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Urban Amphibians of the Texas Panhandle: Baseline Inventory and Habitat Associations in a Drought Year

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Photographs by the senior author.

Abstract.—Habitat loss, degradation, and fragmentation due to urbanization are implicated in amphibian declines worldwide. Conservation efforts require information on resident species and their habitat interactions, but amphibian ecology is largely unstudied in urban centers of the Southern High Plains. Here, we gathered baseline data on amphibian presence, species richness, and habitat preferences at site-specific and landscape scales during a severe drought year in the city of Lubbock, in northwestern Texas. Ephemeral playa wetlands are characteristic of this landscape. During urbanization, these have been extensively modified for stormwater drainage, agriculture, and construction of roads, buildings, and neighborhoods. A semi-arid climate with frequent droughts, together with urbanization, could have an adverse effect on resident amphibians. In 2011, we sampled 23 urban lakes for amphibian presence, using a combination of audio, visual, and larval surveys. We detected five amphibian species at seven lakes; Texas Toads (*Anaxyrus speciosus*) and Spotted Chorus Frogs (*Pseudacris clarkii*) were the most frequently encountered species. We found significant negative effects of nearby road density on amphibian species presence and richness. We also detected significant negative effects of basic pH on amphibian species richness. These data can be used for prioritizing lakes for amphibian conservation strategies, to monitor ecosystem function in urban wetlands, and to guide future development and restoration efforts.

Globally, amphibians are one of the fastest disappearing vertebrate groups as a result of factors such as limited vagility, road mortality, habitat loss, habitat degradation and fragmentation, stocking of fish, spread of invasive species, climate change, and diseases (e.g., Blaustein et al. 1994, Stuart et al. 2004, Pearl et al. 2005, Cushman 2006). As urban boundaries continue to expand, habitats suitable for amphibian breeding and survival decline. Studies of urban ecology and efforts to mitigate urban amphibian declines are usually concentrated in metropolitan centers while smaller urban settlements are largely unstudied (e.g., Parris 2006, Smallbone et al. 2011). Effects of urbanization are less obvious in these areas, and hence they provide a source of valuable information (Smallbone et al. 2011); also enabling an earlier implementation of management strategies in city planning.

A lake located in a residential neighborhood in central Lubbock, Texas. The lake is part of the city's stormwater drainage project and is connected via overflow pipelines to other lakes in the drainage system. Note the impervious storm drains at the bottom left of the photograph.

In urbanized landscapes, amphibians use stormwater ponds and other artificial reservoirs for breeding (e.g., Mason 2008, Ostergaard et al. 2008, Simon et al. 2009). By virtue of their biphasic life cycle, pond-breeding amphibians

An adult Texas Toad (*Anaxyrus speciosus*).

are sensitive to alterations in their aquatic breeding habitat as well as surrounding terrestrial uplands. Degradation of urban aquatic habitats by accumulated pollutants such as heavy metals, pesticides, deicing salts, and other undesirable elements is a major concern (Taylor et al. 2005; Snodgrass et al. 2008a, 2008b). Impeded landscape connectivity in the form of roads and neighborhoods poses physical barriers to dispersal, increases risk of mortality, reduces choice of suitable breeding/terrestrial habitats, and thus has negative effects on resident amphibian populations (Fahrig et al. 1995, Lehtinen et al.1999, Carr and Fahrig 2001, Parris 2006, Andrews et al. 2008).

The Southern High Plains region of the United States has undergone vast anthropogenic modification. Decades of herbivory and agriculture have transformed extensive short-grass prairies into one of the most intensively cultivated zones in the Western Hemisphere (Bolen et al. 1989). Urbanization started in the late 1800s, and Lubbock is presently the largest city in this region (population 233,740; U.S. Census Bureau 2011). Numerous ephemeral "playa" wetlands are the predominant hydrological feature and are centers of biodiversity in this otherwise arid landscape (Haukos and Smith 1994, Johnson et al. 2011). These wetlands, fed by precipitation and surface run-off, also serve as primary breeding habitat for amphibians (Haukos and Smith 1994). Unfortunately, playa wetlands of the Southern High Plains face numerous threats from ongoing landscape modification (Luo et al. 1997, Haukos and Smith 2003).

Lubbock lacks a conventional stormwater drainage system and uses playa wetlands for that purpose. Most playa wetlands in Lubbock have been excavated to increase stormwater retention capacity; approximately 30 playas are part of the city's pipe-connected stormwater-drainage networks. Playa wetlands also have been modified to make way for urban development such as roads, buildings, neighborhoods, and recreational parks. Amphibian ecology has never been studied in urban centers of the Southern High Plains, and little concern has been demonstrated for amphibians in the layout and design of urban environments. Amphibian monitoring in regional urban centers such as Lubbock is virtually nonexistent.

A dry lake located just outside the loop in southern Lubbock, Texas.

Water level quickly recedes after rains.

Thirteen species of amphibians occur in the Southern High Plains (Anderson et al. 1999, Gray et al. 2004). They are xeric-adapted and lead highly terrestrial lives, returning to aquatic habitats only to breed. Many of these species have short hatching times and rapid metamorphosis, enabling juvenile recruitment in highly ephemeral lakes (Degenhardt et al. 1996, Warburg 1997, Denver et al. 1998). The climate of the Southern High Plains is continental steppe or semi-arid savanna, and droughts are a recurring feature (Woodhouse and Brown 2001). Climate models predict a global increase in extreme weather conditions such as drought, which could severely cripple the persistence of amphibian populations in the Southern High Plains (Boone et al. 2003, Seager et al. 2007, Lawler et al. 2009, Seager and Vecchi 2010). In 2011, Lubbock experienced the worst one-year drought documented in its history, having received only 14.9 cm of rainfall — less than a third of its 30-year normal, which stands at 48.6 cm (NOAA 2011, 2012).

The objectives of our study were thus two-fold: (a) Lay the foundation for amphibian monitoring within the city of Lubbock by gathering information on urban amphibian composition in a drought year, and (b) evaluate the influence of site-specific characters and landscape-scale characters on amphibian presence and species richness under these extreme conditions.

Materials and Methods

Amphibian sampling.—We surveyed 23 lakes in the city of Lubbock (Fig. 1) from March to October 2011 and assessed amphibian community composition using a combination of call surveys, visual encounter surveys, and larval dipnet surveys (Fellers et al. 1994) to increase detection probability. Beginning the night after rain events, starting half an hour after sunset, we performed 5-minute call surveys at each lake and identified species calling (Weir and Mossman 2005). Following the call survey, we performed a 20-minute visual encounter survey (Knutson et al. 2004) by walking along the lake shoreline/wading in the shallow regions, and identifying amphibians observed. For two consecutive weeks following call surveys, we sampled lakes for amphibian larvae once a week using a pipe-sampler and a dipnet. The number of samples was standardized based on lake area and efforts were made to sample all microhabitat types. All tadpoles caught were identified (Altig 1970) and then released. The combination of three survey types increased detection probability/confirmed amphibian species presence.

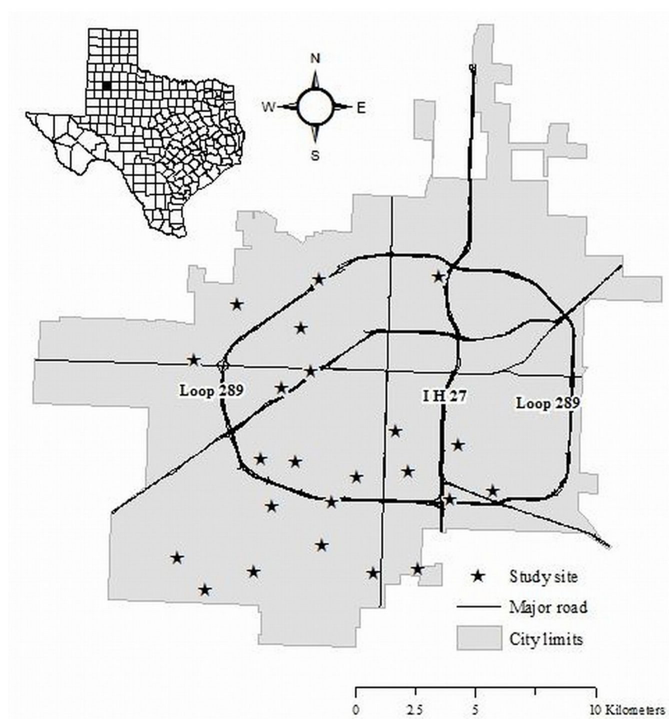

Fig. 1. Map showing all the 23 lakes surveyed for amphibian species presence from March to October 2011 and March to June 2012. All lakes were within Lubbock's city limits and impacted at varying levels by stormwater runoff.

Measurement of site-specific variables.—We recorded water quality variables (pH and conductivity) during call surveys and tadpole surveys using a hand-held YSI 63 meter (YSI Inc., Yellow Springs, Ohio, USA). We also visually estimated percent cover of within-lake emergent vegetation and presence/absence of fish. Hydroperiod was quantified on an ordinal scale based on repeated lake visits: "1" if lakes dried up within two weeks, "2" if lakes dried up within three months (but retained water longer than two weeks), and "3" if lakes held water for more than three months. Lake areas were estimated from the website of the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) and ground-truthed during field surveys. Because connectivity could allow fish and amphibians to migrate between lakes, we also categorized lakes as "1" if they were connected via a pipeline as part of the city's storm water drainage projects, and "0" for those lakes that were not part of the drainage projects.

Measurement of landscape-scale variables.—We defined "landscape" scale as the region within a 500-m radius of the lake, and these regions were non-overlapping. Because amphibian movements are regulated by rainfall, availability of moisture and refugia, danger of desiccation, and predator avoidance, very few individuals of the population actually travel extreme distances (Forester et al. 2006; Semlitsch 2008), and most activities occur within 200 m of the lake edge (Forester et al. 2006). Mean migration distance was reported to be 334 m for ranids, 279 m for bufonids, and 237 m for hylids (Lemckert 2004). Hence, we assumed that landscape characteristics at a spatial scale of 500 m would be adequate for predicting amphibian occurrences.

We obtained land-cover information from the Texas Natural Resources Information System (TNRIS) and the Lubbock city website. We used tools in ArcGIS10 (ESRI, Redlands, California, USA) to calculate road density and distance to the nearest wetland, and ERDAS IMAGINE (Intergraph Corporation Part of Hexagon Group, Huntsville, Alabama, USA) to calculate percentage cover of impervious area. Since area of the "landscape" differed among lakes, road density was expressed as length of road by landscape area to standardize the variable. Age of development surrounding the lake was estimated on an ordinal scale with "1" being the oldest development and "6" the most recently developed. Most of Lubbock's "urban city" falls roughly in the area (hereafter referred to as the "loop") bounded by the loop 289 and I-27 north (Fig. 1). This region was developed much earlier in the city's history and subject to the effects of fragmentation and urbanization for a longer time period. Lakes within the loop were designated a location class "1" and those outside, "0."

Statistical analysis.—We compared abiotic attributes (both site-specific and landscape-scale) with non-parametric Wilcoxon tests of lake categories based on general city location (in/out of the loop), amphibian presence (presence/absence),

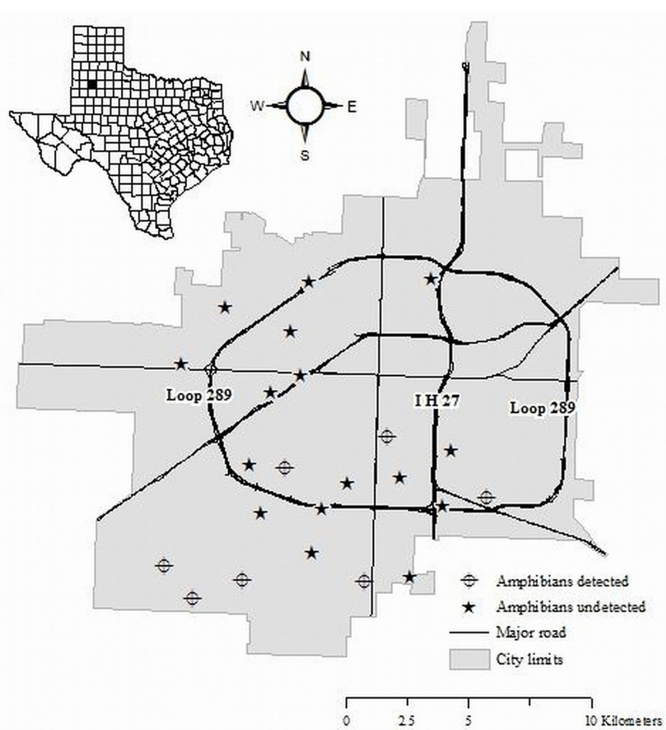

Fig. 2. Map showing the lakes with and without amphibian detection during surveys from March to October 2011. We observed amphibian species at seven lakes during the sampling period in 2011 (n = 23).

Table 1. Amphibians of the Southern High Plains (13 species) and species detected during surveys (in bold) from March to October 2011 in urban lakes in the city of Lubbock, Texas. Amphibians were detected in seven lakes in 2011 (n = 23).

Species	Number of sites found in 2011
Texas Toad *(Anaxyrus speciosus)*	**5**
Great Plains Toad *(Anaxyrus cognatus)*	0
Woodhouse's Toad *(Anaxyrus woodhousii)*	0
Green Toad *(Anaxyrus debilis)*	0
Spotted Chorus Frog *(Pseudacris clarkii)*	**3**
Great Plains Narrow-mouthed Toad *(Gastrophryne olivacea)*	**1**
Plains Spadefoot *(Spea bombifrons)*	**1**
New Mexico Spadefoot *(Spea multiplicata)*	0
Couch's Spadefoot *(Scaphiopus couchii)*	0
American Bullfrog *(Lithobates catesbeianus)*	**1**
Plains Leopard Frog *(Lithobates blairi)*	0
Northern Cricket Frog *(Acris crepitans)*	0
Barred Tiger Salamander *(Ambystoma tigrinum mavortium)*	0

and connectivity to drainage project (connected/unconnected). Because we had a small sample size (n = 23), of which amphibians occurred in very few lakes, we used basic univariate logistic regressions to test predictive ability of each abiotic variable for amphibian presence, species richness, and species-specific presence. All analyses were performed using SAS Ver. 9.3 (SAS Institute Inc., Cary, North Carolina, USA).

Results

Of the 13 species present in this region, we detected five species at only seven of the 23 lakes (Fig. 2; Table 1). Spotted Chorus Frogs (*Pseudacris clarkii*) and Texas Toads (*Anaxyrus speciosus*) were detected most frequently, at three and five sites respectively. We also detected Great Plains Narrow-mouthed Toads (*Gastrophryne olivacea*), Plains Spadefoots (*Spea bombifrons*), and American Bullfrogs (*Lithobates catesbeianus*), a species non-native to the region, at one site each. Other species that are widespread in this region (Gray et al. 2004), such as the Great Plains Toad (*Anaxyrus cognatus*) and New Mexico Spadefoot (*Spea multiplicata*) were not detected in 2011. We observed very few breeding aggregations, most occurring after a heavy thunderstorm in August with rainfall highs of 7.2 cm in certain areas of the city. Larval amphibians occurred only in four of the lakes. See Table 2 for observed species assemblages.

Lakes where amphibians were detected were surrounded by significantly lower road densities and impervious area covers when compared to lakes where no amphibians were detected (Fig. 3; P ≤ 0.05, Wilcoxon test). Of the seven lakes where amphibians were detected, only two were within the loop, whereas the rest were outside the loop (Fig. 2). Road densities and percent covers of impervious surface were greater near lakes located within the loop (Fig. 4; P ≤ 0.05, Wilcoxon test). Lakes within the loop also were characterized by less

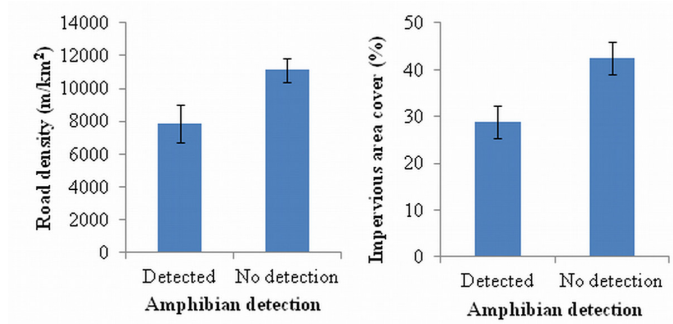

Fig. 3. Comparison of landscape-scale factors (within 500-m radius) —road density and impervious area cover—for urban lakes in the city of Lubbock based on amphibian presence (n = 23). Road density and impervious area cover was significantly lower (P ≤ 0.05*)* for lakes where amphibians were detected by Wilcoxon non-parametric tests. Error bars = ± one SE.

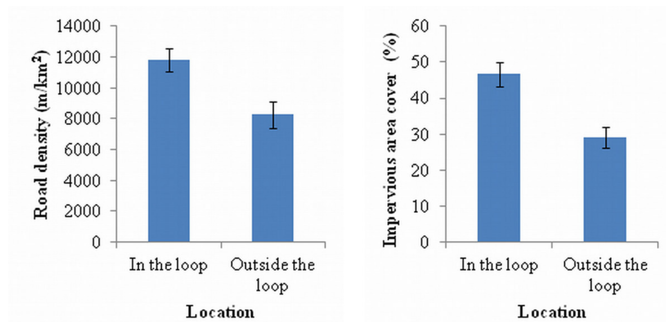

Fig. 4. Comparison of landscape-scale factors (within 500-m radius)—road density and impervious area cover—for urban lakes in the city of Lubbock based on lake location within or outside the city loop (n = 23) in 2011. Road density and impervious area cover was significantly higher (P ≤ 0.05*)* for lakes within the loop by Wilcoxon non-parametric tests. Error bars = ± one SE.

emergent vegetation (P = 0.01, Wilcoxon test) and were surrounded by older developments (P < 0.001; Wilcoxon test).

Logistic regressions further confirmed the previous results. Road density and impervious area surface had significant negative effects on amphibian presence (Fig. 5; P ≤ 0.05,

Table 2. Species assemblages observed during amphibian surveys conducted from March to October 2011 in urban lakes in the city of Lubbock, Texas.

Lake+	*A. speciosus*	*P. clarkii*	*G. olivacea*	*S. bombifrons*	*L. catesbeianus*
13		+	+	+	
85	+	+			
93	+				
94A	+				
27	+				
21	+				+
132		+			

+Lake ID referred from the city of Lubbock's stormwater maps

Table 3. Variables used to describe anuran breeding site and landscape characteristics in 2011 for 23 urban lakes in Lubbock, Texas.

Variable	Mean	Min	Max	SE
Site-specific variables				
Mean pH	7.84	7.03	8.63	0.09
Mean conductivity (µS)	316.60	182.89	509.27	18.13
Lake area (acres)	4.97	0.07	14.26	0.96
Emergent vegetation cover (%)	19.14	0.00	100.00	5.56
Hydroperiod*	—	1	3	—
Fish presence*	—	0	1	—
Presence of connection (storm water connection)*	—	0	1	—
Landscape-scale variables within 500m from the lake edge				
Road density (m/km^2)	10,130.16	3,652.17	17,078.03	677.35
Impervious area cover (%)	38.33	14.06	69.25	2.86
Nearest wetland distance (m)	668.91	149.29	1,506.37	61.20
Location*	—	0	1	—
Age of neighborhood*	—	1	6	—

* Categorical or ordinal variables which have no mean or standard deviation.

Table 4. Range of variable values for individual anuran species measured during amphibian surveys from March to October 2011 urban lakes in the city of Lubbock, Texas.

Variable No. of sites	*A. speciosus* 5	*P. clarkii* 3	*G. olivacea* 1	*S. bombifrons* 1	*L. catesbeianus* 1	*No detection* 16
Mean pH	7.25–8.22	7.03–7.25	7.12	7.12	7.52	7.30–8.63
Mean cond[x] (µS)	241.08–392.48	182.89–392.48	182.89	182.89	251.92	203.60–509.27
Lake area (acres)	2.15–17.18	0.07–3.11	0.59	0.59	17.18	0.07–11.91
Emveg[xx] (%)	0.88–50.00	20–50	45	45	0.88	000.00–100.00
Hp[x]	2.00–3.00	1.00–2.00	2.00	2.00	2.00	1.00–3.00
Fish	0.00–1.00	0.00–0.00	0.00	0.00	1.00	0.00–1.00
Connec[xx]	0.00–1.00	0.00–1.00	0.00	0.00	1.00	0.00–1.00
Road (m/km^2)	6,644.74–12,464.04	3,652.17–6,644.74	6,036.75	6,036.75	12,464.04	6,787.70–17,078.03
Imp[1] (%)	19.17–42.06	14.06–31.26	29.49	29.49	32.63	21.58–69.25
Wetdist[11] (m)	324.25–1,506.37	459.88–868.91	459.88	459.88	1506.37	149.29–1,185.83
Loop	0.00–1.00	0.00–0.00	0.00	0.00	1.00	0.00–1.00
Age	2.00–6.00	4.00–6.00	4.00	4.00	2.00	1.00–6.00

Logistic regression). Road density also had a significant negative effect on amphibian species richness ($P = 0.05$; Ordered logistic regression). pH values tending toward neutral strongly favored amphibian species richness ($P = 0.05$; Logistic regression). See Tables 3 and 4 for further information on predictor values.

Great Plains Narrow-mouthed Toads and Spotted Chorus Frogs were both observed calling from fishless lakes

Table 5. Larval periods for amphibian species of the Southern High Plains.

Amphibian species	Larval period
Couch's Spadefoot (*Scaphiopus couchii*)	7–16 d[1]
Plains Spadefoot (*Spea bombifrons*)	13–20 d[2]
New Mexico Spadefoot (*Spea multiplicata*)	12–19 d[3]
Great Plains Toad (*Anaxyrus cognatus*)	17–45 d[4]
Texas Toad (*Anaxyrus speciosus*)	18–60 d[5]
Spotted Chorus Frog (*Pseudacris clarkii*)	30–45 d[6]
Plains Leopard Frog (*Lithobates blairi*)	~60 d, overwinter[8]
Woodhouse's Toad (*Anaxyrus woodhousii*)	35–49 d[9]
Great Plains Narrow-mouthed Toad (*Gastrophryne olivacea*)	24–50 d[10]
American Bullfrog (*Lithobates catesbeianus*)	>90 d, overwinter[11]
Green Toad (*Anaxyrus debilis*)	21–25 d[12]
Northern Cricket Frog (*Acris crepitans*)	35–90 d[13]
Barred Tiger Salamander (*Ambystoma tigrinum mavortium*)	>70 d[7]

[1]Morey 2005a; [2]Farrar and Hey 2005; [3]Morey 2005b; [4]Graves and Krupa 2005; [5]Dayton and Painter 2005; [6]Sredl 2005; [7]Lannoo and Phillips 2005; [8]Smith and Keinath 2005; [9]Sullivan 2005; [10]Sredl and Field 2005; [11]Degenhardt et al. 1996; [12]Painter 2005; [13]Gray et al. 2005; Venne et al. 2012.

with greater cover of thin-stemmed vegetation, and breeding displays occurred while holding on to thin stems or from atop wooden debris. These lakes were characterized by relatively neutral pH (7.0–7.3) and conductivities of 182.89–392.48 µS, and were located in areas developed recently (since the 1980s) outside the urban loop. They also were surrounded by lower road densities (3,652.17–6,644.74 m/km²) (Table 4). A lone Plains Spadefoot was heard vocalizing at one of these lakes. Texas Toads were observed in two lakes with fish as well as three fishless lakes both within and outside the urban loop. Larger lakes supported Texas Toads (Table 4; $P = 0.05$, Logistic regression). Non-native American Bullfrogs were

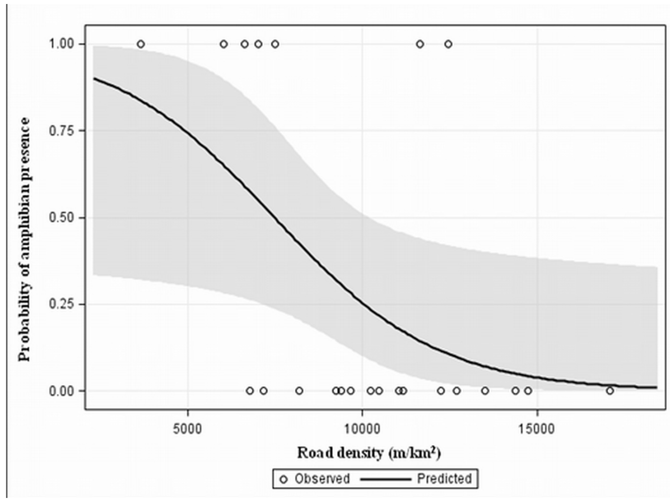

Fig. 5. Probability of occurrence of amphibian species in urban lakes of Lubbock as a function of road density within 500 m of the lake's maximum aquatic extent in 2011 from logistic regression.

recorded at one within-loop fish-filled lake characterized by high cattail (*Typha* sp.) cover.

Discussion

The spring and summer of 2011 were the driest and hottest ever documented in Lubbock, with a record number of days over 37.8 °C (NOAA 2012). As the drought progressed, water levels fell drastically in all of the lakes, with many drying entirely even before the start of summer. While stormwater run-off quickly elevated water levels in the lakes following even small rains, these did not last long under persistent high temperatures.

In our study, amphibians were detected at only 30.4% of the lakes, most of which were characterized by lower road densities, impervious area covers, and lower values of basic pH (Table 4; Figs. 2, 3, 4, and 5). Five of the seven lakes in which we detected amphibians were located outside the loop

An almost metamorphosed Texas Toad toadlet (*Anaxyrus speciosus*).

American Bullfrog (*Lithobates catesbeianus*).

Great Plains Narrow-mouthed Toad (*Gastrophryne olivacea*).

(Fig. 2), where development is relatively recent and lakes are less modified compared to the majority of lakes within the loop. Seventy-five percent of lakes within the loop are connected to the storm water drainage system, and have increased predator (fish) presence and very basic pH (average values of 7.52–8.63). Fringing vegetation is constantly uprooted and surrounding lawns are mowed regularly by local authorities as part of lake-maintenance procedures. Although the occurrence of drought itself might have been responsible for fewer amphibian observations, the data also indicate a negative role of breeding habitat isolation and, possibly, degraded water quality.

This study suggests that landscape-scale features, which are indicators of wetland isolation, are as important as site-specific characteristics that define the health of breeding habitats. Spotted Chorus Frogs were found in three lakes all located at the city's edges, at one of which Great Plains Narrow-mouthed Toads were also observed. Here average pH levels approached neutrality and emergent vegetation was more abundant (Anderson et al. 1999) (Table 4). Both species are very small (1.8–4.1 cm SVL) (Wright and Wright 1949, Clarke 1984, Stebbins 2003) and have thinner skin than other species in the region (Anderson et al. 1999). They also have prolonged breeding and larval periods relative to bufonids and spadefoots (Table 5). Hence these species might be more vulnerable to the threats of dehydration and degraded water quality (Stebbins and Cohen 1995, Wellborn et al. 1996, Anderson et al. 1999, Babbitt and Tanner 2000). These species are also highly vulnerable to fish predation (Voris and Bacon 1966, Hecnar and M'Closkey 1997, Baber and Babbitt 2003).

Bufonids have larger body size when compared to hylids or pelobatids and consequently greater vagility (Texas Toads: 5.1–8.9 cm SVL; Stebbins 2003). The relative unpalatability/distastefulness of their tadpoles to fish has been well documented (Kats et al. 1988, Kurzava and Morin 1998, Baber and Babbitt 2003). These reasons could explain the wider occurrence of Texas Toads in lakes with and without fish. Bullfrogs, which are unpalatable to most fish (Kats et al. 1988, Hecnar and M'Closkey 1997), were detected at one lake that was characterized by thick cattails (*Typha* sp.) and thick fringing vegetation, thus making it suitable for bullfrog breeding (Pope 1964). Although we expected to find bullfrogs at more permanently inundated lakes in the city, the low numbers of detections could be a result of low water levels and a lack of thick emergent/fringing vegetation in the other lakes.

An urban matrix is highly complex, with myriad obstructions to dispersal such as roads, paved surfaces, buildings, neighborhoods, and various other anthropogenic components. Low vagilities and dispersal abilities as a result of small body size (Peters 1983) can negatively influence amphibian distributions in complex terrestrial habitats. Small-bodied species of this region such as the spadefoots (Plains Spadefoot: 3.2–6.3 cm SVL; Stebbins 2003), Spotted Chorus Frogs, and Great Plains Narrow-mouthed Toads could experience difficulty when moving across urban habitats and show increased nestedness at localized sites (Gray et al. 2004). Road mortalities could decimate native populations when amphibians emerge for breeding, a crucial period involving large-scale migrations to breeding pools (Fahrig et al. 1995, Forman and Alexander 1998, Carr and Fahrig 2001). Also, in the event of local extinctions, recolonization might be hindered by anthropogenic barriers to amphibian movement.

Many of the lakes we surveyed are directly linked to surrounding roads and impervious surfaces by storm drains, likely causing accumulations of heavy metal pollutants and salts

Spotted Chorus Frog (*Pseudacris clarkii*).

from roads and paved surfaces, pesticides and fertilizers used for the upkeep of manicured lawns, and other chemical compounds (Hatt et al. 2004; Croteau et al. 2008; Snodgrass et al. 2008a, 2008b). In our study, impervious area cover within 500 m of a lake was positively correlated with pH (r_s = 0.50, P = 0.02). Stormwater ponds have been thought to function as ecological traps because amphibians use them as breeding habitat (Brand and Snodgrass 2009), and this could be especially true in drought years when most other lakes have dried up. Although not documented during sampling, urban aquatic pollutants such as metal and chemical toxicants also have been extensively linked with reduced survival and increased limb malformations in amphibian communities (Snodgrass et al. 2008a, 2008b; Taylor et al. 2005; Egea-Serrano et al. 2012). Since juvenile recruitment is essential for supporting amphibian source populations in urban areas, the need to improve urban breeding-habitat quality is critical. Establishing suitable native vegetative communities in and around urban lakes might help offset pollutant accumulation and enhance water quality, while simultaneously providing suitable sites for ovipositioning and increased concealment from predators (Castelle et al. 1994, Hecnar and M'Closkey 1997).

A newly metamorphosed Texas Toad (*Anaxyrus speciosus*). Note the tail stub.

Prolonged drought periods can have profound effects on amphibian communities (Babbitt and Tanner 2000). Elevated

Calling Texas Toad (*Anaxyrus speciosus*). Note the inflated vocal sac.

temperatures for long durations can increase metabolic rates of aestivating amphibians, cause loss of coordination, paralysis, or even death (Stebbins and Cohen 1995, Grundy and Storey 1998, Young et al. 2011). In the absence of rain, species that rely on large storms to cue reproduction do not initiate breeding, or entire larval cohorts are lost when ponds dry before the completion of metamorphosis (Warburg 1997). Because so few adults emerge, assessment of amphibian communities is difficult during drought years (Dodd 1992).

This study forms the first formal amphibian-monitoring attempt in Lubbock, and information about species-specific distributions, dispersal, and persistence is scarce. Continuous monitoring of city wetlands is required to understand amphibian population distribution and dynamics, especially since a time lag of several decades exists between changes in urbanization and responses in amphibian species occurrence (Lofvenhaft et al. 2004). Climate projections predict higher temperatures, faster evaporation rates, and more sustained droughts for the Southern High Plains region (United States Global Change Research Program 2009). If basic conservation measures can be implemented in the immediate future, we can mitigate urban amphibian declines in this region. Promoting public awareness regarding biodiversity of the Southern High Plains, and actively involving efforts of local neighborhoods to preserve wetland health in urban Lubbock can increase impetus toward amphibian conservation in the city.

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