Summit Lake Western Toad Project
2015 Field Season

Prepared for:

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Fish and Wildlife Compensation program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and the public

Columbia Basin Trust

Nakusp and Area Community Forest

Prepared by:

Jakob Dulisse (Jakob Dulisse Consulting)
John Boulanger (Integrated Ecological Research)
Irene Manley (FLNRO)

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EXECUTIVE SUMMARY

Summit Lake hosts a significant breeding population of western toads (*Anaxyrus boreas*). The western toad is internationally listed as *Near Threatened* by the World Conservation Union, federally listed as *Special Concern* by the Committee on the Status of Endangered Wildlife in Canada and *Blue-listed* by the B.C. Conservation Data Centre. Substantial numbers of adult and juvenile toads (toadlets) are killed by vehicle traffic every year on Highway 6 as they migrate to and from the lake. There are three main migrations as adults move to and from the lake for breeding and toadlets leave the lake for upland habitat. Migration is intermittent, taking place primarily during warm, wet nights for adult toads and following rain events for toadlets.

This is the sixth year of an ongoing project initiated to assess road mortality on long-term western toad population trends. The objectives were to estimate the location, timing, direction and severity of highway mortality; increase the efficacy of three underpass tunnels; and investigate and outline potential remedial measures. In 2011, we began efforts to identify breeding distribution and adult abundance using mark-recapture techniques and through the 2015 field season, we increased our efforts to document nocturnal adult migration locations.

We observed breeding activity on the first day of our lake surveys on 12 May 2015, but breeding activity likely began much earlier because small tadpoles were present at breeding sites 3, 4, and 5 (Figure 1).

In 2015, western toad breeding began earlier than in other years—likely in late April. Major breeding activity was noted at most known breeding areas and the presence of hatchlings was first observed on 12 May. Metamorph emergence and toadlet migration events were also early this year—the 2015 toadlet migration peaked in the last two weeks of July but significant numbers were observed moving across the highway until 15 August.

From 2011-2015, of a total of 1651 adult toads were observed on the highway during surveys—727 were alive and 924 had been killed by vehicular traffic. All live adults were observed at night. Dead adults were recorded during nocturnal surveys and during follow-up morning highway passes.

In 2015, we PIT-tagged an additional 273 adult western toads to bring the total number of PIT-tagged adults to 2238 since 2011. Mark-recapture analysis from 2011-2015 suggests the adult western toad population at Summit Lake may be declining. Although concerning, this result is not statistically significant (confidence limits for population trend (λ) overlap with 1 in all years) and so should be treated with caution. Overall, recapture rates were very low (4-5%) and our analysis suggests high adult mortality and/or high emigration from the study area.

In 2014, MoTI installed a new concrete toad tunnel along Summit Lake and migrating toads (and at least nine other vertebrate wildlife species) have been recorded using it. We continued testing fence design and layout options to use with the concrete and plastic underpasses including plastic, mesh and concrete materials. In 2015 we recorded high use of the concrete and plastic underpasses by adult and juvenile western toads.

In 2015, we installed two independent camera trap systems: one in the concrete underpass and another in the west culvert (plastic) underpass. The cameras were in place from 17 August—06 November 2015. The cameras captured a total of 149 adult toads in both underpasses. All adult toads recorded in the west (plastic) underpass were travelling south (away from Summit Lake) while those in the concrete underpass were recorded travelling both directions, with 61% travelling south.

In addition to western toads, the camera systems recorded an additional nine vertebrate species using the underpasses including long-toed salamander (*Ambystoma macrodactylum*), common garter snake (*Thamnophis sirtalis*), North American deer mouse (*Peromyscus maniculatus*), western jumping mouse (*Zapus princeps*), vole spp. (*Myodes gapperi*, *Microtus longicaudus* or *Microtus pennsylvanicus*), shrew spp. (*Sorex cinereus*, *S. monticolus* or *S. vagrans*), red squirrel (*Tamiasciurus hudsonicus*), short-tailed weasel (*Mustela erminea*) and Pacific wren (*Troglodytes pacificus*).

This season, we continued to incorporated radio telemetry into the project and followed five toads to their hibernation sites near Summit Lake. In 2014 and 2015, a total of 13 toads (ten females and three males) were followed to hibernation sites near Summit Lake. Movement patterns prior to hibernation varied greatly among radio-tagged animals and movements ranged from 0 to 1700 m between tracking visits. Individuals also used different forest types including wetter, older forest on the south side of the lake and drier, more open forest on the north side of Summit Lake.

Ground-level habitat complexity was important to all radio-tagged toads. Adult toads were always found in well-protected, cryptic sites including under fallen leaves, coarse woody debris, root balls, dense shrub or fern cover, in moss cavities, and wedged in rock crevices. Habitat features used for day roosts and hibernacula include small mammal burrows, squirrel middens, unspecified underground cavities, a subterranean streambed, a bedrock crevice, fallen tree root cavities, cavities under rocks in a talus slope and road/rail bed fill, decayed nurse logs and deep deposit of coarse woody debris.

ACKNOWLEDGEMENTS

This project is made possible with the financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders. Thanks also to Columbia Basin Trust (CBT), BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO) and Nakusp and Area Community Forest (NACFOR) for funding this project. Eva Schindler at FWCP provided administration while Amy Waterhouse (FLNRO) and Beth McLeod (True North Forestry Consulting Ltd.) provided mapping support. Thanks to Lindsay Anderson (FLNRO) for securing additional funding and assisting with field work. Anna Lamb-Yorski, Catherine McGlynn, Robert Fox, Thomas Hill, Lindsay Anderson, Kristen Murphy and Amy Waterhouse assisted with field work.

Thanks also to Katie Ward, Chris Price, Dave Heagy and Terry Anderson for partnering on this project. Angus Glass ably organizes Toadfest every season. Thank you to all the Toadfest volunteers who make every year a success. Thanks also to Sally Thomson and Dave Kaegl, operators of the Summit Lake Provincial Park campground, for their assistance during Toadfest.

Also, thanks very much to the BC Ministry of Transportation and Infrastructure for funding the installation of a new wildlife underpass at Summit Lake in the summer of 2014.

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1.0 Introduction

The western toad (*Anaxyrus boreas*), has undergone dramatic population declines in southern parts of its range and as a result was assessed as “Near Threatened” by The World Conservation Union (Hammerson et al. 2004). Federally, it is considered a species of special concern (COSEWIC 2002) and it is blue-listed provincially (CDC 2012). Canadian populations appear stable, however little information exists on population trends (COSEWIC 2002) and there is concern that Lower Mainland and Vancouver Island populations may be declining (Davis 2002). The species decline is attributed to a combination of factors including disease, habitat loss and modification, susceptibility to UV radiation, acid precipitation, road mortality and predation (Davis 2002).

The western toad occurs in forested habitats in western North America over a wide range of elevations. The species is predominantly terrestrial but requires standing or slow moving water less than 50 cm deep for breeding (Corkran and Thoms 1996). Communal mating takes place in ponds, lakes, permanent wetlands and flooded meadows from late January to August, depending on environmental conditions (Davis 2002). Females lay eggs in long strands which average 12,000 eggs. Eggs hatch in seven to ten days and tadpoles remain in the breeding body of water for two to three months. Some breeding sites support millions of tadpoles and they often metamorphose into small toads (metamorphs or toadlets) synchronously (Davis 2002). These concentrated abundances of tadpoles and toadlets support a diversity of predators including reptiles, birds and mammals. Toadlets may disperse greater than one kilometer from breeding ponds into terrestrial and wetland habitat and home range sizes are less than one hectare (Davis 2002). Adults spend most of their time under cover and important terrestrial habitat features include coarse woody debris and mammal burrows. During dry periods, adults may be found near streams or wetlands.

The West Kootenay region supports a high density of breeding western toads (Dulisse and Hausleitner 2010) and the population of western toads at Summit Lake likely represents a significant portion of the species’ breeding population regionally and provincially. The toads at Summit Lake experience significant annual road mortality when migrating individuals cross a five kilometer stretch of Highway 6 (Ohanjanian 1997, Seaton et al. 2005, Seaton 2008, Dulisse et al. 2011). The toad migration at Summit Lake consists of: 1) adults moving from upland, non-breeding habitat in the early spring to the lake to breed; 2) adults leaving the lake and returning to their non-breeding habitat in late spring through fall after breeding; 3) toadlets leaving the lake for non-breeding habitat in late summer or in some cases the following spring. Migration is intermittent; taking place at night for adults and during the day for toadlets, but in all cases involves crossing the highway (Dulisse et al. 2012).

This project was initiated to assess the implications of road mortality on long-term western toad population trends and included the following components:

(a) Adult Toad Mark-recapture data- Data summaries will include; sex weight and SVL of all captures location, environmental conditions, and documented movements of individual recaptures both within year and between years. Population estimates will be produced through a separate contract with a statistician.

(b) Migration of Adult Toads - Timing, numbers and location of adult western toads migrating to and from Summit Lake. Data are collected from drive-by-surveys, time elapsed surveys and monitoring crossing structures. Adult Toad Mortality documented on the hwy or elsewhere will be summarised. Sex specific differences in timing, location of migration of highway mortality will be analysed and discussed. 2015 data will be presented and compared with previous years' data.

(c) Toadlet Migration data - data will be collected following the protocols established in Dulisse and Boulanger 2013. Previously established transects will be sampled during the toadlet migration period. Plot data will be summarised to determine live and dead toadlet densities by established highway sections. The location, seasonal timing and environmental conditions related to toadlet densities will be presented for 2015 and compared with data from previous years.

(d) Assessment and testing of mitigation structures - The contractor will assess the effectiveness of fencing and tunnels at reducing mortality of western toads. Fencing costs and installation will be provided by the MFLRNO-FWCP-section. This section of the report will describe the fence and tunnel design and materials and effectiveness. Photo monitoring to determine toad use of tunnels; adult captures and toadlet numbers and behaviour observed along the fence, comparisons of adult and toadlet mortality estimates in fenced and adjacent unfenced areas.

(e) Recommendations for mitigating structures - Based on the above analyses the contractor will assess the effectiveness of current structures and recommend any changes to these to reduce mortality. Recommendations will include photos and a map of the locations of existing and recommended future crossing structures and associated fencing. Recommendations should be supported by population or demographic data to the greatest extent possible. Methods to monitor the effectiveness of mitigation options should also be detailed.

(f) Deliverables will include excel databases in WSI format for items a) through d), spatial data points, maps and photographs.

1.1. Study Area

Summit Lake is located adjacent to Highway 6, 15 km southeast of Nakusp and 27 km northwest of New Denver (Figure 1). The lake is located at 764 m in elevation and covers an area of 150 hectares with 8400 m of shoreline. It is approximately 3.6 km in length and ranges from 360 m to 611 m wide with a mean depth of 4.4 m and a maximum depth of 17 m. Eight creeks flow through culverts under Highway 6 and into Summit Lake and Bonanza Creek drains Summit Lake to the East (Figure 1).

Highway 6 runs along the south shore of the lake and ranges from 5-300 m from the shoreline. An abandoned rail right of way runs along the north shore of the lake. This rail line has been converted to a multi-use trail. Summit Lake Provincial Park (6 ha) is located on a peninsula which extends northward into the lake from the highway (Figure 1). Facilities in the park include a boat launch, day use picnic area, public beach and 35 vehicle-access camp sites. The park is open seasonally from 27 April to 27 September. To the east of the park, there is a day-use rest area with picnic tables and a boat launch (Figure 1).

Summit Lake falls within Moist Warm Interior Cedar-Hemlock (ICHmw2) biogeoclimatic subzone of the Arrow-Boundary Forest District. The ICHmw2 subzone occurs between 500 m and 1450 m in elevation and is characterised by hot, moist summers and very mild winters with light snowfall (Braumandl and Curran 1992). Tree cover is made up of mixed species including Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), hybrid white spruce (*Picea engelmannii X glauca*), western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*). The most common shrubs are falsebox (*Paxistima myrsinites*) and black huckleberry (*Vaccinium membranaceum*). Common herbs include twinflower (*Linnaea borealis*), prince's pine (*Chimaphila umbellata*), queen's cup (*Clintonia uniflora*) and one-leaved foamflower (*Tiarella trifoliata*) (Braumandl and Curran 1992).

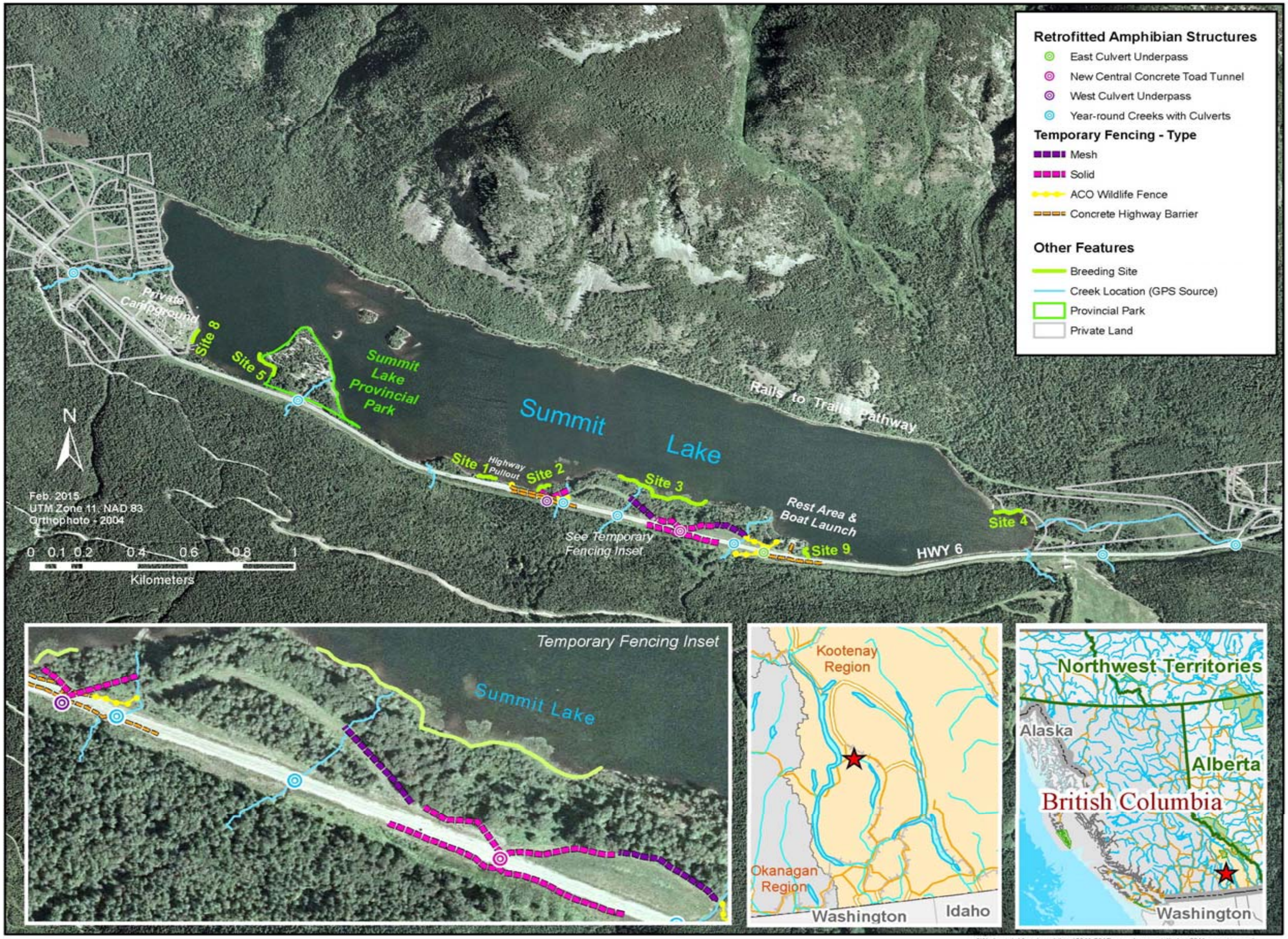

Figure 1. Summit Lake study area showing the locations of existing amphibian infrastructure, creeks and 2014-2015 test fence locations. Note: in 2015, the solid fence temporary fence at the new concrete tunnel was switched to a mesh type (permeable to toadlets).

2.0 Methods

2.1. Adult Migration

In 2015, we used two methods to sample for adult toads on Highway 6: drive-by surveys and incidental toad detections. Drive-by surveys were conducted from 12 May to 02 October along a 4.8 km stretch of Highway 6 from Summit Road just east of Summit Lake to Kingfisher Road, west of Summit Lake (Figure 1). A daytime pass was made prior to sampling where all carcasses were recorded as incidental and removed from the highway. These surveys were conducted from a vehicle driving 30-40 km/hour. They were conducted after sunset between 21:55 and 00:23 and took an average of 15 minutes.

For each drive-by survey, we recorded start and end time, humidity, current precipitation, rain in the past 24 hours, air, pavement and lake temperatures, whether the toad was alive or dead, age (adult vs. subadult), gender, direction of travel (if possible), recapture identification and location (UTMs) of the toad.

All live and dead adult toads observed outside of the drive-by surveys were recorded as incidentals. Nocturnal surveys yielded live and dead toad locations whereas daytime surveys yielded dead animals only (which were removed to avoid double counting). For incidental observations, we recorded whether the toad was alive or dead, age (adult vs. subadult), gender, direction of travel (if possible), recapture identification and location (UTMs) of the toad.

2.2. Breeding Surveys

We conducted canoe surveys throughout the 2011-2015 breeding seasons to document the timing and location of breeding and to capture and PIT-tag adult toads. The entire shoreline of the lake was surveyed but survey effort was concentrated near known breeding areas during the breeding season. We recorded current weather, wind, rain in the past 24 hours and start and end times. Breeding sites were identified as those having multiple pairs of adult toads in amplexus (mating position).

2.3. Mark-recapture

We captured individual adults for mark-recapture by net or hand. Individuals > 40 mm and in good physical condition were marked with a uniquely numbered Biomark HTP9 (9mm), 134.2 kHz glass passive integrated transponder (PIT) tag (Ferner 2007). An insertion was made on the upper dorsal section using a new scalpel and a sterilized PIT tag was massaged under the skin toward the back of the animal. Starting in 2013, we began using smaller Biomark HPT8 (8mm) PIT-tags injected with MK165 Implanter/N165 needles. This reduced handling time and animal stress. We followed provincial hygiene protocols for amphibian fieldwork (MoE 2008) to help reduce the risk of spreading disease. For each animal, we used a single pair of disposable talcfree latex gloves, a new scalpel blade and new plastic sandwich bags for measuring and weighing.

Toads were placed in a holding bucket and released at the site of capture after processing. We did not capture any females while they were laying eggs. Pairs in amplexus were processed and placed, together in a separate chamber until they were reunited and released as a pair. At the time of capture, we determined the gender and mass of each individual and measured snout-vent length. We recorded the capture location, date, search time, pavement, air and lake temperatures, current precipitation, rain in past 24 hours, overcast or sunny, wind, humidity, time of processing, the estimated number of individuals in the group, and recorded if they were vocalizing, in amplexus or basking.

After the first capture, all toads recaptured were scanned using a hand-held PIT-tag scanner. For each recapture event, we recorded the date, time and location and whether individuals were vocalizing, in amplexus or basking. Early in the field season, recaptures were done at the breeding sites and as adults dispersed from the breeding sites, recaptures were conducted by searching the perimeter of the lake for basking individuals. This season, we increased our nocturnal sampling efforts on the highway to capture more migrating adults.

During analysis, we used the yearly data pooled across all sampling areas to assess trends in demography of toads. This approach provided an initial assessment of trends in demography as reflected by the PIT-tag data.

The Pradel (Pradel 1996) model in program MARK (White and Burnham 1999) was used for this analysis. The Pradel model directly estimates three parameters; apparent survival, rates of addition, and capture probabilities with rate of change (λ) estimated as a derived parameter. Apparent survival (ϕ) is the probability that a toad that was on the grid in one sampling year would still be on the grid in the next sampling year. It encompasses both deaths and emigration from the sampling grid. Rate of addition (*f*) is the number of toads on the grids in the current year per toad on the grid in previous year. It encompasses both births and immigration of toads from outside the grid area during the time period between. Apparent survival and rates of addition are added together to estimate change in population size (λ) for the interval between each sampling occasion. Population rate of change is equivalent to the population size for a given sampling period divided by the population size in the previous sampling period ($\lambda=N_{t+1}/N_t$). Given this, estimates of λ will be one with a stable population, less than one if the population is declining and greater than one if the population is increasing.

Estimates of additions and λ assume a constant study area size and that each toad had some opportunity to be capture and recapture each year. Because effort and relative study area size potentially increased from 2011-2012 it is likely these estimate may be biased high and therefore should be interpreted cautiously. Various temporal covariates were used to explore the effect of variation in sampling effort and duration of sampling on capture probabilities. In addition, the distribution of captures each year was mapped to evaluate overall spatial variability in sampling effort.

Sex was entered as a group in this analysis to allow sex-specific estimates of demography. Models were built that considered sex-specific trends and temporal trends in recapture rate and demographic parameters. The fit of models was evaluated using the Akaike Information Criterion (AIC) index of model fit. The model with the lowest AICc score was considered the most parsimonious, thus minimizing estimate bias and optimizing precision The difference in AIC_c values between the most supported model and other models (ΔAICc) was also used to evaluate the fit of models when their AICc scores were close. In general, any model with a ΔAICc score of less than two was worthy of consideration. Estimates from models were model averaged using the relative weight of support (Burnham and Anderson 1998).

The time series of estimates of trend were also used to estimate process variance which is the actual biological variation in trend over time. (Thompson et al. 1998, White et al. 2002) For this approach, the variance components module was used with an underlying λ trend model. Estimates from this model were then compared to the model averaged estimates.

2.4. Toad Underpasses and Test Fences

In July 2014, MoTI installed a new concrete toad tunnel located approximately half way between the east culvert underpass (metal) and west culvert underpass (plastic) (Figure 1). The box culvert was installed in 3m lengths and measures 1.2m x 1.5 m in cross section (Photographs).

In October 2014, concrete wing walls were constructed adjacent to the north and south entrances of the concrete tunnel (Photographs). This experimental technique involved spraying concrete onto plywood forms enforced with rebar.

In 2014 and 2015 we tested two types of temporary fencing materials to direct western toads into the new concrete underpass and west plastic underpass (installed in 2006). All wing walls were aligned diagonally away from the underpass entrances and away from the highway (Figure 1 and Photographs).

The outermost wing fencing on the lake side of the concrete underpass was constructed with marine aquamesh (used in the aquaculture industry) and rebar in order to be semi-passable for toadlets but impassable for adult toads (Figure 1). The middle fencing sections of this fence were made with clear 6 mil plastic sheeting taped to wood stakes—this fencing was attached to the concrete wing walls near the entrance (Figure 1 and Photographs). On the uphill side of the concrete underpass we used aquamesh so adult toads travelling toward the lake would be directed into the underpass but toadlets would not become trapped on the highway (they can pass through the aquamesh).

At the west plastic underpass, we continued testing 6 mil plastic fencing on the lake side. Unfortunately, the topography (steep bank and cliff) on the uphill side of the plastic underpass precludes the construction of a wing fence—the concrete highway barriers are used to direct some adult toads into the underpass.

2.5. Camera Traps

In 2014, we tested a new camera system to monitor the use of the new highway underpass. The system was designed to record every adult toad (and other animal) passing through the tunnel—we tested the system from 25 August to 20 September, 2014. In 2015, we installed two independent camera systems: one in the concrete underpass and another in the west culvert (plastic) underpass. The cameras were in place from 17 August—06 November 2015.

The system consists of an infrared trigger system (Phototrap Model 33) connected to Canon EOS Rebel XT digital SLR camera with a Canon EF-S 18-55mm F3.5-5.6 II lens powered by a 12v 35Ah battery. The camera was triggered by a broken beam setup with an infrared emitter and sensor placed at ground level across the floor of the tunnel (Photographs). The camera was fixed to the ceiling of the tunnel and the built-in flash was used to obtain high quality, colour JPEG images of animals passing through the infrared beam.

2.6. Radio Telemetry

Between 17 August and 30 October 2014, we radio-tagged 15 adult western toads in order to test the transmitter attachment technique described by Burow et al. (2012) and to find overwintering sites. In 2015, we captured and radio-tagged 14 adults and tracked their movements between 09 August and 06 November.

The technique involves attaching the transmitter with a waist belt made from silicon tubing (Cole-Parmer Item# RK-95802-02), AlphaWire PVC tubing (Mouser Electronics Part # PVC10518 CL005) and copper wire (Artistic Wire 28-gauge bare copper wire) (Burow et al. 2012) (Photographs). We used Holohil 3.5g BD-2 transmitters with a 1mm diameter plastic tube embedded in the epoxy of the transmitter.

In 2015, we used an inspection camera (Aardvark HD3M Hi-Definition Inspection Camera System for Android & iOS) to look and photograph inside underground roost and hibernation sites. This wireless camera system enables live viewing, still photography and video recording within small cavities.

2.7. Outreach

The sixth annual Toadfest event, hosted by FWCP, FLNRO, MoE, BC Parks, MoTI and CBT, was held on 12 August 2015 at Summit Lake Provincial Park. Several agencies and organizations, including FWCP, attended with information tables. Volunteer tour leaders escorted groups to collect toadlets for transfer across the highway—the crossing location was controlled by MoTI flaggers. After collection and prior to release, toadlets were counted or weighed at the FWCP table in order to estimate the total number of individuals moved across the highway. Toadlets that were not developed enough (ie, those that still had tails present) were removed from attendee's buckets and released without transporting them across the highway.

3.0 Results and Discussion

3.1. Adult Migration

In 2015, from 05 May to 20 October, adult toads were present on the Highway 6 adjacent to Summit Lake. We estimated the direction of travel for the live individuals and safely transported them across the highway. Out of 415 adult toads detected during these surveys, 218 were alive (65 females, 147 males and 6 unknown sex) and 197 had been killed (36 females, 51 males and 110 unknown sex) by vehicular traffic. Where sex could be determined, we estimated 24 of the 36 dead females we detected on the highway were gravid (through the presence of eggs or egg stain on highway). Figures 2 and 3 show adult western toad detections on Highway 6 and subdivision from 2011-2015 and adult detections during nocturnal surveys on adjacent forest service roads and the rail trail in 2015

From 2011-2015, of a total of 1651 adult toads were observed on the highway during surveys, 727 were alive (243 females, 458 males and 26 unknown sex) and 924 had been killed (167 females, 154 males and 603 undetermined) by vehicular traffic (Figure 2).

Estimated direction of travel data are not included because they are not considered reliable as toads often change their direction of travel due to vehicle disturbance.

It should be noted that these numbers very much underestimate of the total number of adult toads crossing the highway and getting killed. For example in 2015, we only surveyed on 28 out of approximately 193, or 14.5 % of the total available migration nights between 15 April and 25 October. Also, although our surveys were always timed during the peak nightly movement period, we concluded before 02:30 and adult toads have been recorded moving until 06:44 (Figure 6).

Dead and live adult highway detections are summarised from 2011-2014 by 100m highway segment in Figure 4. Fourteen highway segments show adult migration hotspots of 30 or more adult toads per 100m and 7 segments show a density of 35 or more adult toads per 100m with A1 showing the highest (Figure 4). The segments with existing underpass and fence structures in place (C3 and D) show the lowest numbers of adult toads recorded on the highway (Figure 4).

In 2015, we conducted some preliminary nocturnal adult surveys along forest service roads above Summit Lake and the rail trail along the north shore of Summit Lake. A total of 137 adults were detected on the forest service roads and 52 were detected during two nights of surveys on the rail trail (Figure 3). This relatively high capture rate on the rail trail indicates that at least some adults likely migrate to and from habitat the north of Summit Lake, thereby avoiding the highway altogether.

These surveys will continue in 2016 and this information will be used to inform the locations of recommended additional underpass structures. Highway 6 along Summit Lake will be repaved in the next 4 years (Bruce Lintott, pers. comm.)—it would be a good time to install additional wildlife underpasses during this work. Therefore, there is an important opportunity to design and recommend locations for potential "shovel-ready" structures.

The subdivision at the west end of the lake is currently undergoing rapid development. As this area is an important post-breeding season area for adult toads (especially females), we should target local residents for an educational outreach program.

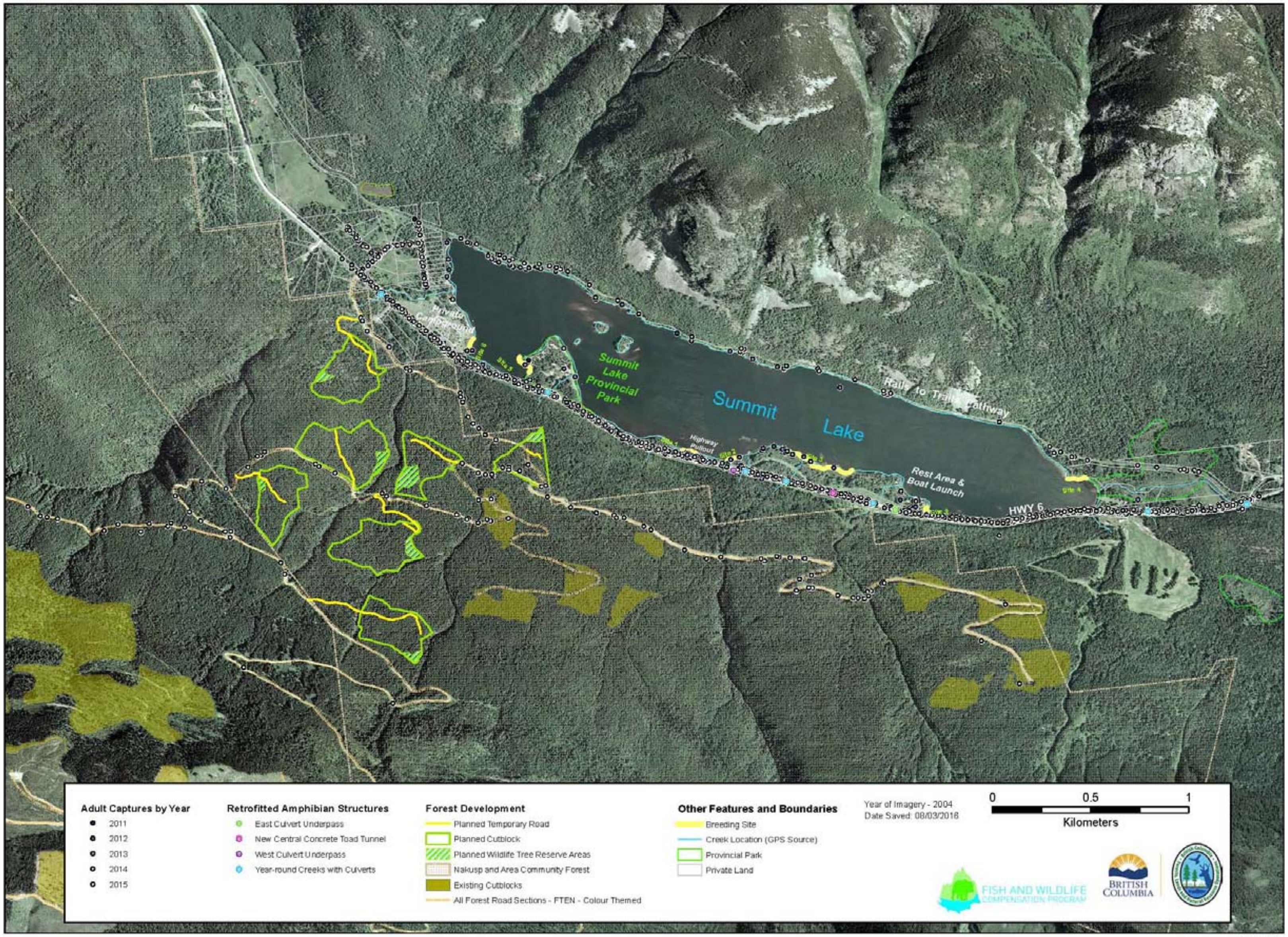

Figure 2. Adult western toad detections on Highway 6 and the subdivision (2011-2015), forest service roads and rail trails (2015).

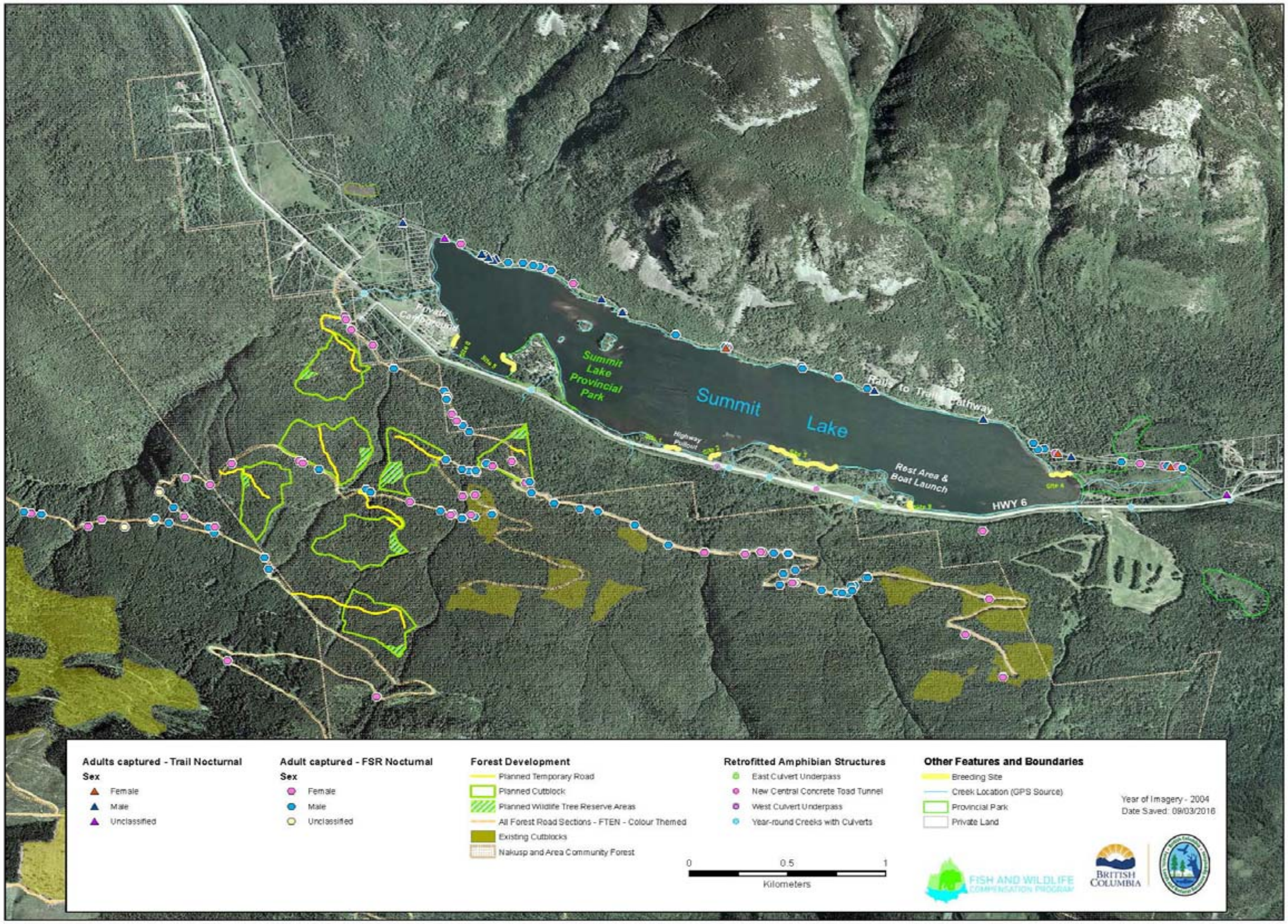

Figure 3. Summary of adult western toad detections on nearby forest service roads and rail trails 2015.

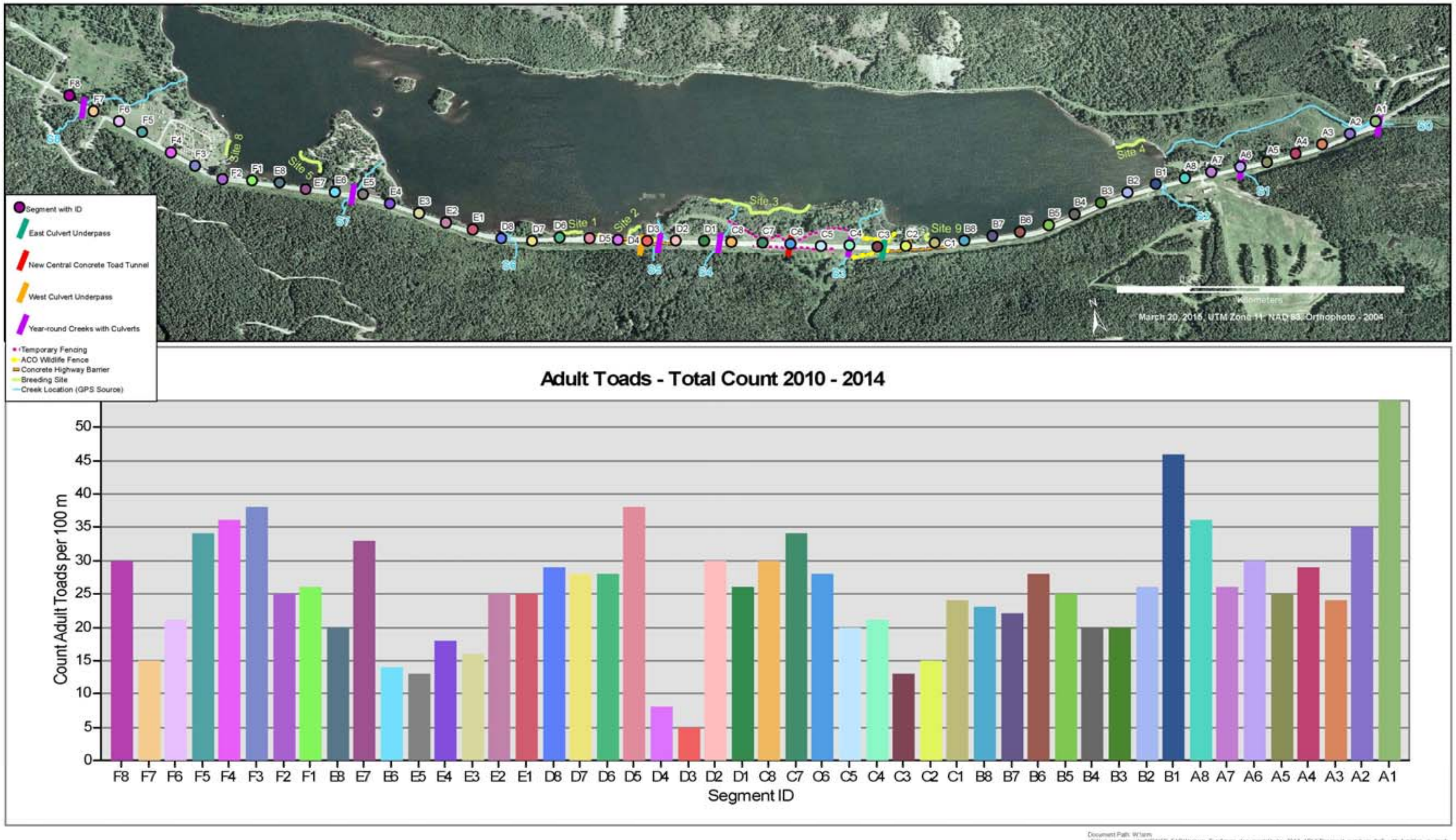

Figure 4. Adult western toads recorded on the Highway 6 at Summit Lake. 2010-2014 field seasons are combined and total counts are shown by highway segment. The colour-coded segment bars below correspond to the segment locations on the map at the top of the figure.

3.2. Breeding Surveys

We observed breeding activity on the first day of our lake surveys on 12 May 2015, but breeding activity likely began much earlier because small tadpoles were present at breeding sites 3, 4, and 5 (Figure 1).

Major breeding activity was noted all known breeding areas with the exception of breeding site 8 (Figure 1). The presence of hatchlings at on 12 May indicates an earlier onset of breeding compared to 2014 when hatchlings were first observed on 21 May (Dulisse 2015). Free-swimming tadpoles were first observed in the lake on 26 May near breeding sites 1, 2, 3, 4 and 5 (Figure 1).

Metamorph emergence and toadlet migration events were also early this year, beginning on 20-21 July 2015 (Kat McGlynn, pers. comm.). The migration was at least two weeks earlier than 2014 which peaked between 12-17 August (Dulisse 2015) and overall toadlet numbers were subjectively estimated to be higher than any other year since this project began in 2011. The 2015 toadlet migration peaked in the last two weeks of July but significant numbers were observed moving across the highway until 15 August.

3.3. Mark-recapture

In 2015, we PIT-tagged an additional 273 adult western toads (75 females and 198 males) to bring the total number of PIT-tagged adults to 2238 (551 females, 1685 males and 2 unknown sex) since 2011.

The number of sampling sessions conducted (pooled across the entire year) was highest in 2011 with a decrease in 2015 to 7 sessions. The sampling effort which was the time spent tagging toads was also highest in 2011 and decreased each year. Efforts were primarily directed at the breeding areas in earlier years compared to latter years, however, the breeding areas were targeted in all years (Table 1).

Table 1. Summary of sampling effort for adult western toad PIT-tag mark-recapture efforts at Summit Lake from 2011-2015.

Year	Total sessions	Sampling effort (minutes)			Duration of sampling (days)
		Total	Breed area	Elapsed time	
2011	18	851	851	2433	49
2012	19	655	616	2162	117
2013	13	465	447	2178	26
2014	12	318	239	1444	78
2015	7	147	94	685	89

The distribution of captures of western toads was reasonably similar from 2011-2015 with a slight increase in spatial coverage after 2011 (Figure 5). Sampling was expanded to the forest service road in 2014 and 2015. These captures were not included in the analysis given that the study area had expanded to the road area in 2014 and 2015 and therefore inclusion of these captures would artificially inflate estimates of λ.

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<u>2011</u>
472 toads tagged
405 males
67 females
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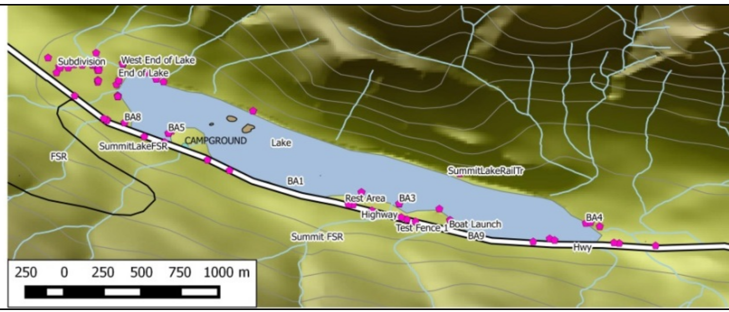

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<u>2012</u>
476 toads tagged
359 males
117 females
12 male recaptures
3 female recaptures
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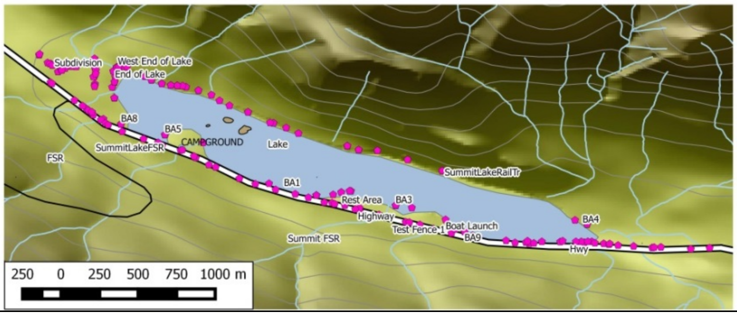

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<u>2013</u>
628 toads tagged
444 males
184 females
45 male recaptures
16 female recaptures
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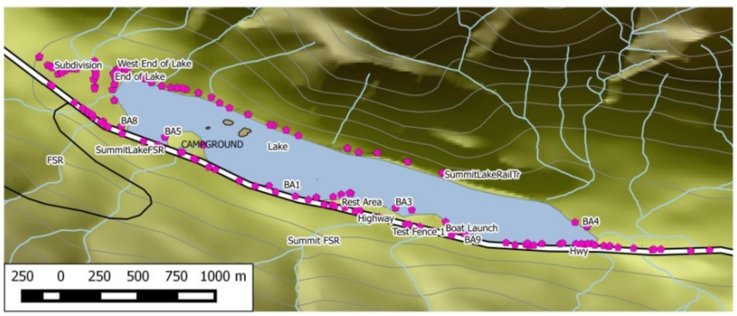

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<td>
<u>2014</u>
502 toads tagged
368 males
134 females
31 male recaptures
4 female recaptures
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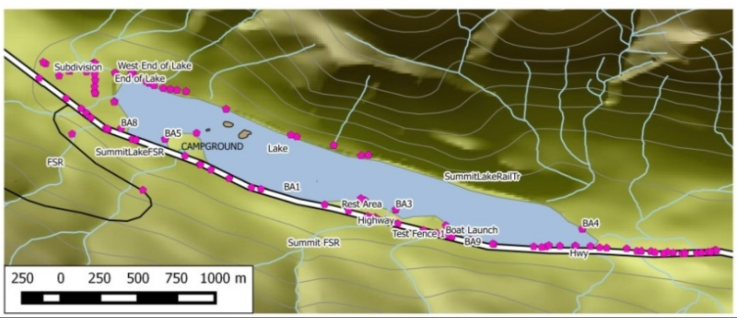
<td>


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<td>
<u>2015</u>
276 toads tagged
202 males
74 females
6 male recaptures
3 female recaptures
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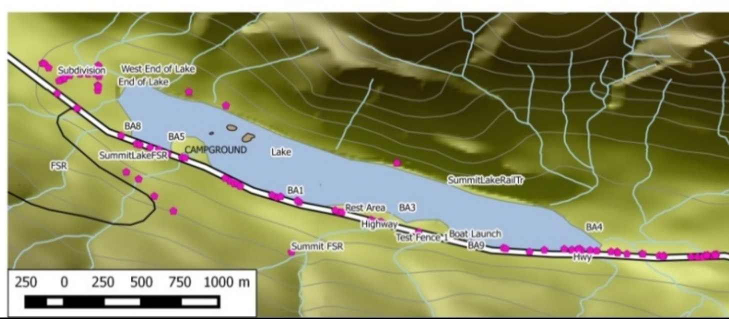

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Figure 5. Summary of adult western toad captures and recaptures by year at Summit Lake. The dots on the map denote approximate capture locations.

The adequacy of yearly sampling effort can also be considered relative to yearly movement of toads (Figure 6). In this case it can be seen that toads that were detected in multiple years moved across the entire north to south lake area. Therefore, small scale difference in spatial sampling effort most likely did not substantially influence the assumption that every toad had a non-zero probability of detection in the study area each year.

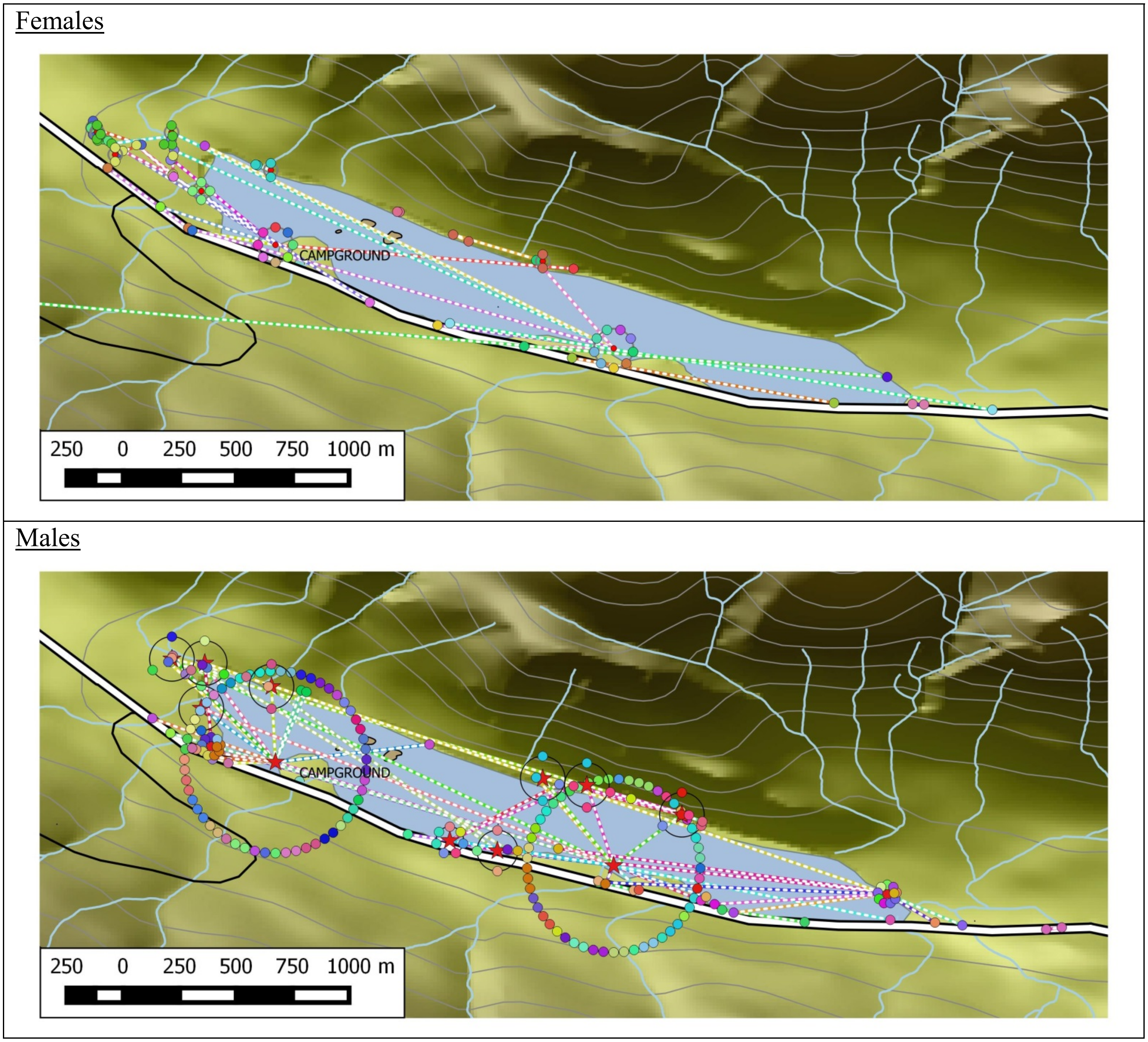

Figure 6. Summary of yearly captures and movement paths for adult western toads that were detected more than once at Summit Lake. Each colored point or line represents an individual PIT-tag. Points are staggered in concentric circles for locations, such as breeding areas, where more than one toad was detected at a given waypoint. In this case the actual location is marked with a star in the middle of the circle.

The number of toads tagged was highest for males with yearly numbers ranging from 202 to 444. In contrast, the number of females tagged was less than 200 in all years. The number of toads recaptured was relatively low each year, especially for females (Table 2). For example, of the 405 males detected in 2011, 1 was recaptured in 2014. For females and males most recaptures occurred the year after initial recapture.

Table 2. Summary of adult western toads PIT-tagged each year and frequencies of recaptures at Summit Lake.

Year	Tagged	Recaptures				
		2012	2013	2014	2015	Total
Males						
2011	405	12	6	1	0	19
2012	359		39	5	1	45
2013	444			25	2	27
2014	368				3	3
2015	202					
Females						
2011	67	3	4	0	0	7
2012	117		12	0	0	12
2013	184			4	1	5
2014	134				2	2
2015	74					

The number of captures and recaptures revealed that about 4-5% of toad that were tagged were recaptured in subsequent years (Table 3). Note that this estimate of recapture will be biased low since a proportion of toads that we captured one year were probably not in the study area the subsequent year to be recaptured. The probability that a toad that was captured in one year will still be in the study area in the subsequent year is estimated as apparent survival (Φ) in the Pradel analysis. The joint analysis of Φ and recapture rate will provide an estimate of recapture that accounts for variation in Φ.

Table 3. Summary of the number of captures and recaptures of PIT-tagged adult western toads from 2011-2015 at Summit Lake.

Gender	Number captures/recaptures			
	1	2	3	Total
Female	533	23	2	558
Male	1604	74	10	1688
Total	2139	97	12	2248

Pradel model selection focused initially on determining base demographic variation for toads through the consideration of variation in Φ and f. A temporal trend model in additions (f) with different intercepts but parallel slopes for sexes (Table 4; model 10) was more supported than an interaction model. A year-specific apparent survival variation model was more supported than constant model (model 21) or a temporal trend model (model 22). A variety of capture probability models were considered with some support for models (as indicated by $\Delta AIC_c<2$) with elapsed time (model 3), effort in breeding areas (model 4), number of sessions (model 5) and effort as covariates of capture probability. Overall, a model with year and sex specific apparent survival, sex-specific trends in additions, and sex-specific capture probabilities was most supported (Model 1).

Table 4. Pradel model selection for the pooled adult western toad data set 2011-2015 at Summit Lake. Sex indicates a specific parameter for males and females Year indicates a parameter was varied each year. A *T* indicates a model that assumes parameter declines as a linear function of year of sampling and *Y* corresponds to a unique value for a given year with year or years denoted as a subscript Akaike Information Criteria (AIC_c), the difference in AIC_c values between the *i*th model and the model with the lowest AIC_c value (Δ_i), Akaike weights (w_i), number of parameters (*K*) and model deviance are presented.

No	Apparent survival (Φ)	Rate of additions(*f*)	Capture probability (*p*)	AIC_c	ΔAIC_c	w_i	K	Deviance
1	sex*year	sex*T	sex	8021.6	0.00	0.18	14	34.0
2	sex*year	sex+T_M+Y_{2011F}	sex	8022.1	0.40	0.15	13	36.4
3	sex*year	sex*T	sex+Elapsed time	8023.1	1.43	0.09	15	33.4
4	sex*year	sex*T	sex+$Effort_{breed\ area}$	8023.4	1.77	0.08	15	33.7
5	sex*year	sex*T	sex+number of sessions	8023.4	1.78	0.08	15	33.7
6	sex*year	sex*T+Y_{2011}	sex	8023.5	1.88	0.07	15	33.8
7	sex*year	sex*T	Sex+Effort	8023.6	1.95	0.07	15	33.9
8	sex*year	sex*T	sex+Y_{1115}	8023.6	2.00	0.07	15	33.9
9	sex*year	sex*T	Sex+Y_{11F}	8023.7	2.01	0.07	15	34.0
10	sex*year	sex+T	sex+T	8024.8	3.19	0.04	14	37.2
11	sex*year	sex*T	sex+effort+duration	8025.3	3.64	0.03	16	33.6
12	sex*year	sex*T	sex+year	8025.7	4.01	0.02	18	29.9
13	sex+year	sex+T	sex	8025.8	4.20	0.02	11	44.2
14	sex*year	sex*T	sex+effort+effort*duration	8027.0	5.35	0.01	17	33.2
15	sex*year	sex*T	sex+y_{11}+y_{15}	8027.3	5.61	0.01	16	35.5
16	sex*year	sex*year	sex	8027.9	6.22	0.01	17	34.1
17	sex*year	sex*year	sex+effort+duration	8031.1	9.50	0.00	20	31.3
18	sex*year	sex*year	sex+$effort^2$	8031.9	10.27	0.00	19	34.1
19	sex*year	sex*year	sex+effort	8031.9	10.27	0.00	19	34.1
20	sex*year	sex*year	sex+duration	8032.4	10.79	0.00	19	34.6
21	Sex*T	Sex*T	sex	8072.1	50.45	0.00	10	92.5
21	sex	Sex*T	sex	8091.5	69.82	0.00	8	115.9
22	constant	constant	constant	8194.2	172.60	0.00	3	228.7

Model averaged estimates of apparent survival (Φ), rates of addition (f) and λ suggested that apparent survival was low (<0.6) for both sexes for all years of the study (Figure 7). In other words, the probability that a toad that was captured in one year would be in the study area in the subsequent year was less than 0.6 in all years and as low as 0.1 to 0.2 in later years of the study. This suggests either emigration to other areas or mortality. Interestingly, apparent survival was highest in the 2012-3 interval and declined in later years for both sexes of toad. This result was not due to model constraints given that all of the supported models allowed year-specific estimates of apparent survival.

In contrast, the rate of additions was relatively high in most years (>0.5) suggesting a high rate of new toads entering the study area (or being born each year). The high rates of addition offset lower apparent survival rates in the 2011-2 and 2012-3 interval so that the overall estimate of trend (λ) for these years was greater than 1 meaning that the population of toads was increasing. In later years, rates of addition were lower and apparent survival was lower and as a result the population of toads decreased (λ <1). Confidence limits for trend overlapped 1 in all year meaning that the estimated trend was not statistically significant.

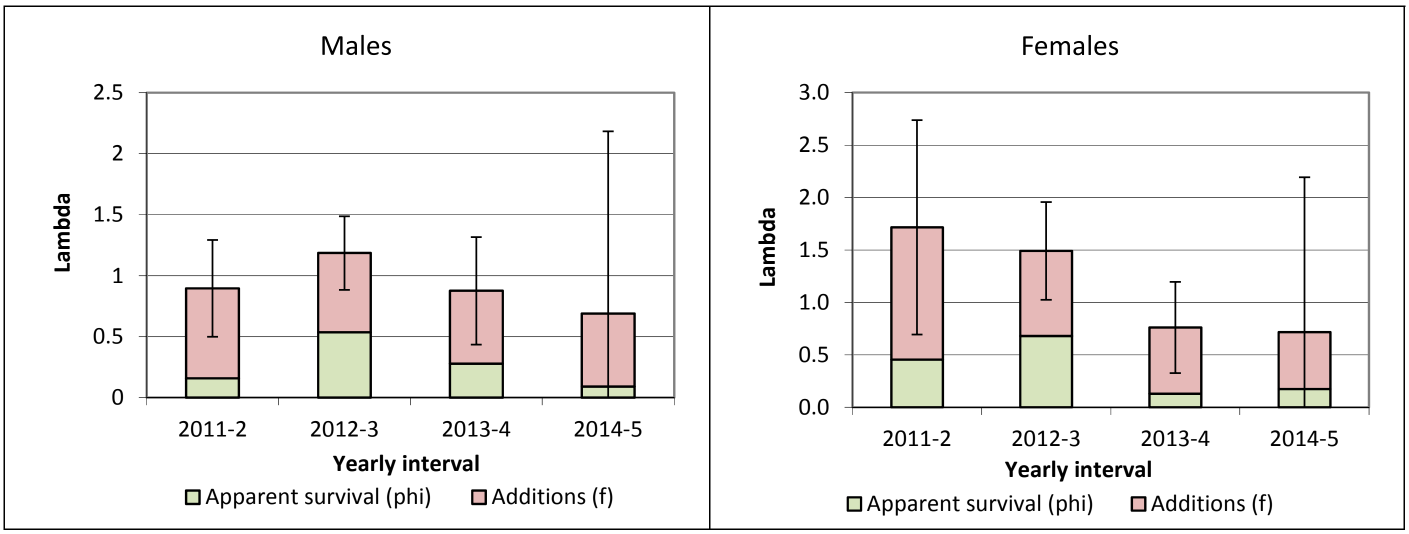

Figure 7. Yearly model averaged apparent survival (Φ), rates of addition (f) and resulting λ estimates (Φ+f=λ).

Process variance for λ was estimated in the variance components module in MARK assuming linear trends in λ for males and females (Figure 8). Process variance is the natural variation in λ that is not due to sampling variance. Estimates of σ were 0.22 (CI=0.10-1.5) and 0.16 (CI=0.03-1.3) for males and female respectively. This can be interpreted to mean that any estimate of λ will vary by ± σ*1.96. The estimates of λ and associated confidence limits are compared in Figure 3. The key difference in estimates are that the variance component model assumes a linear direction trend in λ for males and females whereas the model average estimates compromise the collective assumptions of all the models in Table 4. The main assumptions, as indicated by support of the models is yearly random variation in Φ for males and females but directional trends in additions (Table 4). Confidence limits for the variance component model for males still overlapped 1 for all years, however limits did not overlap 1 for females in 2014-5. As discussed later, these results are based on a limited time series of data and should be interpreted cautiously. Environmental covariates can be used to further understand the apparently large degree of yearly variation in trend estimates.

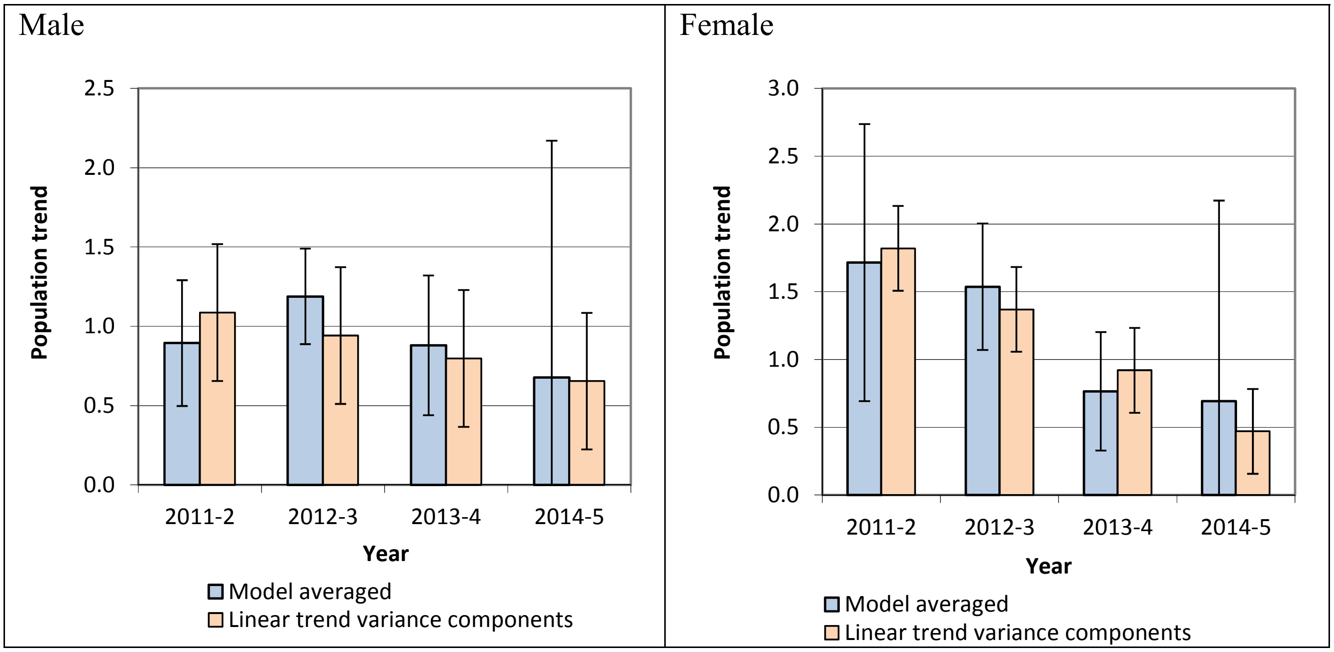

Figure 8. A comparison of model averaged and variance components linear trend model that estimate process variance in trend.

Estimates of capture probabilities suggested that males were easier to recapture than females in all years. Estimates were higher than naïve estimates based on frequencies of redetection (Figure 9). In this context, the Pradel model results suggest that one principal reason for lack of yearly recaptures is due to low survival rates rather than recapture probabilities alone.

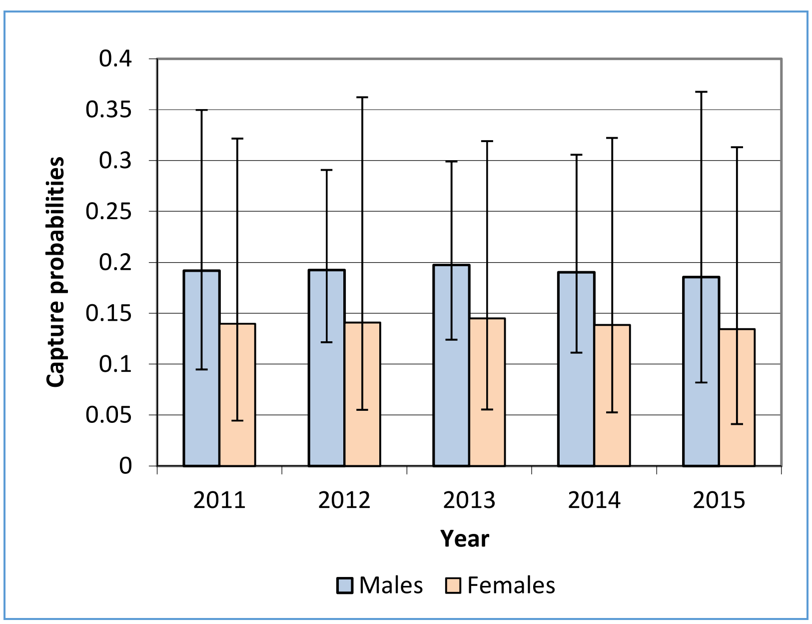

Figure 9. Model averaged estimates of capture probability for adult males and females at Summit Lake.

This analysis is a first step in the overall analysis of the PIT-tag western toad data. The strategy of pooling yearly captures provides a way to simplify the modelling of variation in yearly detection of frogs. Rather than attempt to estimate detection rates for adult toads at breeding areas, highways and other sampling areas, it is assumed that a given toad in the summit lake area has some non-zero probability of capture within the entire duration of sampling each year.
The Pradel model has been shown to be reasonably robust to unequal detection probabilities, however, it is still assumed that all toads will have a non-zero detection probability. The degree of robustness of the Pradel model will also depend on whether there is temporal variation in λ (Hines and Nichols 2002).

The main disadvantage pooling yearly captures is that information from within-year captures is not utilized and therefore precision is potentially reduced. Past analyses (Dulisse et al. 2010) have estimated population size for breeding areas based on multiple sampling sessions. While this approach did provide estimates it also required multiple sampling sessions to obtain enough recaptures to allow estimation of capture probabilities therefore increasing disturbance to breeding toads. In addition, the actual number of toads at the breeding areas varied as the breeding season progressed therefore requiring the use of open population models (such as the POPAN open model) to track changes in population size. Given these challenges, it could be argued that the best application of mark-recapture analyses is to monitor trends and movements rather than attempt point estimates of population size. Future analyses will consider other methods to estimate a baseline population size using within-year detections for years where multiple sampling sessions occurred or using Cormack Jolly Seber open models (McDonald and Amstrup 2001, Amstrup et al. 2005) (that estimate population size as a derived parameter) for the pooled year data.

The general Pradel estimates indicate that there is either a high mortality rate of toads or a large degree of emigration from the Summit lake area each year as indicated in relatively low apparent survival rates. It is likely that visitation of females to the lake does not occur each year which would help explain the low apparent survival rate for females. Low apparent survival of males is more difficult to explain. The high rates of addition certainly follows the general reproductive strategy of toads where large numbers of toadlets are produced each year and therefore it would be expected that there will be a large number of toads recruiting into the adult class each year even if toadlet mortality is high.

It is possible to use yearly covariates to potentially explain variation in demographic as well as recapture rate parameters. For example, in certain years late or early springs resulted in large differences in the time of breeding seasons and potential movements of toads to or from the lake area. It could be hypothesized that these differences may influence the ability of toads to return to the lake each year (apparent survival) or attempt to breed and therefore be detectable in the breeding area surveys. For example, abundance of salmon in local streams was used to assess apparent survival and rates of addition of grizzly bears (*Ursus arctos*) in coastal areas (Boulanger et al. 2004) therefore providing a biological context to demography.

Next Steps in Anyalysis

The following analyses will be undertaken based on the first iteration of the Pradel model analysis

1. The Pradel model analysis will be further enhanced to consider individual covariates and temporal covariates. Individual covariates may include surrogates of age such as weight and length when measured. Temporal covariates will include seasonality and general weather patterns. The ultimate goal will be to determine mechanisms for the observed changes in demography.
2. Estimates of population size of toads will be explored using within year detection data through a robust design approach (Pollock 1982) or a pooled year approach (McDonald 2012). The viability of each approach will depend on sample sizes of within year and between year recaptures.
3. Within-year and between year redetections (Figure 2) will be analyzed to better understand movements between the breeding areas, highway capture sites and sites on northern end of the lake. A multi-strata model approach will be used to estimate movements and apparent survival for each of the detection areas.

3.4. Toad Underpasses and Test Fences

The new concrete underpass was used by western toads and at least nine other vertebrate species (see following section).

The temporary test wing fences continued to work well in directing toadlets and adults. This year, very large numbers of toadlets were observed using the west plastic underpass and concrete underpass. Very few toadlets were observed using the east metal culvert underpass or associated ACO wing fences.

The spray-on concrete wing walls at both entrances of the concrete tunnel have survived two winter snow loads with some cracking but overall are still functioning well (Photographs). We are planning to install a section of ACO fencing on the lake side of the concrete underpass in 2016.

3.5. Camera Traps

Although the camera trap systems were installed late in the season (due to technical challenges), western toads were recorded travelling through the new concrete underpass and the west (plastic) underpass (Table 5). From 17 August to 06 November 2015, the camera trap system captured a total of 149 adult toads in both underpasses (Table 5 and Photographs). All adult toads recorded in the west (plastic) underpass were travelling south (away from Summit Lake) while those in the concrete underpass were recorded travelling both directions, with 61% travelling south (Table 5). Because of unique dorsal markings, it was often possible to identify individual adult toads using these photographs—toads reversed their direction of travel through the tunnels nine times within 2-47 minutes of first being photographed. These individuals are only counted in Table 5 once. Although we could not confirm this through photography alone, it is likely many mammals also pass through the underpasses more than once. Because of this, mammal observations listed in Table 5 should be considered tunnel passes rather than unique individual animals. For example, many of the red squirrel photographs recorded in the west (plastic) underpass likely represent one individual. Smaller mammals, especially North American deer mice and shrew spp. may be spending some time within the underpass tunnels as some individuals appear to be photographed numerous times per night—however small mammal use is restricted to nocturnal hours.

In addition to western toads, the camera systems recorded an additional nine vertebrate species using the underpasses (Table 5): long-toed salamander (*Ambystoma macrodactylum*), common garter snake (*Thamnophis sirtalis*), North American deer mouse (*Peromyscus maniculatus*), western jumping mouse (*Zapus princeps*), vole spp. (*Myodes gapperi*, *Microtus longicaudus* or *Microtus pennsylvanicus*), shrew spp. (*Sorex cinereus*, *S. monticolus* or *S. vagrans*), red squirrel (*Tamiasciurus hudsonicus*), short-tailed weasel (*Mustela erminea*) and Pacific wren (*Troglodytes pacificus*). It is not possible to identify vole or shrew species through photography alone.

Table 5. Summary of vertebrate species photographed by underpass camera traps at Summit Lake from 17 August - 06 November 2015.

Species	West (Plastic) Underpass	Concrete Underpass
Western Toad (adult)	53 (all southward)	75 (28 northward, 46 southward, 1 unknown)
Long-toed Salamander	0	1
Common Garter Snake	2	0
North American Deer Mouse	37	360
Western Jumping Mouse	1	2
Vole sp.	25	74
Shrew sp.	106	150
Red Squirrel	23	0
Short-tailed Weasel	0	1
Pacific Wren	2	0
Unknown small mammal	10	22

During the recording period from 17 August to 06 November 2015, underpass use by adult toads peaked the week of 24 August and then declined with the last pass recorded on 19 October (Figure 10). The cameras should be deployed earlier in the season to capture earlier movements through the underpasses.

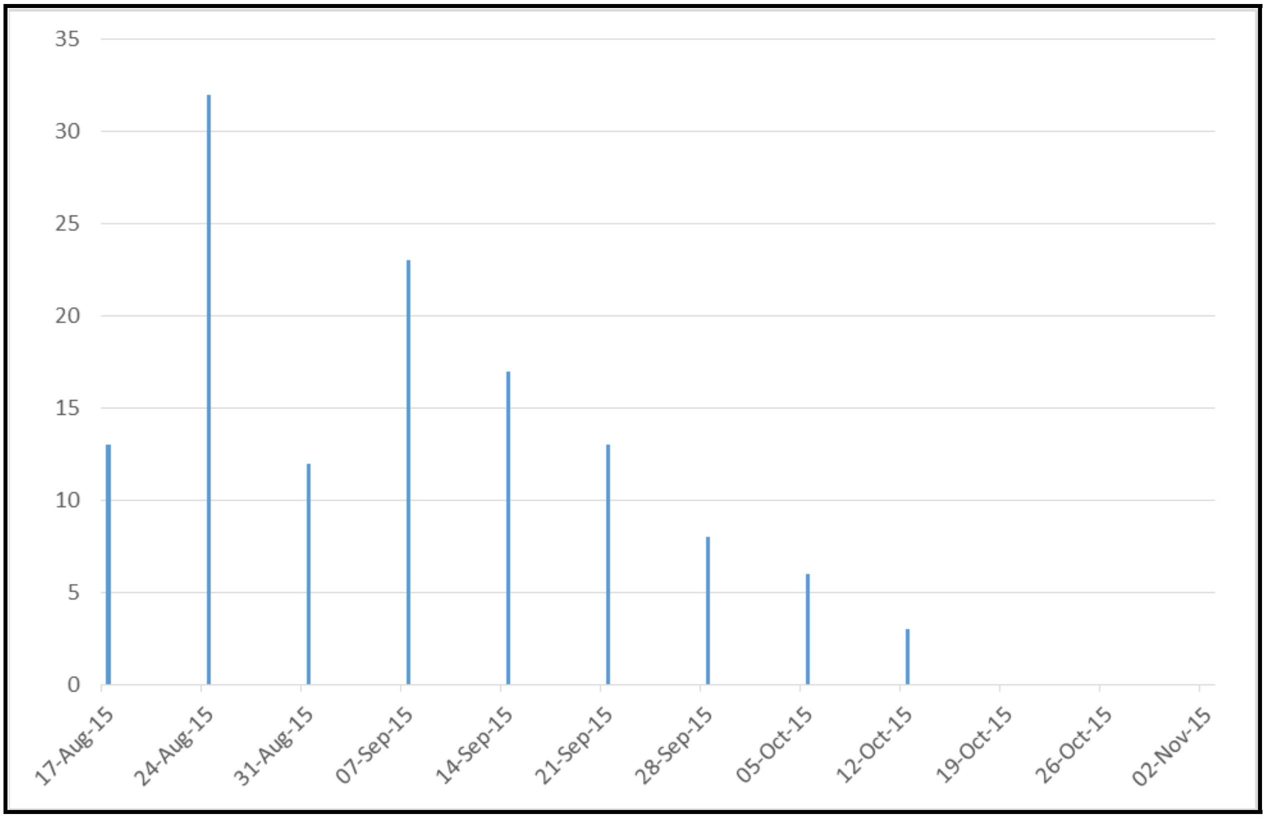

Figure 10. Number of adult western toads by date travelling through Summit Lake underpasses from 17 August – 06 November 2015. Counts for the west (plastic) and concrete underpasses were combined and grouped by week.

Daily movements of adult toads through the underpasses were strictly nocturnal with all use recorded between 18:55 and 06:44, peaking between 20:30 and 23:30 (Figure 11). This confirms that we are capturing the peak adult toad movements during our nocturnal highway surveys which are generally conducted between nightfall and 02:30.

Migrating western toadlets were also recorded by the camera traps but these data are not included because toadlets are probably not large enough to consistently trigger the movement sensor every time (although they do trigger the system often). Also, there are often so many individuals within a single frame that double counting would be impossible to avoid.

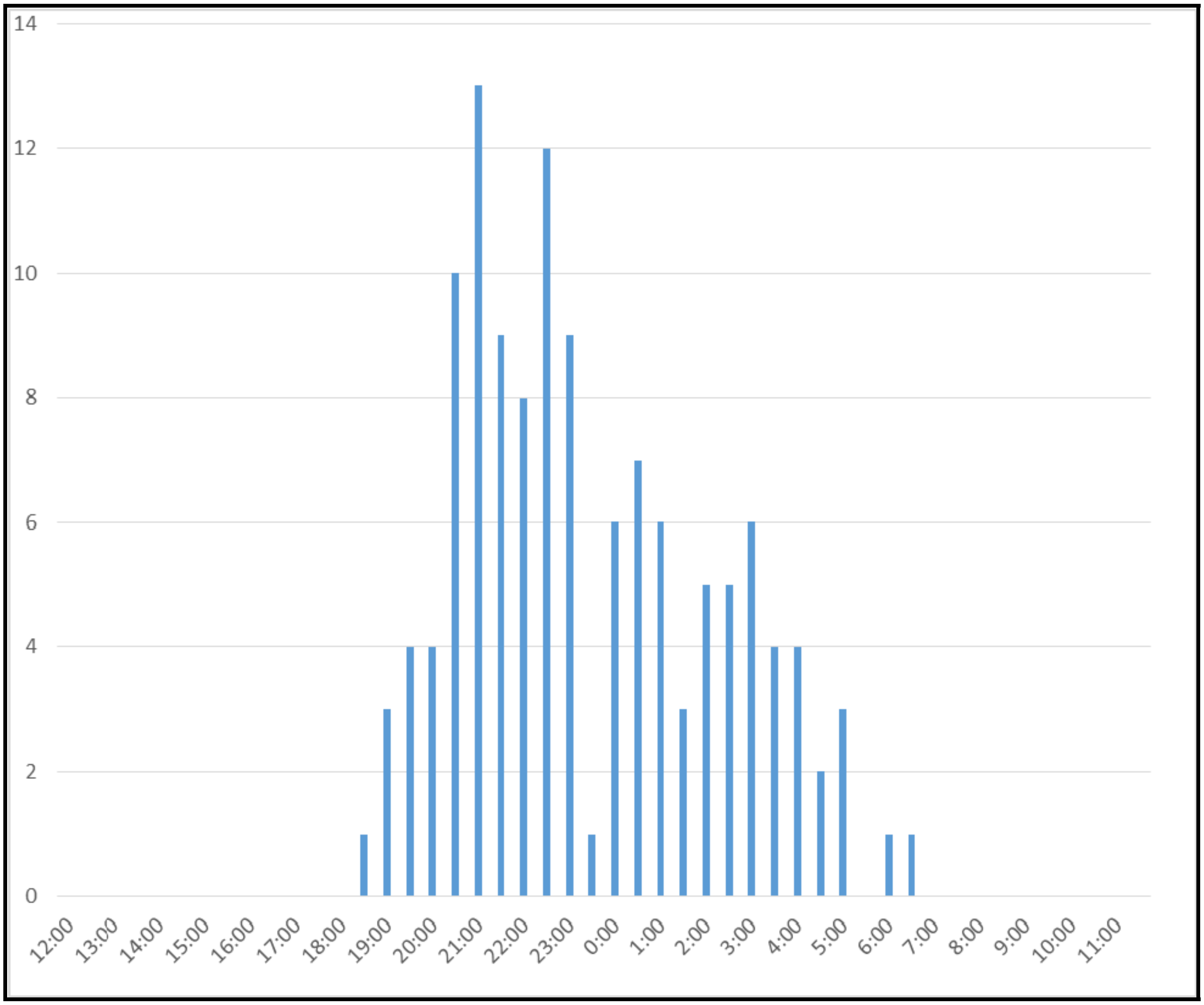

Figure 11. Number of adult western toads by time of day travelling through Summit Lake underpasses from 17 August – 06 November 2015. Counts for the west (plastic) and concrete underpasses were combined and grouped into 30 minute interval periods.

3.6. Radio Telemetry

We had mixed results with the original copper wire belt system—it broke prematurely in at least four cases so we switched to 26 gauge silver wire (Artistic Wire, non-tarnish, silver) and had better success. The silver harness wire would often break after approximately one month attached to a toad so in 2015, we tried to replace the wire at one month intervals. Some toads seemed to have a natural ability to quickly escape an intact harness (i.e without breaking the wire), even when it was reattached and tightened. We did not attempt to radio-tag these individuals after a second escaped harness.

In 2015, tagged toads ranged in weight from 110 to 151 g and we gave priority to tagging females. Locations were obtained every 3-5 days until the transmitter came off (n=6), was removed due to skin lesions (n=1) or until the toad was confirmed to be hibernating (n=7).

Between 09 August and 06 November 2015, we recorded 202 locations for 14 individuals (11 females and three males) (Figure 12 and Table 6). We tracked radio-tagged toads for time periods ranging from less than one night (slipped or broken harnesses) to 89 days and concluded tracking on 06 November when all remaining tagged toads (n=7) were confirmed or estimated to be at their hibernation.

In 2014 and 2015, a total of 13 toads (ten females and three males) were followed to hibernation sites near Summit Lake (Figure 12 and Table 6). Movement patterns prior to hibernation varied greatly among radio-tagged animals and movements ranged from 0 to 1700 m between tracking visits with the longest and quickest movements involving aquatic travel on Summit Lake (Figure 12). The longest cumulative overland movement recorded in 2015 was 2320 m recorded over a 38 day period (Figure 12). This adult female (PIT-tag # 3121071) was captured on the Summit Lake Forest Service Road on 11 August 2015 and then travelled into a very rugged and steep ravine that we were not able to access on foot for several days—she then travelled toward Summit Lake where her radio transmitter fell off near Highway 6 between 18 and 21 September (Figure 12).

Seasonal timing of activity levels varied greatly among individuals. Whereas the adult female mentioned above moved very little after 21 September, a male (PIT-tag # 62395640) was quite active until 29 October 2015.

Several toads moved longer distances (always toward the lake) in late August and early September but moved much shorter distances in the vicinity of the hibernaculum. For example, an adult female captured on Summit Lake Forest Service Road (PIT-tag # 3121062) moved 1476 m through the forest toward Summit Lake over a period of 10 days. After arriving at this site at 21 August, she remained largely inactive within a 50 m^2 area which included her future hibernation site, located approximately 90 m above Highway 6 (Table 6 and Figure 12). She stopped her local movements by 21 September was observed at the same location on 19 February 2016.

Another adult female toad (PIT-tag # 3121073) captured and radio tagged on Highway 6 the night of 09 August 2015 had travelled across Summit Lake by 13 August and was quite active within a 0.22 ha area until 08 October when she began hibernating (Table 6 and Figure 12). Within this 0.22 ha area, her daytime activities included basking along the lake shore (in the water and along the shore) and under shrub cover, especially thimbleberry (*Rubus parviflorus*) and bracken fern (*Pteridium aquilinum*). During this period, she moved an average of 21 m between observations but also had two periods of inactivity: one two day period spent underground in her hibernaculum (a small mammal burrow) and one three day period under leaf litter.

Although communal western toad hibernacula are known from the Canadian boreal forest (Browne and Paszkowski 2010), none were confirmed during our field work. We did see several toadlets sharing an adult underground roost site on 20 October 2015. Also, on 05 and 08 October, many toadlets were observed above ground in the immediate vicinity of a hibernaculum, so it is possible toadlets may share hibernacula with adults.

Different individuals also used different forest types. For example, two toads (PIT-tag # 63610882 and 63610808) that ended up hibernating on the north side of Summit Lake in 2015 used drier, south-facing habitat and were sometimes found basking in the sun on warmer days. Most of the radio-tagged toads used much wetter forest types with more closed canopies and were not observed basking in the weeks and days prior to hibernation.

Ground-level habitat complexity was important to all radio-tagged toads (Photographs). Unseen individuals were often underground in small mammal burrows, squirrel middens, mature tree root cavities, under fallen logs of varying decay and within moss-covered talus. When the toads were visible, they were always in well protected, cryptic positions including under fallen leaves, coarse woody debris, root balls, dense shrub or fern cover, in moss cavities, and wedged in rock crevices (Photographs). Radio-tagged western toads hibernated in small mammal burrows, squirrel middens, unspecified underground cavities, a subterranean streambed, a bedrock crevice, under a fallen tree root cavity, under rocks in a talus slope, under a large, decayed nurse log, under a deep deposit of coarse woody debris and within the rock fill of a forest service road (Table 6 and Photographs).

As a result of habitat observations during radio telemetry, we created a draft document *Western Toad Habitat Considerations for Forestry Operations* (Dulisse et al. 2015). It is hoped this working document will be used to reduce the potential impacts on toad habitat through forestry activities in the Summit Lake area and elsewhere. Radio telemetry efforts should continue next season with a focus on post breeding movements of adult females and hibernacula selection.

Table 6. Radio-telemetry tracking summary of 13 adult western toads followed to hibernacula at Summit Lake, 2014 and 2015.

PIT tag no.	Sex	SVL (mm)	Wt (g)	Date Captured	Date Confirmed at Hibernaculum	Cumulative Distance Travelled (m)	Capture Site	Hibernaculum Description
63610808	Female	97	124	17-Aug-2014	9-Oct-2014	2140	highway near Bonanza Cr	underground in small mammal burrow; signal coming from 50 cm west of entrance; top end of an *Armillaria* root-rot centre with good solar exposure in mature forest
63610882	Male	83	72	23-Sept-2014	22-Oct-2014	3323	forest service road above Summit Lake	under rocks at base of talus slope; rocks covered in moss and dead leaves (paper birch, Douglas-maple); falsebox shrub cover
63610887	Female	94	111	23-Sept-2014	22-Oct-2014	162	forest service road above Summit Lake	under red squirrel midden; spongy ground with no obvious entrance but several options within 5 m
63610893	Female	114	238	19-Sept-2014	24-Oct-2014	219	on road in subdivision	under large mostly decomposed nurse log, several openings into ground visible at base
No PIT tag	Female	101	151	19-Sept-2014	24-Oct-2014	896	against concrete barrier on highway side; moving away from lake?	beneath deep deposit of coarse woody debris and leaves in riparian area near stream
3121010	Female	109	151	11-Aug-2015	8-Oct-2015	1358	forest service road above Summit Lake	Underground; under dead leaves, small woody debris; no shrub cover; Douglas-fir, western redcedar and black cottonwood tree cover
3121022	Female	89	117	25-Sept-2015	13-Oct2015	100	forest service road above Summit Lake	under ground in small subterranean stream bed with flowing water; toad active; no shrubs; tree cover includes Pacific yew, western redcedar, black cottonwood, western hemlock
3121024	Male	105	115	25-Sept-2015	20-Oct-2015	986	forest service road above Summit Lake	20cm under in small mammal burrow under mature western redcedar roots; some falsebox cover and moss, with paper birch leaf litter; western hemlock, western redcedar and Douglas-fir tree cover
3121062	Female	103	141	11-Aug-2015	21-Sept-2015	1510	forest service road above Summit Lake	40-50 inside bedrock crevice under dense moss cover; no shrub cover; Douglas-fir, western redcedar tree cover
3121073	Female	102	140	9-Aug-2015	8-Oct-2015	988	on highway; moving away from lake	Also found in hibernaculum from 4-6 Sept; 40-50 cm down small mammal burrow; thimbleberry, bracken fern shrub cover; paper birch, black cottonwood, western redcedar tree cover; dense leaf cover over entrance; likely good sun exposure in spring
3121075	Female	102	141	21-Aug-2015	21-Sept-2015	712	forest service road above Summit Lake	under big trembling aspen/black cottonwood root wad from fallen trees; very deep cavern with large opening (approx.. 50 cm diam.); thimbleberry shrub cover; black cottonwood and Douglas maple tree cover; at edge of devil's club patch opening with some old-growth habitat values nearby
3121101	Female	104	110	25-Sept-2015	28-Sept2015	169	forest service road above Summit Lake	underground under thimbleberry and paper birch shrub cover; road fill at edge of forest service road; no visible entrances but many options within immediate area
62395640	Male	Unk	Unk	2-Oct-2015	29-Oct-2015	278	on highway; moving away from lake	15cm under rotten log: thimbleberry and fern shrub cover; western redcedar, paper birch, black cottonwood, Douglas-fir, trembling aspen, Douglas maple tree cover; a lot of leaf litter

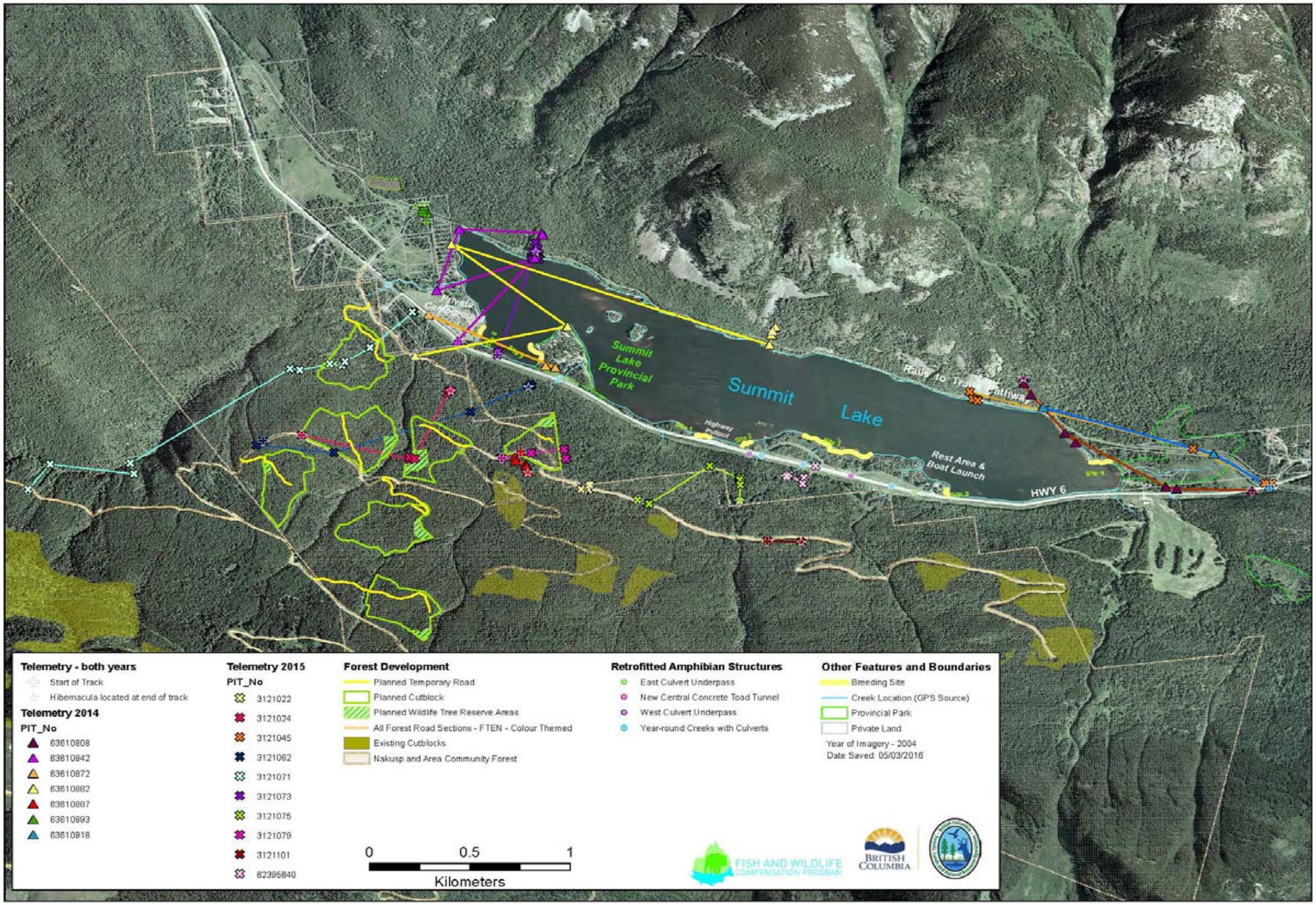

Figure 12. Movement summary of 17 radio-tagged adult western toads tracked at Summit Lake in 2014 and 2015.

3.7. Outreach

An estimated 300 people attended Toadfest in 2015 and approximately 391 toadlets were moved in 84 buckets across the highway—much fewer than in previous years (Table 7). The mean weight of each toadlet in 2015 was 0.60 g, which was larger compared to previous years. Although attendee numbers were similar in 2014 and 2015 compared to other years, fewer toadlets were moved (Table 7) because the toadlet migration peaked before the Toadfest date in both years. There were very few toadlets in the area during Toadfest 2015 and the numbers reflect this.

Because we have to commit to a set Toadfest date well in advance, it is sometimes not possible to synchronize the date with peak toadlet migration. The event requires large numbers of staff and volunteers and therefore requires advanced planning. Also, the general public require an advanced set date—for example, many people plan their summer vacations with this event in mind. Although the toadlet numbers were very low in 2015, this continues to be a successful outreach/education project and will continue as a yearly event.

Table 7. Summary of Toadfest results 2010-2015.

	2011	2012	2013	2014	2015
Total number buckets weighed/counted		541	495	317	84
Estimated total number of toadlets moved	5000	14753	13253	6853	391
Average number of toadlets per bucket		27.3	26.8	21.6	4.7
Average weight of individual toadlet (g)	0.47	0.44	0.43	0.45	0.60

In 2015 and early 2016, Powerpoint presentations on the Summit Lake Western Toad Project were made to approximately 250 people including: University of California and Old Dominion University graduate students at the Hastings Biological Field Station in Carmel, California; College of the Rockies ecology class, Cranbrook; Members of the public, Cranbrook; Gordon Terrace Elementary School, Cranbrook, and; Friends of Kootenay Lake Annual Gathering, Nelson.

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5.0 Photographs

Spray-on concrete wing wall test section.

Detail of spray-on concrete wing wall surface.

Toadlets along solid plastic test fence.

Camera trap setup in the new concrete toad tunnel. Camera is mounted on the ceiling, sensors on either side of floor, control box and battery on wall.

Adult female travelling toward lake in new concrete underpass.

Adult female travelling away from lake in new concrete underpass.

Adult female travelling away from lake in plastic underpass.

Vole species photographed using new concrete underpass.

Shrew species photographed using new concrete underpass.

Short-tailed weasel photographed using new concrete underpass.

Radio-tagged adult toad day roost site in mature western redcedar roots cavity.

Radio-tagged adult toad day roost site under bark of mature western redcedar.


Radio-tagged adult toad day roost site under bank of ephemeral stream bank.


Radio-tagged adult toad day roost site under dense shrub cover.


Radio-tagged adult toad day roost site under woody debris cover.


Radio-tagged adult toad day roost site under woody debris cover. Toad is visible in centre of image.


Radio-tagged adult toad day roost site under mossy woody debris cover.


Radio-tagged adult toad day roost site under mossy rock road fill on downhill side of forest service road.


Radio-tagged adult toad day roost site under woody debris cover. Toad is visible under log just right of centre of image.


Radio-tagged adult toad day roost. Adult is under extensive cover of leaf litter.


Radio-tagged adult toad hibernation site in small mammal burrow. In the fall, the entrance was covered with leaf litter.


The same hibernation site entrance in the fall, showing extensive leaf litter cover.


Radio-tagged adult toad hibernation site in small mammal burrow.


Radio-tagged adult toad hibernation site under large decayed nurse log.

Radio-tagged adult toad hibernation site in squirrel midden.

Radio-tagged adult toad hibernation site under mossy rocks at base of talus slope.

Radio-tagged adult toad hibernation site. Adult toad (see photo, right) was located 30-40 cm inside a bedrock crevice. The entrance is covered with moss.

Adult female in hibernaculum. The toad was located 30-40 cm inside a bedrock crevice.

Radio-tagged adult toad hibernation site. Adult toad (see photo, right) was located 15 cm inside an apparent natural cavity next to a subterranean decayed log.

Radio-tagged adult toad inside hibernation site.