

The Natural History and Distribution of the Green Toad (*Bufo debilis*) in Kansas, with a Report on an Effort to Reintroduce the Species into the Cimarron National Grassland

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INTRODUCTION

The objectives for this study were to 1) gather information on the natural history of the Green Toad (*Bufo debilis*) in Kansas, 2) update the distribution in Kansas for this amphibian, and 3) reintroduce within the Cimarron National Grassland (hereinafter referred to as Grassland) the Green Toad and, if possible, other species of amphibians and reptiles considered extirpated from that area.

The Natural History of the Green Toad in Kansas

Collins (1993) summarized the natural history of the Green Toad in Kansas, and the following is a condensation of his account. The Green Toad is known to inhabit portions of the western two tiers of counties that contain grassy prairies and rugged topography above 2,500 feet and that receive an average of under twenty inches of precipitation annually. The Green Toad is primarily nocturnal although it had been observed chorusing by day. Chorusing and breeding of up to 100–120 males is known to have taken place in grassy pools and other temporary wetlands as early as 17 June and as late as 8 August. The eggs are laid in short strings or singly, and two clutches from Wallace County contained 975 and 1,610 eggs.

Historical Distribution of the Green Toad in Kansas

The Green Toad was first reported to inhabit Kansas by Cragin (1894), based on observations of this amphibian made by him in Barber, Hamilton, and Morton counties during September 1886. Unfortunately, no voucher specimens exist to support Cragin's observations, but there is little reason to doubt the reports from Hamilton and Morton counties, because the species has subsequently been verified from both counties. However, Cragin's observation of this species from Barber County is well outside the verified range, and was discredited by Rundquist (1979).

The Green Toad was first verified from Kansas when Taylor (1929) collected specimens in Morton County in 1926 and 1928, and deposited them at the University of Kansas Natural History Museum (KU). Hill (1931) and Kellogg (1932) reported additional specimens from Morton County, and Kellogg (1932) documented the only known specimen (KU 5642) from Grant county, collected in 1911.

Smith (1932) summarized all known literature records and voucher specimens of the Green Toad in Kansas. Greeley and Logan Counties were added based on voucher specimens deposited in the collections at the University of Kansas Natural History Museum and Kansas State University, respectively. Rundquist (1979) discredited the records of Smith (1932) for Greeley, Hamilton, and Logan counties because voucher specimens for them could not be located. However, Rundquist (1979) noted the existence of a single specimen from Logan County (with no exact locality data) in the collection at the University of Michigan (UMMZ 67442).

Platt et al. (1974) recommended that the Green Toad be designated a threatened species in Kansas, based on the fact that this species had probably experienced a population decline over the last 100 years.

Roth and Collins (1979) recorded a single female Green Toad at a new locality in Wallace County, and Stan Roth observed a chorus of 100–120 individuals at that same site on 17–18 June 1980 (Collins, 1993).

Burkhart (1984) added valuable information on the distribution and status of existing populations of Green Toads in Kansas and pointed out areas that he thought might contain suitable habitat for this amphibian in Kansas. During his study, he observed Green Toads in Wallace County and added new localities for it in Logan County, thereby lending support for the report by Smith (1932) for the latter.

The Green Toad in Morton County, Kansas

No reports or records of the Green Toad in Morton County have been made since the Dust Bowl of the 1930s. Historically (pre-1930), these toads were probably able to survive the cyclical dry periods that visit this region of the state. Unfortunately, prior to the 1930s Morton County supported extensive agriculture and grazing activity, and it is probable that the severe 1930s drought, in combination with the conventional farming and ranching practices utilized up to that time, resulted in the extirpation of the Green Toad in this area (Collins and Collins, 1991).

The following paragraph on the Grassland was provided by Jerry Klein (pers. comm., 1991), United States Forest Service, Elkhart, Kansas.

By 1936, most of Morton County could not be utilized agriculturally and, under the Bankhead-Jones Farm Tenant Act, much of this wasteland was purchased by the Soil Conservation Service (SCS). The SCS amassed 107,000 acres by 1939 and the area became the Land Utilization Project. Administration was transferred to the United States Forest Service on 1 January 1954. In 1960, the Land Utilization Project became part of the National Forest System and was named the Cimarron National Grassland. Today, the Grassland is comprised of 108,175 acres in Morton and Stevens Counties. The Grassland supports over 400 oil wells, 5,000 head of cattle, and a multitude of wildlife viewing and recreation activities. With the return of native habitat in this area, it is possible that the Green Toad may again be able to thrive in the Grassland.

METHODS

Natural History

During field trips in the summers of 1991, 1992, and 1993 (Table 2), observations were made on the breeding, habits, habitat, food, predators, and development of Green Toads in western Kansas. Larval anurans were distinguished using the key by Altig (1970).

Distribution

Literature records of collection localities for the Green Toad were compiled and field trips were made to these areas to observe the habitat. By consulting topographic maps and via extensive driving by car, other localities were sought that were similar in appearance to historical sites used by Green Toads.

Reintroductions

In anticipation of the reintroduction part of this project, on 26 August 1991 Jerry Klein and I selected five suitable sites for the Green Toad within the Cimarron National Grasslands in Morton County, using information previously

compiled about habitat requirements of the species. Careful consideration was given to vegetation, topography, geology and hydrology.

Field trips were conducted throughout 1991, 1992, and 1993 to collect Green Toads. The collection methods for adults was to drive and listen for choruses after heavy thunderstorms. When Green Toads were heard they were collected by hand with the aid of a flashlight. Juveniles were collected by hand during the day on the bottoms of breeding pools that had dried and cracked. Other methods used to locate Green Toads included seining small pools and ponds, listening for choruses, and turning rocks.

Samples of Green Toads were reintroduced into the Grasslands as quickly as possible, often the same night. To differentiate each separate release, specimens were marked by clipping a toe of each using fingernail clippers. Beginning in 1992 trips were made to the Grasslands to evaluate the success of the reintroductions.

RESULTS

Natural History

In many instances, some observations made during this study augment previous literature reports while others are contradictory. Several observations are new for the species in Kansas.

Populations of the Green Toad in Kansas were observed to prefer areas in western Kansas that have native prairie with topographical relief and an intermittent stream, that produces temporary pools. Green Toads were highly associated with the pools of water that form within and below canyon breaks, but they were also found below pond dams and stock tanks. They were occasionally found in areas of little relief as long as a stand of native prairie was present, (Photograph 3). Their small size and disjunct populations made dispersal far from these valleys virtually impossible.

Green Toads were abundant in areas of Tertiary conglomerate as well as Cretaceous chinks. Loamy soils high in clay particles support the highest concentrations of Green Toads. A high clay content in the soils of a depression held water longer, gave the larvae of this species more time to develop, and caused the formation of fissures in the mud as the pools dried. These cracks provided protection and moisture during the summer for newly metamorphosed Green Toads.

During this study, breeding activity was observed from 12 June to 2 September. Heavy precipitation and temperatures steadily over 85°F apparently initiate breeding. After these heavy thunderstorms, Green Toads were found primarily in the pools formed along intermittent streams. The size of pools utilized by this amphibian varied from a low of thirty-two square feet to impounded ponds of 2.2 hectares. All pools had mud bottoms.

Flooded vegetation was present at every site Green Toads were observed. The vegetation within the larger pools consisted primarily of Cockerbur (*Xanthium strumarium*), Snow-on-the-mountain (*Euphorbia marginata*), Swamp Smartweed (*Polygonum amphibium*), and Lady's Thumb (*Polygonum persicaria*). The vegetation in the smaller pools was composed of flooded stands of young Cockerbur, Blue Grama (*Bouteloua gracilis*), and Buffalo Grass (*Buchloe dactyloides*).

Male Green Toads were observed chorusing in numbers from a single individual to groups of 80 at a single pool. Most chorusing took place within the

vegetated margins of the pools. The males would prop themselves up on the vegetation with their front arms while chorusing. Chorusing was witnessed up to 5 meters onto the shore. No solitary males, chorusing or otherwise, were ever found inside the ring of vegetation that had grown up around the inside margin of the pools. Male Green Toads were easily collected while chorusing. When approached, they seldom moved or quit calling.

Breeding was observed many times throughout this study. Pairs were found in amplexus primarily in the deeper areas of the pools that were devoid of vegetation. Eggs laid in this section of the pool had no vegetation to which the eggs could become attached and must surely have sunk to the bottom of the pool. When pairs were approached in the water, they dove out of sight with the male still securely holding on. In Wallace County, a pair in amplexus was discovered on the shore 1.7 meters from water.

A mass of 1,287 eggs were laid and fertilized by a pair of Green Toads from Logan County held in a plastic container containing pieces of Swamp Smartweed and approximately five centimeters of water. The eggs were small and laid singly, no clumps or strings were observed in the clutch. The eggs did not adhere to the container or the Smartweed.

Only four living larval Green Toads (from Logan County) were collected even though seining was attempted on every collecting trip and Grasslands follow-up. From my experience at a small pool in Wallace County, development from egg to toadlet took close to one week. On 29 June 1991, I had been at a locality and thoroughly seined it with no success. The area received a heavy rain that night and few small choruses (5–7 male Green Toads) were heard along a system of pools in a canyon. I returned on 7 July 1991 and most of the water in the pool had evaporated, fissures had developed in the mud, and Green Toad toadlets were abundant yet noticeably smaller than any I have seen. Near the center of the dried pool were the remains of approximately 500 larval amphibians. One-hundred of these tadpoles were examined, 98 were identified as the Plains Spadefoot (*Spea bombifrons*) and two were Green Toad larvae.

When not breeding, adult Green Toads were found above the pools on the hillsides in burrows and under rocks and debris. The flora of these hillsides was primarily comprised of Big Bluestem (*Andropogon provincialis*), Little Bluestem (*Andropogon scoparius*), Sideoats Grama (*Bouteloua curtipendula*), Blue Grama, Buffalo Grass, and Soapweed (*Yucca glauca*) liberally distributed across the landscape.

Green Toads were infrequently observed active in the open by day on steep slopes and flat grassy plains at air temperatures up to 104°F. In Logan County, they were observed at the entrance to the burrows of a Plains Pocket Gopher (*Geomys bursarius*) and a Black-tailed Prairie Dog (*Cynomys ludovicianus*). Green Toads were also collected under rocks in Wallace and Logan counties, and under a discarded sheet of tin in Wallace County.

Juvenile Green Toads were the easiest to locate within a few weeks of their metamorphosis. The toadlets were observed to voluntarily come outside of the mud cracks only in the evenings, but when I walked over these cracks during the day the young toads would flush just ahead of my footsteps. During a late summer thunderstorm or on humid night, the toadlets would disperse to refugia on the hillsides. They were easiest to find under rocks at this time.

Both young and adult toads were observed to consume various species of brown ants, small moths, beetles, and small grasshoppers in captivity. Brown ants were readily consumed, while harvester ants were ignored. Three times I placed a small Green Toad near a harvester ant mound in Wichita County and witnessed a

group of these ants attack the toad. Within fifteen seconds the toad appeared to look wet and the ants immediately left it. The toads were recovered, maintained in captivity, and appeared to have no ill affect from the confrontation.

The most common predator of Green Toads was the Plains Garter Snake (*Thamnophis radix*). Predation by these serpents on the adults, toadlets, and tadpoles of the Green Toad was observed directly. A Tiger Salamander (*Ambystoma tigrinum*) larvae, in Wallace County, was also observed to consume a young Green Toad nearing metamorphose on 13 August 1993.

Distribution

The historical localities, new localities, and areas of suitable habitat that may yet yield Green Toads were incorporated into a distribution map (Figure 1).

The Green Toad is known from Wallace, Logan, Wichita, Greeley, Hamilton, Grant, and Morton counties, but has not been re-verified in Grant and Morton Counties since 1911 and 1928 respectively. Only seven juvenile Green Toads (KU 218838-844) were collected in Hamilton County during this study, despite repeated collecting trips. The largest populations of the Green Toad were found in southeast Wallace County, southwest Logan County, and areas immediately adjacent to the south along Ladder Creek. Suitable habitat consists of vast tracts in this area (Figure 1). Habitat to the south is disjunct and only one locality, in Hamilton County, held a very small population. The sandy Pleistocene deposits of the major river valleys are avoided by Green Toads; they rely instead on the smaller tributaries.

Reintroduction

During the summer of 1991, approximately 300 juvenile Green Toads were collected in Greeley, Hamilton, Wallace and Wichita Counties for reintroduction into the Cimarron National Grasslands. Due to unforeseen delays, none of these specimens were reintroduced, although some were deposited as voucher specimens in the herpetology collection at the Museum of Natural History, University of Kansas, Lawrence.

In preparation a second reintroduction effort in 1992, five suitable sites for Green Toads in the Cimarron National Grasslands were identified, each varying somewhat with respect to topography, exposed geology, and hydrology. The dominant vegetative community of Buffalo Grass (*Buchloe dactyloides*), Soapweed (*Yucca glauca*), Camphor Weed (*Heterotheca latifolia*), Little Bluestem (*Andropogon scoparius*), and Sand Sagebrush (*Artemisia filifolia*) was typical at all five sites. Green Toads were again collected and the introductions were made as follows:

Site 1: SE4 NE4 Sec. 33, T33S, R42W. This site had the best qualities. A small concrete dam creates a small shallow permanent pond just below a running windmill. The excess water of the pond spills into an adjacent intermittent stream that drains the system of rocky hillsides all around. This site has the highest soil clay content of the five sites and fissures were observed in the dryer regions of the stream. A mass of 1,287 eggs collected in Logan County was placed in the windmill pond along with twenty-four adult female and forty-two adult male Green Toads on 7 July 1992. The largest left toe, second from the outside, was clipped on all specimens from this first release.

An additional fourteen adult male Green Toads were released on 18 July 1993.

The third toe in from the outside on the left foot was clipped.

On 26 August 1993, one adult female and six juveniles collected in Logan County on 21 August 1993 were released with an adult male from the same county collected on 15 August 1993. Seventy-five juvenile Green Toads from Logan County, collected on 26 August 1993, were released the same day. Gene Brehm, Wildlife & Parks videographer, filmed this release. During this third reintroduction the Green Toads were released without their toes being clipped for identification.

In each of the remaining four sites sixty-five newly metamorphosed Green Toads were released on 16 August 1992. All of the toadlets were collected on 13 August 1992 from localities in Logan, Wallace, and Wichita Counties.

Site 2: E2 SW4 Sec. 32, T33S, R42W. Situated at the juncture of two valleys is a large pond basin that remained dry during the course of this study, but does periodically hold water, Jerry Klein (pers. com.). This site was selected because of its large drainage and the great number of plants growing in the bottom of the basin. Topographic relief and rock outcrops are not present at this site. Green Toads released at this site can be identified by outside digit on the right side being clipped.

Site 3: SE4 SW4 Sec. 20, T33S, R42W. This site is very easily accessible as a road runs parallel to an eroded stream channel at the bottom of the valley. The topography is moderate and there are numerous Tertiary Oligocene rock outcrops. The stream was never observed running during the study, however small pools were observed at various points along its course during 1992 and 1993. The soils here seem to hold water well and also produce fissures in the mud for newly metamorphosed Green Toads. Green Toads released at this site can be identified by the outside toe on the left foot being clipped.

Site 4: NE4 Sec. 10, T33S, R42W. This is a rugged area with numerous rock outcrops in a moderate sized drainage with fairly poor water holding soils. Wet areas were observed along the stream in 1993 but no pools were observed. Green Toads released at this site can be identified by the largest toe on the right foot, second from outside, being clipped.

Site 5: W2 Sec. 20, T33S, R42W. This locality consists of low rolling hills, moderate drainage, runoff from a working windmill, and few rock outcrops. The toads were released at the windmill pond and at two small pools just south of the pond. Green Toads released at this site can be identified by the middle toe of the right foot being clipped.

Follow-up

The status of the Green Toad in the Cimarron National Grasslands was examined after every release and during periodic field trips to the area. Standing water was seined and rocks were turned in an effort to discover any of the reintroductions or existing populations. No Green Toads were seen during these follow-up investigations.

In 1992, follow-up field trips took place on 28 June, 7-8 July, 26 July, 16 August, and 6 September. In 1993, follow-up field trips took place on 27 June, 18 July, 7-8 August, 26 August, and 5 September. Again, no Green Toads were seen during these follow-up investigations.

DISCUSSION

The extensive observations on the natural history of the Green Toad made during this study are notable. Relatively little was known concerning the ecology of the Green Toad in Kansas and the information presented will aid in making decisions concerning activities that may effect Green Toads.

The time that Green Toads remain as larvae is unknown. Burkhart (1984) estimated the larval life to exceed 25 days in Kansas. From one observation I placed development from egg to toadlet at one week. The actual time is probably dependant on the evaporation and ground absorption rates, water temperature and oxygen content, and the extent of competition between the larvae of Green Toads and of that of sympatric anurans.

A better definition of the distribution of the Green Toad within Kansas was established. The assessment of Green Toad habitat, at localities where they had previously been collected, led to the discoveries of new populations. Voucher specimens and recorded observations from this study have more than quadrupled the number of previously known localities for the Green Toad in Kansas. The Green Toad, in northern localities, is very abundant and often conspicuous. While farther south, historic populations are extirpated or scarce at best. The historic distribution may have once been continuous across these two areas until agriculture activities changed the habitat.

Follow-up field work on the Green Toad reintroductions into the Cimarron National Grasslands yielded no information. No Green Toads were seen or heard. Additional follow-up field work is needed to determine if the Green Toad has been re-established in the Grasslands. Given the secretive nature of these amphibians, however, positive proof may never be obtained, and lack of evidence should not affect future attempts at reintroduction.

During the course of this project, the Red-spotted Toad (*Bufo punctatus*), Eastern Hognose Snake (*Heterodon platirhinos*), Longnose Snake (*Rhinocheilus lecontei*), and the Checkered Garter Snake (*Thamnophis marcianus*) were to be reintroduced as the opportunities arose to do so. These species were selected because Collins and Collins (1992) found no specimens of these four species during their fieldwork in 1987, and because all but the Longnose Snake, last taken in the Grassland in 1979, had not been recorded from the area in over sixty years. Subsequently, Ball (1992) demonstrated that the Longnose Snake and Checkered Garter Snake were still common in the Grassland. His field work and data gathering took place between 1985 and 1991, but were unpublished and unknown to Collins and Collins (1992). Given the discoveries by Ball (1992), reintroductions for the Longnose Snake and Checkered Garter Snake are now considered unnecessary.

Not enough specimens of the Eastern Hognose Snake could be obtained at one time for a viable reintroduction to be attempted, and the Red-spotted Toad was never reintroduced either, because no specimens were obtained. Nonetheless, both taxa remain candidates for reintroduction efforts in the future.

ACKNOWLEDGEMENTS

Many individuals contributed in numerous ways during the course of this study. Without their assistance this project could not have been done .

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My father, R. Bruce Taggart (Hays), shared advice, while I attempted my first project of this type. Joseph T. and Suzanne L. Collins (Lawrence) have been the best friends a budding herpetologist could ever have and they have each assisted on this report.

I am indebted to Karen Toepfer (Hays) for graciously babysitting 300 Green Toadlets for two weeks and John Simmons (Lawrence) who kindly supplied me with information on the Green Toads deposited at KU, under his care.

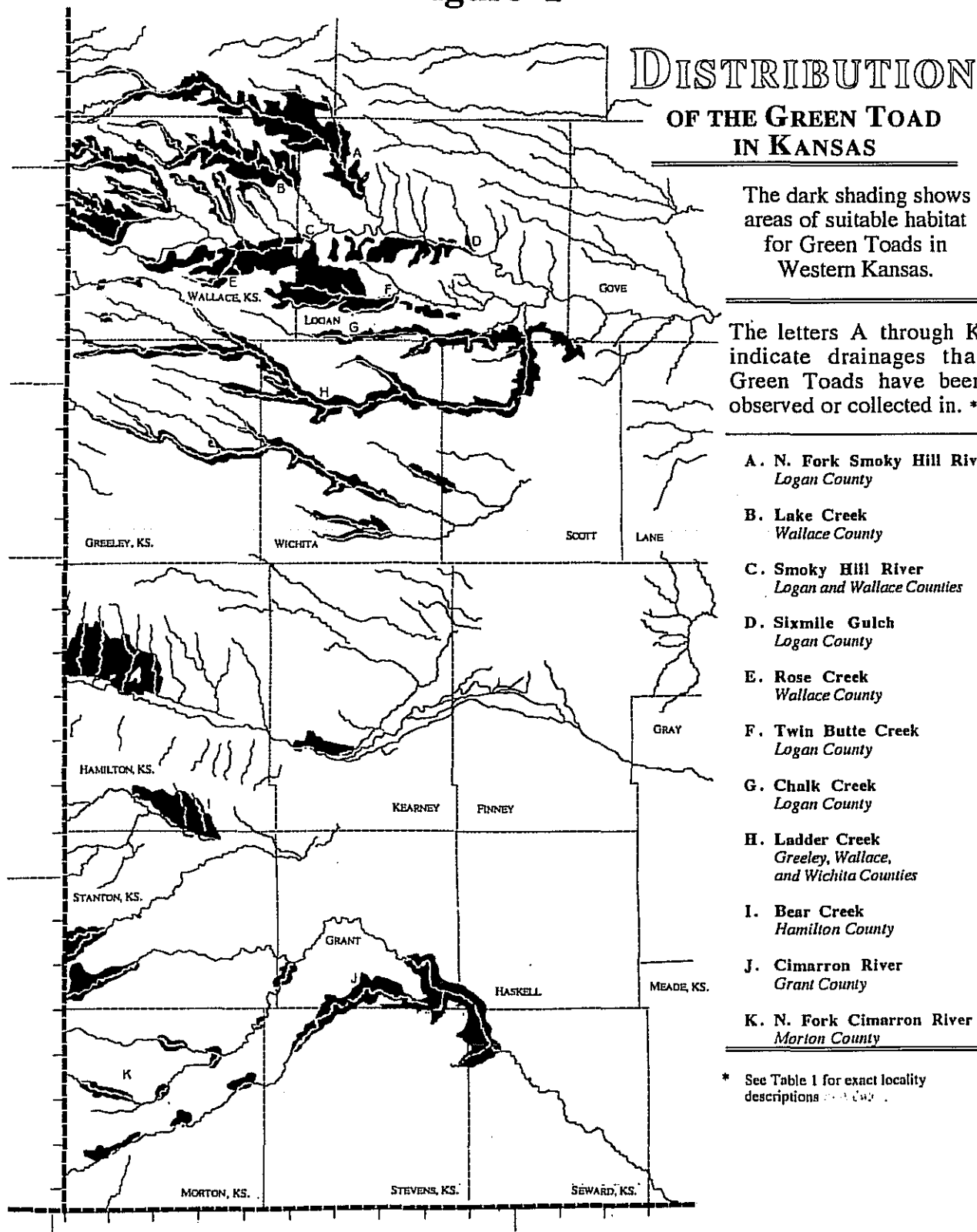
Other friends who assisted with advice are Kelly J. Irwin (Topeka) and Eric M. Rundquist (Lawrence).

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- Figure 1 -



- Table 1 -

Localities in selected Kansas drainages where Green Toads were observed during this study. An asterisk () indicates the two drainages in which no Green Toads were observed, but did contain suitable habitat .*

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- | | |
|---|--|
| <p>A. North Fork Smoky Hill River.
 <i>Logan County</i>
 T11S, R37W
 Section - 13</p> <p>B. Lake Creek.
 <i>Wallace County</i>
 T12S, R38W
 Section - 16</p> <p>C. Smoky Hill River.
 <i>Logan County</i>
 T13S, R34W
 Sections - 32, 33
 T13S, R35W
 Sections - 29, 32, 35
 NE4, Sec.- 27
 T13S, R36W
 Section - 27, 28
 T13S, R37W
 E2, Sec. 35
 SE4, Sec. 26, 32
 T14S, R34W
 Sections - 4, 6, 8
 NW4, Sec.- 7
 NE4, Sec.-17
 T14S, R35W
 Sections - 3, 6
 T14S, R36W
 SE4, Sec.- 5
 Section - 6
 T14S, R37W
 W2 Sec. 4
 <i>Wallace County</i>
 T14S, R39W
 Sections - 9, 12, 13, 14
 S2, Sec.- 11
 NE4, Sections - 8, 11
 NW4, Sec.- 29
 NE4, Sec.- 30
 T14S, R38W
 N2, Sec. 17
 Sections - 4, 5, 6, 8, 9, 16
 Section 7</p> <p>D. Sixmile Gulch
 <i>Logan County</i>
 T13S, R34W
 N2, Sec.- 23</p> | <p>E. Rose Creek.
 <i>Wallace County</i>
 T14S, R39W
 SW4, Sec.- 10
 Sections - 15, 16, 21</p> <p>F. Twin Butte Creek.
 <i>Logan County</i>
 T14S, R37W
 S2 Sec. 29
 NE4, Sec. 20
 SE4, Sec. 28
 N2, Sec. 23
 S2NW4, Sec. 21
 T15S, R37W
 S2, Sections - 4, 5,</p> <p>G. Chalk Creek.
 <i>Logan County.</i>
 T15S, R36W
 Sections - 32, 36</p> <p>H. Ladder Creek.
 <i>Greeley County</i>
 T16S, R39W
 Sections - 8, 11
 <i>Wallace County</i>
 T15S, R40W
 Section - 35
 <i>Wichita County</i>
 T16S, R38W
 Section - 19</p> <p>I. Bear Creek.
 <i>Hamilton County</i>
 T26S, R42W
 SE4, Sec. 12</p> <p>J. Cimarron River *.
 <i>Grant County</i>
 No exact locality.</p> <p>K. North Fork Cimarron River *.
 <i>Morton County</i>
 18 mi N. Elkhart</p> |
|---|--|

- Table 2 -

Summary of Field Work during this study.

<i>Date</i>	<i>County</i>	
<u>1991</u>		
29 June	Wallace	Examined habitat of existing Green Toad localities.
6 July	Hamilton	Searched for new localities. Collected 7 juveniles. KU vouchers.
	Greeley	Searched for new localities. Collected 59 juveniles. KU vouchers.
	Wallace	Searched for new localities. Collected 162 juveniles and one adult male.
7 July	Wichita	Searched for new localities. Collected 67 juveniles. KU vouchers.
26 August	Morton	Selected sites in the Grassland.
<u>1992</u>		
6 June	Wallace	Adult male and adult female collected. KHS field trip. Taken to KU.
7 June	Logan	Adult male collected. KHS field trip. KU voucher specimen.
12 June	Logan	Collected one adult male while chorusing.
6 July	Logan	Collected 23 males, 42 females, and a mass of 1,287 eggs.
7 July	Morton	Released 24 males, 42 females, and eggs collected earlier.
8 July	Hamilton	Searched for new localities and known locality of Green Toads. Observed none.
	Grant	Searched for new localities. Observed no Green Toads.
25 July	Logan	Searched for Green Toads. During the day and none were observed or collected.
26 July	Morton	Follow-up. No Green Toads were observed or collected.
13 August	Logan	Collected 116 juveniles.
	Wallace	Collected 97 juveniles.
	Wichita	Collected 47 juveniles.
16 August	Morton	Released 65 juveniles each at Grassland sites 2,3,4, and 5.
2 September	Wallace	Single adult male chorusing.
6 September	Morton	Follow-up. No Green Toads were observed or collected.
<u>1993</u>		
27 June	Morton	Follow-up. No Green Toads were observed or collected.
17 July	Logan	14 adult males collected at night while chorusing.
18 July	Morton	14 adult males released. No other Green Toads were observed or collected.
7-8 August	Morton	Follow-up. No Green Toads were observed or collected.
15 August	Logan	Collected 1 adult male while chorusing.
21 August	Logan	Collected 1 adult female and 6 juveniles active by day.
26 August	Logan	Collected 75 juveniles during the morning.
	Morton	Released Toads collected 15-26 August. No other Green Toads seen.
5 September	Logan	During the day, none were observed or collected.

FEATURE ARTICLES

Status of *Bufo debilis* (Anura: Bufonidae) in Kansas

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Cragin (1894) first reported the Green Toad, *Bufo debilis* Girard, from Kansas, based on specimens he allegedly observed in September 1886 in Morton, Barber, and southern Hamilton counties. Voucher specimens do not exist from that report and Rundquist (1979) has discredited the specimen from Barber County.

Taylor (1929) noted an unspecified number of Morton County specimens he observed and collected from 1926–1928. Hill (1931) and Kellogg (1932) reported on Taylor's Morton County specimens in their respective accounts. Additionally, Kellogg (1932) documented the only known specimen from Grant County (KU 5642, no specific locality), collected in 1911.

Smith (1932) compiled all known literature records and voucher specimens of *Bufo debilis* in Kansas. He added one Greeley County specimen from the University of Kansas Natural History Museum and six Logan County specimens from the Kansas State College (now Kansas State University) vertebrate collection.

Rundquist (1979) discredited Smith's (1932) records for Greeley and Logan counties, as well as Cragin's (1894) Hamilton County observation, because voucher specimens could not be located. Rundquist (1979) confirmed that a single specimen from Logan County (no other data) did exist in the University of Michigan Museum of Zoology (UMMZ 67442).

Platt et al. (1974) listed *Bufo debilis* as rare in Kansas and, subsequently, this anuran received formal protection as a threatened species under the Kansas Nongame and Endangered Species Conservation Act of 1975 (K.S.A. 32-501 to 32-510) and Kansas Department of Wildlife and Parks regulations K.A.R. 23-17-1 and 23-17-2. As defined by Kansas Administrative Regulation 23-17-2, southwest Logan and southeast Wallace counties became designated

critical habitat for *B. debilis* populations in Kansas.

Roth and Collins (1979) reported a single female (KU 182086) at a new locality in Wallace County (see Appendix). Burkhart (1984) contributed information regarding the distribution and status of existing populations, and identified areas of suitable habitat within the remainder of the state. He did not observe *Bufo debilis* in Wallace County, but collected new locality vouchers (KU 192337–38 and KU 193301–03) along the Twin Butte Creek drainage in Logan County (Figure 1, Site C).

The principal objectives of this project were to make observations on *Bufo debilis* populations and update their distribution in Kansas. Observations were made from 1991 to 1994. If enough specimens were collected to support a restocking effort, a repatriation of *B. debilis* into the Cimarron National Grassland was to be attempted.

The collection localities of *Bufo debilis* museum specimens and literature reports were examined and evaluated as to vegetation type, soil composition, geology, hydrology, and topography. Using these assessments as basic habitat requirements, potential localities were sought. When searching for possible sites, areas of relief were determined from USGS 1:100,000-scale metric topographical maps. These areas were then physically examined to assess their similarity to the historical localities.

Once suitable habitat was located, field trips were taken on rainy nights during the late spring and throughout the summer during the course of this study. Roads to pre-selected optimal sites through suitable habitat were driven at night after heavy thunderstorms. Frequent stops were made to listen for choruses in adjacent pasture lands.

Specimens of *Bufo debilis* were observed in Wallace, Logan, Wichita, Greeley, and Hamilton counties. Observations were made on the breeding, habitat, food, and preda-

tors of this secretive amphibian. Voucher specimens and recorded observations (see Appendix) from this study have more accurately detailed the range of *B. debilis* in Kansas.

Bufo debilis seems to prefer areas of native prairie vegetation with considerable topographical relief and presence of an intermittent stream. Following thunderstorms, they congregate at pools of water formed within and below canyon breaks. All localities at which *B. debilis* were observed were grazed by cattle. *B. debilis* was abundant in geologic substrates of conglomerate (Tertiary: Miocene: Ogallala) as well as in association with large limestone and chalk outcrops (Cretaceous: Niobrara). Loamy soils, in particular those soils characterized by slow to moderate permeability, moderate to high water holding capacity and rapid surface runoff, supported the highest concentrations of *B. debilis*. The Colby-Kim-Midway soil association of Wallace and Logan counties is characterized by these properties and supports the greatest concentration of *B. debilis* in Kansas.

The high clay content in these soils permits greater moisture retention, permitting anuran larvae maximal developmental time. These soils also enhance fissure formation in the mud of drying pools, providing microhabitat for recently transformed toadlets. Creusere and Whitford (1976) noted similar affinities of arid-adapted anurans, including *Bufo debilis*, to mud fissures, and noted that of all refugia available to juvenile anurans, the least percentage of mortality was found among the individuals that used the fissures. At every *B. debilis* chorus site, juveniles were ultimately seen in association with the fissures of the dried pool bottom within a few weeks of metamorphosis.

The toadlets voluntarily emerged from mud cracks only at dusk. However, as I walked on the dried pool bottom during the day, toadlets did emerge just ahead of my footsteps. By the end of the summer, juvenile *Bufo debilis* were observed less frequently in association with the pools, but were more commonly found under rocks on the surrounding hillsides.

Breeding activity was observed from 12 June through 2 September after heavy precipitation and daytime air temperatures greater than 29° C. The breeding pools were dry and covered with dense vegetation prior to flooding. The size of the pool utilized varied from 2.9 m² to shallow impounded ponds of up to 3,000 m² and the depth of the pools varied from 33–76 cm. At a site in Logan County, *Bufo debilis* used the pooled runoff from a nearby stock tank for breeding. All the pools used by *B. debilis* had bottoms composed of a high clay content sediment, never limestone or conglomerate. The vegetation was emergent around the pool margin and inundated by water in the deeper sections of the pools.

Flooded vegetation was present at every site *Bufo debilis* were observed. Vegetation in the larger pools consisted primarily of *Xanthium strumarium* (Cocklebur), *Euphor-*

bia marginata (Snow-on-the-mountain), *Polygonum amphibium* (Swamp Smartweed), and *P. persicaria* (Lady's Thumb). The primary vegetation in the smaller pools was composed of flooded stands of small *X. strumarium*, *Bouteloua gracilis* (Blue Grama), and *Buchloe dactyloides* (Buffalo Grass). Breeding sites did not possess representatives of plant families characteristic of a permanent aquatic environment (e.g. sedges, duckweeds, cattails or the pond weeds). Small fish and blooms of filamentous algae were infrequently observed in the pools.

At the breeding pools, the number of adult male *Bufo debilis* observed varied from a single individual to choruses of approximately 80 specimens. Adult males called with their forelegs propped on the vegetation around the pool margin. When approached they never moved nor quit calling and were therefore easily collected by hand with the aid of a headlamp. Chorusing by individual adult males was witnessed up to five m from the water's edge on mud banks and rain-moistened grassy slopes.

Pairs of *Bufo debilis* in pectoral amplexus were found inside the ring of emergent vegetation around the inner margin of the pools. When pairs were approached, the female would often dive out of sight, still carrying the male. A single pair in amplexus was discovered on the shore in Wallace County, 1.7 m from the pool.

Other animals occupied these same pools as well. Among other amphibia, *Ambystoma mavortium* (Barred Tiger Salamander), *Spea bombifrons* (Plains Spadefoot), *Rana blairi* (Plains Leopard Frog), *Bufo woodhousii* (Woodhouse's Toad), *Pseudacris maculata/triseriata* complex (Chorus Frog), *Acris crepitans* (Northern Cricket Frog), and *Rana catesbeiana* (Bullfrog) were all observed at the pools in decreasing order of abundance. The most numerous macroscopic invertebrates observed in the pools included members of the Crustacean families Streptocephalidae, Leptestheriidae, and Lepiduridae (Eubranchiopoda) (Pennak 1953). Other Crustaceans identified from the pools were Daphnidae and Bosminidae (Cladocera) and Cyclopidae and Senecellidae (Copepoda).

On 6 July 1992, a pair in amplexus was collected in Logan County and temporarily maintained in a four-quart hard plastic container with cuttings of *Polygonum amphibium* and approximately five cm of water. A mass of 1,287 eggs was laid by the female shortly after being placed in the container. The eggs were laid singly and no strings were observed in the clutch. The eggs did not adhere to themselves, the container, or *P. amphibium*. The egg mass was deposited at a site at the Cimmaron National Grassland later the same night. Fertilization was not confirmed though it may have occurred.

Adult *Bufo debilis* were found by day at the pools, and on the surrounding hillsides under rocks and human refuse, and once at the entrance to a *Cynomys ludovicianus* (Black-Tailed Prairie Dog) burrow in Logan County. The flora of

these hillsides was comprised primarily of *Agropyron smithii* (Western Wheatgrass), *Sporobolus giganteus* (Tall Dropseed), *Andropogon provincialis* (Big Bluestem), *A. scoparius* (Little Bluestem), *Bouteloua curtipendula* (Sideoats Grama), *B. gracilis*, and *B. dactyloides*. Soapweed (*Yucca glauca*) was liberally distributed across the upland landscape.

Bufo debilis was occasionally observed in the open on the steep slopes and grassy plains during the day. An adult male from Logan County was collected on a talus slope at an air temperature of 35° C at 1321 hours, and a sub-adult individual was found along a cattle trail in Wallace County at 1516 hours and an ambient air temperature of 24° C. Seymour (1973) reported *B. debilis* active by day at 15° C. He observed them basking on wet mud banks in direct sunlight and increasing their body temperatures up to 30.9° C.

In the field, Green Toads were observed consuming various small insects, principally ants (Hymenoptera) and small Lepidopterans, Coleopterans, and Orthopterans. Harvester ants (*Pogonomyrmex occidentalis*), which were common in areas of suitable habitat, were typically ignored. Three times a single *Bufo debilis* toadlet was placed near a harvester ant mound in Wichita County. Three to seven ants attacked the toadlet each time, and within fifteen seconds the toadlet appeared wet and the ants immediately left it. The toadlet was recovered and maintained for two weeks in captivity with no apparent ill effects resulting from the confrontation.

Thamnophis radix (Plains Garter Snake) was the most commonly observed predator on the adults, toadlets, and tadpoles of *Bufo debilis*. A larval *Ambystoma mavortium* was observed consuming a young *B. debilis* near metamorphosis at night on 13 August 1993 in Wallace County. Creusere and Whitford (1976) observed predation on *B. debilis* by *Heterodon nasicus* (Western Hognose Snake), *Masticophis flagellum* (Coachwhip), and *Pituophis catenifer* (Gopher Snake) in the Chihuahuan Desert. All three of these serpents are common throughout western Kansas (Collins, 1993).

Time to metamorphosis in *Bufo debilis* is uncertain. Zweifel (1968) studied the eggs from specimens collected in Cochise County, Arizona, and found that at an optimal water temperature of 33.1° C the embryos hatched within 24 hours. At 18.2° C, hatching required 140 hours. Strecker (1926) suggested that metamorphosis of *B. debilis* in Texas took less than three weeks. Burkhart (1984) estimated the larval life to exceed 25 days in Kansas.

Based on one observation at a pool in Wallace County, development from zygote to toadlet was placed at eight days. On 29 June 1991, the pool was seined and contained no amphibian larvae. The area received heavy rain that night and a few small choruses of *Bufo debilis*, 5–7 males each, were heard along the system of pools in the canyon, along with smaller choruses of *Rana blairi*, *Spea*

bombifrons, and *Bufo woodhousii*. On 7 July 1991, most of the water in the pool had evaporated, fissures had developed in the mud, and toadlets were abundant on the dried pool bottom. Near the center of the dried pool were approximately 500 dead anuran larvae. *S. bombifrons* tadpoles were the only species of larvae identified (Altig 1970). The precise time from zygote to metamorphosis is probably dependent on a number of environmental variables, e.g. soil permeability, evaporation rate, water temperature (Zweifel 1968), dissolved oxygen content, and competition between *B. debilis* larvae and that of sympatric anurans, as well as constraints of phylogeny.

Green Toads appear to avoid the large sandy alluvial floodplains of the major river valleys, as they were only found in more rugged habitat adjacent to smaller tributaries. However, during heavy rains, tadpoles or eggs are surely swept into the larger rivers. This mechanism may serve as a primary means of dispersal down the watershed and allow for gene exchange across otherwise isolated populations. The small individual size and currently disjunct populations of *Bufo debilis* make terrestrial dispersal far from these valleys virtually impossible. In northwestern Kansas localities, *B. debilis* is abundant and often conspicuous. Historic populations farther south are extirpated or scarce at best. The historic distribution may have once been continuous across these two areas until agricultural practices and simultaneous drought modified the habitat.

The largest populations of *Bufo debilis* were found in the Smoky Hill River drainage of southeast Wallace County, southwest Logan County, and areas immediately adjacent to the south, along Ladder Creek in Greeley and Wichita counties (Fig. 1). Suitable habitat exists in vast contiguous tracts in this area. Habitat to the south, in the Arkansas River drainage, is isolated due to large-scale agricultural activity.

Hammerson (1991) reported a single specimen of *Bufo debilis* from Picture Canyon in Baca County, Colorado, collected on 12 June 1988 (Sec. 7, T35S, R47W). This locality is 62.8 km west of Morton County, Kansas on the Colorado and New Mexico border at the western edge of what were the most extreme dust bowl conditions (Fig. 2). Picture Canyon is part of the deeply dissected and rugged Black Mesa system, and has not been cultivated within historical times.

Only seven juvenile *Bufo debilis* (KU 218838–844) were collected in Hamilton County in 1991. Since then no specimens have been observed there, despite repeated collecting trips the subsequent three summers. However, rainfall conditions in southwest Kansas appeared suboptimal during this study.

Bufo debilis has not been observed in Grant and Morton counties since 1911 and 1928 respectively. Collins and Collins (1991) thoroughly studied the herpetofauna of the

Cimarron National Grassland and indicated that the severe change in habitat conditions due to the drought of the 1930's, combined with the prevailing farming and ranching practices at that time, resulted in the extirpation of *Bufo debilis* from Morton County and adjacent areas. Morton County was one of the most devastated areas during the Dust Bowl (Figure 2). Today 43,777 ha of Morton County has been incorporated into the Cimarron National Grass-

land (Fig. 1) and reseeded to native grasses and forbs, thereby restoring suitable habitat and offering protection under the auspices of the United States Forest Service.

I toe-clipped and released 422 *Bufo debilis* (see Appendix) at five sites in the Cimarron National Grassland in 1992 and 1993. In addition, a mass of 1,287 eggs were placed in a windmill runoff pool in 1992 at the Grassland site considered the most suitable for *B. debilis* based on

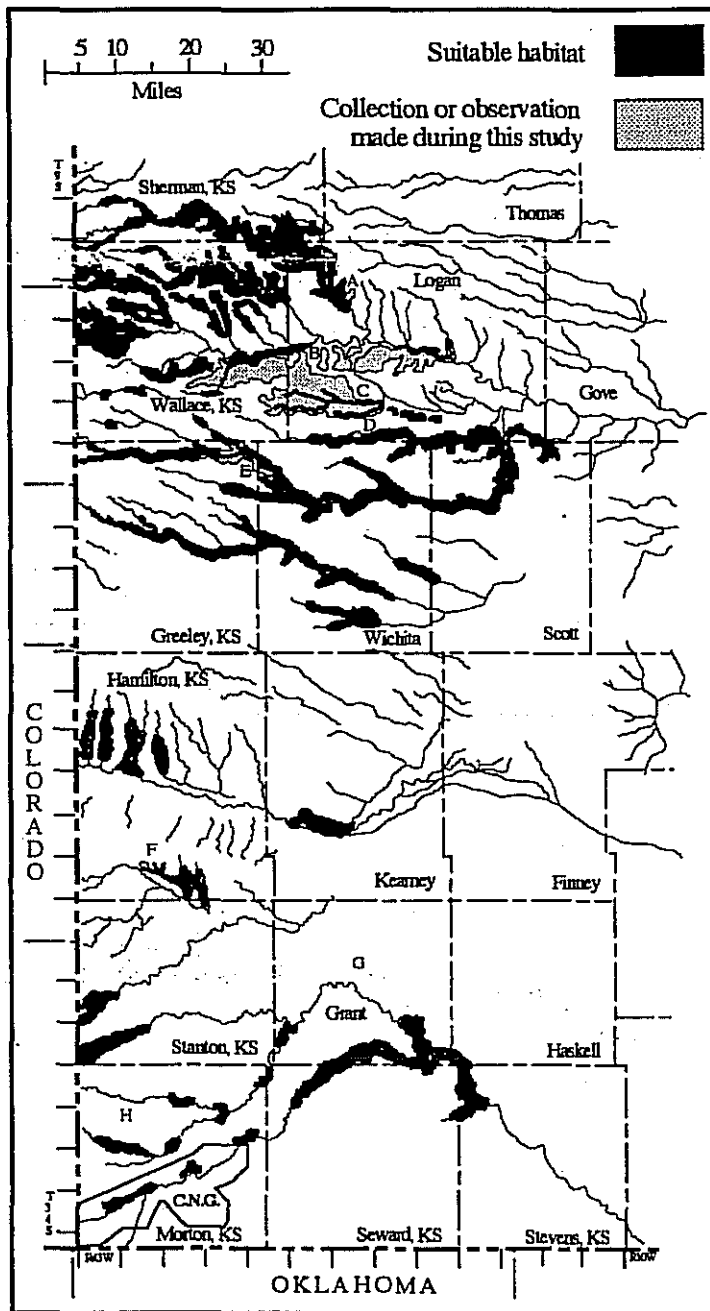


Figure 1. General localities where Green Toads (*Bufo debilis*) were observed or collected during this study and areas of their possible occurrence within Kansas. C.N.G. = Cimarron National Grassland, the site of an attempted repatriation. Letters A-H correspond to localities listed in the Appendix.

geological, hydrological, and vegetative similarities to the northwestern Kansas sites with extant populations. No specimens have been observed on the Grassland since the repatriations and future work is needed to determine the present status of the reintroductions and to assess the feasibility for further reintroductions.

I recommend that future studies examine the genetic relationships of *Bufo debilis* throughout Kansas and adjacent states using a marker based on nuclear DNA (i.e. allozymes). How long the Smoky Hill River populations have existed in allopatry and the degree of divergence they have reached in isolation cannot be assessed without these data. This information is important from a biodiversity and conservation point of view; it will allow us to determine if this population is simply disjunct or a new taxon endemic

to Kansas. Determining genetic diversity in these populations will also be very useful in future repatriation attempts.

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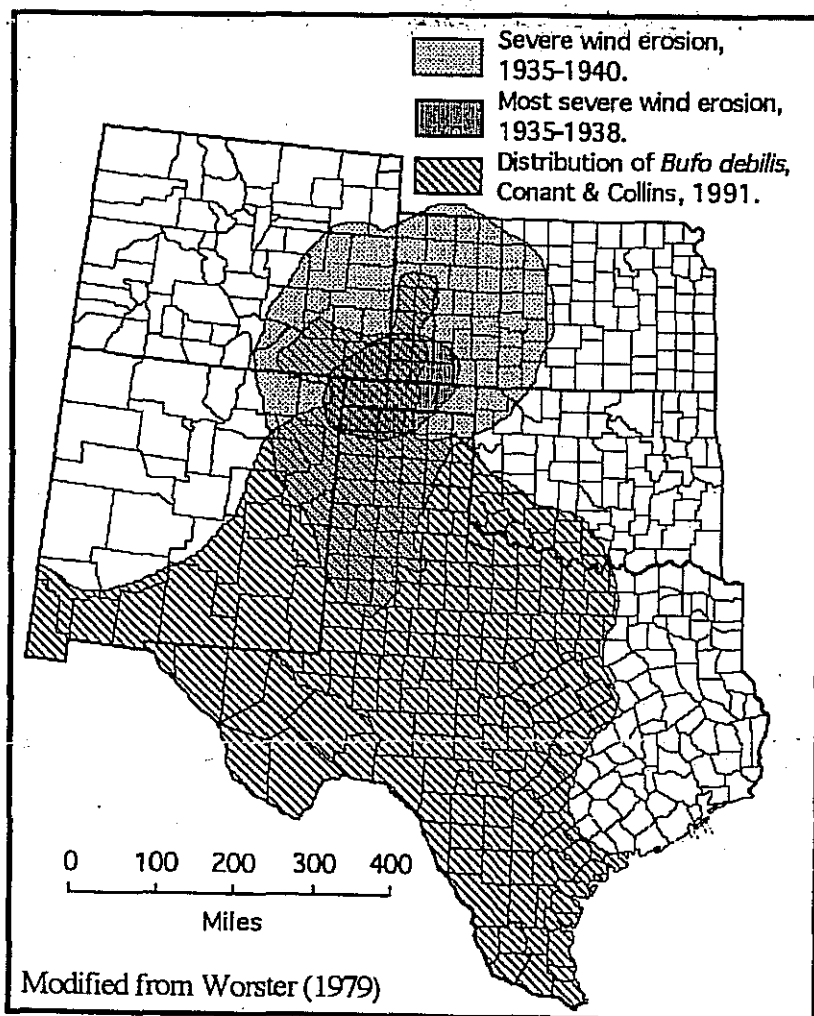


Figure 2. The Dust Bowl of the 1930's. Extent of erosional damage attributed to the wind during the drought and subsequent Dust Bowl in the lower Great Plains from 1935 through 1940. Drought conditions extended far beyond the boundaries shown here, but this area was particularly hard hit by drought and wind erosion. The range of the Green Toad (*Bufo debilis*) has been superimposed. Modified from Worster (1979).

Bufo debilis back into the Cimarron National Grassland. Eugene D. Fleharty (FHSU), Kelly J. Irwin (Texas A&M University), Jay Taggart, R. Bruce Taggart, and Karen Toepfer also rendered assistance.

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APPENDIX

Sites where *Bufo debilis* were observed and/or specimens were or have been collected. Lettered headings correspond to the letters in Figure 1.

A. North Fork Smoky Hill River. Logan Co: T13S, R36W, Sec. 2. B. Smoky Hill River's Southern tributaries. Logan Co: T13S, R34W, N Sec. 23 (KU 220752-53); Sec. 32, 33: T13S, R35W, Sec. 29, 32, 35; NE Sec. 27 (KU 211368, KU 212582); T13S, R36W, Sec. 27, 28: T13S, R37W, E Sec. 35; SE Sec. 26, 32: T14S, R34W, Sec. 4, 6, 8; NW Sec. 7; NE Sec. 17: T14S, R35W, Sec. 3, 6: T14S, R36W, SE Sec. 5; Sec. 6: T14S, R37W, W Sec. 4. Wallace Co: T14S, R38W, N Sec. 17; Sec. 4, 5, 6, 8, 9, 16; Sec. 7 (KU 186731-36, KU 153046); 6.4 km S Wallace (KU 182086): T14S, R39W, Sec. 9, 12, 13, 14, 15, 16, 21; S Sec. 11; NE Sec. 8, 11; NW Sec. 29; NE Sec. 30; SW Sec. 10; Sec. 12 (KU 220754-55). C. Twin Butte Creek drainage. Logan Co: T13S, R37W, Sec. 35 (KU 193303); T14S, R37W, S Sec. 29; NE Sec. 20; SE Sec. 28; N Sec. 23; NW Sec. 21: T15S, R37W, S Sec. 4, 5; 24 km S & 6.4 km W McAllaster (KU 192337-38); 19.6 km S & 4.8 km W McAllaster (KU 193301-02). D. Chalk Creek drainage. Logan Co: T15S, R36W, Sec. 32, 36. E. Ladder Creek Drainage. Greeley Co: T16S, R39W, Sec. 8, 11 (KU 218823-27). Wallace County, T15S, R40W, Sec. 35. Wichita Co: T16S, R38W, Sec. 19 (KU 218845). F. Bear Creek drainage. Hamilton Co: T26S, R42W, SE Sec. 12 (KU 218838-44). G. Cimarron River drainage. Grant Co: No specific locality (KU 5642); No specific locality (UMIMZ 67442). H. North Fork Cimarron River drainage. Morton Co: no specific locality (KU 564345), 18 mi N Elkhart (KU 5646-5654).

Release sites and number of *Bufo debilis* released (males:females:juveniles:embryos).

T33S, R42W, SE/NE Sec. 33, (57:25:81:1287); E/SW Sec. 32, (0:0:65:0); T34S, R43W, SE/SW 4 Sec. 2, (0:0:65:0); NE Sec. 10, (0:0:65:0); W Sec. 20, (0:0:65:0).