Western Toad Monitoring Study in Kentucky Alleyne Provincial Park, July – August 2012

Prepared For

BC Parks, Thompson-Cariboo Region

Prepared By

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EXECUTIVE SUMMARY

Kentucky Alleyne Provincial Park contains a communal breeding site of the Western Toad (*Anaxyrus boreas*), a species listed as Special Concern in Canada and on Schedule 1 of the *Species At Risk Act*. Western toads are particularly vulnerable to disturbances and mortality when congregated at breeding sites and when migrating between breeding sites and foraging and overwintering sites on land. In Kentucky Alleyne Park, newly metamorphosed toadlets leave the breeding pond *en masse* in late summer, when the park receives heavy recreational use, and are vulnerable to roadkill on park roads. Spring migration of adults to the breeding site occurs in April – May when the campsites are still closed, and the park receives less visitor activity.

Here we report on movements of juvenile Western Toads from the breeding site, located between Kentucky and Alleyne lakes (referred to as West Pond), to terrestrial habitats in late July – August 2012 and provide recommendations to reduce disturbance to the breeding site and mitigate road mortality of toads. The project was carried out within the framework of a community-based amphibian monitoring program started in the region in 2011 by Nicola Naturalist Society in collaboration with Biolinx Environmental Research Ltd.

In 2012, assisted by herpetologists, 11 volunteers surveyed for toads in the park for a total of 113 hours. A student from Thompson Rivers University contributed to the project by surveying the breeding site for emerging toadlets for a course project. The procedure was to count toads along transects on two roads, where anecdotal information suggested that the toadlets cross: a paved road leading to campsites along Kentucky Lake (Main Campsite road transect: 18 sections of 10 m) and a gravel road that branches from above road (Boat Launch road transect: 20 sections of 10 m). Additionally, toadlets were surveyed and assigned to abundance categories along West Pond (Pond transect: 100 sections of 12.5 m, encircling the entire pond) and along a trail between the pond and the Main Campsite road (Connector Path transect: 44 sections of 12.5 m). The pond transect was surveyed on 7 days from 28 July to 21 August. The road and path transects were surveyed on 10 days from 6 and 24 August. Additional to transect surveys, two time-lapse cameras recorded images of the road surface at strategic points every 15 min from 30 July to 24 August. Traffic volume was recorded with a counter installed near the start of the Main Campsite road by BC Parks on 25 July.

The main findings of the study are as follows:

- The peak migration of toadlets away from the pond occurred in early August over a brief period. The greatest numbers of toads were recorded on parks roads on 6 – 9 August, based on transect counts and camera images. A second, smaller peak of road crossing occurred on 24 August, based on camera images.
- Rainfall appeared to trigger and facilitate migratory movements of toadlets. Both peak periods were associated with rainfall events, and no rain fell between the two movement periods.

- In 2012, the main travel route of the toadlets away from the pond was from the south end of West Pond towards the southwest into the forest. The travel corridor intersected a trail by the pond (Connector Path transect) and the paved access road to the Kentucky Lake campsites (Main Campsite road transect).
- The road crossing site documented in 2012 was farther west and up the hill, away from the campsites by the lake, than indicated by anecdotal observations from previous years. Toadlets may be more spread out in years when their abundance is relatively high or when conditions are wet over longer periods than observed in 2012.
- Although large numbers of tadpoles, and later toadlets, were present in the pond (10,000s), the number of toadlets recorded on roads during transect surveys was low; a total of 1258 dead and 31 live toadlets were counted on the Main Campsite road transect. However, numerous live toadlets were seen on the road surface outside the transect survey periods, as well in the forest along the side of the road during the surveys. The latter included an aggregation of 2000+ toadlets in a swale on the west side of this road, indicating that these toadlets had successfully crossed it. Previous anecdotal observations suggest that the number of toadlets on roads is much higher in some years, with toadlets covering large areas of the road surface at crossing points.
- Analyses of camera images from 30 July to 24 August 2012 resulted in the detection of 348 live and 66 dead toadlets within a small (approximately 20 m^2) area of the Main Campsite Road covered by the camera view. All but 6 images were from one camera, which was moved on 6 August to the main travel route identified from transect surveys.
- During the first two weeks of August, the Main Campsite road received consistent traffic throughout much of the day, reaching a mean of up to 24 vehicles per hour. In contrast, there was little traffic at night, especially during early morning hours, providing a window for the toadlets to migrate safely across the road. Migration of toads appears to be more dependent on weather conditions than on time of day, and rainfall during the day could result in increased exposure to traffic.

We recommend the following measures for monitoring toads and mitigating threats in the park:

- Additional surveys to confirm the location of the toad travel routes and document possible year to year variation in road crossing sites.
- Mitigating disturbance to toads from park visitors
    - Develop and install interpretive signage that describes the life history and migration of Western Toads in the park and ways to reduce human disturbance of toadlets.
    - Implement a temporary closure of public access to the south end of West Pond where toad aggregations are greatest and to the trail above the pond that the toadlets cross.

- Management of fish stocking and cattle
    - To reduce stress on the Western Toad population in the park, consider shifting fish stocking away from the West Pond to other sites, such as the adjacent East Pond or other water bodies in the park.
    - Monitor habitat condition in and around West Pond and manage pressure from cattle by regulating cattle densities in the park; currently cattle are let in the park in fall, resulting in little direct temporal overlap with toads.
- Mitigating road mortality
    - Closure of the Kentucky Lake campsite access road during the brief periods when toads migrate would be the most effective way of reducing toadlet mortality; however, it but may not be an option because the migration out of the pond occurs within the busiest park use time of the year. Installation of an underpass with associated drift fencing is a viable alternative.
    - Ideally, another year of monitoring is required before an underpass is installed to provide adequate baseline information.
    - Based on monitoring results in 2012, we have identified a suitable site for an underpass on the Main Campsite Road to the Kentucky Lake campsites. This site is deemed suitable because a) it received heavy use by migrating toadlets; b) there is a depression leading up from West Pond to this site, suggesting that it is natural movement corridor for toads; c) channeling toadlets to this site by drift fences would direct them away from high recreational use areas located farther down.
    - A cattleguard underpass is the preferred option because its wide width and light from above are expected to facilitate movements of toads. A metal culvert with a wide (minimum of 60 cm) floor width provides a cheaper but somewhat less desirable option.
    - Temporary drift fencing to direct toadlets towards the underpass is required. Installation and maintenance of drift fencing is a suitable stewardship activity for volunteers.
    - The effectiveness of any underpass structures needs to be monitored, and funding should be set aside for this purpose.
    - In addition to mitigating road mortality, an underpass would have educational opportunities and would help spread the message that it is unacceptable to drive over amphibians, especially in parks that are meant to preserve wildlife and their habitats, while also providing recreational opportunities to enjoy nature.

1.0 INTRODUCTION AND BACKGROUND

The Western Toad (*Anaxyrus boreas*) is listed as Special Concern in Canada (COSEWIC 2002 and in press) and is on Schedule 1 of the *Species At Risk Act*. Similar to many other amphibians, Western Toad populations have undergone declines and even extirpations in parts of their range for reasons that are only partially understood but that include emerging diseases, loss of breeding habitat, and habitat fragmentation by roads and human developments.

Kentucky Alleyne Provincial Park contains a communal breeding site (referred to as West Pond) where Western Toads from the surrounding landscape congregate during a short breeding season in spring. Tadpoles are gregarious and congregate along shallow pond edges, feeding mainly on algae (Figure 1). By late summer, the tadpoles metamorphose into toadlets and leave the pond, migrating into the surrounding forest *en masse* during a short period. After spending several years in the surrounding landscape, they return to the breeding sites as mature adults, starting the cycle over again. Surveys in adjacent ponds within and around the park have failed to located toads, suggesting that the West Pond is an important breeding site for the local toad population.

Western Toads congregate at several stages of their life-cycle, often giving the appearance of extreme abundance, when in fact the toads in aggregations may represent all breeding adults or the entire reproductive output for a wide area for the year. Their habit of aggregating and migrating between aquatic breeding sites and terrestrial foraging and overwintering sites make the toads extremely vulnerable to disturbances and accidental mortality (COSEWIC, in press). In Kentucky Alleyne Provincial Park, toads have to cross roads when migrating to and from the breeding site and are vulnerable to roadkill. Toadlets are particularly vulnerable because their migration away from the pond coincides with the peak period of recreational activity in the park in August. Previous, anecdotal observations suggested that large numbers are killed on park roads.

Here we report on movements of juvenile Western Toads from the West Pond in Kentucky Alleyne Provincial Park to terrestrial habitats in late July – August 2012 and provide recommendations to mitigate disturbance to toads at the breeding site and, in particular, when migrating across park roads. The project was carried out as a collaborative effort by Nicola Naturalist Society and Biolinx Environmental Research Ltd. The project is conducted within the framework of a community-based amphibian monitoring program started in the area in 2011 with the aim of obtaining baseline information on amphibian distributions, identifying threats, and involving community

members, landowners, and land managers in amphibian conservation and stewardship activities (Ovaska et al. 2011).

Figure 1. Western Toad breeding site in West Pond, Kentucky Alleyne Provincial Park.

Black band along the shore is a mass of toad tadpoles.

2.0 STUDY AREA AND METHODS

2.1 Study area

West Pond, located between Kentucky and Alleyne lakes in the Kentucky Alleyne Provincial Park, is relatively steep-sided, and it appears that water levels undergo wide seasonal and multi-year fluctuations and have receded considerably in recent years. There is no vegetated riparian area, and uplands in the vicinity of the pond are sparsely vegetated by low shrubs and herbaceous plants. The pond bottom is soft and consists of fine silt/clay mixture and very few aquatic plants are present. By July, there is

significant algal growth along the perimeter of the pond, and tadpoles feed on the algal mats. The site is used as childrens' fishing pond and is stocked annually with trout. A small artificial sandy beach has been constructed on the northeast shore of the pond to facilitate fishing.

2.2 Transect surveys

To determine where the toad migration route traversed roads, transects were established along roads and paths where anecdotal information suggested the toadlets cross (see Figure 3 in **Results** for the location of the transects). The transects were established in July 2012. One transect was along the paved park road leading to the campsites along Kentucky Lake (referred to as Main Campsite road transect); it consisted of 18 10-m sections with inconspicuous markers placed at the side of the road. A second transect (referred to as Boat Launch road transect) was along the gravel road that branches off the Main Campsite road, leading to the boat launch; it consisted of 20 10-m sections, encompassing the entire length of this spur road. In addition, a transect (referred to as Pond transect) was established about 2 m inland from the water line around the entire West Pond, where the toads breed. This transect was divided into 50 sections of 25 m; wooden stakes indicated the start and end of sections. Another off-road transect (referred to as Connector Path transect) was established along a path that the toadlets were expected to cross, just west of the pond. This transect consisted of 22 sections of 25 m, marked with wooden stakes. The centre of each section along both the path and pond transect were marked with flagging, resulting in 12.5 m sections along which toadlets were counted.

Volunteers were organized to conduct surveys along the transects, and training sessions were held at the site on 25 July by Biolinx Environmental Research Ltd personnel and on 8 August 2012 by Nicola Naturalist Society staff. During each survey, volunteers walked slowly along the road and path transects and recorded the number of live and dead toads seen within each section. The pond transect was surveyed by Chantelle Forseille, student from Thomson Rivers University, Kamloops, as part of a directed studies course project.

For each survey, volunteers were instructed to record the date, time (start and stop) and weather conditions (air temperature, wind, cloud cover, and precipitation), in addition to the number and location of toads found (see Appendix 1 for the datasheets used). On the roads volunteers marked the location of each roadkill toad with white chalk to avoid double counting during subsequent surveys. Volunteers were also asked to record any observations of toads seen away from the transects and possible disturbances to toads or predation events that they might observe. Along each section of the pond transect, the observer estimated the abundance of toads within three zones: along an estimated

1 m strip on grass, centered on the transect line; along the same section but within the muddy shoreline (mud zone of varying width); and along the same section but in water (tadpoles and toadlets), as far as could be seen from the transect on land. Because it was impossible to accurately count the number of toadlets along the pond, they were assigned to abundance categories within each transect section: N (none), L (low) <10, M (medium) 10 – 100, H (high): 100 – 1000, and VH (very high) >1000.

The pond transect was surveyed on 7 days from 28 July to 21 August. The road and path transects were surveyed on 10 days from 6 and 24 August (see Appendix 2 for dates and survey conditions).

Raw data associated with the transects are shown in Appendices 2 – 4.

2.3 Time-lapse cameras

Two time-lapse cameras (Reconyx PC900) were used to monitor the timing of toadlet migration across the park road to campsites along Kentucky Lake. They were deployed in locations deemed optimal based on anecdotal information on toadlet movements in past years (see Figure 4 in **Results** for their locations). The cameras were installed on 30 July 2012. Camera 1 was moved on 6 August to a new location (labeled 1b on map) because the crossing area was found to be farther west and up the hill than initially thought, and it failed to capture movements of toadlets in its initial location.

The cameras were installed on trees adjacent to the road at the height of approximately 2 m. The cameras were mounted on a bracket that allowed us to point the camera downwards to capture toadlets on road and to avoid capturing pictures of park visitors (Figure 2). They were secured to the tree with a cable and locks to discourage vandalism. The camera view covered approximately 20 m^2 of the road surface.

The cameras were set to take an image every 15 min throughout the 24 h period. The images were off-loaded on 6, 8 and 24 August, when the cameras were also removed. The images were analyzed by viewing two subsequent images side by side using Adobe Photoshop® or Picasa® software.

Raw data associated with time-lapse cameras are shown in Appendix 5.

Figure 2. Time-lapse camera mounted to point towards the road surface (top) (not in final location), and the section of road surface shown by Camera 1 along Main Campsite road to Kentucky Lake (white chalk bars = ca. 30 cm).

2.4 Traffic counter

BC Parks installed a traffic counter that used magnetic traffic counter technology near the start of the Main Campsite Road on 25 July 2012. The counter was dug into the ground to a depth of about 30 cm next to the asphalt and covered with soil. BC Parks provided us with the data from the counter.

3.0 RESULTS AND DISCUSSION

3.1 Pre-migratory distribution and abundance

Surveys of the shoreline of the West Pond showed that toadlet abundance increased from 28 July – 5 August and then declined sharply from 8 – 21 August (Table 1; Figure 3). Toadlet abundance was already high around the pond at the start of the surveys on 28 July, with 46, 50 and 42% of the transect segments having medium to very high abundance in the grass, mud- and water-zones, respectively. Toadlet abundance around the pond peaked on 4 August with 96, 100 and 75% having medium - very high abundance in these zones, respectively. The abundance of toadlets increased the most in the mud- and grass-zones from 28 July – 4 August, suggesting that the toadlets were leaving the water and moving onto land to start their migration. This was confirmed by counts on the Connector Path transect further away from the pond.

The toadlets were most concentrated along the southwestern shoreline of the West Pond at the start of surveys on 28 July; this distribution pattern became more pronounced during the period of peak abundance on 4 – 5 August (Figure 3). Smaller aggregations were noted along the northern and west-central shorelines from 28 July – 5 August, but they tended to disappear on and after 8 August. On 12 August, only 21% of transect segments had any toadlets (medium or low abundance), indicating that most toadlets had migrated out of the pond (Table 1). This percentage declined to only 3.8% on 21 August, indicating that nearly all toadlets had left the pond (Table 1).

Table 1. Summary of relative abundance of Western Toad metamorphs along three zones of the West Pond transect.

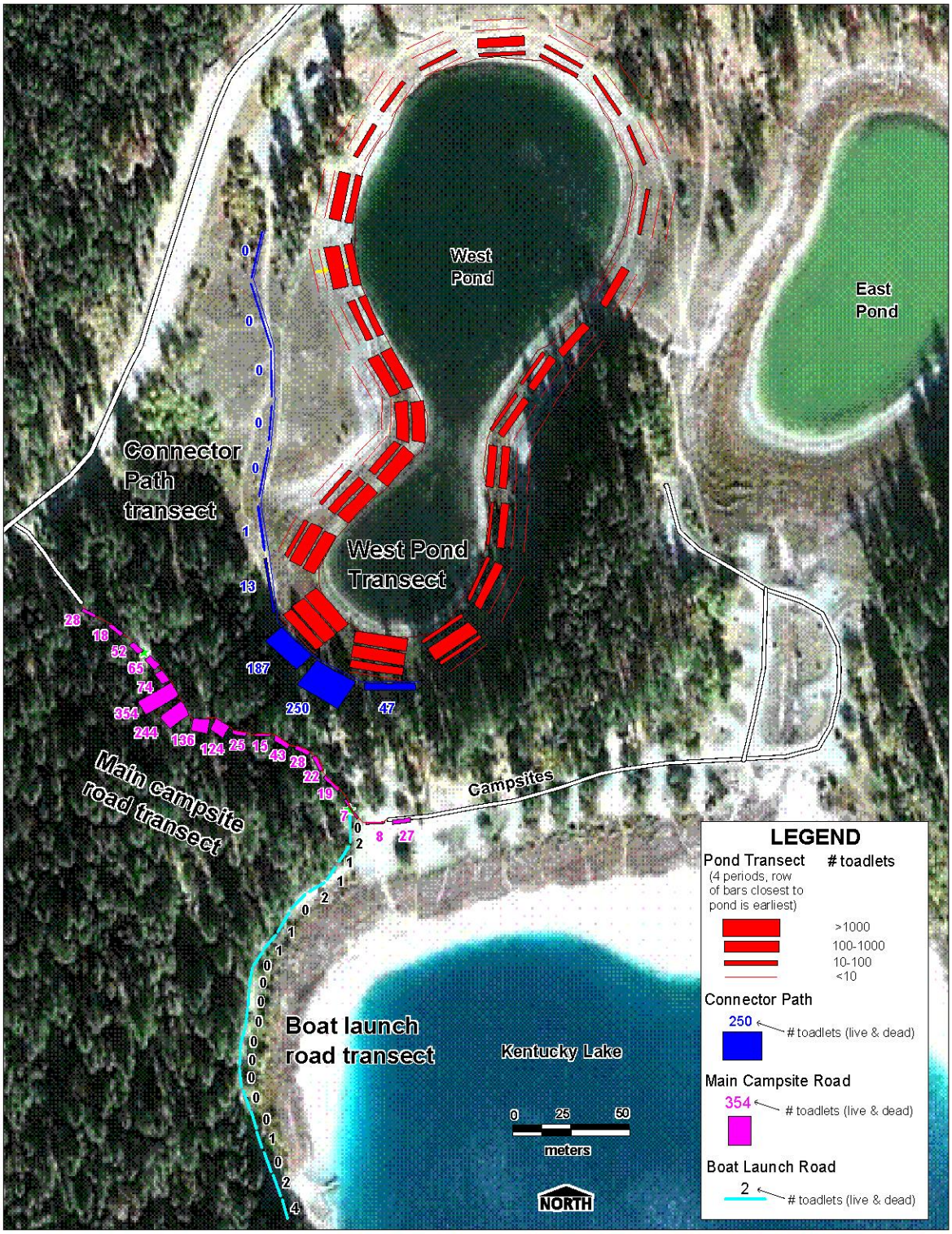
Abundance categories: N(none); L (low) <10; M: 10 – 100; H (high): 100 – 1000; VH (very high) >1000

Toad abundance category by date	Grass zone (transect)	Mud zone	Water zone
7/28/2012:			
VH	9	10	3
H	9	10	8
M	6	6	11

Toad abundance category by date	Grass zone (transect)	Mud zone	Water zone
L	4	0	4
N	24	26	26
7/30/2012:			
VH	12	0	0
H	4	0	0
M	13	15	11
L	12	20	15
N	11	17	26
08/04/2012:			
VH	5	7	0
H	23	24	5
M	22	21	34
L	1	0	12
N	1	0	1
08/05/2012:			
VH	6	4	0
H	14	15	1
M	22	23	19
L	9	6	29
N	1	4	3
08/08/2012:			
VH	0	0	0
H	2	0	0
M	7	2	0
L	3	9	4
N	40	41	48
08/12/2012:			
VH	0	0	0
H	0	0	0
M	4	0	0
L	7	0	0
N	41	52	52
8/21/2012:			
VH	0	0	0
H	0	0	0
M	0	0	0
L	2	0	0
N	50	52	52

Figure 3. Abundance of toadlets recorded on pond and road transects in Kentucky-Alleyne Provincial Park in 2012.

Numbers of toadlets (live & dead combined) along the Connector Path and roads were compiled for all surveys (6 -24 Aug); abundance was scored as categories along the pond transect during 4 periods: Period 1 (28, 30 Jul); Period 2 (4, 5 Aug); Period 3: (8, 12 Aug); Period 4 (21 Aug).



3.2 Migratory movements and mortality of toadlets

In 2012, the main travel route of toadlets was from the southwestern end of West Pond towards the southwest into the forest. The travel corridor intersected a path by the pond (Connector Path; Figure 3) and the paved access road to the Kentucky Lake campsites (Main Campsite road; Figures 4 and 5). Largest numbers of toadlets were counted within a 40 m section of the Main Campsite road (road transect segments 5 – 9), most of which were roadkills. Few toadlets were documented on other roads, including the Boat Launch Road.

The path and road transect data show that the migration of toadlets from the West Pond occurred over a very short period in 2012, with most observations occurring from 6 – 9 August. Most of the toadlets were observed along the Main Campsite road with 19 live and 1200 dead toadlets counted on 8 August, and along the Connector Path with 318 live toads counted on 6 August (Tables 2 and 3). The number of toadlets observed on the Connector Path declined markedly on 8 August (only 33 live toadlets), suggesting that a large pulse of toadlets had moved through the area around 6 August towards the Main Campsite road.

The counts of live toads along roads were very low (only 31 in total during scheduled surveys), probably because most toadlets crossed the road at night or when the road surface was wet, whereas most surveys prior to 11 August were conducted during hot, dry conditions (Appendix 2). For example, around 8:30 h on 8 August, there was an incidental observation of at least 200 live toadlets on the Main Campground Road (A. Burger, pers. notes). It had rained the night before but at 8:30 h the road still had damp patches along the edges. The official survey of the road transect did not start until about 11:00 h, and by this time the temperature was higher and the road and its edges had completely dried out from the rain the night before. Toadlets were also often seen in the grassy edges of the road and in the surrounding forest during the surveys, but not on the road surface itself. Because the road surveys did not start until 6 August, it is possible that toadlets migrated across the road prior to this date. However, no dead toadlets were observed on the road on 6 August, suggesting that the main migration occurred from 6 – 9 August.

Although large numbers of tadpoles and later toadlets were present in the pond (10,000s), the number of toadlets recorded on the roads was relatively low; a total of 1258 dead and 31 live toadlets were counted on the 180 m-long transect along the Main Campsite Road. An aggregation estimated to consist of over 2000 toadlets was observed in a swale on the south side of this road in the forest, indicating that these toadlets had successfully crossed the road (Figure 4). This moist swale on the south side of the road provided a moist refuge for migrating toadlets (Figure 6).

Figure 4. Detail of crossing sites of toadlets across the park access road to the Kentucky Lake campsites, showing the location of the presumed travel route (arrow), road transect counts of toadlets, and a large aggregation of toadlets on the south side of the road (star).

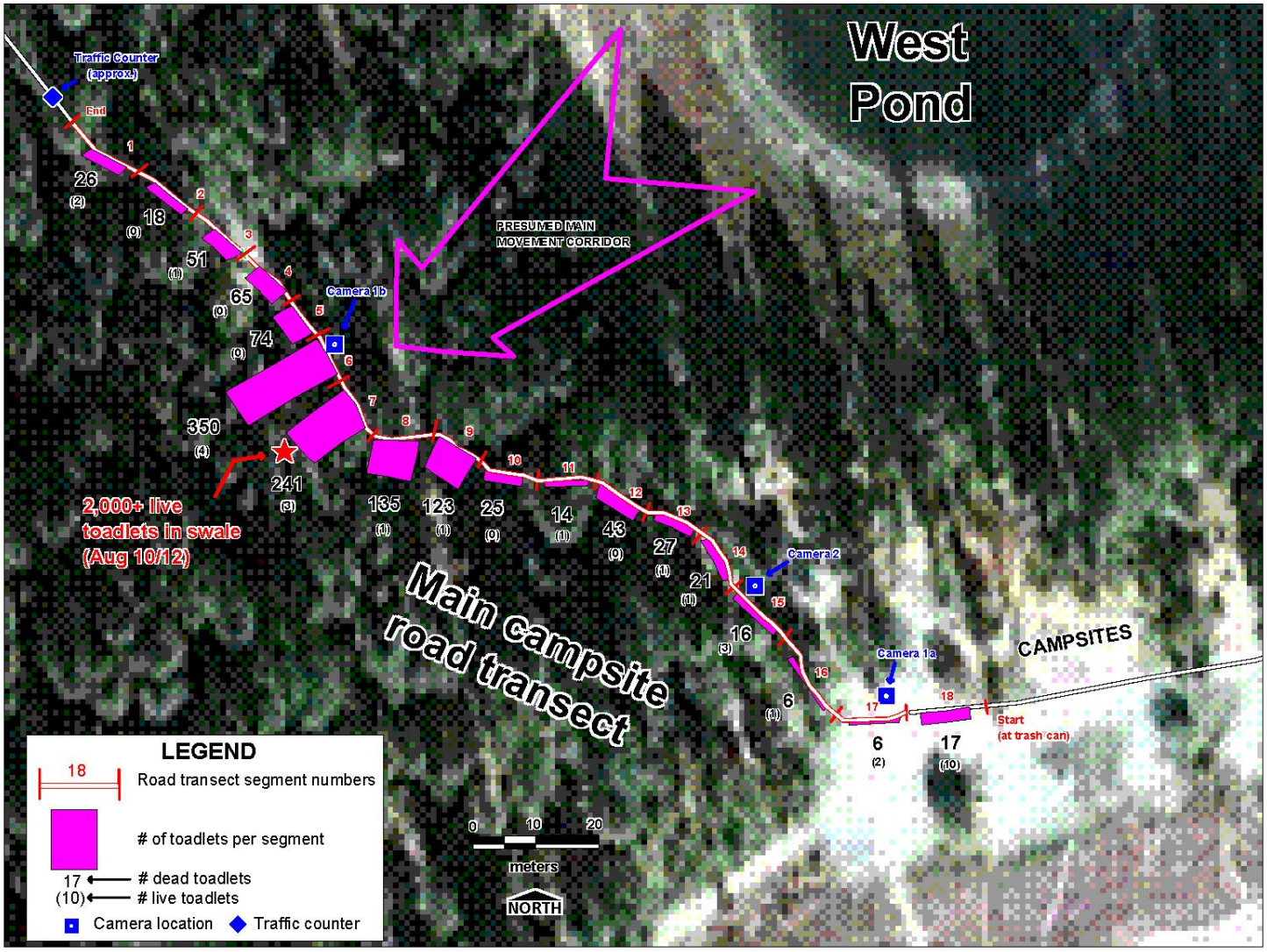


Table 2. Summary of numbers of Western Toad metamorphs counted along road transects during surveys in 7 days in August 2012.

Transect or Road name	Section (10 m)	Toadlets, live	Toadlets, dead
Main Campsite road	1	2	26
Main Campsite road	2	0	18
Main Campsite road	3	1	51
Main Campsite road	4	0	65
Main Campsite road	5	0	74
Main Campsite road	6	4	350
Main Campsite road	7	3	241
Main Campsite road	8	1	135
Main Campsite road	9	1	123
Main Campsite road	10	0	25
Main Campsite road	11	1	14
Main Campsite road	12	0	43
Main Campsite road	13	1	27
Main Campsite road	14	1	21
Main Campsite road	15	3	16
Main Campsite road	16	1	6
Main Campsite road	17	2	6
Main Campsite road	18	10	17
Total		31	1258
Boat Launch road	0	0	0
Boat Launch road	1	1	1
Boat Launch road	2	1	0
Boat Launch road	3	1	0
Boat Launch road	4	1	1
Boat Launch road	5	0	0
Boat Launch road	6	1	0
Boat Launch road	7	1	0
Boat Launch road	8	0	0
Boat Launch road	9	0	0
Boat Launch road	10	0	0
Boat Launch road	11	0	0
Boat Launch road	12	0	0
Boat Launch road	13	0	0
Boat Launch road	14	0	0
Boat Launch road	15	0	0
Boat Launch road	16	0	0
Boat Launch road	17	1	0
Boat Launch road	18	0	0
Boat Launch road	19	0	2
Boat Launch road	20	2	2
Total		9	6

Table 3. Summary of numbers of Western Toad metamorphs counted along the path between West Pond breeding site and Main Campsite Toad during surveys in 7 days in August 2012.

Transect name	Long section (25 m)	Toadlets, live	Toadlets, dead (#)
Connector path	1	42	5
Connector path	2	222	28
Connector path	3	177	10
Connector path	4	13	0
Connector path	5	1	0
Connector path	6	0	0
Connector path	7	0	0
Connector path	8	0	0
Connector path	9	0	0
Connector path	10	0	0
Connector path	11	0	0
Total		455	43

Figure 5. Area of the Main Campsite road to Kentucky Lake where juvenile Western Toads crossed the road in August 2012.

Toadlets crossed within a ca. 40 m section of the road both behind and in front of the observer. Faint chalk marks indicate locations of dead toads. A moist swale where toadlets aggregated after crossing the road can be seen in front of the big log on the right.

Figure 6. A moist swale on the south side of the Main Campsite road to Kentucky Lake where toadlets aggregated after crossing the road.

Both the road crossing site and abundance of toadlets documented in 2012 differed from anecdotal observations in previous years as reported to us. The crossing site in 2012 was further up the hill, away from the campsites, than reported for previous years. Previous observations suggest that the number of toadlets on roads is much higher in some years, with the toadlets covering large areas of the road surface at crossing points. It is possible that in 2012 much of the migration occurred at night during a brief period with suitable wet conditions (see above) and was missed by observers. Alternatively, there might have been high mortality from other sources, such as predation, before the aggregations of toadlets started migrating.

3.3 Time-lapse camera data

3.3.1 Overview

Analyses of camera images from 30 July to 24 August 2012 resulted in the detection of 348 live toadlets within a small section of the Main Campsite Road covered by the camera view (Table 4). All but 6 images showing toads were from Camera 1 after it was moved on 6 August to a more appropriate location (labeled Camera 1b in Figure 4). In

addition to live toadlets, this camera also captured images of 66 dead toadlets, first noted on image taken at 11:45 h on 9 August, but only after their locations had been marked with chalk by the crew surveying the transects.

The placement of cameras in the path of the main migration is critical and requires knowledge of movement routes prior to camera installation. It should be noted that the camera only showed a small segment of the road (about 20 m^2), as it had to be positioned pointing down towards the road surface and be fairly close to the toadlets to permit their detection. Some toadlets might well have been missed, as it was often difficult to see them in the images due to their small size (about 2 cm long). Often, the best way to find them was to compare subsequent images to detect movement across the road. Despite these limitations, the time-lapse cameras provided round-the-clock monitoring that was impossible to achieve otherwise and allowed us to obtain detailed information on the timing of the migration movement of toadlets at one point within the main migration corridor on the Main Campsite Road.

Table 4. Summary of numbers of Western Toad metamorphs counted from time-lapse camera images from the Main Campsite road in August 2012.

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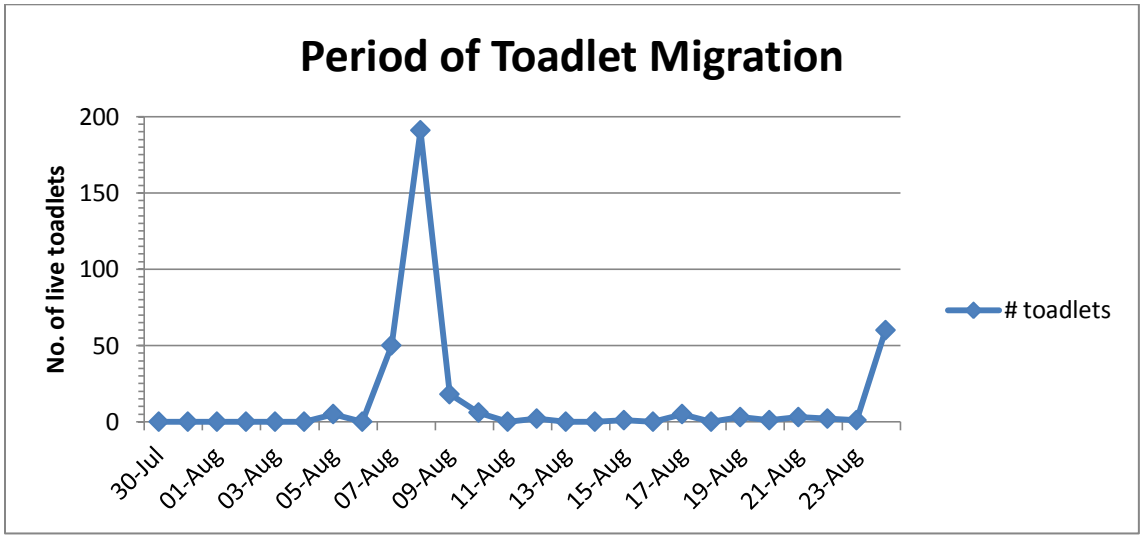
Date	Camera 1: # toadlets	Camera 2: # toadlets	Total
30-Jul	0	0	0
31-Jul	0	0	0
01-Aug	0	0	0
02-Aug	0	0	0
03-Aug	0	0	0
04-Aug	0	0	0
05-Aug	0	5	5
06-Aug	0	0	0
07-Aug	50	0	50
08-Aug	190	1	191
09-Aug	18	0	18
10-Aug	6	0	6
11-Aug	0	0	0
12-Aug	2	0	2
13-Aug	0	0	0
14-Aug	0	0	0
15-Aug	1	0	1
16-Aug	0	0	0
17-Aug	5	0	5
18-Aug	0	0	0
19-Aug	3	0	3
20-Aug	1	0	1

Date	Camera 1: # toadlets	Camera 2: # toadlets	Total
21-Aug	3	0	3
22-Aug	2	0	2
23-Aug	1	0	1
24-Aug	60	0	60
Total	342	6	348

3.3.2 Timing of toadlet migration

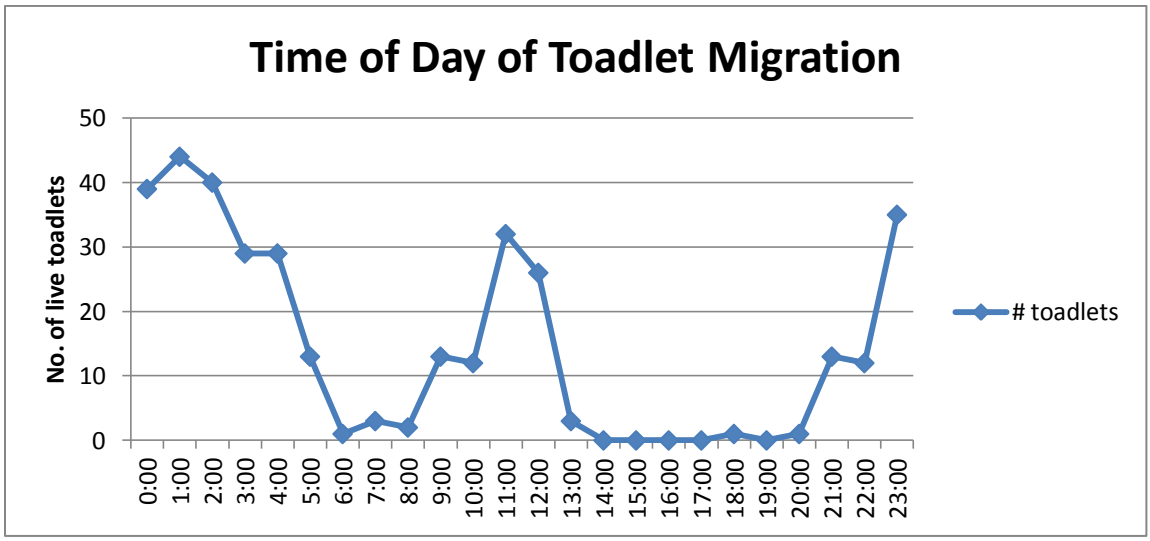
Most observations (74.4%) of live toadlets on the camera images were between 7 and 9 August (Figure 7). The ground crews also detected most movements during this period but starting on 6 August. The cameras missed movements on 6 August, because at this time both cameras were in locations farther to the west down the hill, where they were largely ineffective. Interestingly, the images show a second, smaller peak (17.5% of the toadlets detected by the cameras) on the road on 24 August. By this time, the transect surveys were only sporadic as the migration was thought to have passed, and this movement was undetected on the ground. The cameras were removed on 24 August, so the duration of this second movement period is unknown. However, the main migration was almost certainly during the earlier peak period when most of the toadlets were observe leaving the pond and when a large contingent of toadlets was sighted in the forest.

Figure 7. Number of juvenile Western Toads by day observed in camera images on Main Campsite Road in Kentucky Alleyne Provincial Park in August 2012.



The time of day when the toadlets moved across the road was variable but shows some interesting patterns (Figure 8). Most movements occurred either at night (from 23 h – 5 h) or morning (from 9 h – 11 h). No toads were found in the images from late afternoon to early evening (from 14 h – 20 h). Conditions in the forest and the road surface may have been too warm and dry for movements at this time. This daily pattern may not hold if wet conditions persist throughout the day, and it is likely that migrating toadlets move continuously on rainy days.

Figure 8. Number of juvenile Western Toads by hour observed in camera images on Main Campsite Road in Kentucky Alleyne Provincial Park in 2012.



3.3.3 Weather conditions in relation to toadlet migration

The park is located within a region that is characteristically warm and dry during July and August, and the year 2012 was no exception. Environment Canada's (2012) weather records from the Merritt STP station show a rain event from 22 – 24 July, when the toads were still in the pond and just starting to emerge, but no measurable amount of rain was recorded since then until 23 August, when 4 mm of rain fell (Appendix 6). Note that the Merritt station is at a lower elevation (609 m) and 26 km northwest from Kentucky Alleyne Provincial Park (990 m), resulting in warmer conditions and somewhat different precipitation patterns. A trace amount of rainfall was recorded at the Merritt weather station on 7 Aug, but rain was more substantial at the Kentucky Alleyne site and was detected in time-lapse camera images. Records kept by the campsite host show heavy rain in 7 August, and rain intermittently continuing through 8 August (Nedham, pers. comm. 2012).

Both observed peaks in toadlet movements in August 2012 occurred either during or immediately after rainfall. The camera images revealed two rain events during the monitoring period: on 7 August and on 23 August. These were confirmed by the campsite host's notes (Nedham, pers. comm. 2012). On 7 August, rain started at 21:00 h and continued through part of the night. Toadlets were detected in the images from 21:15 h onwards, by which time the road was fully wet, to the morning of the following day and continued in lower numbers over the following two days. Subsequently, no rain fell until 23 August; this rainfall event also shows in data from the Merritt STP weather station (Appendix 6). On 23 August, rain started at 23:30 h, and toadlets were detected in the images from 10:00 – 13:00 h the following day. Unfortunately, the camera was removed on this day, so no further information was collected.

Within the tolerance limits of the toads, temperature is expected to be less important than rainfall in facilitating toadlet migration movements; however hot and dry conditions, as well as low temperatures, are likely to curtail movements. In Kentucky Alleyne Park, the sensor on Camera 2 recorded hourly air temperatures that varied widely over the 24 h period (Figures 9 and 10). The lowest temperatures were in the early morning hours, whereas the highest temperatures were in the late afternoon, when toadlets usually did not move. Interestingly, most movements took place from 6 to 8 August, when night-time lows were above 10°C, and petered off on 9 August when temperature dropped to a low of 4°C. The campsite host recorded light frosting on picnic tables on the morning of 10 August (Nedham pers. comm. 2012).

Figure 9. Air temperatures obtained from Camera 2 on Main Campsite road to Kentucky Lake during 12 days from 30 July to 10 August 2012.

Each cycle corresponds to a 24 h period.

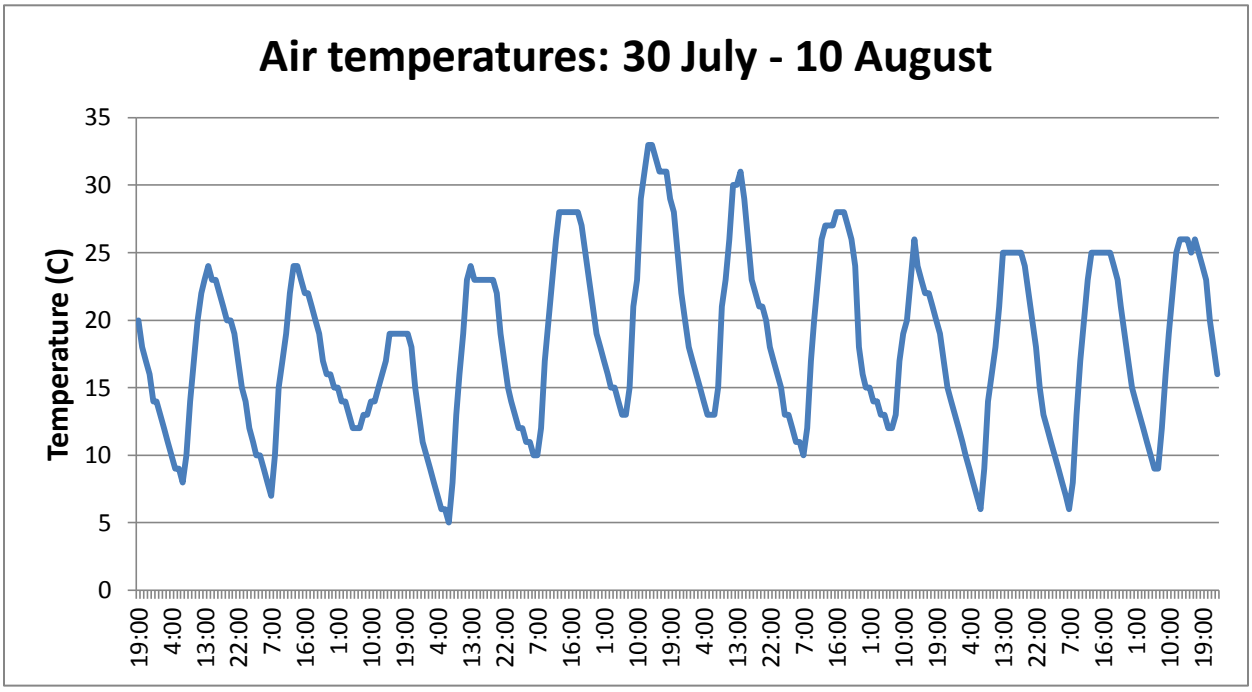
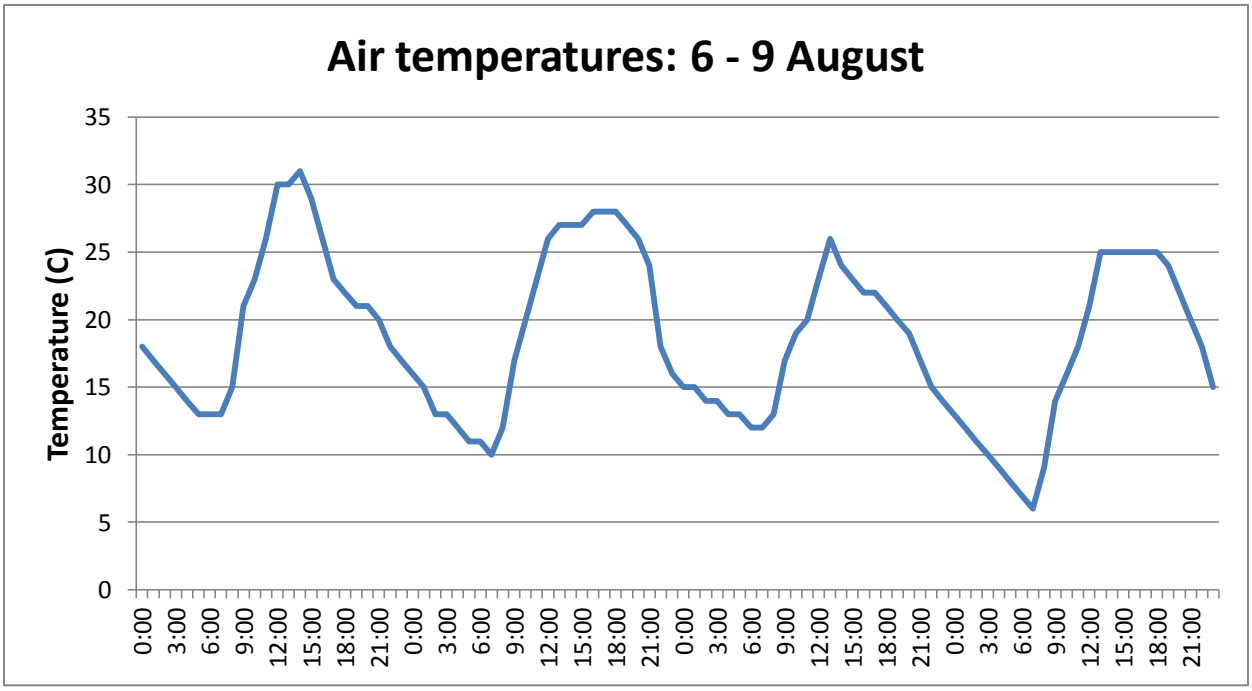


Figure 10. Air temperatures obtained from Camera 2 on Main Campsite road to Kentucky Lake during peak days of toadlet migration from 6 – 9 August 2012.

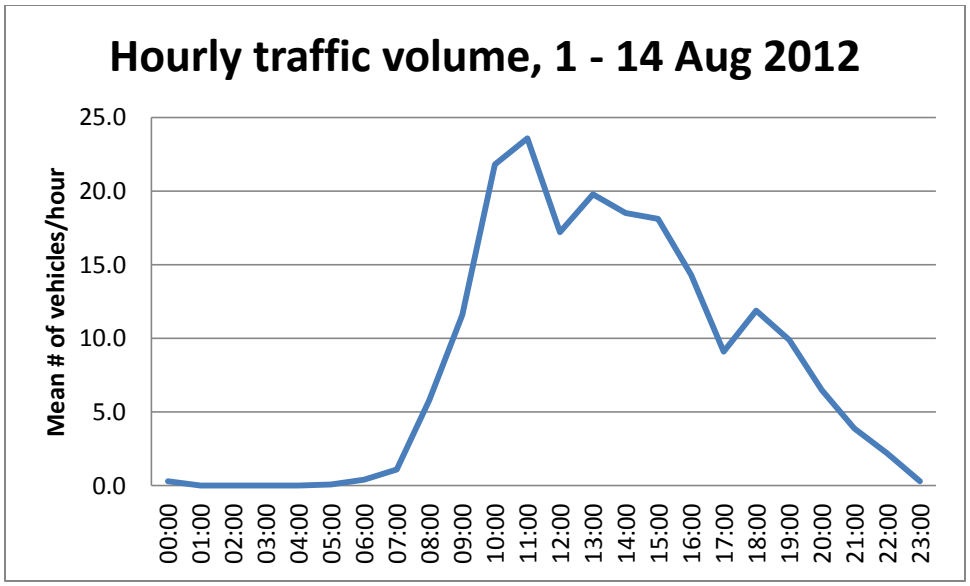
Each cycle corresponds to a 24 h period.



3.4 Traffic volume

Traffic volume on the Main Campsite Road was relatively high during daylight hours, as indicated by data provided by BC Parks from a traffic counter installed near the entrance of the access road. During the first two weeks of August, this road received consistent traffic throughout much of the day, reaching a mean of up to 24 vehicles per hour (Figure 11). In contrast, there was little traffic at night, especially during early morning hours, providing a window for the toadlets to migrate safely across the road. This window may not be adequate, if rainfall events happen to occur during the day, triggering movements. Migration of toads appears to be more dependent on weather conditions, such as rain and availability of moisture, than on the time of day.

Figure 11. Traffic volume (average number of vehicles per hour) on the access road to the Kentucky Lake campsites from 1 to 14 August 2012. Traffic counter data provided by BC Parks.



4.0 COMMUNITY SUPPORT AND VOLUNTEE EFFORTS

This project was completely largely with volunteer efforts within the framework of a regional community amphibian monitoring program, started in 2011 as a collaborative effort by Nicola Naturalist Society and herpetologists from Biolinx Environmental Research Ltd. From 21 June – 24 August 2012, 11 volunteers participated in toad monitoring, expending 113 hours in surveys at Kentucky Alleyne Provincial Park. These surveys included toad surveys on designated transects on park roads and a trail during

the migration period in August and surveys of ponds within and in the immediate vicinity of the park for breeding amphibians in June. In addition to surveys, Nicola Naturalist Society personnel spent numerous hours coordinating volunteer efforts and analyzing data from time-lapse cameras.

A student from Thompson Rivers University conducted surveys along the West Pond toad breeding site as part of a directed studies program and helped analyze time-lapse camera images and summarize pond survey data.

Biologists from Biolinx Environmental Research Ltd. conducted five field visits to the site from May to August 2012, consulted with BC Parks personnel on site, and donated their time to analyze data and prepare this report.

5.0 RECOMMENDATIONS FOR MONITORING AND MITIGATING THREATS

5.1 Additional monitoring and surveys

Ideally, another year of monitoring should be carried out to confirm the location of the toad travel routes and to document possible year to year variation in road crossing sites. For example, the crossing sites may shift, or additional sites may be used, in years when toadlet numbers are high or when weather conditions are different. In other areas, migrating amphibians are more spread out when conditions are wet (Beasley, pers. comm. 2012).

Having good baseline information allows for effective mitigation measures. During our conversations with researchers working on amphibian roadkill mitigation, the following points were emphasized: 1) assess whether roadkill loss negatively affects the population, 2) determine locations of road crossings over several years, and 3) ensure that there are commitments to follow-up monitoring before embarking on underpass installation (Conference Call, pers. comm. 2012, Wind, pers comm. 2012).

At Kentucky Alleyne Provincial Park, roadkill of adults during the spring migration to the breeding pond in April – May is not an issue, because the camping area is closed and the park receives relatively few visitors. At this site, the road mortality is associated with the migration of toadlets out of the pond in August when the park and campsites are busy. During 2012, we only detected a small fraction of the toadlets that migrated from the pond. The significance of road mortality of toadlets to the population is unknown and would take intense efforts to determine. However, the precautionary principle should be applied, especially in protected areas that are mandated to protect wildlife and the

natural environment, in addition to catering to recreational pursuits of visitors. Roadkill is an anthropogenic source that augments other sources of mortality and could contribute to or hasten population declines.

The following improvements to monitoring methods are recommended:

- Surveys should be timed to coincide with optimal conditions for toad movement; this will require an observer to be on site and more frequent surveys after rainfall. Surveys should start just prior to migration to ensure the period of peak migration is not missed. During periods of dry weather, the survey period may have to be lengthened to detect delayed movements by toadlets.
- Monitoring should include periodic surveys of the forest adjacent to the main campsite road to detect aggregations of toadlets that have crossed the road but were missed during on-road surveys or that have not yet crossed the road and are seeking refuge due to dry conditions
- Surveys should be broadened to include all paved campsite and access roads in the park in the vicinity of the West Pond to detect other possible crossing areas used by toadlets; casual observations away from the roads surveyed in 2012 detected no toadlets.
- Weather conditions, including precipitation and temperature, should be monitored on site.

In addition, the effectiveness of any mitigation measures to reduce toadlet disturbance or mortality such as signage, trail closures or crossing structures needs to be monitored (see below).

5.2 Mitigating disturbance to toads from park visitors and other threats

We recommend Interpretive signage be installed that describes the life history and migration of the Western Toad in the park and ways to reduce the disturbance of toadlets by humans. With increased awareness, park visitors will be more likely to change their behaviour and reduce unintended negative effects on toads. Such changes may include greater supervision of children, avoidance of sensitive areas near the West Pond, and a reduction in unnecessary vehicular traffic during peak migratory periods (e.g., at night or early morning). The signs should also stress the importance of keeping garbage, waste water, and contaminants out of the water. The potential of introducing chytrid fungus from other water bodies should be explained and that fishing equipment and boats should be clean and dry before use in the park.

We also recommend temporary closure of public access to the south end of West Pond where toad aggregations are greatest, so that the soft pond edge substrate is not degraded by deep footprints, movements of toads are not disrupted, and mortality from

stepping on toadlets is reduced. Parks should also consider re-locating the north-south access path to the West Pond near the camp host's site some distance to the east, so as to avoid aggregations of toadlets.

To reduce stress on the Western Toad population in the Park, fish stocking should be shifted away from the West Pond to other sites, such as the East Pond or other water bodies in the park. Also, careful management of cattle grazing in the Park would prevent excessive trampling of the West Pond by cattle, and potential degradation of water quality and shoreline substrate. Currently cattle are let in the park for the fall, resulting in little direct temporal overlap with toads. Some grazing might be beneficial so that the open nature of the shoreline preferred by breeding toads is maintained.

5.3 Underpass to mitigate road mortality

Ideally, closure of the Kentucky Lake campsite access road during the brief periods when toads migrate would be the most effective way of reducing toadlet mortality. However, because the migration occurs during the busiest park use period of the year in August, this may not be an option, and an underpass is a viable alternative. An underpass is passive and, once in place, functions with minimal human interference. It requires no trapping and handling of the animals, as do "bucket brigades", which consist of manually moving toads across roads. However, it does require drift and barrier fencing that need to be maintained. Drift fencing is needed to guide the animals towards the underpass and to reduce unnecessary milling; barrier fencing along road sides is needed to prevent animals from back tracking onto the road. Predation risk from avian predators, such as crows, or mammalian predators, such as mink, may be increased and needs to be monitored in case modifications are required.

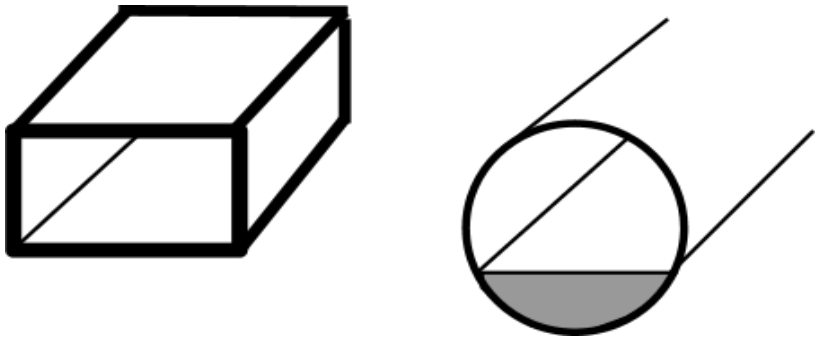
Based on results from one year of monitoring in 2012, we have identified a potential site for an underpass on the Main Campsite road to the Kentucky Lake campsites. This site is between Transect Segments 6 and 8 in Figure 4, uphill and to the west of the campsites. This site is where the peak migration occurred in 2012, and it is suitable because:

- it received heavy use by migrating toadlets;
- channeling toadlets to this site by drift fences would direct them away from high recreational use areas located farther down;
- installation of a crossing structure would be logistically more feasible at this site than farther down because of terrain features and higher grade;
- there appears to be a depression leading up from West Pond to this site, suggesting that it is natural movement corridor for toads.

Amphibian road mortality mitigation is in place at a number of sites in British Columbia (Appendix 7). Various designs for underpasses have been used in these studies. Most of the underpass structures are relatively new, and although effectiveness monitoring is in place at a number of sites, complete results are still pending. Nevertheless, some patterns are evident based on the experience in the province and elsewhere. The general consensus is that wider underpasses are more effective than narrow ones (Ovaska et al. 2004, Conference Call, pers. comm. 2012). The critical measurement is the floor width, which should be no less than 60 cm. If culverts are used, rectangular ones are preferred due to their greater floor width at the crossing level, but this width could also be achieved by round culverts that are partially filled with substrate material (Figure 12). To decrease predation opportunities while animals are concentrated in or at the entrance of the tunnel, it is important to provide cover-objects where they can hide. Because underpasses are only used seasonally, it is advisable to make provisions so the tunnel can be closed off when not used by toadlets. This will ensure that predators such as mink are not habituated to use them as travel corridors. Because the road is narrow and the underpass span is relatively short (approximately 5 m), it may not be necessary to supplement light in the tunnel. Painting the ceiling white is a possibility to increase the amount of reflected light (Conference Call, pers. comm. 2012).

Figure 12. Cross section of two types of tunnels.

The grey shaded area shows partial filling of a round culvert with substrate to increase floor width.



<u>Option A. Optimal design: Cattleguard and fencing</u>

PROS:

- Easier to channel animals to the underpass because of the wide entrance.
- Wide entrance and light from above are expected to facilitate movements of toadlets through the underpass and reduce milling at the tunnel entrance.
- Easy to place numerous cover objects in and around the underpass for toadlets to seek refuge from predators.

CONS:

- More costly than a culvert

Option B. Culvert and fencing

PROS:

- Relatively inexpensive, although recommended square or wide diameter culverts might add to cost

CONS:

- Possibility that toadlets are reluctant to enter the tunnel, although using a large diameter culvert (at least 60 cm floor width) will help.
- Milling at the tunnel entrance may increase predator risk.
- Fewer opportunities to reduce predation risk within the tunnel by placement of cover objects than with a cattleguard.

If BC Parks decides to go ahead with the installation of an underpass, a biologist should be on site to determine the exact location and provide advice on its installation.
Drift fences will need to be installed for the period of migration to channel toadlets to the underpass. The length and exact location of drift fences required at the Kentucky Alleyne site are uncertain and need to be determined on the ground. Relatively long drift fences (50 m or more) are expected to be needed. We recommend that inexpensive plastic drift fencing be used and that it be taken down yearly after the toadlet migration period (see Appendix 7 for details). Construction and maintenance of drift fences is a suitable stewardship activity for volunteers.

5.4 Monitoring of underpass and fencing

The effectiveness of any underpass structures needs to be monitored, and funding should be set aside for this purpose. There should be follow-up monitoring to document behaviour of toadlets at the entrance of the underpass and proportions of the toadlets using it, and to assess predation risk. Monitoring the toadlet migration provides excellent opportunities for local communities and park users to participate in stewardship activities. In addition to mitigating road mortality, an underpass would have educational opportunities. Increasing awareness associated with a crossing structure would help spread the message that it is unacceptable to drive over amphibians and that road mortality can have serious consequences to these inconspicuous and often overlooked creatures that nevertheless play important roles in ecosystems.

6.0 LITERATURE CITED

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Appendix 1. Volunteer datasheet used for toadlet counts on roads and transects.

Kentucky Alleyne Park toad project **Observer name……………………………………..** **Date ……. August 2012**

Time (start): ________ **Time (end):** ________

Air temp (°C): _____ **Wind (circle):** calm light moderate high

Rain (circle): none drizzle light moderate heavy **Cloud cover (circle):** clear <50% >50% overcast

Toad abundance categories (if large numbers seen; otherwise count): **N** (none); **L** (low) <10; **M**: 10 – 100; **H** (high): 100 – 1000; **VH** (very high) >1000

Transect or Road[1]	**Section**[2]	**# toadlets, live**[3] **(N, L, M, H, VH)**	**# toadlets, dead**[4]	**Notes** (predators, e.g., crows; adult toads; people or cars during survey)
A) Kentucky Rd Transect	1-2			
10 m sections Starts at square in road about 30 m below the top road junction with Bates Rd. Flagging is on the right side of the road going down the hill.	2-3			
	3-4			
	4-5			
	5-6			
	6-7			
	7-8			
	8-9			
	9-10			
	10-11			
	11-12			
	12-13			
	13-14			
	14-15			
	15-16			
	16-17			
Flagging crosses the road	17-18			
Blue trash container	18-end			
~~				
B) Connector Path	1-1a			
12.5 m sections Count toadlets on path only.	1a-2			
	2-2a			
	2a-3			
	3-3a			
	3a-4			
	4-4a			
	4a-5			
	5-5a			
	5a-6			
	6-6a			
	6a-7			
	7-7a			
	7a-8			

	8-8a			
	8a-9			
	9-9a			
	9a-10			
	10-10a			
	10a-11			
	11-11a			
Ends at water tap at campsite loop	11a-tap			

Notes on data entry

[1] Refer to map for transect numbers and road names.
[2] Transect stakes or flagging tape mark sections. For camp site roads use the camp site numbers, e.g., 15-16
[3] Count toads on road surface between markers; estimate abundance using categories shown on top of data sheet.
[4] Count roadkill toadlets; estimate numbers using above categories if there are too many to count; to avoid double-counting, circle roadkills with chalk. Don't count previously marked roadkills.

If you check the campsite roads please also complete this section – whether or not you find any live or dead toadlets. Tick each road checked. If you find live or dead toadlets then enter this information in the spaces below – use one line for each section that has live or dead toadlets present.

BL – Boat Launch Road

KC – Kentucky Campsite Road

WP – West Pond Campsite Rd

AC – Alleyne Campsite Rd

BR – Bates Road

Transect or Road[1]	**Section**[2]	**# toadlets, live**[3] **(N, L, M, H, VH)**	**# toadlets, dead**[4]	**Notes** (predators, e.g., crows; adult toads; people or cars during survey)

Appendix 2. Search conditions during toad surveys at Kentucky Alleyne Provincial Park, August 2012.

BL – Boat Launch Road, KC – Kentucky Campsite Road, WP – West Pond Campsite Rd, AC – Alleyne Campsite Rd, BR – Bates Road

Date	Observer(s)	Transects searched	Time start	Time stop	Temp. (air, C°)	Wind (code)	Cloud cover (code)	Rain	Notes
6-Aug	Andrea Lawrence	KC, CON	15:45	16:20	26	2		none	Extended KC transect by 8 sections uphill and renumbered all sections; CON transect done before it was divided into subsections
8-Aug	Anne Tang, Sheila Curnow	BL	11:00	11:55	23	1	2	none	Volunteer training; Alan set-up new flags at every 10 m on BL road (1 - 20)
8-Aug	Anne Tang, Sheila Curnow, Liis Jeffries	CON	11:30	11:55	23	1	2	none	Volunteer training
8-Aug	Dakota & Meg O'Donovan, Noah Bergman	KC	11:00	12:00	24	2	2	none	Volunteer training
10-Aug	Andrea Lawrence	BL, KC, WP, AC, BR	11:55	13:15	24	2	1	none	Very few toadlets found; sign of previous dead toadlets gone in 48 h (70%)
10-Aug	Lennart & Jeffrey Sopuck	BL, KC, CON	20:20	21:38	20	1	1	none	
10-Aug	Lennart & Jeffrey Sopuck	BL, KC, CON	23:11	0:00	13	1	1	none	
11-Aug	Lennart & Jeffrey Sopuck	BL, KC, CON	6:08	7:10	9	1	1	none	
11-Aug	Lennart & Jeffrey Sopuck	BL, KC, CON	9:05	10:15	18	1	1	none	
11-Aug	Lennart & Jeffrey Sopuck	BL, KC, CON	12:14	12:52	28	2	1	none	No toadlets on roads; 2000+ seen in swale at WPT 78 as before
11-Aug	Chantelle Forseille	KC, CON							No toadlets found

Date	Observer(s)	Transects searched	Time start	Time stop	Temp. (air, C°)	Wind (code)	Cloud cover (code)	Rain	Notes
12-Aug	Anne Tang	BL, KC	10:50	11:50	32	1	1	none	No live toads on roads; toads moving in hollow/dip of main road
14-Aug	Liis Jeffries	BL, KC, CON	6:50	8:00	18	2	1	none	
15-Aug	Sheila Curnow	BL, KC, CON	8:00	9:10	11	2	1	none	No toads seen, except a few on CON path. According host, temp went down to 7C last night
17-Aug	Sheila Curnww	BL, KC, CON	19:00	19:45	27	1	1	none	
20-Aug	Andrea Lawrence	BL, KC, CON	13:50	14:30	28	3	2	none	
24-Aug	Andrea Lawrence, Alan Burger	BL, KC, CON	6:05	6:55	14	1	2	none	Took down cameras; walked from KL campsite road culvert along beach 300m because a camper reported toadlets along that shore; said there were not as many as in previous years.
28-Jul	Chantelle Forseille	West Pond	14:00	16:00	26	1	1	none	
30-Jul	Chantelle Forseille	West Pond	18:00		21	2	1	none	
4-Aug	Chantelle Forseille	West Pond	13:00	14:00	24	1	1	none	
5-Aug	Chantelle Forseille	West Pond	16:00	17:00	31	1	1	none	
8-Aug	Chantelle Forseille	West Pond	11:00			1	1	none	
12-Aug	Chantelle Forseille	West Pond	19:00		19	1	1	none	
21-Aug	Chantelle Forseille	West Pond	18:30	19:00		1	1	none	

Appendix 3. Results of toad surveys along road and path transects at Kentucky Alleyne Provincial Park, August 2012.

See Appendix 1 or 2 for explanation of transect and road codes.

Date	Time (start)	Transect or Road name	Section	Sub-section	Toadlets, live (# or abundance category)	Toadlets, dead (#)
6-Aug	15:45	KC	1		2	0
6-Aug	15:45	KC	6		2	5
6-Aug	15:45	KC	8		0	4
6-Aug	15:45	KC	9		0	5
6-Aug	15:45	CON	1		9	0
6-Aug	15:45	CON	2		150	0
6-Aug	15:45	CON	3		150	0
6-Aug	15:45	CON	4		9	0
8-Aug	11:00	BL	1		L	L
8-Aug	11:00	BL	2		L	N
8-Aug	11:00	BL	3		L	N
8-Aug	11:00	BL	4		L	L
8-Aug	11:00	BL	5		N	N
8-Aug	11:00	BL	6		L	N
8-Aug	11:00	BL	7		L	N
8-Aug	11:00	BL	17		L	N
8-Aug	11:30	CON	2	a	25	12
8-Aug	11:30	CON	3	a	3	1
8-Aug	11:30	CON	3	b	5	6
8-Aug	11:00	KC	1		0	26
8-Aug	11:00	KC	2		0	17
8-Aug	11:00	KC	3		0	50
8-Aug	11:00	KC	4		0	60
8-Aug	11:00	KC	5		0	71
8-Aug	11:00	KC	6		1	341
8-Aug	11:00	KC	7		2	231
8-Aug	11:00	KC	8		0	127
8-Aug	11:00	KC	9		1	110
8-Aug	11:00	KC	10		0	22
8-Aug	11:00	KC	11		0	13
8-Aug	11:00	KC	12		0	42
8-Aug	11:00	KC	13		0	26
8-Aug	11:00	KC	14		1	20
8-Aug	11:00	KC	15		2	16
8-Aug	11:00	KC	16		1	6
8-Aug	11:00	KC	17		2	6
8-Aug	11:00	KC	18		9	16
10-Aug	11:55	KC	4		0	1
10-Aug	11:55	KC	8		0	1
10-Aug	11:55	KC	10		0	2

Date	Time (start)	Transect or Road name	Section	Sub-section	Toadlets, live (# or abundance category)	Toadlets, dead (#)
10-Aug	20:30	BL	19		0	2
10-Aug	20:30	BL	20		0	2
10-Aug	21:03	KC	4		0	1
10-Aug	21:03	KC	5		0	2
10-Aug	21:03	KC	6		0	1
10-Aug	21:03	KC	7		0	4
10-Aug	21:03	KC	8		0	2
10-Aug	21:03	KC	9		0	5
10-Aug	20:20	CON	1	a	11	0
10-Aug	20:20	CON	1	b	6	0
10-Aug	20:20	CON	2	a	2	6
10-Aug	20:20	CON	2	b	8	5
10-Aug	20:20	CON	3	a	3	1
10-Aug	20:20	CON	3	b	7	2
10-Aug	23:30	BL	8		0	0
10-Aug	23:30	BL	10		0	0
10-Aug	23:30	BL	11		0	0
10-Aug	23:30	BL	18		0	0
10-Aug	23:53	KC	7		0	1
10-Aug	23:53	KC	11		0	0
10-Aug	23:11	CON	2	b	0	1
11-Aug	6:27	BL	20		2	0
11-Aug	6:27	BL	12		0	0
11-Aug	6:40	KC	6		1	0
11-Aug	6:40	KC	7		1	0
11-Aug	6:40	KC	11		1	0
11-Aug	6:40	KC	13		1	0
11-Aug	6:08	CON	2	a	3	0
11-Aug	6:08	CON	3	a	1	0
11-Aug	10:00	KC	7		0	1
11-Aug	10:00	KC	8		1	0
11-Aug	10:00	KC	12		0	1
11-Aug	9:10	CON	1	a	1	0
11-Aug	9:10	CON	1	b	3	0
11-Aug	9:10	CON	2	a	2	0
11-Aug	9:10	CON	2	b	4	0
11-Aug	9:10	CON	3	a	1	0
12-Aug	10:50	KC	2		0	1
12-Aug	10:50	KC	3		0	1
12-Aug	10:50	KC	4		0	3
12-Aug	10:50	KC	6		0	3
12-Aug	10:50	KC	8		0	1
12-Aug	10:50	KC	9		0	2
12-Aug	10:50	KC	10		0	1
12-Aug	10:50	KC	11		0	1

Date	Time (start)	Transect or Road name	Section	Sub-section	Toadlets, live (# or abundance category)	Toadlets, dead (#)
14-Aug	7:15	BL	0		0	0
14-Aug	6:50	KC	3		1	0
14-Aug	6:50	KC	7		0	2
14-Aug	6:50	KC	18		1	1
14-Aug	7:30	CON	1	a	6	0
14-Aug	7:30	CON	1	b	10	4
14-Aug	7:30	CON	2	a	11	2
14-Aug	7:30	CON	2	b	14	0
14-Aug	7:30	CON	3	a	3	0
14-Aug	7:30	CON	3	b	2	0
14-Aug	7:30	CON	4	a	2	0
15-Aug	8:00	CON	2	a	L	L
15-Aug	8:00	CON	2	b	L	L
17-Aug	19:00	KC	5		0	L
17-Aug	19:00	KC	7		0	L
17-Aug	19:00	KC	9		0	L
17-Aug	19:00	KC	13		0	L
17-Aug	19:00	CON	1	a	0	L
17-Aug	19:00	CON	2	b	L	0
17-Aug	19:00	CON	3	a	L	0
17-Aug	19:00	CON	3	b	L	0
17-Aug	19:00	CON	4	a	L	0
20-Aug	13:50	KC	7		0	1
24-Aug	6:05	KC	14		0	1
24-Aug	6:05	KC	15		1	0
24-Aug	6:05	CON	4	a	1	0
24-Aug	6:05	CON	5	a	1	0

Appendix 4. Results of toad surveys around West Pond at Kentucky Alleyne Provincial Park, July – August 2012.

Toad abundance categories: N (none); L (low) <10; M: 10 – 100; H (high): 100 – 1000; VH (very high) >1000

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
28-Jul	14:00	1	0	A	M	H	H
28-Jul	14:00	2	0	B	VH	H	M
28-Jul	14:00	3	1	A	H	VH	H
28-Jul	14:00	4	1	B	VH	H	H
28-Jul	14:00	5	2	A	VH	VH	H
28-Jul	14:00	6	2	B	VH	VH	H
28-Jul	14:00	7	3	A	VH	VH	VH
28-Jul	14:00	8	3	B	VH	VH	VH
28-Jul	14:00	9	4	A	VH	VH	VH
28-Jul	14:00	10	4	B	VH	VH	H
28-Jul	14:00	11	5	A	VH	VH	H
28-Jul	14:00	12	5	B	H	VH	H
28-Jul	14:00	13	6	A	H	H	M
28-Jul	14:00	14	6	B	H	H	M
28-Jul	14:00	15	7	A	L	M	M
28-Jul	14:00	16	7	B	H	N	M
28-Jul	14:00	17	8	A	N	N	M
28-Jul	14:00	18	8	B	M	N	M
28-Jul	14:00	19	9	A	N	N	N
28-Jul	14:00	20	9	B	L	N	L
28-Jul	14:00	21	10	A	N	N	L
28-Jul	14:00	22	10	B	N	N	N
28-Jul	14:00	23	11	A	N	N	L
28-Jul	14:00	24	11	B	N	N	N
28-Jul	14:00	25	12	A	N	N	N
28-Jul	14:00	26	12	B	M	H	M
28-Jul	14:00	27	13	A	M	VH	H
28-Jul	14:00	28	13	B	N	M	N
28-Jul	14:00	29	14	A	N	N	N
28-Jul	14:00	30	14	B	N	N	N
28-Jul	14:00	31	15	A	N	N	N
28-Jul	14:00	32	15	B	N	N	N
28-Jul	14:00	33	16	A	N	N	N
28-Jul	14:00	34	16	B	N	N	N
28-Jul	14:00	35	17	A	N	N	N
28-Jul	14:00	36	17	B	N	N	N
28-Jul	14:00	37	18	A	N	N	N
28-Jul	14:00	38	18	B	N	N	N
28-Jul	14:00	39	19	A	N	N	N
28-Jul	14:00	40	19	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
28-Jul	14:00	41	20	A	M	M	N
28-Jul	14:00	42	20	B	M	M	N
28-Jul	14:00	43	21	A	H	H	M
28-Jul	14:00	44	21	B	H	H	M
28-Jul	14:00	45	22	A	L	M	L
28-Jul	14:00	46	22	B	L	N	N
28-Jul	14:00	47	23	A	N	M	N
28-Jul	14:00	48	23	B	L	N	N
28-Jul	14:00	49	24	A	N	M	N
28-Jul	14:00	50	24	B	N	N	N
28-Jul	14:00	51	25	A	H	H	H
28-Jul	14:00	52	25	B	H	H	M
30-Jul	18:00	1	0	A	H	M	L
30-Jul	18:00	2	0	B	H	M	L
30-Jul	18:00	3	1	A	H	L	M
30-Jul	18:00	4	1	B	H	L	M
30-Jul	18:00	5	2	A	VH	M	L
30-Jul	18:00	6	2	B	VH	M	M
30-Jul	18:00	7	3	A	VH	L	M
30-Jul	18:00	8	3	B	VH	M	M
30-Jul	18:00	9	4	A	VH	M	M
30-Jul	18:00	10	4	B	VH	L	L
30-Jul	18:00	11	5	A	VH	L	M
30-Jul	18:00	12	5	B	VH	M	M
30-Jul	18:00	13	6	A	M	L	M
30-Jul	18:00	14	6	B	M	M	M
30-Jul	18:00	15	7	A	M	L	L
30-Jul	18:00	16	7	B	M	N	N
30-Jul	18:00	17	8	A	L	M	N
30-Jul	18:00	18	8	B	N	N	N
30-Jul	18:00	19	9	A	N	N	N
30-Jul	18:00	20	9	B	L	N	N
30-Jul	18:00	21	10	A	L	L	N
30-Jul	18:00	22	10	B	N	N	N
30-Jul	18:00	23	11	A	N	N	N
30-Jul	18:00	24	11	B	L	L	N
30-Jul	18:00	25	12	A	L	L	L
30-Jul	18:00	26	12	B	L	M	L
30-Jul	18:00	27	13	A	L	M	M
30-Jul	18:00	28	13	B	L	M	M
30-Jul	18:00	29	14	A	N	L	L
30-Jul	18:00	30	14	B	N	L	L
30-Jul	18:00	31	15	A	N	N	N
30-Jul	18:00	32	15	B	N	L	N
30-Jul	18:00	33	16	A	N	N	N
30-Jul	18:00	34	16	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
30-Jul	18:00	35	17	A	N	N	N
30-Jul	18:00	36	17	B	L	N	N
30-Jul	18:00	37	18	A	L	N	N
30-Jul	18:00	38	18	B	N	N	L
30-Jul	18:00	39	19	A	L	N	L
30-Jul	18:00	40	19	B	M	L	L
30-Jul	18:00	41	20	A	M	M	L
30-Jul	18:00	42	20	B	N	N	L
30-Jul	18:00	43	21	A	L	L	N
30-Jul	18:00	44	21	B	M	L	N
30-Jul	18:00	45	22	A	M	M	N
30-Jul	18:00	46	22	B	M	M	L
30-Jul	18:00	47	23	A	M	N	N
30-Jul	18:00	48	23	B	M	L	N
30-Jul	18:00	49	24	A	M	N	N
30-Jul	18:00	50	24	B	M	L	N
30-Jul	18:00	51	25	A	VH	L	N
30-Jul	18:00	52	25	B	VH	L	N
4-Aug	13:00	1	0	A	VH	VH	M
4-Aug	13:00	2	0	B	VH	VH	M
4-Aug	13:00	3	1	A	VH	VH	M
4-Aug	13:00	4	1	B	H	H	M
4-Aug	13:00	5	2	A	H	VH	L
4-Aug	13:00	6	2	B	H	VH	L
4-Aug	13:00	7	3	A	H	H	L
4-Aug	13:00	8	3	B	H	H	L
4-Aug	13:00	9	4	A	VH	H	L
4-Aug	13:00	10	4	B	H	H	L
4-Aug	13:00	11	5	A	VH	H	M
4-Aug	13:00	12	5	B	H	VH	M
4-Aug	13:00	13	6	A	H	VH	M
4-Aug	13:00	14	6	B	H	H	M
4-Aug	13:00	15	7	A	H	H	M
4-Aug	13:00	16	7	B	VH	H	L
4-Aug	13:00	17	8	A	M	H	M
4-Aug	13:00	18	8	B	M	H	H
4-Aug	13:00	19	9	A	M	M	H
4-Aug	13:00	20	9	B	M	M	H
4-Aug	13:00	21	10	A	M	M	H
4-Aug	13:00	22	10	B	M	H	H
4-Aug	13:00	23	11	A	M	M	M
4-Aug	13:00	24	11	B	M	H	M
4-Aug	13:00	25	12	A	H	H	M
4-Aug	13:00	26	12	B	M	H	M
4-Aug	13:00	27	13	A	M	H	M
4-Aug	13:00	28	13	B	M	M	M

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
4-Aug	13:00	29	14	A	M	M	M
4-Aug	13:00	30	14	B	M	M	L
4-Aug	13:00	31	15	A	M	M	L
4-Aug	13:00	32	15	B	L	M	L
4-Aug	13:00	33	16	A	M	M	L
4-Aug	13:00	34	16	B	M	M	M
4-Aug	13:00	35	17	A	H	H	M
4-Aug	13:00	36	17	B	H	H	M
4-Aug	13:00	37	18	A	H	H	M
4-Aug	13:00	38	18	B	M	M	M
4-Aug	13:00	39	19	A	M	M	M
4-Aug	13:00	40	19	B	H	M	M
4-Aug	13:00	41	20	A	H	M	M
4-Aug	13:00	42	20	B	H	M	M
4-Aug	13:00	43	21	A	H	H	M
4-Aug	13:00	44	21	B	M	M	M
4-Aug	13:00	45	22	A	M	M	M
4-Aug	13:00	46	22	B	M	M	M
4-Aug	13:00	47	23	A	H	M	L
4-Aug	13:00	48	23	B	M	M	M
4-Aug	13:00	49	24	A	H	H	M
4-Aug	13:00	50	24	B	H	H	M
4-Aug	13:00	51	25	A	H	H	M
4-Aug	13:00	52	25	B	H	H	M
5-Aug	16:00	1	0	A	VH	VH	M
5-Aug	16:00	2	0	B	VH	VH	M
5-Aug	16:00	3	1	A	H	M	M
5-Aug	16:00	4	1	B	M	M	M
5-Aug	16:00	5	2	A	M	M	L
5-Aug	16:00	6	2	B	M	M	L
5-Aug	16:00	7	3	A	M	M	L
5-Aug	16:00	8	3	B	M	H	L
5-Aug	16:00	9	4	A	H	H	L
5-Aug	16:00	10	4	B	H	H	L
5-Aug	16:00	11	5	A	H	H	M
5-Aug	16:00	12	5	B	H	H	M
5-Aug	16:00	13	6	A	M	M	L
5-Aug	16:00	14	6	B	M	M	L
5-Aug	16:00	15	7	A	M	M	L
5-Aug	16:00	16	7	B	H	M	L
5-Aug	16:00	17	8	A	M	M	L
5-Aug	16:00	18	8	B	M	M	L
5-Aug	16:00	19	9	A	L	L	L
5-Aug	16:00	20	9	B	L	L	L
5-Aug	16:00	21	10	A	N	N	N
5-Aug	16:00	22	10	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
5-Aug	16:00	23	11	A	L	L	M
5-Aug	16:00	24	11	B	M	M	M
5-Aug	16:00	25	12	A	M	M	M
5-Aug	16:00	26	12	B	M	M	M
5-Aug	16:00	27	13	A	M	H	M
5-Aug	16:00	28	13	B	M	M	M
5-Aug	16:00	29	14	A	M	M	M
5-Aug	16:00	30	14	B	M	M	M
5-Aug	16:00	31	15	A	M	M	M
5-Aug	16:00	32	15	B	L	L	L
5-Aug	16:00	33	16	A	L	M	M
5-Aug	16:00	34	16	B	L	L	L
5-Aug	16:00	35	17	A	M	M	L
5-Aug	16:00	36	17	B	L	M	L
5-Aug	16:00	37	18	A	L	M	L
5-Aug	16:00	38	18	B	L	L	L
5-Aug	16:00	39	19	A	M	M	L
5-Aug	16:00	40	19	B	H	H	L
5-Aug	16:00	41	20	A	H	H	L
5-Aug	16:00	42	20	B	H	H	L
5-Aug	16:00	43	21	A	H	H	L
5-Aug	16:00	44	21	B	M	M	L
5-Aug	16:00	45	22	A	H	H	L
5-Aug	16:00	46	22	B	H	H	L
5-Aug	16:00	47	23	A	H	H	L
5-Aug	16:00	48	23	B	H	H	L
5-Aug	16:00	49	24	A	VH	H	M
5-Aug	16:00	50	24	B	VH	H	M
5-Aug	16:00	51	25	A	VH	VH	M
5-Aug	16:00	52	25	B	VH	VH	H
8-Aug	11:00	1	0	A	H	M	L
8-Aug	11:00	2	0	B	M	L	L
8-Aug	11:00	3	1	A	M	L	L
8-Aug	11:00	4	1	B	M	L	N
8-Aug	11:00	5	2	A	M	L	N
8-Aug	11:00	6	2	B	L	L	N
8-Aug	11:00	7	3	A	N	N	N
8-Aug	11:00	8	3	B	L	L	N
8-Aug	11:00	9	4	A	N	N	N
8-Aug	11:00	10	4	B	N	N	N
8-Aug	11:00	11	5	A	N	N	N
8-Aug	11:00	12	5	B	N	L	N
8-Aug	11:00	13	6	A	N	N	N
8-Aug	11:00	14	6	B	N	N	N
8-Aug	11:00	15	7	A	N	N	N
8-Aug	11:00	16	7	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
8-Aug	11:00	17	8	A	N	N	N
8-Aug	11:00	18	8	B	N	N	N
8-Aug	11:00	19	9	A	N	N	N
8-Aug	11:00	20	9	B	N	N	N
8-Aug	11:00	21	10	A	N	N	N
8-Aug	11:00	22	10	B	N	N	N
8-Aug	11:00	23	11	A	N	N	N
8-Aug	11:00	24	11	B	N	N	N
8-Aug	11:00	25	12	A	N	N	N
8-Aug	11:00	26	12	B	N	N	N
8-Aug	11:00	27	13	A	N	N	N
8-Aug	11:00	28	13	B	N	N	N
8-Aug	11:00	29	14	A	N	N	N
8-Aug	11:00	30	14	B	N	N	N
8-Aug	11:00	31	15	A	N	N	N
8-Aug	11:00	32	15	B	N	N	N
8-Aug	11:00	33	16	A	N	N	N
8-Aug	11:00	34	16	B	N	N	N
8-Aug	11:00	35	17	A	N	N	N
8-Aug	11:00	36	17	B	N	N	N
8-Aug	11:00	37	18	A	N	N	N
8-Aug	11:00	38	18	B	N	N	N
8-Aug	11:00	39	19	A	N	N	N
8-Aug	11:00	40	19	B	N	N	N
8-Aug	11:00	41	20	A	N	N	N
8-Aug	11:00	42	20	B	N	N	N
8-Aug	11:00	43	21	A	N	N	N
8-Aug	11:00	44	21	B	N	N	N
8-Aug	11:00	45	22	A	N	N	N
8-Aug	11:00	46	22	B	L	N	N
8-Aug	11:00	47	23	A	N	N	N
8-Aug	11:00	48	23	B	N	N	N
8-Aug	11:00	49	24	A	M	N	N
8-Aug	11:00	50	24	B	M	L	N
8-Aug	11:00	51	25	A	M	L	N
8-Aug	11:00	52	25	B	H	M	L
12-Aug	19:00	1	0	A	M	N	N
12-Aug	19:00	2	0	B	M	N	N
12-Aug	19:00	3	1	A	M	N	N
12-Aug	19:00	4	1	B	L	N	N
12-Aug	19:00	5	2	A	L	N	N
12-Aug	19:00	6	2	B	L	N	N
12-Aug	19:00	7	3	A	L	N	N
12-Aug	19:00	8	3	B	L	N	N
12-Aug	19:00	9	4	A	N	N	N
12-Aug	19:00	10	4	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
12-Aug	19:00	11	5	A	N	N	N
12-Aug	19:00	12	5	B	N	N	N
12-Aug	19:00	13	6	A	N	N	N
12-Aug	19:00	14	6	B	N	N	N
12-Aug	19:00	15	7	A	N	N	N
12-Aug	19:00	16	7	B	N	N	N
12-Aug	19:00	17	8	A	N	N	N
12-Aug	19:00	18	8	B	N	N	N
12-Aug	19:00	19	9	A	N	N	N
12-Aug	19:00	20	9	B	N	N	N
12-Aug	19:00	21	10	A	N	N	N
12-Aug	19:00	22	10	B	N	N	N
12-Aug	19:00	23	11	A	N	N	N
12-Aug	19:00	24	11	B	N	N	N
12-Aug	19:00	25	12	A	N	N	N
12-Aug	19:00	26	12	B	N	N	N
12-Aug	19:00	27	13	A	N	N	N
12-Aug	19:00	28	13	B	N	N	N
12-Aug	19:00	29	14	A	N	N	N
12-Aug	19:00	30	14	B	N	N	N
12-Aug	19:00	31	15	A	N	N	N
12-Aug	19:00	32	15	B	N	N	N
12-Aug	19:00	33	16	A	N	N	N
12-Aug	19:00	34	16	B	N	N	N
12-Aug	19:00	35	17	A	N	N	N
12-Aug	19:00	36	17	B	N	N	N
12-Aug	19:00	37	18	A	L	N	N
12-Aug	19:00	38	18	B	N	N	N
12-Aug	19:00	39	19	A	N	N	N
12-Aug	19:00	40	19	B	N	N	N
12-Aug	19:00	41	20	A	N	N	N
12-Aug	19:00	42	20	B	N	N	N
12-Aug	19:00	43	21	A	N	N	N
12-Aug	19:00	44	21	B	L	N	N
12-Aug	19:00	45	22	A	N	N	N
12-Aug	19:00	46	22	B	N	N	N
12-Aug	19:00	47	23	A	N	N	N
12-Aug	19:00	48	23	B	N	N	N
12-Aug	19:00	49	24	A	N	N	N
12-Aug	19:00	50	24	B	N	N	N
12-Aug	19:00	51	25	A	N	N	N
12-Aug	19:00	52	25	B	M	N	N
21-Aug	18:30	1	0	A	N	N	N
21-Aug	18:30	2	0	B	L	N	N
21-Aug	18:30	3	1	A	N	N	N
21-Aug	18:30	4	1	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
21-Aug	18:30	5	2	A	N	N	N
21-Aug	18:30	6	2	B	N	N	N
21-Aug	18:30	7	3	A	N	N	N
21-Aug	18:30	8	3	B	N	N	N
21-Aug	18:30	9	4	A	N	N	N
21-Aug	18:30	10	4	B	N	N	N
21-Aug	18:30	11	5	A	N	N	N
21-Aug	18:30	12	5	B	N	N	N
21-Aug	18:30	13	6	A	N	N	N
21-Aug	18:30	14	6	B	N	N	N
21-Aug	18:30	15	7	A	N	N	N
21-Aug	18:30	16	7	B	N	N	N
21-Aug	18:30	17	8	A	N	N	N
21-Aug	18:30	18	8	B	N	N	N
21-Aug	18:30	19	9	A	N	N	N
21-Aug	18:30	20	9	B	N	N	N
21-Aug	18:30	21	10	A	N	N	N
21-Aug	18:30	22	10	B	N	N	N
21-Aug	18:30	23	11	A	N	N	N
21-Aug	18:30	24	11	B	N	N	N
21-Aug	18:30	25	12	A	N	N	N
21-Aug	18:30	26	12	B	N	N	N
21-Aug	18:30	27	13	A	N	N	N
21-Aug	18:30	28	13	B	N	N	N
21-Aug	18:30	29	14	A	N	N	N
21-Aug	18:30	30	14	B	N	N	N
21-Aug	18:30	31	15	A	N	N	N
21-Aug	18:30	32	15	B	N	N	N
21-Aug	18:30	33	16	A	N	N	N
21-Aug	18:30	34	16	B	N	N	N
21-Aug	18:30	35	17	A	N	N	N
21-Aug	18:30	36	17	B	N	N	N
21-Aug	18:30	37	18	A	N	N	N
21-Aug	18:30	38	18	B	N	N	N
21-Aug	18:30	39	19	A	N	N	N
21-Aug	18:30	40	19	B	N	N	N
21-Aug	18:30	41	20	A	N	N	N
21-Aug	18:30	42	20	B	N	N	N
21-Aug	18:30	43	21	A	N	N	N
21-Aug	18:30	44	21	B	N	N	N
21-Aug	18:30	45	22	A	N	N	N
21-Aug	18:30	46	22	B	N	N	N
21-Aug	18:30	47	23	A	N	N	N
21-Aug	18:30	48	23	B	N	N	N
21-Aug	18:30	49	24	A	N	N	N
21-Aug	18:30	50	24	B	N	N	N

Date	Time (start)	Short section	Long Section (25 m)	Sub-section (12.5 m)	Transect (grass)	Mud-zone	Water zone
21-Aug	18:30	51	25	A	N	N	N
21-Aug	18:30	52	25	B	L	N	N

Appendix 5. Toadlets detected in images from time-lapse cameras, August 2012.

Observer	Camera ID	Date	Time	Number of toadlets	Notes
AB	1	7-Aug	20:00	0	
AB	1	7-Aug	20:15	0	
AB	1	7-Aug	20:30	0	
AB	1	7-Aug	20:45	0	
AB	1	7-Aug	21:00	0	rain starts - road getting wet
AB	1	7-Aug	21:15	2	road fully wet
AB	1	7-Aug	21:30	0	
AB	1	7-Aug	21:45	3	
AB	1	7-Aug	22:00	2	
AB	1	7-Aug	22:15	4	
AB	1	7-Aug	22:30	2	
AB	1	7-Aug	22:45	2	
AB	1	7-Aug	23:00	10	
AB	1	7-Aug	23:15	2	
AB	1	7-Aug	23:30	8	
AB	1	7-Aug	23:45	15	
AB	1	8-Aug	0:00	7	
AB	1	8-Aug	0:15	14	
AB	1	8-Aug	0:30	9	
AB	1	8-Aug	0:45	9	
AB	1	8-Aug	1:00	8	
AB	1	8-Aug	1:15	13	
AB	1	8-Aug	1:30	14	
AB	1	8-Aug	1:45	8	
AB	1	8-Aug	2:00	11	road starting to dry out
AB	1	8-Aug	2:15	7	
AB	1	8-Aug	2:30	14	
AB	1	8-Aug	2:45	8	
AB	1	8-Aug	3:00	6	
AB	1	8-Aug	3:15	9	
AB	1	8-Aug	3:30	9	
AB	1	8-Aug	3:45	5	
AB	1	8-Aug	4:00	10	
AB	1	8-Aug	4:15	5	
AB	1	8-Aug	4:30	7	

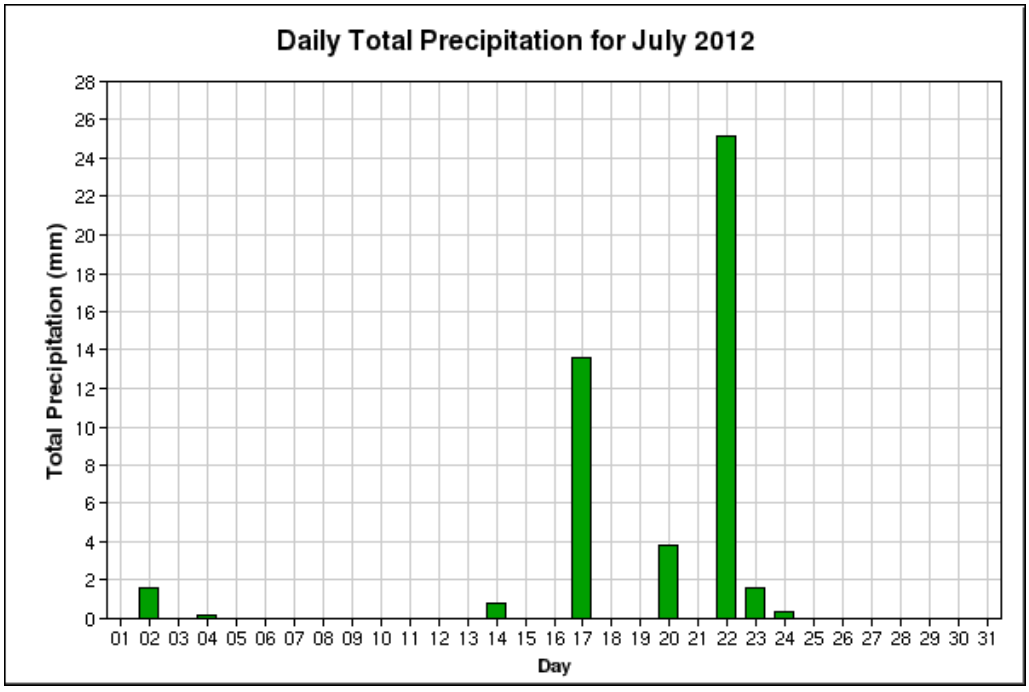
Observer	Camera ID	Date	Time	Number of toadlets	Notes
AB	1	8-Aug	4:45	7	
AB	1	8-Aug	5:00	6	
AB	1	8-Aug	5:15	4	road surface about 40% dry
CF	1	9-Aug	9:00	1	
CF	1	9-Aug	9:15	0	
CF	1	9-Aug	9:30	4	
CF	1	9-Aug	9:45	6	
CF	1	9-Aug	10:00	3	
CF	1	9-Aug	10:15	0	
CF	1	9-Aug	10:30	1	
CF	1	9-Aug	10:45	1	
CF	1	9-Aug	11:45	66	toads circled dead
CF	1	9-Aug	13:45	1	
CF	1	9-Aug	21:30	1	
CF	1	10-Aug	1:15	1	
CF	1	10-Aug	9:30	1	
CF	1	10-Aug	9:45	1	
CF	1	10-Aug	10:00	0	
CF	1	10-Aug	10:15	2	
CF	1	10-Aug	10:30	1	
CF	1	12-Aug	6:15	1	
CF	1	12-Aug	10:30	1	
CF	1	15-Aug	21:45	1	
CF	1	17-Aug	20:15	1	
CF	1	17-Aug	21:00	3	
CF	1	17-Aug	21:15	1	
CF	1	19-Aug	21:45	2	
CF	1	19-Aug	22:00	1	
CF	1	20-Aug	22:45	1	
CF	1	21-Aug	5:45	1	
CF	1	21-Aug	7:45	1	
CF	1	21-Aug	18:15	1	
CF	1	22-Aug	12:15	1	
CF	1	22-Aug	12:30	1	
CF	1	23-Aug	8:30	1	
CF	1	23-Aug	23:30	0	Rain Starts
CF	1	24-Aug	7:00	0	Road Drying Out
CF	1	24-Aug	10:45	3	
CF	1	24-Aug	11:00	2	
CF	1	24-Aug	11:15	7	
CF	1	24-Aug	11:30	7	
CF	1	24-Aug	11:45	16	
CF	1	24-Aug	12:00	5	
CF	1	24-Aug	12:15	6	
CF	1	24-Aug	12:30	11	
CF	1	24-Aug	12:45	2	

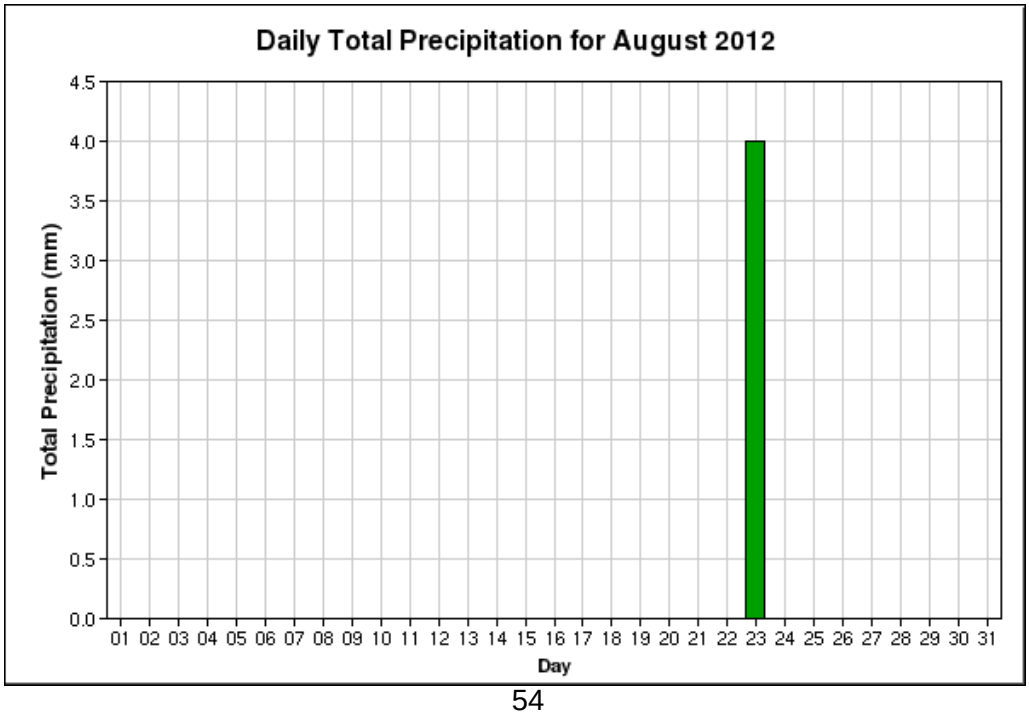
Observer	Camera ID	Date	Time	Number of toadlets	Notes
CF	1	24-Aug	13:00	1	
CF	1	x			No Toads found on pictures from 9 Aug 13:00 - 10 Aug 08:45
CF	1	x			No Toad found on pictures from 9 Aug 10:30 - 13:30
CF	1	x			No Toad found on pictures from 9 Aug 14:00 - 21:15
CF	1	x			No Toad found on pictures from 9 Aug 21:15 -10 Aug 01:00
CF	1	x			No Toad found on pictures from 10 Aug 01:30 - 21:15
CF	1	x			No Toad found on pictures from 10 Aug 10:45 -12 Aug 06:00
CF	1	x			No Toad found on pictures from 12 Aug 06:30 - 10:15
CF	1	x			No Toad found on pictures from 12 Aug 10:45 -15 Aug 21:30
CF	1	x			No Toad found on pictures from 16 Aug 22:00 -17 Aug 20:00
CF	1	x			No Toad found on pictures from 17 Aug 20:00 -20:45
CF	1	x			No Toad found on pictures from 17 Aug 22:00 - 19 Aug 21:00
CF	1	x			No Toad found on pictures from 19 Aug 22:30
CF	1	x			No Toad found on pictures from 20 Aug 23:00 h-20 Aug 21:30 h
CF	1	x			No Toad found on pictures from 21 Aug 6:00 -21 Aug 7:30
CF	1	x			No Toad found on pictures from 21 Aug 08:00 h-22 Aug 18:00 h
CF	1	x			No Toad found on pictures from 21 Aug 18:30 - 22 Aug 12:00
CF	1	x			No Toad found on pictures from 22 Aug 12:45 -23 Aug 08:15
CF	1	x			No Toad found on pictures from 23 Aug 23:45 - 24 Aug 10:30
AB	2	30-Jul	18:30		Start of series
AB	2	2-Aug	11:00	0	start to rain
AB	2	2-Aug	11:15	0	road wet
AB	2	2-Aug	11:30	0	road starting to dry out
AB	2	2-Aug	11:45	0	road drying
AB	2	2-Aug	12:00	0	road drying
AB	2	2-Aug	12:15	0	road drying
AB	2	2-Aug	12:30	0	road drying
AB	2	2-Aug	12:45	0	road dry
AB	2	2-Aug	13:00		
AB	2	5-Aug	5:30	2	Below are the only toadlets recorded in this series (all are possible toadlets - none is 100% certain)

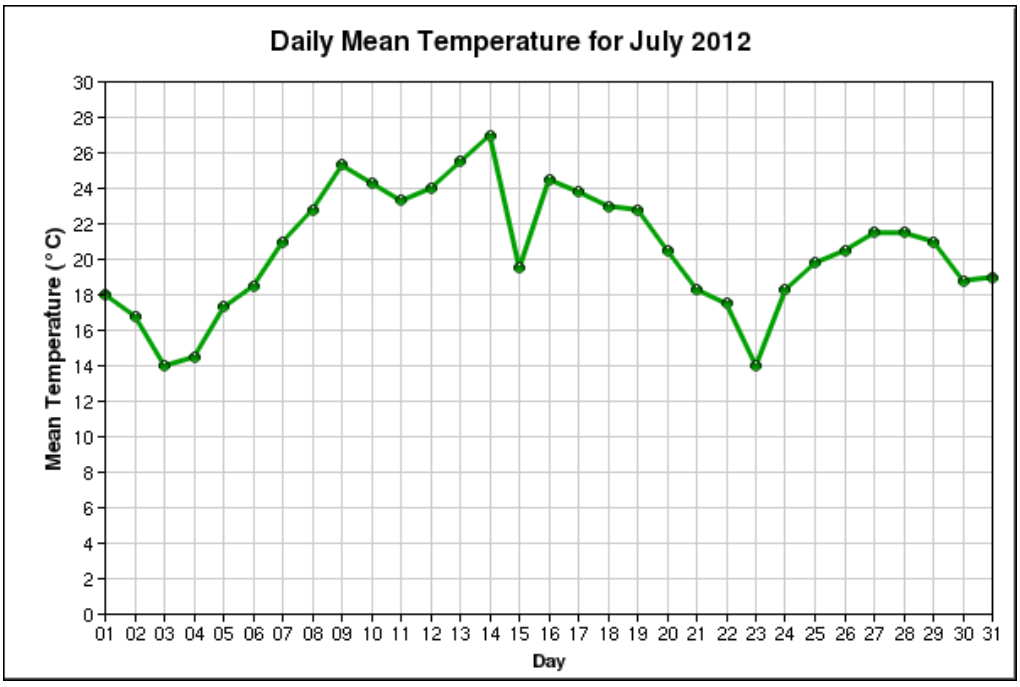
Observer	Camera ID	Date	Time	Number of toadlets	Notes
AB	2	5-Aug	7:15	2	
AB	2	5-Aug	8:00	1	
AB	2	6-Aug	16:00		End of series
CE	2	8-Aug	13:45	1	
CE	2	12-Aug	1:45	0	a mouse at the lower edge of pictures
AB	2				No toadlets or any other event of note until
CE	2	x			No Toads found on pictures from 8 Aug 12:00-13:30
CE	2	x			No Toads found on pictures from 8 Aug 14:00 - 24 Aug 18:00

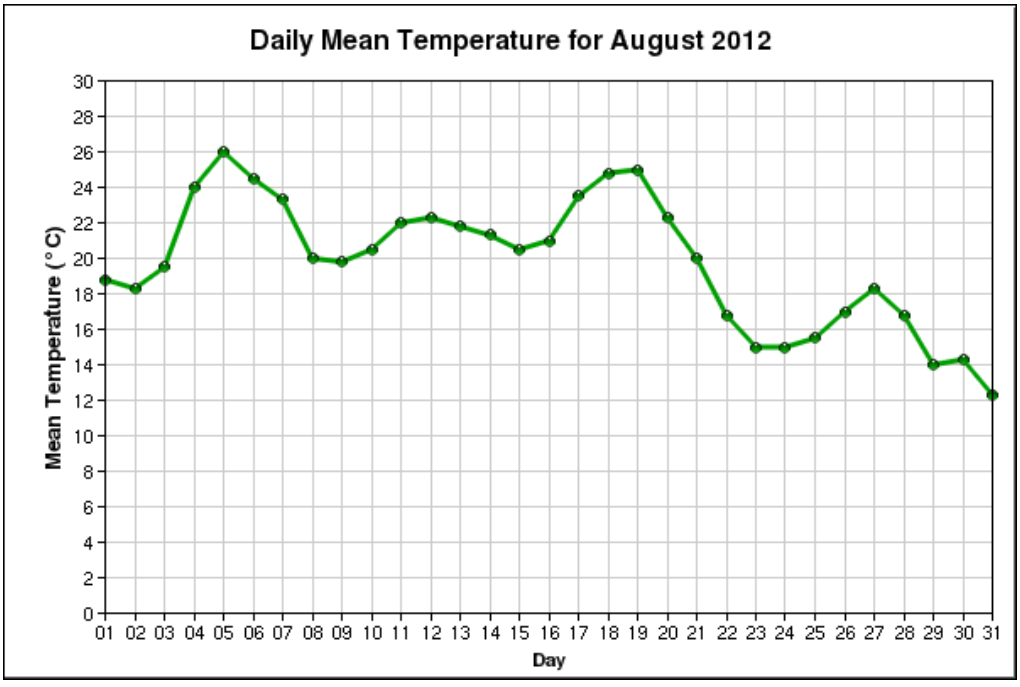
Appendix 6. Total daily rainfall and average air temperature recorded for July and August 2012 at Merritt STP weather station (50°06'51.004"N; 120°48'03.005" W; elevation 609 m). Figures reproduced from Environment Canada (2012).

Note that the station is at lower elevation (609 m) and 26 km NW from Kentucky Alleyne Provincial Park (elevation 990 m), resulting in warmer conditions and somewhat different precipitation patterns. The Figure does not show trace amount of rainfall at Merritt STP on 7 Aug that was detected in time-lapse camera images at the Kentucky –Alleyne site.






Daily Mean Temperature for July 2012
Mean Temperature (°C)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day


Daily Mean Temperature for August 2012
Mean Temperature (°C)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day

Appendix 7. Overview of amphibian crossing structures with emphasis on experience in British Columbia.

Provincial Best Management Practices provide a review of amphibian crossing structures and their effectiveness, based on experiences in Europe and North America (Ovaska et al. 2004). The following principles for effective deployment of underpasses to mitigate road mortality of amphibians are presented in that document (pp. 32-33; square brackets added to indicate measures that are not applicable to Kentucky Alleyne):

- Proper location of tunnels and fences based on knowledge of target species and their migration routes
- Orientation of tunnels from winter/foraging grounds to breeding grounds.
- [2-way tunnels with large diameter (such as 1 m) are effective and also allow for passage of a variety of other animals]. Smaller tunnels with slots for ambient light and moisture can be effective; these include grated tunnels placed flush with the road surface.
- Proper construction and maintenance of fencing to avoid breaching and circumvention by animals.
- Where fencing is parallel to the road, guiding systems are needed to direct animals to tunnels
- Interval between tunnels 50 m or less
- Taking appropriate control measures to avoid flooding of tunnels
- Monitoring of tunnel use to assess its effectiveness and need for refinements

Projects that protect migrating amphibians are taking place in at least 10 locations throughout B.C. (Govindarajulu, pers. comm. 2012; Table 5). Of these projects, six focus (including this project) on minimizing road mortality of dispersing toadlets. At most sites, volunteers have been used to capture toadlets and transport them across the road in a bucket, hence the name “bucket brigade”. An example of this is at the Ryder Lake site in Chilliwack (http://fraservalleyconservancy.ca/). At highway sites, tunnels have been installed to facilitate crossing of the road by amphibians. On the Sea-to-Sky Highway, culverts with a diameter of 1 to 3 m were installed at strategic locations under the road. On the Ucluelet-Tofino highway, a 1.6 m wide rectangular concrete tunnel was installed in 2011, and follow-up research show that amphibians are using it (Western Toad is not one of the focal species at this site, Conference Call. 2012). At Wake Lake on Vancouver Island, juvenile Western Toads used a small (50 cm diameter) metal culvert one summer but not the next (Wind, pers. comm. 2012).

In British Columbia, the following design features have been found to be important in the effectiveness of crossing structures for amphibians. The passageway under the road should have a minimum floor width of 60 cm, and to decrease predation risk, cover

objects should be placed on the floor for amphibians to hide. The wider the passageway, the more light is allowed in, the toadlets are less concentrated, and more refuges can be provided. Therefore, as the length of the passageway increases, so should its width. Another important feature is to install barrier and drift fences to guide the migrating amphibians to the passageway. Drift fences can take various shapes and can be made cheaply with thick (6 mm) plastic sheets, about 50 cm tall, and propped up with wooden stakes or rebar (http://www.env.gov.bc.ca/wld/frogwatch/), or more expensively with pre-made concrete blocks (http://www.acocan.ca). The cheap plastic fences require yearly installation and maintenance, an activity that is suitable for volunteers. The concrete block fence requires only a yearly visit to ensure for example that overhanging vegetation does not provide escape routes for amphibians. Drift fencing may increase the risk of predation because animals are concentrated, but providing cover objects for them to hide under can reduce this risk. Potentially increased predation associated with fencing will likely be much less than road mortality without fencing, so there is a net benefit.

The ultimate wildlife underpass is provided by elevating the road on pillars for many meters, but this is very expensive. Metal or concrete culverts of sufficient width have been shown to be used by amphibians and other wildlife at various sites; however, it is still not clear how well they work at the population level (Malt 2012). In the Merritt area, cattleguards are common throughout the surrounding rangeland and would provide an excellent underpass for amphibians because they are relatively wide and open and readily available, although we are not aware of previous examples of their use in this manner. Consultations with people working on mitigating amphibian road mortality in B.C. supported using cattleguards (Conference Call, pers. comm. 2012).

Table 5. Summary of projects with amphibian roadkill mitigation in British Columbia; draft obtained from P. Govindarajulu, BC Ministry of Environment, December 2012.

Region/Location	Size/type of road	Species*	Mitigation	Fence	Tunnel	Bucket brigade	Primary Contact	Comments
Sea to Sky Highway	Highway	RAAU, PSRE, ?	Yes	Yes	Yes, multiple	No	Josh Malt	Pre and post monitoring, reports available
Courtenay	Secondary road	RAAU, PSRE, ?	Yes				Joe Materi	
Ucluelet, Pacific Rim National Park	Highway	RAAU, PSRE, ?	Yes	Yes	Yes	Yes	Barb Beasley	Pre and post monitoring, reports available

Region/Location	Size/type of road	Species*	Mitigation	Fence	Tunnel	Bucket brigade	Primary Contact	Comments
Courtenay	Highway	ANBO	Yes	Partial ?	Yes	Yes	Elke Wind/Len Seilecki (MOT)	Reports available
Highway 97 Osooyous	Highway	SPIN, PSRE, ?	Yes	Yes	Yes, multiple	No	Jonquil Crosby	Reports available
Summit Lake, Nakusp	Highway	ANBO	Yes	Yes	Yes	Yes	Irene Manley/Jakob Dulise	Reports available
Wake Lake, Duncan	Secondary road	ANBO	Yes	Partial ?	No	Yes	Elke Wind/Shari Willmott	Volunteer effort
Duncan	Secondary road	ANBO	Yes	Partial ?	No	Yes	To be checked	Volunteer effort by general public
Ryder Lake, Chilliwack	Secondary road	ANBO	Yes	?	No	Yes	Lisa Fox	Reports available
Creston Valley WMA	Dike road	LIPI	No				Barb Houston/ Purnima G	Initial stages, initial baseline report available

*ANBO – Western Toad; PSRE – Pacific Treefrog; RAAU – Northern Red-legged Frog; LIPI – Northern Leopard Frog