Has the Western Chorus Frog (*Pseudacris triseriata*) Declined in Western Ottawa, Ontario?

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To determine whether the Western Chorus Frog has declined in western Ottawa, we conducted auditory surveys at historical locations as well as at various other wetlands. Western Chorus Frogs were detected at 12 of 18 historical locations. Wetland habitat remained at all historical locations where the species was not detected. There was no difference in the year of historical records for sites where Western Chorus Frogs were (median 1987.5) and were not (median 1987.5) detected. In the present study, Western Chorus Frogs were also detected at 30 locations where they had not been previously reported. Historical sites where Western Chorus Frogs were not detected were not significantly farther away from known Western Chorus Frog sites (median distance: 2.2 km) than historical sites where Western Chorus Frogs were detected (median distance: 1.4 km). Land use variables for historical sites where Western Chorus Frogs were and were not detected did not vary significantly at any spatial scale from 0.5 to 2.0 km. Western Chorus Frogs were detected in areas with up to 50% forest cover and up to 86% agricultural cover at the 1.0-km radius. The lack of historical data makes it difficult to assess the current status of the Western Chorus Frog in western Ottawa. The species may have declined, remained approximately the same (by shifting to different breeding sites), or even increased its distribution (by colonizing additional sites).

Key Words: Western Chorus Frog, *Pseudacris triseriata*, amphibian decline, Ottawa, Ontario.

The Western Chorus Frog (*Pseudacris triseriata*) is a small hylid treefrog. It has declined in southern Quebec (Daigle 1997), northern New York (Gibbs et al. 2005), and southeast of Ottawa in eastern Ontario (Seburn et al. 2008). These declines have all occurred in an area where the mitochondrial DNA of specimens resembles that of the Boreal Chorus Frog (*P. maculata*) rather than that of the Western Chorus Frog (Lemmon et al. 2007). Morphologically, however, individuals resemble the Western Chorus Frog, and to date they have retained this species name (COSEWIC 2008*). According to Marsh Monitoring surveys conducted across the Great Lakes region, the Western Chorus Frog declined significantly between 1995 and 2007 (Archer and Jones 2009). Largely as a result of declines in Quebec, the Great Lakes/St. Lawrence–Canadian Shield population of the Western Chorus Frog in Canada has been designated threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2008*).

The Ottawa area is adjacent to the Outaouais region of Quebec, where declines in the Western Chorus Frog have been observed (COSEWIC 2008*). Our objectives were threefold: to assess whether the Western Chorus Frog persisted at historical sites in the Ottawa area, to determine the extent of its current distribution and to examine the effect of habitat variables on its distribution.

Study Area and Methods

All surveys were conducted in suburban and rural western Ottawa (Figure 1), an area of approximately 600 km^2. Records of calling Western Chorus Frogs were obtained from the Ontario Herpetofaunal Atlas (Oldham and Weller 2000*). The year 1990 was selected as a cut-off date for historical records, as this is before Western Chorus Frogs declined in eastern Ontario (Seburn et al. 2008). A number of records were excluded because of a lack of precise locality information. Additionally, a few records with locations less than 500 m apart were not considered separate locations. This resulted in a total of 18 historical locations with observations dating from 1977 to 1990 (Table 1, Figure 1).

Daytime auditory surveys were conducted during the calling season of the Western Chorus Frog (early to late April) from 2006 to 2010. A known site with Western Chorus Frogs was visited at the start of each survey to confirm calling was occurring that day. Historical locations were relocated using a GPS. Auditory surveys were conducted from roadside locations, with the exception of a few locations in public parks where the location of the historical record was away from a road. Auditory surveys lasted from 1 to 5 minutes, depending upon weather conditions (e.g., strong, temporary wind) and traffic noise. All historical locations where Western Chorus Frogs were not confirmed on the first survey were surveyed in a subsequent year to increase the detection probability. Additional sites were surveyed by listening at wetlands visible from roads and, at one location, on foot in a park.

The degree of isolation for historical sites where Western Chorus Frogs were detected and not detected was tested by measuring the distance from each site to

TABLE 1. Location of historical sites with Western Chorus Frogs (*Pseudacris triseriata*) in western Ottawa pre-1991, showing those sites where Western Chorus Frogs were detected/not detected in follow-up surveys between 2006 and 2010. ID is the Ontario Herpetofaunal Atlas record number.

ID	Latitude (°N)	Longitude (°W)	Year	Follow-up year	Western Chorus Frogs present
52915	45.3778	76.2644	1990	2008, 2009	N
48634	45.4375	76.2351	1990	2008	Y
10203	45.4495	76.2149	1988	2008	Y
48573	45.2632	76.1230	1990	2007, 2009	N
48570	45.2445	76.0971	1990	2007	Y
48567	45.2365	76.0868	1990	2007	Y
48560	45.1685	76.0473	1990	2008	Y
10204	45.1520	75.9796	1988	2008, 2009	N
10205	45.2502	75.9698	1985	2006	Y
10206	45.3466	75.9600	1988	2007	Y
123366	45.3952	75.9582	1982	2007	Y
10214	45.3607	75.8823	1987	2009	Y
10215	45.3509	75.8745	1987	2006	Y
10217	45.3401	75.8705	1987	2009	Y
10216	45.3520	75.8464	1987	2006	Y
10208	45.3026	75.8304	1987	2006, 2009	N
123356	45.3000	75.8214	1977	2006, 2009	N
10209	45.3235	75.8051	1987	2006, 2009	N

the closest known occupied site. The two groups (historical sites where Western Chorus Frogs were detected and historical sites where Western Chorus Frogs were not detected) were compared using the non-parametric Mann-Whitney test. Land use information was obtained from the Southern Ontario Land Resource Information System (SOLRIS). The layer represents the landscape in 15 × 15 m pixels from 2000 to 2003, and it is derived from a combination of satellite imagery, topographic maps, and aerial photography (Ontario Ministry of Natural Resources 2007). Land use was separated into the following classes for analysis: forest cover (>60% tree cover, including plantations), built-up area (including residential, commercial, and industrial areas, and outdoor recreation areas, such as golf courses), wetlands (≥ 0.5 ha in area), and agriculture (a broad category that includes intensive croplands as well as old fields and forest clearings). Road information was obtained from the Ontario Roads Network vector layer (Ontario Ministry of Natural Resources).

We calculated the proportional area for each land use class (expressed as a percentage) and the length of road (in km) surrounding each site at radii of 0.5, 1.0, 1.5, and 2.0 km. Land use variables at a larger spatial scale may be correlated with frog landscape ecology (e.g., Gibbs et al. 2005), but, in this case, a larger radius would result in some areas extending across the Ottawa River into adjacent Quebec. The proportional area for each land use class was also calculated for 104 random, non-overlapping sites at a 1.0-km radius to describe the variability in the land use data across the study area. We used binary logistic regression to test whether land use classes could be used to distinguish occupied Western Chorus Frog sites from random sites. ArcMap 10.0 was used for all spatial analyses and Minitab and R for all statistical analyses.

Results

Western Chorus Frogs were heard calling at 12 of 18 historical locations (Table 1, Figure 1), a 33% decline in detection. Wetland habitat remained at all 6 historical locations where Western Chorus Frogs were not detected. There was no difference in the year of historical records of sites where Western Chorus Frogs were (median 1987.5) and were not (median 1987.5) detected. Additional surveys confirmed Western Chorus Frogs at 30 new locations (Table 2, Figure 1).

Historical sites where Western Chorus Frogs were not detected had a median distance of 2.2 km (range 0.8–4.4 km) from any known extant Western Chorus Frog location, while historical sites where Western Chorus Frogs were detected had a median distance of 1.4 km (range 0.8–5.1 km). This difference was not significant ($W = 105.0$, $P = 0.43$).

Land use variables for historical sites where Western Chorus Frogs were and were not detected did not vary significantly at any spatial scale ($P > 0.05$). Habitat variables at 1.0 km are presented to illustrate the range of the data (Table 3). Land use variables for forest ($P = 0.36$), wetland ($P = 0.24$), and agriculture ($P = 0.67$) were not significant in the logistic regression analysis comparing sites where Western Chorus Frogs were detected to random sites. Western Chorus Frogs were detected in areas with forest cover ranging from <1 to 50%, reflecting, essentially, the full range of habitat variation found within the study area (Table

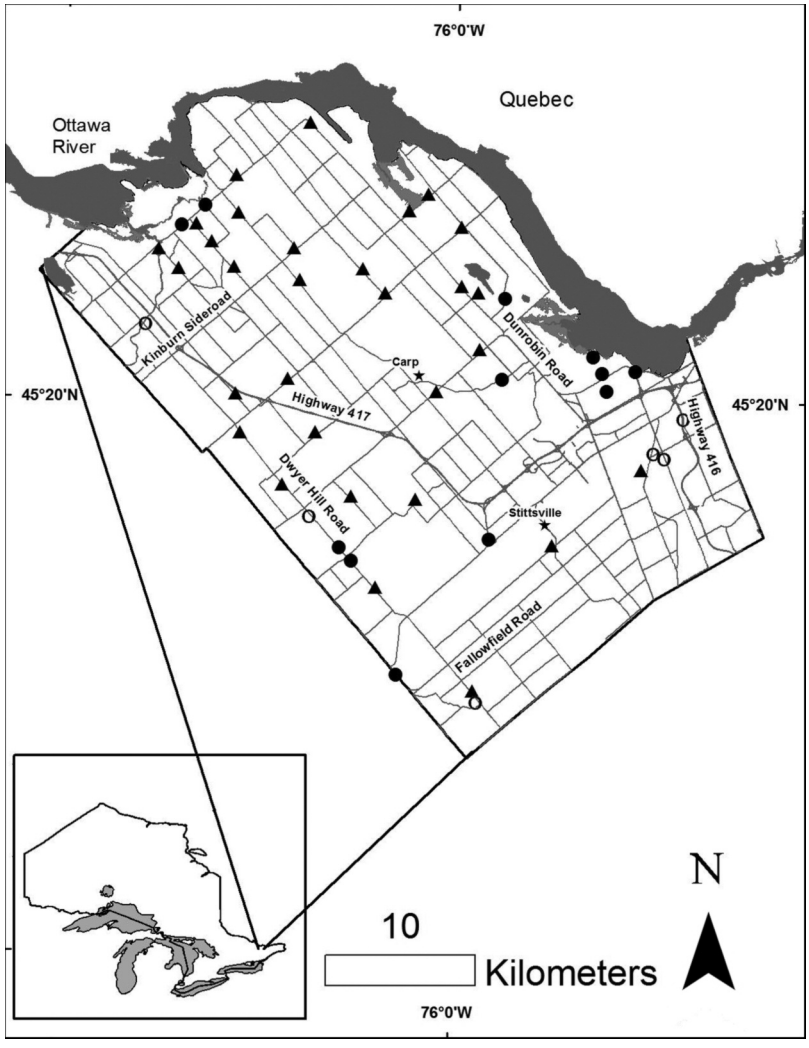

FIGURE 1. Distribution of Western Chorus Frog (*Pseudacris triseriata*) locations in western Ottawa. Circles represent historical locations (pre-1991). Filled circles: Western Chorus Frogs detected on follow-up surveys between 2006 and 2010; open circles: Western Chorus Frogs not detected on follow-up surveys between 2006 and 2010. Triangles represent additional locations where Western Chorus Frogs were detected between 2006 and 2010.

4). Western Chorus Frogs were detected in areas with up to 86% agricultural land, whereas over 12% of the landscape sites had greater agricultural cover (Table 4).

Discussion

There are a number of limitations to this study. The historical data were not collected systematically, but opportunistically, as part of the Ontario Herpetofaunal Atlas (Oldham and Weller 2000*). The data were collected by multiple people and it is possible that some auditory reports were confused with the agonistic or territorial call of a Spring Peeper (*Pseudacris crucifer*) which is also a trill (COSEWIC 2008*). In addition, locality information may not have been correctly recorded. While these errors may have occurred, the historical data for the 6 locations where Western Chorus Frogs were not detected in the current survey were all submitted by known and experienced observers. It is unlikely that the Western Chorus Frogs were misidentified or that erroneous locality information from the past would correspond to an existing wetland.

An additional limitation is that the historical data are not geographically well dispersed. Historical sites

TABLE 2. Location of additional sites in western Ottawa surveyed between 2006 and 2010 where Western Chorus Frogs (*Pseudacris triseriata*) were detected.

Latitude (°N)	Longitude (°W)	Location	Year
45.2752	76.0875	South March Road	2006
45.2739	76.0327	Old Almonte Road	2007
45.3986	75.9813	Constance Lake Road	2007
45.3389	76.0160	March Road	2007
45.2818	76.1463	Upper Dwyer Hill Road	2008
45.3130	76.1826	Upper Dwyer Hill Road	2009
45.2926	75.8404	Stony Swamp	2009
45.4021	75.9954	March Road	2009
45.4381	75.9960	Thomas Dolan Parkway	2009
45.4576	76.0245	Vance's Sideroad	2009
45.4476	76.0409	Vance's Sideroad	2009
45.4999	76.1264	Dunrobin Road	2009
45.4453	76.1867	Carp Road	2009
45.4114	76.2371	Mohrs Road	2009
45.4230	76.2539	Mohrs Road	2009
45.4677	76.1884	Galetta Sideroad	2009
45.1592	75.9822	Dwyer Hill Road	2010
45.4386	76.2223	John Shaw Road	2010
45.4280	76.2093	John Shaw Road	2010
45.4128	76.1898	John Shaw Road	2010
45.4241	76.1389	Kinburn Road	2010
45.4121	76.0799	Stonecrest Road	2010
45.3979	76.0605	Stonecrest Road	2010
45.3363	76.1869	Breezy Hills Road	2010
45.3458	76.1425	Panmure Road	2010
45.3136	76.1188	Vaughn's Sideroad	2010
45.3644	75.9794	March Road	2010
45.4053	76.1334	Carp Road	2010
45.2205	76.0661	Dwyer Hill Road	2010
45.2470	75.9162	Fernbank Road	2010

are clustered in some areas and completely lacking in other areas (Figure 1). Another limitation is the lack of historical data on wetlands where Western Chorus Frogs were known to be absent in the past. Natural succession can lead to amphibians selecting different breeding sites. This may result in no net loss in the number of breeding populations, but resurveys of only historical sites would detect a decline (e.g., Skelly et al. 2003).

It seems unlikely that Western Chorus Frogs persist at any of the 6 historical locations where they were not detected in the current survey period, as a follow-up survey was carried out in a subsequent year and the species was not detected at any of the 6 sites (Table 1).

The level of apparent decline detected in the current study is comparable to that reported elsewhere: Western Chorus Frogs are now absent at 34.6% of historical locations in northern New York state (Gibbs et al. 2005) and approximately 30% of known locations in the Outaouais area of Quebec (across the Ottawa River from Ottawa) (COSEWIC 2008*). In contrast, the Western Chorus Frog was not detected at 95% of historical locations in eastern Ontario southeast of Ottawa (Seburn et al. 2008) and is gone from approximately 90% of its range in the Montérégie area, south of the St. Lawrence River, in Quebec (COSEWIC 2008*).

The cause or causes of declines in the Western Chorus Frog remain speculative. Destruction of wetlands is a major threat in some areas of Quebec (Daigle 1997; Picard and Desroches 2004*); however, Western Chorus Frogs have also disappeared from areas where wetlands remain (Gibbs et al. 2005; Seburn et al. 2008; current study). The presence of wetlands during the breeding season may not be sufficient, as changes in precipitation can lead to ponds drying earlier and the loss of some amphibian species (McMenamin et al. 2008). Regional decline in total precipitation does not appear to be the issue in Ottawa, as the wettest 5-year period in the last 25 years was from 2006 to 2010 (Environment Canada 2011*).

There may be large-scale landscape differences between western Ottawa and the area east of Ottawa where Western Chorus Frogs are known to have declined (Seburn et al. 2008). For example, in eastern Ontario soils are generally less acidic in western Ottawa and to the west (Marshall et al. 1979). Western Chorus Frogs in New York state were also more likely to persist in areas with less acidic soil (Gibbs

TABLE 3. Land use variables associated with historical sites (pre-1991) where Western Chorus Frogs (*Pseudacris triseriata*) were detected/not detected in follow-up surveys between 2006 and 2010 at the 1.0-km radius (range in parentheses). Land use variables (except roads) are expressed as a percentage of the total area from each observation point. Road data are presented in kilometers of road. Land use variables were compared using the non-parametric Mann-Whitney test (*W*).

	Historical sites resurveyed, 2006–2010			
	Western Chorus Frogs detected	Western Chorus Frogs not detected		
Land use 2006–2010	median (range)	median (range)	*W*	*P*
Forest (%)	28.0 (7.9–50.2)	16.7 (7.0–37.4)	44.0	0.2417
Built-up (%)	0.8 (0–36.5)	0.1 (0–14.0)	46.5	0.4824
Wetlands (%)	26.9 (12.5–51.9)	28.8 (18.3–63.3)	65.0	0.4824
Agriculture (%)	41.8 (8.3–67.9)	34.7 (5.3–72.5)	54.0	0.8149
Roads (km)	4.4 (1.6–10.9)	4.0 (2.8–13.5)	59.0	0.8883

TABLE 4. Land use variables (expressed as a percentage) associated with all sites where Western Chorus Frogs (*Pseudacris triseriata*) were detected during surveys between 2006 and 2010 ($n = 42$) and at random locations across the landscape ($n = 104$) at the 1.0-km radius (range in parentheses). Threshold indicates the percentage of landscape sites that exceeded the maximum land use value for Western Chorus Frog sites (e.g., 2.9% of landscape sites have >50.2% forest cover).

	Sites where Western Chorus Frogs were detected	Random locations across the landscape	
Land use (%)	median (range)	median (range)	Threshold (%)
Forest	17.8 (0.3–50.2)	16.7 (0–69.1)	2.9
Wetlands	18.6 (2.8–66.7)	12.0 (0–74.3)	1.9
Agriculture	46.5 (8.1–86.4)	50.8 (5.2–95.8)	12.5

et al. 2005); however, studies have suggested that reduced pH has no effect on growth or development of Western Chorus Frog tadpoles (Kiesecker 1996).

As Western Chorus Frog populations are extirpated, remaining populations may be more at risk of extirpation as a result of increased geographic isolation and reduced connectivity across the landscape (COSEWIC 2008*). This may be exacerbated by the fact that populations of the short-lived Western Chorus Frog are likely to be relatively prone to extirpation as the result of even a single extreme event (e.g., premature drying up of a breeding pond).

Western Chorus Frogs typically remain within 275 m of the breeding pond (Desroches et al. 2001*), suggesting that dispersal is relatively limited. Historical sites where Western Chorus Frogs were not detected were not farther away from extant Western Chorus Frog sites than currently occupied sites were, although there are limitations to our isolation analysis. It is unlikely that all sites with Western Chorus Frogs were detected, given the fact that surveys were largely restricted to wetlands visible from roads. The probability of extirpation also likely varies between small isolated wetlands and areas with multiple wetlands (e.g., Trenham et al. 2003). In addition, while distance is a measure of isolation, the type of intervening habitat is likely just as important for dispersal (e.g., Seburn et al. 1997), and it is known that roads impede the dispersal of Western Chorus Frogs (Picard and Desroches 2004*; Whiting 2004).

Isolation may be a significant factor for at least two historical sites where Western Chorus Frogs were not detected in the current survey. The most eastern historical location where Western Chorus Frogs were not detected has urban landscape to the east and a major highway directly to the west. It had the highest values for roads and built-up areas at all spatial scales, making it highly unlikely that Western Chorus Frogs could recolonize the site. Similarly, the most western historical site where Western Chorus Frogs were not detected is now surrounded by a landscape of intensive agricultural croplands. This site had the lowest forest cover and highest agricultural cover at all spatial scales, and it has apparently little suitable habitat for Western Chorus Frogs.

Western Chorus Frogs occupied a wide range of habitats in the study area, occurring in areas with forest cover ranging from <1 to 50% at a radius of 1.0 km (Table 4). Given that most of the study area had less than 50% forest cover, this maximum value likely does not reflect a true threshold limit for the species. In addition, Western Chorus Frogs were found in areas with up to 86% agricultural cover. Their absence from areas with greater agricultural cover may indicate that such areas are inhospitable to Western Chorus Frogs. Future studies should continue to determine threshold

values for land use variables in a variety of landscapes so that habitat-predictive models for Western Chorus Frogs can be developed.

Surrounding agricultural land use at a 1-km scale was not a significant factor influencing Western Chorus Frog distribution in our study. In contrast, in upstate New York, Western Chorus Frogs were found to decline in areas with greater cultivated land (Gibbs et al. 2005); however, this relationship was documented at a 5–10 km scale. This apparent contradiction is possibly due to differences in scale as well as a difference in the way agricultural land use was classified in the two studies. In the present study, the land classification pooled data for habitats that are likely to be suitable for Western Chorus Frogs (e.g., old field) with inhospitable habitats (e.g., intensive cropland) into one broad category, while the New York study differentiated agriculture into cultivated grasses, row crops, and pasture.

If surveys had been conducted at historical locations only, it would appear that the Western Chorus Frog had declined by 30% in western Ottawa. The additional surveys indicated that it remains widespread across most of the region. Although the Western Chorus Frog may have declined, there are two other ways the data can be interpreted: 1) the number of Western Chorus Frog sites remained essentially unchanged over time, with a shift to different breeding sites but with no net loss of sites; or 2) the number of Western Chorus Frog sites increased, with a shift to different breeding sites resulting in a net increase in the number of sites. A key question is how many of the 30 new Western Chorus Frog sites are newly colonized breeding sites and how many are just newly documented. Without historical data on these 30 sites, it is difficult to know whether the Chorus Frog has truly declined. Given the declines in other areas, future monitoring is warranted.

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