Population Ecology of Fowler's Toad (*Anaxyrus fowleri*)

at Long Point, Ontario.

Field Report for 2013

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Summary

For the 26th consecutive breeding season the abundance of Fowler's toads (*Anaxyrus fowleri*) was surveyed at Long Point, Ontario, by tracking and identifying all adults and juveniles within a study area parallel to 10 km of Lake Erie shoreline. During 41 days of spring survey (May 1 through June 10, 2013), 10 adult males (mean SVL = 59.5 ± 3.1 mm) and 20 adult females (mean SVL = 62.9 ± 5.6 mm) were captured in the 8.3 km wide Main Study Area (between 80°22'15" and 80°28'24" W longitude). Toads were individually identified based on digital photographs of their unique dorsal spot patterns using computer-based image recognition software. Population size was estimated to consist of *N* = 11 ± 0 (S.E.) adult males and *N* = 22 ± 2 (S.E.) adult females, which continues an overall downward trend that began in 2004. Six adult male toads were recaptured from the previous year, giving an overwinter survival rate of 29%. The first observations of toad activity, including calling, were on May 3. A total of 2,512 tadpoles were rescued from an ephemeral beach pool breeding site and raised at varying densities in pens in experimental ponds located in the Thoroughfare Point Unit of the Long Point NWA. Both growth rate and development rate were retarded at the highest densities (up to 5.0 tadpoles per litre). A total of 140 toadlets were ultimately released into the environment, an average survival rate of 5.5%, which is considered good for toads under natural conditions. Based on this year's results, improvements to the protocol can be designed for next year.

Introduction

Fowler's toad (*Anaxyrus fowleri*) is listed as Endangered under both the *Ontario Endangered Species Act* and the federal *Species at Risk Act* in Canada (COSEWIC 2010). The largest remaining population in Canada has long been considered to be at Long Point, Ontario, a 35 km sand spit extending eastward into Lake Erie (Green 1989) at the northern limit of the species' range. Populations also occur at Rondeau and along the Niagara shoreline of Lake Erie. The population of *A. fowleri* at Long Point has been surveyed annually for 25 years from 1988 through 2012 by systematically searching for toads within a defined study area which runs parallel to 10 km of Lake Erie shoreline (Fig. 1). The males are easy to locate at breeding sites as they can be tracked by their persistent calling and will return to calling sites often over multiple successive nights (Laurin and Green 1990). Females, because they are cryptic in behaviour, non-vocal and spend little time at breeding sites, are more difficult to census, yet they may be studied as thoroughly as the males if the beach is properly surveyed (Green 2013).

An intensive monitoring approach has enabled accurate determinations of the numbers of Fowler's Toads from year to year within the study area. The toads' population size fluctuated around a mean of 298 ± 15 (S.E.) male toads between 1988 and 2004, however, mean population size steadily decreased beginning in 2004 to reach 31 ± 2 (S.E.) male toads to 2013 (Greenberg and Green 2013). Female abundance paralleled that of the males (Green 2013). This shift from regulated population dynamics to a declining trend was attributed to the loss of available breeding habitat due to invasive common reeds, *Phragmites australis* (Greenberg and Green 2013) which, in recent years, has become the dominant emergent vegetation in these areas (Wilcox et al., 2003; Badzinski et al., 2008). The Crown Marsh in particular, located in the middle of the study area, has seen a great increase in the abundance of *P. australis* (Badzinski et al., 2008; Greenberg and Green, 2013).

In response, six ponds, each divided into two sub-basins, were dug by the Canadian Wildlife Service in the Long Point National Wildlife Area east of Long Point Provincial Park in the spring of 2013 (Fig. 2). If loss of breeding habitat due to the reeds is a significant cause of the decline in abundance of Fowler’s Toads at Long Point, then increasing the presence of breeding habitat should result in increased recruitment success of the toads. Therefore, the objectives of study in 2013 were to collect one last year of data for the long term population survey before the habitat intervention has its effect on the toad populations, to determine if Fowler’s toad tadpoles can successfully grow to metamorphosis in the experimental ponds, and to assess possible effects of density on growth and development rate in the tadpoles.

Materials and Methods

The Long Point Site – The area of study is a ca. 10 km stretch of shoreline at the western base of Long Point, Ontario, consisting of beach, dunes and marshlands. Along much of the dune area are cottages and roads. The area of settlement extends north in some places into regions that were previously marshland; however most of the marsh and much of the dune and foreshore are protected land. Nowhere is the studied region more than approximately 500 m wide.

The region can be divided in to two study areas. The larger, Main Study Area to the west (Fig. 1) lies between 42.577° – 42.583° N latitude and 80.373° – 80.472° W longitude. This area, which extends about 8.3 km from the western end of Hastings Drive at Big Creek NWA, east to the Thoroughfare Point Management Unit of the Long Point NWA, has been continuously surveyed for Fowler’s Toads each spring since 1988 (Green 1992; Yagi and Green 2012). The individual sites in this study area where toad choruses have been at some point encountered are as previously reported (Green 1992; Table 1; Fig. 1). These chorus sites were largely in marshes amid bulrushes, cattails, or emergent sedges, though some others were in flooded shallow depressions. Toads have also been found calling from temporary beach pools.

The smaller, Thoroughfare Study Area to the east consists of the beaches, dunes and marshes of the Thoroughfare Point Unit of the Long Point NWA where intensive spring and summer surveys were begun in 2013 following the installation of the six experimental ponds (Table 2, Fig. 2) by the Canadian Wildlife Service. This area lies between 42.573° – 42.577° N latitude and 80.354° – 80.373°" W longitude, a distance of about 1.6 km stretching from the eastern boundary of Long Point Provincial Park to the western edge of the Long Point Company property.

Spring Survey – The standard protocol used to survey the Fowler's Toad population in the Main Study Area has been to find, hand-capture, and uniquely mark every adult toad present. This year, the surveyed region also included the Thoroughfare Study Area. All known breeding and foraging sites (Fig. 1) as well as the experimental ponds (Fig. 2) were inspected nightly by car and on foot throughout the 41 day period, from May 1 through June 10, that encompasses the entire breeding season. We measured snout-vent length (SVL) of all toads (including juveniles) with dial callipers and digitally photographed the dorsal surface of each toad upon every capture for individual identification (Fig. 3). Fowler's toads possess distinct and unique spot patterns on their dorsal side that remain unchanged throughout their lives. By comparing these spot patterns, individuals can be identified with the aid of image recognition software developed by Alan Schoen (Yagi and Green 2012). Daily air, water and ground temperatures were recorded throughout the study period using Hobotemp® dataloggers. Rainfall was measured daily with plastic rain gauges (0.5 mm accuracy).

Adult males were easily discernible by their black throats and release calls when handled. Females, though, lack any particular features to distinguish them from juveniles of either sex except size. Therefore, SVL measurements of all white-throated toads, females and juveniles, were plotted as histograms with 1mm intervals and Bhattacharya's (1967) method, as implemented in the program FiSAT II vers. 1.2.2 (FAO, 2005) was applied so as to discern the two length distributions corresponding to juveniles and adult females. This procedure must be repeated every year due to large year-to-year variation in average body size (Middleton and Green 2011).

The nightly individual capture/recapture data was used to estimate the male and female population sizes for the breeding season (Donnelly and Guyer 1994) in the Main Study Area for comparison with previous years. These estimations were computed using the closed capture procedures embodied in the program MARK (White *et al*. 1982; Rexstad and Burnham 1991) under the assumptions that capture probabilities varied with time (Chao *et al*. 1992). Nightly individual capture/recapture data of juvenile toads identified using image-recognition software were used to estimate the juvenile population size in the same way.

Experimental Ponds — Fowler's toad tadpoles were collected from the only breeding site, a temporary beach pool, located during the spring survey and were raised in eight different density levels within each of three experimental ponds in the Thoroughfare Study Area. The tadpoles were placed in floating enclosures of various sizes to protect them from predation and adjust density (Fig. 4). The enclosures were made with a plywood and Styrofoam frame, and with fly screening for the bottom and mosquito mesh for the sides. In two ponds, a total of 1,600 tadpoles were divided equally into each set of eight enclosures (100 tapoles/enclosure). In the third pond, a total of 912 tadpoles randomly assigned to 4 equally-sized enclosures at differing abundances. Digital photographs of random samples of 20 tadpoles were taken for each enclosure three times a week throughout the summer, until metamorphosis, allowing for the collection of body size measurements using ImageJ software. Growth rate and size at metamorphosis of tadpoles from each density treatment were calculated.

Once tadpoles reached metamorphosis, they were moved to a terrestrial enclosure until they reached a minimum weight of 0.3 g. Digital photographs were taken of each toadlet's dorsal spot pattern, after which the toadlets were released into the open terrestrial habitat (Fig. 4). Night-time surveys of the beach at the Thoroughfare Study Area to look for adults, juveniles and toadlets were conducted until early September.

Results

Spring survey – The activity of toads during the 2013 spring survey period was episodic and dependent on temperature (Fig. 5). The first male toads were heard on May 3, 43 days after the vernal equinox (Fig. 6) and captured on May 5. Males were consistently encountered until May 10, when evening air temperatures dropped to 9.0 ± 2.5 °C. Toads were encountered consistently again from May 16 until May 22 but not during the period May 23 – May 26, when air temperatures dropped to 8.0 ± 1.7 °C. Calling males were not heard in the Big Creek Marsh in close proximity to any named north of the dunes, however calling was heard west of Hastings 4, and males were found calling in a temporary beach pool at Hastings 1. Calling was also heard in the distance at Pines, Johnson/LPPPW and east of the Thoroughfare Survey Area in a temporary beach pool. The first female toad was caught on May 3 but females were not consistently encountered until they began to appear on the beaches towards the end of May (Fig. 5). Throughout the survey, the proportion of toads that had been previously captured rose steadily, so that by the end of the survey there were few toads that had not been captured before.

In total, there were 308 captures of 120 toads over the 41 day spring survey period in both study areas. In the Main Study Area, there were 145 captures of 50 individual toads. The 10 different males were caught an average of 5.8 times each, to yield an estimated abundance of 10 ± 0 (S.E.) individuals (Table 3), the lowest abundance of males yet recorded in 25 years of surveys (Fig. 7). Based on the size-distribution histogram for white-throated individuals (Fig. 8), and using Bhattacharya’s (1967) method, 20 individuals > 53 mm SVL could be identified as adult females. These 20 females were caught an average of 2.05 time each to yield an estimated abundance (N_{females}) of 22 ± 2 (S.E.) (Table 4, Fig. 7). Twenty juveniles were caught 2.36 times each for an estimated total number of juveniles of 21 ± 0 (S.E.) individuals. This gave a ratio of 0.68 juvenile per adult toad. Average SVL was 59.5 ± 2.9 mm among males (Table 3) and 62.9 ± 5.6 among females (Table 4, Fig. 9), in conformity to the significant tendency for lower population densities to be correlated with larger toads (Fig. 10). Six males were recaptured from the previous year, giving a total overwinter survival rate of 28.6% (Table 3).

In the Thoroughfare Study Area, we made 163 captures of 70 individual toads during the spring survey period. These consisted of 36 captures of 13 males (3.0 captures/toad), 70 captures of 23 females (3.0 captures/toad) and 56 captures of 33 juveniles (1.7 captures/toad). The equal frequency of capture for males and females reflects the lack of any breeding detected in the Thoroughfare Study Area in 2013; all captures were recorded on the beach.

Experimental ponds and summer survey — Overall, within both study areas, we made a total of 489 captures of 210 individual toads between 13 June and 11 August, 2013. This consisted of made 118 captures of 43 males, 196 captures of 81 females, 153 captures of 64 juveniles and 22 captures of 22 toadlets. The toadlets, averaging 24.2 mm SVL, were found on the beaches beginning on July 20th. In the Main Study Area we made 61 captures of 22 males, 82 captures of 37 females, 65 captures of 27 juveniles and 11 captures of 11 toadlets whereas the Thoroughfare Study Area, we made 57 captures of 26 males, 114 captures of 50 females, 88 captures of 43 juveniles and 71 captures of 27 toadlets.

Tadpole growth rates differed according to density. At the lowest density treatment (0.08 tadpole per litre), tadpoles grew of average 1.51 mm/day but at the highest density treatment (5.0 tadpoles per litre) tadpoles grew only an average 0.44 mm/day (Fig.11). Mean body mass at metamorphosis showed similarly negative relationship between density and growth as increasing density conditions gave rise to newly metamorphosed toadlets with smaller body sizes (Fig. 12). Out of the original 2,512 tadpoles raised in pens in the experimental ponds, a total of 140 toadlets were ultimately released into the environment, an average survival rate of 5.5%, which is not considered particularly low for toads (Banks and Beebee 1988).

Discussion

The year 2013 showed a further decrease in Fowler's toad population size in continuation of a decade-long downward trend in abundance in our study site (Greenberg and Green 2013). Population fluctuations spanning orders of magnitude are not uncommon for amphibians (Pechmann *et al.* 1991) and are often attributable to variation in juvenile recruitment (Alford, 1999; Berven, 1990, 1995, 2009; Beebee et al. 1996). Over the 25-year course this study, years with an abundance of juveniles sometimes produce large cohorts that could be observed over successive years (Middleton 2012). While severe winter storms were likely culprits of the population crashes of 1986 and 1994, annual survival rates for adults are highly variable, ranging from 0.20 to 1.00, mean = 0.47 (Middleton 2012). Nevertheless, the spread of the invasive common reed, *Phragmites australis*, in the marshes at Long Point (Wilcox et al. 2003; Badzinski 2006) is associated with the loss of breeding habitat for the toads, and thus a diminution in recruitment of juveniles into the adult population and a declining trend in their abundance (Greenberg and Green 2013).

The experimental ponds installed in 2013 in the Long Point NWA show promise for being able to mitigate factors responsible for population decline in these toads. Toadlets produced from the experimental ponds may be expected to have an overall positive effect on the population's survival. The only site used by Fowler's Toads this past spring, within the entire 10 Km long combined study area, was an ephemeral beach pool that washed out due to dynamic wave action of the lake before any tadpoles in it had time to reach metamorphosis. Thus the production of toadlets in 2013 was entirely due to the invention of rearing tadpoles in the experimental ponds. Nevertheless, tadpoles raised under the two highest density conditions took a significantly longer time to begin showing signs of metamorphosis, and metamorphosed at a smaller body mass than the tadpoles that were raised under low density conditions. The slower growth and late metamorphosis may be due to many factors associated with high density conditions, such as the stress of being in a small space, limited food or limited surface area in which to bask in warmer waters. Further information will be collected next season by continuing with the density treatments in the experimental ponds.

The 5.5% survival rate of tadpoles through to metamorphosis in our experimental ponds is encouraging. Such survival rates in the wild are invariably very low among pond-breeding amphibians. For example, Banks and Beebee (1988) found survival rates from tadpole to toadlet in five ponds in the U.K. to range from 1.4% to 5.2% among Natterjack Toads, *Pseudepidalia calamita*, which are ecologically similar to Fowler's Toads in their preference for sand dune and shoreline habitats. Many of the losses in our ponds may be attributed to slow growth rates among tadpoles at the highest density conditions such that they failed to metamorphose in a timely manner. Predation of toadlets by garter snakes and water snakes was also high in some of our enclosures. Survival rate can be improved by carefully adjusting tadpole density in rearing pens and by ensuring that enclosures for toadlets are more reliably snake-proof.

Future mark-recapture monitoring of the Long Point population, especially in the Thoroughfare Study Area, will enable monitoring of the growth and survival of individuals released from the experimental ponds. Information on their survival and dispersal will be collected next season and, by using the new photo recognition software, we will be able to identify individuals and gather further information on individual growth, survival and movement in the terrestrial habitat. However, with the introduction artificial ponds into the landscape and active mitigation measures designed to enhance toadlet survival, the 25-year long study of changes in abundance in the Fowler's Toad population in the Main Study Area has, effectively, come to an end and a new study has begun.

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Literature Cited

Alford, R. and S. Richards. 1999. Global amphibian declines: a problem in applied ecology. Ann. Rev. Ecol. Syst. 30:133-65.

Badzinski, S.S., S. Proracki S.A. Petrie and D. Richards. 2008. Changes in the distribution & abundance of common reed (*Phragmites australis*) between 1999 and 2006 in marsh complexes at Long Point – Lake Erie. Ontario Ministry of Natural Resources, Peterborough.

Banks, B., and T.J.C. Beebee. 1988. Reproductive success of natterjack toads *Bufo calamita* in two contrasting habitats. Journal of Animal Ecology: 475-492.

Beebee, T.J.C., J.S. Denton and J. Buckley. 1996. Factors affecting population densities of adult natterjack toads, *Bufo calamita*, in Britain. J. Applied Ecol. 33:263-268.

Berven, K. A. 1990. Factors affecting population fluctuations in larval and adult stages of the wood frog, (*Rana sylvatica*). Ecology 71:1599-1608.

Berven, K. A. 1995. Population regulation in the wood frog, *Rana sylvatica*, from three diverse localities. Australian J. Ecology 20:385-392.

Berven, K. 2009. Density dependence in the terrestrial stage of wood frogs: evidence from a 21-year population study. *Copeia* 2: 328-338.

Bhattacharya, C.G., 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics, 23: 115-135.

Chao, S., M. Lee, and S.L. Jeng. 1992. Estimation of population size for capture-recapture data when capture probabilities vary by time and individual animal. *Biometrics* 48:201-216.

COSEWIC. 2010. COSEWIC assessment and status report on the Fowler’s Toad *Anaxyrus fowleri* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 58 pp.(www.sararegistry.gc.ca/status/status_e.cfm).

Donnelly, M.A., and C. Guyer. 1994. Mark-recapture. pp. 183-200, *In* W.R Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek and M.S. Foster (eds.). Measuring and monitoring biological diversity. Standard methods for amphibians. Smithsonian Inst. Press, Washington.

FAO, 2005. FiSAT II, vers. 1.2.2 FAO-ICLARM Stock Assessment Tools. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.

Gray M. J., and L.M. Smith. 2005. Influence of land use on postmetamorphic body size of Playa Lake amphibians. Journal of Wildlife Management 69(2):515-524.

Green, D.M. 1989. Fowler's Toads, (*Bufo woodhousii fowleri*) in Canada: biology and population status. *Can. Field. Nat*. 103:486-496.

Green, D.M. 1992. Fowler's toads, *Bufo woodhousii fowleri*, at Long Point, Ontario: changing abundance and implications for conservation. *In* C.A. Bishop and K.E. Pettit (eds.), Declines in Canadian Amphibian Populations: Designing a National Monitoring Strategy, pp. 37-45. Canadian Wildl. Serv. Occ. Publ. 76, Environment Canada, Ottawa.

Green, D.M. 2013 Sex ratio and breeding population size in Fowler’s Toad, *Anaxyrus* (= *Bufo*) *fowleri*. Copeia 2013: 647–652.

Green, D.M., A.R. Yagi, and S.E. Hamill. 2011. Recovery strategy for the Fowler’s Toad (*Anaxyrus fowleri*) in Ontario. Ontario Recovery Strategy Series. Ontario Ministry of Natural Resources, Peterborough, Ontario. vi + 21pp.

Greenberg, D.A. and D.M. Green. 2013. Effects of an invasive plant on population dynamics in toads. Conservation Biology 27:1049-1057.

Hota, A. K. 1994. Growth in amphibians. Gerontology 40:147-160.

Laurin, G., and D.M. Green. 1990. Spring emergence and male breeding behaviour of Fowler's toads, (*Bufo woodhousei fowleri*), at Long Point, Ontario. Can. Field-Nat. 104:429-434.

Middleton, J. 2012. Population ecology of a declining amphibian in relation to density. M.Sc. Thesis, Department of Biology, McGill University, Montreal

Middleton, J., and D.M. Green. 2011. Population ecology of Fowler's Toad (*Anaxyrus fowleri*) at Long Point, Ontario, with notes on alternative methods for recognizing individual animals. Field Report for 2011. Canadian Wildlife Service, Environment Canada, Ontario Ministry of Natural Resources and Ontario Parks.

Rexstad, E., and K. Burnham. 1991. User's guide for interactive program CAPTURE. Colorado Collaborative Fish Wildl. Res. Unit, Fort Collins.

White, G.C., D.R. Anderson, K.P. Burnham and D.L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos Nat. Lab. Publ. LA-8787-NERP:1-235.

Wilcox, K. L., S. A. Petrie, L. A. Maynard, and S. W. Meyer. 2003. Historical distribution and abundance of *Phragmites australis* at Long Point, Lake Erie, Ontario. Journal of Great Lakes Research 29:664-680.

Yagi, K. and D. M. Green. 2012. Population Ecology of Fowler's Toad (*Anaxyrus fowleri*) at Long Point, Ontario. Field Report for 2012. Canadian Wildlife Service, Environment Canada, Ontario Ministry of Natural Resources and Ontario Parks.

Table 1. Breeding site locations surveyed for Fowler's Toads in the Main Study Area at Long Point, Ontario.

	Site	Latitude N	Longitude W	Description and Location
Hastings Drive				
1	Hastings Drive 4	42.576	80.472	2.6 km W of Hastings Drive and Highway #59 intersection. Two sections include a marshy area along a permanent bay 30 m NW of the parking area and a much smaller isolated section 15-20 m NE of parking area.
2	Hastings Drive 3½	42.575	80.467	2.4 km W of Hastings Drive and Highway #59 intersection is a shallow semi-permanent marshy area.
3	Hastings Drive 3	42.575	80.465	1.8 km W of Hastings Drive and Highway #59 intersection is a shallow semi-permanent marshy area 15 m W of a much deeper channel
4	Hastings Drive 2	42.576	80.457	0.6 km W of Hastings Drive and Highway #59 intersection where a permanent bay is 15 m N of road (easy access via walking trail)
5	Hastings Drive 1	42.577	80.448	0.4 km W of Hastings Drive and Highway #59 intersection where a large bay is approximately 20 m N of road
Crown Marsh				
6	Winston Parkway	42.581	80.423	Channel and surrounding marshy area N and E of gate on dirt road about 50 m N of Winston and Highway #59 intersection

7	Brant Parkway	42.582	80.420	Semi-permanent pond and surrounding marshy area 80 m N of Brant and Highway #59 intersection
8	Pines Parkway	42.583	80.417	Semi-permanent pond and surrounding marshy area 65 m NNE of Pines and Highway #59 intersection
9	Johnson Avenue	42.582	80.413	Marshy area immediately east and west of street (80 m N of Highway #59)
10	Long Point Provincial Park West (LPPPW)	42.582	80.411	Marshy area N of Highway #59 directly opposite gate to the old section of provincial park (1.2 km W of LPPP western boundary)
11	Austin Parkway	42.582	80.404	Marshy area 40 m west of Austin Parkway to the immediate north of Highway #59, including channel and marshy area at very northern end of the street where the paved road becomes dirt and access controlled by a gate.
Long Point Provincial Park				
12	Lighthouse	42.582	80.396	50 m W of LPPP western boundary about 45 m N of Long Point Portage Historical Plaque on Highway #59
13	Boat Ramp	42.583	80.388	0.6 km E of western LPPP boundary, immediately east and west of cement boat ramp and docks.
14	Feeding Pond	42.581	80.386	Artificial pond 150 m North of road
15	Parking Lot	42.580	80.377	3 m E of additional car parking lot near gate to Turtle Dunes Campground (1.4km E of western LPPP boundary)

16	Thoroughfare Point	42.577	80.372	4 m east of CWS (Canadian Wildlife Service) monument at eastern end of Long Point Provincial Park (LPPP) boundary, including 1) "Small Pond" - 10 m NE of CWS monument in a hollow N of the dunes at Thoroughfare Point. 2) "Big Pond" - 55 m NE of CWS monument at the CWS/LPPP boundary. 3) "Bay" - 30 m N of CWS monument along CWS/LPPP boundary (20 m NW of Small Pond).

Table 2. Locations of experimental breeding ponds for Fowler's Toads installed in 2013 at the Thoroughfare Point Unit of the Long Point National Wildlife Area (see Figure 2).

Pond	º Latitude N	º Longitude W
1	42.5762	80.3702
2	42.5756	80.3668
3	42.5753	80.3647
4	42.5751	80.3620
5	42.5755	80.3600
6	42.5748	80.3572

Table 2. Survey dates, dates of first emergence and number of active nights during the study period for male and female Fowler's toads, *Anaxyrus fowleri* at Long Point Ontario.

	Survey		Males		Females	
Year	Start	End	emergence	active nights	emergence	active nights
1988	2 May	1 June	14 May	13		
1989	3 May	19 June	16 May	21		
1990	2 May	5 June	8 May	9	15 May	
1991	3 May	11 June	9 May	25		
1992	2 May	9 June	9 May	18	11 May	13
1993	4 May	8 June	8 May	21	8 May	
1994	30 April	6 June	19 May	13	21 May	
1995	1 May	6 June	12 May	19	23 May	
1996	1 May	8 June	16 May	16	30 May	
1997	9 May	8 June	23 May	13	5 June	
1998	5 May	5 June	4 May	28	6 May	
1999	4 May	7 June	3 May	23	5 May	
2000	27 April	9 June	5 May	22	17 May	13
2001	30 April	8 June	3 May	21	11 May	10
2002	29 April	13 June	5 May	22	6 May	17
2003	30 April	14 June	7 May	13	10 May	19
2004	30 April	9 June	5 May	30	10 May	25
2005	1 May	9 June	9 May	20	10 May	16
2006	1 May	8 June	8 May	17	4 May	13
2007	1 May	9 June	9 May	16	10 May	14
2008	1 May	9 June	10 May *	13	25 May	13
2009	1 May	10 June	6 May *	22	13 May	19
2010	1 May	10 June	21 May*	16	19 May	18
2011	1 May	10 June	13 May	17	29 May	12
2012	1 May	10 June	3 May	21	13 May	19
2013	1 May	10 June	3 May	24	3 May	24

* toads detected foraging but not calling

Table 3. Numbers of male individual captured, estimated numbers of individuals, numbers of recaptured individuals, recapture rates and mean snout vent lengths (SVL) for male Fowler's toads, *Anaxyrus fowleri*, at Long Point, Ontario, within the bounds of the Main Study Area between 80.372º and 80.472º W longitude.

	N males (+/- S.E.)		Year to year recaptures		mean SVL
Year	captured	estimated	number	Rate	(mm ± S.D.)*
1988	12	12 ± 0	n/a	n/a	51.8 ± 3.9
1989	46	41 ± 1	1	0.083	56.0 ± 3.8
1990	61	156 ± 40	2	0.043	51.3 ± 3.2
1991	294	430 ± 29	1	0.016	51.5 ± 2.7
1992	229	307 ± 16	8	0.027	52.3 ± 2.8
1993	265	394 ± 23	13	0.057	50.9 ± 3.0
1994	83	93 ± 4	1	0.004	54.2 ± 2.2
1995	43	43 ± 1	13	0.166	55.3 ± 3.2
1996	37	39 ± 2	10	0.232	56.0 ± 2.3
1997	31	31 ± 1	5	0.135	57.1 ± 3.4
1998	180	191 ± 4	2	0.065	55.3 ± 2.8
1999	67	74 ± 4	23	0.128	56.1 ± 3.2
2000	51	63 ± 5	8	0.119	54.7 ± 3.2
2001	69	69 ± 4	19	0.373	53.9 ± 3.0
2002	184	240 ± 23	18	0.261	53.8 ± 3.8
2003	72	134 ± 14	26	0.141	53.6 ± 3.9
2004	150	174 ± 6	52	0.722	52.7 ± 3.6
2005	78	89 ± 5	25	0.167	54.3 ± 2.5
2006	39	48 ± 4	15	0.192	55.8 ± 3.4
2007	39	42 ± 3	9	0.231	55.6 ± 3.4
2008	32	42 ± 6	11	0.282	58.3 ± 3.8
2009	34	37 ± 2	3	0.094	59.7 ± 3.3
2010	16	20 ± 3	6	0.176	59.9 ± 4.0
2011	15	15 ± 0	0	0.000	61.4 ± 4.9
2012	21	21 ± 0	0	0.000	57.1 ± 6.3
2013	10	10 ± 0	6	0.286	59.5 ± 2.9

Table 4. Numbers of female individuals captured, estimated numbers of individuals and estimated mean snout vent lengths (SVL) for female Fowler's toads, *Anaxyrus fowleri*, at Long Point Ontario, within the bounds of the Main Study Area between 80.372º and 80.472º W longitude. Data sufficient to estimate abundances were not available for all years.

	N females (+/- S.E.)		estimated mean SVL
Year	Captured	estimated	(mm)*
1988		-	68.0 ± 2.3
1989	30	41 ± 6	65.9 ± 5.2
1990	1	-	62.1 ± 0.9
1991	17	-	53.9 ± 4.0
1992	24	-	55.0 ± 1.3
1993	47	-	51.7 ± 2.3
1994	16	-	55.9 ± 2.2
1995	16	21 ± 4	55.2 ± 3.4
1996	8	-	62.3 ± 4.6
1997	1	-	59.4 ± 3.3
1998	202	156 ± 5	55.7 ± 3.5
1999	64	72 ± 9	62.6 ± 2.6
2000	33	129 ± 56	62.3 ± 2.7
2001	18	24 ± 8	62.8 ± 4.3
2002	64	198 ± 79	59.7 ± 4.9
2003	66	127 ± 41	57.5 ± 7.6
2004	138	173 ± 10	55.7 ± 5.5
2005	60	81 ± 7	59.4 ± 4.3
2006	30	71 ± 19	60.1 ± 2.4
2007	44	54 ± 2	59.2 ± 3.7
2008	42	51 ± 8	65.2 ± 4.3
2009	25	28 ± 2	65.1 ± 6.0
2010	24	26 ± 2	65.5 ± 5.2
2011	12	12 ± 0	69.5 ± 5.4
2012	43	44 ± 1	64.3 ± 4.0
2013	20	22 ± 2	62.9 ± 5.6

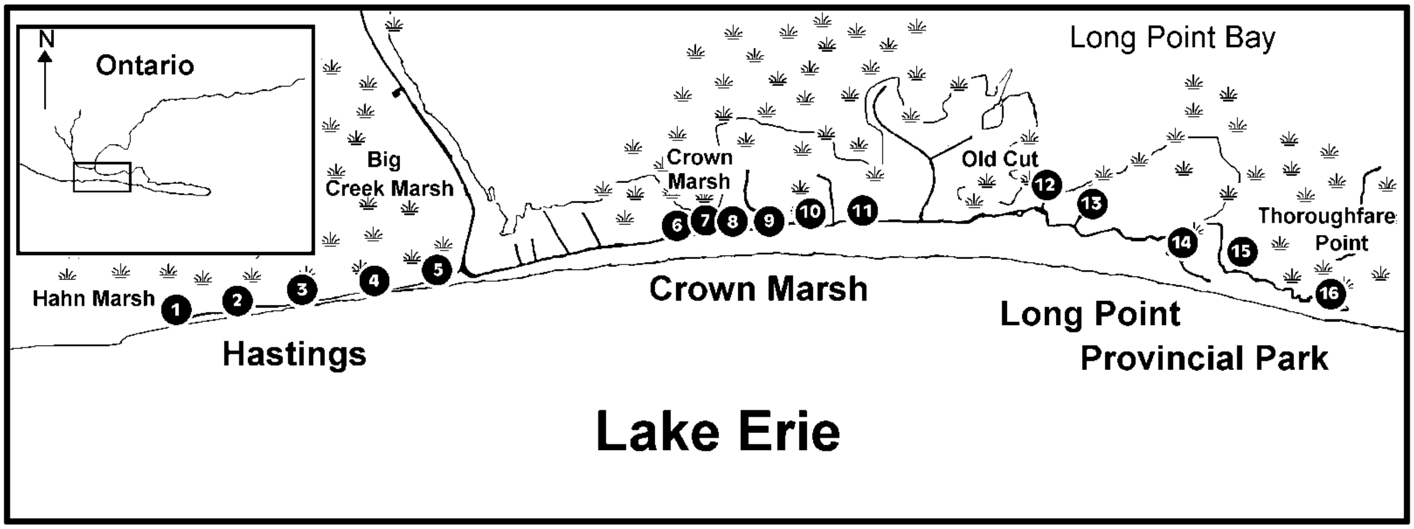

Figure 1. The Main Study Area at the western base of Long Point showing the sites principally surveyed for Fowler's toads (see Table 1). 1) Hastings Drive 4, 2) Hastings Drive 3, 3) Hastings Drive 2, 4) Hastings Drive 1, 6) Winston Parkway, 7) Brant and Pines Parkways, 9) Johnson Avenue (now Buck Lane), 10) Long Point Provincial Park West (LPPPW), 11) Austin Parkway, 12) Boat Ramp, 13) Feeding Pond, 14) Parking Lot, 15) Big Pond, 16) Thoroughfare Point. Surveys also included the adjacent beaches, on Lake Erie.

Figure 2. Experimental breeding ponds for Fowler’s Toads installed in 2013 at the Thoroughfare Point Unit of the Long Point National Wildlife Area. A) Locations of ponds, numbered 1 through 6 (see Table 2). GoogleEarth image, 27 Sept., 2013. B) Pond No. 1 in March of 2013.

Figure 3. Standard photographs used to identify and match individual toads. These photographs represent two captures of the same individual on different nights as identified by the image-recognition software. Despite differences in orientation of the animal in each photograph, the software system reconizes that the pattern of dorsal spots on the animal is the same in each image.

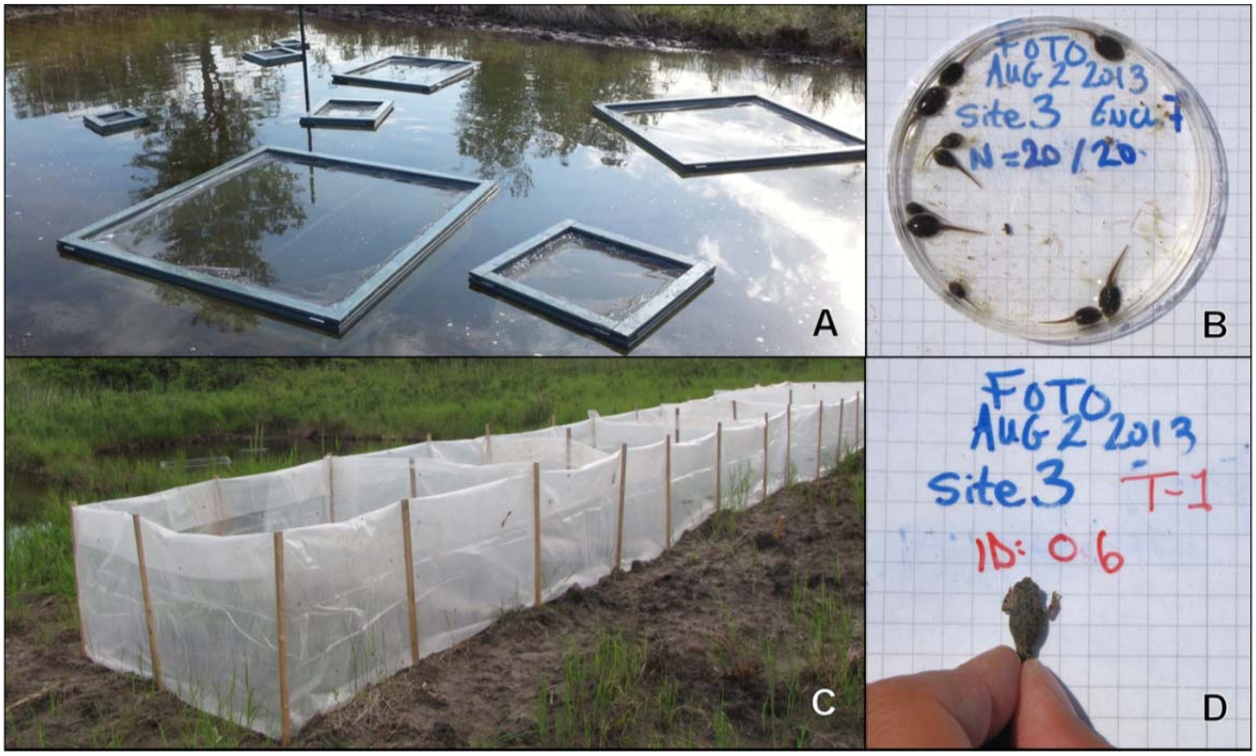

Figure 4. Enclosures in the Thoroughfare Study Area for Fowler's Toad tadpoles and toadlets. A) Aquatic enclosures in an experimental pond for raising tadpoles at varying densities. B) Standardized digital photograph taken of tadpoles to measure growth rate until metamorphosis. C) Terrestrial enclosures for toadlets, one for each treatment group, until they reached releasable size. D) Standardized digital photograph of a toadlet to record identifying individual dorsal spot pattern prior to release in open terrestrial habitat.

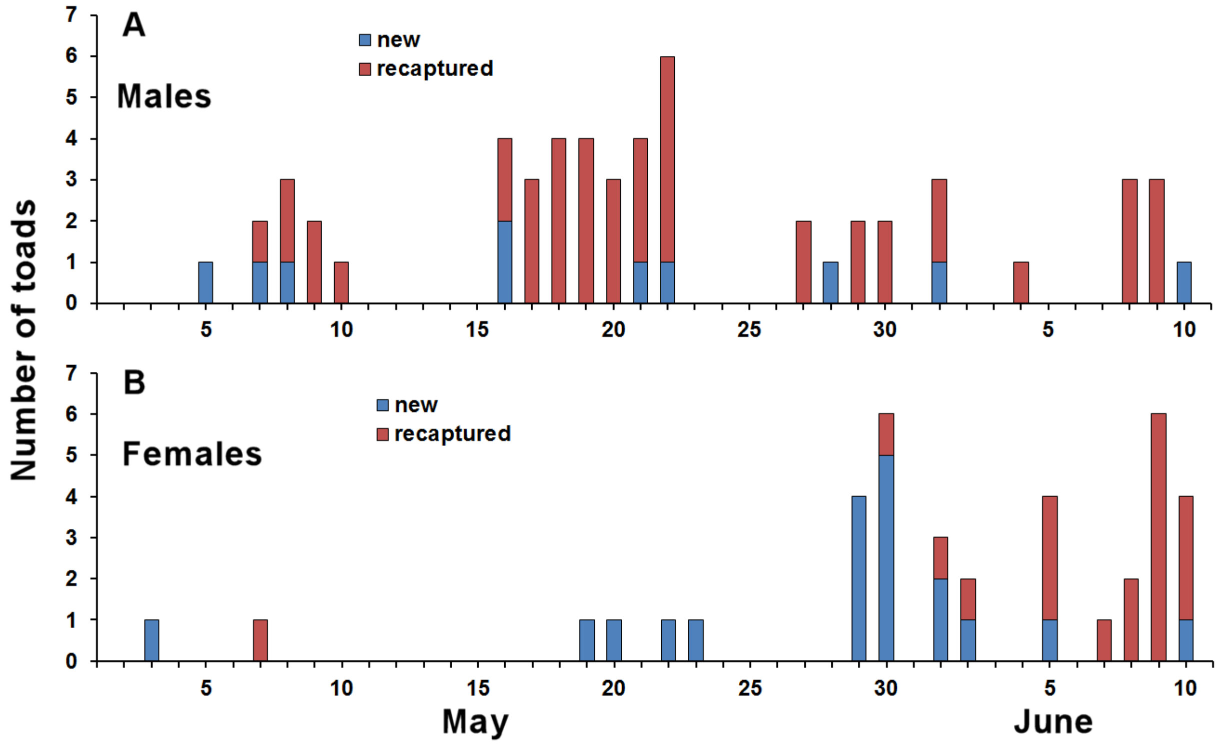

Figure 5. Record of captures and recaptures for A) male and B) female Fowler's toads (*Anaxyrus fowleri*) in Long Point Ontario, during the spring survey in the Main Study Area (Fig. 1) from May 1 through June 10, inclusive.

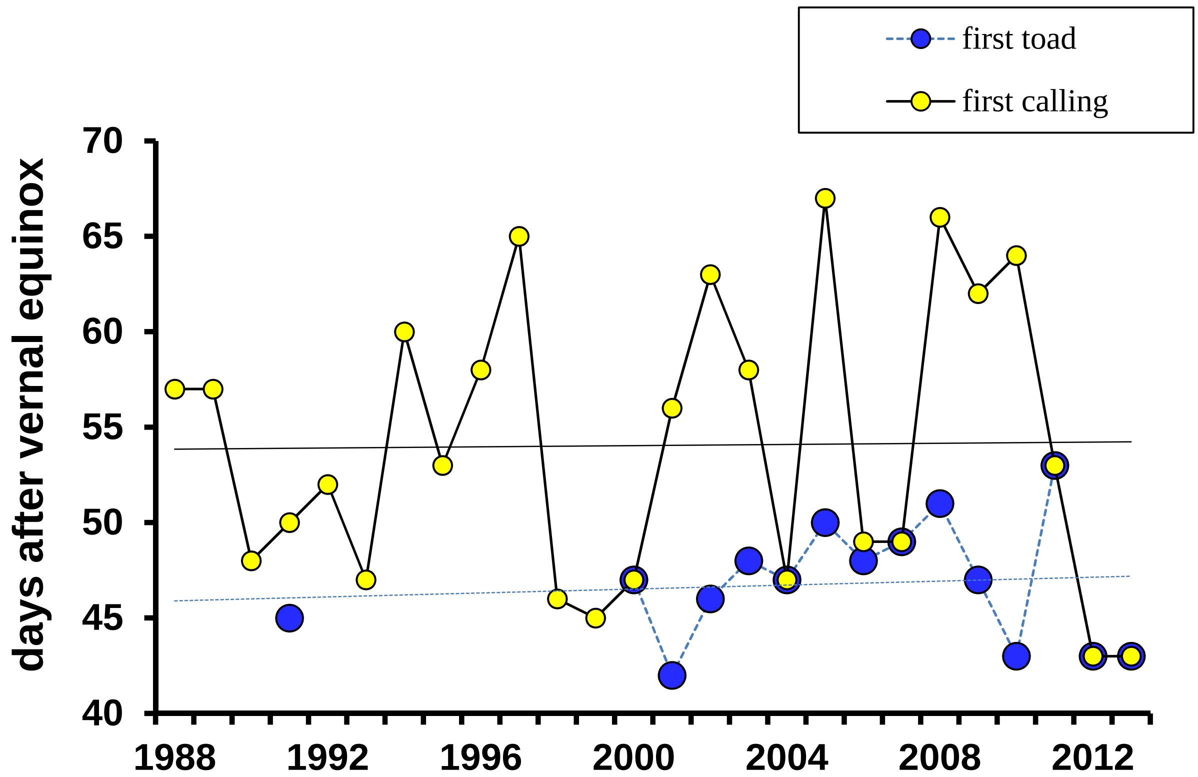

Figure 6. Dates of first calling and first toad encountered in spring for male Fowler's toads (*Anaxyrus fowleri*) in theMain Study Area at Long Point, Ontario, 1988-2013 inclusive (see Table 2).

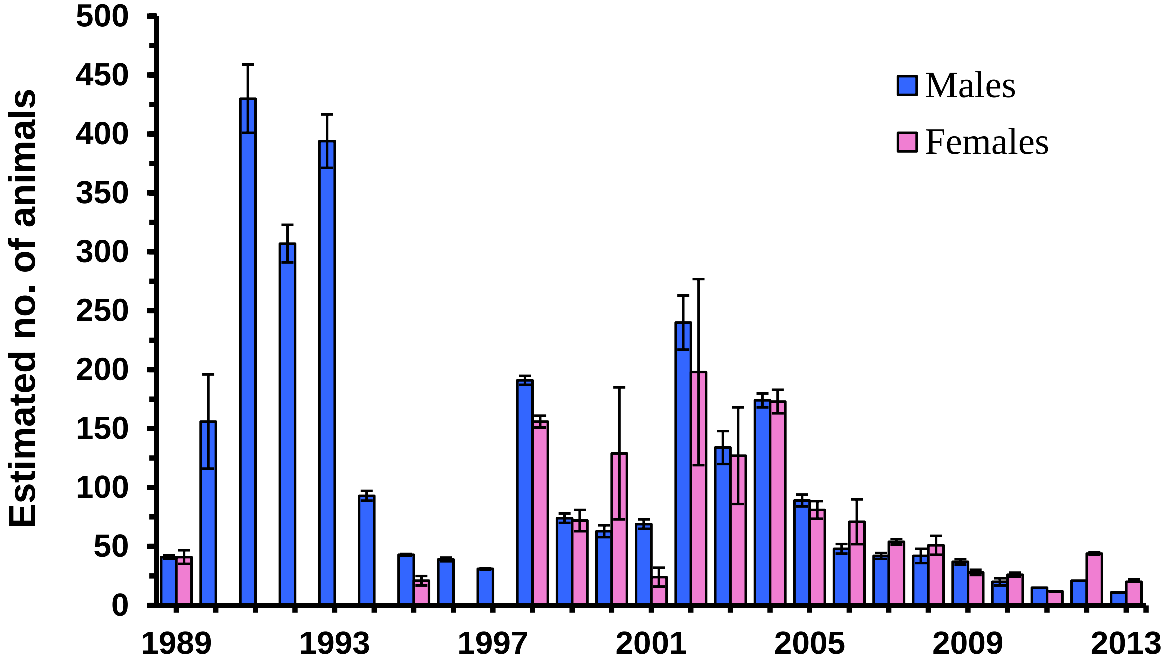

Figure 7. Estimated numbers of male and female Fowler's toads, *Anaxyrus fowleri*, in the Main Study Area at Long Point, Ontario, over 25 years, from 1989 to 2013, inclusive.

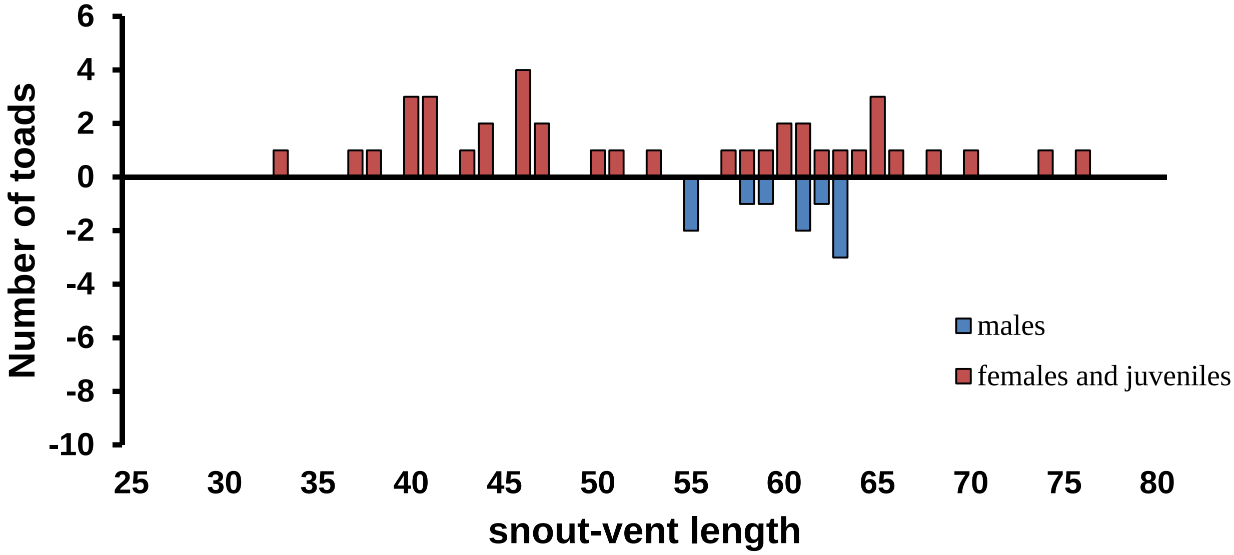

Figure 8. Distribution of snout-vent lengths (SVL) for Fowler's toads at Long Point, Ontario, in 2013, within the Main Study Area (Fig. 1).

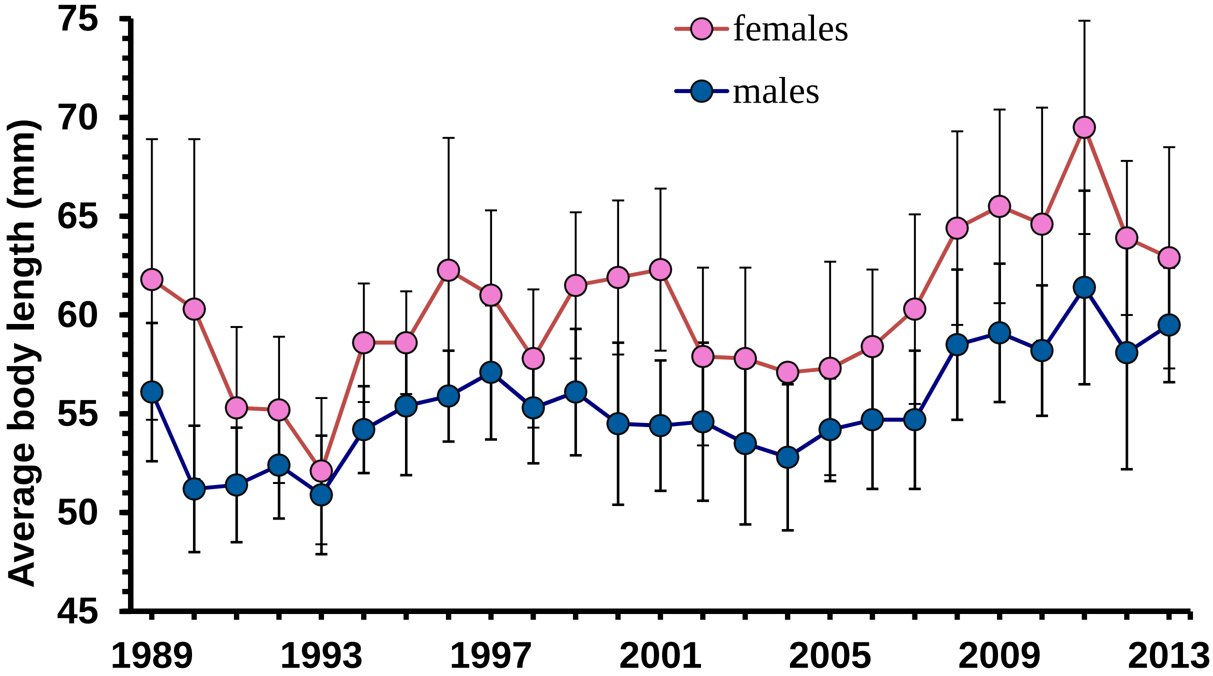

Figure 9. Average snout-to-vent length, with std. dev., for adult male and female Fowler's toads (*Anaxyrus fowleri*) in in the Main Study Area at Long Point Ontario, from 1989 to 2013, inclusive (from Tables 3 and 4).

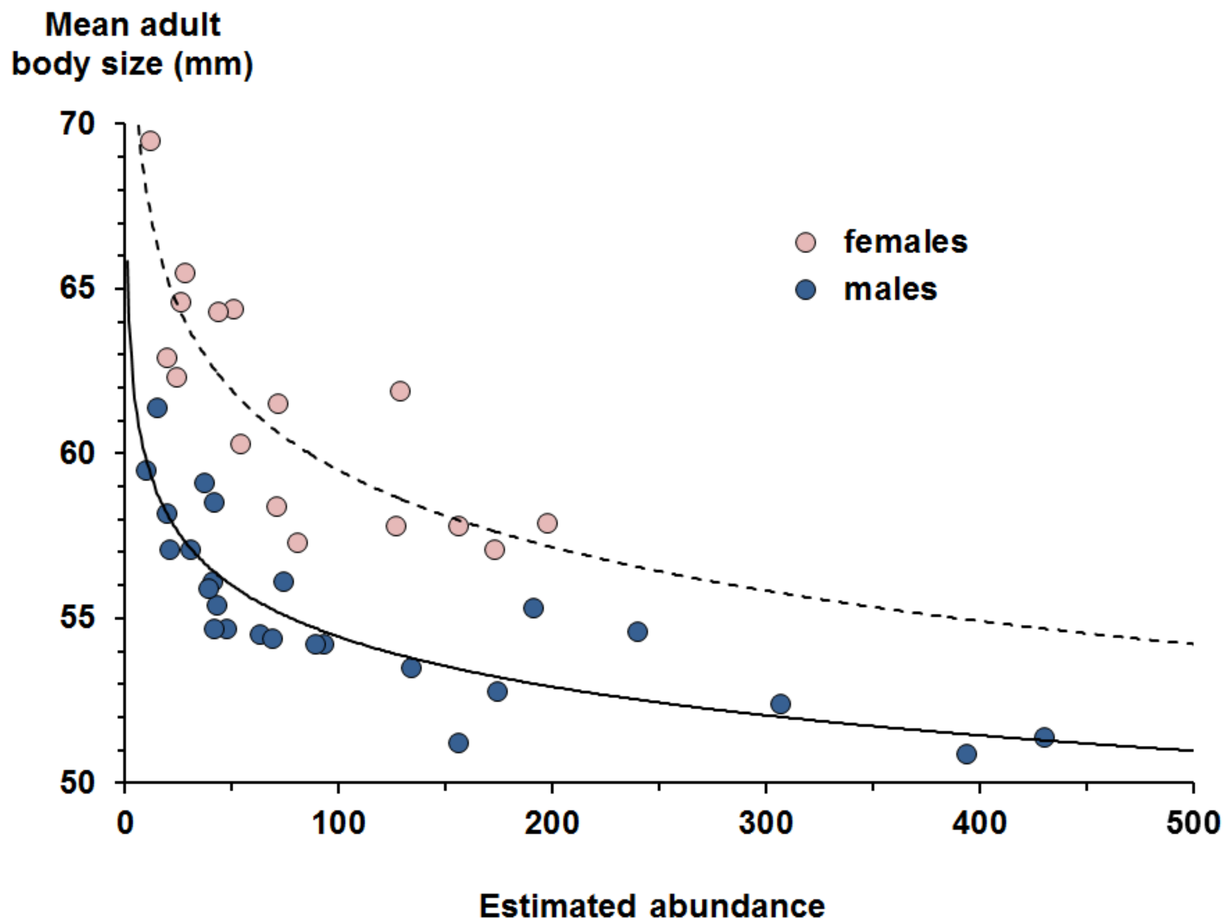

Figure 10. Body size of male (r^2= 0.752) and female (r^2= 0.707) Fowler's Toads in the Main Study Area in relation to abundance.

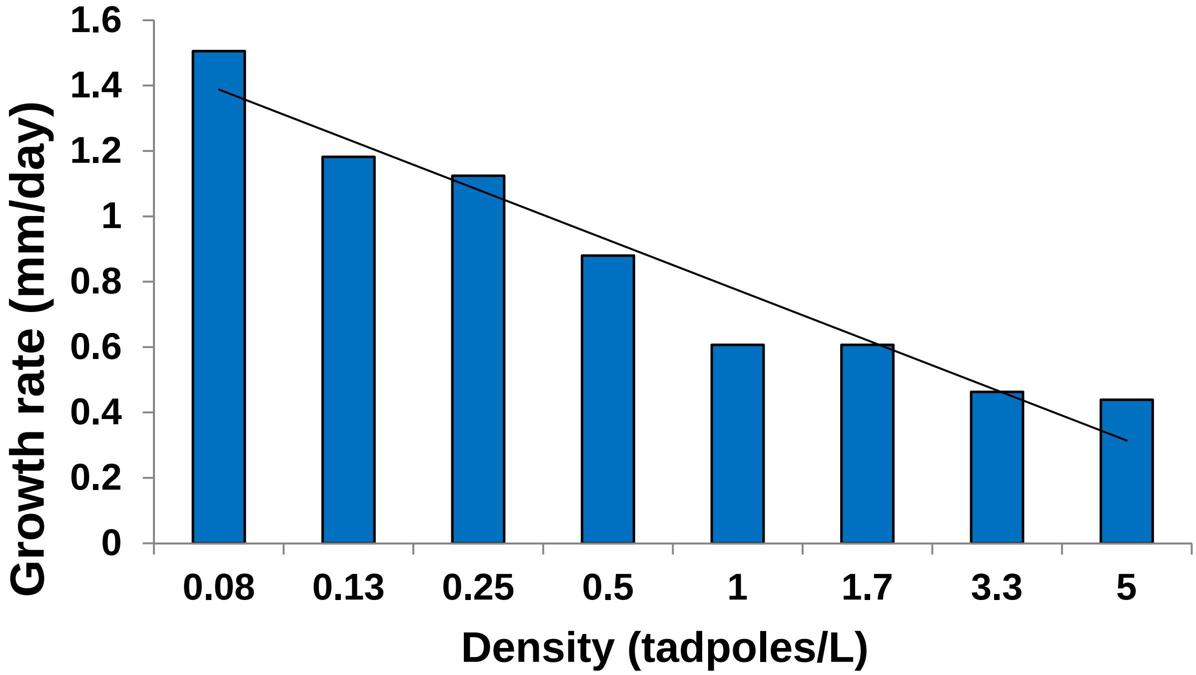

Figure 11. Mean tadpole growth rate according to density. The difference in total body length measurements were averaged from treatment day 1 to day 16. The resulting trend is a negative relationship between growth rate and increasing density conditions (r^2= 0.94).

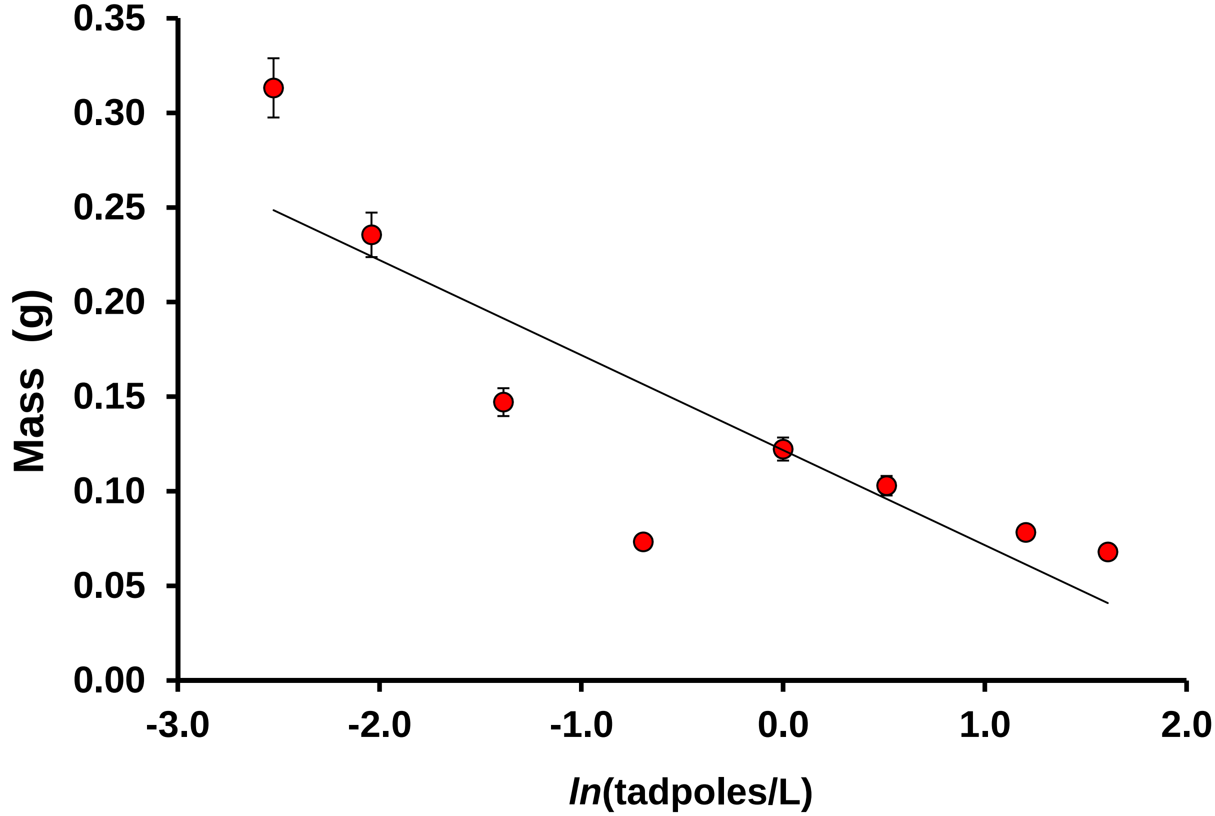

Figure 12. Mean toadlet body mass at metamorphosis, with standard error, according to density in term of *ln*(tadpoles/L). The relationship shows a strong negative trend (r^2= 0.74) showing the effect of increasing density conditions during tadpole development on their resulting metamorphic size.