Have salamanders declined in Ontario?

David C Seburn[1]

Erin Mallon[2]

[1]Seburn Ecological Services

2710 Clarenda St, Ottawa, Ontario, K2B 7S5

[2]Ontario Nature

214 King Street West, Suite 612, Toronto, ON M5H 3S6

Prepared for

Ontario Wildlife Foundation

Ottawa Field-Naturalists' Club

October 2015

Abstract

Amphibians are known to be declining around the world. Although most affected species are frogs, salamanders are declining as well. The Ontario Reptile and Amphibian Atlas (ORAA) is a citizen science project that tracks reptiles and amphibians across the province over time. Data from the ORAA indicate that salamanders are absent from many historical areas of Ontario. This result could be from a true decline or a lack of recent observations from many areas. To test this we conducted surveys for salamanders in 25 historical 10x10 km grid squares across eastern Ontario. Result highlights:

- Checked 3876 cover objects in 25 grid squares
- Confirmed Red-backed Salamanders present in 21 of 25 (84%) squares surveyed
- Found 202 individual salamanders of 6 different species
- 90% of salamanders found were Red-backed Salamanders
- The median number of cover objects checked to detect a species varied from 34 for Red-backed Salamanders to >100 for Blue-spotted and Spotted Salamanders
- Found up to 3 species of salamanders per square
- Provided the first recent records for Spotted Salamanders in 4 squares, and for Blue-spotted and Two-lined Salamanders in 1 square
- Provided the first records ever for 4 species of salamander in 5 squares

Our results strongly suggest that lack of survey effort explains much of the apparent decline of salamanders in eastern Ontario. The lack of results for species other than Red-backed Salamanders may be because they have more limited distributions in forests as they are reliant on wetlands for breeding, or because they spend more time underground, making them more difficult to detect. The ORAA volunteers should be encouraged to survey for salamanders in historical squares to better improve our current understanding of the distribution of these species.

Next steps: (1) Update databases and distribution maps for all species of salamanders with our current data; (2) Prepare a blogpost on our work to encourage the ORAA volunteers to survey historical squares for salamanders; (3) Prepare a scientific paper on our results to be submitted to the journal the Canadian Field-Naturalist.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Amphibian populations are known to be declining around the world (Wake and Vrendenburg 2008, Collins and Crump 2009, Collins 2010). A global assessment of all known amphibian species found that one-third were threatened with extinction (Stuart et al. 2004). Although amphibian declines are often associated only with frogs, salamanders are also declining with at least two apparent extinctions (Rovito et al. 2009). Salamander declines have been reported in Europe (van der Sluijs et al. 2013), central America (Rovito et al. 2009), and North America (Bank et al. 2006, Means and Travis 2007). Declines have been observed in both aquatic (Wheeler et al. 2003, Lowe 2012) and terrestrial salamanders (Maerz et al. 2009, Caruso and Lips 2013). Some species have even declined within protected areas where habitat loss has not been an issue (Bank et al. 2006). The cause or causes of many of these declines remain uncertain, although disease (Bosch and Martínez-Solano 2006), pollution (Bank et al. 2006), invasive species (Maerz et al. 2009), habitat loss (Arntzen 2015), and climate change (Parra-Olea et al. 2005, Caruso et al. 2014) are all probable causes. In addition, a chytrid fungus (*Batrachochytrium salamandrivorans*) likely introduced to Europe from Asia, is causing mortality of European salamanders and may also be lethal to North American species (Martel et al. 2014).

Salamander declines are important as salamanders are a critical component of forest ecosystems. The biomass of woodland salamanders can be greater than that of birds or small mammals (Burton and Likens 1975). Salamanders are significant predators of forest floor invertebrates and their loss from forest ecosystems could have significant effects on invertebrate diversity, soil dynamics and nutrient cycling (Davic and Welsh 2004).

The Ontario Reptile and Amphibian Atlas (ORAA) is documenting the current distribution of amphibians and reptiles across Ontario, using 10x10 km grid squares, similar to the provincial Breeding Bird Atlas managed by Bird Studies Canada. The ORAA is a citizen science project that relies on volunteer observers, researchers and land managers. Currently over 2500 people have contributed over 350,000 records. The data from the ORAA indicate that salamanders have declined significantly. For example, the

Eastern Red-backed Salamander *(Plethodon cinereus*) has no recent records (last 20 years) from over 400 grid squares where it was historically known to occur. In other words, this species may have been eliminated from more than 400 grid squares (more than 40,000 km^2), which is an area larger than the entire country of Switzerland. Similar trends have also been found for other woodland salamanders. Although salamanders may have declined, it is also possible that they have been under-reported from a lack of surveys. We conducted targeted surveys for salamanders in grid squares of eastern Ontario lacking recent reports to assess whether the perceived decline is real or a result of lack of surveys.

2.0 Study Area and Methods

We defined eastern Ontario as our study area because a large number of grid squares in this region lack recent reports of salamanders. Within this area we identified grid squares with historical records of the Red-backed Salamander but no records in the last 20 years. For each historical grid square we determined if there was public land (provincial parks or Crown land) within the square that could be easily surveyed. The presence of provincial parks in an area was determined by using Google maps, and Crown land presence was determined using the Ontario government's Crown Land Use Policy Atlas (http://www.giscoeapp.lrc.gov.on.ca/web/MNR/NHLUPS/CLUPA/Viewer/Viewer.html). For each square with public land we determined the last year of observation for all other species of woodland salamanders. Priority was given to squares with multiple species of salamanders with only historical records, but an effort was also made to include squares from across eastern Ontario.

Roads adjacent to (or on) public land were driven to select sites with deciduous or mixed woods to be surveyed for salamanders. Once a site was selected it was surveyed in a standardized manner to ensure consistency of results. The two authors, both experienced field biologists, searched under appropriate cover objects (woody debris such as branches, small logs, bark, or debris such as boards or sheet metal) for one hour (Figure 1). Surveys were stopped before one hour elapsed if all historical salamander

species had been detected. We recorded the total number of cover objects searched in each square, the number of cover objects searched to first detect each species, as well as the number of individuals of each species. The location (determined by GPS), date, time and weather conditions were recorded for each survey. On a few occasions only one biologist (DCS) conducted the surveys and in these cases, the survey lasted two hours to compensate for the reduction in surveyors.

Figure 1. Searching for salamanders.

To determine the abundance of salamanders within grid squares we considered only squares where we conducted full, one hour surveys and the target species was detected. The non-parametric Krusal-Wallis test was used for statistical comparisons using Mintab 8.3. QGIS 2.0 was used for data mapping.

3.0 Results

We surveyed 25 grid squares lacking recent records of the Red-backed Salamander from 15 July to 18 September (Appendix). All but three squares were surveyed from 11-18 September. Significant rainfall occurred on the weekend of 12-13 September. Soils under cover objects were damp to wet for the following week when most of our surveys occurred. Twelve of the surveys were within provincial parks and the remaining surveys were conducted on Crown land.

Red-backed Salamanders were detected in 21 of the 25 squares (Figure 2). There was not any obvious spatial pattern to squares where Red-backed Salamanders were not detected.

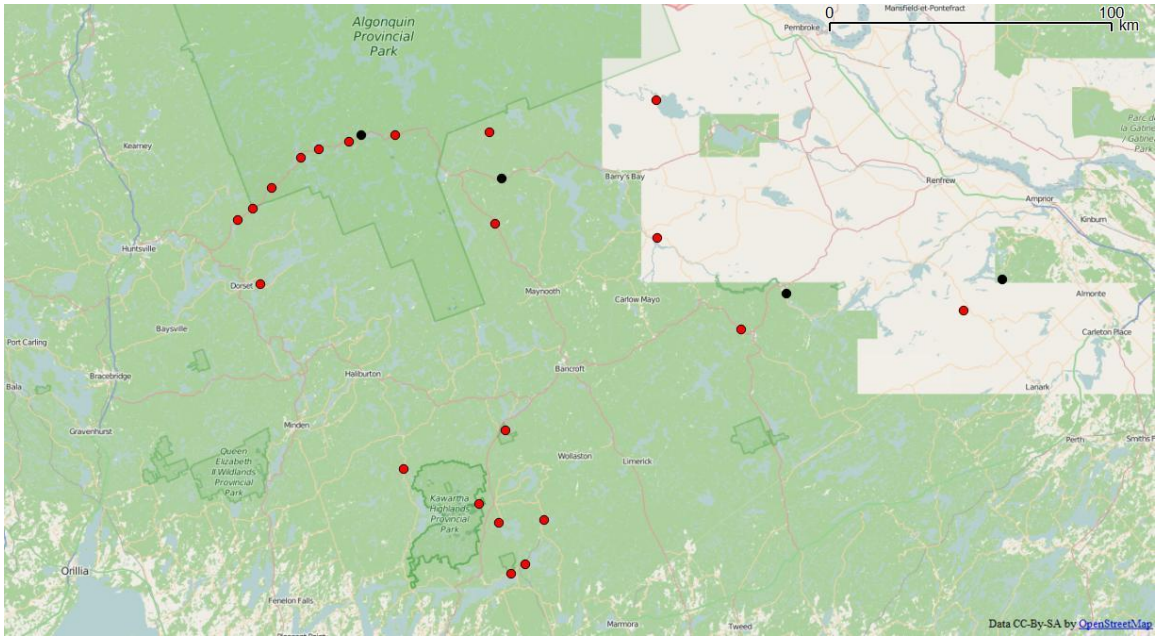

Figure 2. Location of 25 grid squares surveyed for salamanders. Red circles indicate Red-backed Salamanders were detected and black circles indicate they were not detected.

Our surveys resulted in 202 observations of salamanders. We provided the first recent records for a number of squares:

- 21 squares for the Red-backed Salamander
- 4 squares for the Spotted Salamander (*Ambystoma maculatum*)
- 1 square for the Northern Two-lined Salamander (*Eurycea bislineata*)
- 1 square for the Blue-spotted Salamander (*Ambystoma laterale*)

In addition, our surveys resulted in the first records ever for some squares:

- 2 squares for the Eastern Newt (*Notophthalmus viridescens*)
- 1 square for the Four-toed Salamander (*Hemidactylium scutatum*)
- 1 square for the Blue-spotted Salamander
- 1 square for the Spotted Salamander

Did the age of the historical record affect the likelihood of finding Red-backed Salamanders? There was no significant difference between the date of the last observation of Red-backed Salamanders in squares where they were detected (median

date = 1988, range: 1977-1994) compared with those squares where they were not detected (median date = 1987, range: 1984-1993; $H = 0.01$, $p > 0.9$).

Although the Red-backed Salamander was found in 21 of 25 squares surveyed, other species of salamanders were found in only 1-7 squares and rarely was more than one individual found in a square (Table 1). Red-backed Salamanders made up 90% (183 of 202) of all salamanders encountered. Considering the three most common species, the median number of individuals per square was 8 (range: 2-37) for Red-backed Salamanders, 1 (range: 1-2) for Blue-spotted Salamanders, and 1 (range: 1-1) for Spotted Salamanders. The number of individuals of the three species in each square differed significantly ($H = 15.13$, $p < 0.01$).

Table 1. Results of salamander surveys in 25 grid squares in eastern Ontario.

Species	# of squares found in	Total # of individuals found	Maximum # of individuals/square
Lungless Salamanders			
Red-backed Salamander (Figure 3)	21	183	37
Four-toed Salamander	1	1	1
Two-lined Salamander	2	4	3
Mole Salamanders			
Blue-spotted Salamander (Figure 4)	4	5	2
Spotted Salamander	7	7	1
Newts			
Eastern Newt (Figure 3)	2	2	1

We surveyed a total of 3876 cover objects in the 25 grid squares. There were a median of 205 (range: 148-272) cover objects checked per square when full surveys were conducted. Red-backed Salamanders were the first species detected in 90% (19 of 21 squares) of the squares where they were found. Considering the three species found in four or more squares, the median number of cover objects checked to detect a species was 34 (range: 1-145) for Red-backed Salamanders, 129.5 (range:34-204) for Blue-spotted Salamanders, and 154 (range: 6-187) for Spotted Salamanders (Figure 6). These detection rates were significantly different ($H = 9.46$, $p < 0.01$).

Figure 3. Eastern Red-backed Salamander (*Plethodon cinereus*)

Figure 4. Blue-spotted Salamander (*Ambystoma laterale*)

The median number of species of salamanders found in each square was 1 (range: 0 to 3). Most squares had one or two species detected (Figure 7). No salamanders were found in two squares. One of those squares was within Algonquin Provincial Park and had records of five species of salamanders, one recent (Spotted Salamander) and the rest historical. The other site was on Crown land southeast of Algonquin Park and it had two historical species. Three species of salamanders were detected in two squares. There was no overlap in the species in these two squares. In one square Blue-spotted, Spotted and Four-toed Salamanders were found and in the other Red-backed and Northern Two-lined Salamanders, and Eastern Newts were found.

Figure 5. Eastern Newt (*Notophthalmus viridescens*)

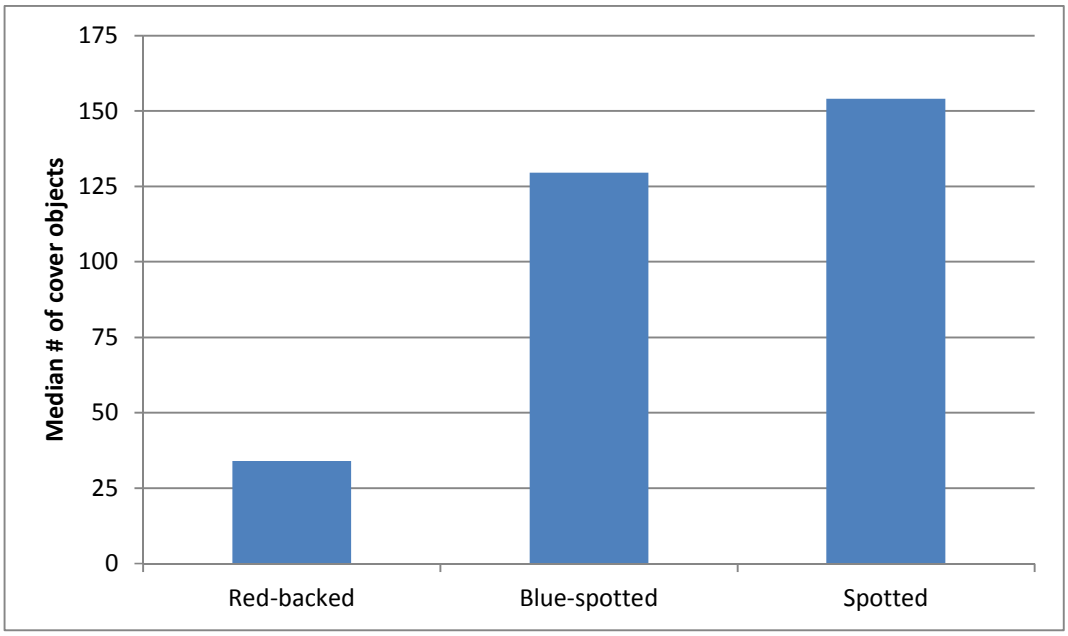

Figure 6. Median number of cover objects searched to detect the three most common species of salamanders.

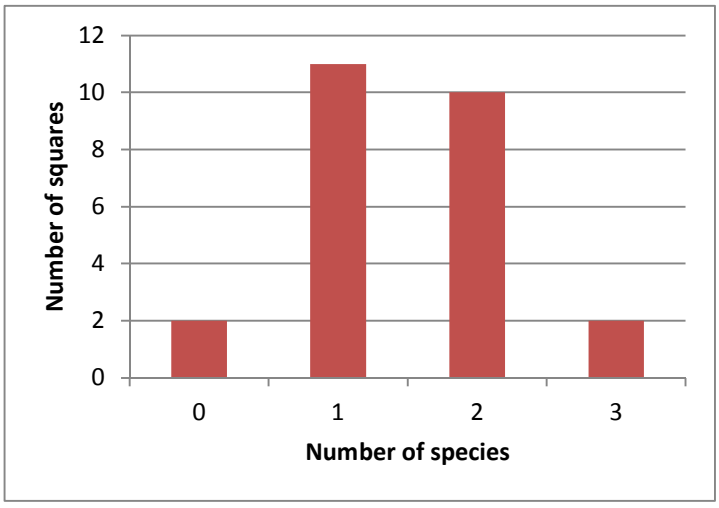

Figure 7. Number of species of salamanders detected in each square surveyed.

4.0 Discussion

The results for the Red-backed Salamander are extremely clear. A one hour survey was able to detect the species in 84% of the sites. These results indicate that the main explanation for the lack of recent records for Red-backed Salamanders across eastern Ontario is a lack of survey effort.

The low detection rate for the other species of salamanders could be an indication that those species have declined, or it could be a result of other factors. The Red-backed Salamander is the only species of salamander in Ontario that does not depend upon aquatic habitat for breeding. Because of this fact, Red-backed Salamanders may be more widespread across forested habitat whereas other species may be more closely restricted to areas around wetlands or other aquatic breeding habitat (Figure 8). For example, Blue-spotted Salamanders were only found within 300 m of a breeding pond (Ryan and Calhoun 2014).

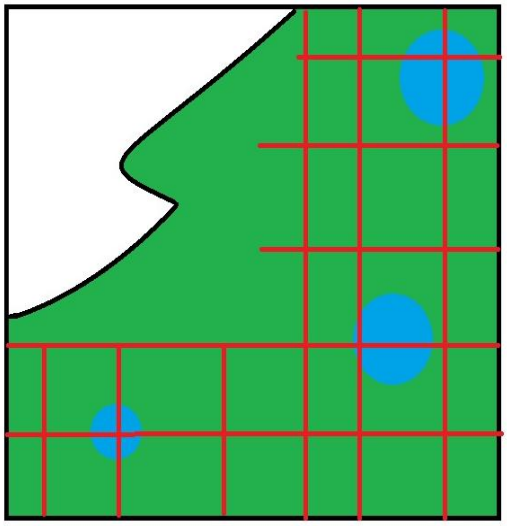

Figure 8. Schematic representation of potential salamander habitat within an area. Green areas represent forest habitat, blue circles represent areas occupied by wetland-dependent salamanders and red lines represent area occupied by Red-backed Salamanders.

Another explanation for the lack of observations of other salamanders is that many species of salamanders spend much of their time below ground, where they cannot be observed. In one study, over 95% of radio tracking locations of Spotted Salamanders were below ground (Faccio 2003). If over 90% of individuals of some species were below ground, it is not surprising so few were detected. Longer surveys at each square would likely have increased the chance of detecting other species.

The lack of recent observations in many of these squares is quite striking. For example, we confirmed the presence of Red-backed Salamanders in 11 of the 12 squares within provincial parks. In one case the first cover object we checked had one

underneath it. These parks are easily accessible and Red-backed Salamanders were found near major hiking trails. The obvious conclusion is that few people are surveying for salamanders for the Ontario Reptile and Amphibian Atlas. This may be due to the cryptic nature of salamanders compared to other amphibians and reptiles that are reported more often to the ORAA. For example, basking turtles and calling frogs can be detected without much effort, but finding salamanders usually requires actively searching under cover objects. Although citizen science is a powerful tool that can help monitor many species of wildlife, it does have its limitations. Cryptic species such as salamanders appear to be under-reported because of the effort required to locate them.

Our results suggest that salamanders (and in particular the Red-backed Salamander) remain widespread across eastern Ontario. It is possible that salamanders are not faring as well in other parts of the province. Mole salamanders were rarely encountered in systematic amphibian surveys in southern Ontario, possibly because of widespread loss of forest cover (Hecnar 1997). Although data from the ORAA is valuable in demonstrating where salamanders are known to presently occur, historical squares should not be assumed to indicate a current absence of the species without additional data. The ORAA volunteers should be encouraged to visit historical grid squares and survey for salamanders to provide a more complete understanding of their current distribution in Ontario.

5.0 Next steps

As a result of this work funded by the Ontario Wildlife Foundation and the Ottawa Field-Naturalist's Club Research Fund we will take the following steps:

- Update databases and distribution maps for all species of salamanders with our current data;
- Prepare a blogpost for the Ontario Nature website on our work to encourage atlas volunteers to survey historical squares for salamanders; completed October 2015 (visit http://www.ontarionature.org/connect/blog/mind-the-data-gap/)
- Prepare a scientific paper on our results to be submitted to the journal the Canadian Field-Naturalist.

6.0 Literature Cited

Arntzen, J.W. 2015. Drastic population size change in two populations of the Golden-Striped Salamander over a forty-year period—Are Eucalypt plantations to blame? Diversity 7:270-294.

Bank, M.S., J.B. Crocker, S. Davis, D.K. Brotherton, R. Cook, J. Behler, and B. Connery. 2006. Population decline of northern dusky salamanders at Acadia National Park, Maine, USA. Biological Conservation 130:230-238.

Bosch, J., and I. Martínez-Solano. 2006. Chytrid fungus infection related to unusual mortalities of *Salamandra salamandra* and *Bufo bufo* in the Penalara Natural Park, Spain. Oryx 40:84-89.

Burton, T.M., and G.E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook experimental forest, New Hampshire. Copeia 1975:541-546.

Caruso, N.M., and K.R. Lips. 2013. Truly enigmatic declines in terrestrial salamander populations in Great Smoky Mountains National Park. Diversity and Distributions 19:38-48.

Caruso, N. M., M.W. Sears, D.C. Adams, and K.R. Lips. 2014. Widespread rapid reductions in body size of adult salamanders in response to climate change. Global change biology 20:1751-1759.

Collins, J.P. 2010. Amphibian decline and extinction: What we know and what we need to learn. Diseases of Aquatic Organisms 92:93-99.

Collins, J.P. and M.L. Crump. 2009. Extinction in Our Time: Global Amphibian Decline. Oxford University Press, Oxford.

Davic, R.D. and H.H. Welsh. 2004. On the ecological roles of salamanders. Annual Review of Ecology, Evolution, and Systematics 35:405-434.

Faccio, S.D. 2003. Postbreeding emigration and habitat use by Jefferson and spotted salamanders in Vermont. Journal of Herpetology 37:479-489.

Hecnar, S.J. 1997. Amphibian pond communities in southwestern Ontario. Amphibians in decline: Canadian studies of a global problem. Society for the Study of Amphibians and Reptiles, St. Louis, Missouri, 1-15.

Lowe, W.H. 2012. Climate change is linked to long-term decline in a stream salamander. Biological Conservation 145:48-53.

Martel, A., M. Blooi, C. Adriaensen, P. Van Rooij, W. Beukema, M.C. Fisher, R.A. Farrer, B.R. Schmidt, U. Tobler, K. Goka, K.R. Lips, C. Muletz, K.R. Zamudio, J. Bosch, S. Lötters, E. Wombwell, T.W. J. Garner, A.A. Cunningham, A. Spitzen-van der Sluijs, S. Salvidio, R. Ducatelle, K. Nishikawa, T.T. Nguyen, J.E. Kolby, I. Van Bocxlaer, F. Bossuyt, and F. Pasmans. 2014. Recent introduction of a chytrid fungus endangers western Palearctic salamanders. Science 346:630-631.

Maerz, J.C., V.A. Nuzzo, and B. Blossey. 2009. Declines in woodland salamander abundance associated with non-native earthworm and plant invasions. Conservation Biology 23:975-981.

Means, D.B., and J. Travis. 2007. Declines in ravine-inhabiting dusky salamanders of the southeastern US Coastal Plain. Southeastern Naturalist 6:83-96.

Parra-Olea, G., E. Martínez-Meyer, and G.P.P. De León. 2005. Forecasting climate change effects on salamander distribution in the highlands of central Mexico. Biotropica 37:202-208.

Rovito, S.M., G. Parra-Olea, C.R. Vásquez-Almazán, T.J. Papenfuss, and D.B. Wake. 2009. Dramatic declines in neotropical salamander populations are an important part of the global amphibian crisis. Proceedings of the National Academy of Sciences 106:3231-3236.

Ryan, K.J. and A.J. Calhoun. 2014. Postbreeding habitat use of the rare, pure-diploid Blue-spotted Salamander (*Ambystoma laterale*). Journal of Herpetology 48:556-566.

Stuart, S., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fishman, and R.W. Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783–1786.

van der Sluijs, A.M., F. Spikmans, W. Bosman, M. de Zeeuw, T. van der Meij, E. Goverse, M. Kik, F. Pasmans, and A. Martel. 2013. Rapid enigmatic decline drives the fire salamander (*Salamandra salamandra*) to the edge of extinction in the Netherlands. Amphibia-Reptilia 34:233-239.

Wake, D.B., and V.T. Vredenburg. 2008. Are we in the midst of the sixth mass extinction? A view from the world of amphibians. Proceedings of the National Academy of Sciences 105:11 466–11 473.

Wheeler, B. A., E. Prosen, A. Mathis, and R.F. Wilkinson. 2003. Population declines of a long-lived salamander: a 20+-year study of hellbenders, *Cryptobranchus alleganiensis*. Biological Conservation 109:151-156.

7.0 Appendix

Table A1. Summary of 25 grid squares surveyed for salamanders. Red = Red-backed Salamander; Blue = Blue-spotted Salamander; Spot = Spotted Salamander; 4-T = Four-toed Salamander; 2-L = Two-lined Salamander.

ID	Square	Location	Date	Red	Blue	Spot	4-T	Newt	2-L
1	18UR81	White Lake	15-Jul	N	Y	Y	Y	N	N
2	18UR70	S of White Lake	15-Jul	Y	N	N	N	N	N
3	17QK25	Kawartha Highlands PP	27-Aug	Y	Y	N	N	N	N
4	17QK37	Silent Lake PP	11-Sep	Y	N	Y	N	N	N
5	17QK06	Irondale	13-Sep	Y	N	N	N	N	N
6	17QK34	Petroglyphs PP	14-Sep	Y	N	Y	N	N	N
7	18TQ64	E of Petroglyphs PP	14-Sep	Y	N	Y	N	N	N
8	18TQ65	Blue Mtn	14-Sep	Y	N	N	N	N	N
9	17QK35	Jack Lake	14-Sep	Y	N	N	N	N	N
10	17PL71	Russell Landing	15-Sep	Y	N	N	N	Y	Y
11	17PL62	Oxtongue River PP	15-Sep	Y	Y	N	N	N	N
12	17PL63	Entrance Algonquin PP	15-Sep	Y	N	N	N	N	N
13	17PL73	West Gate Algonquin PP	15-Sep	Y	N	Y	N	N	N
14	17PL74	Tea L Algonquin PP	16-Sep	Y	N	N	N	N	N
15	17PL84	Smoke L Algonquin PP	16-Sep	Y	N	Y	N	N	N
16	17PL94	Mew L Algonquin PP	16-Sep	Y	N	N	N	N	N
17	17PL95	E of Mew L Algonquin PP	16-Sep	N	N	N	N	N	N
18	17QL05	Kearney L Algonquin PP	16-Sep	Y	N	Y	N	N	N
19	17QL22	SE of Whitney	17-Sep	Y	N	N	N	N	N
20	17QL24	W of Madawaska	17-Sep	N	Y	N	N	N	N
21	17QL25	N of Madawaska	17-Sep	Y	N	N	N	N	N
22	18TR95	Bonnechere PP	17-Sep	Y	N	N	N	N	N
23	18TR92	Combermere	18-Sep	Y	N	N	N	Y	N
24	18UR10	Denbeigh	18-Sep	Y	N	N	N	N	Y
25	18UR30	Griffith	18-Sep	N	N	N	N	N	N