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Historical Changes in a Herpetofaunal Assemblage in the Flint Hills of Kansas

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ABSTRACT.—To assess changes in the herpetofauna in the northern Flint Hills of Kansas, we conducted a survey on the Fort Riley Military Reservation (Riley and Geary counties) in 1993 and compared our results with those of C. E. Burt and other early collectors. Of 46 species reported before 1930, 37 were found in 1993. Four species recorded before 1930 and not found in 1993 (*Bufo cognatus, Carphophis vermis, Thamnophis radix* and *Crotalus horridus*) are known or believed to persist in Riley and Geary counties. Four other species (*Heterodon platirhinos, Nerodia erythrogaster, N. rhombifer* and *Regina grahamii*) have not been reported in over 50 yr and may be extirpated locally. Two additional species (*Spea bombifrons* and *Trachemys scripta*) found in 1993 were not reported by early collectors. Changes in relative abundance of species from pre-1930 to 1993 were few, and there was no evidence of decline in amphibian populations. With the exception of declines in species dependent on rare habitats located in the floodplain of major rivers, the herpetological assemblage in the Fort Riley area has changed little during the past 70–100 yr. We attribute this stability to land uses that have maintained large tracts of native vegetation.

INTRODUCTION

One of the most difficult problems in conservation biology is the lack of baseline data against which to measure population changes. Because amphibian populations have apparently declined sharply in many areas (Blaustein and Wake, 1990; Wake, 1991), quantitative data on this group in particular should be gathered to form a baseline data set, and compared to historical accounts whenever possible. Biologists also have noted the loss of biodiversity in the Great Plains region of the United States (Samson and Knopf, 1994), where conversion of native vegetation to agricultural uses has been pervasive. Although native populations of many Great Plains organisms certainly have been reduced since presettlement days, quantitative assessments of changes in reptile and amphibian populations are few (Ludwig *et al.*, 1992; Lannoo *et al.*, 1994).

We conducted an intensive, year-long herpetofaunal survey of the Fort Riley Military Reservation (FRMR) in northeastern Kansas in 1993. Herpetological investigations in the FRMR area (Riley and Geary counties) date back into the 19th century (Hallowell, 1857; Mozley, 1878; Cragin, 1881, 1885) when FRMR served as a stepping-off point for military and scientific expeditions. In addition, the presence of Kansas State University in Manhattan led to contributions to the knowledge of the region's biota. Dice (1923) described the natural communities in the Manhattan area and mentioned associated amphibians and reptiles. Burt (1927) provided an annotated list of 42 species in Riley County. Herein we provide the results of our herpetological survey, and compare the species assemblage and relative abundance of reptiles and amphibians we observed to historical accounts published 66 yr earlier.

METHODS

Study site.—Geary and Riley counties are located in northeastern Kansas in the Flint Hills physiographic province. The Flint Hills consist of gently rolling terrain underlain by Permian limestones and shales (Schöewe, 1949). The native vegetation consisted primarily of tallgrass prairie, with woody vegetation restricted to stream and river valleys and other topographical features protected from fire (Abrams and Hulbert, 1987). Because of the large amount of chert in the soils, much of the Flint Hills is unsuitable for cultivation and remains in prairie. The major land use is livestock grazing.

Fort Riley Military Reservation (FRMR) is a 40,897 ha infantry training center located along the Kansas and Republican rivers in western Geary and Riley counties. Extensive areas of gently rolling uplands contrast with steeper topography along the rivers and major tributaries. The current vegetation consists mostly of native tallgrass prairie with wooded areas along streams and successional grasslands in areas that were previously cultivated. Digital orthophotography derived from black-and-white National Aerial Photography Program maps at the Kansas Applied and Remote Sensing program, University of Kansas, was analyzed for the extent and percent cover of four land cover classes on FRMR: woodland, 7150 ha (17.3%); grassland, 33,166 ha (80.2%); urban, 769 ha (1.9%); and water, 270 ha (0.6%). Woodland areas consist of oak (*Quercus* spp.) and mixed deciduous forest, successional woodlands and brush. The Kansas and Republican river valleys (2760 ha) contain habitats not found elsewhere on FRMR, including wetlands, low prairie, areas of sandy soils, cottonwood-willow riparian forests, oxbows and large rivers. River-bottom cover classes are distributed as follows: woodland, 1102 ha (39.9%); grassland, 1223 ha (44.3%); urban, 306 ha (11.1%); and water, 129 ha (4.7%). River-bottom woodlands included mixed deciduous riparian forest and successional woodlands. Grasslands in river bottoms consist mostly of planted, non-native grasses in developed areas. Little native prairie (<100 ha) remains in the river bottoms.

Survey techniques.—We inventoried the herpetofauna of FRMR in 1993 (Busby *et al.*, 1994). Approximately 128 person-days (days where an individual spent ≥6 h in the field) were spent conducting field studies on FRMR from April through October 1993. The monthly distribution of person-days was as follows: April (13.5), May (24), June (47), July (17.5), August (10), September (14) and October (1). A variety of survey and capture methods were used to inventory, as completely as possible, the species present in all habitats. Surveys were made throughout all accessible areas of FRMR, although because of greater accessibility and habitat diversity, the southern portion of the base received the most emphasis. A voucher specimen of each species was preserved and deposited in the Natural History Museum, University of Kansas. All other specimens were released at the point of capture.

Artificial shelters have been successfully used as a nondestructive and productive herpetofaunal census technique (Fitch, 1987, 1992; DeGraaf and Yamasaki, 1992). Artificial shelters were constructed of plywood, most being ca. 1 × 1 m squares. Twenty arrays of 10 boards each were placed in five habitat types (prairie, successional grassland, brush, forest and river bottom). In each array, shelters were placed 30–50 m apart in a line. Shelters were set out in April and checked periodically until 7 September.

Drift fences with funnel traps were used in the Republican and Kansas river valleys, areas that contain distinctive bottomland habitats not found elsewhere on FRMR and that generally lack the surface rock or other cover objects that can be searched with opportunistic methods. Drift fences were constructed of two sheets of 36 cm × 3 m sheets of galvanized "valley" sheeting arranged end to end. Funnel traps were placed at each end of the drift

fence. Funnel traps were similar to those described by Fitch (1987) and constructed of 6-mm hardware cloth with a funnel at one end. From 5–13 drift fences were operated from late May to late September. Several fences had to be dismantled and moved because of flooding. Drift fences were operated for a total of 922 trap days.

Opportunistic surveys were performed in a variety of habitats throughout FRMR at all times of the day. Surveyors intensively searched the ground, water and vegetation. Wherever available, turnable rocks and other cover objects were examined. In many cases, opportunistic surveys were made semiquantitative by recording the amount of time spent in each habitat searched; these results were subsequently standardized by calculating person-h spent by habitat. Aural surveys for anuran breeding choruses were made throughout the spring and early summer. Nocturnal "road cruising" was employed throughout the study in accessible areas to capture amphibians and reptiles on roads.

Aquatic turtles were sampled using double hoop nets with 1-m diam hoops covered with nylon mesh (Memphis Net and Twine Co.). Four aquatic habitats were sampled from 24 August to 17 September: riverine (Kansas and Republican rivers), oxbow lakes, Milford Reservoir, and upland ponds and lakes. Traps were anchored in shallow water with rebar, baited with canned sardines, and checked daily for a total of 64 trap-nights. Turtles were also documented by observing basking individuals on sunny days and when crossing roads.

Habitat analysis.—Three broad habitat classes are presented here that combine more specific habitats described by Dice (1923) and Busby *et al.* (1994). Grassland consisted primarily of upland native tallgrass prairie, but also included successional grasslands. Woodland included brush and woodland on uplands and gallery forest along streams. River bottom included a variety of vegetative cover types in the Kansas and Republican river valleys, including cottonwood-willow riparian forest, successional woodland, low prairie, planted grassland and old field. For purposes of presenting funnel trap results, river-bottom sites were separated into grass (consisting of native and non-native, grasslands) and woodland edge (consisting of open, successional woodlands and woodland-grassland edge).

Historical data.—Burt (1927) reported on his own collections from 1923 to 1927, and supplemented this list with information from two collections and earlier published records (Cragin, 1881, 1885; Branson, 1904; Dice, 1923). In addition, we checked records of specimens from Riley and Geary counties housed in the University of Kansas Natural History Museum (KU), Field Museum of Natural History (FMNH), Philadelphia Academy of Natural Sciences (ANSP), University of Michigan Museum of Zoology (UMMZ), U.S. National Museum of Natural History (USNM), American Museum of Natural History (AMNH), San Diego Society of Natural History (SDSNH) and the Museum of Comparative Zoology, Harvard University (MCZ).

RESULTS

A total of 3523 individuals representing 39 species of reptiles and amphibians were observed (Table 1). Amphibians comprised over 60% of the total individuals and included one species of salamander (*Ambystoma tigrinum*) and eight species of frogs and toads. A high proportion of anuran observations (especially of *Acris crepitans, Bufo woodhousii* and *Rana blairi*) were of recent metamorphs, and reproductive success seemed to be high for most anuran species. The record rainfall levels of 1993 (total precipitation on FRMR was 135.4 cm in 1993 vs. an average annual rainfall of 81 cm; Marshall Airfield weather station, FRMR; Jantz *et al.*, 1975) seemed to have a favorable effect on anuran reproduction. Drift fences with funnel traps accounted for 7.6% of all amphibian observations; the remaining 92.4% of observations were made with opportunistic methods.

Six species of lizards were observed (Table 1). Most lizard captures (74.4%) were made

TABLE 1.—Estimated abundances of amphibians and reptiles reported by Burt, 1927 (direct quotations) and this study (1993). Abundance categories follow Clarke *et al.* (1958) and apply only within the limits of the habitat of the species and during the season when individuals are expected to be present: A = abundant (individuals found in large numbers on almost any visit); C = common (individuals found regularly and in small numbers); O = Occasional (individuals found irregularly, not observed during most visits); S = scarce (only a few individuals recorded), and — = absent. Total number of individuals observed during this study are in parentheses

Species	Abundance	
	Burt, 1927	This study
Amphibians		
Ambystoma tigrinum	Several have been brought	O (17)
Acris crepitans	Very common	A (236)
Bufo cognatus[1]	—	—
Bufo woodhousii	Often found, many are seen	A (437)
Gastropryne olivacea	Large numbers in spring	C (206)
Hyla chrysoscelis	One specimen	O (37)
Pseudacris triseriata[1]	—	A (713)
Rana blairi	Very common	A (353)
Rana catesbeiana	Common	C (142)
Spea bombifrons	—	S (3)
Lizards		
Cnemidophorus sexlineatus	Taken in small numbers	C (105)
Crotaphytus collaris	Most common lizard	C (97)
Eumeces obsoletus	Common, easily taken	A (197)
Ophisaurus attenuatus	Taken occasionally	O (10)
Phrynosoma cornutum	Sometimes—small numbers	S (3)
Scincella lateralis	Not in large numbers	O (7)
Snakes		
Agkistrodon contortrix	More abundant than people	O (12)
Carphophis vermis	Very abundant in shaded	—
Coluber constrictor	Many specimens every year	C (29)
Crotalus viridis[2]	Branson reported [one]	—
Crotalus horridus	Branson reported [two]	—
Diadophis punctatus	Abundant	A (617)
Elaphe emoryi	Commonly found	C (28)
Elaphe obsoleta	Not abundant	O (16)
Heterodon nasicus	Supposed to range area	S (2)
Heterodon platirhinos[3]	Not been taken frequently	—
Lampropeltis calligaster	Not very commonly seen	S (1)
Lampropeltis getula	Only specimen taken recently	S (4)
Lampropeltis triangulum	Common	C (35)
Nerodia erythrogaster[1,3]	—	—
Nerodia rhombifer[1,3]	—	—
Nerodia sipedon	Often seen in creek	O (4)
Pituophis catenifer	Common in cultivated areas	S (3)
Regina grahamii[3]	One specimen	—
Storeria dekayi	Rather common species	S (3)
Tantilla gracilis	Often found, abundant—spring	C (39)
Tantilla nigriceps	Branson (1904) reported	S (1)
Thamnophis radix	A specimen	—

TABLE 1.—Continued

Species	Abundance	
	Burt, 1927	This study
Thamnophis sirtalis	Very common	O (11)
Thamnophis proximus	One specimen	S (1)
Tropidoclonion lineatum	Often found	O (18)
Turtles		
Apalone spinifera	taken oftener [than *A. mutica*]	C (10)
Apalone mutica	A specimen	C (9)
Chelydra serpentina	most common [turtle]	C (7)
Chrysemys picta	A turtle was collected	C (19)
Graptemys ouachitensis	One is in Museum	O (14)
Terrapene ornata	Several in recent years	C (25)
Trachemys scripta	—	A (52)

[1] Specimen(s) reported before 1930
[2] Specimen erroneously reported from Riley County
[3] Possibly extirpated in Riley and Geary counties

during opportunistic surveys; 24.6% were captured in funnel traps (Table 2). Seventeen species of snakes were observed. Of the 824 individual snakes observed, the great majority (95%) were captured during opportunistic surveys. Funnel traps yielded 29 individuals (3.5%), and 12 (1.5%) individuals were found beneath artificial shelters. For most snake species, relatively few individuals were observed. The one exception was *Diadophis punctatus,* which was more commonly encountered than all other snakes combined. Six aquatic and one terrestrial turtle species were observed (Table 1). Most of the aquatic turtles we observed were captured in turtle traps (61.2%; Table 3); the remainder (38.8%) were observed during opportunistic surveys. Overall, most reptiles and amphibians were collected opportunistically. Yet, the use of a variety of sampling methods resulted in a more complete survey. Two species (*Ambystoma tigrinum* and *Heterodon nasicus*) were only observed with funnel traps (Table 2).

Most species of reptiles and amphibians were found in more than one habitat type (Tables 2–4) and many of these species are best characterized as habitat generalists. Species that were associated primarily with grasslands were: *Gastrophryne olivacea, Pseudacris triseriata, Ophisaurus attenuatus, Lampropeltis triangulum, Pituophis cantenifer, Tantilla gracilis* and *Tropidoclonion lineatum.* Species found principally in or near wooded habitats included *Hyla chrysoscelis, Scincella lateralis, Agkistrodon contortrix, Storeria dekayi* and *Elaphe obsoleta.* Two species (*Spea bombifrons* and *Heterodon nasicus*) were observed exclusively in river-bottom habitats, whereas others (*e.g., Diadophis punctatus, Bufo woodhousii, Acris crepitans*) reached their highest abundance there.

The 39 species found in this study compare to 46 species reported by Burt (1927) and other collectors before 1930 (Table 1). Records of species reported before 1930 from Riley and Geary counties and not documented by Burt are as follows: *Bufo cognatus*—Kansas: Riley Co: near Manhattan, 1879 (MCZ 2041), Kansas: Geary Co: Junction City, 1912 (KU 5908–9), Kansas: Fort Riley (ANSP 13777), Kansas: Riley Co, 1928 (UMMZ 72388); *Pseudacris triseriata*—Kansas: Riley Co: Manhattan, 1929 (FMNH 18081–82); *Heterodon nasicus*—Kansas: Riley Co: Manhattan (AMNH 36741); *Nerodia erythrogaster*—Kansas: near Manhattan, 1929 (UMMZ 67863, 74433); and *N. rhombifer*—Kansas: near Manhattan, 1929 (UMMZ

TABLE 2.—Reptiles and amphibians captured in funnel traps in two river-bottom habitats on Fort Riley Military Reservation in 1993. Data are numbers of individuals adjusted for the number of trap-days (grassland, 302 trap-days and woodland edge, 437). The number of individuals is in parentheses

Species	Total no. individ.	River-bottom habitat	
		Grassland	Woodland edge
Amphibians			
Ambystoma tigrinum	11	0.036 (11)	—
Bufo woodhousii	31	0.040 (12)	0.043 (19)
Gastrophryne olivacea	1	—	0.002 (1)
Pseudacris triseriata	6	—	0.014 (6)
Rana blairi	90	0.192 (58)	0.073 (32)
All amphibians:	139	0.268 (81)	0.133 (58)
Lizards			
Cnemidophorus sexlineatus	51	0.043 (13)	0.089 (39)
Eumeces obsoletus	37	0.053 (16)	0.048 (21)
All lizards:	88	0.096 (29)	0.137 (60)
Snakes			
Coluber constrictor	11	0.017 (5)	0.014 (6)
Elaphe guttata	2	0.007 (2)	—
Elaphe obsoleta	5	—	0.011 (5)
Heterodon nasicus	2	0.007 (2)	—
Thamnophis sirtalis	5	0.013 (4)	0.002 (1)
All snakes:	25	0.043 (13)	0.027 (12)

67862). Seven snake species reported before 1930 (*Carphophis vermis, Crotalus viridis, C. horridus, Heterodon platirhinos, Nerodia erythrogaster, N. rhombifer, Regina grahamii* and *Thamnophis radix*) were not found in 1993 (Table 1).

Five species collected since 1930 in Riley and Geary counties, but not reported before this date nor during this study were: *Bufo americanus*—Kansas: Riley Co: Manhattan, 1937 (MVZ 36857); *Eumeces faciatus*—Kansas: Riley Co: Manhattan, 1933 (SDSNH 15577–80); *Eumeces septentrionalis*—Kansas: Riley Co: Exit 310 on I-70, 1975 (KU 158488); *Sceloporus undulatus*—Kansas: Riley Co: Manhattan, 1937 (MVZ 36879–80); and *Sistrurus catenatus*—

TABLE 3.—Relative abundance of aquatic turtles observed in four habitat types on Fort Riley Military Reservation in 1993. Data are numbers of individuals captured in live traps adjusted for the number of trap days (rivers, 14 trap days; oxbows, 10; reservoir, 7; and upland pond, 11). The number of individuals is in parentheses

Species	Total no. individ.	Riverine	Oxbow	Reservoir	Pond
Apalone mutica	9	0.64 (9)	0.0	0.0	0.0
Apalone spinifera	7	0.07 (1)	0.60 (6)	0.0	0.0
Chelydra serpentina	3	0.07 (1)	0.10 (1)	0.14 (1)	0.0
Chrysemys picta	10	0.0	0.10 (1)	0.43 (3)	0.54 (6)
Graptemys ouachitensis	8	0.43 (6)	0.20 (2)	0.0	0.0
Trachemys scripta	45	0.0	4.10 (41)	0.14 (1)	0.27 (3)
All aquatic turtles:	82	2.14 (30)	6.0 (60)	0.71 (5)	1.36 (15)

TABLE 4.—Relative abundance of amphibians and terrestrial reptiles observed during semi-quantitative surveys in three habitat types on Fort Riley Military Reservation in 1993. Data are numbers of individuals adjusted for the number of field-hours searched in each habitat (grassland, 167.7 h; woodland, 35.7 h; and river-bottom, 9.4 h). The number of individuals is in parentheses

Species	Total no. individ.	Upland grassland	Upland woodland	River-bottom
Amphibians				
Acris crepitans	48	0.20 (34)	0.17 (6)	0.85 (8)
Bufo woodhousii	131	0.44 (73)	0.03 (1)	6.06 (57)
Gastrophryne olivacea	189	1.03 (172)	0.20 (7)	1.06 (10)
Pseudacris triseriata[1]	451	2.66 (446)	0.0	0.53 (5)
Rana blairi	45	0.22 (37)	0.11 (4)	0.43 (4)
Rana catesbeiana	17	0.06 (10)	0.11 (4)	0.32 (3)
Spea bombifrons	2	0.0	0.0	0.21 (2)
All amphibians:	883	4.60 (772)	0.62 (22)	9.47 (89)
Turtles				
Terrapene ornata	10	0.05 (9)	0.03 (1)	0.0
Lizards				
Cnemidophorus sexlineatus	32	0.15 (25)	0.11 (4)	0.32 (3)
Crotaphytus collaris	87	0.48 (81)	0.17 (6)	0.0
Eumeces obsoletus	131	0.74 (124)	0.11 (4)	0.32 (3)
Ophisaurus attenuatus	5	0.03 (5)	0.0	0.0
Phrynosoma cornutum	2	0.01 (2)	0.0	0.0
Scincella lateralis	4	0.0	0.08 (3)	0.11 (1)
All lizards:	261	1.41 (237)	0.48 (17)	0.74 (7)
Snakes				
Agkistrodon contortrix	8	0.02 (4)	0.11 (4)	0.0
Coluber constrictor	9	0.05 (9)	0.0	0.0
Diadophis punctatus	505	2.24 (376)	0.45 (16)	12.02 (113)
Elpahe emoryi	19	0.10 (16)	0.06 (2)	0.11 (1)
Elaphe obsoleta	1	0.0	0.03 (1)	0.0
Lampropeltis getula	4	0.02 (4)	0.0	0.0
Lampropeltis triangulum	27	0.16 (26)	0.03 (1)	0.0
Nerodia sipedon	2	0.01 (1)	0.03 (1)	0.0
Pituophis catenifer	3	0.02 (3)	0.0	0.0
Storeria dekayi	1	0.0	0.03 (1)	0.0
Tantilla gracilis	39	0.23 (39)	0.0	0.0
Tropidoclonion lineatum	16	0.10 (16)	0.0	0.0
All snakes:	634	2.95 (494)	0.73 (26)	12.13 (114)

[1] Numbers estimated from choruses

Kansas: Riley Co: Sec. 1, T11S, R7E, 1992 (KU 220807), Kansas: Geary Co: 26.5 km E and 4.0 km S Wreford, 1976 (KU 170644).

DISCUSSION

Species presence.—Most species of reptiles and amphibians reported from Riley and Geary counties through 1929 were confirmed on FRMR in 1993 (Table 1). Four species reported from early studies and not encountered during our study (*Bufo cognatus, Carphophis vermis,*

Crotalus horridus and *Thamnophis radix*) have been documented in recent years, in or close to, Riley and Geary counties (Heinrich and Kaufman, 1985; Collins, 1993; Kazmaier, 1993). These four species are at the edges of their ranges in this area and are rarely reported. All may occur on FRMR in low numbers. Four other species reported before 1930 (*Heterodon platirhinos, Nerodia erythrogaster, N. rhombifer* and *Regina grahamii*) have not been reported in recent years and may be extirpated from Riley and Geary counties. The paucity of early reports of these latter four species and their dependence on habitats not well-represented in the northern Flint Hills suggest populations may never have been high. The three water snakes prefer permanent wetlands that occur mainly in the major river valleys and are now greatly reduced in extent. *Heterodon platirhinos* prefers sandy substrates (Platt, 1969) that in Riley and Geary counties are restricted to major river valleys. The final species documented by early collectors and not found in 1993, *Crotalus viridis,* was reported by Branson (1904) and is believed to have been incorrectly labeled. Before 1900, FRMR was a frequent shipping point for specimens collected elsewhere, and many of these specimens were labeled "Fort Riley." No specimens of *Crotalus viridis* are known to have been collected on FRMR, nor is it likely this western species occurred there within historic times.

Of the two species not documented in early studies and observed in 1993, one, *Spea bombifrons,* is an inconspicuous species that occurs in low numbers in the northern Flint Hills (Heinrich and Kaufman, 1985). We suspect this species, which in Riley and Geary counties may be restricted to sandy bottomlands, was simply overlooked by early collectors. *Spea bombifrons* is fossorial and an "explosive" breeder, and could easily be missed during its brief breeding period. This species ranges eastward along the Missouri River floodplain to Illinois (Johnson, 1987), and the eastern limits of its range remain poorly known (*e.g.,* Huggins, 1971). In contrast, the other species not reported by Burt, *Trachemys scripta,* is currently widespread and abundant. This turtle may have benefited from the construction of numerous small impoundments, but the absence of early records is surprising.

Relative abundance.—Differences in relative abundance between early studies and our study (Table 1) may be due to methodological differences, biases inherent in a 1-yr study or reflect real changes. We believe biases in field techniques are responsible for some of the differences reported in Table 1. Using turtle traps, for example, we found four of five aquatic turtle species to be common in appropriate habitat (Table 3). We suspect the fact that early studies documented few turtles had more to do with a limited ability to capture animals rather than any real changes in abundance of these species.

Differences in time spent in various habitats can also bias relative abundance values. In our study, a disproportionate amount of time was spent in sandy bottomlands, a rare habitat of FRMR. This was the one habitat where *Cnemidophoris sexlineatus* was encountered commonly; elsewhere this lizard is found occasionally in sparsely vegetated uplands. Burt (1927) reported spending considerable time along Wildcat Creek, and several species that currently occupy wooded slopes along streams (*Storeria dekayi, Carphophis vermis, Nerodia sipedon* and *Thamnophis sirtalis*) were reported by Burt to be more common than we found them to be in 1993. Lastly, few individuals of the bullsnake (*Pituophis catenifer*) were captured in 1993. Burt reported the bullsnake was common, and in recent years road-killed specimens have been frequently observed (FRMR Natural Resources staff, pers. comm.). The unusually cool, wet conditions during 1993 may have resulted in reduced activity by this snake.

Two species seem to have changed relative abundance between early and recent studies. First, intensive surveys in 1993 for *Phrynosoma cornutum* (Busby *et al.,* 1994) resulted in the located of only three individuals, all in sparsely vegetated uplands. Burt (1927) reported that this lizard was "sometimes taken in small numbers under flat rocks, or near them, and several have been seen in the sand dunes along the Kansas River." These observations and

the large number of specimens taken from this area before 1930 suggest that *Phrynosoma cornutum* has declined on FRMR, as it has through much of its range (Price, 1990). Secondly, populations of *Hyla chrysoscelis,* a woodland species, seem to have increased. Breeding choruses were heard at several locations in 1993, yet Burt (1927) reported only a single specimen.

Relative abundance of all amphibians in 1993 was similar to, or higher than, that reported by Burt (Table 1). The wet spring and summer provided favorable conditions for amphibian activity and reproduction. Studies have shown that annual variation in amphibian reproduction is great and that apparent population sizes fluctuate widely from year to year (Pechmann *et al.,* 1991; Duellman 1995). Thus, the relative abundance we report may have an upward bias due to the favorable conditions for amphibians in 1993. In any event, we found no evidence for amphibian declines on FRMR.

Community stability.—The herpetofaunal assemblage in the FRMR area has experienced modest changes in species composition and relative abundance since the 1920s. We attribute this stability in the herpetofaunal community in large part to the persistence of large areas of native vegetation on FRMR and in the Kansas Flint Hills as a whole. Because of the presence of chert in the soils much of the Flint Hills is unsuitable for cultivation, and consequently, large areas of native tallgrass prairie remain. This stands in marked contrast to the Great Plains and Midwest as a whole, where loss of natural habitats due to agriculture and other development has been pervasive (Samson and Knopf, 1994). Other studies of long-term changes in the central United States have detected major changes in herpetofaunal communities (Ludwig *et al.,* 1992; Lannoo *et al.,* 1994), and loss of habitat has been cited as a major factor for the observed changes. Results of this study point to the important role land uses compatible with the maintenance of native habitats have for the conservation of herpetofaunal communities.

Habitat changes.—Although native vegetation remains the dominant land cover on FRMR, major changes in land cover have occurred since the base was established, and these changes have direct implications for the herpetofauna: (1) The Kansas and Republican river valleys have been extensively altered, both on FRMR and off the base, by agricultural development, urbanization and large reservoir construction. These river valleys provide habitats, including wetlands, low prairie, areas of sandy soils, cottonwood-willow riparian forests, oxbows and large rivers, not found or rarely found elsewhere on the base. On FRMR, most remaining bottomland habitat is heavily disturbed or planted to exotic species. Species likely to be affected adversely by habitat loss and degradation in the river valleys include *Bufo cognatus, Spea bombifrons, Phrynosoma cornutum, Heterodon platirhinos, H. nasicus, Nerodia erythrogaster, N. rhombifer, Regina grahamii, Thamnophis radix* and *T. proximus.* Habitat alteration in the Kansas and Republican river valleys seems to have impacted the herpetofaunal assemblage more than any other single factor. (2) The Flint Hills region originally had less woody vegetation because of fire caused by lightning and Native Americans, and grazing by native herbivores (Abrams, 1986). Fire was actively suppressed on FRMR from its establishment in the 1860s until the 1960s. Beginning in the 1970s, a controlled burn policy was adopted and now areas are burned 2–3 yr of every 5 yr (Craig Phillips, pers. comm.). Although this increase in woody vegetation probably has caused shifts in abundance of some herpetofauna species (*e.g., Hyla chrysoscelis*), the magnitude of woody expansion is sufficiently modest that changes in the herpetofaunal community are not conspicuous from the available data. (3) Currently, there are no livestock grazing on FRMR, and populations of large native grazers are low. Consequently, the height and density of herbaceous vegetation is substantially greater than on surrounding areas used for livestock grazing and presumably is also greater than during pre-European settlement conditions.

This favors some species (*e.g., Ophisaurus attenuatus*) and works to the disadvantage of others (*e.g., Cnemidophorus sexlineatus* and *Phrynosoma cornutum*). In contrast, privately owned lands in this region are mostly used for livestock grazing. (4) Training maneuvers with heavy vehicles create disturbance that impact the vegetation, disturb and compact the soil and have other effects. This disturbance may have complex effects on reptile and amphibian populations. Negative effects no doubt occur through trampling, soil compaction and destruction of vegetation. However, disturbance also creates surface heterogeneity by exposing surface rock, creating temporary pools used by breeding anurans, providing sparsely vegetated areas for basking, etc. Based on our observations at FRMR, one-time or occasional disturbance that increased surface heterogeneity resulted in increased herpetofaunal use, whereas frequent or severe disturbance had strong negative impacts on the herpetofaunal community, much as predicted by the intermediate disturbance hypothesis (Connell, 1978; Peet *et al.,* 1983).

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