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The Platte River in central Nebraska, USA, was historically surrounded by mixed grass and tallgrass prairies and wet meadows, but many of those habitats were lost or altered during the last century with unknown effects on animals that reside in them. Researchers first surveyed herpetofauna on part of a large island preserve in the Platte River, Mormon Island, Hall County, Nebraska, in 1980 when the land was protected for conservation. They documented 10 species, including three species of amphibians and seven species of reptiles. We inventoried herpetofauna after 30 years of conservation management on Mormon Island and adjacent Shoemaker Island. We captured four species of amphibians and 11 species of reptiles, including five species not detected in the previous survey. New species documented on the preserve were the Bullfrog (*Lithobates catesbeianus*), Eastern Racer (*Coluber constrictor*), Smooth Green Snake (*Liochlorophis vernalis*), Redbelly Snake (*Storeria occipitomaculata*), and Lined Snake (*Tropidoclonion lineatum*). Smooth Green Snakes represent a new county record, and Redbelly Snakes represent the easternmost published distributional limit for this disjunct population in central Nebraska. Documentation of additional snake species likely reflects a more intensive trapping regime and possibly habitat changes since 1980. Presence of Bullfrogs on Mormon Island probably was linked to excavation of a backwater slough that created a site for overwintering tadpoles. Herein we describe the variable life-history characteristics, habitats, and seasonal activity patterns among these 15 species of herpetofauna on the large river islands. We also discuss how restoration activities and hydrologic changes may influence the presence and abundance of herpetofauna in the region. Understanding the occurrence, habitat use, and seasonality of amphibians and reptiles in this topographically unaltered (i.e., unplowed) reach of river will aid in managing the central Platte River ecosystem to protect and maintain its biological integrity for all organisms.

Key words: reptiles, amphibians, turtles, Nebraska, Platte River, floodplain, prairie, grassland, herpetofauna.

Introduction

Many grasslands along rivers in the Great Plains have been converted to agricultural lands during the last century (Sidle et al., 1989) or lost to woody encroachment due to suppression of wildfires and alterations to hydrologic flow (Williams, 1978; Eschner et al., 1983; Sidle et al., 1989; Johnson, 1994; Briggs et al., 2002). Along the Platte River in Nebraska, limited grasslands persist, especially those that represent mesic, tallgrass prairies (Nagel and Kolstad, 1987; Schneider et al., 2005, 2011). The Platte River valley in central Nebraska is an important migratory stopover site for waterfowl (Sharpe et al., 2001; National Research Council (NRC), 2005; Schneider et al., 2005), Sandhill Cranes (*Grus canadensis*; Krapu et al., 1984; Tacha et al., 1984), and endangered Whooping Cranes (*Grus americana*; NRC, 2005), with central portions of the river designated as critical habitat for Whooping Cranes (United States Fish and Wildlife Service (USFWS), 1978). Grasslands and wet meadows also provide breeding sites for declining populations of grassland birds along the Central Flyway (Askins, 1993; Knopf, 1994; Kim et al., 2008). Most research and conservation efforts in the Platte River valley emphasize migratory birds and their habitats, but relatively little is known about the use and importance of such habitats for non-migratory vertebrates (NRC, 2005). Other vertebrates, such as herpetofauna, are important components of the ecosystem because many are predators or prey of migratory birds (e.g., Ernst and Ernst, 2003; Geluso and Harner, 2013; Geluso et al., in press).

Herpetofauna represent a unique group of vertebrates with life-history traits that connect them to contrasting habitats during their lifetime. Those with biphasic life histories, such as toads and frogs, require aquatic habitats for oviposition and tadpole development, whereas adults of some species mainly reside in terrestrial habitats. Many reptiles also require mesic habitats for certain life history functions. Reptiles have porous egg shells that imbibe water unlike those of birds. For reptilian eggs, the hydric environment can influence development and hatching success of turtles (Packard et al., 1982), snakes (Gutzke and Packard, 1987), and lizards (Packard et al., 1982; Somma, 1989; Somma and Fawcett, 1989). Somma (1989) demonstrated neonatal Northern Prairie Skinks (*Plestiodon septentrionalis*) were larger at hatching with increased levels of soil moisture. Foraging and overwintering behaviors of reptiles also are tied to aquatic/terrestrial interfaces. Many garter snakes are terrestrial but forage on prey species from aquatic habitats, such as fish, frogs, tadpoles, and sala-

manders (Rossman et al., 1996; Fogell, 2010), and their winter survival in hibernacula increases with greater saturation levels of substrates (Costanzo, 1986, 1989). Thus, the local floodplain hydrology can affect survival and fitness of herpetofauna, as well as influence distributional limits.

In 1980, the herpetofauna of Mormon Island, Hall County, Nebraska, was surveyed after establishment of a preserve for migratory birds, especially Whooping and Sandhill Cranes (Jones et al., 1981). Researchers documented 10 species of herpetofauna, including three species of anurans (*Anaxyrus woodhousii*, *Pseudacris maculata*, *Lithobates blairi*), three species of turtles (*Chelydra serpentina*, *Chrysemys picta*, *Apalone spinifera*), two species of lizards (*P. septentrionalis*, *Aspidoscelis sexlineata*), and two species of snakes (*Thamnophis radix*, *Thamnophis sirtalis*; Jones et al., 1981). Goldowitz and Whiles (1999) also detected the same three species of anurans in surveys of backwater sloughs in 1997-1998. The island preserve consisted mainly of unplowed grasslands due to mesic soils maintained by a high water table (Nagel, 1981); most of the island was too wet to support row-crop agriculture. Thirty years after the original herpetofaunal survey, we surveyed Mormon Island and part of the adjacent island Shoemaker Island for herpetofauna in 2009-2010. Large-scale habitat restoration and changes to land management activities have occurred in the region since the original inventory of herpetofauna to maintain and enhance habitats for migratory birds. Herein we report on the current herpetofauna composition, comment on the natural history of species, and discuss the potential influence of habitat alterations on occurrences of amphibians and reptiles.

Study Area

Our survey was conducted on Mormon and Shoemaker islands in Hall County, Nebraska, along the Platte River on lands owned by the Crane Trust. A preserve was established on Mormon Island in 1980 to help protect and maintain the physical, hydrological, and biological integrity of the region for migratory birds, especially Whooping Cranes and Sandhill Cranes. The original land acquisition was an 858-ha parcel of western Mormon Island, but other lands were acquired subsequently, including additional parts of Mormon Island and portions of adjacent Shoemaker Island, totaling about 1650 ha (Figure 1). In 1980, most of the land purchased on Mormon Island consisted of unplowed, native mixed and tallgrass prairie, but 67 ha had been plowed for cultivated fields for corn, alfalfa, and soybeans (Nagel, 1981). In 2010, large portions of the islands continued to be dominated by wet meadows sustained by high groundwater levels, especially where linear, shallow depressions (sloughs or swales) intercepted the water table (Henszey et al., 2004). Other notable landscape features included small, isolated woodlands, human-made ponds, networks of shallow, linear sloughs, and a deep slough on Shoemaker Island ("Big Slough") that remains inundated for longer periods than surrounding sloughs (Figure 1).

Since 1981, the Crane Trust has implemented rotational grazing, burning, and haying regimes on the islands to improve grassland health. In addition, large-scale restoration activities have been conducted over the past two decades, including removal of trees to open habitat for grassland birds, restoration of former agricultural fields to tallgrass prairie, and recreation of a backwater slough on the north side of Mormon Island in autumn 2006 (the slough is connected on the east, downstream end to a channel of the Platte River; Figure 1).

Methods and Materials

From June 2009 to November 2010, we recorded observations of herpetofauna on Mormon and Shoemaker islands (Figure 1). Most observations were obtained during an intensive herpetological study examining the effects of burning and grazing in grassland habitats from April to September 2010 (Harner and Geluso, 2011). Other opportunistic observations were recorded while studying birds, mammals, and invertebrates on the property. We also targeted reptiles and amphibians in other habitats by searching for individuals under fallen trees and branches as well as scattered debris (e.g., plywood, corrugated metal sheeting, and tarps). We also placed artificial cover objects made from plywood (hereafter, coverboards; 0.6 m x 0.6 m by 9.5 mm thick) in forests, grasslands, open woodlands, along sloughs, and along ecotones between forest and grassland habitats. In September 2010, we placed two wire and nylon funnel traps to catch aquatic turtles in a channel of the Platte River for six days.

To examine the effects of burning and grazing on herpetofauna, we constructed 64 arrays (eight arrays in eight pastures) that each consisted of a linear, 10-m drift fence constructed of wooden stakes and woven polypropylene silt fences, with a total of 32 arrays in sloughs and 32 arrays in adjacent upland grasslands. Silt fences bisected sloughs and allowed slow-moving water to flow though the material to preserve the integrity of wetland habitats (Enge, 1997). Associated with each drift fence was one 0.6 x 0.6 m plywood coverboard placed one-third of the way from one end of each fence, two pitfall traps consisting of black five-gallon buckets (Crawford and Kurta, 2000) set flush to ground level (one at an end of the drift fence and the other one-third from the other end), and one funnel trap (Gee's® Galva-

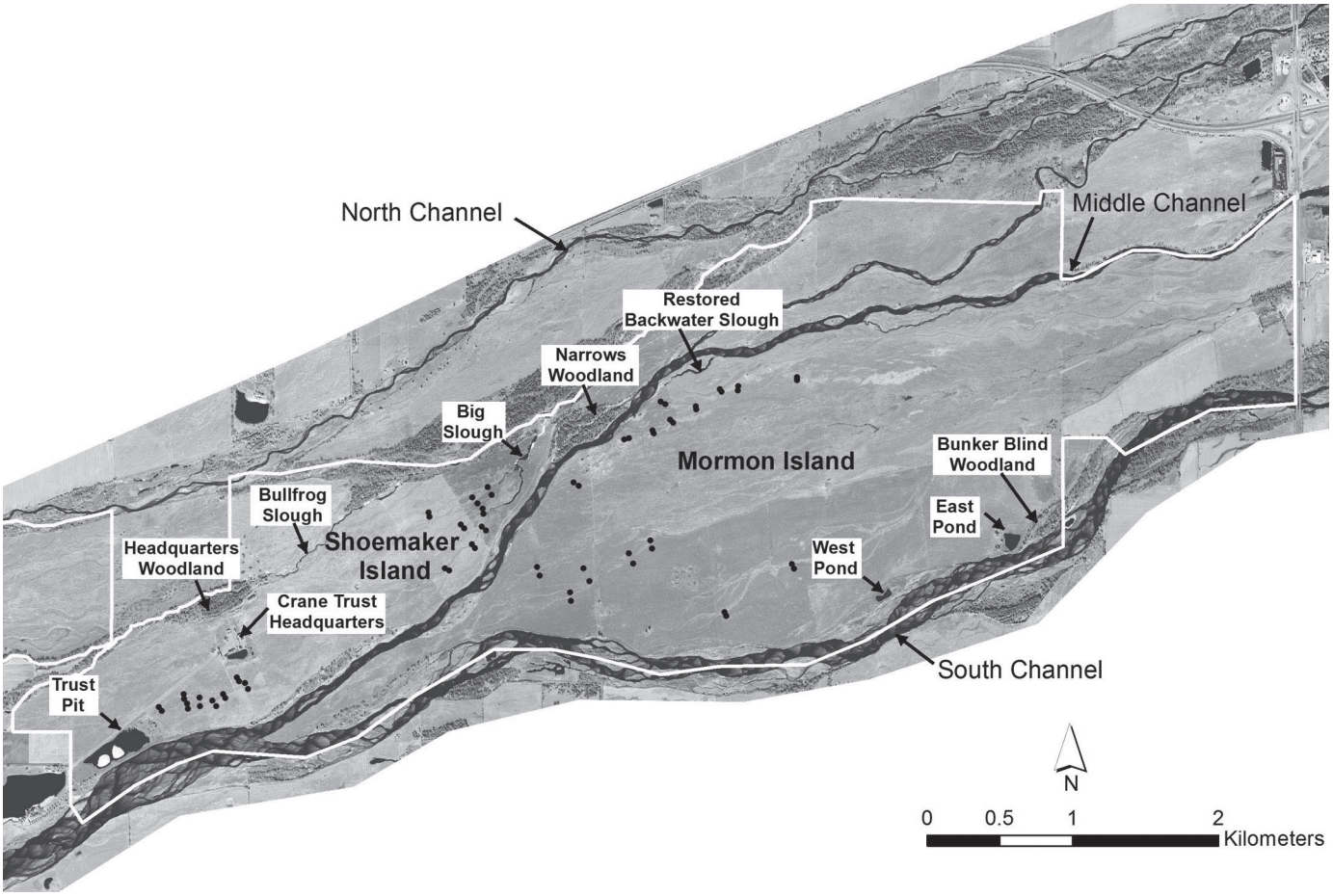

Figure 1. Location of Sampling Sites and Other Features on Mormon and Shoemaker Islands along the Platte River in Central Nebraska, USA. Black dots indicate locations of arrays. Base image was from 28 October 2010, courtesy of Platte River Recovery Implementation Program.

nized Minnow Traps, Model G-40, Tackle Factory, Fillmore, NY, USA) at the end of the drift fence opposite the pitfall trap. Three pastures were burned and grazed in spring 2010 (hereafter referred to as grazed), three pastures were burned and then rested from grazing in 2010 (hereafter referred to as burned), and two pastures were not burned nor grazed in 2010 (hereafter referred to as rested). From May to September, pitfall traps and funnel traps were opened and checked six to 10 days per month. We constructed electric fences for arrays in grazed pastures to prevent cattle from disturbing traps and fences. We mowed vegetation inside electric fences so plant heights were similar to those outside fences grazed by cattle. Herein we report the general occurrences of species from our grazing and burning study, but not the specific effects of treatments on abundance and species richness of herpetofauna.

For each amphibian and reptile captured during our burning and grazing study, we recorded species, details on size (e.g., total length, tail length, snout-vent length, carapace length, and weight via Pesola scales, where appropriate for the species), and trap type (funnel, coverboard, pitfall, or observational). For figures of individuals captured per day of effort (see *Accounts of Species*), we included recaptured individuals to best present data on seasonal activity of herpetofauna in habitats. We marked each individual, if large enough, with a unique number via a battery-operated, hand-held cauterizing unit (Change A Tip: Hi-Lo Temperature Cautery Kit, Bovie Medical, Clearwater, FL, USA; Winne et al., 2006). We recorded sex of individuals if possible based on external morphological characteristics or cloacal probing for the presence or absence of a hemipenis.

A few voucher specimens were collected, some with preserved tissues, especially those representing new species for the study area or county. All specimens and respective tissues were deposited at the Sternberg Museum of Natural History, Fort Hays State University, Hays, Kansas. All handling, marking, and euthanizing techniques were approved by the University of Nebraska at Kearney's Institutional Animal Care and Use Committee. Common and scientific names used herein, as well as the order presented below for species accounts, follow Fogell (2010).

Results

From June 2009 to November 2010, we documented 15 species of herpetofauna on Mormon and Shoemaker islands, including four anuran, three turtle, two lizard, and six snake species (Table 1). Species not documented by Jones et al. (1981) were the Bullfrog (*Lithobates catesbeianus*), Eastern Racer (*Coluber constrictor*), Smooth Green Snake (*Liochlorophis vernalis*), Redbelly Snake (*Storeria occipitomaculata*), and Lined Snake (*Tropidoclonion lineatum*). We captured over 1,660 individuals in funnel traps, in pitfalls, and under coverboards. We marked over 1,100 individuals from 10 species with a low, overall recapture rate of 6.6%. The low recapture rate implies the effective population sizes for abundant species is relatively high in the area.

We did not observe a single distinct peak of seasonal activity combining all individuals documented in arrays (Figure 2a); however, individual species tended to have unimodal or bimodal peaks in activity (see *Accounts of Species*).

Accounts of Species

Woodhouse's Toad (*Anaxyrus woodhousii*)

Woodhouse's Toad is common throughout Nebraska in various habitats, including near human settlements (Jones et al., 1981; Lynch, 1985; Ballinger et al., 2010). In South Dakota, Woodhouse's Toad appears to prefer sandy habitats along rivers, although individuals also are known from upland habitats (Timken and Dunlap, 1965). On Mormon Island, Jones et al. (1981) reported individuals most common along sandy banks of the Platte River, whereas Goldowitz and Whiles (1999) observed them almost exclusively in ephemeral sloughs in their study of different types of wetland sloughs. We observed Woodhouse's Toads throughout Mormon and Shoemaker islands. We observed Woodhouse's Toads in all grassland pastures including grazed (n = 23 individuals), burned (n = 11), and rested (n = 5). We also frequently observed toads in open, sandy habitats along the south side of Mormon Island. On summer nights, individuals foraged near building lights at Headquarters on Shoemaker Island. Individuals were observed regularly on gravel and paved roads at night after rains. Tadpoles were present in isolated pools in the active river channel during a low-flow period in 2009. Lynch (1985) reported similar observations of toads breeding in pools of water along rivers as waters recede following spring flooding in Nebraska, whereas Bateman et al. (2008) documented high densities of Woodhouse's Toads in pools supported by elevated ground water along the Rio Grande in New Mexico. Chytrid fungus, *Batrachochytrium dendrobatidis*, was detected in Woodhouse's Toads along the Platte River, with 35% of sampled individuals testing positive (Harner et al., in press).

Individuals called frequently during spring and summer from small ponds in grasslands. We first heard a Woodhouse's Toad calling on 15 April from a small, shallow pool that was also occupied by Boreal Chorus

Table 1. Total Number of Amphibians and Reptiles Captured in Trapping Arrays and Observed Opportunistically on Mormon and Shoemaker Islands, Hall County, Nebraska.[1]

Common name	Scientific name	Observations	Abundance
Northern Prairie Skink	*Plestiodon septentrionalis*	427	Common
Common Garter Snake	*Thamnophis sirtalis*	424	Common
Plains Garter Snake	*Thamnophis radix*	366	Common
Plains Leopard Frog	*Lithobates blairi*	271	Common
Lined Snake	*Tropidoclonion lineatum*	71	Uncommon
Boreal Chorus Frog	*Pseudacris maculata*	48	Uncommon
Woodhouse's Toad	*Anaxyrus woodhousii*	39	Uncommon
Redbelly Snake	*Storeria occipitomaculata*	5	Rare
Smooth Green Snake	*Liochlorophis vernalis*	3	Rare
Common Snapping Turtle	*Chelydra serpentina*	3	Rare
Six-lined Racerunner	*Aspidoscelis sexlineata*	2	Rare
Bullfrog	*Lithobates catesbeianus*	2	Rare
Eastern Racer	*Coluber constrictor*	2	Rare
Northern Painted Turtle	*Chrysemys picta*	1	Rare
Spiny Softshell[2]	*Apalone spinifera*	0	
TOTAL		1664	

[1]Trapping arrays were situated in grassland habitats. Totals represent captures and not unique individuals. We marked many individuals but had relatively few recaptures of individuals across species. Abundance designations reflect individuals in grassland habitats.

[2]A species captured in aquatic turtle traps deployed in Platte River not associated with trapping arrays.

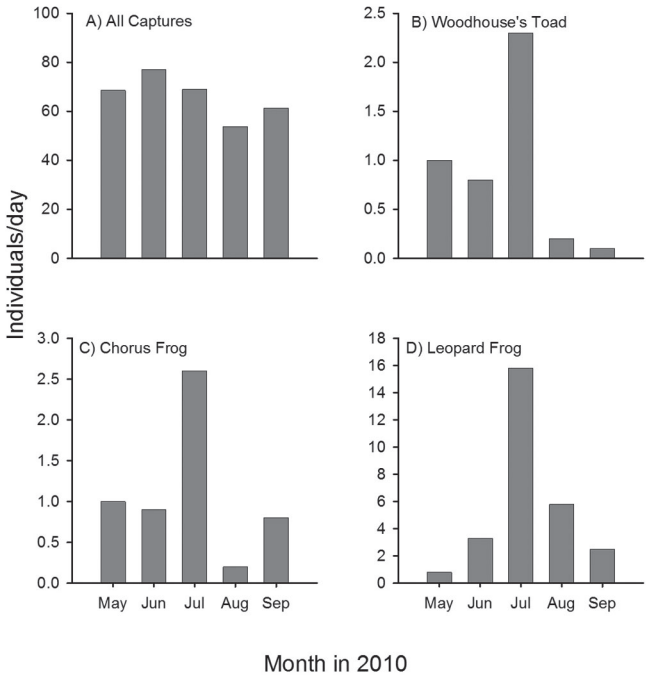

Figure 2. Average Number of Individuals Captured per Day of Effort each Month in Grassland Trapping Arrays on Mormon and Shoemaker Islands, Hall County, Nebraska, in 2010. A) All species, B) Woodhouse's Toad (*Anaxyrus woodhousii*), C) Boreal Chorus Frog (*Pseudacris maculata*), and D) Plains Leopard Frog (*Lithobates blairi*).

Frogs (*Pseudacris maculata*). Jones et al. (1981) first reported Woodhouse's Toads on Mormon Island around the first of May. We documented individuals every month from April to September, with the most captures in July (Figure 2b). In July all captures consisted of toadlets ≤35 mm in snout-vent length (n = 23). Our earliest capture of a toadlet in trapping arrays was 6 July; it had a snout-vent length of 20 mm. Our last observation of a Woodhouse's Toad was 9 September. The largest adult captured had a snout-vent length of 90 mm and weight of 75 g.

Boreal Chorus Frog (*Pseudacris maculata*)

Boreal Chorus Frogs occur in many habitats in Nebraska from woodlands to grasslands and breed in temporary as well as permanent water bodies (Ballinger et al., 2010; Fogell, 2010). Jones et al. (1981) reported Boreal Chorus Frogs most abundant on the western end of Mormon Island. Goldowitz and Whiles (1999) reported Boreal Chorus Frogs most abundant in intermittent sloughs compared to perennial or ephemeral sloughs. We documented individuals on western parts of the island, as well as throughout the remainder of the island in grasslands and wetlands. On Shoemaker Island, individuals were present but not as common as on Mormon Island. Overall, individuals were most abundant in shallow and intermittent bodies of water, such as sloughs, marshes, or other wetland depressions, but occasionally individuals were calling or captured in grasslands away from water. In contrast, we did not observe individuals in perennial waters, such as large perennial ponds or streams with continually flowing water, an observation consistent with Goldowitz and Whiles (1999) who detected the greatest abundance of Boreal Chorus Frogs in intermittent sloughs compared to perennial or ephemeral sloughs. Absence of Boreal Chorus Frogs in perennial sloughs likely reflected the presence of predatory fish (Ballinger et al., 2010) and abundance of exotic Bullfrogs that are predatory on many organisms (e.g., Krupa, 2002), including native frog species (Moyle, 1973; Bury and Luckenbach, 1976; Fisher and Shaffer, 1996).

The earliest in the year that we heard Boreal Chorus Frogs calling was on 18 March 2010, and they called on most warm nights throughout spring and after heavy rains in summer. For example in June 2009, Boreal Chorus Frogs were calling frequently from grasslands on Mormon Island and around the Headquarters after rains. We captured many individuals 25-50 m away from wetlands, likely because these frogs disperse from aquatic habitats to drier habitats after breeding (Ballinger et al., 2010). Individuals were documented every month from March to November, except in October when we were not at the study site. July was the month with the greatest number of captures per trapping array (Figure 2c), and most of these were recent metamorphs. While removing pitfalls in November, many individuals were around buckets in both wetland and upland habitats in depressions with ground water. The lastest calls of the season were heard on 8 November 2010. On Mormon Island, Goldowitz and Whiles (1999) documented peaks in activity in April and November but not in July in 1997-1998. Our trapping regime likely missed those peaks in activity because arrays were not in operation during early and late months of the year.

Plains Leopard Frog (*Lithobates blairi*)

Plains Leopard Frogs are common in aquatic habitats with permanent water throughout eastern and southern Nebraska (Ballinger et al., 2010; Fogell, 2010). Plains Leopard Frogs were the most abundant herpetofauna observed during the survey by Jones et al. (1981) on Mormon Island. Goldowitz and Whiles (1999) observed that Plains Leopard Frogs were most abundant in perennial sloughs compared to ephemeral and intermittent sloughs. Plains Leopard Frogs were the 4th most encountered species during our survey. We captured Plains Leopard Frogs in arrays across Mormon and Shoemaker islands in aquatic slough habitats (n = 156) and nearby upland sites (n = 102). Grazed grass-

lands contained shallow pools of water that held water most of the summer, and froglets were abundant in and around such pools, especially in July. We rarely observed Plains Leopard Frogs in the perennial stream on Shoemaker Island where Bullfrogs were abundant (Figure 1). Chytrid fungus was detected in Plains Leopard Frogs along the Platte River, including individuals captured at Shoemaker Island (Harner et al., in press).

We heard individuals first calling in early April, observed egg masses as early as 15 April, and captured the first metamorphosed froglets on 30 June (snout-vent lengths of 20-30 mm). The greatest number of captures occurred in July, which consisted mostly of froglets (Figure 2d). Average snout-vent length of all individuals captured was 38.1 ± 11.6 mm (mean ± SD, range 15-100 mm; Figure 3a). We last observed many individuals in aquatic habitats on 8 November 2010. Plains Leopard Frogs were regurgitated from *T. radix* on 18 July, 10 September, and 23 September. The frog on 23 September had a snout-vent length of 65 mm and was consumed by a *T. radix* with weight of 70 g and total length of 56 cm. On 18 and 20 July, we regurgitated a Plains Leopard Frog from a two different *T. sirtalis*. The largest individual was captured on 10 September (weight 38 g and snout-vent length 75 mm). We recaptured three individuals of a total of 175 marked frogs for a recapture rate of <2%.

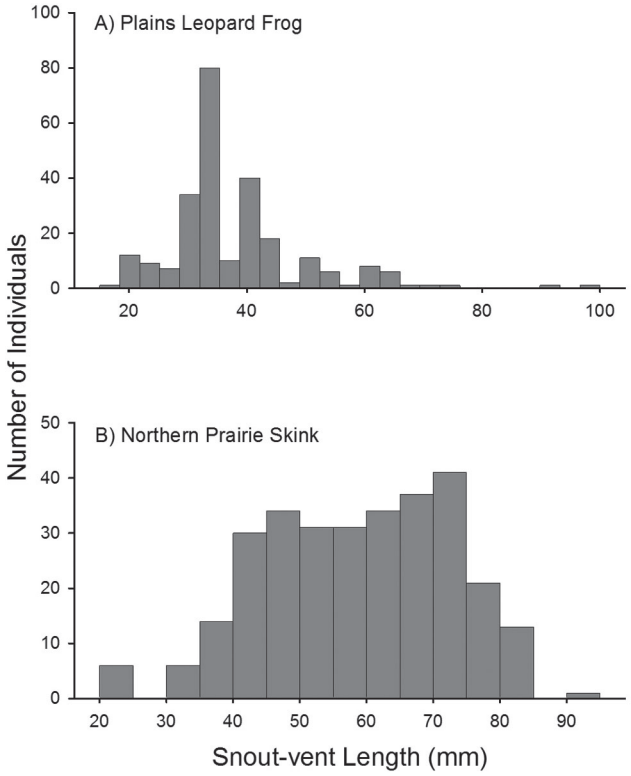

Figure 3. Histogram of Snout-Vent Lengths (mm) of A) Plains Leopard Frogs (*Lithobates blairi*) and B) Northern Prairie Skinks (*Plestiodon septentrionalis*) Captured in Grassland Trapping Arrays on Mormon and Shoemaker Islands, Hall County, Nebraska, in 2010.

Bullfrog (*Lithobates catesbeianus*)

Bullfrogs occur in large bodies of permanent water across Nebraska (Ballinger et al., 2010; Fogell, 2010). Fogell (2010) postulated that Bullfrogs originally were native only in the Nemaha River drainage of southeastern Nebraska but now occur across the state due to stocking practices. At northern latitudes, such as Nebraska, tadpoles take two years to metamorphosis into froglets (Ballinger et al., 2010). Tadpoles have specific requirements in aquatic habitats during winter, such as non-freezing water. Jones et al. (1981) did not document Bullfrogs on Mormon Island but listed them as a species of possible occurrence. Jones et al. (1981) suspected Bullfrogs might occur in two large ponds on the island, but they did not observe any Bullfrogs. Jones et al. (1981) noted that in western Nebraska Bullfrogs only occur in large ponds containing vegetation. The ponds on Mormon Island lacked emergent vegetation during both studies and contained predatory fish. Bullfrogs were reported previously from Hall County (Fogell, 2010).

We observed and captured both adult Bullfrogs and tadpoles on Mormon and Shoemaker islands. On Shoemaker Island, Bullfrogs were abundant in a perennial flowing stream north of Headquarters (i.e., Bullfrog Slough; Figure 1) and in a perennial slough that ponded due to a downstream earthen dam (Big Slough; Figure 1). In large ponds near Headquarters (Figure 1), a few males were heard calling in summer, but ponds lacked tadpoles, likely due to fish predation on eggs. On Mormon Island we observed adults and tadpoles only in the backwater slough on the north side of the island excavated in 2006. Bullfrogs were conspicuously absent from ponds on the south side of Mormon Island as was observed by Jones et al. (1981). Our only capture of a Bullfrog in an array was near the excavated slough on Mormon Island.

Our earliest seasonal observation of a Bullfrog was on 13 March 2010 when a large individual was observed partially buried in sediments in the perennial stream on Shoemaker Island. A sample of 46 adult females averaged 92 mm in snout-vent length (range 55-170 mm) whereas 30 adult males averaged 116 mm (range 90-145 mm).

We documented that Bullfrogs from Shoemaker Island had high rates of infection by chytrid fungus (42%) in 2010 (Harner et al., 2011). Bullfrogs are often carriers of this pathogen (Daszak et al., 2004; Garner et al., 2006), and thereby may be negatively impacting native frogs by spreading this pathogen throughout the islands.

Common Snapping Turtle (*Chelydra serpentina*)

The Common Snapping Turtle occurs in many types of aquatic habitats across Nebraska, such as streams, rivers, and ponds (Ballinger et al., 2010; Fogell, 2010). On Mormon Island, individuals were known from the two ponds on the south side of the island as early as April (Jones et al., 1981; Figure 1). We observed Common Snapping Turtles on Shoemaker Island in and around sloughs. We suspect these turtles still occur on Mormon Island, but we did not attempt to capture them in ponds during our study. Our earliest seasonal observation of a Common Snapping Turtle occurred on 14 April 2010; an individual was partially buried underwater in mud in an intermittent slough north of Headquarters (Figure 1). On 3, 5, and 7 June, we captured two small individuals (carapace lengths 8 and 10 cm) in pitfall traps along a perennial slough. Our latest seasonal observation was an individual with carapace 5 cm in length on 23 September 2010 near a perennial slough.

Northern Painted Turtle (*Chrysemys picta*)

Northern Painted Turtles mainly inhabit permanent bodies of water in Nebraska (Ballinger et al., 2010; Fogell, 2010). Jones et al. (1981) documented a Northern Painted Turtle in the east pond on Mormon Island in mid-June and considered it a rare species on the preserve. We observed Northern Painted Turtles mainly associated with human-made ponds on Mormon and Shoemaker islands (Figure 1). Our earliest seasonal observation was an individual basking on a log on 28 March 2010 in a pond by Headquarters. We frequently observed individuals on logs in the west pond on the south side of Mormon Island and on logs in the perennial stream north of Headquarters (Figure 1). We observed individuals traveling in grasslands on Shoemaker Island (14 April, 27 May, and 14 July), whereas others were observed on roads. The individual on 14 July likely emerged from the water to lay eggs. In the Sandhills of Nebraska, Northern Painted Turtles come ashore to lay eggs from mid-May to mid-July (Iverson and Smith, 1993). We collected the carapace of an individual adjacent to a perennial slough that ponded due to a downstream earthen dam (Big Slough; Figure 1). Our voucher specimen represents the first collected from the county (Ballenger et al., 2010; Fogell, 2010).

Spiny Softshell (*Apalone spinifera*)

The Spiny Softshell occurs in large rivers, streams, and reservoirs in Nebraska, except in northwestern parts of the state (Ballinger et al., 2010; Fogell, 2010), as well as in ponds and marshes (Fogell, 2010). Jones et al. (1981) documented this turtle species on Mormon Island June-September. We did not trap extensively for aquatic turtles during our study, but on 29 August 2010, we captured a Spiny Softshell Turtle along the southern edge of Mormon Island in a sandy channel of the Platte River. We photographed and released the individual because of prior records from the island (Jones et al., 1981). Due to the sandy substrata of all river channels around the preserve, we expect Spiny Softshells occur throughout the area and possibly in some of the human-made ponds. Smooth Softshells (*Apalone mutica*) might occur in the area, but they have yet to be detected.

Northern Prairie Skink (*Plestiodon septentrionalis*)

Distribution of the Northern Prairie Skink coincides with tallgrass prairies in the Great Plains, and these skinks occur primarily in the eastern third of Nebraska, especially along major rivers (Ballinger et al., 2010). On Mormon Island, Jones et al. (1981) observed Northern Prairie Skinks along ecotones of woodlands and grasslands. Interestingly, Jones et al. (1981) did not observe these skinks in central parts of Mormon Island in the large, grassland pastures, but in our study, Northern Prairie Skinks were the most abundant species captured in grasslands located away from woodlands on both islands (Table 1). The Northern Prairie Skink was abundant across all types grassland pastures (i.e., burned, grazed, and rested pastures) and along edges between forested and grassland habitats. Individuals also were observed in grassy patches within wooded habitats.

Our earliest seasonal observation of an individual was under a coverboard in a small wooded area on 14 April 2010. We observed skinks every month from April to November, except in October when we were not at the study site. The greatest number of captures was in June (Figure 4a), likely corresponding to increased activity associated with mating (late May; Ballinger et al., 2010) and movement and construction of nest cavities prior to oviposition (June; Somma, 1987). Males with reddish-colored chins and sides of heads were observed from 20 May to 22 July. Hatchlings were observed in trapping arrays beginning on 5 August, with the smallest individuals 20-30 mm in length and weights 0.5-1.0 g. Average snout-vent length of all unique individuals captured was 56.7 ± 14.1 mm (mean ± SD, range 20-90 mm; Figure 3b). Northern Prairie Skinks were still abundant and active on 26 September 2010. We marked 290 skinks and recaptured 68 individuals, for a recapture rate of about 23%, the highest of all common species.

Six-lined Racerunner (*Aspidoscelis sexlineata*)

Racerunners occur throughout most of Nebraska and are abundant in open, sparsely vegetated habitats with sandy soil (Ballinger and Jones, 1985; Ballinger et al., 2010; Fogell, 2010). Jones et al. (1981) and this study observed Six-lined Racerunners frequently on the south side of Mormon Island in patches of open, sandy habitats.

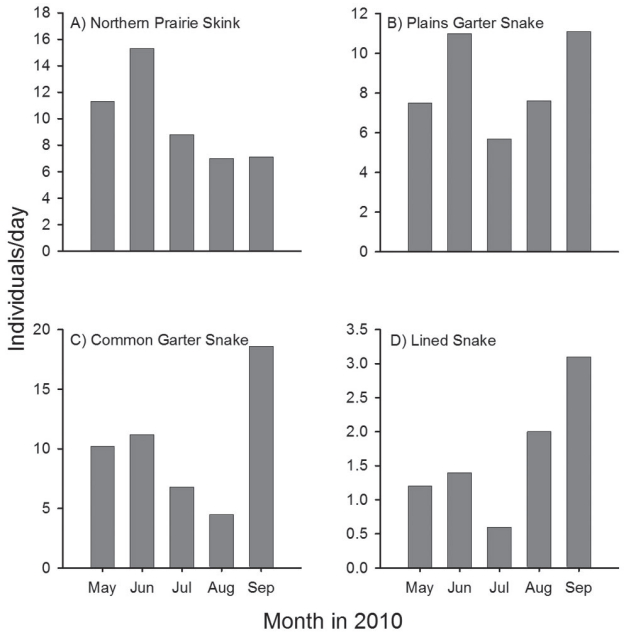

Figure 4. Average Number of Individuals Captured per Day of Effort each Month in Grassland Trapping Arrays on Mormon and Shoemaker Islands, Hall County, Nebraska, in 2010. A) Northern Prairie Skink (*Plestiodon septentrionalis*), B) Plains Garter Snake (*Thamnophis radix*), C) Common Garter Snake (*Thamnophis sirtalis*), and D) Lined Snake (*Tropidoclonion lineatum*).

This unique sandy habitat was deposited by wind in the 1930s (Nagel, 1981). We only captured one individual in a grazed pasture and another in a burned pasture in trapping arrays. We observed individuals only in June, July, and September, but we did not spend much time in habitats on the south side of Mormon Island.

Eastern Racer (*Coluber constrictor*)

Eastern Racers occur in various habitats across Nebraska, including grasslands, shrubby areas, and old fields (Ballinger et al., 2010; Fogell, 2010). Wilgers and Horne (2006) observed that Eastern Racers tend to avoid tallgrass prairies lacking recent burns, likely because they prefer open habitats (Collins et al., 2010). Jones et al. (1981) did not observe Eastern Racers on Mormon Island, and they suggested the species was absent due to the high water table yielding it unsuitable for hibernation. We captured Eastern Racers on Shoemaker Island on 9 and 12 August 2010, one in a grazed pasture (male, total length 71 cm) and one in a rested pasture (female, total length 81 cm). Both individuals were subadults, based on the faded, blotched pattern on their dorsum. We suspect individuals were dispersing through the area, as we never documented adults at the study site. The species was known previously from Hall County (Fogell, 2010).

Smooth Green Snake (*Liochlorophis vernalis*)

Records of Smooth Green Snakes are reported mainly from moist grasslands in central and northeastern Nebraska (Ballinger et al., 2010; Fogell, 2010). Jones et al. (1981) did not document Smooth Green Snakes on Mormon Island, but we observed three Smooth Green Snakes on Shoemaker Island in burned pastures. On 29 June, a gravid female was captured under a wooden coverboard; on 18 July, one was observed in a grassland; and on 22 July, a male was found dead on a dirt road. All observations occurred in grazed pastures, but the small sample size makes it impossible to draw conclusions about habitat associations. Observations in grazed areas may represent individuals traveling across pastures, with individuals more visible and seeking shelter in open fields. Another researcher observed Smooth Green Snakes by the Headquarters on Shoemaker Island (L. Ramírez Yáñez, pers. comm.). We expect this species also occurs on Mormon Island. It is unknown how abundant Smooth Green Snakes are at the study site because our mesh size on funnel traps precluded capturing individuals of this and other small snake species. Observations from Hall County represent a new county record for the state (Ballinger et al., 2010; Fogell, 2010). Smooth Green Snakes are known from adjacent Merrick, Kearney, and Sherman counties (Ballinger et al., 2010, Fogell, 2010).

Redbelly Snake (*Storeria occipitomaculata*)

Redbelly Snakes occur mainly across eastern parts of the United States, but disjunct populations reside in the plains states (Ernst, 2002; Fogell, 2010). One isolated population is located along the Platte River in central Nebraska. In Nebraska, Redbelly Snakes are known from Buffalo (Lynch, 1985), Dawson (Peyton, 1989), Hall (Ballinger and Beachly, 1999), Kearney (Geluso, 2012), and Phelps (Ballinger et al., 2010; Fogell, 2010) counties. Redbelly Snakes primarily inhabit woodlands (Triplehorn, 1948; Smith, 1963; Fogell, 2010). Jones et al. (1981) did not observe Redbelly Snakes on Mormon Island, and it was not listed as a possible species on the preserve.

We documented Redbelly Snakes on Mormon and Shoemaker islands in both wooded and grassland habitats, but individuals were only captured in grasslands located near (< 500 m) woodlands. We did not capture Redbelly Snakes in arrays on the west side of Mormon Island, where there were no trees, but we readily observed individuals along the edge of the only remaining wooded area situated on the southern edge of the island, the Bunker Blind Woodland (Figure 1). On Shoemaker Island we captured five individuals under coverboards and in pitfall traps in grazed and ungrazed pastures. On 24 and 28 April 2010, we observed individuals basking on dirt roads <25 m from a chan-

nel of the Platte River. Our earliest seasonal date of observation was 14 April, and our latest date of observation was 11 September. Redbelly Snakes are known to be active later in the year than our observations on the preserve (24 October; Geluso, 2012). We captured individuals in May (n = 2), June (n = 1), and September (n = 2) in arrays. The largest individual in arrays was 28.5 cm in length and the smallest was 14.2 cm. Our captures represent a new species for the preserve (Jones et al., 1981) and easternmost published records for this disjunct population along the Platte River in Nebraska (Ballinger et al., 2010; Fogell, 2010).

Additional studies are warranted to delineate the subspecific status of this population and habitat requirements for this population in Nebraska. To date, specimens from central Nebraska have been referred to as *S. o. pahasapae* (Peyton, 1989; Ballinger and Beachly, 1999), but to our knowledge, a formal investigation of subspecific status has not been conducted.

Plains Garter Snake (*Thamnophis radix*)

The Plains Garter Snake is common in wet prairies and along ponds, lakes, marshes, and rivers across Nebraska (Ballinger et al., 2010; Fogell, 2010). Fogell (2010) states this species avoids woodlands but occurs along wooded ecotones, but Jones et al. (1981) states it uses large trees and fallen logs in riparian woodlands for hibernation. On Mormon Island, Jones et al. (1981) reported the Plains Garter Snake along the Platte River, in wet meadows, around large trees, and in dry prairies.

Plains Garter Snakes were the 3rd most common species captured in trapping arrays on Mormon and Shoemaker islands (Table 1). Individuals were captured in burned, grazed, and rested pastures, as well as in woodlands. Our earliest seasonal observation was on 14 April and our latest aboveground seasonal observation was on 19 October. The most captures were in June and September (Figure 4b). Jones et al. (1981) also observed the species most active in June. Individuals were observed around pitfall traps when we removed them in November, with many depressions containing ground water.

The largest female *T. radix* captured had a total length of 77 cm and a weight of 130 g, whereas the largest male captured was 66 cm and 95 g. Young-of-year snakes first were captured on 10 August with total lengths of 17-21 cm and weights of 1.5-3.0 g. Average snout-vent length of uniquely numbered females was 419 ± 89 mm (mean ± SD, range 200-625 mm, n = 145; Figure 5a), whereas snout-vent length of males was 398 ± 69 mm (mean ± SD, range 195-570 mm, n = 110; Figure 5b). Snakes commonly regurgitated earthworms when handled in May, June, and September. On 3 occasions, individuals regurgitated a Plains Leopard Frog (18 July, 10 September, and 23 September), and once an individual regurgitated a small mouse (18 July). While handling this species by the tail, many individuals spun in circles attempting to escape. We recaptured 11 individuals of a total of 281 marked snakes for a recapture rate of about 4%, and most of those were captured the following day in the same trap array.

Common Garter Snake (*Thamnophis sirtalis*)

The Common Garter Snake has a statewide distribution (Ballinger et al., 2010; Fogell, 2010), but in the Sandhills and western Nebraska it is usually associated with riverine habitats (Ballinger et al., 2010). This species most frequently occurs in habitats near water sources (Jones et al., 1981; Fogell, 2010). On Mormon Island, Jones et al. (1981) observed the species most often near ponds and along channels of the Platte River.

The Common Garter Snake was the 2nd most frequently captured herpetofauna during our study (Table 1). Almost all observations were from grasslands, including burned, grazed, and rested pastures. We also observed a few individuals under coverboards in small wooded habitats along the Platte River in spring and autumn. Our earliest seasonal observation was on 14 April 2010, and our latest aboveground seasonal observation was on 8 November 2010. We captured the most Common Garter Snakes in September, followed by May

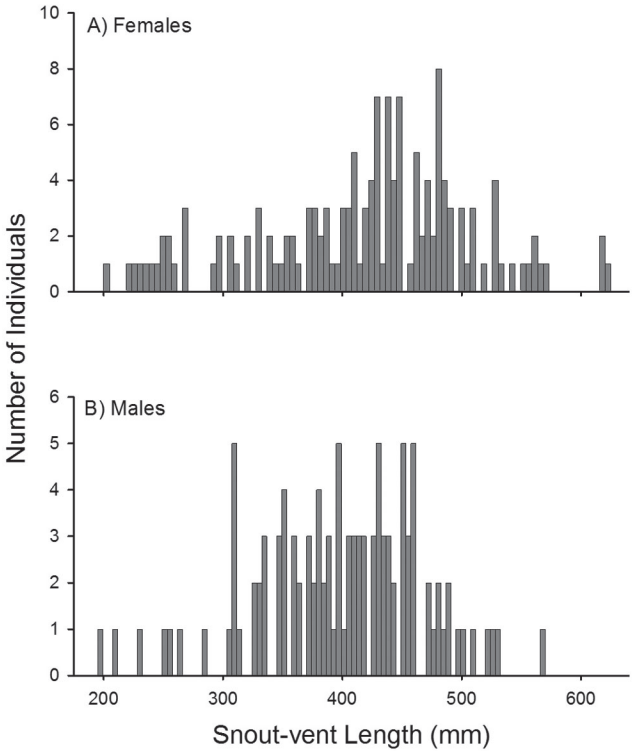

Figure 5. Histogram of Snout-Vent Lengths (mm) of A) Female and B) Male Plains Garter Snakes (*Thamnophis radix*) Captured in Grassland Trapping Arrays on Mormon and Shoemaker Islands, Hall County, Nebraska, in 2010.

and June (Figure 4c). On 18 November, while removing pitfalls for the season, we observed individuals under buckets, with up to 15 individuals of both *Thamnophis* species together along with Boreal Chorus Frogs. Snakes were partially submerged in ground water under some buckets. Costanzo (1989) demonstrated that *T. sirtalis* submerged in water had higher winter survival rates than those not submerged in water.

The largest female captured by weight was 200 g with a total length of 85 cm (18 August); she was likely a gravid female. The largest female captured by length was 89 cm with a weight of 145 g (23 September). The largest male was 88.5 cm long and 138 g. Young-of-year snakes were first captured on 12 August with total lengths of 20-21 cm and weights of 1.5-3.0 g. Average snout-vent length of females was 494 ± 104 mm (mean ± SD, range 235-690 mm, n = 148; Figure 6a), whereas snout-vent length of males was 461 ± 83 mm (mean ± SD, range 215-710 mm, n = 164; Figure 6b). Earthworms were the most frequently observed prey item, with individuals regurgitating worms in May, June, July, and September. An individual (total length 87 cm and weight 155 g) in May regurgitated over 10 g of earthworms. Plains Leopard Frogs were observed in the diet on 18 July and 20 July. Meadow Voles (*Microtus pennsylvanicus*) and Cinereus Shrews (*Sorex cinereus*) also were consumed by Common Garter Snakes. Fitch (1999) demonstrated a seasonal shift in prey items for *T. sirtalis* in Kansas, with earthworms, small mammals, and frogs commonly observed in their diet. As with *T. radix*, many individuals had a spinning behavior to attempt to escape while handling snakes by the tail. We recaptured 12 individuals of a total of 337 marked snakes for a recapture rate of about 4%.

Lined Snake (*Tropidoclonion lineatum*)

Lined Snakes mainly occur in southeastern Nebraska and along the Platte River to Lincoln County (Ballinger et al., 2010; Fogell, 2010). This species resides in open prairies and along woodland edges (Ballinger et al., 2010). In tallgrass prairies in northeastern Kansas, Lined Snakes were more abundant in pastures burned yearly compared to those burned every four years or rested for longer periods (Wilgers and Horne, 2006). Jones et al. (1981) did not observe this species on Mormon Island. Lined Snakes were previously known from Hall County (Fogell, 2010).

We observed Lined Snakes frequently on both Mormon and Shoemaker islands (Table 1), and they were our 5th most frequently captured species. We captured 71 individuals, and Lined Snakes were captured in all eight grassland pastures with arrays. Our earliest seasonal date of observation was 18 May, and our latest date of observation was 26 September. We most frequently

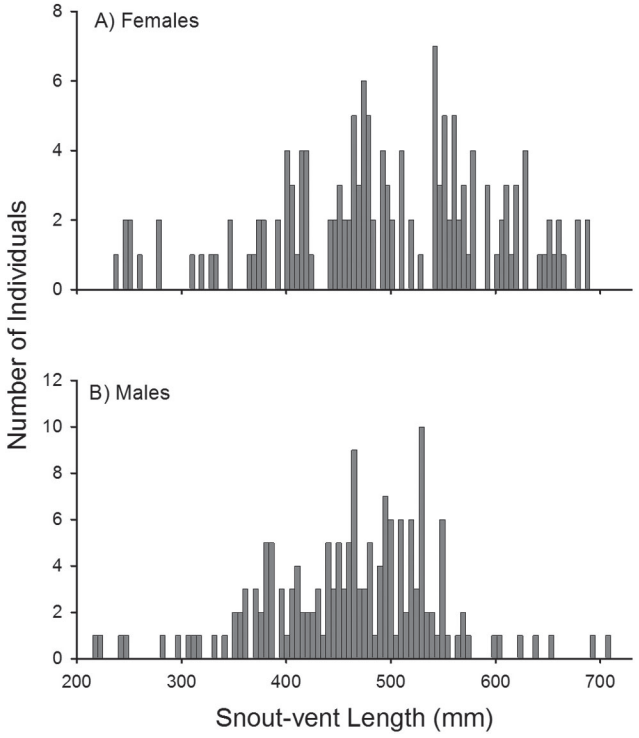

Figure 6. Histogram of Snout-Vent Lengths (mm) of A) Female and B) Male Common Garter Snakes (*Thamnophis sirtalis*) Captured in Grassland Trapping Arrays on Mormon and Shoemaker Islands, Hall County, Nebraska, in 2010.

observed individuals in September (Figure 4d). Lined Snakes were observed more often in drier, upland arrays than in sloughs (Harner and Geluso, 2011). The largest female was 34 cm in length with weight of 24 g, and the largest male was 34 cm and 20.5 g. The first young-of-year was captured on 18 August with a total length of 10 cm and weight of about 1 g. Additional young-of-year were captured 23-26 September with total lengths of 12-14 cm and weight of about 1 g. We did not recapture any of the 31 marked individuals.

Discussion

We documented 15 species of herpetofauna in floodplain habitats of the Platte River on Mormon and Shoemaker islands, including five species not reported previously on Mormon Island by Jones et al. (1981), and one amphibian species not reported by Goldowitz and Whiles (1999). A 50% increase in known herpetofaunal species shows the importance of inventory and monitoring activities in the region to capture changing environmental conditions, as well as to detect species that may have been missed in previous surveys. During the past three decades on Mormon and Shoemaker islands, grazing pressure has been reduced, frequency of prescribed burning has increased, and former agricultural pastures have been restored to native prairie. In addition, wood-

lands have been cleared and a backwater slough excavated. All of these alterations potentially affect herpetofauna, as they influence vegetative cover, plant species composition, and availability of water.

Large-scale changes to aquatic and terrestrial habitats on Mormon and Shoemaker islands appear related to the increased abundance of Northern Prairie Skinks, Lined Snakes, and Eastern Racers. Jones et al. (1981) postulated that the absence of three species of snakes (Lined Snakes, Bullsnakes (*Pituophis catenifer*), and Eastern Racers) was related to "the high water table at Mormon Island that prevents snakes from having a suitable deep space for hiding and hibernation . . .", as well as Lined Snakes' intolerance of wet conditions. We documented both the Lined Snake and Eastern Racer in the area, with Lined Snakes the 5th most abundant species captured during our study. Moreover, although the Northern Prairie Skink was observed during both surveys, Jones et al. (1981) reported, "It was not found in the central pasture." In contrast, 28% of our total captures were from two arrays in that same "central pasture," and all of our sampling arrays were in grasslands where the Northern Prairie Skink was the most abundant species of all 15 species of herpetofauna on the preserve. Such anecdotal evidence suggests that the water table has lowered or the grasslands have become more arid in the area since 1980, allowing such species to now occur in or inhabit the area in greater densities. Long-term monitoring of groundwater and various vertebrate communities (i.e., not only migratory birds) will contribute to the understanding of this ecosystem, especially as we face regional changes in hydrology and temperature regimes.

Resource managers continue to apply restoration techniques over large areas of the central Platte River to create and maintain habitat for endangered and threatened species of migratory birds: the Whooping Crane, Interior Least Tern (*Sterna antillarum athalassos*), and Piping Plover (*Charadrius melodus*) (NRC, 2005), as well as Sandhill Cranes and grassland birds. Those restoration techniques often involve felling riparian woodlands to remove visual obstructions, clearing vegetation from river islands to create nesting and roosting habitat, and creating and/or re-contouring backwater sloughs to increase off-channel aquatic habitat. Such actions usually are initiated to improve habitats for a single species or assemblage of species (e.g., Whooping Cranes or grassland birds), but such restoration activities also may be beneficial or detrimental to other non-target species in the area. While herpetofauna are not currently a focal species for conservation and restoration activities in the Platte River valley, they may be affected by such activities and warrant on-going monitoring in this ecosystem.

Our study represents the first published documentation of invasive, nonnative Bullfrogs on the islands, and we observed large numbers (hundreds) of Bullfrogs in some sloughs, suggesting they have increased dramatically in the last decades, as neither previous survey reported them (Jones et al., 1981; Goldowitz and Whiles, 1999). Excavation of a backwater slough in 2006 may have contributed to presence of Bullfrogs on Mormon Island, as the deep slough provided the only site on the island with suitable conditions for overwintering tadpole development and survival; no other sloughs on Mormon Island have such deep channel morphology. The two other permanent water bodies on Mormon Island, the East and West ponds (Figure 1), appear unsuitable for bullfrogs due to a lack of cover from predatory fish (Jones et al., 1981; this study). The excavated slough also provides a continuous connection to the main river channel, a conduit for species movement. Sloughs with similar, deep channel morphologies have been created throughout the Platte River valley, and they also may be providing ideal conditions for the recruitment of exotic and invasive Bullfrogs. The occurrence of Bullfrogs needs ongoing monitoring, as they negatively affect other native herpetofauna and other organisms by their voracious feeding habitats (e.g., Krupa, 2002) and their ability to carry chytrid fungus (Harner et al., 2011, in press), which is contributing to global amphibian declines (Collins, 2010).

Large-scale removal of woodlands along the central Platte River to create grassland habitats and open river channels (NRC, 2005) likely has negatively impacted the isolated population of Redbelly Snakes, a species of concern in Nebraska (Schneider et al., 2005, 2011). Redbelly Snakes appear to require wooded habitats in the Platte River valley (this study), as the species does in eastern parts of its distribution (Triplehorn, 1948; Smith, 1963). Moreover Eastern Red-cedars (*Juniperus virginiana*) are dominating forest understories in the Platte River valley, where once islands were wooded almost exclusively with cottonwoods, elms, and willows before settlement by Europeans (Eschner et al., 1983; Williams, 1978; Johnson, 1994). Eastern Red-cedars affect the composition and abundance of avifauna and small mammals in the Great Plains (Horncastle et al., 2005; Frost and Powell, 2011), but it is unclear how such changes to woodland composition may affect Redbelly Snakes or other herpetofauna.

We predict additional species will be added to the list of species occurring on Mormon and Shoemaker islands with more directed sampling efforts and continued regional habitat changes. We suspect that the Smooth Softshell occurs in sandy channels of the Platte River in Hall County; however, there are no records of this species along the Platte River in central or western parts of the state (Ballinger et al., 2010). The absence of the Northern Water Snake (*Nerodia sipedon*) is unclear, but

it might be linked to a lack of suitable hibernacula. This species has been documented along the Platte River to the east and west of the preserve, and the area appears to contain appropriate habitats with ample prey. Furthermore, we predict the Ornate Box Turtle (*Terrapene ornata*), Bullsnake, and Prairie Lizard (*Sceloporus consobrinus*) will be observed on the preserve if grassland habitats become drier with a concomitant reduction in vegetative density. All three species occur to the west in open, more arid floodplains of the Platte River in Dawson and Gosper counties (Ballinger et al., 2010; Fogell, 2010; Geluso, 2012).

Natural history characteristics for herpetofauna occurring on Mormon and Shoemaker islands demonstrate the varied life-history attributes for species. Our study illustrates that there is no single best time of the year to study this community of herpetofauna, and future research in the region should extend studies into April as well as October and November for a better understanding of early- and late-seasonal activity patterns (see Goldowitz and Whiles, 1999). Variation in life-history characteristics of different species also demonstrates the need for management regimes that yield a diversity of habitats in the Platte River valley, with contrasting aquatic and terrestrial habitats requisite for a number species. Floodplains of rivers create and maintain a diversity of habitats, sustaining the vital proximity of abundant ecotones between aquatic and terrestrial systems as well as woodland and grassland habitats for herpetofauna (Bateman et al., 2008; Tockner et al., 1999; Tockner et al., 2006; A. Bridger and K. Geluso, unpublished data).

Our study represents an important benchmark survey of herpetofauna composition and relative abundance as land management and conservation efforts continue to manage, restore, and protect floodplain habitats of the central Platte River for migratory birds. Herpetofauna are currently not a focal species in the Platte River valley because such species are not listed as threatened or endangered under the Endangered Species Act. However, indirect effects of land management on herpetofauna warrant consideration because these species are important food items as well as predators of migratory bird species. For example, endangered Whooping Cranes are animalivous, consuming various vertebrate species such as frogs, snakes, mice, and egg masses of frogs (Allen, 1952). Recent observations demonstrated the direct linkage of Whooping Cranes feeding on herpetofauna on wintering grounds and in shallow wetlands near the Platte River on migratory stopovers (Geluso and Harner, 2013; Geluso et al., in press). Continued success of protecting endangered species along the Platte River requires more than a focus on physical habitat, but rather a broader view that includes other interconnected attributes of the system that contribute to species survival, such as complex trophic linkages that, in some cases, include herpetofauna.

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Literature Cited

Allen RP. (1952) *The Whooping Crane*. Research Report No. 3 of the National Audubon Society, National Audubon Society, New York, NY. 246 pp.

Askins RA. (1993) Population trends in grassland, shrubland, and forest birds in eastern North America. In DM Power (Editor), *Current Ornithology,* Volume 11, pp. 1–34. (New York, NY: Plenum Press)

Ballinger RE, and Beachly W. (1999) Geographic distribution: *Storeria occipitomaculata* (Redbelly Snake). *Herpetological Review* 30(4):236–237.

Ballinger RE, Lynch JD, and Smith GR. (2010) *Amphibian and reptiles of Nebraska.* (Oro Valley, AZ: Rusty Lizard Press)

Ballinger RE, and Jones SM. (1985) Ecological disturbance in a Sandhills prairie: Impact and importance to the lizard community on Arapaho Prairie in western Nebraska. *The Prairie Naturalist* 17(2):91-100.

Bateman H, Harner MJ, and Chung-MacCoubrey A. (2008) Abundance and reproduction of toads (*Bufo*) along a regulated river in the southwestern United States: Importance of flooding in riparian ecosystems. *Journal of Arid Environments* 72(9):1613–1619.

Briggs JM, Hoch GA, and Johnson LC. (2002) Assessing the rate, mechanisms, and consequences of the conversion of tallgrass prairie to *Juniperus virginiana* forest. *Ecosystems* 5(6):578–586.

Bury RB, and Luckenbach RA. (1976) Introduced amphibians and reptiles in California. *Biological Conservation* 10(1):1–14.

Collins JP. (2010) Amphibian decline and extinction: what we know and what we need to learn. *Diseases of Aquatic Organisms* 92(2-3):93–99.

Collins JT, Collins SL, and Taggart TW. (2010) *Amphibians, reptiles, and turtles in Kansas.* (Eagle Mountain, UT: Eagle Mountain Publishing)

Costanzo JP. (1986) Influence of hibernaculum microenvironment on the winter life history of the garter snake (*Thamnophis sirtalis*). *Ohio Journal of Science* 86(5):199–204.

Costanzo JP. (1989) Effects of humidity, temperature, and submergence behavior on the survivorship and energy use in hibernating garter snakes, *Thamnophis sirtalis*. *Canadian Journal of Zoology* 67(10):2486–2492.

Crawford E, and Kurta A. (2000) Color of pitfall affects trapping success for anurans and shrews. *Herpetological Review* 31(4):222–224.

Daszak P, Strieby A, Cunningham AA, Longcore JE, Brown CC, and Porter D. (2004) Experimental evidence that the bullfrog (*Rana catesbeiana*) is a potential carrier of chytridiomycosis, an emerging fungal disease of amphibians. *Herpetological Journal* 14(4):201–207.

Enge KM. (1997) Use of silt fencing and funnel traps for drift fences. *Herpetological Review* 28(1):30–31.

Ernst CH. (2002) *Storeria occipitomaculata*. *Catalogue of American Amphibians and Reptiles* 759:1–8.

Ernst CH, Ernst EM. (2003) *Snakes of the United States and Canada.* (Washington D.C.: Smithsonian Institution Press)

Eschner TR, Hadley RF, and Crowley KD. (1983) *Hydrologic and morphologic changes in channels of the Platte River basin in Colorado, Wyoming, and Nebraska: A historical perspective.* (Geological Survey Professional Paper 1277-A)

Fisher RN, and Shaffer HB. (1996) The decline of amphibians in California's great central valley. *Conservation Biology* 10(5):1387–1397.

Fitch HS. (1999) *A Kansas snake community: Composition and changes over 50 years.* (Malabar, FL: Krieger Publishing Company)

Fogell DD. (2010) *A field guide to the amphibians and reptiles of Nebraska.* (University of Nebraska-Lincoln, NE: Institute of Agriculture and Natural Resources)

Frost JS, and Powell LA. (2011) Cedar infestation impacts avian communities along the Niobrara River Valley, Nebraska. *Restoration Ecology* 19(4):529–536.

Garner TWJ, Perkins MW, Govindarajulu P, Seglie D, Walker S, Cunningham AA, and Fisher MC. (2006) The emerging amphibian pathogen *Batrachochytrium dendrobatidis* globally infects introduced populations of the North American bullfrog, *Rana catesbeiana*. *Biology Letters* 2(3): 455–459.

Geluso K. (2012) Sixteen county records of herpetofauna from south-central Nebraska, 2011. *Collinsorum*: *Journal of Kansas Herpetology* 1(2-3):3–6.

Geluso K, and Harner MJ. (2013) *Nerodia clarkii clarkii* (Gulf Saltmarsh Watersnake): Predation. *Herpetological Review* 44(1):156–157.

Geluso K, Krohn BT, Harner MJ, and Assenmacher MJ. (In press) Whooping cranes consume plains leopard frogs at migratory stopover sites in Nebraska. *The Prairie Naturalist*

Goldowitz BS, and Whiles MR. (1999) *Investigations of fish, amphibians and aquatic invertebrates species within the middle Platte River system.* Final Report, Platte Watershed Program, University of Nebraska-Lincoln, Lincoln, NE. 32 pp.

Gutzke WHN, and Packard GC. (1987) Influence of the hydric and thermal environments on eggs and hatchlings of bull snakes, *Pituophis melanoleucus*. *Physiological Zoology* 60(1):9–17.

Harner MJ, and Geluso, K. (2011) *Response of herpetofauna to grazing and fire in wet, tallgrass prairies along the Platte River.* Final Report, Nebraska Game and Parks Commission, Lincoln, NE. 57 pp.

Harner MJ, Merlino JN, Wright GD. (In press) Chytrid fungus in Woodhouse's toads, plains leopard frogs, and American bullfrogs along the Platte River, Nebraska, USA. *Herpetological Review*

Harner MJ, Nelson AJ, Geluso K, and Simon DM. (2011) Chytrid fungus in American bullfrogs (*Lithobates catesbeianus*) along the Platte River, Nebraska, USA. *Herpetological Review* 42(4):549-551.

Henszey RJ, Pfeiffer K, and Keough JR. (2004) Linking surface- and ground-water levels to riparian grassland species along the Platte River in central Nebraska, USA. *Wetlands* 24(3):665–687.

Horncastle VJ, Hellgren EC, Mayer PM, Ganguli AC, Engle DM, and Leslie DM, Jr. (2005) Implications of invasion by *Juniperus virginiana* on small mammals in the southern Great Plains. *Journal of Mammalogy* 86(6):1144–1155.

Iverson JB, and Smith GR. (1993) Reproductive ecology of the painted turtle (*Chrysemys picta*) in the Nebraska Sandhills and across its range. *Copeia* 1993(1):1–21.

Johnson WC. (1994) Woodland expansion in the Platte River, Nebraska: Patterns and causes. *Ecological Monographs* 64(1):45–84.

Jones SM, Ballinger RE, and Nietfeldt JW. (1981) Herpetofauna of Mormon Island Preserve, Hall County, Nebraska. *The Prairie Naturalist* 13(2):33–41.

Kim DH, Newton WE, Lingle GR, and Chaves-Ramirez F. (2008) Influence of grazing and available moisture on breed densities of grassland birds in the central Platte River valley, Nebraska. *Wilson Journal of Ornithology* 120(4):820–829.

Knopf FL. (1994) Avian assemblages on altered grasslands. *Studies in Avian Biology* 15:247–257.

Krapu GL, Facey DE, Fritzell EK, and Johnson DH. (1984) Habitat use by migrant sandhill cranes in Nebraska. *Journal of Wildlife Management* 48(2):407–417.

Krupa JJ. (2002) Temporal shift in diet in a population of American bullfrog (*Rana catesbeiana*) in Carlsbad Caverns National Park. *The Southwestern Naturalist* 47(3):461–467.

Lynch JD. 1985 Annotated checklist of the amphibians and reptiles of Nebraska. *Transactions of the Nebraska Academy of Sciences* 13:33–57.

Moyle PB. (1973) Effects of introduced bullfrogs, (*Rana catesbeiana*), on the native frogs of the San Joaquin Valley, California. *Copeia* 1973(1):18–22.

Nagel HG. (1981) Vegetation ecology of Crane Meadows. Report, Nature Conservancy and the Platte River Whooping Crane Critical Habitat Maintenance Trust, Alda, NE. 69 + 11 pp.

Nagel HG, and Kolstad OA. (1987) Comparison of plant species composition of Mormon Island Crane Meadows and Lillian Annette Rowe Sanctuary in central Nebraska. Transactions of the Nebraska Academy of Sciences 15:37–48.

National Research Council (NRC). (2005) *Endangered and threatened species of the Platte River.* (Washington, DC: The National Academies Press)

Packard MJ, Packard GC, and Boardman TJ. (1982) Structure of eggshells and water relations of reptilian eggs. *Herpetologica* 38(1):136–155.

Peyton MM. (1989) Geographic distribution: *Storeria occipitomaculata* (Redbelly Snake). *Herpetological Review* 20(1):13.

Rossman DA, Ford NB, and Seigel RA. (1996) *The garter snake: Evolution and ecology.* (Norman, OK: University of Oklahoma Press)

Schneider R, Humpert M, Stoner K, and Steinauer G. (2005) *The Nebraska natural legacy project: a comprehensive wildlife conservation strategy.* (Lincoln, NE: The Nebraska Game and Parks Commission)

Schneider R, Stoner K, Steinauer G, Panella M, and Humpert M. (2011) *The Nebraska natural legacy project: state wildlife action plan. 2nd ed.* (Lincoln, NE: The Nebraska Game and Parks Commission)

Sharpe RS, Silcock WR, and Jorgensen JG. (2001) *Birds of Nebraska: Their distribution and temporal occurrence.* (Lincoln, NE: University of Nebraska Press)

Sidle JG, Miller ED, and Currier PJ. (1989) Changing habitats in the Platte River Valley of Nebraska. *The Prairie Naturalist* 21(2):91–104.

Smith HM. (1963) The identity of the Black Hills population of *Storeria occipitomaculata*, the red-bellied snake. *Herpetologica* 19(1):17–21.

Somma LA. (1987) Reproduction of the prairie skink, *Eumeces septentrionalis*, in Nebraska. *Great Basin Naturalist* 47(3):373–374.

Somma LA. (1989) Influence of substrate water content on neonate size in the prairie skink, *Eumeces septentrionalis*. *Great Basin Naturalist* 49(2):198–200.

Somma LA, and Fawcett JD. (1989) Brooding behavior of the prairie skink, *Eumeces septentrionalis*, and its relationship to the hydric environment of the nest. *Zoological Journal of the Linnean Society* 95(3):245–256.

Tacha TC, Vohs PA, and Iverson GC. (1984) Migration routes of sandhill cranes from mid-continental North America. *Journal of Wildlife Management* 48(3):1028–1033.

Timken RL, and Dunlap DG. (1965) Ecological distribution of two species of *Bufo* in southeastern South Dakota. *Proceedings of the South Dakota Academy of Sciences* 44:113–117.

Tockner K, Schiemer F, Baumgartner C, Kum G, Weigand E, Zweimuller I, and Ward JV. (1999) The Danube restoration project: Species diversity patterns across connectivity gradients in the floodplain system. *Regulated Rivers: Research and Management* 15(1-3):245–258.

Tockner K, Klaus I, Baumgartner C, and Ward JV. (2006) Amphibian diversity and nestedness in a dynamic floodplain river (Tagliamento, NE-Italy). *Hydrobiologia* 565(1):121–133.

Triplehorn CA. (1948) *Storeria occipitomaculata* in northwestern Ohio. *Copeia* 1948(2):133.

United States Fish and Wildlife Service (USFWS). (1978) Determination of critical habitat for the whooping crane. *Federal Register* 43(94):20938–20942.

Wilgers DJ, and Horne EA. (2006) Effects of different burn regimes on tallgrass prairie herpetofaunal species diversity and community composition in the Flint Hills, Kansas. *Journal of Herpetology* 40(1):73–84.

Williams GP. (1978) The case of the shrinking channels: The North Platte and Platte rivers in Nebraska. *Circulars of the United States Geological Survey* 781. 48 pp.

Winne CT, Willson JD, and Andrews KM. (2006) Efficacy of marking snakes with disposable medical cautery units. *Herpetological Review* 37(1):52–54.