 

Response of Herpetofauna to Grazing and Fire in Wet, Tallgrass Prairies along the Platte River

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Executive Summary

Wet, tallgrass prairies and sedge, wet meadows historically dominated the floodplain of the Platte River in central Nebraska and provided a mosaic of aquatic and terrestrial habitats utilized by wildlife, including the endangered whooping crane (*Grus americana*). Wet meadow habitats declined in the last century, and remnant prairies are managed by grazing and prescribed burning to mimic historical disturbances. No studies have examined amphibians and reptiles (collectively named herpetofauna) along the Platte River in Nebraska to document their responses to land management. We examined responses of herpetofauna to fire, grazing, and habitat position (sloughs and uplands) in wet, tallgrass prairies and sedge, wet meadows along the Platte River. We also documented natural history observations of herpetofauna and related them to a survey conducted at the same location 30 years ago. Finally, we examined prevalence of chytrid fungus in amphibians along the Platte River.

To meet these objectives, we installed 64 monitoring arrays on Mormon and Shoemaker islands, in Hall County, Nebraska, on lands managed by the Crane Trust. Arrays consisted of drift fences, cover boards, buckets, and funnel traps placed in uplands, lowlands, burned pastures, burned and grazed pastures, and rested pastures. We monitored arrays April-September 2010 for 6-11 days per month. We also conducted targeted searches and recorded incidental observations of herpetofauna in 2009 and 2010. To document chytrid fugus, we swabbed anurans, targeting American bullfrogs (*Lithobates catesbeianus*) from Shoemaker Island, and analyzed samples for *Batrachochytrium dendrobatidis* using real-time (Taqman) PCR to amplify the ITS1 region.

We observed 15 species of herpetofauna, including 4 species of amphibians and 11 species of reptiles. We captured over 1,600 individuals, most of which were unique captures. The most frequent captures were prairie skinks (*Plestiodon septentrionalis*), common garter snakes (*Thamnophis sirtalis*), plains garter snakes (*T. radix*), and plains leopard frogs (*Lithobates blairi*). Species not previously documented on the preserve included the American bullfrog (*Lithobates catesbeianus*), eastern racer (*Coluber constrictor*), smooth green snake (*Liochlorophis vernalis*), redbelly snake (*Storeria occipitomaculata*), and lined snake (*Tropidoclonion lineatum*). The smooth green snake represented a county record, and observations of redbelly snakes represented the easternmost records for a disjunct population occurring in central Nebraska. We did not detect an effect of grazing on herpetofaunal abundance. Burned pastures, however, had more captures and greater species richness compared to pastures that were not burned. We detected high prevalence of chytrid infection in American bullfrogs (41% of captured individuals), but did not detect chytrid in Woodhouse's toads (*Anaxyrus woodhousii*) or plains leopard frogs (*Lithobates blairi*).

Collectively, our results demonstrate that herpetofauna thrive in sedge, wet meadows and wet, tallgrass prairies associated with large islands on the Platte River in the presence of moderate grazing and fire. The abundance of amphibians and reptiles makes them a likely prey base and predatory influence in this ecosystem, and their roles as such need to be considered in future research and conservation activities. Additionally, spread of chytrid fungus from American bullfrogs to native anurans must be monitored, especially for leopard frogs and chorus frogs, whose activity levels and densities are high during whooping crane stopovers along the Platte River.

Chapter 1

Response of Herpetofauna to Grazing and Fire in Wet, Tallgrass Prairies along the Platte River

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Abstract

Wet, tallgrass prairies and sedge, wet meadows historically were common along the floodplain of the Platte River in central Nebraska and provided a mosaic of aquatic and terrestrial habitats utilized by wildlife, including the federally endangered whooping crane (*Grus americana*). Wet meadow habitats declined in the last century, and remnant prairies are actively managed by grazing and prescribed burning to mimic historical disturbances. No studies have examined amphibians and reptiles along the Platte River in Nebraska to document their responses to land management. We examined responses of herpetofauna to burning, grazing, and resting pastures in wet, tallgrass prairies and sedge, wet meadows along the Platte River. We also compared abundances of herpetofauna between low-lying areas (sloughs) and nearby uplands. We captured > 1600 individuals of 13 species from spring to autumn 2010 on Mormon and Shoemaker islands. We did not detect an effect of grazing on herpetofaunal abundances. Pastures rested from burning, however, had reduced abundances and species diversity compared to burned pastures. We also found species-specific responses to burning/resting and to habitat position. Collectively, our results contribute fundamental information about the effects of two commonly used land management tools on a potential prey base for the endangered whooping crane in the unique wet meadow habitats of the Platte River.

Keywords: Amphibians, reptiles, herpetofauna, Platte River, rangeland management, tallgrass prairie, slough, floodplain

Introduction

Floodplains associated with large rivers are among the most endangered ecosystems globally (Tockner and Stanford 2002). Naturally functioning floodplains have a mosaic of aquatic and terrestrial habitats that maintain a variety of microsites for organisms and contribute to the high biological diversity and productivity of river ecosystems (Naiman et al. 1993, Naiman and Décamps 1997, Ward et al. 1999, Stanford et al. 2005). Organisms with biphasic life cycles, such as amphibians and many species of insects, rely on aquatic and terrestrial habitats and their ecotones. Landscape alterations negatively affect riparian organisms, especially when changes reduce inundation of off-channel aquatic habitats and/or reduce habitat complexity (Nilsson and Berggren 2000).

Amphibians and reptiles are a major component of tropic networks in wetland and riparian systems (e.g., Stebbins and Cohen 1995), and many species of herpetofauna require ephemeral aquatic habitats or are sensitive to moisture gradients during different stages of their life cycles. Herpetofauna are both a prey base (e.g., egg masses and tadpoles of frogs) and predators (e.g., nest predation by snakes) in ecosystems. Amphibians require ponds and other aquatic habitats for breeding; the biogeochemical environment of these habitats affects their developmental rates and predatory pressures (Werner 1986, Newman 1992). Soil moisture influences growth rates and hatching success of lizards, snakes, and often turtles, with eggs having greater hatching success and larger hatchlings when exposed to optimal hydric conditions (Packard et al. 1982). This occurs because reptilian eggs have flexible shells that absorb water, unlike the eggs of birds (Cunningham and Hurwitz 1936). The diversity of habitats on floodplains supports high amphibian species richness and abundance (Tockner et al. 2006, Indermaur et al. 2009), especially where elevated groundwater maintains off-channel habitat (Bateman et al. 2008). Unfortunately, amphibians, like freely flowing rivers, are in decline globally (Collins and Crump 2009), in part due to sensitivity to changing environmental conditions. Alterations to floodplains that affect herpetofaunal diversity and abundance (e.g., Bateman et al. 2008, 2009) likely have cascading effects on aquatic and terrestrial food webs along rivers.

Prairie rivers in central North America were historically shaped by large-scale disturbances, including floods, droughts, wildfires and grazing by bison (Matthews 1988, Johnson 1994, Dodds et al. 2004). Today, most prairie rivers have entirely regulated, over-appropriated flows with little remnant of a natural flow regime, and they are embedded in a landscape converted from prairie to row-crop agriculture. Surrounding grasslands, where they remain, are managed with prescribed burning and grazing by cattle or bison to restore some of the historical disturbance regimes (Fuhlendorf et al. 2008, Helzer 2010). Studies have examined the effects of burning and grazing in prairies on a range of organisms, but few have included herpetofauna in tallgrass prairies (Cavitt 2000, Setser and Cavitt 2003, Wilgers and Horne 2006, Wilgers et al. 2006, Wilgers and Horne 2007). In some regions, such as along the Platte River in central Nebraska, prairies extend to river banks, and burning and grazing regimes are applied at the floodplain scale.

The Platte River is one of the most regulated rivers in the world, with storage reservoirs, diversion dams, and groundwater wells installed widely in the twentieth century to support irrigated agriculture, urban water supplies, and hydropower (Natural Research Council 2005). It also is a locus for conservation and large-scale ecosystem restoration, largely due to the habitat that the river provides for endangered and threatened species (Freeman 2008, Smith 2011). The Platte River originates in Wyoming and Colorado and extends through Nebraska to its confluence with the Missouri River. The Big Bend Reach of the Platte River from Lexington to Chapman, Nebraska, is a key stopover location for over three hundred species of migratory birds that traverse the Central Flyway of North America, including the federally endangered whooping crane (*Grus americana*) (Natural Research Council 2005). The whooping crane is the rarest of the world's fifteen species of cranes (Natural Research Council 2005, Freeman 2008), and the size of the largest, natural migratory flock is less than 300 individuals (Chavez-Ramirez and Wehtje *in press*), having rebounded from 15 in 1941 (Allen 1952). During migration, whooping cranes use wet meadow habitats (Allen 1952), but these meadows have been reduced or eliminated from much of the Platte River in the last century (Eschner et al. 1983, Sidle et al. 1989).

Management activities in the central Platte River focus on maintaining habitat for whooping cranes and other endangered and threatened species (Smith 2011), but it is not well understood how whooping cranes use the Platte's floodplain for foraging. The diet of whooping cranes is largely unknown during migratory stopovers (Allen 1952, Austin and Richert 2001). The whooping crane is omnivorous, and relative to the much more abundant sandhill crane (*G. canadensis*), the whooping crane is "more aquatic in its habits" and "seems to have a far greater preference for animal foods" (Allen 1952). However, few observations have identified actual food items eaten by whooping cranes during migration, and most information about diet is indirect, focusing on habitat surveys after whooping cranes have left the site. Evidence suggests, however, that herpetofauna were an important prey base for the whooping crane. Allen (1952) cites personal communication with a land owner: "In old buffalo wallows on the prairies of Nebraska and elsewhere they [whooping cranes] fed on the egg masses of frogs and toads." Allen (1952) also cites an unpublished manuscript that stated, "…it would seem that crustacea, fishes, amphibians and reptiles in the shallows of the Platte River constitute the bulk of its food in that area." More recently, of 50 direct observations of food consumption by whooping cranes, one was a frog, and four were snakes or other (Austin and Richert 2011). Whooping cranes also have been observed eating snakes and lizards on the wintering grounds in Texas (Allen 1952, Chavez-Ramirez et al. 1996).

Purpose and Objectives

The goal of our study was to evaluate effects of land management activities on herpetofauna inhabiting large floodplain islands along the Platte River that are conserved for whooping cranes and other migratory birds. Specifically, we evaluated how cattle grazing and prescribed burning affected the abundance of herpetofauna. We also investigated responses of herpetofauna to variation in local topography and compared abundances between linear, wetland depressions (sloughs) and adjacent higher-elevation surfaces (uplands). The research was conducted in wet, tallgrass prairies and sedge wet meadows—two types of habitats that are rare and a priority for conservation in Nebraska (Schneider et al. 2005). Collectively, our results contribute fundamental information about the effects of two commonly used land management tools on a potential prey base for the endangered whooping crane in wet meadow habitats of the Platte River.

Study Site

This study was conducted on lands owned and managed by the Platte River Whooping Crane Critical Habitat Maintenance Trust, Inc. (hereafter: The Crane Trust) on Shoemaker and Mormon islands, Hall County, Nebraska (40°47.660′N, 98°26.722′W; Fig. 1), ~15 km southwest of Grand Island. Here the Platte River flows eastward, and its relatively flat floodplain is traversed by numerous linear depressions (sloughs) that create a ridge/swale structure on the landscape (Henszey et al. 2004). Sloughs remain inundated for various time periods depending on precipitation, water table elevations, and river flow (Henszey et al. 2004, Whiles and Goldowitz 2001, 2005). As a result, the floodplain is comprised of a mosaic of mid- and tallgrass prairie plant communities structured largely by the availability of soil moisture (Henszey et al. 2004, Meyer et al. 2010). Water table elevations are typically within 1-3 m of the ground surface (Wesche et al. 1994; Henszey et al. 2004); where lowland depressions occur, such as in sloughs, sites may be inundated for much of the year (Harner and Whited 2011).

The land was managed with rotational burning, cattle grazing, and resting to promote habitat heterogeneity and productive grasslands (Kim et al. 2008, Helzer 2010). We studied pastures under three different management regimes (Fig. 1; Table 1): (1) burned and not grazed, (2) burned and grazed, and (3) rested (not burned or grazed). The burned pastures were burned in March 2010 preceding the study. Domesticated cattle (*Bos taurus*) were introduced to burned and grazed pastures in May or June 2010, removed mid-summer, and returned to pastures late-summer (Table 1). Rested pastures were burned in spring 2007, grazed in 2007 and 2008, and then rested from burning and grazing in 2009 and 2010.

Table 1. Type of land management, location, area, and stocking rate of cattle in pastures where herpetofauna were monitored on Shoemaker and Mormon islands.

		Location[1]				
Pasture	**Management**	**Easting**	**Northing**	**Area (ha)**	**Stocking rate[2]**	**Months grazed[3]**
Big Slough	Burned	546949	4516450	29	0	0
Field 2 East	Burned & grazed	549423	4517330	93	2	3.5
Field 2 West	Burned	547979	4516890	9	0	0
HQ	Burned & grazed	545118	4515010	19	5	1.5
Marsh	Burned	544773	4514910	10	0	0
Middle	Burned & grazed	546529	4516120	33	2	3.5
Mormon SW	Rested	548416	4515800	125	0	0
Mormon W	Rested	546984	4515700	91	0	0

[1]Pasture center; NAD 83 Zone 14N
[2]Cow/calf pairs per ha
[3]Months grazed: Field 2 East and Middle: May-June, September-October 15, 2010; HQ: June 8-24 and September 10-24, 2010

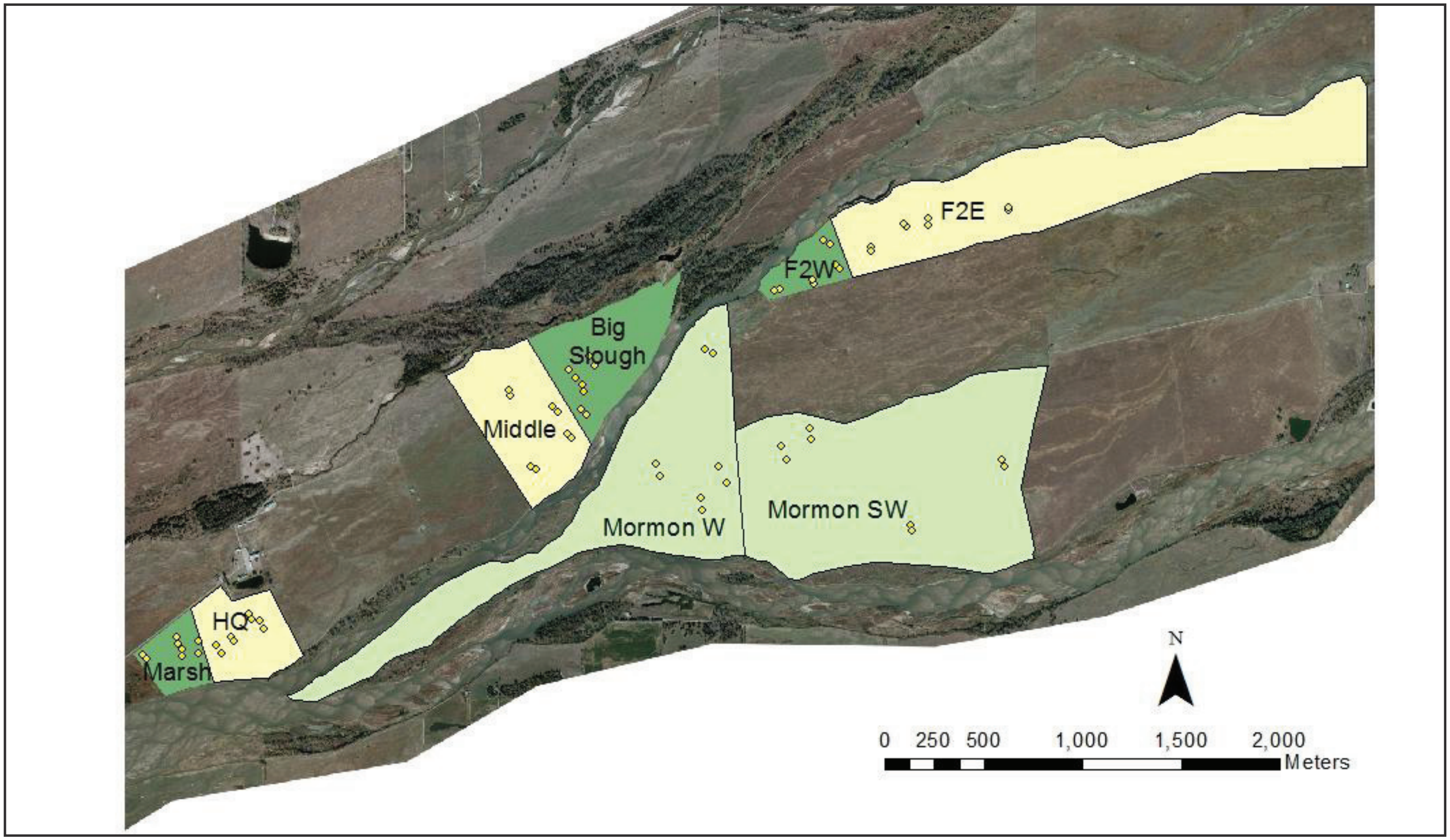

Figure 1. Location of pastures and herp arrays on Mormon and Shoemaker islands along the Platte River in central Nebraska, USA. Dark green pastures were burned and not grazed, light green pastures were rested (not grazed for 2 seasons), and yellow pastures were burned and then grazed in 2010. Yellow diamonds indicate locations of herp arrays, with neighboring arrays in uplands and sloughs. Base image from October 2010.

Methods

Monitoring of Herpetofauna

We installed 64 monitoring arrays on Mormon and Shoemaker islands. Arrays consisted of a linear 10-m drift fence constructed of wooden stakes and silt fences. We placed a 0.6 x 0.6 m plywood cover board (9.5 mm thick) along each fence, two pitfall traps consisting of black 5-gallon buckets sunk into the ground to ground level (one placed along the drift fence and the other located at an end of the drift fence), and one funnel trap at the other end of the drift fence (Fig. 2).

Arrays were paired between slough and upland sites (Fig. 3), and four pairs of arrays were placed in each pasture (Fig. 1). Arrays located in grazed pastures were protected from cattle with an electric fence (Fig. 3), and enclosed areas were mowed as needed. We determined sex, measured body mass and length, and marked individuals by cauterizing for most individuals captured (see Geluso and Harner, Chapter 2). We monitored arrays May-September 2010 for 6-11 days per month. Voucher specimens were archived at the Sternberg Museum, Fort Hays State University, Kansas. Common and scientific names follow Fogell (2010).

Figure 2. Traps for catching herpetofauna: pitfall traps (left), coverboards (center), and funnel traps (right).

Figure 3. Examples of herp arrays in a slough (left panel) and grazed upland (right panel).

Measurement of Habitat Variables

Plant height and biomass were measured at each array on 16 July 2010. Random point locations were selected in which average plant height was recorded and vegetation clipped in a 1/8 m^2 area. Vegetation was dried at 60 ºC and weighed. With aerial imagery from October 2010, we measured distances of the following landscape features to the center of each array: nearest river bank, inundated off-channel habitat (slough or pond), forest patch, and road. We also used LiDAR imagery to calculate the average elevation of the ground surface and the average NDVI value (an index of vegetation productivity) near the areas. *Note*: *Analyses of landscape features are not presented in this report*.

Statistical Analyses

To test for effects of grazing and hydrology, we limited our inference to the three pasture pairs that were burned in spring 2010 and compared burned pastures that were either grazed or not grazed (Fig. 1). For the most frequently captured species, we then examined species-specific responses to grazing and habitat position within this same subset of six pastures. Finally, to test for effects of burning, we compared burned pastures, whether they were grazed or ungrazed, to rested pastures (Fig. 1).

We applied negative binomial regression modeling (Hilbe 2008) to analyze counts of herpetofauna (glm.na analysis within MASS package in R; R Development Core Team (2008)). We selected the negative binomial model because data were over dispersed (variances greater than means), so the classically used Poisson regression model overestimated the significance of statistical results. We tested for over dispersion with a likelihood ratio test for the nested Poisson and negative binomial models. The data for captures of the lined snake (*Tropidoclonion lineatum*) were not over dispersed, so a Poisson regression was used for this species.

We applied a quantitative method of model section, the Akaike information criterion (AIC), to measure the relative goodness of fit of the statistical models. For assessing the effects of grazing, burning, and hydrology, we created a set of candidate models that included pasture, treatment (burned and grazed, burned and not grazed, and rested), and habitat (slough and upland). We ran these models for all captures combined, and then for the most frequently captured species. Plant biomass was log-transformed. We ranked the candidate models according to their AIC values using stepAIC in R and selected the best models.

We reported the significance of the models, as well as the explained deviance (how much variation in the dependent variable is explained by the model). The explained deviance was calculated as 100 x (null deviance –residual deviance)/null deviance (Zuur et al. 2011).

Results

Overall captures: We captured 1611 amphibians and reptiles in arrays, representing 13 species (Table 2). The most common captures were prairie skinks (*Plestiodon septentrionalis*; 26%), common garter snakes (*Thamnophis sirtalis*; 26%), plains garter snakes (*T. radix*; 22%), and plains leopard frogs (*Lithobates blairi*; 16%). We also captured five species not previously documented at the site: American bullfrog (*Lithobates catesbeianus*), eastern racer (*Coluber constrictor*), smooth green snake (*Liochlorophis vernalis*), redbelly snake (*Storeria occipitomaculata*), and lined snake (*Tropidoclonion lineatum*). Lined snakes were the fifth most abundant capture (Table 2). Approximately 100 individuals were known recaptures; of the recaptures, about three quarters were prairie skinks. Pastures had 9-11 species, and total captures ranged from 126 to 259 individuals (Table 3). Sloughs had 47% and uplands 53% of the total captures (Table 4).

Table 2. Total numbers of individuals captured in herp arrays at the Crane Trust May-September 2010. Note, individuals observed while checking arrays are not included in this table, thus numbers differ from Geluso and Harner (2011, Chapter 2 of this report).

Common name	**Scientific name**	**Count**
Prairie skink	*Plestiodon septentrionalis*	416
Common garter snake	*Thamnophis sirtalis*	414
Plains garter snake	*Thamnophis radix*	361
Plains leopard frog	*Lithobates blairi*	257
Lined snake	*Tropidoclonion lineatum*	71
Chorus frog	*Pseudacris maculata*	48
Woodhouse's toad	*Anaxyrus woodhousii*	31
Redbelly snake	*Storeria occipitomaculata*	5
Smooth green snake	*Opheodrys vernalis*	1
Six-lined racerunner	*Aspidosclis sexlineatus*	2
Eastern racer	*Colubra constrictor*	2
American bullfrog	*Lithobates catesbeianus*	2
Snapping turtle	*Chelydra serpentina*	1
Total		*1611*

Table 3. Numbers of individuals captured in pastures at the Crane Trust May-September 2010.

		Burned & Ungrazed Pastures			Burned & Grazed Pastures			Rested Pastures	
Common name	**Scientific name**	**Big Slough**	**Marsh**	**Field 2 W**	**Middle**	**HQ**	**Field 2 E**	**Mormon W**	**Mormon SW**
Prairie skink	*Plestiodon septentrionalis*	50	43	49	89	35	71	30	49
Common garter snake	*Thamnophis sirtalis*	70	74	45	70	65	32	38	20
Plains garter snake	*Thamnophis radix*	45	58	32	41	49	41	58	37
Plains leopard frog	*Lithobates blairi*	46	62	32	24	42	33	16	2
Lined snake	*Tropidoclonion lineatum*	19	3	7	8	3	5	16	10
Chorus frog	*Pseudacris maculata*		7	19		6	2	9	5
Woodhouse's toad	*Anaxyrus woodhousii*		10	1	6	4	5	2	3
Redbelly snake	*Storeria occipitomaculata*	3	1		1	0			
Smooth green snake	*Opheodrys vernalis*				1				
Six-lined racerunner	*Aspidosclis sexlineatus*			1	1				
Eastern racer	*Colubra constrictor*		1			1			
American bullfrog	*Lithobates catesbeianus*	1		1					
Snapping turtle	*Chelydra serpentina*	1							
Total		*235*	*259*	*187*	*241*	*205*	*189*	*169*	*126*

Table 4. Total numbers of individuals captured in sloughs and uplands.

Common name	Scientific name	Position Slough	Upland
Prairie skink	*Plestiodon septentrionalis*	165	251
Common garter snake	*Thamnophis sirtalis*	219	195
Plains garter snake	*Thamnophis radix*	170	191
Plains leopard frog	*Lithobates blairi*	155	102
Lined snake	*Tropidoclonion lineatum*	17	54
Chorus frog	*Pseudacris maculata*	16	32
Woodhouse's toad	*Anaxyrus woodhousii*	15	16
Redbelly snake	*Storeria occipitomaculata*	3	2
Smooth green snake	*Opheodrys vernalis*	0	1
Six-lined racerunner	*Aspidosclis sexlineatus*	1	1
Eastern racer	*Colubra constrictor*	1	1
American bullfrog	*Lithobates catesbeianus*	2	0
Snapping turtle	*Chelydra serpentina*	1	0
Total		*765*	*846*

Effect of grazing on burned pastures: Grazing altered habitat structure by changing height and biomass of vegetation on the pastures that were burned (Fig. 4). Plant biomass was 634 ± 60 g/m^2 (mean ± standard error) on ungrazed and 221 ± 39 g/m^2 on grazed pastures ($P < 0.001$); plant height was 80 ± 4.2 cm on ungrazed and 28 ± 4.5 cm on grazed pastures ($P < 0.001$). Sloughs also had higher plant height and biomass than uplands ($P < 0.001$). Total captures of herpetofauna, however, were indistinguishable between grazed and ungrazed pastures ($P = 0.773$) and between sloughs and uplands ($P = 0.582$), despite the strong effects of grazing and habitat position on vegetation structure.

Figure 4. Fence line separating pastures that were grazed (left; Middle Pasture) and ungrazed (right; Big Slough Pasture). Photo taken 26 August 2010.

The five most frequently captured species responded differently to habitat position (sloughs and uplands; Table 4), and none showed a response to grazing. Habitat position explained some of the variation in captures of plains leopard frogs (25%; $P = 0.006$), with more captured in sloughs. Habitat position also was important for prairie skinks (18%; $P = 0.049$) and lined snakes (47%; $P < 0.001$), both of which were more abundant in uplands. Habitat position did not explain significant variation in captures of garter snakes ($P = 0.239$ for common garter snakes and $P = 0.282$ for plains garter snakes).

Effect of resting pastures from burning: Rested pastures had the lowest captures of herpetofauna, and none of the rare species were captured in rested pastures (Table 3). Whether a pasture was rested or burned explained 14% of the variation in captures of common garter snakes ($P = 0.001$) and 29% of the captures of plains leopard frogs ($P < 0.001$); with fewer individuals captured in rested pastures (Table 3). Lined snakes, in contrast, were more abundant in rested pastures ($P = 0.038$). As before, habitat position was important for prairie skinks ($P = 0.016$) and lined snakes ($P = 0.001$), with more captures in uplands.

Discussion

Our study represents the most comprehensive study of the response of herpetofauna to land management conducted in a tallgrass prairie (e.g., Wilgers and Horne 2006, Wilgers et al. 2006), and it contributes fundamental information about herpetofauna in the state of Nebraska (Ballinger et al. 2010). Documentation of these vertebrates and their responses to grazing and burning provides important baseline information for habitat types that are rare in Nebraska (Schneider et al. 2005) and beyond. Tallgrass prairies have declined to less than 5% of their distribution prior to European settlement of the North American Great Plains (Samson and Knopf 1994) and are a focus of widespread land management and restoration efforts. Only a few studies have focused on the response of herpetofauna to land management (mostly burning) in tallgrass prairies, and these primarily have been conducted in the Flint Hills of northeastern Kansas (Cavitt 2000, Setser and Cavitt 2003, Wilgers and Horne 2006, Wilgers et al. 2006, Wilgers and Horne 2007). The tallgrass prairie in our study, like in the Flint Hills, was largely protected from plowing because the region was sub-optimal for agriculture—in our case, due to elevated water tables and saturated soils (Nagel et al. 1981) and in the Flint Hills, due to shallow, rocky soils. Both regions provide reference conditions for the herpetofaunal community structure of tallgrass prairies, but these amphibian and reptilian communities may differ in their composition and response to land management, due to differences between the study sites in terms of soil structure and moisture levels, regional climate, and hydrological influences.

Our study was the first to explicitly examine the effects of grazing on herpetofauna in tallgrass prairies. Other studies have examined the effect of fire in tallgrass prairies that were grazed (e.g., Cavitt 2000, Wilgers et al. 2006), but the effect of grazing has not been a focus of those investigations. We tested for the influence of cattle grazing on pastures that were all burned the previous spring, with half of the pastures subsequently grazed. We did not detect an effect of grazing on herpetofaunal abundance, either across species or for individual species, even though grazing pressure was intense enough to significantly reduce plant height and biomass. Studies in other systems have detected negative effects of grazing, either via direct (e.g., trampling) or indirect (e.g., changes in habitat structure or thermal regimes) effects. For example, Jones (1981) found that grazing reduced the abundance and diversity of lizards in Arizona, due to changes in vegetative structure, especially elimination of low-height vegetation. Homyack and Giuliano (2002) excluded cattle from riparian zones in Pennsylvania and found that grazing reduced numbers of northern queen snakes (*Regina septemvittata*) and eastern garter snakes (*Thamnophis sirtalis*), but had no detectable effect across all herpetofaunal species combined. We did not detect such species-specific effects of grazing, and this may be due to the rotational nature of the grazing regime employed at the site, with resting from grazing mid-summer and the presence of nearby, non-grazed sites that may have served as refugia or source populations.

In contrast to grazing, we detected an effect of burning pastures, with rested (i.e. not burned) pastures having a lower total abundance of herpetofauna, as well as reduced species richness. At the species level, common garter snakes and plains leopard frogs were more abundant in the burned pastures, while lined snakes were more common in rested pastures. Others have documented species-specific responses to burning in tallgrass prairies. Setser and Cavitt (2003) captured more eastern racers and common garter snakes in long-term unburned compared to recently burned tallgrass prairies. Cavitt (2000) showed evidence of negative effects of burning on eastern racers (*Coluber constrictor*). Wilgers and Horne (2006) detected species-specific responses of herpetofauna to different burn regimes (1-yr, 4-yr, and long-term unburned), with species responding to changes in vegetation structures and microhabitat. Wilgers and Horne (2007) identified increased predation of artificial snakes by raptors in burned pastures. Our inference regarding the effects of fire was limited, because the rested pastures were next to one another and not well replicated, and half of the burned pastures were subsequently grazed. However, the patterns suggested that resting pastures from fire may have negative consequences for some species and favor others, as has been shown for birds in the region (i.e. Henslow's sparrow; Kim 2005).

A pronounced finding of our study was the positive response of herpetofauna to habitat position. Prairie skinks and lined snakes were more abundant in drier, less vegetated upland habitats, whereas plains leopard frogs were abundant in sloughs. This finding is important because much of the Platte River's floodplain has been leveled to support agriculture, thus removing topographic gradients. Although these natural variations in topography are relatively small (typically < 2 m), they have strong implications for the availability of soil moisture and surface waters that are maintained by the shallow water table in the region (Henszey et al. 2004, Harner and Whited 2011). Furthermore, inundation of sloughs and wet meadows decreased in recent decades on Mormon and Shoemaker Islands (Harner and Whited 2011), indicating that groundwater levels may be declining. Herpetofauna in the region may be tracking some of these broader hydrological trends. In a survey of herpetofauna of Mormon Island by Jones et al. (1981), prairie skinks were the least abundant capture, and they found no lined snakes. In contrast, prairie skinks were our most abundant capture and lined snakes our fifth most abundant. Jones et al. (1981) postulated that the lack of several snake species, including lined snakes, was due to the high water table that precluded hiding and hibernation. Differences in abundances of prairie skinks and lined snakes could simply reflect differences in sampling effort between studies. Alternatively, abundance of these more xeric species today may be indicative of a dryer environment than when Jones et al. (1981) surveyed Mormon Island.

The use of sloughs by plains leopard frogs and the seasonality of frog captures (Geluso and Harner, Chapter 2) have important implications for conservation. Availability of sloughs and wet meadow habitats has decreased in the last century along the Platte River (Williams 1978, Eschner et al. 1983, Sidle et al. 1989), so the physical aquatic habitat available for anurans has declined. If plains leopard frogs used historical sloughs to the extent that they used the sloughs in our system, then there would have been a tremendous biomass of these organisms throughout the Platte River valley. Plains leopard frogs remain active well into autumn (Geluso and Harner, Chapter 2), into the time period where whooping crane stopovers are concentrated along the Platte River in late October and early November, with a peak on 27 October (Austin and Richert 2001). Similarly, chorus frogs are abundant in early spring (Geluso and Harner, Chapter 2) when whooping crane stopovers peak on 12 April (Austin and Richert 2001). From a correlative perspective, frogs may represent an important herpetological prey base for whooping cranes during fall and spring migrations. This is noteworthy because both species of frogs are at risk of decline in the region from spread of the pathogen *Batrachochytrium dendrobatidis* (chytrid fungus). We have measured high rates of infection by chytrid fungus in American bullfrogs in sloughs on Shoemaker Island that are co-inhabited by plains leopard frogs and chorus frogs (Harner et al. *in press;* Chapter 3). Chytrid infections have been recently reported in chorus frogs

(*Pseudacris maculata* and *P. triseriata*) and northern leopard frogs (*Lithobates pipiens*) in Colorado and Wyoming (Young et al. 2007; Muths et al. 2008). Spread of this pathogen from invasive American bullfrogs to native anurans of the Platte River may diminish a potential prey base for whooping cranes during migration.

Collectively, our results demonstrate that herpetofauna thrive in sedge, wet meadows and wet, tallgrass prairies associated with large islands on the Platte River in the presence of moderate grazing and fire. Fires and variation in local topography appear to enhance the abundance and diversity of reptiles and amphibians. The abundance of herpetofauna makes them a likely prey base and predatory influence in this ecosystem, and their roles as such need to be considered in future research and conservation activities. There is a need to conserve and manage habitat for herpetofauna to ensure that they continue to function in the tropic network of the Platte River floodplain. Additionally, spread of chytrid fungus from American bullfrogs to native anurans must be monitored, especially for plains leopard frogs and chorus frogs, whose activity levels and densities are high in autumn and spring, during whooping crane stopover along the Platte River.

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Chapter 2

Reexamination of Herpetofauna on Mormon Island, Hall County, Nebraska, with Notes on their Natural History

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ABSTRACT In 1980, the herpetofauna of Mormon Island, Hall County, Nebraska, was first surveyed, and researchers documented 10 species, including 3 species of amphibians and 7 species of reptiles. During opportunistic surveys and targeted research on herpetofauna mainly in 2009 and 2010, we documented 15 species—4 species of amphibians and 11 species of reptiles on Mormon Island and adjacent Shoemaker Island. Species not previously documented on the preserve included the bullfrog (*Lithobates catesbeianus*), eastern racer (*Coluber constrictor*), smooth green snake (*Liochlorophis vernalis*), redbelly snake (*Storeria occipitomaculata*), and lined snake (*Tropidoclonion lineatum*). The smooth green snake represents a county record, and observations of redbelly snakes represent the easternmost published records for the disjunct population occurring in central Nebraska. Documentation of four additional snake species in the area likely reflect a more intensive trapping regime from the past survey or large-scale changes to habitat on the island that may indicate drier conditions at the site. Occurrence of a reproductive population of bullfrogs on Mormon Island reflects a recent slough restoration in 2006 that created habitats on the island suitable for this exotic and invasive species. We observed differences in life-history characteristics, habitats, and seasonal activity patterns among these 15 species. A diversity of habitats must be maintained by land managers in the central Platte River valley to support these species, especially those that require multiple habitats to successfully reproduce or survive temperate seasonal climatic variation. Proximity of differing habitats also appears requisite because many species are incapable of large-distance movements. Understanding the occurrence and habitat use by herpetofauna in this relatively topographically unaltered reach (i.e., unplowed) of the river will aid wildlife and land managers to better manage and restore parts of this unique and important ecosystem for multiple vertebrate groups in the Big Bend reach of Platte River.

KEY WORDS reptiles, amphibians, Nebraska, Platte River, flood plain, redbelly snake.

INTRODUCTION

Many grasslands during the last century, especially those along rivers in the Great Plains, have been converted to agricultural lands (Sidle et al. 1989) or reduced due to woody encroachment via wildfire suppression 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 exist, especially those that represent mesic, tallgrass prairies in the river's floodplain (Nagel and Kolstad 1987, Schneider et al. 2005). The Platte River valley in central Nebraska is a well-known migratory stopover site for waterfowl (NRC 2005, Schneider et al. 2005) and sandhill cranes (*Grus canadensis*; Krapu et al. 1984, Tacha et al. 1984), and represents designated critical habitat during migration for the endangered whooping crane (*Grus americana*; NRC 2005). Grasslands, including those with elevated water tables (i.e., wet meadows), also support many declining grassland bird species (Askins 1993, Knopf 1994) that breed in the central Platte River valley (Kim et al. 2008), including the only record of nesting Henslow's sparrows in the state (Kim 2005). While most research and conservation efforts in the valley emphasize migratory bird species (i.e., grassland and endangered species) and their habitats, relatively little is known about the use of such habitats by non-migratory vertebrates (NRC 2005). These vertebrates are important components of ecosystem dynamics and function because many are predators or the prey base of migratory birds.

River floodplains, with their proximity of aquatic and terrestrial habitats, provide areas for a diverse array of species to carry out many life-history functions (Gilbert et al. 1994, Bateman et al. 2008). Herpetofauna (reptiles and amphibians) represent a unique group of vertebrates with life-history traits that connect many species 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. Reptiles have flexible eggshells that imbibe water unlike those of birds. For reptilian eggs, the hydric environment influences 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). For example, Somma (1989) demonstrated neonatal prairie skinks were larger at hatching with increased levels of soil moisture. Foraging and overwintering behaviors of reptiles also are tied to aquatic/terrestrial ecotones. For example, many garter snakes are terrestrial but forage on prey species from aquatic habitats, such as fish and frogs (Fogell 2010), and winter survival increases with greater saturation levels of substrates (Costanzo 1986, 1989). Thus, the local hydrology (i.e., ground water and river flow) of floodplains likely plays an important role in the survival and fitness of herpetofauna on developmental and temporal scales as well as influences distributional limits of species.

In 1980, the herpetofauna of Mormon Island, Hall County, Nebraska, originally was surveyed after establishment of a preserve for migratory bird species, especially whooping and sandhill cranes (Jones et al. 1981). Researchers documented 10 species of herpetofauna, including 3 anurans (*Anaxyrus woodhousii*, *Pseudacris maculata*, *Lithobates blairi*), 3 turtles (*Chelydra serpentina*, *Chrysemys picta*, *Apalone spinifera*), 2 lizards (*Plestiodon septentrionalis*, *Aspidoscelis sexlineata*), and 2 snakes (*Thamnophis radix*, *Thamnophis sirtalis*; Jones et al. 1981). The island consisted mainly of unplowed grasslands due to the shallow depth to groundwater (i.e., lands were not conducive to row-crop agricultural practices) but ponds, woodlots, and small agricultural fields also were present. Thirty years later, we resurveyed the original island preserve and an adjacent island for herpetofauna. Large-scale, land management practices have occurred since the last survey, such as forest removal, slough restoration, and reestablishment of prairies from cultivated agricultural fields. Herein we report on current herpetofauna composition of the area, comment on the natural history of species, and discuss the potential influence of large-scale habitat alterations on species occurrences.

STUDY AREA

Our survey was conducted on Mormon and Shoemaker islands in Hall County, Nebraska, along the Platte River south of the cities of Grand Island and Alda. The land is owned and managed by the Platte River Whooping Crane Critical Habitat Maintenance Trust, Inc., Wood River, Nebraska. This preserve was established in 1978 in a court-settlement agreement to protect and maintain the physiological, hydrological, and biological integrity of the region for migratory birds. The original land acquisition was a 858-ha area of western Mormon Island, and since then, other land has been acquired including additional parts of Mormon Island and the adjacent Shoemaker Island. In 1980, most of the land purchased on Mormon Island consisted mainly of unplowed, native prairie, but 67 ha had been plowed for cultivated fields for corn, alfalfa, and soybeans (Nagel 1981). Some of these prairies represent wet meadows with elevated groundwater levels (Henszey et al. 2004). Small woodlands, human-made ponds, and linear, shallow depressions also exist on the landscape. Both islands are surrounded by channels of the Platte River. On Shoemaker Island a perennial stream flows through the property (Harner and Whited 2011). Since 1981, woodlands as well as trees along the edges of islands were cleared to create more habitats for grassland bird species. Agricultural fields on Mormon Island have been restored to tallgrass prairies. In autumn 2006, a backwater slough was excavated on the north side of Mormon Island. The slough is connected on the east, downstream end to a channel of the Platte River.

METHODS

From June 2009 to November 2011, we recorded observations of herpetofauna on Mormon and Shoemaker islands. Most observations were obtained during an intensive herpetological study examining the effects of fire and grazing on these organisms in upland and lowland (i.e., sloughs = shallow, linear wetland representing former river channels) grassland habitats from April to September 2010. Other opportunistic observations were gathered while conducting research on birds, mammals, and invertebrates on the property. We also conducted specific searches for reptiles and amphibians in all major habitats. Those searches included examination for individuals under fallen trees and branches as well as scattered debris (e.g., plywood, corrugated metal sheeting, and tarps) on the preserve. 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 large wire and nylon funnel traps to catch aquatic turtles in a channel of the Platte River for six days.

To examine the effects of fire and grazing on herpetofauna, we constructed 64 arrays (8 arrays in 8 pastures) that each consisted of a linear 10-m drift fence constructed of wooden stakes and silt fences with 32 arrays in uplands and 32 arrays in sloughs (Fig. 1). These were selected because fences that bisected wet depressions (sloughs) still allowed water to flow though the material, thus preserving the integrity of the wetland habitat. Associated with each drift fence was one 0.6 x 0.6 m plywood coverboard (9.5 mm thick) placed along each fence, two pitfall traps consisting of black 5-gallon buckets sunk into the ground to ground level (one placed along the drift fence and the other located at an end of the drift fence), and one funnel trap (round minnow trap, Cabela’s Inc., Sidney, NE) at the other end of the drift fence (Fig. 2). From May to September, pitfall traps and funnel traps were opened and checked for 6-10 days a month. For arrays in grazed pastures, we constructed electric fences around arrays to prevent cattle from disturbing traps (Fig. 3). Inside electric fences, we mowed vegetation to keep plant heights similar to those grazed by cattle. Herein we report general occurrences of species from that study, not the specific effects of treatments on abundance and diversity herpetofauna; see Harner and Geluso (2011—other chapter of this report) for those results.

Fig. 1. Examples of silt fences used in trapping arrays to capture herpetofauna on Mormon and Shoemaker islands, Hall County, Nebraska. The photograph on the left shows an upland array in the foreground and a slough array in the background. The right photograph represents the only slough that had perennial flows during our study.

Fig. 2. Trapping arrays consisted of one 10-m silt fence, two 5-g black buckets, one 0.6 x 0.6 m plywood coverboard, and 1 funnel trap. One bucket was buried flush with the ground level just inside an end wooden stake of the silt fence (left photo) whereas the other was located about one-third in from the other end of the silt. The single funnel trap was located on the other end of the silt fence (right photo) from the end with the bucket. A small screen was placed in front of the funnel trap to guide animals into the opening of the funnel (right photo). The single plywood coverboard was placed alongside the silt fence near the middle.

Fig. 3. Photograph demonstrates the construction of electric fences around trapping arrays to prevent disturbance by cattle. Electric fences were constructed using t-posts, yellow-black polywire, blitzers (Model 12VID-5, Zareba Systems, Ellendale, MN), bailing wire, plastic and porcelain insulators, and car batteries.

For each reptile and amphibian captured during our grazing study, we recorded species, details on size (total length, tail length, snout-vent length, carapace length, and weight via Pesola scales; appropriate to species; Fig. 4), and type of trap (funnel, coverboard, bucket, or observational). For figures of individuals captured per day of effort, we did not exclude recaptured individuals to best present data on activity of herpetofauna in habitats.

Fig. 4. For each individual, we recorded information such as species, total length (upper left photo measuring total length of lined snake), snout-vent length (upper right photo measuring northern prairie skink and bottom left photo measuring Woodhouse's toad), tail length (upper right photo also measuring tail length of northern prairie skink), and mass (bottom right photograph).

If individuals were large enough, we marked each individual with unique number with a battery-operated, hand-held cauterizing unit (Change A Tip: Hi-Lo Temperature Cautery Kit, Bovie Medical, Clearwater, FL; Fig. 5). If possible, we recorded sexes of species based on external morphological characteristics or cloacal probing for the presence or absence of a hemi-penis (Fig. 6). Voucher specimens were collected, especially those representing new species for the study area or county. For some vouchers, we also preserved tissues for future genetic studies. All specimens and respective tissues were deposited at the Sternberg Museum, 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.

Fig. 5. Marking herpetofauna with a portable, hand-held, battery-operated cauterizing unit. Left photograph we are marking a lined snake by marking ventral scales to individually recognize individuals. Right photograph represents a northern prairie skink with the unique number of 142.


Fig. 6. Probing lined snake to determine sex.

Common and scientific names used herein as well as the order presented below for species accounts follow Fogell (2010). Photographs are by K. Geluso, M. Harner, M. Morten, and A. Bridger and were taken at the study area unless specified.

RESULTS

From 12 June 2009 to November 2011, we observed 15 species of herpetofauna on Mormon and Shoemaker islands, including 4 anurans, 3 turtles, 2 lizards, and 6 snakes. Species not documented in the prior survey included the bullfrog (*Lithobates catesbeianus*), eastern racer (*Coluber constrictor*), smooth green snake (*Liochlorophis vernalis*), redbelly snake (*Storeria occipitomaculata*), and lined snake (*Tropidoclonion lineatum*; Table 1). We captured over a total of 1,660 individuals in funnel traps, in buckets, and under coverboards (Fig. 7), which far exceeded our initial expectations of abundance of herpetofauna in the area. In general, the recapture of individuals was low, thus the effective population for the abundant species must be relatively high in the area.

Table 1. Numbers of amphibians and reptiles observed or captured in trapping arrays and opportunistically while checking arrays associated with a study on the effects of burning and grazing on herpetofauna. All trapping arrays were situated in grassland habitats. Although we marked many individuals, totals below represent captures and not unique individuals. Note, we had relatively few recaptures of individuals across species. Abundance reflects captures in arrays in grassland habitats.

Species			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
Painted turtle	*Chrysemys picta*	1	Rare
Spiny softshell[a]	*Apalone spinifera*	0	
TOTAL		1664	

[a]Species captured in turtle trap in Platte River not associated with trapping arrays.

Fig. 7. Captures of garter snakes (*Thamnophis radix* and *T. sirtalis*) in a funnel trap (left photograph). Capture of a plains garter snake (*T. radix*) in a 5-gallon bucket (right photograph).

In trapping arrays, we did not observe a single distinct peak of seasonal activity with captures of all species (Fig. 8); however, individual species tended to have a unimodal or bimodal peak in activity (see Accounts of Species). While removing buckets at the end of our project in mid November 2010, we observed some species (*Thamnophis sirtalis*, *Thamnophis radix*, *Pseudacris maculata*) under buckets, many submerged in ground water.

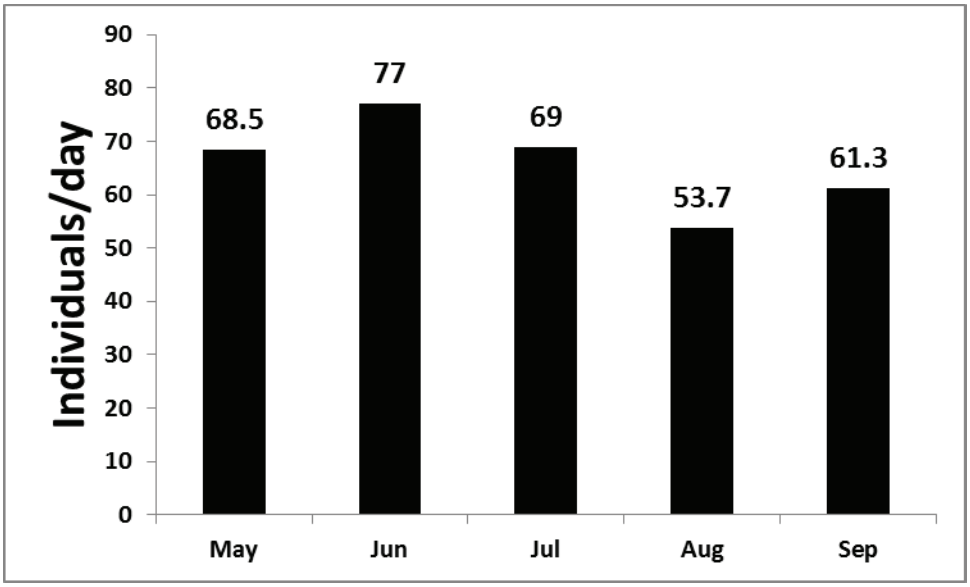

Fig. 8. Number of individuals captured per day of effort each month collectively for all species captured in trapping array in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

ACCOUNTS OF SPECIES

<u>Woodhouse's Toad (*Anaxyrus woodhousii*)</u>

Woodhouse's toad is common throughout Nebraska in a variety of 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 commonly along sandy banks of the Platte River. We observed Woodhouse's toads throughout Mormon and Shoemaker islands. We observed individuals in all grassland pastures including burned and grazed (*n* = 23), burned and not grazed (*n* = 11), and not burned and not grazed (*n* = 5). We also frequently discovered toads in open, sandy habitats along the south side of Mormon Island, and on summer nights, individuals foraged under outside lights around the Headquarters buildings. After rains, individuals commonly were observed on gravel and paved roads at night. Tadpoles of *A. woodhousii* were present in an isolated pool in the active river channel during a low-flow period in 2009. Lynch (1985) reports on similar observations of toads breeding in pools of water along rivers as waters recede following spring flooding in Nebraska.

We frequently heard individuals calling during spring and summer from small pools of water in grasslands. The first individual heard calling was on 15 April from a small, shallow pool also occupied by chorus frogs. Previously, Jones et al. (1981) first reported individuals on Mormon Island around the first of May. We documented individuals every month from April until September with the most captures in July (Fig. 9). Our last capture date was 9 September. In July, all individuals captured consisted of toadlets ≤3.5 cm 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 2 cm. The largest adult captured had a snout-vent length of 9 cm and mass of 75 g.

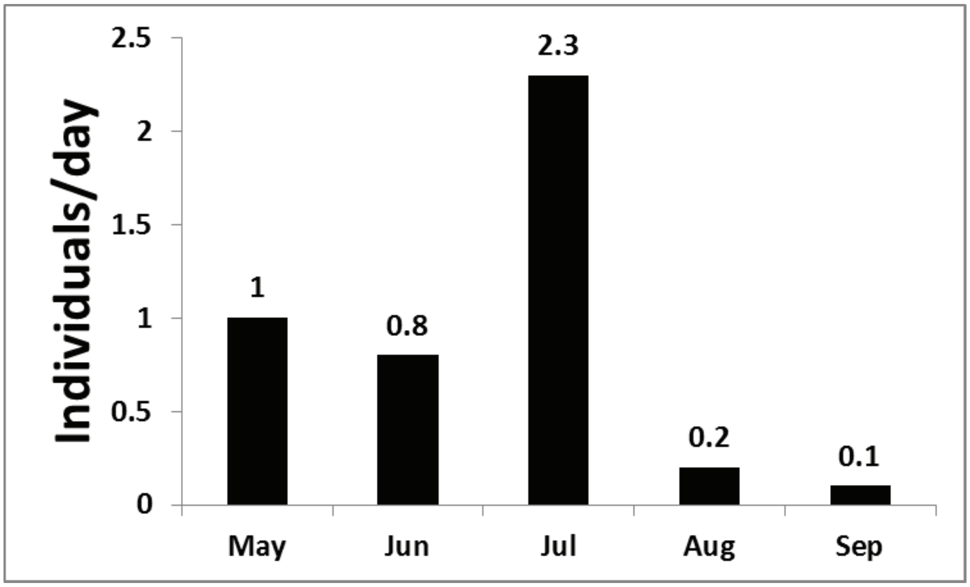

Fig. 9. Number of Woodhouse's toads (*Anaxyrus woodhousii*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

Fig. 10. Woodhouse's toad (*Anaxyrus woodhousii*) from Mormon Island, Hall County, Nebraska.

<u>Boreal Chorus Frog (*Pseudacris maculata*)</u>

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). On Mormon Island, Jones et al. (1981) reported chorus frogs most abundant on the west peninsula of the island. We documented individual on western parts of Mormon Island as well as throughout the remainder of the island in grassland and wetland habitats. On Shoemaker

Island, individuals were present but not as widespread as on Mormon Island. Individuals were most abundant in shallow or intermittent bodies of water, such as sloughs, marshes, or other wetland depressions, but occasionally individuals were calling or captured in grasslands away from water. We did not observe individuals occurring in perennial waters on the property, such as large perennial ponds and streams with continually flowing water. Such an absence might reflect the presence of predatory fish (Ballinger et al. 2010) and abundance of exotic bullfrogs that are predatory on many types of organisms (e.g., Krupa 2002), including native populations of frogs (Moyle 1973, Bury and Luckenbach 1976, Fisher and Shaffer 1996).

On 18 March 2010, we heard the first individuals calling, and *P. maculata* could be heard calling on most warm nights throughout spring. After heavy rains in June 2009, chorus frogs also were abundant and calling across Mormon Island in pastures and around the Headquarters area on Shoemaker Island not associated with wetland habitats. After breeding, chorus frogs are known to disperse from aquatic habitats to drier habitats (Ballinger et al. 2010), likely reflecting many of our captures 25-50 m away from aquatic slough habitats. Our latest individual heard calling was on 8 November 2010. Individuals were documented every month from March to November, except in October when we were not at the study site. The month with the greatest number of captures per trapping array effort was July. While removing buckets in November, many individuals were observed under and on the outsides of buckets in both slough and upland habitats in holes saturated with ground water.

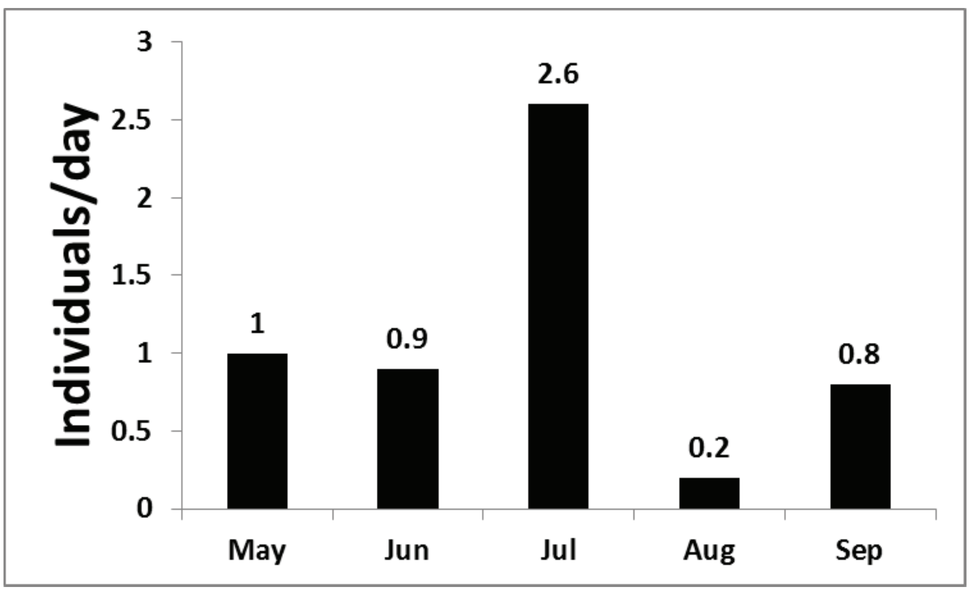

Fig. 11. Number of boreal chorus frogs (*Pseudacris maculata*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

Fig. 12. Boreal chorus frog (*Pseudacris maculata*) from Shoemaker Island, Hall County, Nebraska.

Plains Leopard Frog (*Lithobates blairi*)

Plains leopard frogs are common in eastern and southern parts of Nebraska generally inhabiting aquatic environments with permanent water (Ballinger et al. 2010, Fogell 2010). On Mormon Island, Jones et al. (1981) noted this species was the most abundant herpetofauna observed during their study and was first observed in April. We captured plains leopard frogs in arrays across Mormon and Shoemaker islands in aquatic slough habitats (*n* = 156) and drier upland sites (*n* = 102; Fig. 13). Individuals, especially froglets, were abundant and most readily observed in shallow pools of ponding water in grazed grasslands where water was present for most of the summer. Leopard frogs rarely were observed in a perennial stream on Shoemaker Island where bullfrogs were abundant.

We heard individuals calling starting in early April, observed egg masses as early as 15 April (Fig. 14), and first captured metamorphosed froglets on 30 June with snout-vent lengths of 2-3 cm. Our latest observation of many individuals in aquatic habitats was on 8 November 2010. The month with the greatest number of captures per trapping array effort was July (Fig. 13), with many individuals as froglets. On 18 July, 10 September, and 23 September, leopard frogs were regurgitated from *T. radix*; the frog on 23 September had a snout-vent length of 6.5 cm and was consumed by a *T. radix* with mass of 70 g and total length of 56 cm. On 18 and 20 July, we regurgitated a single leopard frog each from a *T. sirtalis*. Our largest leopard frog was captured on 10 September; it had a mass of 38 g and snout-vent length of 7.5 cm.

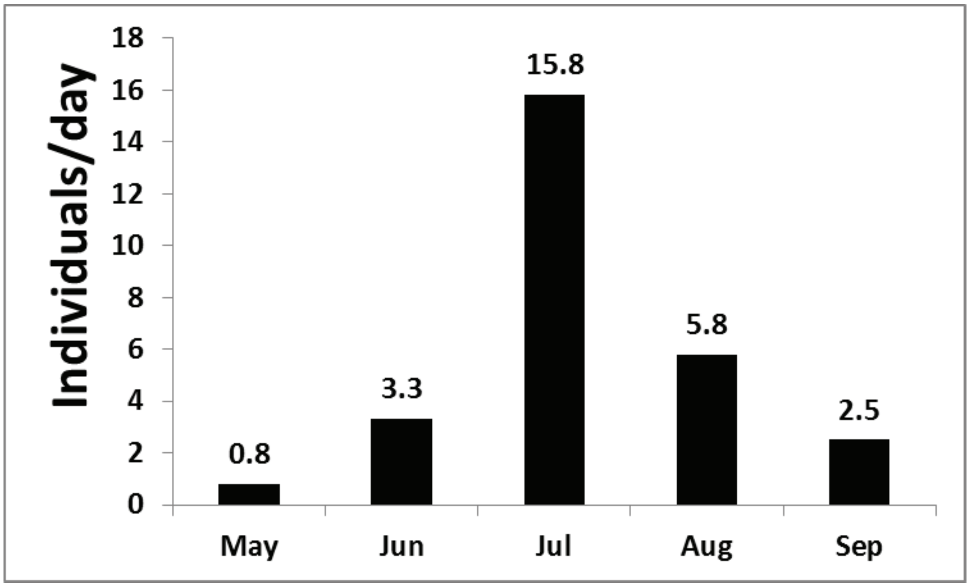

Fig. 13. Number of plains leopard frogs (*Lithobates blairi*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

Fig. 14. Photographs of the plains leopard frog (*Lithobates blairi*) adult (upper photographs) and egg mass (lower photograph) from Mormon and Shoemaker island, Hall County, Nebraska. Note the white spot in the tympanum and the broken dorsolateral folds that help identify this species from the northern leopard frog (*Lithobates pipiens*).

<u>Bullfrog (*Lithobates catesbeianus*)</u>

Bullfrogs occur statewide in large bodies of permanent water (Ballinger et al. 2010, Fogell 2010). Fogell (2010) postulated that bullfrogs only were native to parts of southeastern Nebraska in the Nemaha River drainage, but bullfrogs now occur across the state due to stocking practices in the past. At northern latitudes, such as Nebraska, tadpoles take two years (i.e., one winter) to metamorphosis into froglets (Ballinger et al. 2010), thus they have specific requirements in aquatic habitats for overwinter survival, such as non-freezing deep 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 the two large ponds on Mormon Island, but noted that in western Nebraska the species occurs in large ponds only associated with marshes; the two ponds lacked much emergent vegetation during their study and ours.

We observed and captured bullfrogs and their tadpoles on both Mormon and Shoemaker islands. On Shoemaker Island, bullfrogs were abundant in flowing bodies of water, especially in a perennial flowing stream north of Headquarters and in a slough that ponded due to a downstream dam. In large ponds near Headquarters, some males were heard calling in summer but ponds appeared to lack tadpoles. On Mormon Island, we only observed bullfrogs and their tadpoles in a recently excavated backwater slough on the north side of the island; the slough was dug in 2006. Bullfrogs were conspicuously absent from ponds on the south side of Mormon Island, as was also observed by Jones et al. (1981). Our only capture of a bullfrog in an array was in a pitfall trap was near the human-made slough on Mormon. Bullfrogs previously were known from Hall County (Fogell 2010).

In an associated project on Shoemaker Island, we published the first documented presence of chytridiomycosis in the state (Harner et al. in press), an emerging infectious disease in amphibians caused by the pathogen *Batrachochytrium dendrobatidis*. Bullfrogs had a high infection rate (41%) of this pathogen on Shoemaker Island (Harner et al. in press), which likely has had detrimental effects on native frogs because bullfrogs are often carriers of this pathogen (Daszak et al. 2004; Garner et al. 2006). We sampled 46 adult females that averaged 92 mm in snout-vent length (range 55-170 mm) and 30 adult males that averaged 116 mm (range 90-145 mm). Our earliest observation of a bullfrog was on 13 March; a large individual was observed partially buried in sediments in the perennial stream on Shoemaker Island.

Fig. 15. Adult bullfrog (*Lithobates catesbeianus*) in the left photograph, and student researchers sampling a bullfrog for chytrid fungus on Shoemaker Island, Hall County, Nebraska (right photograph).

<u>Common Snapping Turtle (*Chelydra serpentina*)</u>

In Nebraska, the common snapping turtle has a statewide distribution, occurring in many aquatic habitats (Ballinger et al. 2010, Fogell 2010). On Mormon Island, individuals are known from the two large ponds on the south side of the island, with individuals documented as early as April (Jones et al. 1981). We only observed common snapping turtles on Shoemaker Island but suspect the species still occurs on Mormon Island; we did not attempt to capture turtles in those ponds during our study. Our earliest observation occurred on 14 April 2010; a large individual was discovered underwater and partially buried in mud in an intermittent slough just north of Headquarters (Fig. 16). On 3, 5, and 7 June, we captured two smaller individuals (carapace lengths 8 and 10 cm) in pitfall traps along a perennial slough. Our latest observation was a small individual (carapace 5 cm in length) observed in a pitfall trap on 23 September also near the perennial slough (Fig. 16).

Fig. 16. An adult and juvenile snapping turtle (*Chelydra serpentina*) from Shoemaker Island, Hall County, Nebraska.

Northern Painted Turtle (*Chrysemys picta*)

Northern painted turtles mainly inhabit permanent bodies of water throughout Nebraska (Ballinger et al. 2010, Fogell 2010). Jones et al. (1981) documented this turtle species in a pond on Mormon Island in mid-June and considered the species rare on the preserve. We observed painted turtles on both Mormon and Shoemaker islands, mainly associated with human-made ponds. Our earliest 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. On three occasions, we observed individuals traveling in grasslands on Shoemaker Island (14 April, 27 May, and 14 July), whereas others were observed on roads (Fig. 17). The individual on 14 July likely emerged from the water to lay eggs; in the Sandhills of Nebraska, 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 slough that ponded due to a downstream dam. Our voucher material represents the first specimen collected from the county (Ballenger et al. 2010, Fogell 2010).

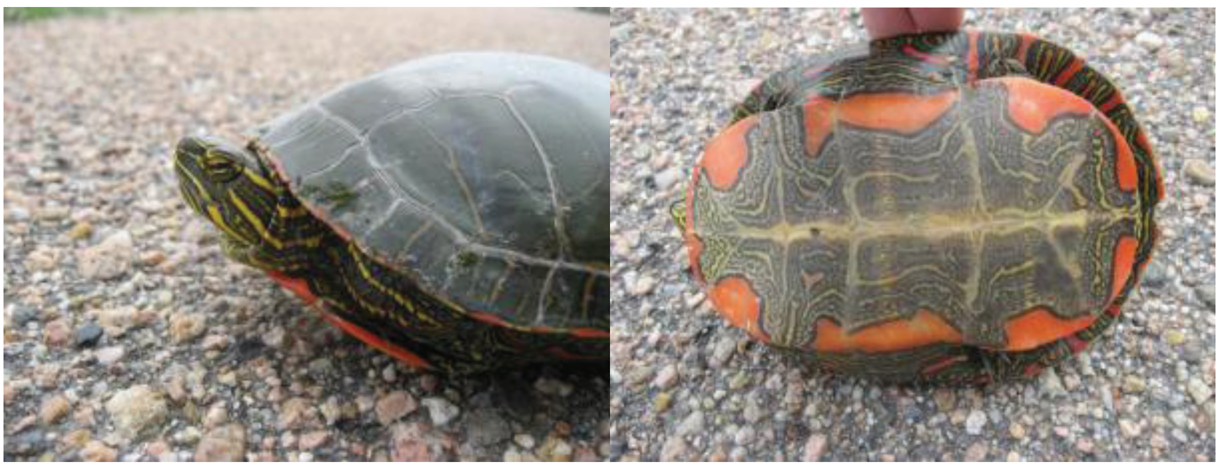

Fig. 17. A painted turtle (*Chrysemys picta*) observed crossing the paved road leading to the Headquarters area on Shoemaker Island.

Spiny Softshell (*Apalone spinifera*)

In Nebraska, the spiny softshell occurs in large rivers, streams, and reservoirs (Ballinger et al. 2010), and Fogell (2010) added the species also occurs in ponds and marshes including those that are seasonal. The spiny softshell occurs throughout the state except in northwestern parts (Ballinger et al. 2010, Fogell 2010). On Mormon Island, individuals were documented June through September (Jones et al. 2010). On 29 August 2010, we captured a single spiny softshell turtle along the southern edge of Mormon Island in a sandy channel of the Platte River (Fig. 18). We did not trap extensively for aquatic turtles during our study. We photographed and released the individual because of prior records from the island (Jones et al. 1981). Due to the sandy substrate of all river channels around the preserve, we suspect spiny softshells occur throughout the area and possibly some of the human-made ponds near river channels. We also suspect that smooth softshells (*Apalone mutica*) might occur in the area.

Fig. 18. A spiny softshell (*Apalone spinifera*) captured in a turtle trap on the south side of Mormon Island in a channel of the Platte River, Hall County, Nebraska.

Northern Prairie Skink (*Plestiodon septentrionalis*)

The distribution of the northern prairie skink appears to overlap tallgrass prairies in the Great Plains (Ballinger et al. 2010). In Nebraska, this species occurs mainly in the eastern third of the state (Ballinger et al. 2010), especially along major river drainages. On Mormon Island, Jones et al. (1981) observed that individuals were most abundant along the ecotone between woodlands and grasslands, but the species was not observed in central parts of large grassland pastures. During our study, the northern prairie skink was the most abundant species captured in grassland pastures away from woodlands on both islands (Table 1). The northern prairie skink was abundant across all grassland pastures (grazed, burned, and rested) and along the ecotone between forested and grassland habitats on both islands. Individuals also were observed in grassy patches in forested habitats.

Our earliest observation of a skink was on 14 April 2010 under a coverboard in a small forested area. Individuals were documented every month from March to November, except in October when we were not at the study site. The month with the greatest number of captures per trapping array effort was June followed by May (Fig. 19), which likely corresponds to increased activity associated with mating behaviors (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 20 May – 22 July. Juveniles that hatched this year were observed in trapping arrays beginning on 5 August (Fig. 20); the smallest individuals had lengths of 2-3 cm with masses 0.5-1.0 g. Skinks were still abundant and active across pastures on 26 September 2010. Recaptured individuals represented about 20% of captures.

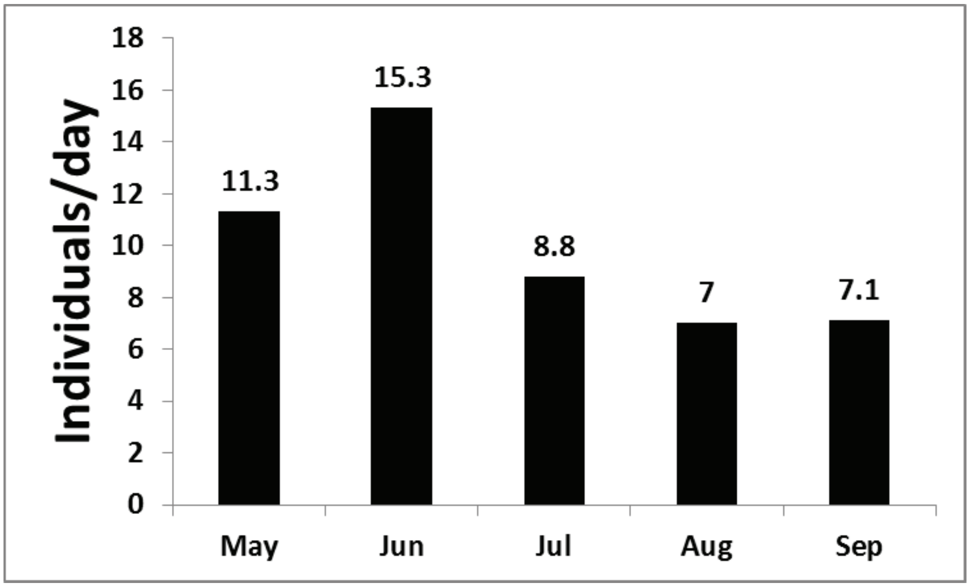

Fig. 19. Number of northern prairie skinks (*Plestiodon septentrionalis*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

Fig. 20. A subadult with a blue tail and darker ground color (left photograph) and adult (right photograph) northern prairie skink (*Plestiodon septentrionalis*) from Mormon and Shoemaker islands, Hall County, Nebraska.

Six-lined Racerunner (*Aspidoscelis sexlineata*)

Racerunners occur throughout most of Nebraska, except in some eastern parts and panhandle of the state (Ballinger et al. 2010, Fogell 2010). This species is most abundant in open, sparsely vegetated habitats with sandy soils (Ballinger et al. 2010). The former survey (Jones et al. 1981) survey and ours readily observed this species most frequently on the south side of Mormon Island in patches of open, sandy habitats (Fig. 21). This unique sandy habitat apparently was substrate blown in by winds in the 1930s (Nagel 1981). In trapping arrays, we captured only two individuals; all arrays were located in dense prairies. In arrays, one individual was captured in a grazed pasture and the other in a burned but ungrazed pasture. We only observed them in June, July, and September, but we did not spend much time in habitats on the south side of Mormon Island. Individuals were conspicuously absent in October 2011 after observing many young individuals in early September on the south side of Mormon Island.

Fig. 21. A six-lined racerunner (*Aspidoscelis sexlineata*) from sandy habitats on the south side of Mormon Island, Hall County, Nebraska.

<u>Eastern Racer (*Coluber constrictor*)</u>

Eastern racers occur across the state, but few records are known from northeastern parts of Nebraska (Ballinger et al. 2010, Fogell 2010). The species occurs in various habitats, but Wilgers and Horne (2006) suspected it might avoid tallgrass prairies without recent burns. On Mormon Island, Jones et al. (1981) reported the species was likely absent from the study site due to the high water table, yielding it unsuitable for hibernation. We captured eastern racers on Shoemaker Island on 9 and 12 August 2010 (Fig. 22), one in a grazed pasture (male, total length 71 cm) and one in a non-grazed pasture (female, total length 81 cm). Both individuals were subadults based on the faded, blotched pattern (Fig. 22). We suspect these individuals were dispersing through the area; we did not document adults at the study site. The species previously was known from Hall County (Fogell 2010).

Fig. 22. A subadult eastern racer (*Coluber constrictor*) from Shoemaker Island, Hall County, Nebraska.

Smooth Green Snake (*Liochlorophis vernalis*)

In Nebraska, records of the smooth green snake occur mainly in central and northeastern parts of the state in moist grasslands (Ballinger et al. 2010, Fogell 2010). Jones et al. (1981) did not document the smooth green snake in their study on Mormon Island and did not mention it as a possible species on the preserve. We observed three smooth green snakes during this project, all on Shoemaker Island in pastures burned and grazed in 2010 (Fig. 23). On 29 June 2010, one gravid female was captured under a wooden cover board; on 18 July 2010, one was observed in grasses but was not captured; and on 22 July 2010, a male was found dead on a dirt road. All observations occurred in grazed pastures, but such few observations during the study make conclusions about habitat associations at our study site impossible. We suspect observations in grazed areas represent individuals traveling across pastures, with individuals being more readily visible or seeking shelter in open fields. Another researcher has observed green snakes by the Headquarters area on Shoemaker Island in the past (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 likely precluded our abilities to capture more individuals of this and other small species of snakes. Our observations from Hall County represent a new county record for the state (Ballinger et al. 2010, Fogell 2010). Our records fill in a gap in distribution along the Platte River. Smooth green snakes are known from the adjacent counties of Merrick, Kearney, and Sherman (Ballinger et al. 2010, Fogell 2010).

Fig. 23. Left photograph is a smooth green snake (*Liochlorophis vernalis*) captured on Shoemaker Island, Hall County, Nebraska. The right photograph is a close-up of a smooth green snake captured in Webster County, Nebraska.

Redbelly Snake (*Storeria occipitomaculata*)

Redbelly snakes mainly occur across eastern parts of the United States, but two isolated, disjunct populations occur in the plains states (Ernst 2002, Fogell 2010). One population occurs in the Black Hills of South Dakota and the other 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 (K. Geluso, unpublished data), and Phelps (Ballinger et al. 2010, Fogell 2010) counties. Most references for habitat of this species throughout its range state woodlands as its primary habitat (Triplehorn 1948, Smith 1963, Fogell 2010). Jones et al. (1981) did not observe this species of snake in their study on Mormon Island and did not mention it as a possible species on the preserve.

We observed redbelly snakes on Mormon and Shoemaker islands in both wooded and grassland habitats (Fig. 24); however, individuals were not captured in grasslands if woodland habitats were not nearby (i.e., <500 m). For example, our arrays on the west side of Mormon Island failed to produce redbelly snakes. We observed the most individuals along the edge of a wooded area on the southeastern edge of Mormon Island; here, individuals were observed regularly under coverboards and on the two-track dirt road adjacent to the woodlands. On Shoemaker Island we captured five under coverboards and in pitfall traps in grazed and ungrazed pastures. In spring (24 and 28 April 2010), we observed individuals basking on dirt roads <25 m from a channel of the Platte River. Our earliest date of observation was 14 April and our latest date of observation was 28 October. In arrays, we captured individuals in May (n = 2), June (n = 1), and September (n = 2). In arrays, our largest individual captured in arrays was 28.5 cm in total length and the smallest was 14.2 cm.

Our captures represent a new species for the preserve (Jones et al. 1981) and the easternmost records for the isolated, disjunct population of redbelly snake along the Big Bend Reach of 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 the species 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.

The redbelly snake currently is listed as a Tier II species of concern in Nebraska (Schneider et al. 2005). Due to the priority of conserving lands along the Platte River for migratory species of birds (NRC 2005), such as the whooping and sandhill crane, large-scale alterations to habitats have occurred in the Big Bend reach of the Platte River. For example, many hectares of trees have been removed in recent decades to create grassland habitats (NRC 2005, personal observation), but we find it important to understand whether such management actions are negatively affecting this non-migratory vertebrate species in the area that clearly represents a unique population. Many studies report that islands and banks of the Platte River before settlement in the early 1800s, especially between Fort Kearny and Grand Island, were quite wooded almost exclusively with cottonwoods, elms, and willows (Eschner et al. 1983, Williams 1978, Johnson 1994). This relict population appears associated with wooded habitats and current efforts to clear large-scale area might be deleterious for this species.

Fig. 24. Photographs of redbelly snakes (*Storeria occipitomaculata*) from Mormon and Shoemaker islands, Hall County, Nebraska.

Plains Garter Snake (*Thamnophis radix*)

The plains garter snake has a statewide distribution in Nebraska and is common in wet prairies and other mesic habitats along ponds, lakes, marshes, and rivers (Ballinger et al. 2010, Fogell 2010). Fogell (2010) states this species avoids woodlands but occurs along woodland ecotones, whereas 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 prairie habitat.

Plains garter snakes were the third 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 along the Platte River (Fig. 26). Our earliest observation was on 14 April and our latest aboveground observation was in 19 October. June and September were the months with the most captures per effort (Fig. 25). Jones et al. (1981) observed the species most active in June. In November, individuals were observed in holes when removing buckets; many holes contained ground water. The largest female captured had a total length of 77 cm with a weight of 130 g; the largest male capture was 66 cm in length and 95 g. Juvenile snakes were first captured on 10 August with total lengths of 17-21 cm and weights of 1.5-3 g. Earthworms were observed in the diet in May, June, and September. On three occasions, individuals regurgitated a plains leopard frog (18 July, 10 September, and 23 September) and on one occasion an individual regurgitated a small mouse (18 July). Only about 5% of individuals captured were recaptures, and most of those were individuals captured the following day in the same trap array. While handling this species by the tail, many individuals were observed to have a spinning behavior to attempt to escape.

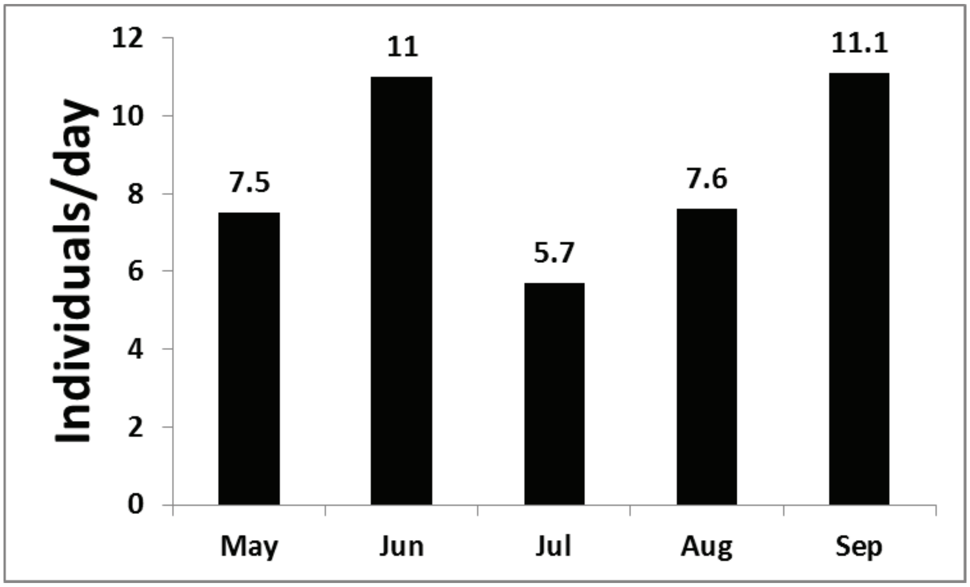

Fig. 25. Number of plains garter snakes (*Thamnophis radix*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.


Fig. 26. Photographs of the plains garter snake (*Thamnophis radix*) from Mormon and Shoemaker islands. In both photographs, notice the lateral line is on scale rows 3 and 4 counting up from ventral scales.

Common Garter Snake (*Thamnophis sirtalis*)

The common garter snake has a statewide distribution (Ballinger et al. 2010, Fogell 2010), but it usually is associated with habitats in river valleys in the Sandhills and other western parts of the state (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 commonly near ponds and along channels of the Platte River.

The common garter snake was the second most common species of herpetofauna on Mormon and Shoemaker islands during our research (Table 1; Fig. 28). 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 observation was on 14 April 2010 whereas our latest aboveground observation was on 8 November 2010. September was the month with the greatest number of captures followed by captures in May and June (Fig. 27). 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 chorus frogs. Under some buckets, snakes were partially submerged in ground water. Although this appeared counter intuitive, Costanzo (1989) demonstrated that *T. sirtalis* submerged in water had higher 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), and 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 had a total length of 88.5 cm and 138 g. Juvenile snakes were first captured on 12 August with total lengths of 20-21 cm and weights of 1.5-3 g. Earthworms were the most frequently observed prey item with individuals regurgitating worms in May, June, July, and September. In May, an individual (total length 87 cm and weight 155 g) regurgitated over 10 g of earthworms. On 18 July and 20 July, the plains leopard frogs were observed in the diet of this species. For small mammals, both meadow voles (*Microtus pennsylvanicus*) and masked shrews (*Sorex cinereus*) were observed consumed by common garter snakes. Only about 5% of captures represented recaptured individuals. While handling this species by the tail, many individuals were observed to have a spinning behavior to attempt to escape.

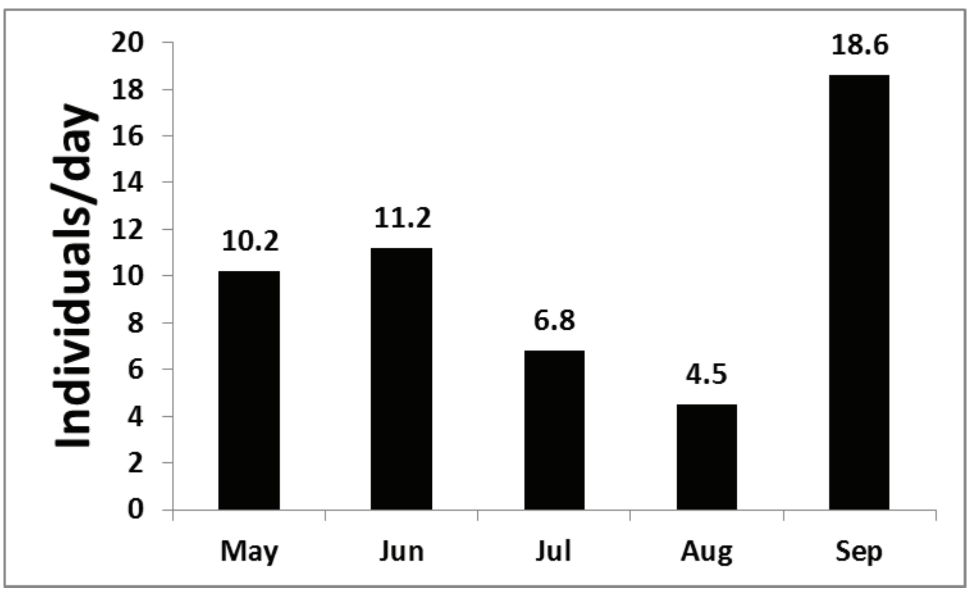

Fig. 27. Number of common garter snakes (*Thamnophis sirtalis*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

Fig. 28. Photographs of the common garter snake (*Thamnophis sirtalis*) from Mormon and Shoemaker islands, Hall County, Nebraska. The photograph on the left demonstrates the lateral line that occurs on scale rows numbers 2 and 3 compared to scale rows 3 and 4 as with the plains garter snake (*Thamnophis radix*).

<u>Lined Snake (*Tropidoclonion lineatum*)</u>

In Nebraska, the lined snake mainly occurs in southeastern parts of the state 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 than those burned every four years or rested for longer periods (Wilgers and Horne 2006). Jones et al. (1981) did not observe this species in their study on Mormon Island and did not mention it as a possible species on the preserve. Lined snake were previously known from Hall County (Fogell 2010).

We observed lined snakes relatively frequently on both Mormon and Shoemaker islands (Table 1; Fig. 30). We captured 71 individuals, and they were captured in all eight grassland pastures with arrays. Our earliest date of observation was 18 May and our latest date of observation was 26 September. We most frequently observed individuals in September (Fig. 29). Lined snakes were observed more often in upland arrays than those in sloughs (Harner and Geluso 2011—other chapter of this report).

The largest female had a total length of 34 cm with weight of 24 g, and the largest male had a total length of 34 cm with a weight of 20.5 g. The first juvenile was captured on 18 August; it had a total length of 10 cm and weight of about 1 g. Additional juveniles were captured 23-26 September with total length of 12-14 cm and weight of about 1 g. Of 31 individuals marked, we never documented a recaptured individual.

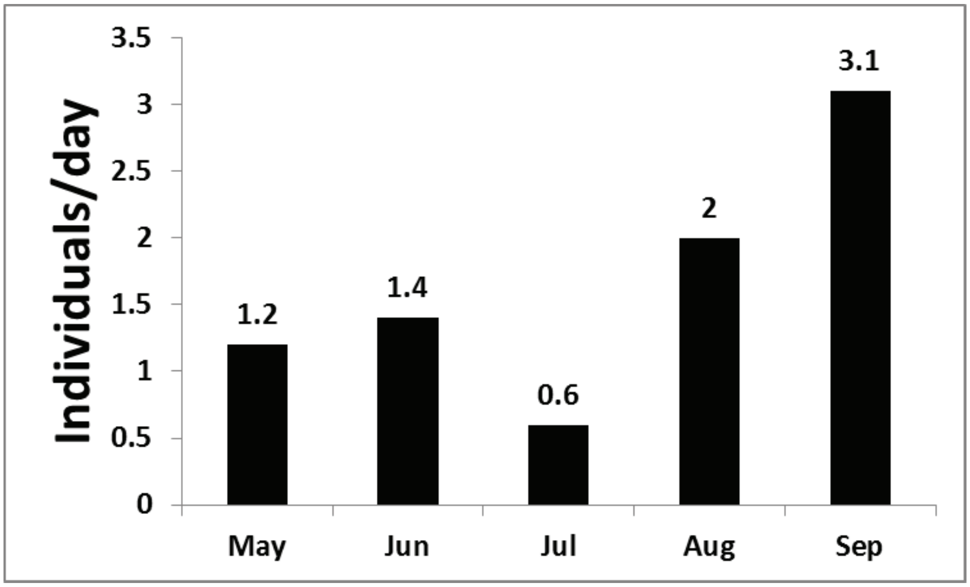

Fig. 29. Number of lined snakes (*Tropidoclonion lineatum*) captured per day of effort each month in 2010 in trapping arrays located in grasslands on Mormon and Shoemaker islands, Hall County, Nebraska.

Fig. 30. Photographs of lined snakes (*Tropidoclonion lineatum*) from Mormon and Shoemaker islands. Note the two rows of half moons on the ventral scales of this species in the right photograph.

DISCUSSION

Our survey of Mormon and Shoemaker islands in the floodplain of the Platte River documented 15 species of herpetofauna that included 5 additional species not reported in an earlier survey in 1980 (Jones et al. 1981). It is unclear at this time whether such differences for most species represent captures due to a more intensive trapping regime employed by us or whether such differences relate to large-scale changes in habitats on the preserve. Elucidating such differences are important for future conservation efforts in the region, especially if they are related to current management practices, conservation efforts, or human use of surface water and groundwater resources in the Platte River valley. It is also important to determine if such changes relate to regional climatic conditions (i.e., global warming) to assist future conservation efforts with predictive models on how such climatic changes (i.e., temperatures and water availability) will affect habitats in the valley. Warmer and drier climates in the future in the Platte River valley may resemble current issues observed on Southwestern rivers with their loss of native cottonwood (*Populus* spp.) stands being replaced by exotic and invasive species such as saltcedars (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*).

The occurrence of bullfrogs on Mormon Island appeared directly related to a large-scale restoration project that created a backwater slough in 2006. Besides the two ponds on the south side of the island that likely were unsuitable for bullfrogs (Jones et al. 1981), the digging of a backwater slough provided the only requisite conditions for overwinter bullfrog tadpoles on the island. The slough varies in depth, with some areas being deep enough for winter survival, and continual upwelling from ground water that feeds slough flows also prevents it from freezing to harmful depths for tadpoles. Backwater sloughs with upwelling ground water are known for their warmer temperatures than surrounding water and are important for other wildlife species, such as wintering and migrating waterfowl. Such restoration projects appear beneficial for some wildlife species in the region but possibly deleterious for others. Bullfrogs are exotic and invasive species to central and western Nebraska (Fogell 2010), and their voracious feeding habits and harmful fungus negatively affect other native species.

The northern prairie skink was observed during both surveys (Jones et al. 1981, this study) but its relative abundance in grassland habitats cannot be more extreme. Jones et al. (1981) reported "It was not found in the central pasture," but two of our pastures, with 199 captures representing 28% of our total captures, were in this same former "central pasture." Moreover, drift fences with funnel traps were employed by Jones et al. (1981) during their survey, although details are lacking where these were placed and how many were deployed. In our study, funnel traps associated with 10-m drift fences accounted for 110 captures of skinks, 26% of the total captured in arrays. An explanation for such a contrasting difference is not known. One possibility relates to possible changes in groundwater levels. Harner and Whited (2011) demonstrated that groundwater levels appear to have dropped on Mormon and Shoemaker islands since the early 1950s, reducing both the aboveground and below ground water. Such changes may increase survival of hibernating reptiles. Jones et al. (1981) postulated that the lack of three species of snakes on the island, including lined snakes, bullsnakes (*Pituophis catenifer*), and eastern racers, were due to "the high water table at Mormon Island that prevents snakes from having a suitable deep space for hiding and hibernation, which may restrict the number of species on the preserve." Might this explanation also apply to the overwintering habits of the northern prairie skink in the grassland pasture?

Both the lined snake and eastern racer were documented in our survey, but notably dismissed from occurring in the area by Jones et al. (1981) due to high groundwater levels. Moreover, Jones et al. (1981) stated that lined snakes are likely rare in the region and spend much of their time under cover. Lined snakes were the fifth most abundant herpetofauna, and we would consider them an uncommon grassland species on the preserve (Table 1). Grassland pastures on the islands basically lacked cover objects, except the canopy of tall grasses on burned plots and a vegetative thatch layer on those rested from cattle grazing, yet we still observed a moderate numbers of individuals. Harner and Geluso (2011—other chapter of this report) demonstrated that lined snakes were more abundant in upland habitats than in sloughs across these pastures. Other studies state lined snakes prefer more open habitats (Ballinger et al. 2010) and pastures burned annually (Wilgers and Horne 2006). Eastern races are reported as upland, terrestrial species. Thus, the presence of both the lined snakes and eastern racers also appears to suggest more large-scale habitat changes with regards to drier habitats related to decreasing groundwater levels. If such a trend continues into the future, we might predict additional herpetofauna to be added to the list, such as ornate box turtle (*Terrapene ornata*) and prairie lizard (*Sceloporus consobrinus*), both of which occur further west in floodplains of the Platte River in Dawson and Gosper counties (K. Geluso, unpublished data). Such species generally inhabit more open, sandy habitat in drier regions of the state.

Our study presents a summary of natural history characteristics for the diverse array of species occurring on Mormon and Shoemaker islands. Such information demonstrates the variety of life-history attributes unique to each species. We observed that amphibians and skinks had unimodal activity patterns centered in summer; however for snakes, activity of many common species peaked in September. Thus, there is no one best time of the year to study the assemblage of herpetofauna, and future research in the region should extend studies into October and November for a better understanding of late-season activity patterns. Moreover, variation in life-history characteristics for species demonstrates the need for management regimes that yield heterogeneous habitats across the landscape in the Platte River valley. Contrasting habitats are requisite for a number species, and single species management regimes for species like the whooping crane likely will have detrimental outcomes for the health of the ecosystem (NRC 2005). For example, large-scale removal of woodlands along the central Platte River probably has had negative outcomes for the isolated population of redbelly snake in the region. Floodplains of large freely flowing rivers create and maintain a diversity of habitats, with the unique proximity of abundant ecotones between aquatic and terrestrial systems. Regulated rivers, such as the Platte River, have greatly reduced habitat complexity and likely support a different abundance of flora and fauna than in the past. To protect the integrity of the Platte River, a more broad-scale, ecosystem approach is required to understand how all of species that reside in the region interact and are vital for other species.

Conclusions.—Our study represents another important benchmark survey for future herpetological studies to compare to in the future as land management and conservation efforts continue to manage, restore, and protect this unique area of the central flyway for many species of migratory birds. While it is unlikely that management practices will be focused upon herpetofauna (except for potentially the redbelly snake), these species likely influence ecosystem function and arguably should have a broader implication for management strategies in the future. For example, the diet of the endangered whooping crane is fairly animalivous, consuming various vertebrate species such as frogs, snakes, mice, and egg masses of frogs (Allen 1952). Continued success of protecting species of concern requires complete understanding of life history requirements throughout their breeding, wintering, and migratory habitats.

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Chapter 3

Chytrid Fungus in American Bullfrogs (*Lithobates catesbeianus*) along the Platte River, Nebraska, USA

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Introduction

Chytridiomycosis is an emerging infectious disease in amphibians that was discovered in the late 1990s (Berger et al. 1998; Longcore et al. 1999), with retrospective surveys indicating isolated cases dating to 1902 in Japan (Goka et al. 2009), 1938 in Africa (Weldon et al. 2004), and 1961 in North America (Ouellet et al. 2005). This disease is caused by the pathogen *Batrachochytrium dendrobatidis* (*Bd*), a species of chytrid fungus, and it is hypothesized to contribute to amphibian declines worldwide (Berger et al. 1998; Daszak et al. 1999; Lips et al. 2006; Collins 2010). *Bd* has been detected in amphibians on all six continents inhabited by amphibians, and large numbers of *Bd*-positive samples have been collected from various sites across North America (www.Bd-maps.net; accessed 7 June 2011). The central United States, however, has not been sampled extensively for *Bd*. To date, no published accounts of *Bd* exist for amphibians from Nebraska, USA, although two localities with *Bd* in Nebraska are noted online (www.Bd-maps.net; J. Krebs, Henry Doorly Zoo, Omaha, Nebraska, and Zimmerman Ranch, Dunning, Nebraska). Our objective was to determine whether *Bd* is present along the Platte River in south-central Nebraska.

Methods

We sampled anurans along the Platte River in Hall County, Nebraska, on land managed by Platte River Whooping Crane Maintenance Trust located on Shoemaker Island (40.7884°N, 98.4650°W). We prioritized capturing *Lithobates catesbeianus* (American Bullfrog) because they are nonclinical carriers of *Bd* (Daszak et al. 2004; Garner et al. 2006), are abundant in Nebraska (Fogell 2010), and are a concern for wildlife management worldwide due to their invasiveness (Ficetola et al. 2007). We targeted sampling along two sloughs (linear, water-filled depression) surrounded by mesic, tall-grass prairie (Fig. 1; Slough 1 start: 40.7921°N, 98.4628°W; end: 40.7939°N, 98.4584°W; Slough 2: start: 40.7959°N, 98.4444°W, end: 40.7989°N, 98.4421°W). We also opportunistically collected *Anaxyrus woodhousii* (Woodhouse's Toad) and *Lithobates blairi* (Plains Leopard Frog) from these sloughs, as well as nearby point locations across the island, including isolated ponds, puddles, and roads (Fig. 1). Samples were collected 28 April, 5 June, 9 and 10 July, and 3 and 6 September 2010.

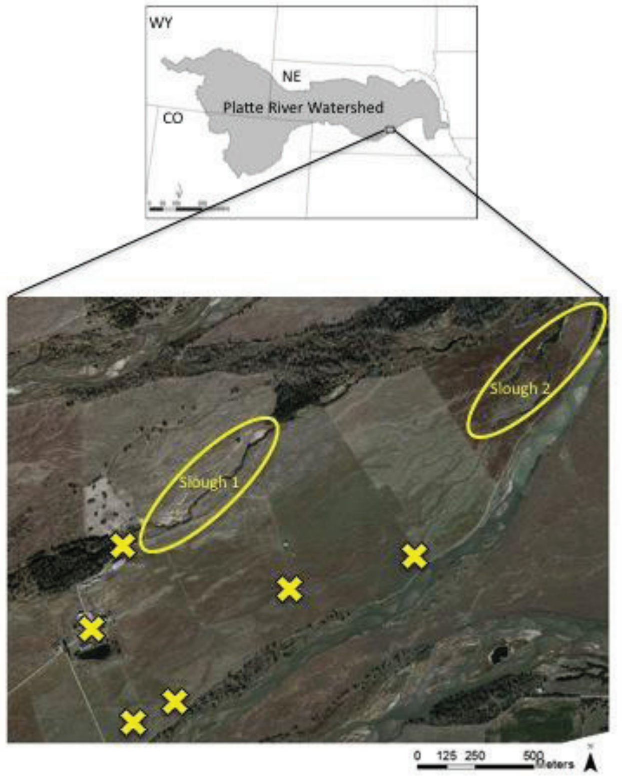

Figure 1. Location of sampling sites along the Platte River in central Nebraska, USA. Locator map shows the study region within the Platte River watershed. Aerial photograph depicts Shoemaker Island (Hall County, Nebraska) where anurans were sampled. Most sampling occurred in sloughs 1 and 2, and opportunistic captures were collected from point locations (denoted by X). Aerial photograph was taken in October 2010.

To minimize contamination, we captured amphibians by hand while wearing disposable vinyl gloves that we changed between each capture. We also captured some Plains Leopard Frogs with nets from ponds and puddles. Each animal captured was kept individually in plastic or cloth bags until processed in the field and then released; plastic bags were disposed after one usage whereas cloth bags were washed between samples. For each individual, we determined sex and visually examined for wounds and other abnormalities. We sampled for *Bd* following protocols of the Amphibian Disease Laboratory, Institute for Conservation Research at the San Diego Zoo and used their preferred sampling kits, comprised of plastic-handled, fine tip cotton swabs (Dryswab™; MW113; Medical Wire & Equipment Co. LTD., England) and screw-top storage tubes (Cryogenic Vials, Nalge Nunc International, New York). We swabbed the skin on ventral surfaces, targeting the pelvic patch, thighs, and toe webbing, making 5 passes on each surface with a single swab for each animal. The swab was air-dried, and the tip placed in an individually marked vial.

Samples were shipped to the San Diego Zoo for processing where they were analyzed for *Bd* using real-time (Taqman) PCR to amplify the ITS1 region (Boyle et al. 2004). Results were reported as positive or negative. We examined associations among *Bd* presence, sex, sampling date, and sampling location with Pearson Chi-square tests in PASW Statistics version 18 (Chicago, Illinois, USA).

Results

We captured a total of 118 amphibians, including 76 adult American Bullfrogs, 1 American Bullfrog tadpole, 20 Plains Leopard Frogs, and 21 Woodhouse's Toads. We detected *Bd* only in American Bullfrogs, with 31 adults (41%) testing positive. We did not detect an association between *Bd* infection and sex (X^2=1.14, df = 1, P = 0.28) or sampling location (X^2=1.81, df = 2, P = 0.40), but we found an association between *Bd* infection and sampling date (X^2= 14.12, df = 2, P = 0.001), with 67% of American Bullfrogs testing positive in April, 0% testing positive in June, and 39% testing positive in July. We observed infected American Bullfrogs in both sloughs; the one American Bullfrog sampled from an isolated pond located 600 m from the sloughs tested negative. No infected individuals were detected in the other two species, even in sloughs with infected American Bullfrogs (N = 2 Woodhouse's Toads collected from Slough 1, N = 18 Plains Leopard Frogs collected from Slough 1, and N = 1 Plains Leopard Frog from Slough 2).

Discussion

We detected high prevalence of *Bd* (41%) in American Bullfrogs along the Platte River in central Nebraska. Other central USA accounts of *Bd* include surveys in the north-central United States (Iowa, Wisconsin, and Michigan), where *Bd* was detected in nine species, including American Bullfrogs (Sadinski et al. 2010); surveys in Colorado and Wyoming, where *Bd* was widely distributed (51% of sites examined) in Boreal Toads (*Bufo boreas boreas*), Western Chorus Frogs (*Pseudacris triseriata*), Northern Leopard Frogs (*Lithobates pipiens*), and Wood Frogs (*Lithobates sylvaticus*) (Young et al. 2007); and surveys along the Rocky Mountains, where *Bd* was detected in six species (Muths et al. 2008). Additional surveys of *Bd* throughout the central United States are warranted to gain baseline information about the presence of this pathogen, especially as it relates to species that have declined in recent decades for unknown reasons (e.g., Hayes and Jennings 1986).

Accumulating evidence supports the "novel pathogen hypothesis" to explain the recent worldwide invasion of *Bd* (Rosenblum et al. 2009). This specifically suggests that human-mediated movement of infected frogs, including the American Bullfrog, precipitated *Bd* range expansion (Fisher and Garner 2007; Schloegel et al. 2009a,b). In light of this, our results are a special concern for the region as American Bullfrogs were introduced to waterways throughout Nebraska in the 20th century and appear to be expanding their distribution (Fogell 2010). American Bullfrogs were not documented in surveys of herpetofauna in 1980 on an island adjacent to our study site (Jones et al. 1981), but they were abundant in our 2010 surveys.

Expansion of American Bullfrogs could result in the introduction of *Bd* to the native amphibians in the region, notably Plains Leopard Frogs, Woodhouse's Toads, and Boreal Chorus Frogs. *Bd* infections already have been reported in Chorus Frogs (*Pseudacris maculata* and *P. triseriata*) and Northern Leopard Frogs (*Lithobates pipiens*) in Colorado and Wyoming (Young et al. 2007; Muths et al. 2008). Although we did not detect *Bd* in Plains Leopard Frogs or Woodhouse's Toads, a number of factors may have prevented this. Our sample size was small (Skerratt et al. 2008), and studies have shown lower prevalence of *Bd* during the summer (Longcore et al. 2007; Retallick et al. 2004; Voordouw et al. 2010). In our study, most positive detections of *Bd* were at the earliest sampling date (April) in American Bullfrogs, but we captured most Plains Leopard Frogs and Woodhouse's Toads at later sampling dates, thus we may have missed a seasonal peak in infection. In addition, recent work suggests that our collection method (swabbing) is less sensitive than other methods (toe clips and bag rinses) for detection (Voordouw et al. 2010).

Additional surveys of native anurans need to be conducted at this site to monitor potential cascading effects of transmission of *Bd* from invasive American Bullfrogs. Prevalence of *Bd* varies among American Bullfrog populations, but it is frequently high (Garner et al. 2006), and American Bullfrogs are often nonclinical carriers (Daszak et al. 2004; Garner et al. 2006). Despite high genetic similarity of isolates, different strains of *Bd* differ in virulence (Berger et al. 2005; Fisher et al. 2009; Rosenblum et al. 2009), yet there appears to be little host specificity (James et al. 2009; Rosenblum et al. 2009). Thus, *Bd* strains carried by American Bullfrogs likely are easily spread to other native species. Therefore, characterization of the strain of *Bd* in this region is needed because American Bullfrogs occur in the same water bodies with many native species and may threaten them, especially if carrying a lethal strain.

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