L., D. W. Daniel, S. T. McMurry, and L. M. Smith. 2015. Soil organic carbon in playas and adjacent prairies, cropland, and Conservation Reserve Program land of the High Plains, USA. Soil and Tillage Research 156:16–24.

Park, C. N. 2017. Evaluating how wetland presence and restoration effects landscape and resource use of pollinator communities in an agricultural matrix. Thesis, Oklahoma State University, Stillwater, USA.

Park, C. N., L. M. Overall, L. M. Smith, T. LaGrange, and S. McMurry. 2017. Melittofauna and other potential pollinators in wetland and uplands in south central Nebraska (Insecta: Apoidea). Zootaxa 4242:255–280.

Pearse, A. T., G. L. Krapu, D. A. Brandt, and P. J. Kinzel. 2010. Changes in agriculture and abundance of snow geese affect carrying capacity of sandhill cranes in Nebraska. Journal of Wildlife Management 74:479–488.

Pearse, A. T., G. L. Krapu, R. R. Cox, Jr., and B. E. Davis. 2011. Spring-migration ecology of northern pintails in south-central Nebraska. Waterbirds 34:10–18.

Pearse, A. T., R. T. Alisauskus, G. L. Krapu, R. R. Cox, Jr. 2011. Changes in nutrient dynamics of midcontinent greater white-fronted geese during spring migration. Journal of Wildlife Management 75:1716–1723.

Pearse, A. T., G. L. Krapu, and R. R. Cox, Jr. 2013. Comparative spring-staging ecology of sympatric arctic-nesting geese in south-central Nebraska. American Midland Naturalist 169:371–381.

Pfost, M. A. 2008. Do behavior and abundance of spring-staging ducks vary with road proximity to wetlands in Nebraska's Rainwater Basin? Thesis, University of Nebraska, Kearney, USA.

Poor, J. P. 1997. The value of additional Central Flyway wetlands in Nebraska's Rainwater Basin - Three essays. Dissertation, University of Nebraska, Lincoln, USA.

Poor, J. P. 1999. The value of additional Central Flyway wetlands: The case of Nebraska's Rainwater Basin wetlands. Journal of Agricultural and Resource Economics 24:253–265.

Post van der Burg, M. 2005. Factors affecting songbird nest survival and brood parasitism in the Rainwater Basin region of Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Raines, R. R., M. C. Gilbert, R. A. Gersib, W. S. Rosier, and K. F. Dinan. 1990. Regulatory planning for Nebraska's Rainwater Basin wetlands (advanced identification of disposal areas). Prepared for the Rainwater Basin advanced identification study. U.S. Environmental Protection Agency, Region VII, Kansas City, Kansas and U.S. Army Engineer District, Omaha, Nebraska, USA.

Rainwater Basin Joint Venture. 1993. Water management options for wetland development in the Rainwater Basin. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 1994. Best management practices for Rainwater Basin wetlands. Public Lands Work Group, Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2013a. The Rainwater Basin Joint Venture Implementation Plan. Rainwater Basin Joint Venture. Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2013b. Rainwater Basin Joint Venture Waterfowl Plan. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2013c. Rainwater Basin Joint Venture Shorebird Plan. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2013d. Rainwater Basin Joint Venture Waterbird Plan. Rainwater Basin Joint Venture, Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2014. Implementation plan for the Rainwater Basin Joint Venture: A summary. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Rainwater Basin Joint Venture Public Lands Workgroup. 2016. Best management practices for Rainwater Basin wetlands. Rainwater Basin Joint Venture Report, Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2017. Best management practices for Rainwater Basin wetlands – A summary document. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Reichert, A. L. 1999. Multiple scale analyses

of whooping crane habitat in Nebraska. Dissertation, University of Nebraska, Lincoln, USA.

Riens, J. R. 2009. Assessment of macroinvertebrates, water quality, and pollution risk modeling in playa wetlands of Rainwater Basin waterfowl production areas. Thesis, University of Nebraska, Kearney, USA.

Riens, J. R., M. S. Schwarz, F. Mustafa, and W. W. Hoback. 2013. Aquatic macroinvertebrate communities and water quality at buffered and non-buffered wetland sites on federal waterfowl production areas in the Rainwater Basin, Nebraska. Wetlands 33:1025–1036.

Robichaux, R. M. 2010. Correlating climate with late-winter wetland habitat in the Rainwater Basin, south-central Nebraska. Thesis, Kansas State University, Manhattan, USA.

Robichaux, R. M., and L. B. M. Harrington. 2009. Environmental conditions, irrigation reuse pits, and the need for restoration in the Rainwater Basin wetland complex, Nebraska. Papers of the Applied Geography Conferences 32:217–225.

Rolfsmeier, S. B. 1992. A preliminary survey of the vegetation of the playa wetlands of Deuel, Keith, and Perkins counties in southwest Nebraska. Report to the Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Rundquist, B. 1990. Wetlands in the Rainwater Basin: Benefits are in the eye of the beholder. Conservation and Survey Division, University of Nebraska, Lincoln. Resource Notes 5:11–15.

Schepker, T. J. 2017. Evaluating the relationship between local food availability and wetland landscape structure in determining dabbling duck habitat use during spring migration. Thesis, University of Missouri, Columbia, USA.

Schepker, T. J., T. LaGrange, and E. B. Webb. 2018. Are waterfowl food resources limited during spring migration? A bioenergetic assessment of playas in Nebraska's Rainwater Basin. Wetlands 39:173–184.

Schepker, T. J., E. B. Webb, D. Tillitt, and T. LaGrange. 2019. Neonicotinoid insecticide concentrations in agricultural wetlands and associations with aquatic invertebrate communities. Agriculture, Ecosystems, and Environment 287. http://doi.org/10.1016/j.agee.2019.106678.

Schildman, G., and J. Hurt. 1984. Update of Rainwater Basin Wetland survey. Survey of habitat work plan K-83. W-15-R-40. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Schoengold, K., and H. P. Jones. 2019. The economic feasibility of variable rate irrigation technology for wetland restoration. University of Nebraska-Lincoln NebGuide G2318.

Sharpe, R. S., W. R. Silcock, and J. G. Jorgensen. 2001. Birds of Nebraska: Their distribution and temporal occurrence. University of Nebraska Press, Lincoln, USA.

Sherfy, M. H., M. J. Anteau, and A. A. Bishop. 2011. Agricultural practices and residual corn during spring crane and waterfowl migration in Nebraska. Journal of Wildlife Management 75:995–1003.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Smith, B. J., K. F. Higgins, and C.F. Gritzner. 1989. Land use relationships to avian cholera outbreaks in the Nebraska Rainwater Basin area. Prairie Naturalist 21:125–136.

Smith, B. J., and K. F. Higgins. 1990. Avian cholera and temporal changes in wetland numbers and densities in Nebraska's Rainwater Basin area. Wetlands 10:1–5.

Smith, B. J., K. F. Higgins, and W. L. Tucker. 1990. Precipitation, waterfowl densities and mycotoxins: their potential effect on avian cholera epizootics in the Nebraska Rainwater Basin area. Transactions of North American Wildlife and Natural Resources Conference 55:269–282.

Smith, L. M. 1998. Research needs for the Rainwater Basin of Nebraska: A hierarchical approach. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Smith, L. M. 2003. Playas of the Great Plains. University of Texas Press, Austin, Texas, USA.

Smith, L. M., D. A. Haukos, S. T. McMurry, T. LaGrange, and D. Willis. 2011. Ecosystem services provided by playa wetlands in the High Plains: Potential influences of USDA conservation programs and practices. Ecological Applications 21:S82–S92.

Starks, P. J. 1984. Analysis of rain basin depressions of Clay County, Nebraska. Thesis, University of Nebraska, Omaha, USA.

Stutheit, R. 1988. Occurrence of Ross's geese (Chen rossii) detected from avian cholera losses. Nebraska Bird Review 56:44–46.

Stutheit, R. G. 1988. Work Plan S-87, Mortality and disease investigations. W-15-R-44. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Stutheit, R. G. 2004. Getting the mud out (silt removal to restore Rainwater Basins). NEBRASKAland. Nebraska Game and Parks Commission. April:30–33.

Stutheit, R. G., M. C. Gilbert, P. M. Whited, and K. L. Lawrence, editors. 2004. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of Rainwater Basin depressional wetlands in Nebraska. erdc/el tr-04-4. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi, USA.

Swanson, L. D. 1986. The profitability of wetland drainage in the Rainwater Basin of Nebraska, prepared for the U.S. Environmental Protection Agency, Region VII, Kansas City, Kansas, USA.

Tang, Z., X. Li, and E. Harvey. 2011. Developing LiDAR-derived wetland maps to assess conservation design practices for playa wetlands in Rainwater Basin. Final Report to U.S. Environmental Protection Agency for grant # 97723501. University of Nebraska, Lincoln, USA.

Tang, Z. X. Li, N. Zhao, R. Li, and E. F. Harvey. 2012. Developing a restorable wetland index for Rainwater Basin wetlands in south-central Nebraska: A multi-criteria spatial analysis. Wetlands 32:975–984.

Tang, Z., R. Li, X. Li, W. Jiang, and A. Hirsh. 2014. Capturing LiDAR-derived hydrologic spatial parameters to evaluate playa wetlands. Journal of the American Water Resources Association 50:234–245.

Tang, Z. Y. Gu, Z. Dai, Y. Li, T. LaGrange, A. Bishop, and J. Drahota. 2015. Examining playa wetland inundation conditions for National Wetland Inventory, Soil Survey Geographic Database, and LiDAR data. Wetlands 35:641–654.

Tang, Z., Y. Gu, J. Drahota, T. LaGrange, A. Bishop, and M. Kuzila. 2015. Using fly ash as a marker to quantify culturally-accelerated sediment accumulation in playa wetlands. Journal of the American Water Resources Association 51:1643–1655.

Tang Z., Y. Gu, W. Jiang, Y. Xue, A. Bishop, T. LaGrange, and E. Nugent. 2016. Use RUSLE2 Model to assess the impact of soil erosion on playa inundation and hydrophyte conditions in the Rainwater Basin, Nebraska. Environmental Monitoring and Assessment 188:319.

Tang, Z, Y. Li, Y. Gu, W. Jiang, Y. Xue, Q. Hu, T. LaGrange, A. Bishop, J. Drahota, and R. Li. 2016. Assessing Nebraska playa wetland inundation status during 1985–2015 using Landsat data and Google Earth Engine. Environmental Monitoring and Assessment 188:654.

Tang, Z., J. Drahota, Q. Hu, and W. Jiang. 2017. Examining playa wetland contemporary conditions in the Rainwater Basin, Nebraska. Wetlands 38:25-36.

Tidwell, P. R. 2010. Nutrient reserves, food preferences and mass change of waterfowl migrating through the Rainwater Basin of Nebraska. Thesis, Arkansas Tech University, Russellville, USA.

Tidwell, P. R., E. B. Webb, M. P. Vrtiska, and A. A. Bishop. 2013. Diets and food selection of female mallards and blue-winged teal during spring migration. Journal of Fish and Wildlife Management. 4:63–74.

Uden, D. R. 2012. Agricultural landuse change impacts on bioenergy production, avifauna, and water use in Nebraska's Rainwater Basin. Thesis, University of Nebraska, Lincoln, USA.

Uden, D. R., M. L. Hellman, D. G. Angeler, and C. R. Allen 2014. The role of reserves and anthropogenic habitats for functional connectivity and resilience of ephemeral wetlands. Ecological Applications 24:1569–1582.

Uden, D. R., C. R. Allen, A. A. Bishop, R. Grosse, C. F. Jorgensen, T. G. LaGrange, R. G. Stutheit, and M. P. Vrtiska. 2015. Predictions of future ephemeral springtime waterbird stopover habitat availability under global change. Ecosphere 6:1–26.

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1986. North American Waterfowl Management Plan. Washington, D.C., USA.

U.S. Fish and Wildlife Service. 2007. Comprehensive Conservation Plan: Rainwater Basin Wetland Management District. U.S. Fish and Wildlife Service, Rainwater Basin Wetland Management District, Kearney, Nebraska, and U.S. Fish and Wildlife Service, Region 6, Mountain-Prairie Region, Lakewood, Colorado, USA.

U.S. Fish and Wildlife Service. 2011. Land Protection Plan – Rainwater Basin Wetland Management District expansion. U.S. Fish and Wildlife Service, Lakewood, Colorado, USA.

U.S. Fish and Wildlife Service, Canadian Wildlife Service, and Mexican Ministry of Environment, Natural Resources, and Fisheries. 2012. North American Waterfowl Management Plan, 2012: People Conserving Waterfowl and Wetlands. Washington, D.C., USA.

U.S. Fish and Wildlife Service and Nebraska Game and Parks Commission. 1986. Rainwater Basin of Nebraska migratory bird habitat acquisition plan. 30.

Verheijen, B., D. M. Varner, and D. A. Haukos. 2018. Effects of large-scale wetland loss on network connectivity of the Rainwater Basin, Nebraska. Landscape Ecology 33:1939–1951.

VonBank, J. A. 2020. Migration, Movement, and Winter Ecology of Midcontinent Greater White-Fronted Geese. Ph.D. Dissertation, Texas A&M University-Kingsville, USA.

Vrtiska, M. P., and S. Sullivan. 2009. Abundance and distribution of lesser snow and Ross's geese in the Rainwater Basin and central Platte River Valley of Nebraska. Great Plains Research 19:147–155.

Walters, R. A. 2003. Evaluation of chemical and mechanical soil disturbance for controlling reed canary grass in south-central Nebraska. Thesis, University of Nebraska, Kearney, USA.

Webb, E. B., L. M. Smith, M. P. Vrtiska, and T. G. LaGrange. 2010. Effects of local and landscape variables on wetland bird habitat use during migration through the Rainwater Basin. Journal of Wildlife Management 74:109–119.

Webb, E. B., L. M. Smith, M. P. Vrtiska, and T. G. LaGrange. 2010. Community structure of wetland birds during migration through the Rainwater Basin. Journal of Wildlife Management 74:765–777.

Webb, E. B., L. M. Smith, M. P. Vrtiska, and T. G. LaGrange. 2011. Factors influencing behavior of wetland birds during spring migration in the Rainwater Basin. Waterbirds 34:457–467.

Wilson, R. D. 2010. Evaluating hydroperiod response in the Rainwater Basin wetlands of south-central Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Windingstad, R. M., J. J. Hurt, A. K. Trout, and J. Cary. 1984. Avian cholera in Nebraska's Rainwater Basins. Transactions of North American Wildlife and Natural Resources Conference 49:577–583.

Xue, Y., Z. Tang, Q. Hu, and J. Drahota. 2019. Using the electromagnetic induction survey method to examine the depth to clay soil layer (Bt horizon) in playa wetlands. Journal of Soils and Sediments 20:556–570.

Zhang, H. 2018. Wetland conservation effects result in enhanced playa functionality in the Rainwater Basin, Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Zhang, H., Z. Tang, A. Bishop, J. Drahota, T. LaGrange, and D. Varner. 2019. Conservation significantly improves wetland conditions: Evaluation of playa wetlands in different conservation status. Wetlands Ecology and Management 28:85–102.

CENTRAL TABLE PLAYAS

Flowerday, C. 2001. Huge 'meteorite crater' near Merna likely caused by wind, say NU scientists. Conservation and Survey Division, University of Nebraska-Lincoln, Resource Notes 15:11–13.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

SOUTHWEST PLAYAS

Cariveau, A. B., and D. Pavlacky. 2009. Biological inventory and evaluation of conservation strategies in Southwest Playa wetlands. Final report to Nebraska Game and Parks Commission and Playa Lakes Joint Venture. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Cariveau, A. B., D. C. Pavlacky, A. A. Bishop, and T. G. LaGrange. 2011. Effects of surrounding land use on playa inundation following intense rainfall. Wetlands 31:65–73.

Fowler, E. 2005. The Southwest Playas. NEBRASKAland. Nebraska Game and Parks Commission. October:38–45.

LaGrange, T. Nebraska's Southwest Playa Wetlands. 2011. NEBRASKAland. Nebraska Game and Parks Commission. April:47.

O'Connell, J. L., D. W. Daniel, S. T. McMurry, and L. M. Smith. 2015. Soil organic carbon in playas and adjacent prairies, cropland, and Conservation Reserve Program land of the High Plains, USA. Soil and Tillage Research 156:16–24.

Rolfsmeier, S. B. 1992. A preliminary survey of the vegetation of the playa wetlands of Deuel, Keith, and Perkins counties in southwest Nebraska. Report to the Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

TODD VALLEY

Jorgensen, J. G., and S. J. Brenner. 2020. Migratory shorebird, waterfowl and waterbird use of wetlands in the Todd Valley, Nebraska. Nongame Bird Program, Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Lueninghoener, G. C. 1947. The post-Kansan geologic history of the Lower Platte Valley area. University of Nebraska-Lincoln Studies No. 2:82.

SANDHILLS

Adane, Z. A., P. Nasta, V. A. Zlotnik, and D. A. Wedin. 2018. Impact of grassland conversion to forest on groundwater recharge in the Nebraska Sand Hills. Journal of Hydrology: Regional Studies 15:171–183.

Befus, K. M., M. B. Cardenas, J. B. Ong, and V. A. Zlotnik. 2012. Classification and delineation of groundwater–lake interactions in the Nebraska Sand Hills (USA) using electrical resistivity patterns. Hydrogeology Journal 20:1483–1495.

Bellrose, F.C. 1980. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Bleed, A. and C. Flowerday, editors. 1990. An atlas of the Sand Hills. Atlas No. 5, Second Edition. Conservation and Survey Division, University of Nebraska, Lincoln, USA.

Brejda, J. J., L. E. Moser, S. S. Waller, S. R. Lowry, P. E. Reece, and J. T. Nichols. 1989. Atrazine and fertilizer effects on Sandhills subirrigated meadow. Journal of Range Management 42:104–108.

Clausen, M., M. Fritz, and G. Steinauer. 1989. The Nebraska Natural Heritage Program two-year progress report. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Cunningham, Z. C. 2011. Breeding fidelity and landscape effects on distribution of mallards and duck broods in the Nebraska Sandhills. Thesis, University of Nebraska, Lincoln, USA.

Cunningham, Z., L. A. Powell, M. P. Vrtiska, S. E. Stephens, and J. A. Walker. 2016. Skewed age ratios of breeding mallards in the Nebraska Sandhills. American Midland Naturalist 175:280–285.

DaRugna, O. A. 2020. Recreational activity dynamics at Valentine National Wildlife Refuge. Thesis, University of Nebraska, Lincoln, USA.

Dreier, C. A. 2018. Nebraska Wetland Condition Assessment: Intensification of the National Wetland Condition Assessment throughout Nebraska. Thesis. University of Nebraska, Lincoln, USA.

Ducey, J. E. 1990–1991. Ditching of wetlands in the Nebraska Sandhills, A case study of Grant County. Transactions of the Nebraska Academy of Sciences 18:1–10.

Engberg, R. A. 1984. Appraisal of data for groundwater quality in Nebraska. U.S. Geological Survey Paper 2245, Washington, D.C., USA.

Erickson, N. E., and D. M. Leslie, Jr. 1987. Soil-vegetation correlations in the Sandhills and Rainwater Basin wetlands of Nebraska. Biological Report 87. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Farrar, J. 2000. Sandhills fens, windows on geologic history. NEBRASKAland. Nebraska Game and Parks Commission. May:40–45.

Farrar, J. 2011. Potash- boom and bust in the Sandhills. NEBRASKAland. Nebraska Game and Parks Commission. January:34–41.

Fowler, E. 2016. Fishing the Sandhills, a guide to Nebraska Sandhills lakes. NEBRASKAland. Nebraska Game and Parks Commission. May:34–54.

Gilbert, M. C., M. W. Freel, and A. J. Bieber. 1980. Remote sensing and field evaluation of wetlands in the Sandhills of Nebraska. U.S. Army Corps of Engineers report, Omaha, Nebraska, USA.

Ginsberg, M. 1985. Nebraska's Sandhills lakes – a hydrogeologic overview. Water Resources Bulletin 21:573–578.

Glover, J. D. 2020. Common Carp (*Cyprinus Carpio*) affect water quality and macroinvertebrate communities in Nebraska Sandhill lakes. Thesis. Oklahoma State University, Stillwater, USA.

Gosselin, D. C. 1997. Major-ion chemistry of compositionally diverse lakes, Western Nebraska, U.S.A.: Implications for paleoclimatic interpretations: Journal Paleolimnology 17:33–49.

Gosselin, D. C., S. Sibray, and J. Ayers. 1994, Geochemistry of closed-basin, K-rich alkaline lakes, Western Sand Hills, Nebraska: Geochimica et Cosmochimica Acta 58:1403–1418.

Gosselin, D. C., V. Sridhar, E. F. Harvey, and J. W. Goeke. 2009. Hydrological effects and groundwater fluctuations in interdunal environments in the Nebraska Sandhills. Great Plains Research 16:17–28.

Grier, B. 1999. Cottonwood-Steverson Wildlife Management Area. NEBRASKAland. Nebraska Game and Parks Commission. March:38–45.

Gregory, C. J., S. J. Dinsmore, L. A. Powell, and J. G. Jorgensen. 2011. Nest survival of long-billed curlew in Nebraska. Wader Study Group Bulletin 118:109–113.

Haag, J. 2022. Turtles at home in Nebraska. NEBRASKAland. Nebraska Game and Parks Commission. April:18–25.

Harvey, F. E., J. B. Swinehart, and T. M. Kurtz. 2007. Ground water sustenance of Nebraska's unique Sand Hills peatland fen ecosystems. Groundwater 45:218–234.

Istanbulluoglu, E., T. J. Wang, O. M. Wright, and J. D. Lenters. 2012. Interpretation of hydrologic trends from a water balance perspective: the role of groundwater storage in the Budyko hypothesis. Water Resource Research 48:WOOH16.

Johnsgard, P. A. 1995. This fragile land, a natural history of the Nebraska Sandhills. University of Nebraska Press, Lincoln. Nebraska, USA.

Jolley, J. C., E. S. Albin, M. A. Kaemingk, and D. W. Willis. 2013. A survey of aquatic invertebrate communities in Nebraska Sandhill lakes reveals potential alternative ecosystem states. Journal of Fish and Wildlife Management 4:151–162.

Keech, C. and R. Bentall. 1971. Dunes on the plains: The Sandhills region of Nebraska. Resource Report No. 4. Conservation and Survey Division, University of Nebraska, Lincoln, USA.

LaBaugh, J. W. 1986. Limnological characteristics of selected lakes in the Nebraska Sandhills, U.S.A., and their relation to chemical characteristics of adjacent ground water. Journal of Hydrology 86:279–298.

Loope, D. B. and J. B. Swinehart. 2000. Thinking like a dune field: Geological history in the Nebraska Sandhills. Great Plains Research 10:5–35.

Loope, D. B., J. B. Swinehart, and J. P. Mason. 1995. Dune-dammed paleovalleys of the Nebraska Sand Hills: Intrinsic versus climatic controls on the accumulation of lake and marsh sediments. Geological Society of America Bulletin 107:396–406.

Mack, G. D., editor. 1993. Sandhill Management Plan: A Partnership Initiative. U.S. Department of the Interior, Fish and Wildlife Service. Kearney, Nebraska, USA.

Mack, G. D. 1995. Sandhills partnerships. NEBRASKAland. Nebraska Game and Parks Commission. May:34–43.

Mason, J. P., J. B. Swinehart, and D. B. Loope. 1997. Holocene history of lacustrine and marsh sediments in a dune-blocked drainage, southwestern Nebraska Sandhills, USA. Journal of Paleoclimatology 17:67–83.

McCarraher, D. B. 1977. Nebraska's Sandhills lakes. Nebraska Game and Parks Commission. Lincoln, Nebraska, USA.

McMurtrey, M. D., R. Craig, and G. Schildman. 1972. Nebraska wetland survey. Habitat Work Plan K-71. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Natural Resources Commission. 1993. Report on the Sandhills Area Study. Nebraska Natural Resources Commission, Lincoln, Nebraska, USA.

Nichols, J. T., P. A. Duncan, and D. C. Clanton. 1993. Seasonal trends in forage quality of plants in subirrigated meadows of the Nebraska Sandhills. Transactions of the Nebraska Academy of Sciences 20:25–32.

Novacek, J. M. 1989. The water and wetland resources of the Nebraska Sandhills. Pages 340–384 in A. van der Valk, editor. Northern Prairie Wetlands. Iowa State University Press, Ames, USA.

Ong, J. B. 2010. Investigation of spatial and temporal processes of lake-aquifer interactions in the Nebraska Sandhills. Dissertation, University of Nebraska, Lincoln, USA.

Ong, J. B., and V. A. Zlotnik. 2011. Assessing lakebed hydraulic conductivity and seepage flux by potentiomanometer. Ground Water 49:270–274.

Ong, J. B., J. W. Lane, Jr., V. A. Zlotnik, T. Halihan, and E. A. White. 2010. Combined use of frequency-domain electromagnetic and electrical resistivity surveys to delineate near-lake groundwater flow in the semi-arid Nebraska Sandhills, USA. Hydrogeology Journal 18:1539–1545.

Panella, M. J., and C. Rothe-Groleau. 2021.

Blanding's Turtle (*Emydoidea blandingii*): Species Conservation Assessment. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Richert, A. L. 2001. Sandhills Perception Study, Minnesota State University and University of Nebraska State Museum, Lincoln, Nebraska, USA.

Rossman, N. R., V. A. Zlotnik, C. M. Rowe, and J. Szilagyi. 2014. Vadose zone lag time and potential 21st century climate change effects on spatially distributed groundwater recharge in the semi-arid Nebraska Sandhills. Journal of Hydrology 519:656–669.

Rundquist, D. C. 1983. Wetland inventories of Nebraska's Sandhills. Resource Report No. 9. Conservation and Survey Division, University of Nebraska, Lincoln, USA.

Sandhills Task Force. 2014. Sandhills Task Force Strategic Plan. Printed by the Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Scholtz, R., D. Twidwell, 2022. The last continuous grasslands on Earth: Identification and conservation importance. Conservation Science and Practice 4:e626. http:/doi.org/10.1111/csp2.626.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Sridhar, V., K. G. Hubbard, and D. A. Wedin. 2006. Assessment of soil moisture dynamics of the Nebraska Sandhills using long-term measurements and a hydrology model. Journal of Irrigation and Drainage Engineering 132:463–473.

Steinauer, G. A. 1992. Sandhills Fens. NEBRASKAland. Nebraska Game and Parks Commission. July: 16–31.

Steinauer, G. A. 1994. Alkaline wetlands of the North Platte River valley. NEBRASKAland. Nebraska Game and Parks Commission. June:18–43.

Steinauer, G. A. 1995. Identification of and conservation strategies for Sandhills fens in Cherry County, Nebraska. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Steinauer, G. A., S. B. Rolfsmeier, and J. Phillips Hardy. 1996. Inventory and floristics of Sandhills fens in Cherry County, Nebraska. Transactions of the Nebraska Academy of Sciences 23:9-21.

Steinauer, G. A. 1998. The Loups, lifeblood of central Nebraska. NEBRASKAland. Nebraska Game and Parks Commission. June:24–33.

Steinauer, G. A. 2009. The shifting Sandhills vegetation. NEBRASKAland. Nebraska Game and Parks Commission. December:26–33.

Steuter, A., J. S. Hall, and M. L. Khoury. 2003. Conserving the biological diversity of the central mixed-grass prairie: a portfolio designed for conservation action. The Nature Conservancy, Omaha, Nebraska, USA.

Szilagyi, J., V. A. Zlotnik, J. B. Gates, and J. Jozsa. 2012. Mapping mean annual groundwater recharge in the Nebraska Sandhills, USA. Hydrogeology Journal 19:1503–1513.

Tolstead, W. 1942. Vegetation of the northern part of Cherry County, Nebraska. Ecological Monographs 12:255–292.

Turner, J. K., and D. C. Rundquist. 1980. Wetlands inventory of the Omaha district. U.S. Army Corps of Engineers, Omaha District, Nebraska, USA.

Ullah, A., and D. Rundquist 1998. Monitoring and mapping changes in the areal extent of standing water, wet soil, and wetland vegetation at Enders Lake: An examination of environmental variability through analyses of historical aerial and satellite imagery. Center for Advanced Land Management Information Technology, University of Nebraska, Lincoln, USA.

U.S. Fish and Wildlife Service. 1960. Drainage report Nebraska, 1954-1958. U.S. Fish and Wildlife Service, Minneapolis, Minnesota, USA.

Vrtiska, M. P. Movement of trumpeter swans in the Sandhills. 2017. NEBRASKAland. Nebraska Game and Parks Commission. January-February:69.

Vrtiska, M. P. Sandhills trumpeters. 2020. NEBRASKAland. Nebraska Game and Parks Commission. June:50–59.

Vrtiska, M. P., and S. L. Oldenburger. 2002. Waterfowl breeding population and production surveys. Unit Report. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Vrtiska, M. P., and L. A. Powell. 2011. Estimates of duck breeding populations in the Nebraska Sandhills using double observer methodology. Waterbirds 34:96–101.

Walker, J. A., Z. J. Cunningham, M. P. Vrtiska, S. E. Stephens, and L. A. Powell. 2008. Low reproductive success of mallards in a grassland-dominated landscape in the Sandhills of Nebraska. Prairie Naturalist 40:1–13.

Wang T. J., E. Istanbulluoglu, J. Lenters, and D. Scott. 2009. On the role of groundwater and soil texture in the regional water balance: An investigation of the Nebraska Sand Hills, USA. Water Resources Research 45:W10413.

Wang, T. J., D. A. Wedin, T. E. Franz, and J. Hiller. 2014. Effect of vegetation on the temporal stability of soil moisture in grass-stabilized semi-arid sand dunes. Journal of Hydrology 521:447–459.

Winter, T. C. 1988. A conceptual framework for assessing cumulative impacts on the hydrology of nontidal wetlands. Environmental Management 12:605–620.

Winter, T. C., D. O. Rosenberry, D. C. Buso, and D. A. Merk. 2001. Watersource to four U.S. wetlands: implications for wetland management. Wetlands 21:462–473.

Wolfe, C. 1984. Physical characteristics of the Sandhills: wetlands, fisheries, and wildlife. Pages 54-61 in Water Resources Seminar Series: the Sandhills of Nebraska, yesterday, today, and tomorrow. University of Nebraska, Lincoln, Nebraska, USA.

Zlotnik, V. A., M. Burbach, J. Swinehart, D. Bennett, S. C. Fritz, D. Loope, and F. Olaguera. 2007. Using direct-push methods for aquifer characterization in dune-lake environments of the Nebraska Sandhills. Environmental & Engineering Geoscience 13:205–216.

LOUP/PLATTE RIVER SANDHILLS

Farrar, J. 1974. Storm over the Sandhills. NEBRASKAland. Nebraska Game and Parks Commission. July:32–34 and 48.

Schildman, G. 1974. Wetland Survey. Survey of habitat work plan K-74. W-15-R-30. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Steinauer, G.A. 1998. The Loups, lifeblood of central Nebraska. NEBRASKAland. Nebraska Game and Parks Commission. June:24–33.

EASTERN SALINE

Allgeier, W. 2005. The behavioral ecology and abundance of tiger beetles inhabiting the eastern Saline Wetlands of Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Clausen, M., M. Fritz, and G. Steinauer. 1989. The Nebraska Natural Heritage Program: A two-year progress report. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Coke, G. R. 2008. Groundwater dynamics within the Saline Wetland alluvial of the little Salt Creek valley, Lancaster County, Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Cunningham, D. 1985. Villains, miscreants, and the salt of the earth. NEBRASKAland. Nebraska Game and Parks Commission. July:14–19 and 48.

Ducey, J. 1985. Nebraska's salt basin going, going, nearly gone. NEBRASKAland. Nebraska Game and Parks Commission. July:20–24.

Ducey, J. E. 1987. Biological features of Saline Wetlands in Lancaster County, Nebraska. Transactions of the Nebraska Academy of Sciences 15:5–14.

Farrar, J., and R. A. Gersib. 1991. Nebraska salt marshes: Last of the least. NEBRASKAland. Nebraska Game and Parks Commission. June:1–23.

Farrar, J. 2001. Rock Creek wetlands. NEBRASKAland. April. Nebraska Game and Parks Commission. April:10–19.

Farrar, J. 2003. Tiger of the marsh (the Salt Creek tiger beetle). NEBRASKAland. Nebraska Game and Parks Commission. March:18–25.

Farrar, J. 2005. Preserving the last of the least. NEBRASKAland. Nebraska Game and Parks Commission. January-February:46.

Farrar, J. Shoemaker Marsh. 2009. NEBRASKAland. Nebraska Game and Parks Commission. April:12–21.

Forsberg, M. 1999. Wanderings in a salt marsh. NEBRASKAland. Nebraska Game and Parks Commission. May:38–45.

Forsberg, M. Success in the salt marsh. 2018. NEBRASKAland. Nebraska Game and Parks Commission. August-September:26–38.

Fowler, E. Beetles on the brink. 2012. NEBRASKAland. Nebraska Game and Parks Commission. June: 40–45.

Fowler, E. Salt Creek tiger beetle. 2017. NEBRASKAland. Nebraska Game and Parks Commission. March:62–63.

Gersib, R. A., and G. Steinauer. 1990. An inventory and general assessment of eastern Nebraska Saline Wetlands in Lancaster and southern Saunders Counties. Nebraska Game and Parks Commission. Lincoln, Nebraska, USA.

Gilbert, J. 2008. Groundwater mixing dynamics in the Saline Wetlands of the Little Salt Creek Watershed, Lancaster County, Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Gilbert, M. C., and R. G. Stutheit, editors. 1994. Resource categorization of Nebraska's Eastern Saline Wetlands. Prepared for the Eastern Nebraska Saline Wetlands Interagency Study Project. U.S. Army Corps of Engineers, Omaha District and Nebraska Game and Parks Commission.

Gosselin, D. C., F. E. Harvey, and C. D. Frost, 2001. Geochemical evolution of groundwater in the Great Plains (Dakota) aquifer of Nebraska: Implications for management of a regional aquifer system. Ground Water 39:98–108.

Greenwald, J. 2007. Preserving saline wetlands on the urban fringe. Thesis, University of Nebraska, Lincoln, USA.

Harvey, F. E., J. F. Ayers, and D. C. Gosselin. 2007. Groundwater dependence of endangered ecosystems: Nebraska's Eastern Saline Wetlands. Ground Water 45:736–752.

Hitchcock, J. 2010. Habitat conservation planning guide for Nebraska's eastern Saline Wetlands. Thesis, University of Nebraska, Lincoln, USA.

Kaul, R. B. 1975. Vegetation of Nebraska (circa 1850). Conservation and Survey Division, University of Nebraska, Lincoln, USA. [Map].

Kelly, B. B. 2011. Using electrical resistivity imaging to map saline groundwater and subaqueous spring discharge: An example from the Saline Wetlands of eastern Nebraska. Thesis, University of Nebraska, Lincoln, USA.

LaGrange, T., T. Genrich, D. Schulz, B. Lathrop, and G. Johnson. 2003. Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Murphy, R. A. 1992 Problem identification and planning strategies for saline wetland protection in Lancaster County, Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Nabity, P. D., and K. D. Hoagland. 2006. Seed viability of inland saline wetlands in agro-ecosystems. Great Plains Research 16:173–180.

Poague, K., and J. Dinan. 1997. International shorebird survey report for southeastern Nebraska – Spring 1997. The Nebraska Bird Review 65:127–131.

Rolfsmeier, S. B. 1991. The flora and plant communities of the Ceresco saline basins, southern Saunders County, Nebraska. Unpublished report to the Lower Platte South Natural Resources District, Lincoln, Nebraska, USA.

Saline Wetlands Conservation Partnership. 2018. Nebraska's Saline Wetlands Conservation Plan. City of Lincoln, Nebraska, USA.

Shirk, C. J. 1924. An ecological study of the vegetation of an inland saline area. Thesis, University of Nebraska, Lincoln, USA.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Sorenson, E. 2005. Saline wetlands of eastern Nebraska: surface expressions of regional groundwater flow in the Rock Creek Watershed. Thesis, University of Nebraska, Lincoln, USA.

Spomer, S. M., and L. G. Higley. 1993. Population status and distribution of the Salt Creek Tiger Beetle. *Cicindela nevadica lincolniana* Casey (*Coleoptera: Cicindelidae*). Journal of the Kansas Entomological Society 66:392–398.

Spomer, S. M., and L. G. Higley. 1997. Nebraska's salt marsh tigers. University of Nebraska State Museum. Museum Notes # 97. Lincoln, Nebraska, USA.

Steinauer, G. 2020. Saving saltwort – Returning salt to salt marshes. NEBRASKAland. Nebraska Game and Parks Commission. June:32–35.

Taylor, T. J., and L. D. Krueger, editors. 1997. Mitigation guidelines for Nebraska's eastern saline wetlands. Prepared for the Eastern Saline Wetlands Interagency Study Project. U.S. Environmental Protection Agency, Region VII, and U.S. Army Corps of Engineers, Omaha, District, Omaha, Nebraska, USA.

Ungar, W., W. Hogan, and M. McClelland. 1969. Plant communities of saline soils at Lincoln, Nebraska. American Midland Naturalist 82:564–577.

U.S. Department of Agriculture. 1996. Rock Creek Saline Wetland Cooperative River Basin Study. Natural Resources Conservation Service, Lincoln, Nebraska, USA.

Welsh, R. 2022. Pass the salt. NEBRASKAland. Nebraska Game and Parks Commission. May:48.

Zlotsky, A., and J. Yost. 1998. Little Salt Fork Marsh Preserve: Restoration of an inland saline wetland. Land and Water 42:49–51.

WESTERN ALKALINE

Grier, B. 2009. Cranes on the North Platte. NEBRASKAland. Nebraska Game and Parks Commission. March:42–45.

Rolfsmeier, S. B. 1993. The saline wetland-meadow vegetation and flora of the North Platte River Valley in the Nebraska Panhandle. Transactions of the Nebraska Academy of Sciences 20:13–24.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Steele, G. V., and T. G. LaGrange. 2012. Investigation of restoration of wetlands in the Pumpkin Creek watershed upstream of Nebraska Highway 71, Banner and Scotts Bluff Counties, Western Nebraska. U.S. Geological Survey Study Plan, Lincoln, Nebraska, USA.

Steinauer, G. 1994. Alkaline wetlands of the North Platte River valley. NEBRASKAland. Nebraska Game and Parks Commission. June:18–43.

Varner D. M., A. T. Pearse, A. A. Bishop, J. I. Davis, J. C. Denton, R. C. Grosse, H. M. Johnson, E. J. Munter, K. D. Schroeder, R. E. Spangler, M. P. Vrtiska, and A. E. Wright. 2020. Roosting habitat use by sandhill cranes and waterfowl on the North and South Platte rivers in Nebraska. Journal of Fish and Wildlife Management 11:56–67.

PLATTE RIVER

Aiken, J. D. 1999. Balancing endangered species protection and irrigation water rights: the Platte River Cooperative Agreement. Great Plains Natural Resources Journal 3:119–158.

Alexander, K. D., and M. R. Whiles. 2000. A new species of Ironoquia (*Trichoptera: Limnephilidae*) from an intermittent slough of the central Platte River, Nebraska. Entomological News 111:1–7.

Anderson, A., E. D. Miller, B. Noonan, and C. A. Faanes, editors. 1989. The Platte River system: a resource overview. Interim Final Report. U.S. Fish Wildlife Service, Denver, Colorado, USA.

Austin, J. E., and A. L. Richert. 2001. A comprehensive review of observational and site evaluation data of migrant whooping cranes in the United States, 1943-99. U.S. Geological Survey Report, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Baasch, D. M., P. D. Farrell, J. M. Farsworth, and C. B. Smith. 2017. Nest-site selection by interior least terns and piping plovers at managed, off-channel sites along the Central Platte River in Nebraska. Journal of Field Ornithology 88:236–249.

Baasch, D. M., P. D. Farrell, A. J. Caven, K. C. King, J. M. Farnsworth, and C. B. Smith. 2019. Sandhill crane use of riverine roost sites along the central Platte River in Nebraska, USA. Monographs of the Western North American Naturalist 11:1–13.

Bliss, Q. P., and S. Schainost. 1973. Platte River Basin Level B Stream Inventory Report. Nebraska Game and Parks Commission. Lincoln, Nebraska, USA.

Brinley Buckley, E. M., C. R. Allen, M. Forsberg, M. Farrell, and A. J. Caven. 2017. Capturing change: the duality of time-lapse imagery to acquire data and depict ecological dynamics. Ecology and Society 22:30.

Brinley Buckley, E. M., A. J. Caven, J. D. Wiese, and M. J. Harner. 2021. Assessing the hydroregime of an archetypal riverine wet meadow in the central Great Plains using time-lapse imagery. Ecosphere 12(11):e03829.

Brinley Buckley, E. M., B. L. Gottesman, A. J. Caven, M. J. Harner, and B. C. Pijanowski. 2021. Assessing ecological and environmental influences on boreal chorus frog (*Pseudacris maculata*) spring calling phenology using multimodal passive monitoring technologies. Ecological Indicators 121:e107171.

Buckley, T. J. 2011. Habitat use and abundance patterns of sandhill cranes in the Central Platte River Valley, Nebraska, 2003-2010. Thesis, University of Nebraska, Lincoln, USA.

Bureau of Sociological Research. 1988. Nebraskans' participation in nature-associated recreation in the Platte River Valley. Nebraska Annual Social Indicator Survey. University of Nebraska, Lincoln, USA.

Burns, A. W. 1981. Simulated hydrologic effects of possible groundwater and surface alternatives in and near the Platte River, south central Nebraska. U.S. Geological Survey, Open-file Rep. 81-1116, Denver, Colorado, USA.

Caven, A. J., E. M. Brinley Buckley, K. C. King, J. D. Wiese, D. M. Baasch, G. D. Wright, M. J. Harner, A. T. Pearse, M. Rabbe, D. M. Varner, B. Krohn, N. Arcilla, K. D. Schroeder, and K. F. Dinan. 2019a. Temporospatial shifts in sandhill crane staging in the Central Platte River Valley in response to climatic variation and habitat change. Monographs of the Western North American Naturalist 11:33–76.

Caven, A. J., E. M. Brinley Buckley, J. D. Wiese, B. Taddicken, B. Krohn, T. J. Smith, and A. Pierson. 2019b. Appeal for a comprehensive assessment of the potential ecological impacts of the proposed Platte-Republican Diversion Project. Great Plains Research 29:123–135.

Caven, A. J., J. Malzahn, T. Franti, and E. M. Brinley Buckley, editors. 2019c. Proceedings of the Thirteenth Platte River Basin Ecosystem Symposium, 5-6 June 2018, Wood River, NE, USA. Nebraska Water Center, University of Nebraska, Lincoln, USA.

Caven, A. J., J. M. Malzahn, K. D. Koupal, E. M. Brinley Buckley, J. D. Wiese, R. Rasmussen, and C. Steenson. 2019d. Adult Whooping Crane (*Grus americana*) consumption of juvenile channel catfish (*Ictalurus punctatus*) during the avian spring migration in the Central Platte River Valley, Nebraska, USA. Monographs of the Western North American Naturalist 11:14–23.

Caven, A. J., B. Ostrom, A. Fowler, J. D. Wiese, and K. C. King. 2019e. New Wilson's phalarope nesting record from the Central Platte River Valley, Mormon Island, Hall County, Nebraska. Nebraska Bird Review 87:100–114.

Caven, A. J., D. M. Varner, and J. Drahota. 2020. Sandhill crane abundance in Nebraska during spring migration: Making sense of multiple data points. Transactions of the Nebraska Academy of Sciences 40:6–18.

Caven, A. J., K. D. Koupal, D. M. Baasch, E. M. Brinley Buckley, J. Malzahn, M. L. Forsberg, and M. Lundgren. 2021. Whooping Crane (*Grus americana*) family consumes a diversity of aquatic vertebrates during fall migration stopover at the Platte River, Nebraska. Western North American Naturalist 81:592–607.

Caven, A. J., J. D. Wiese, W. R. Wallauer, and K. J. Mosher. 2018. First description of a bald eagle (*Haliaeetus leucocephalus*) actively depredating an adult sandhill crane (*Antigone canadensis*). Western North American Naturalist 78:216–220.

Caven, A. J., and E. M. Brinley Buckley. 2017. Greater Sandhill Crane (*Antigone canadensis tabida*) copulation detected along the Big Bend of the Platte River, south-central Nebraska. Nebraska Bird Review 85:83–84.

Caven, A. J., K. C. King, J. D. Wiese, and E. M. Brinley Buckley. 2017. A descriptive analysis of regal fritillary (*Speyeria idalia*) habitat utilizing biological monitoring data along the Big Bend of the Platte River, NE. Journal of Insect Conservation 21:183–205.

Caven, A. J., J. Salter, and K. Geluso. 2017. *Opheodrys vernalis* (*Liochlorophis vernalis*) (Smooth Greensnake). Fire mortality and phenology. Herpetological Review 48:864–865.

Conklin, D. J. J., S. P. Canton, J. W. Chadwick, and W. J. Miller. 1995. Habitat suitability curves for selected fish species in the central Platte River, Nebraska. Rivers 5:250–266.

Cunningham, D. 1983. River portraits: The Platte. NEBRASKAland. Nebraska Game and Parks Commission. January:29–30.

Currier, P. 1982. The floodplain vegetation of the Platte River: Phytosociology, forest development, and seedling establishment. Dissertation, Iowa State University. Ames, USA.

Currier, P. J. 1989. Plant species composition and groundwater levels in a Platte River wet meadow. Pages 19–24 in Proceedings of the 11th North American Prairie Conference, Lincoln, Nebraska, USA.

Currier, P. J. 1991. Reclamation of crane roosting habitat on the Platte River and restoration of riverine wetlands. Pages 403-417 in J. Harris, editor, Proceedings of the 1987 International Crane Workshop, International Crane Foundation, Baraboo, Wisconsin, USA.

Currier, P. J. 1995. Woody vegetation expansion and continuing declines in open channel habitat on the Platte River in Nebraska. Platte River Whooping Crane Critical Habitat Maintenance Trust, Grand Island, Nebraska, USA.

Currier, P. J. 1995. Relationships between vegetation, groundwater hydrology, and soils on Platte River wetland meadows. Pages 172 in Proceedings of the 1995 Platte River Ecosystem Symposium, Kearney, Nebraska, USA. [Abstract].

Currier, P. J. 1995. Restoration of functioning wet meadows on the Platte River -- experimentation with reseeding, constructed wetlands, and hydrology. Pages 179–202 in Proceedings of the 1995 Platte River Basin Ecosystem Symposium, Kearney, Nebraska, USA.

Currier, P. J. 1998. Wetland restoration on the Platte River floodplain in Nebraska. Pages 611–627 in S. K. Majumdar, E. W. Miller and F. J. Brenner, editors. Ecology of Wetlands and Associated Systems. Pennsylvania Academy of Sciences, Pennsylvania, USA.

Currier, P. J., G. R. Lingle, J. G. VanDerwalker. 1985. Migratory bird habitat on the Platte and North Platte Rivers in Nebraska. Platte River Whooping Crane Critical Habitat Maintenance Trust, Grand Island, Nebraska, USA.

Currier, P. J., and J. W. Ziewitz. 1985. Application of a sandhill crane model to the management of habitat along the Platte River. Pages 315–325 in J. C. Lewis, editor. Proceedings 1985 Crane Workshop, Platte River Whooping Crane Habitat Maintenance Trust, Grand Island, Nebraska, USA.

Currier, P. J., and B. S. Goldowitz. 1995. Artificially constructed backwaters and their impact on groundwater levels beneath an adjacent wet meadow on the Platte River in central Nebraska. Pages 203–222 in Proceedings of the 1995 Platte River Basin Ecosystem Symposium, Kearney, Nebraska, USA.

Davis, C. A. 1991. The ecology of macroinvertebrates inhabiting native grasslands and their role in the feeding ecology of sandhill cranes. Thesis, Iowa State University, Ames, USA.

Davis, C. A. 1999. Migration chronology and habitat use by sandhill cranes in central Nebraska. Pages 41 in G. Lingle, editor. Tenth Platte River Basin Ecosystem Symposium, Kearney, Nebraska, USA. [Abstract].

Davis, C. A. 2003. Habitat use and migration patterns of sandhill cranes along the Platte River, 1998-2001. Great Plains Research 13:199–216.

Davis, C. A. 2005. Breeding bird communities in riparian forests along the Central Platte River, Nebraska. Great Plains Research 15:199–211.

Davis, C. A., and P. A. Vohs. 1992. The ecology of native grasslands macroinvertebrates and feeding ecology of Sandhill Cranes. Pages 175 in D. W. Stahlecker, editor. Proceedings of the Sixth North American Crane Workshop, Regina, Saskatchewan, Canada. [Abstract].

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 26:438–454.

Dority, B. R., R. Thompson, S. Kaskie, and L. Tschauner. 2017. The economic impact of the annual crane migration on Central Nebraska. College of Business and Technology, University of Nebraska, Kearney, USA.

Dreier, C. A. 2018. Nebraska Wetland Condition Assessment: Intensification of the National Wetland Condition Assessment throughout Nebraska. Thesis. University of Nebraska, Lincoln, USA.

Eubanks, T. L., Jr., R. B. Ditton, and J. R. Stoll. 1998. Platte River nature recreation study. Prepared for the U.S. Environmental Protection Agency, Region VII, Fermata Inc., Austin, Texas, USA.

Eubanks, T. L., Jr. 1999. Wildlife-associated recreation along Nebraska's Platte River (Phase II): The economic impact of hunting and fishing on the middle Platte River in Nebraska. Prepared for U.S. Environmental Protection Agency, Region VII, Fermata Inc., Austin, Texas, USA.

Faanes, C. A., and M. J. Levalley. 1993. Is the distribution of sandhill cranes on the Platte River changing? Great Plains Research 3:297–304.

Faanes, C. A., and G. R. Lingle. 1995. Breeding birds of the Platte River Valley of Nebraska. U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

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.

Farrar, J. 1992. Platte River instream flow -Who needs it. NEBRASKAland. Nebraska Game and Parks Commission. December:38–47.

Farrar, J. 1980. Wings over the Platte. NEBRASKAland. Nebraska Game and Parks Commission. Febrruary:18–35.

Folk, M. J. 1989. Roost site characteristics of sandhill crane in the North Platte River Valley of Nebraska. Thesis, North Dakota State University, Fargo, USA.

Folk, M. J., and T.C. Tacha. 1990. Sandhill crane roost site characteristics in the North Platte River Valley. Journal of Wildlife Management 54:480–486.

Forsberg, M. 1996. Wet meadows of the Platte. NEBRASKAland. Nebraska Game and Parks Commission. May:36–47.

Forsberg, M. 2000. Odyssey of the sandhill cranes. NEBRASKAland. Nebraska Game and Parks Commission. May:10-17.

Fowler, E. A. Historic gathering. 2022. NEBRASKAland. Nebraska Game and Parks Commission. January-February:30–35.

Frankforter, J. D. 1995. Association between local land use and herbicide concentrations in wetlands of the Platte River Basin, Nebraska. Pages 539-48 in Versatility of wetlands in the agricultural landscape, K. L. Campbell editor. American Society of Agricultural Engineers, Tampa, Florida, USA.

Frith, C. A. 1974. The ecology of the Platte River as related to sandhill cranes and other waterfowl in southcentral Nebraska. Thesis, University of Nebraska, Kearney, USA.

Geluso, K., and M. J. Harner. 2013. Reexamination of herpetofauna on Mormon Island, Hall County, Nebraska, with notes on natural history. Transactions of the Nebraska Academy of Sciences 33:7–20.

Goldowitz, B. S., and M. R. Whiles. 1999. Investigations of fish, amphibians and aquatic invertebrate species within the middle Platte River system. Prepared for U.S. Environmental Protection Agency, Region VII, Platte River Whooping Crane Maintenance Trust, Wood River, Nebraska, USA.

Harner, M. J., G. D. Wright, and K. Geluso. 2015. Overwintering sandhill cranes (*Grus canadensis*) in Nebraska, USA. Wilson Journal of Ornithology 127:457–466.

Hay, M. A., and G. R. Lingle. 1981. The birds of Mormon Island Crane Meadows. The Nature of Conservancy, Grand Island, Nebraska, USA.

Helzer, C. J. 1996. The effects of wet meadow fragmentation on grassland birds. Thesis, University of Nebraska, Lincoln, USA.

Helzer, C. J., and D. E. Jelinski. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. Ecological Applications 9:1448–1458.

Henszey, R. J., K. Pfeiffer, and J. R. Keough. 2004. Linking surface and ground water levels to riparian grassland and species along the Platte River in central Nebraska, USA. Wetlands 24:665–687.

Hurr, R. T. 1981. Ground-water hydrology of Mormon Island Crane Meadows Wildlife Area near Grand Island, Hall County, Nebraska. U.S. Geological Survey, Denver, Colorado, USA.

Iverson, G. C., P. A. Vohs, and T.C. Tacha. 1987. Habitat use by mid-continent sandhill cranes during spring migration. Journal of Wildlife Management 51:448–458.

Jenkins, A. 1999. The Platte River Cooperative Agreement: A basinwide approach to endangered species issues. Great Plains Research 9:95–113.

Joeckel, R. M., and G. M. Henebry. 2008. Channel and island change in the lower Platte River, Eastern Nebraska, USA: 1855–2005. Geomorphology 102:407–418.

Johnson, O. J., and K. Geluso. 2017. Distributional and reproductive records

of bats from south-central Nebraska. Occasional Papers, Museum of Texas Tech University 347:1–15.

Johnson, W. C. 1994. Woodland expansion in the Platte River, Nebraska: Patterns and causes. Ecological Monographs 64:45–84.

Johnson, W. C. 1998. Adjustment of riparian vegetation to river regulation in the Great Plains, USA. Wetlands 18:608-618.

Johnson, W. C. 1999. Response of riparian vegetation to streamflow regulation and land use in the Great Plains. Great Plains Research 9:357–69.

Johnson, W. C., and S. E. Boettcher. 2000. The pre-settlement Platte: Wooded or prairie river? Great Plains Research 10:39–68.

Jones, S., R. Ballinger, and J. Nietfeldt. 1981. Herpetofauna of Mormon Island Preserve Hall County, Nebraska. Prairie Naturalist 13:33–41.

Jorde, D. G., G. L. Krapu, and R. D. Crawford. 1983. Feeding ecology of mallards wintering in Nebraska. Journal of Wildlife Management 47:1044–1053.

Jorde, D. G., G. L. Krapu, R. D. Crawford, and M. A. Hay. 1984. Effects of weather on habitat selection and behavior of mallards wintering in Nebraska. Condor 86:258–265.

Kessler, A. C., J. W. Merchant, C. R. Allen, and S. D. Shultz. 2011. Impacts of invasive plants on sandhill crane (*Grus canadensis*) roosting habitat. Invasive Plant Science and Management 4:369–377.

Kim, D. H., W. E. Newton, G. R. Lingle, and F. Chavez-Ramirez. 2008. Influence of grazing and available moisture on breeding densities of grassland birds in the central Platte River Valley, Nebraska. Wilson Journal of Ornithology 120:820–829.

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 25:135–152.

Kirsch, E. 1988. On the edge...on the Platte. Endangered. NEBRASKAland. Nebraska Game and Parks Commission. March:36–41.

Kirsch, E. M. 1996. Habitat selection and productivity of least terns on the lower Platte River, Nebraska. Wildlife Monographs 132:3–48.

Knopf, F. L., and M. L. Scott. 1990. Altered flows and created landscapes in the Platte River headwaters, 1840-1990. Pages 47–70 in J. M. Sweeney, editor. Management of dynamic ecosystems. North Central Section, The Wildlife Society, West Lafayette, Indiana, USA.

Krahulik, J. R. 2002. Effects of land management and habitat change on wet meadow invertebrate diversity in south-central Nebraska. Thesis, University of Nebraska, Kearney, USA.

Krapu, G. L. 1981. Losses of riparian wetlands of the Platte River in relation to use by cranes. Page 355 in B. Richardson, editor. Wetland values and management. Minnesota Water Planning Board, St. Paul, USA (abstract, page 355).

Krapu, G. L., D. E. Facey, E. K. Fritzell, and D. H. Johnson. 1984. Habitat use by migrant sandhill cranes in Nebraska. Journal of Wildlife Management 48:407–417.

Krapu, G. L., D. A. Brandt, and R. R. Cox, Jr. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: Trends with important implications for wildlife management. Landscape Ecology 32:127–136.

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 North American Crane Workshop 9:185–191.

Krapu, G. L., D. A. Brandt, K. L. Jones, and D. H. Johnson. 2011. Geographic distribution of the mid-continent population of sandhill cranes and related management applications. Wildlife Monographs 175:1–38.

Krapu, G. L., D. A. Brandt, P. J. Kinzel, and A. T. Pearse. 2014. Spring migration ecology of the mid-continent sandhill crane population with an emphasis on use of the Central Platte River valley, Nebraska. Wildlife Monographs 189:1–41.

Lewis, J. 1974. Ecology of the sandhill crane in the southeastern Central Flyway. Dissertation, Oklahoma State University, Stillwater, USA.

Lingle, G. R., and M. A. Hay. 1982. A checklist of the birds of Mormon Island Crane Meadows. Nebraska Bird Review 50:27–36.

Lingle, G. R. 1992. History and economic impact of crane watching in central Nebraska. Proceedings North American Crane Workshop 6:25–29.

Lingle, G. R. 1994. Birding Crane River: Nebraska's Platte. Harrier Publications, Grand Island, Nebraska, USA.

Lingle, G. 1995. 1994 Breeding Bird Census: wetland sedge meadow I and II. Journal of Field Ornithology 66 [Supplemental]:100–101.

Lingle, G. 1996. 1995 Breeding Bird Census wetland sedge meadow I and II. Journal of Field Ornithology 66 [Supplemental]:76–77.

Lingle, G., and P. Bedell. Year. 1989. 1988 Breeding Bird Census wetland sedge meadow I and II. Journal of Field Ornithology 60 [Supplemental]:65–66.

Lingle, G., and P. Bedell. 1990. 1989 Breeding Bird Census wetland sedge meadow I and II. Journal of Field Ornithology 61 [Supplemental]:72–73.

Lingle, G., S. Bergman, and J. Liske. 1994. 1993 Breeding Bird Census wetland sedge meadow I and II. Journal of Field Ornithology 65 [Supplemental]:107–108.

Lingle, G., and W. S. Whitney. 1991. 1990 Breeding Bird Census wetland sedge meadow I and II. Journal of Field Ornithology 62 [Supplemental]:77–78.

Lingle, G. R. 1981. Mormon Island Crane Meadows - Protecting habitat for cranes along the Platte River, Nebraska. Pages 17-21 in J. C. Lewis, editor. 1981 Crane Workshop, Grand Teton National Park, Wyoming. National Audubon Society, Tavernier, Florida, USA.

Lingle, G. R., G. A. Wingfield, and J. W. Ziewitz. 1987. The migration ecology of whooping cranes in Nebraska, USA. Pages 395–401 in International Crane Workshop, Heilongjiang Province, China.

Liske, J. 2001. Twenty years of Platte River floodplain restoration (Nebraska). Restoration and Reclamation Review 7:1–7.

Malzahn, J., A. J. Caven, M. Dettweiler, and J. D. Wiese. 2018. Sandhill crane activity in the Central Platte River Valley in late May and early June. Nebraska Bird Review 86:175–180.

Malzahn, J., A. J. Caven, and J. D. Wiese. 2020. Characteristics of a river otter (*Lontra canadensis*) maternal den in the Central Platte River Valley, NE. Transactions of the Nebraska Academy of Sciences 40:30–38.

Malzahn, J. M., A. J. Caven, S. Warren, B. L. Ostrom, and D. M. Ferraro. 2021. Habitat associations and activity patterns of herpetofauna in the Central Platte River Valley, Nebraska, with notes on morphometric characteristics. Transactions of the Nebraska Academy of Sciences 41:88–105.

McLean, R. P., G. D. Wright, and K. Geluso. 2015. Cope's Gray Treefrog (*Hyla chrysoscelis*) along the Platte River, Hall County, Nebraska. Collinsorum 4:2–4.

Meyer, C. K., S. G. Baer, and M. R. Whiles. 2008. Ecosystem recovery across a chronosequence of restored wetlands in the Platte River Valley. Ecosystems 11:193–208.

Meyer, C. K., and M. R. Whiles. 2008. Macroinvertebrate communities in restored and natural Platte River slough wetlands. Journal of North American Benthological Society 27:626–639.

Meyer, C. K., M. R. Whiles, and S. G. Baer. 2010. Plant community recovery following restoration in temporally variable riparian wetlands. Restoration Ecology 18:52–64.

Missouri River Basin Commission. 1976. Report on the Platte River Basin, Nebraska level B study. Omaha, Neb. 252 pp.

Nagel, H. G., and R. Harding. 1987. Effects of water table depth and soil factors on

invertebrate populations. Prairie Naturalist 19:251–258.

Nagel, H. G., T. Nightengale, and N. Dankert. 1991. Regal fritillary butterfly population estimation and natural history on Rowe Sanctuary, Nebraska, USA. Prairie Naturalist 23:145–152.

Nelson, R. W., J. R. Dwyer, and W. E. Greenberg. 1988. Regulated scouring in a sand-bed river for channel habitat maintenance: A Platte River waterfowl case study. Water Resources Management 2:191–208.

Nemec, K. T., and T. B. Bragg. 2008. Plant-feeding Hemiptera and Orthoptera communities in native and restored mesic tallgrass prairies. Restoration Ecology 16:324–335.

Norling, B. S., S. H. Anderson, and W. A. Hubert. 1992. Roost sites used by sandhill crane staging along the Platte River, Nebraska. Great Basin Naturalist 52:253–261.

Ostrom, B. L., A. J. Caven, J. M. Malzahn, and A. Vogel. 2020. Snowy plover activity in the Central Platte River Valley in May 2019. Transactions of the Nebraska Academy of Sciences 40:24–29.

Pauley, N. M., M. J. Harner, E. M. Brinley Buckley, P. R. Burger, and K. Geluso. 2018. Spatial analysis of borrow pits along the Platte River in south-central Nebraska, USA, in 1957 and 2016. Transactions of the Nebraska Academy of Sciences 38:36–46.

Parrish, T. L., W. A. Hubert, S. H. Anderson, M. Pucherelli, and W. Mangus. 2001. Distributions of roosting sandhill cranes as identified by aerial thermography. Prairie Naturalist 33:93–99.

Pearse, A. T., G. L. Krapu, D. A. Brandt, and P. J. Kinzel. 2010. Changes in agriculture and abundance of snow geese affect carrying capacity of sandhill cranes in Nebraska. Journal of Wildlife Management 74:479–488.

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. U.S. Geological Survey Open-File Report 2016–1209. U.S. Geological Survey, Reston, Virginia, USA.

Peyton, M. M., and J. L. Maher. 1995. A survey of mussels (Mollusca: Bivalvia) in the Platte River system and associated irrigation and hydropower canal and lake systems west of Overton, Nebraska. Transactions of the Nebraska Academy of Sciences 22:43–48.

Pfeiffer, K. 1999. Evaluation of wet meadow restorations in the Platte River valley. Pages 202–206 in J. Springer, editor. Proceedings of the Sixteenth North American Prairie Conference. University of Nebraska, Kearney, USA.

Pfeiffer, K., and P. Currier. 2005. An adaptive approach to channel management on the Platte River.
Proceedings North American Crane Workshop 9:151–154.

Rabbe, M. R., A. J. Caven, and J. D. Wiese. 2019. First description of a bald eagle (*Haliaeetus leucocephalus*) attempting depredation on an adult Whooping Crane (*Grus americana*) of the Aransas-Wood Buffalo population. Monographs of the Western North American Naturalist 11:24–32.

Ramírez-Yáñez, L. E., F. Chávez-Ramírez, D. H. Kim, and F. Heredia-Pineda. 2011. Grassland bird nesting on restored and remnant prairies in southcentral Nebraska. Ecological Restoration 29:8–9.

Platte River Recovery Implementation Program. 2007. Platte River Program Baseline Document. Kearney, Nebraska, USA.

Rapp, R. E., A. Datta, S. Irmak, T. J. Arkebauer, S. Z. Knezevic. 2012. Integrated management of common reed (*Phragmites australis*) along the Platte River in Nebraska. Weed Technology 26:326–333.

Reichert, A. L. 1999. Multiple scale analyses of whooping crane habitat in Nebraska. Dissertation, University of Nebraska, Lincoln, USA.

Reinecke, K. J., and G. L. Krapu. 1986. Feeding ecology of sandhill cranes during spring migration in Nebraska. Journal of Wildlife Management 50:71–79.

Renfrew, R. B., D. H. Johnson, G. Lingle and W. D. Robinson. 2006. Avian response to meadow restoration in the central Great Plains. Pages 313-324 in Prairie Invaders: Proceedings of the 20th North American Prairie Conference, University of Nebraska, Kearney, USA.

Riggins, J. J. 2004. Terrestrial invertebrates as bio-indicators of wet meadow restoration success. Thesis, University of Nebraska, Kearney, USA.

Riggins, J. J., C. A. Davis, and W. Hoback. 2009. Biodiversity of belowground invertebrates as an indicator of wet meadow restoration success (Platte River, Nebraska). Restoration Ecology 17:495–505.

Runge, J. T. 1998. Soil invertebrate responses to fluctuating groundwater levels: a community analysis. Thesis, University of Nebraska, Kearney, USA.

Safina, C., L. Rasenbluth, C. Pustmueller, K. Strom, R. Klataske, M. Lee, and J. Beya. 1989. Threats to wildlife and the Platte River. Environmental Policy Analysis Department Report No. 33. National Audubon Society, New York, USA.

Seamans, M. E. 2021. Status and harvests of sandhill cranes: Mid-continent, Rocky Mountain, Lower Colorado River Valley and Eastern Populations. Administrative Report, U.S. Fish and Wildlife Service, Lakewood, Colorado, USA.

Sherfy, M. H., M. J. Anteau, and A. A. Bishop. 2011. Agricultural practices and residual corn during spring crane and waterfowl migration in Nebraska. Journal of Wildlife Management 75:995–1003.

Sidle, J. G., E. D. Miller, and P. J. Currier. 1989. Changing habitats in the Platte River Valley of Nebraska USA. Prairie Naturalist 21:91–104.

Simpson, A. 2001. Soil vegetation correlations along hydrologic gradient in the Platte River wet meadows. Thesis, University of Nebraska, Kearney, USA.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

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 92:1414–1419.

Smith, D. 1997. Influence of landscape structure on habitat availability and use by sandhill cranes in four geographic regions of the Platte River, Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Sparling, D. W., and G. L. Krapu. 1994. Communal roosting and foraging behavior of staging sandhill cranes. Wilson Bulletin 106:66–77.

Stahlecker, D. W. 1993. Availability of stopover habitat for migrant whooping cranes in Nebraska. Pages 132-140 in R. P. Urbanek and D. W. Stahlecker, editors. Proceedings of the Seventh North American Crane Workshop. Biloxi, Mississippi, USA.

Stoll, J. R., R. B. Ditton, and T. L. Eubanks. 2006. Platte River birding and the spring migration: Humans, value, and unique ecological resources. Human Dimensions of Wildlife 11:241–254.

Sutton, M. O., and N. Arcilla. 2019. New breeding record and location for Wilson's phalarope (*Phalaropus tricolor*) in the Nebraska Great Plains, USA. Prairie Naturalist 50:74–75.

Tye, S. P., K. Geluso, and M. J. Harner. 2017. Early emergence and seasonality of the red-bellied snake (*Storeria occipitomaculata*) along the Platte River in south-central Nebraska, USA. Transactions of the Nebraska Academy of Sciences 37:11–17.

Uerling, C. C., M. J. Hamel, and M. A. Pegg. 2019. Fish community response to habitat variables in two restored side channels of the lower Platte River, Nebraska. River Research and Applications 35.2:178-187.

U.S. Fish and Wildlife Service. 1978. Nebraska stream evaluation map. Office of Biological Service. Washington, D.C., USA.

U.S. Fish and Wildlife Service. 1981. The Platte River Ecology Study, Special Research Report. Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Varner D. M., A. T. Pearse, A. A. Bishop, J. I. Davis, J. C. Denton, R. C. Grosse, H. M. Johnson, E. J. Munter, K. D. Schroeder, R. E. Spangler, M. P. Vrtiska, and A. E. Wright. 2020. Roosting habitat use by sandhill cranes and waterfowl on the North and South Platte rivers in Nebraska. Journal of Fish and Wildlife Management 11:56–67.

Vercauteren, T. 1998. Local scale analysis of sandhill crane use of lowland grasslands along the Platte River, Nebraska. Thesis, University of Nebraska, Lincoln, USA.

Vrtiska, M. P., and N. Lyman. 2004. Wintering Canada geese along the Platte Rivers of Nebraska. Great Plains Research 14:115–128.

Whiles, M. R., and B. S. Goldowitz. 1998. Biological responses to hydrologic fluctuation in wetland sloughs of the central Platte River. Pages 3-18 in Proceedings of the 9th Platte River Basin Ecosystem Symposium, Kearney, Nebraska, USA.

Whiles, M. R., and B. S. Goldowitz. 2001. Hydrologic influences on insect emergence production from central Platte River wetlands. Ecological Applications 11:1829–1842.

Whiles, M. R., and B. S. Goldowitz. 2005. Macroinvertebrate communities in Central Platte River wetlands: Patterns across a hydrologic gradient. Wetlands 25:462–472.

Whiles, M. R., B. S. Goldowitz, and R. E. Charlton. 1999. Life history and production of a semi-terrestrial limnephilid caddisfly in an intermittent Platte River wetland. Journal of the North American Benthological Society 18:533–544.

Whitney, W. S. 1999. Prairie and wetland restoration along the Central Platte River, 1991-1998. Pages 207-215 in J. T. Springer, editor. Proceedings of the Sixteenth North American Prairie Conference, University of Nebraska, Kearney, USA.

Wiese, J. D., and A. J. Caven. 2017. *Tropidoclonion lineatum* (lined snake), *Thamnophis sirtalis* (common gartersnake). Refugia and mortality. Herpetological Review 48:868–869.

Wiese, J. D., K. C. King, A. J. Caven, and N. Arcilla. 2017. Winter predation of an adult spiny softshell (*Apalone spinifera*) likely committed by a bald eagle (*Haliaeetus leucocephalus*) in central Nebraska. Collinsorum 6:14–19.

Wiese, J. D., and A. J. Caven. 2018. Dataset of the physical conditions of green ash (*Fraxinus pennsylvanica*) in riparian woodlands along the central Platte River. Data in Brief 21:948–952.

Wright, G. D., M. J. Harner, and J. D. Chambers. 2014. Unusual wintering distribution and migratory behavior of the whooping crane (*Grus americana*) in 2011-2012. Wilson Journal of Ornithology 126:115–120.

Wu, W. 2003. Riverine landscape of the middle Platte River: Hydrological connectivity and physicochemical heterogeneity. Dissertation, University of Nebraska, Lincoln, USA.

Zuerlin, E. J. 2001. Instream flow rights for the Platte River - A major tributary of the Missouri River. Pages 1-12 in Proceedings of the Eleventh Platte River Basin Ecosystem Symposium, University of Nebraska, Kearney, USA.

MISSOURI RIVER

Bouc, K. 1983. The Missouri. NEBRASKAland. Nebraska Game and Parks Commission. January:90–101.

Bouc, K. 1998. Missouri River restoration. NEBRASKAland. Nebraska Game and Parks Commission. March:16–23.

Bouc, K. 2002. America looks west: Lewis and Clark on the Missouri – Special Issue. NEBRASKAland. Nebraska Game and Parks Commission. August/September:130.

Dixon, M. D., W. C. Johnson, M. L. Scott, and L. A. Rabbe. 2012. Dynamics of plains cottonwood (*Populus deltoides*) forests and historical landscape change along unchannelized segments of the Missouri River, USA. Environmental Management 49:990–1008.

Ducey, J. E., 1993. Wetlands in the historic Missouri Valley brought trappers, explorers, naturalists. Page 170 in R. Kuzelka, and C. Flowerday, editors. Flatwater: A history of Nebraska and its water. Conservation and Survey Division, University of Nebraska, Lincoln, USA.

Fowler, E. 2003. Canoeing the Missouri River: Fort Randall Dam to the Niobrara boat landing. NEBRASKAland. Nebraska Game and Parks Commission. June:16–23.

Fowler, E. 2003. New life for the mighty Mo? NEBRASKAland. Nebraska Game and Parks Commission. December:10–19.

Fowler, E. 2004. Canoeing the Missouri River: Gavin's Point Dam to Ponca State Park. NEBRASKAland. Nebraska Game and Parks Commission. June:36–41.

Fowler, E. 2008. Mussels of the Missouri. NEBRASKAland. Nebraska Game and Parks Commission. May:18–19.

Fowler, E. Langdon Bend – Wetlands work is attracting ducks and hunters. 2014. NEBRASKAland. Nebraska Game and Parks Commission. November:40–45.

Funk, J. L., and J. W. Robinson. 1974. Changes in the channel of the lower Missouri River and effects on fish and wildlife. Missouri Department of Conservation, Aquatic Series 11:52.

Galat, D. L., and A. G. Frazer, editors. 1996. Overview of river-floodplain ecology in the upper Mississippi River Basin. J. A. Kelmelis, editor, Volume 3. Science for floodplain management into the 21st century. U.S. Government Printing Office, Washington, D.C., USA.

Galat, D. L., C. R. Berry, W. M. Gardner, J. C. Hendrickson, G. E. Mestl, G. J. Power, C. Stone, and M. R. Winston. 2005. Spatiotemporal patterns and changes in Missouri River fishes. American Fisheries Society Symposium 45:249–291.

Galloway, G. E. 1994. Sharing the challenge: Floodplain management into the 21st century. Report of the interagency Floodplain Management Review Committee to the Administration Floodplain Management Task Force. U.S. Army Corps of Engineers, Washington, D.C., USA.

Harberg, M. C., J. I. Remus, S. C. Rothe, J. Becic, and L. W. Hesse. 1993. Restoration planning for an abandoned Missouri River chute. Pages 360–371 in L. W. Hesse, C. B. Stalnaker, N. G. Benson, and J. R. Zuboy, editors. Restoration planning for the rivers of the Mississippi River ecosystem. National Biological Survey Biological Report 19, Washington, D.C., USA.

Hellman, M. L. 2013. Amphibian occupancy and functional connectivity of restored wetlands in the Missouri River floodplain. Thesis. University of Nebraska, Lincoln, USA.

Hesse, L. W., J. C. Schmulbach, J. M. Carr, K. D. Keenslyne, D. G. Unkenholz, J. W. Robinson, and G. E. Mestl. 1989. Missouri River fishery resources in relation to past, present, and future stresses. Pages 352–371 in Proceedings of the International Large River Symposium, Canadian Special Publication of Fisheries and Aquatic Sciences.

Hesse, L. W., and G. E. Mestl. 1993. An alternative hydrograph for the Missouri River based on precontrol condition. North American Journal of Fisheries Management 13:360–366.

Hesse, L. W., and W. Sheets. 1993. The Missouri River hydrosystem. Fisheries 18:5–14.

Hesse, L. W., G. E. Mestl, P. P. Sensenbaugh, P. A. Thornblom, R. J. Hollis, T. L. Nuttlemann, J. A. Vaughn and J. A. Harrison. 1993. Recreational use survey of the Missouri River in Nebraska. Nebraska Game and Parks Commission, Lincoln, NE, USA.

Hopps, E. C. 2012. Avian diversity and habitat use on the wetland reserve program lands in the lower Missouri River valley. Prairie Naturalist 44:79–97.

Jacobson, R. B., T. P. Janke, and J. J.

Skold. 2011. Hydrologic and geomorphic considerations in restoration of river-floodplain connectivity in a highly altered river system, Lower Missouri River, USA. Wetlands Ecology and Management 19:295–316.

Kaemingk, M. A., B. D. S. Graeb, C. W. Hoagstrom, and D. W. Willis. 2007. Patterns of fish diversity in a mainstem Missouri River reservoir and associated delta in South Dakota and Nebraska, USA. River Research and Applications 23:786–791.

Latka, D. C., J. Nestler, and L. W. Hesse. 1993. Restoring physical habitat in the Missouri River: A historical perspective. Pages 350–359 in L. W. Hesse, C. B. Stalnaker, N. G. Benson, and J. R. Zuboy, editors. Proceedings of restoration planning for the rivers of the Mississippi River ecosystem. National. Biological Survey Biological Report 19, Washington, D.C., USA.

Mestl, G. E., and L. W. Hesse. 1993. Secondary production of aquatic insects in the unchannelized Missouri River, Nebraska. Pages 341–349 in L. W. Hesse, C. B. Stalnaker, N. G. Benson, and J. R. Zuboy, editors. Restoration planning for the rivers of the Mississippi River ecosystem. National. Biological Survey Biological Report 19, Washington, D.C., USA.

National Research Council. 2002. The Missouri River ecosystem: Exploring the prospects for recovery. National Academy Press, Washington, D.C., USA.

National Park Service. 1980. Missouri River National Recreational River management plan. National Park Service, Washington, D.C., USA.

National Park Service. 1982. The Nationwide Rivers Inventory. Washington, D.C., USA.

Nguyen, J. Turtles on the Missouri. 2015. NEBRASKAland. Nebraska Game and Parks Commission. July:48–53.

Rolfsmeier, S. 2003. Plant communities and rare plant species on the Omaha and Winnebago Indian Reservations. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Schainost, S. 1976. Survey of 1975 commercial fisheries industry in Nebraska. Fishery Division, Project Number 2-223-R. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Sheriff, S. L., R. B. Renken, and T. B. Treiman. 2011. Missouri River public use assessment: Final report. Results from the 2004 survey of river users. Missouri Department of Conservation, Columbia, Missouri, USA.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Steffensen, K. D., D. A. Shuman, and S. Stukel. 2014. The status of fishes in the Missouri River, Nebraska: shoal chub (*Macrhybopsis hyostoma*), sturgeon chub (*M. gelida*), sicklefin chub (*M. meeki*), silver chub (*M. storeriana*), flathead chub (*Platygobio gracilis*), plains minnow (*Hybognathus placitus*), western silvery minnow (*H. argyritis*), and brassy minnow (*H. hankinsoni*). Transactions of the Nebraska Academy of Sciences 34:49–67

Steffensen, K. D., B. L. Eder, and M. A. Pegg. 2014. Fish community response to floodplain inundation in a regulated river. Journal of Freshwater Ecology 29:413–427.

Steffensen, K. D. 2015. The status of fishes in the Missouri River, Nebraska: Selected ancient fishes. Transactions of the Nebraska Academy of Sciences 35:53–60.

U.S. Army Corps of Engineers. 1978. Final environmental impact statement Missouri River, South Dakota, Nebraska, North Dakota, Montana streambank erosion control. U.S. Army Engineer District, Omaha, Nebraska, USA.

U.S. Fish and Wildlife Service. 1980. Missouri River stabilization and navigation project, Sioux City, Iowa to mouth. Fish and Wildlife Coordination Act Report. U.S. Fish and Wildlife Service, North Kansas City, Missouri, USA.

U.S. Fish and Wildlife Service. 1988. Great Lakes and Northern Great Plains piping plover recovery plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota, USA.

U.S. Fish and Wildlife Service. 1990. Recovery plan for the interior population of the least tern (*Sterna antillarum*). U.S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

VanderHam, A. E. 2014. Informing flood plain wetland restoration using amphibian monitoring. Thesis. University of Nebraska, Lincoln, USA.

Yager, L. A., M. D. Dixon, T. C. Cowman, and D. A. Soluk. 2013. Historic changes (1941-2008) in side channel and backwater habitats on an unchannelized reach of the Missouri River. River Research Applications 29:493–501.

ELKHORN RIVER

Grier, B. 1983. The Elkhorn River. NEBRASKAland. Nebraska Game and Parks Commission. January:66–71.

Farrar, J. 1999. A bend in the river. NEBRASKAland. Nebraska Game and Parks Commission. April:28–37.

NIOBRARA RIVER

Adolf, S. L., K. Higgins, C. D. Kruse, and G. Pavelka. Distribution and productivity of least terns and piping plovers on the Niobrara River. Proceedings of the South Dakota Academy of Science 80:231–245.

Alexander, J. S., R. B. Zelt, and N. J. Schaepe. 2010. Hydrogeomorphic and hydraulic habitats of the Niobrara River, Nebraska-with special emphasis on the Niobrara National Scenic River. U.S. Geological Survey Scientific Investigations Report 2010-5141.

Ducey, J. E. 1989. Birds of the Niobrara River valley, Nebraska. Transactions of the Nebraska Academy of Sciences 17:37–60.

Farrar, J. 1983. The Niobrara. NEBRASKAland, Nebraska Game and Parks Commission. January:102–113.

Farrar, J. 2003. The Niobrara National Scenic River: A long and tortuous course. NEBRASKAland, Nebraska Game and Parks Commission. May:10–19.

Farrar, J. 2003. The Niobrara National Scenic River: Looking back, looking ahead. NEBRASKAland, Nebraska Game and Parks Commission. June:20–27.

Forsberg, M. 1997. Jewel on the Niobrara. NEBRASKAland, Nebraska Game and Parks Commission. July:8–15.

Kantak, G. E. 1995. Terrestrial plant communities of the middle Niobrara Valley, Nebraska. Southwestern Naturalist 40:129–138.

Smeenk, N. A. 2019. Assessing the ecological condition of Nebraska's wetland resources and amphibian communities: An intensification of the Environmental Protection Agency's 2011 National Wetland Condition Assessment. Dissertation, University of Nebraska, Lincoln, USA.

Spurgeon, J., M. Pegg, P. Parasiewicz, and J. Rogers. 2019. River-wide habitat availability for fish habitat guilds: Implications for in-stream flow protection. Water 11:1132.

NEBRASKA GAME AND PARKS COMMISSION OFFICES

PANHANDLE
P.O. Box 725
Alliance, Nebraska 69301
(308) 763-2940

SOUTHWEST
308 E. State Farm Road
North Platte, Nebraska 69101
(308) 535-8025

SANDHILLS
P.O. Box 508
Bassett, Nebraska 68714
(402) 684-2921

SOUTHCENTRAL
1617 First Ave.
Kearney, Nebraska 68847
(308) 865-5310

NORTHEAST
2201 N.13th St.
Norfolk, Nebraska 68701
(402) 370-3374

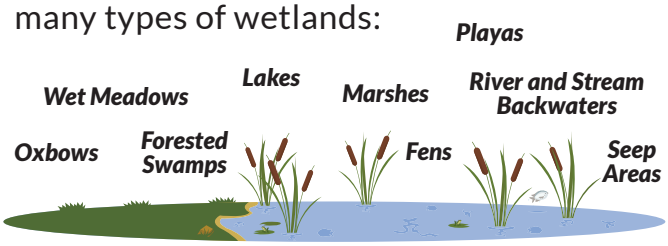
SOUTHEAST
P.O. Box 30370
Lincoln, Nebraska 68503
(402) 471-5561

Sedge wrens can be found in wet meadow wetlands in eastern Nebraska. ETHAN FREESE, PLATTE BASIN TIMELAPSE

Clean water? Flood protection? Wildlife habitat? Groundwater recharge?

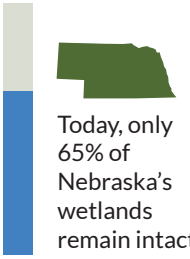
Not without wetlands

Nebraska has diverse wetlands across the state, in every county. There are many types of wetlands:

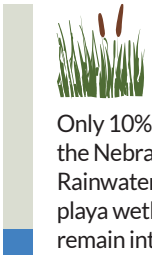


Over the past 250 years, wetlands have declined at an alarming rate, mostly due to land conversion.

Only half the world's wetlands remain intact.



Today, only 65% of Nebraska's wetlands remain intact.



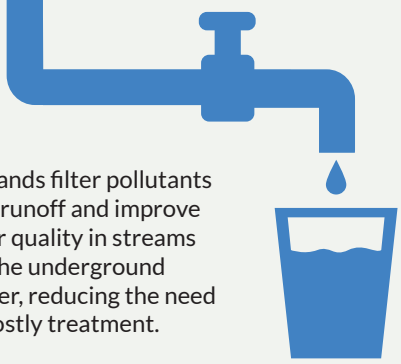
Only 10% of the Nebraska Rainwater Basin playa wetlands remain intact.*

What we lose when we lose wetlands:

Sufficient clean water

95%

of Nebraska drinking water comes from groundwater, which is naturally filtered by wetlands



Wetlands filter pollutants from runoff and improve water quality in streams and the underground aquifer, reducing the need for costly treatment.

Groundwater recharge

Many wetlands slowly release water into the ground to recharge groundwater. Sandhills and playa wetlands recharge a significant portion of the state's Ogallala Aquifer.

Protection from disaster

Wetlands hold water, making flooding and soil erosion less likely.

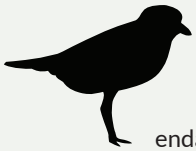
Diverse wildlife

Nebraska is unique in that it possesses **three** major wetland complexes that are of international importance to wildlife.

90%

The Platte River provides roosting habitat for 90% of the continent's sandhill crane population.

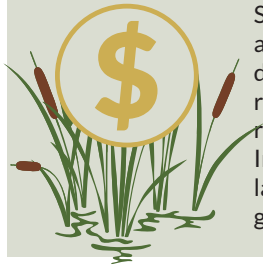
Wetlands play an important role by providing habitat for threatened and endangered species.



70%

of the state's threatened and endangered species, such as piping plovers and whooping cranes, depend on wetlands.

Revenue in tourism and hunting recreation



Streams and wetlands are major economic drivers because of their role in hunting, fishing, recreation, and agriculture. In the Rainwater Basin landscape, every acre generates $20 in revenue.

Nebraska species relying on wetlands

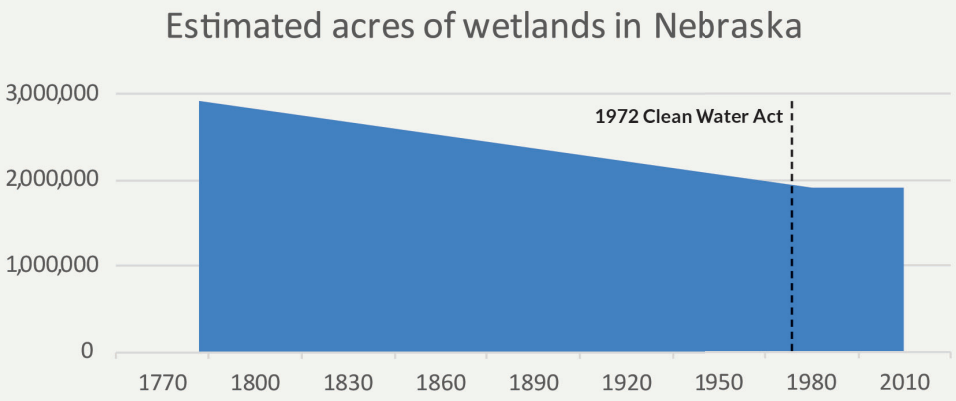
100% of amphibians

50% of birds and plants

38% of reptiles

36% of mammals

Because of the Clean Water Act, the Farm Bill, State Title 117, and other federal, state, and local protections, we have effectively slowed the rate at which we are losing wetlands.



More than

100,000 acres conserved

over the past 25 years

How we conserve wetlands:

- Protection
- Restoration
- Management
- Inventory
- Research and Education

Conservation Programs

Wetland conservation programs like the USDA's Wetland Reserve Easement Program (WRE, formerly called Wetlands Reserve Program or WRP), provide alternatives for flood-prone cropland, helping producers reduce input costs and maximize net farm income. There are numerous other voluntary incentive programs for wetland conservation provided by federal, state, and local agencies.

The City of Lincoln has recognized the importance of wetlands and is actively working to conserve them.

$110 million

in grant funds, which pump money into local economies, have been awarded over the past 25 years to protect and restore wetlands. The Nebraska Environmental Trust is crucial in providing the required non-federal match to these federal sources.

Many communities have struggled with nitrates in drinking water and declining water tables, caused by a lack of wetland areas near their water source. Wetlands can help to address these water quality issues.

But we need to continue to conserve wetlands and maintain the funding for conservation programs or we will see a rapid decline once again.

NEBRASKA CONSERVATION ROUNDTABLE

The Nebraska Conservation Roundtable considers preserving wetlands to be a top priority because of their impact on Nebraska's fish and wildlife.

LEARN MORE AT
NebraskaWetlands.com

Without wetlands...

- quality of rivers and groundwater declines
- less water for irrigation and drinking
- loss of wildlife habitat
- loss of recreational opportunities
- increased flooding

**Approximately. Sources: A guide to Nebraska's wetlands and their conservation needs, Ted LaGrange, 2005. Wetlands program plan for Nebraska, Ted LaGrange, 2015. United States Environmental Protection Agency.*

2018-80586-12/18-MS

Published by the Nebraska Game and Parks Commission

COVER: A black-necked stilt wandering and feeding in a Sandhills wetland area near Lakeside in southern Sheridan County.
JON FARRAR, NEBRASKALAND

BACK COVER: A duck hunter placing decoys during a hunt in December enjoys the recreational opportunity provided by a Rainwater Basin wetland on the Pintail Wildlife Management Area in Hamilton County.
ERIC FOWLER, NEBRASKALAND

WETLANDS of nebraska

Visit NebraskaWetlands.com to explore more about the state's wetlands. Find six amazing films about Nebraska's most common wetland types, additional print publications, and interactive, online content.

2021-103942 TR (11-09-2022)