Cheyenne Bottoms
Premier wetland in Kansas

James S. Aber, Susan E.W. Aber, and Robert L. Penner II

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Front Cover: Overview of TNC Cheyenne Bottoms Preserve. The pool at center is fed by Deception Creek that enters from the upper left. Cattail occupy the marsh at bottom. Kite aerial photograph by the authors.

Back Cover: Autumn view looking northward over TNC Cheyenne Bottoms Preserve. Pools are full following repeated rains and flooding during the summer of 2025. Kite aerial photograph by the authors.

About the Authors

Susan E.W. Aber is a Halstead, Kansas native, and James S. Aber was born and raised in Kansas City, Missouri. Since meeting as students at the University of Kansas and marrying, they have resided most of their adult years in Emporia, Kansas. JSA received a Ph.D. in Geology from the University of Kansas, and he is a Distinguished Professor Emeritus, Emporia State University. His wide-ranging international experiences include northern and central Europe, North and South America involving glaciation, wetlands, tectonics, and remote sensing. SEWA received her Ph.D in Library and Information Management from Emporia State University, and she is faculty emerita at San José State University, California. She has international experience across Europe, southeastern Asia and North America with expertise in mineralogy, gemstones, and maps and GIS for librarians. Both have conducted considerable research about and published on Kansas geology, wetlands, paleontology, and wind energy. They are partners for kite aerial photography.

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Introduction

Cheyenne Bottoms are a major wetland complex in a regional group of wetlands in central Kansas. The "bottoms" is considered to be among several of the most significant sites for shorebird and waterfowl migration in the United States and across North America (Zimmerman 1990). At least 356 bird species have been spotted there, some of which are threatened or endangered—whooping crane (*Grus americana*), peregrine falcon (*Falco peregrinus*), piping plover (*Charadrius melodus*) and least tern (*Sternula antillarum*) (Penner 2010). On this basis, Cheyenne Bottoms are designated as a Ramsar Wetland of International Importance (Ramsar List 2025). Ramsar is the International Convention on Wetlands, which currently includes more than 2500 sites around the world covering more than 2.5 million km^2 (Ramsar About 2025).

The Cheyenne Bottoms depression is a large, natural, oval-shaped basin, covering about 165 km^2 (64 square miles); it has a flat floor with an elevation around 550 m (~1800 feet), which is 6-12 m (20-40 feet) lower than the Arkansas River at Great Bend (Fig. 1). It is the terminal point of the enclosed drainage basin of Blood Creek and Deception Creek. Cheyenne Bottoms are divided between the state-owned Cheyenne Bottoms Wildlife Area of nearly 8000 ha (20,000 acres) in the downstream (southeastern) portion and The Nature Conservancy (TNC) Cheyenne Bottoms Preserve of more than 3200 ha (>8000 acres) in the upstream (northwestern) portion, as well as various private land parcels (Fig. 2).

The *Kansas School Naturalist* published an issue on Cheyenne Bottoms in 1985 by Marvin Schwilling, when the state wildlife area was the only existing preserve. Schwilling was a biologist with a special interest in birds, and he worked for the Kansas Department of Wildlife and Parks (KDWP) from 1952 until 1990 (KDWP 2011). Of course, many things have changed since the 1985 *KSN* issue—significant upgrades to the state wildlife area and entry of TNC, both during the 1990s. The Kansas Wetland Education Center opened in 2009 as a cooperative venture of the KDWP and Fort Hays State University. Other partners include Ducks Unlimited, the City of Great Bend, and TNC. This *KSN* issue represents a 40-year update for Cheyenne Bottoms and is dedicated to the memory of Marvin Schwilling.

Geologic basis

The Cheyenne Bottoms depression is situated in Cretaceous bedrock overlying Permian salt-bearing strata. The basin margins are mostly bedrock, but the southeastern side is unconsolidated young sandy sediment. The cause of sinking at Cheyenne Bottoms is likely due to Pleistocene (Ice Age) fault movement that allowed groundwater to penetrate deeply and partly dissolve the Hutchinson Salt approximately 300 m (~1000 feet) below the surface (Aber, Aber and Everhart 2023). The faults are perhaps an expression of the intersection of regional fractures or an ancient meteorite impact structure in the Proterozoic basement about 1200 m (~4000 feet) deep (Merriam 2011). Wind erosion

during repeated drought periods may have further scoured the basin and built sand dunes to the east near Claflin.

Cheyenne Bottoms have existed as a closed depression for more than 100,000 years. During the Late Pleistocene Epoch, recurring episodes of wetland, lake, and dryland conditions took place in response to climatic fluctuations as glaciers expanded and shrank around the world. Such environmental shifts have continued during the modern Holocene Epoch (last 10,000 years) with drought and flood cycles that lasted decades to centuries. Several major floods have occurred in the past century; some of these were severe enough to transform the bottoms into a large lake covering more than 75 km^2 (>30 square miles) (Schwilling 1985). At other times, the bottoms have dried up completely during droughts.

Wetland characteristics

What is a wetland, and what distinguishes wetlands from other types of natural environments? Among the most widely accepted definitions is that of Cowardin et al. (1979), which was adopted by the U.S. Fish and Wildlife Service:

> *Land where an excess of water is the dominant factor determining the nature of soil development and the types of animals and plant communities living at the soil surface. It spans a continuum of environments where terrestrial and aquatic systems intergrade.*

This definition comprises three aspects—water, soil, and organisms, which are accepted by wetland scientists as the basis for recognizing and describing wetland environments (Aber, Pavri and Aber 2012). Each of these factors is essential for recognizing wetlands. Groundwater is represented by the water table or zone of saturation. For wetlands, groundwater is at the surface or within the soil root zone during all or part of the growing season. Note that some wetlands, including Cheyenne Bottoms, may become dry on a seasonal or year-to-year basis, but at other times are flooded for extended periods (Fig. 3).

Hydric soils are characterized by frequent, prolonged saturation and low oxygen content, which lead to anaerobic chemical environments where organic matter and reduced iron are present (Fig. 4). Again, such soils may dry out periodically, but they retain physical and chemical characteristics that formed during water saturation. Soils are the least visible component of wetlands, but they are essential for wetland plants and animals to thrive.

Wetland plants, known as hydrophytes, are adapted to grow in standing water or saturated soils. Such plants include mosses, sedges, reeds, cattail and horsetail, rice, mangroves, cypress, and cranberries. As noted, water levels tend to vary in wetlands on seasonal and yearly time periods according to climatic conditions and human management. Some wetland plants are able to tolerate substantial variations in soil moisture and water level, but others have strict water requirements for survival. This is the basis for a general classification of hydrophytes (Whitley et al. 1999):

- Shoreline – plants that grow in wet soil on raised hummocks or along the shorelines of streams, ponds, bogs, marshes, and lakes. These plants grow at or above the level of standing water; some may be rooted in shallow water. Common examples are horsetails (*Equistem* sp.), buttonbush (*Cephalanthus occidentalis*) and saltcedar (*Tamarix* sp.) (Fig. 5).

- Emergent – plants that are rooted in soil that is commonly underwater. These plants grow up through the water, so that stems, leaves and flowers emerge in air above water level. Typical examples include spike rushes (*Eleocharis* sp.), cattails (*Typha* sp.), and bulrushes (*Schoenoplectus tabernaemontani*) (Fig. 6).
- Floating – plants whose leaves mainly float on the water surface. Much of the plant body is underwater and may or may not be rooted in the substrate. Only small portions, namely flowers, rise above the water level. Two common types are pondweeds (*Potamogeton* sp.) and duckweeds (*Lemna minor*) (Fig. 7).
- Submerged – plants that are largely underwater with few floating or emergent leaves. Flowers may emerge briefly in some cases for pollination. Water milfoil (*Myriophyllum* sp.) is a good example (Fig. 8).

This triad—water, soil, plants—is the modern approach for wetland identification under many circumstances that include greatly different environments that come in many forms. Notice that water quality is not specified—salinity varies from fresh, to brackish, to marine, to hypersaline. Acidity may span the entire range of naturally occurring pH values. Depth of standing water in pools and hollows is typically too deep to walk through but too shallow to swim in. Emergent vegetation ranges from heavily forested swamps to nearly bare playas and mudflats. Wetlands are found in all climatic and topographic settings around the world.

Cheyenne Bottoms water sources

Extreme variations in available water have made Cheyenne Bottoms subject to water management endeavors since the late 19th century, when the first water diverted from the Arkansas River was channeled into the bottoms. Wetland management strategies differ substantially between the state Cheyenne Bottoms Wildlife Area and TNC Cheyenne Bottoms Preserve.

The modern water-supply scheme for the state wildlife area was constructed in the 1950s and significantly enhanced in the 1990s to maintain a reliable water reserve. It involves dams, canals, levees, and high-capacity pumps to move water into and out of several artificial pools. The state wildlife area receives some water via direct precipitation and runoff from Blood Creek and Deception Creek. It also obtains water from outside the drainage basin via a canal from Walnut Creek (Fig. 9). Water levels are manipulated in several artificial pools and marshes in order to control cattail infestation and to optimize environments for migrating waterbirds. The outlet during floods is via a canal to the southeast next to the Kansas Wetland Education Center (see Fig. 2).

The Kansas Wetland Education Center (KWEC) is located on the southeastern edge of the state wildlife area. Construction began in 2007, but was delayed because of flooding, when the bottoms turned into a huge ephemeral lake for several months. After raising the site construction base, the building began to take shape in the spring of 2008 (Fig. 10). KWEC opened officially in 2009, and is certainly worth a visit to peruse the exhibits. Nature watching is encouraged, and hunting during regulated seasons is allowed in the state wildlife area.

The Nature Conservancy, on the other hand, makes no attempt to control water levels on its Cheyenne Bottoms Preserve, which is managed for shorebirds and grassland birds as well as waterfowl. Since the 1990s, TNC has removed barriers or artificial controls, where possible, to restore natural water flow from Deception Creek and Blood Creek to maintain near-natural wetland habitats. Overflow during floods from TNC land spills into the state wildlife area. As a result of this policy, TNC wetlands display marked environmental changes during drought and flood episodes (Fig. 11). Nature watching is encouraged, but hunting is allowed only on 623 ha (1540 acres) of TNC land.

Wetland vegetation

Besides water, vegetation is the most obvious clue for wetland status. Three key emergent wetland plants are indicators for wildlife habitat conditions in Cheyenne Bottoms marshes and pools, namely bulrushes, spike rushes, and cattail. Bulrushes and spike rushes are beneficial for wildlife as they provide food, shelter, and nesting habitats. Cattails are used by some wildlife for food, shelter, and nesting, and they are incorporated as natural nutrient filters in some human-created water treatment wetlands. However, cattails may have negative ecological consequences, as noted below.

Cattails were absent to scare at Cheyenne Bottoms in the early and mid-20th century, but by the 1970s an invasion was underway. Broadleaf cattail (*Typha latifolia*) and narrowleaf cattail (*Typha angustifolia*) were thought to have hybridized in the Cheyenne Bottoms vicinity (Zimmerman 1990). However, latest genetic testing has demonstrated only narrowleaf cattail at the state wildlife area (Moorberg, Travis and Ahlers 2024). Narrowleaf cattail is now the primary large emergent hydrophyte having displaced bulrushes into a minor role (Fig. 12).

Cattails possess several traits that lead to dominance among emergent vegetation in freshwater marsh environments (Aber, Penner and Aber 2021). These include self-pollination, wind-dispersed seeds, aggressive clonal spreading via extensive rhizomes, rapid growth rate and uptake of nutrients, efficient root aeration and storage of carbohydrates in rhizomes, tall mature stature, and production of copious litter as well as suppression of seed germination and growth of other emergent plants. These characteristics, taken together, give cattail a competitive advantage over other typical emergent wetland plants. As a consequence, cattail is able to establish dense, nearly monotypic stands that cover many acres in extent (Fig. 13).

The invasion and dominance of cattail have many deleterious impacts on wetland vegetation and wildlife resulting in reduced biodiversity (Larkin et al. 2011; Bansal et al. 2019). The primary impact of *Typha* on waterbirds is by displacing those plants and animals that provide their food. Furthermore, cattail may infill wetlands and preclude most shorebird and waterfowl usage, which depends on shallow open pools and bare mudflats. Control of cattail is a priority for both the state wildlife area and TNC Cheyenne Bottoms Preserve. Methods to limit cattail growth include manipulating water levels, prescribed fires, mowing and disking, haying, and cattle grazing (Fig. 14).

TNC attempted several methods to control cattail, based on natural flood and drought cycles (Fig. 15), but none of these proved effective beyond a few years. In spite of these efforts, cattail eventually overwhelmed the marshes and pools. TNC was forced to

conduct aerial spraying over selected portions of its marshes with glyphosate aquicide in 2017, 2018 and 2019 in order to control cattail as well as reed grass (*Phragmites*), another invasive species (Fig. 16; Aber, Penner and Aber 2021). This spraying campaign greatly reduced cattail thickets, and the marsh-and-pool complex recovered quickly by 2020 (Fig. 17).

Wildlife at Cheyenne Bottoms

Birds are the most obvious and best known type of wildlife seen at Cheyenne Bottoms. The site is an important point for rest and nourishment for hundreds of thousands of waterbirds in their seasonal migrations along the Central Flyway between northern summer breeding grounds and southern winter ranges (Fig. 18). Cheyenne Bottoms and its neighbor Quivira National Wildlife Refuge are key links between wetlands along the U.S. and Mexican Gulf Coast and farther south and numerous wetlands and large lakes northward into Canada and Alaska (Figs. 19 and 20).

The great flocks of birds need large amounts of food to fuel their long-distance migrations. The cornerstone species of this food pyramid are chironomids (midges) that fly over the marshes and their larvae (bloodworms) that live in the organic-rich soils (Zimmerman 1990). Midge larvae are concentrated in mudflats that are submerged by shallow water. Shorebirds and waterfowl feed on the bloodworms underwater and also when the mudflats emerge above water. Thus, shorebirds and waterfowl mostly prefer open, shallow pools and wet, exposed mudflats. In addition to chironomids, many other invertebrate animals thrive in Cheyenne Bottoms including various ants, dragonflies, mosquitos, crayfish, and snails. Crayfish live underground in wet meadows and mudflats, and they build chimney structures that rise above the surface to provide air circulation, but during droughts crayfish are likely to die (Fig. 21). Among the few fishes, carp and fathead minnows are both well adapted for the aquatic environment. Herpetofauna, namely amphibians and reptiles, are likewise abundant in the wet meadows, marshes, and pools (Fig. 22). The ephemeral aquatic system at Cheyenne Bottoms is commonly free of fishes, which allows increased survival of eggs (frogs) and various invertebrates that serve as food for birds and other larger animals.

Shorebirds are recognized by their long legs for wading in shallow water and highly specialized beaks for probing into mud (Fig. 23). Waterfowl, on the other hand, swim. Ducks, for example, fall in two general groups based on their food-collecting behavior—dabbling ducks and diving ducks (Aber, Pavri and Aber 2012). Dabblers favor shallow water in marshes; they tip up their tails and browse on aquatic vegetation and small animals that they can reach from the water surface. Diving ducks prefer deeper water of pools, in which they dive to the bottom in search of food. Fishing birds at Cheyenne Bottoms are herons, egrets, pelicans and cormorants. Raptors include several hawk species, osprey, eagles, and falcons (KDWP 2009). They exploit the aquatic environment to catch fish, amphibians, rodents, snakes, crayfish, small birds, and other animals (Fig. 24)

Mammals are generally not so obvious at Cheyenne Bottoms, but there are many in the drier prairie zones, such as American badger (*Taxidea taxus*), black-tailed jack rabbit (*Lepus californicus*), coyote (*Canis latrans*), pocket gopher (*Geomys bursarius*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Schmidt et al. 2021 – 2025). In the

marshes and pools, mink (*Neovison vison*) and muskrat (*Ondatra zibethicus*), a common prey of mink, are present. Muskrats are considered a keystone species, as they consume cattails and their lodges provide nest platforms for geese and ducks (Zimmerman 1990). Muskrats prefer deeper water of pools; thus, low water level limits their activity.

Climatic cycles

Cheyenne Bottoms, like other prairie wetlands, suffer recurring cycles between droughts and floods that may last years or decades. During the period between 1895 and 1980, nine major floods took place (Zimmerman 1990). The flood of 1927-28, for example, resulted in a large lake that covered at least 75 km^2 (30 square miles) to as much as 140 km^2 (54 square miles) (Schwilling 1985). These flood intervals were separated by droughts in which the bottoms dried up completely at times.

This cyclic pattern has continued into the 21st century. The natural management approach at TNC Cheyenne Bottoms Preserve is best suited to demonstrate the impacts of these climatic cycles on the wetland environment, as documented by repeated seasonal and annual ground observations and kite aerial photography (Aber et al. 2006; Aber, Penner and Aber 2021).

Cycles of drought and flooding cause repeated disturbances of the marsh-and-pool complex in terms of water-level and soil-moisture conditions. During the past two decades, three significant drought episodes led to dry pools and mudflats for TNC wetlands:

- Second half of 2005 through early 2007.
- Late 2011 through mid-2013.
- Most of 2022 through 2024 (Fig. 25)

As drought conditions develop, surface water recedes, and extensive mudflats are exposed. Eventually soil moisture dries up and wetland vegetation dies down, although seeds survive in the soil. These conditions allow wind erosion of bare mudflats, and much fine sediment blows away. As water level drops and soils dry out, opportunistic plants invade quickly to occupy the available space. Many weedy plants spread through TNC wetlands during droughts (Table 1). Cattle grazing provides a source of income for TNC. These cattle graze on some of the mudflat plants, but avoid other vegetation. The species that cattle do not graze, thus, are able to thrive (Fig. 26). These conditions are unsuitable for many wildlife species, particularly for migrating shorebirds and waterfowl, which bypass Cheyenne Bottoms for more favorable wetlands elsewhere.

Droughts develop gradually over intervals of two or three years or longer. However, floods may bring droughts to a sudden end, as happened in 2007, 2013, 2019, and 2025 at TNC Cheyenne Bottoms Preserve. The flood of 2007 was comparable to that of 1927-28. During such floods, water refills the deeper pools, and mudflats are submerged. Non-wetland plants die out, and various hydrophytes begin recovering from seeds that have survived in the soil. Flood water transports sediment and nutrients that facilitate this recovery (see Fig. 3). Once again, flocks of shorebirds and waterfowl return along with other wetland wildlife.

Unexpected vegetation blooms may take place during transitions following floods or droughts. One example is mosquito fern, also known as fairy moss or water fern, which is the genus *Azolla* (Aber et al. 2010). Mosquito fern covered much of the marsh-and-pool water surface in the autumn of 2009 (Fig. 27). *Azolla* had not been noted in TNC marshes before. How *Azolla* entered TNC marshes is unknown, but several means are possible. Following the mosquito-fern bloom in 2009, it was nearly absent from TNC marshes during the drought period 2011-13. It appeared once again during the wet interval 2014-2015, but has not been seen since. A similar bloom of duckweed took place in 2020 following flooding in 2019 (Fig. 28).

A bloom of water smartweed happened in late spring 2025. Water smartweed, also called water knotweed and by other names (*Polygonum amphibium*), is a common inhabitant of the TNC wetland complex. Water smartweed has the ability to grow on exposed mudflats as well as in the water of shallow pools (USFS 2025). Following three years of drought, spring rains had partly refilled some deeper pools. This allowed water smartweed to spread across pools and surrounding moist mudflats (Fig. 29). However, the water smartweed bloom proved to be short lived, as continued rain led to flooding of the pool-marsh complex. Other emergent plants, including *Phragmites*, became well established by late summer 2025, and by autumn an algal bloom was quite apparent (Fig. 30).

The mix of various plant communities indicates the dynamic and highly variable character of ecosystems under the passive management scheme at TNC Cheyenne Bottoms Preserve (Aber, Pavri and Aber 2012). Frequent changes in water levels lead to alternate flooding and drying of marsh-and-pool zones seasonally and year to year. Thus, fleeting environmental conditions may arise. As a result of these cycles, the vegetation is always in a state of flux, and ephemeral plant communities may come and go. Both vegetation and wildlife thrive during wet periods, but must adapt during droughts. This situation mimics other natural wetland conditions in the Great Plains region and demonstrates long-term wetland stability in the face of fluctuating climatic and environmental conditions.

Impacts of Cheyenne Bottoms

As the premier wetland of Kansas, Cheyenne Bottoms represents a unique habitat and key site for migrating shorebirds and waterfowl on the Central Flyway and is a focal point for bird watching and hunting. The economic impact of tourism is significant through hunting fees as well as money spent locally for lodging, food, and supplies. On average, more than 60,000 people visit Cheyenne Bottoms each year for bird watching, hunting, environmental studies, fishing, and trapping (KWEC 2025). According to Ducks Unlimited, these visitors provide nearly $3 million annually in economic benefit to the local community (DU 2021).

These economic indicators are impressive, but the environmental impact is much greater. Cheyenne Bottoms host significant percentages of the world's populations of several shorebird species. In recognition of this importance, Cheyenne Bottoms are part of the Wetlands and Wildlife National Scenic Byway that connects to Quivira National Wildlife Refuge, another Ramsar Wetland of International Importance south of the Arkansas River (Fig. 31). In 2022, the KWEC was recognized as one of the world's best wetland visitor centers and was selected for a Star Wetland Centre Award by Ramsar (FHSU 2022).

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Common hydrophytes		Common weeds	
Blunt spike rush	*Eleocharis obtusa*	Foxtail barley	*Hordeum jubatum*
Narrow-leaf cattail	*Typha angustifolia*	Musk thistle	*Carduus nutans*
Lesser duckweed	*Lemna minor*	Velvetleaf	*Abutilon theophrasti*
Pondweeds	*Potamogeton* sp.	Spiny cocklebur	*Xanthium spinosum*
Mosquito fern	*Azolla* sp.	Eastern redcedar	*Juniperus virginiana*
Great bulrush	*Schoenoplectus tabernaemontani*	Poison hemlock	*Conium maculatum*
Water smartweed	*Polygonum amphibium*	Snow-on-the-mountain	*Euphorbia marginata*
Water speedwell	*Veronica anagallis-aquatica*	Willow	*Salix* L.

Table 1. Selection of plants often seen in TNC Cheyenne Bottoms Preserve by common and *Latin* names. Hydrophytes dominate during wet periods, and weeds are typical of droughts. Based on Aber et al. (2006) and many other sources.

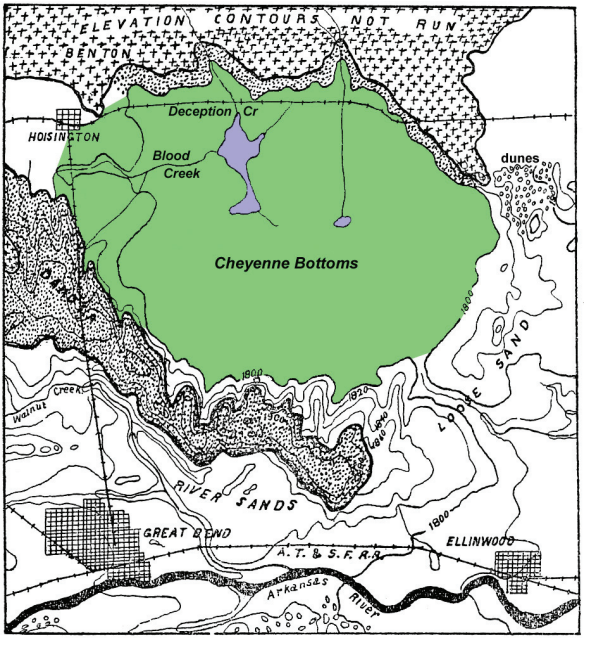


Figure 1. Sketch map of Cheyenne Bottoms (shaded green) near Great Bend, Barton County, central Kansas. Elevation contour lines given in feet; adapted from Haworth (1897, fig. 1).

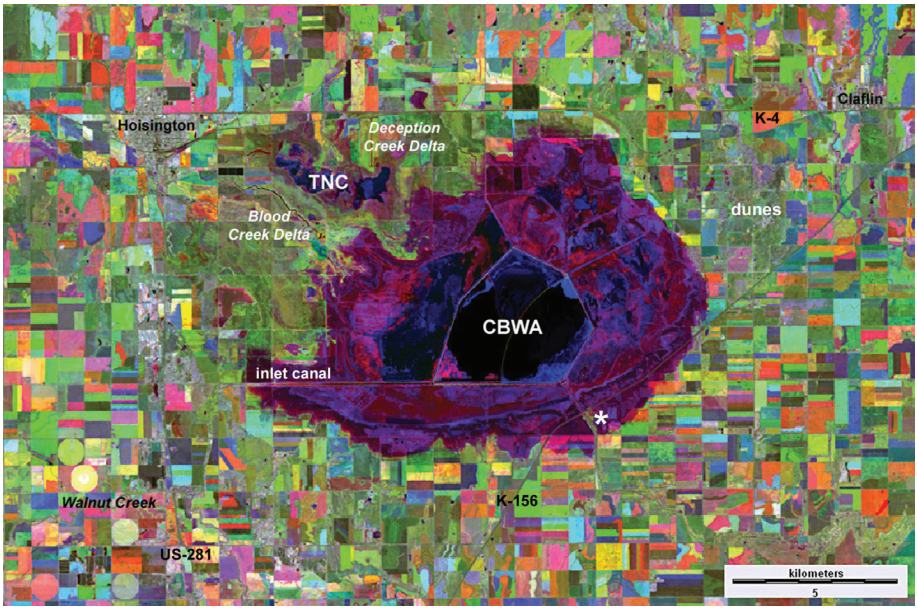


Figure 2. Multi-year composite, near-infrared satellite image of Cheyenne Bottoms vicinity for summers 2006, 2007, and 2009. Bright colors represent significant changes in land cover from year to year; dull-gray colors indicate little change in land cover. The broad maroon-purple zone shows the extent of flooding in 2007; black and dark blue show perennial water bodies. CBWA – Cheyenne Bottoms Wildlife Area; TNC – The Nature Conservancy. Deltas of Deception Creek and Blood Creek have partly filled in the northwestern portion of the bottoms. The inlet canal carries water from Walnut Creek across a drainage divide into CBWA. Location of the Kansas Wetland Education Center is marked (*). Datasets from EarthExplorer, U.S. Geological Survey https://earthexplorer.usgs.gov/

Figure 3. High-water overview of Deception Creek and pools in TNC Cheyenne Bottoms Preserve. Brown color of water is from suspended sediment (clay & silt) washed in by a recent flood in May 2007. Flooding continued throughout the next several months. Kite aerial photograph by the authors.

Figure 4. Shallow, saline groundwater soaks upward through clayey silt to evaporate at the surface of this salty mudflat at Dry Lake, a wetland on the High Plains in western Kansas. Note dark masses of organic-rich sediment that indicate the lack of oxygen, and green color shows iron in a reduced chemical state. This soil displays a strong rotten-egg odor, which is a sign of hydrogen sulfide. Comb is 5 inches long.

Figure 5. Saltcedar (*Tamarix* sp.) growing beside an irrigation canal near Fallon, Nevada. Saltcedar is a large bush or small tree, up to 4 m tall, with attractive pink flowers, often used as an ornamental garden tree. Saltcedar has become an invasive plant that grows in dense thickets along streams, rivers and wetlands in the western United States, including Kansas.

Figure 6. Great bulrush (*Schoenoplectus tabernaemontani*), also known as softstem bulrush, is among the most beneficial emergent wetland plants (Whitley et al. 1999). Although the surface of the mudflat is dry, roots reach moisture below and sustain the plants in this drought year (2012) at Cheyenne Bottoms. Plants stand about 2 m tall.

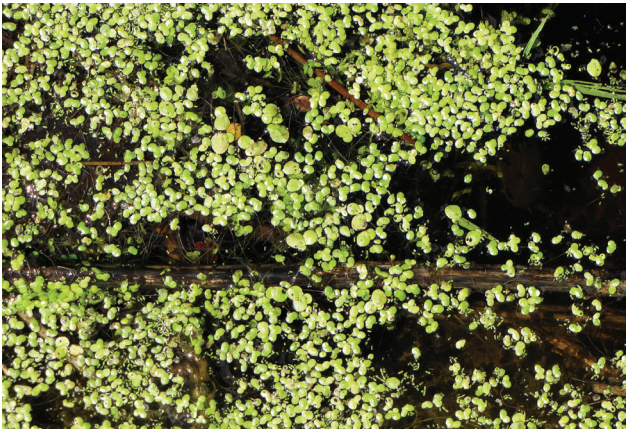


Figure 7. Lesser duckweed (*Lemna minor*) covers the water surface. The duckweed fronds resemble split green peas. They are major food resources for birds, mammals, and fish in wetland environments. Drainage ditch in the Middle Loup River valley, north-central Nebraska.

Figure 8. Water milfoil (*Myriophyllum* sp.) seen through shallow, clear water at Turner Falls, Oklahoma. *Myriophyllum* means many or countless (Greek: *myrios*) leaves (Latin: *phyllus*), which refers to its many, finely divided leaves. It provides food and shelter for fish and invertebrates from Alaska to Texas.

Figure 9. Water supply for the state Cheyenne Bottoms Wildlife Area. A – dam on Walnut Creek that impounds and diverts water into the inlet canal that crosses the drainage divide into the state wildlife area (see Fig. 2). B – water pipelines, high-capacity pumps, and control structures for adjusting water levels in pools. Photographs by the authors.

Figure 10. Kansas Wetland Education Center. A – under construction in the spring of 2008. The building is semicircular with a demonstration marsh behind it (to left). The outlet canal for the state wildlife area runs along the right side, and KS 156 highway is visible in the lower right corner. Kite aerial photograph by JSA with P. and J. Johnston. B – interior view of displays shortly after the center opened. Photograph by the authors.

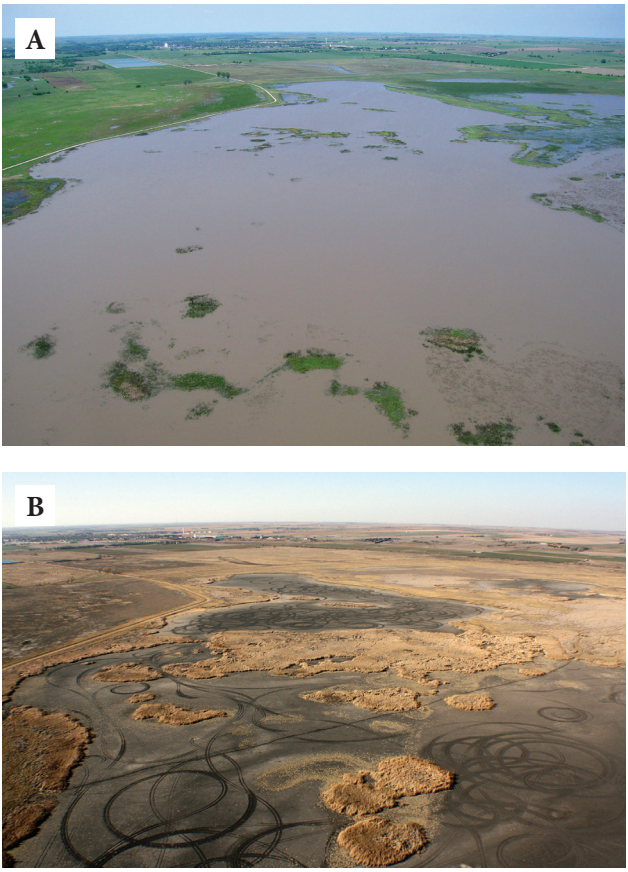


Figure 11. The Nature Conservancy pool-marsh complex contrasting drought and flood conditions. Similar views looking toward the northwest with Hoisington on the far horizon. A – waxing flood status in May 2007. Flood level increased during the summer and closed all TNC access. B – completely dry pools and dormant vegetation in November 2012. Tracks on dry mudflat were made by all-terrain vehicles. Kite aerial photographs by the authors.

Figure 12. Author (SEWA) demonstrates a tall stand of cattail. Although the surface of the mudflat is dry, roots reach moisture below and sustain the plants during a drought year (2012) at TNC Cheyenne Bottoms Preserve.

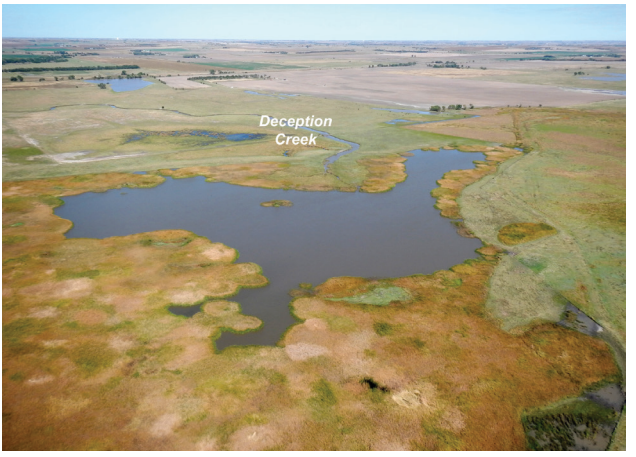


Figure 13. Looking northeast toward the delta of Deception Creek in early autumn. Cattail clones are distinct circular patches that have grown together and reduced the pool around the delta of Deception Creek. Kite aerial photograph, October 2016; compare with Fig. 3.

Figure 14. Smoke rises from late-winter prescribed burning of vegetation thatch as a means to control cattail infestation in the state Cheyenne Bottoms Wildlife Area. Kite aerial photograph by the authors, March 2010.

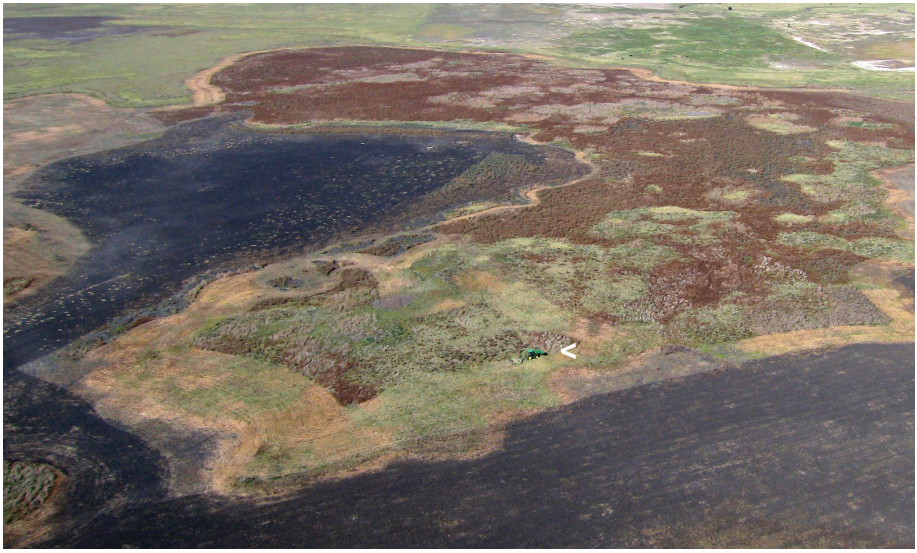


Figure 15. Drought conditions at TNC Cheyenne Bottoms Preserve. Mudflats (dark brown) were disked, and a large tractor (<) is mowing down cattail thatch. The intention was to mimic heavy buffalo grazing. However, a large bank of cattail seeds remained in the soil. Kite aerial photograph, October 2006.

Figure 16. Looking toward the delta of Deception Creek in TNC Cheyenne Bottoms Preserve. Stripes in the foreground were sprayed with aquicide in July, and emergent vegetation is now mostly dead. Cattail thickets to the north (behind) were not sprayed. Kite aerial photograph, September 2018; compare with Fig. 13.

Figure 17. Overview of TNC Cheyenne Bottoms Preserve in June 2020. Extensive open pool following aerial spraying of cattail and the exceptionally wet year in 2019. The bright yellow-green color is duckweed floating on the water surface along the shore and in areas of dead cattail thatch. Kite aerial photograph by the authors; compare with Fig. 11.

Figure 18. Four major North American waterfowl flyways. The Central Flyway (green) crosses Cheyenne Bottoms (*) in Kansas. Map posted online by the U.S. Fish & Wildlife Service; obtained and adapted from Wikimedia Commons. https://commons. wikimedia.org/wiki/File: Flyways_map_(29995934172).jpg

Figure 19. Gulf coastal area of South Texas. Laguna Madre on the right and wetlands of the Laguna Atascosa National Wildlife Refuge on the left. Laguna Madre is a shallow, high-salinity lagoon between Padre Island and the mainland. More than 400 bird species are documented here, which is more than at any other U.S. national wildlife refuge (Laguna Atascosa NWR 2025). Kite aerial photograph by the authors.

Figure 20. Old Wives Lake, a large ephemeral water body in southern Saskatchewan, Canada. It is part of the Chaplin-Old Wives-Reed Lakes wetland complex that spans about 42,000 ha (~100,000 acres). Extensive wet meadows, mudflats, and shallow saline water host more than 30 species of nesting shorebirds during the summer breeding season (WHSRN 2025). A high shoreline is marked by a sinuous line of brush across the left side. Kite aerial photograph by the authors.

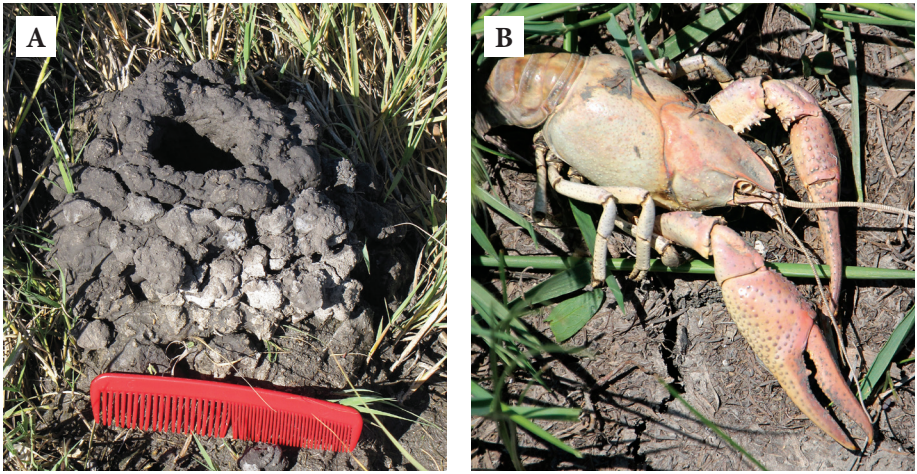


Figure 21. Crayfish at TNC Cheyenne Bottoms Preserve. A – freshly constructed crayfish burrow distinguished by a chimney-like structure of mud built above the ground surface. This is the favored habitat for Graham's crayfish snake (*Regina grahamii*). Comb is 5 inches long. B – well-preserved crayfish exoskeleton seen during an extended drought interval. Photographs by the authors.

Figure 22. Herpetofauna at TNC Cheyenne Bottoms Preserve. Plains gartersnake *(Thamnophis radix*) has caught a small American bullfrog (*Rana catesbeiana*) at the edge of a prairie marsh. The snake already has swallowed the entire right hind leg of the frog, which has ceased to struggle. Photograph by the authors.

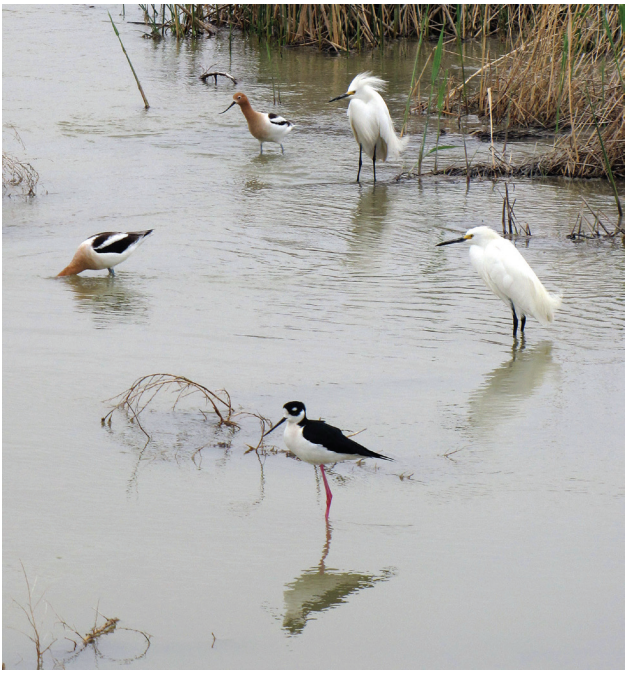


Figure 23. Shorebirds typically seen in marshes at Cheyenne Bottoms. Each species has distinctive beaks, legs, and feet for its particular feeding and wading habits. Black-necked stilt (*Himantopus mexicanus*) lower center; American avocets (*Recurvirostra americana*) upper left; snowy egrets (*Egretta thula*) upper right. Photograph by the authors.

Figure 24. Ferruginous hawk (*Buteo regalis*) is an occasional visitor to Cheyenne Bottoms (KDWP 2009). It is the largest hawk species in North America. Photograph by the authors.

Figure 25. Extended drought conditions at TNC Cheyenne Bottoms Preserve in June 2024. Pools and mudflats are completely dry and covered by weedy vegetation. The yellow-green plant in foreground is foxtail barley (*Hordeum jubatum*), and the small mound (*) supports poison hemlock (*Conium maculatum*). Black dots on left are cattle. View looking northeast toward the dry channel of Deception Creek. Kite flyers in lower right corner. Compare with Figs. 3 and 13.

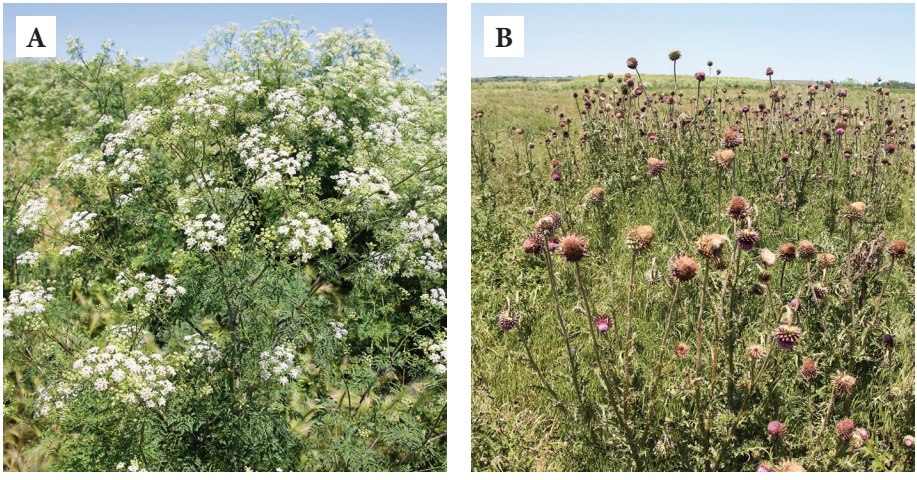


Figure 26. Undesirable plants that thrive during droughts at TNC Cheyenne Bottoms Preserve. A – poison hemlock (*Conium maculatum*) often occurs in wetlands. All parts of this plant are highly toxic to livestock and humans. B – musk thistle (*Carduus nutans*), also known as nodding thistle, is considered a noxious weed in Kansas. It is an early successional plant that establishes quickly on disturbed sites and is unpalatable for livestock. TNC is conducting a major effort to control this weed.

Figure 27. Mosquito fern (*Azolla* sp.) at TNC Cheyenne Bottoms Preserve, October 2009. Maroon-colored vegetation floating on the water surface. White spot near top is a flock of pelicans; black dots on right are cattle. Helium-blimp aerial photograph.

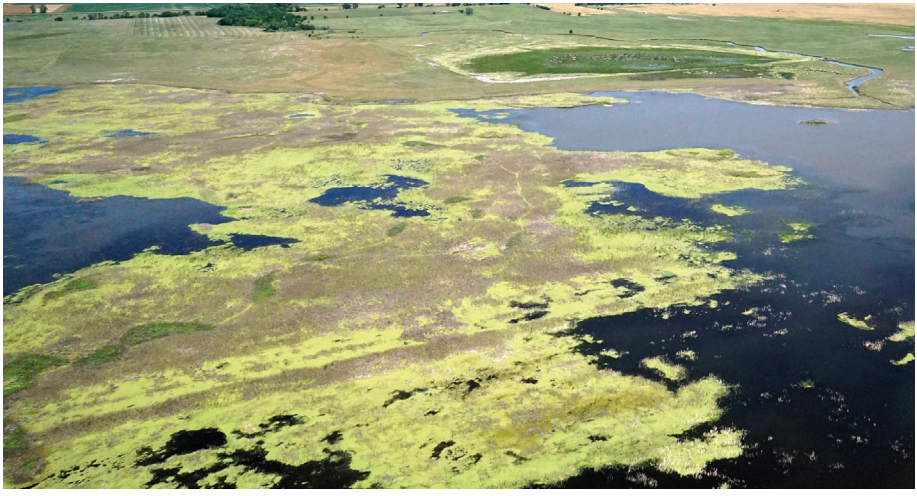


Figure 28. Lesser duckweed (*Lemna minor*) floats on water surface and appears bright yellow-green in color. High water level following aerial spraying of 2017-19 and flooding in 2019. View northward with Deception Creek at upper right. Kite aerial photograph by the authors, June 2020.

Figure 29. Overview of moist mudflats and pools covered mainly by water smartweed (*Polygonum amphibium*) that appears as green carpets which are surrounded by foxtail barley (*Hordeum jubatum*) in straw-yellow color. Shallow water shows through the smartweed at the centers of deeper pools. Looking toward the northwest; kite aerial photograph by the authors, June 2025.

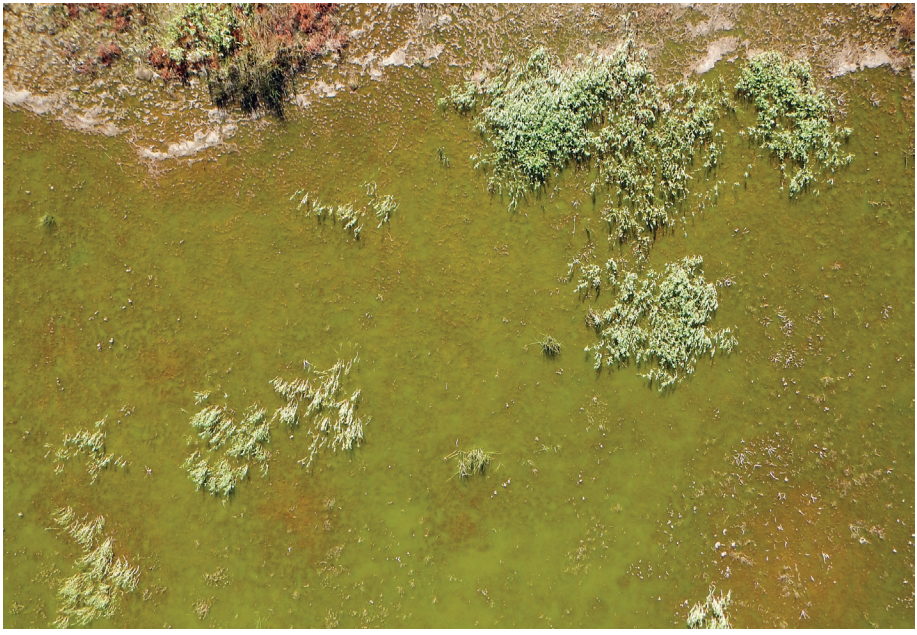
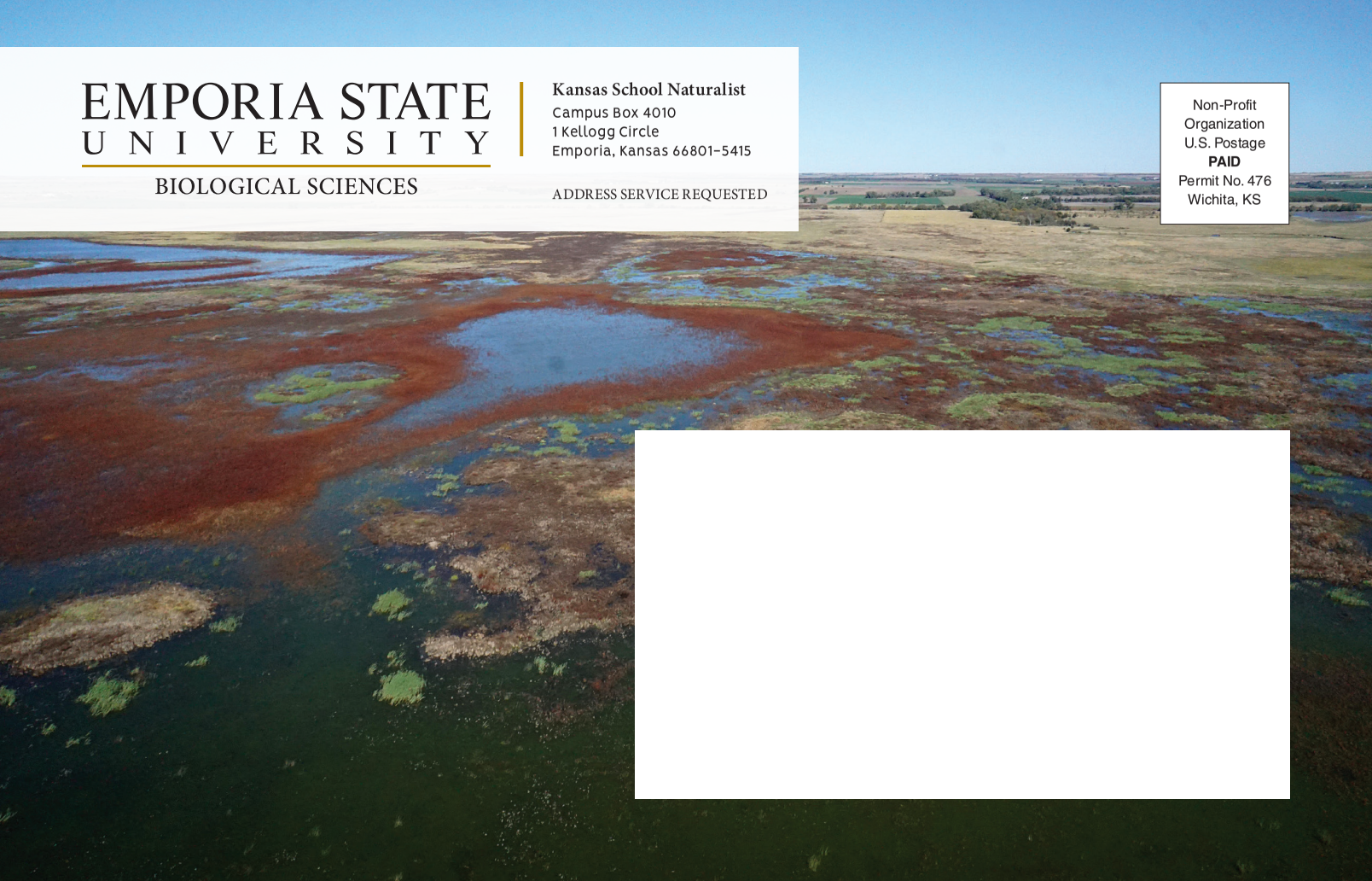


Figure 30. Green pea-soup appearance of algal bloom. Vertical close-up shot in shallow water near the pool margin with common reed grass (*Phragmites*) emergent in pale-green clumps. Kite aerial photograph by the authors, October 2025.

Figure 31. Road sign on state highway 4 marking the Wetlands and Wildlife National Scenic Byway near Claflin, Kansas.



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