British Columbia Community Bat Program Annual Bat Count (2012-2018)

Update: February 2019

Photo: Sunshine Coast Wildlife Project

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Executive Summary

White-Nose Syndrome is an emerging fungal disease that results in high mortality of susceptible bat species. It has not yet been detected in British Columbia but occurs in nearby Washington State and is expected in BC in the near future. To monitor the spread of the disease, identify species-specific impacts, and track recovery of affected species, we need a statistically-robust program for monitoring bat populations. The BC Annual Bat Count offers good potential for monitoring population trends in some species of bat that use human structures for roosting, such as the federally-endangered Little Brown Myotis (*Myotis lucifugus*).

The Annual Bat Count is currently the only long-term roost monitoring program in the province. It can contribute to the North American Bat Monitoring Program launched in 2016, covers much of BC, and is cost-effective due to the large volunteer component and regional coordinators who implement the Count as part of the BC Community Bat Program. The Annual Bat Count has been conducted from 2012 – 2018, is growing each year, and has data on seven bat species at 389 sites. To-date, no substantial declines have been detected at any Bat Count sites.

Key successes of the Annual Bat Count in 2018 are:

- continued increases in volunteer participation,
- an increase in the number of sites monitored in the regions where WNS is expected imminently (Fraser Valley/ Vancouver, Sunshine Coast, Vancouver Island /Gulf Islands) and across the province, and
- an increased proportion of sites where the species of bat has been identified by genetics or acoustics.

This report provides a summary of the data available to-date, to identify gaps and prioritize future data collection efforts. Review of the data up to 2018 has highlighted several actions that can be improved to ensure that the Annual Bat Count develops into a more effective, robust monitoring program. These recommendations for 2019 include:

- improve sample sizes in all regions and for all species. We need to:
  - recruit additional sites, especially in regions where WNS is expected to arrive,
  - emphasize conducting **two** counts in the pre-pup period, to better estimate maximum colony size, and
  - emphasize annual, multi-year sampling especially at sentinel sites, for data to contribute to trend analysis,
- identify species, particularly at sentinel sites,
- improve retention of interested homeowners and volunteers through communication and outreach,
- continue to work with NABat and the BC government on power analysis to determine the number of sites required and to incorporate count data into NABat,

- develop consistent methodology to flag sites showing potential population declines (e.g. significant percent decrease in maximum pre-pup counts) in a timely way,
- research possible analysis methods and secure funding to begin analyses.

To achieve current Annual Bat Count objectives and address the recommendations for 2019, the Community Bat Program needs ongoing funding for coordination, data management, analysis and reporting. We also require funding for regional coordinators to conduct counts, engage, train and coordinate volunteers, communicate and provide feedback to volunteers to encourage retention in the program, and funds for DNA analysis, acoustic monitoring equipment, and acoustic analysis. The Annual Bat Count is one component of the BC Community Bat Program. As the Annual Bat Count has grown, it has required more resources from the CBP. Current funding levels are insufficient to support a larger Annual Bat Count, and other funding and partnerships must be secured.

Yuma Myotis in a maternity roost. Photo: Sunshine Coast Wildlife Project

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Introduction

White-Nose Syndrome (WNS) is an emerging, invasive disease of North American bats caused by the introduced fungus, *Pseudogymnoascus destructans* (Pd). The disease has killed over six million bats in eastern North America since 2006 and nearly extirpated (90% -100% mortality) some previously abundant species (e.g. Little Brown Myotis (*Myotis lucifugus*) and Northern Myotis (*M. septentrionalis*)), now listed by the Species at Risk Act (SARA) as endangered in Canada (B.C. Conservation Data Centre 2019). In March 2016 WNS was detected for the first time west of the Rocky Mountains, in Washington State within 150 km of the British Columbia (BC) border, putting BC's bats at extreme risk from the disease. Many of BC's 16 bat species have not yet been exposed to WNS, and it is unknown what the full impact of the disease in BC might be.

Bats are important to our environment and our economy, helping to control forest, agricultural, and urban pests. The endangered Little Brown Myotis can eat 600 mosquitoes per hour (Nagorsen and Brigham 1993) and researchers estimate that bats provide billions of dollars in pest control services annually in the United States (Kunz 2011, Kasso and Balakrishnan 2013). A rapid response to WNS is required to understand and mitigate this significant threat, protect our bat populations, and reduce economic impacts.

One component of WNS response is monitoring the impacts to, and potential recovery of, different species of bats. The ability to reliably detect trends in bat populations depends on a number of factors, including years sampled, number of sites counted, number of bats per site, and annual variation (Walsh et al. 2001). Statistically robust methods for monitoring bat populations have been developed in several European countries in response to long-term population declines and the need to determine if recovery targets are reached (e.g. Walsh et al*.* 2001, Warren and Witter 2002, Barlow et al. 2015).

In Canada, the national BatWatch program (BatWatch 2019) is beginning to collect data potentially useful for long-term monitoring. In British Columbia (BC), BatWatch has not yet been formally adopted. The BC Community Bat Program independently conducts the only long-term roost monitoring project in the province. Beginning in 2012 with the Kootenay Community Bat Project, the BC Community Bat Program has expanded remarkably quickly across the province. One facet of the Program is the Annual Bat Count, which involves exit counts conducted at summer day roost sites in anthropogenic structures. Goals of the Annual Bat Count include raising awareness of bats, promoting stewardship of colonies, and ultimately providing information on bat species and numbers.

The Annual Bat Count is coordinated at the provincial level, providing consistent methods and datasheets, plus data management and storage. On the ground, the Annual Bat Count is implemented by regional coordinators. As part of their contribution to the Program, regional coordinators are responsible for ensuring that a number of counts occur in their region. Coordinators usually do several counts themselves, particularly at important roost sites. They also recruit, organize, and train volunteers to assist with Counts, as is done in the United Kingdom's National Bat Monitoring Program (Barlow et al. 2015).

Volunteer involvement varies by region and depends in part on the direction and goals of the Regional

Community Bat Program. Overall, the program has included diverse volunteers including private landowners, local stewardship groups, interested citizen-scientists, and government staff (e.g. BC Parks, FLNRO Ecosystems, Canadian Wildlife Service).

The Annual Bat Count has a strong potential to provide trend data for those bat species in BC that regularly use anthropogenic structures. As the program matures and expands, it will need additional focus on some aspects of the program to obtain statistically reliable trends. Specific recommendations to prioritize and improve data collection were made prior to the 2017 and 2018 field seasons (Kellner 2018). Several of these recommendations have been addressed, while new recommendations have also been added for 2019.

The purposes of this report are to:

1) update the summary of available BC Bat roost counts from across the province to include data from 2018 and any recently-available data from previous years,
2) assess the success of the program in meeting the recommendations made prior to the 2018 field season, and
3) continue to provide recommendations to improve the program, to make it an effective tool for monitoring the response of selected bat populations to WNS and other threats from 2017 to 2021.

This report is preliminary in nature and does not include any statistical analyses of the data.

Acknowledgements

The BC Community Bat Program is a joint venture of regional bat projects across the province. It is funded by Habitat Conservation Trust Foundation, Forest Enhancement Society of BC, Habitat Stewardship Program, the Province of BC, and many regional funding partners. Thank you to all the Regional Coordinators who locate roost sites, identify candidate sites for the Annual Bat Count, and engage, organize, and train volunteers. BC Parks has done an exceptional job of ongoing counts at many sites over the years. Orville Dyer (BC MoE) has provided valuable guidance and input to the program, as well as participating in bat counts. We especially thank Juliet Craig and the Kootenay Community Bat Project, who started the Annual Bat Count in BC. Finally, the Annual Bat Count could not occur without our many dedicated volunteers, who collect data for the program.

Methods

The Annual Bat Count is a repeated summer emergence count at day roosts in anthropogenic structures (e.g. houses, barns, bat houses). It also includes count data from one cave used as a maternity roost. These roost sites are usually identified through the work of the BC Community Bat Program. Regional Coordinators conduct, and promote volunteer participation in, bat exit counts at roost sites during designated sampling periods. The program covers much of BC, although sites tend to be clustered where there is a longer history of the bat program, a larger human population, or more bat activity (Figure 1).

Counts are done at day roost sites; there are occasionally several sites at one location, with each site being counted separately and ideally on the same night. For example, a property with an attic roost and two bat boxes in the yard would be one location with three count sites, and multiple counts are done at each site. Data are generally analyzed by site, a structural feature with bats exiting (or not), instead of by location, which was a subjective grouping of known roost sites in an area. Roost sites are classified into 9 structure types (barn, unoccupied house, occupied house, church, outbuilding, bridge, tree, bat box/condo, or other.

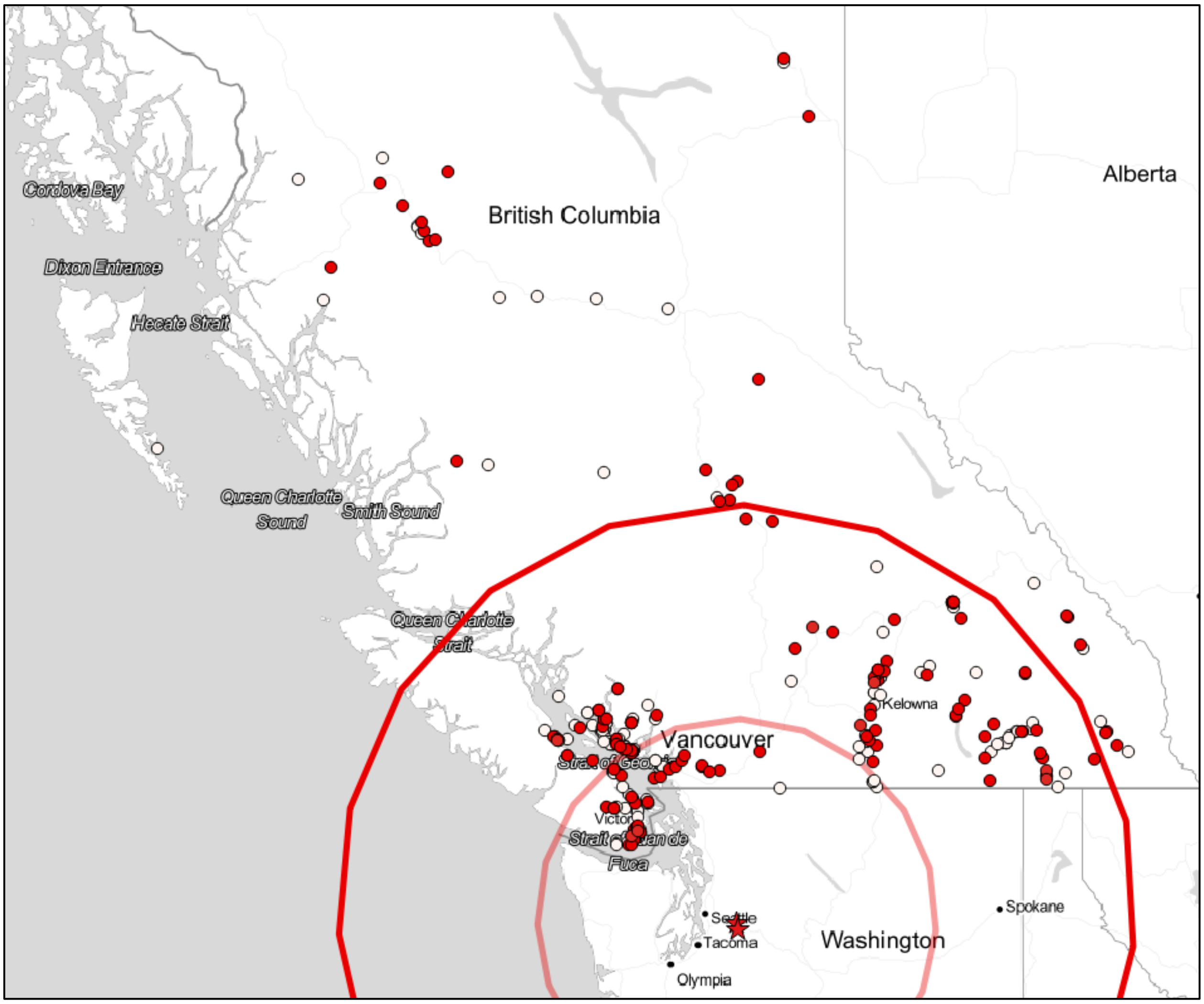

Figure 1. Map of sites sampled in the Annual Bat Count (2012 to 2018). Colour of dot represents the number of years sampled – red dots have two or more years of data and are useful for trend analysis; white dots have one year of data. The 2016 WNS detection site in Washington is indicated by a red star; concentric rings show the 250 km and 500 km radius from the Washington detections to suggest where WNS might arrive first for count prioritization.

Coordinators and/or volunteers conduct between one and four visual counts of bats exiting roosts at dusk. Ideally, two counts occur between June 1 and 21 (the 'pre-pup period', before pups can fly). These counts are the highest priority, and are consistent with North American Bat Monitoring Program (NABat) protocols (Loeb et al 2015). Two more counts are recommended once pups are flying (called the 'post-pup period'). In 2018, dates for post-pup counts were switched to July 11 – August 5 (from July 21 – Aug 15 in 2017 and earlier), because of many reports of colonies being vacated by early to mid- August. We hoped that the earlier count window would facilitate counts before colonies began to disperse.

The Annual Bat Count is meant to be repeated yearly for as long as possible, but depends on funding, access to count sites, and volunteer availability. Data is recorded for each count, and submitted to the regional or provincial coordinator or BC Ministry of Environment and Climate Change Strategy or Ministry of Forests, Lands, Natural Resource Operations and Rural Development staff. Ultimately, count data is entered into the BC Wildlife Species Inventory database[1]. Detailed methods can be found on our website[2] .

Species identification

Verification of the species using a roost site may be done through DNA analysis of guano samples (Wildlife Genetics International, Nelson). Alternatively, some regional coordinators have access to ultrasonic bat detectors (e.g. Echometer Touch (Wildlife Acoustics), Anabat Walkabout (Titley Electronics), RoostLogger (Titley Electronics)), which can provide information on species. Identifications based solely on acoustics are taken as confirmation if the acoustic files are analyzed by a trained bat biologist. Species identification may also be done by qualified biologists through identification of dead bats or live capture by mist-netting. Although these three methods 'confirmed' species identifications for this reported, final confirmation of species presence generally requires genetic verification and is the preferred method, if available.

Criteria for identifying maternity roosts

Two methods of identifying maternity roosts have been used up to 2017. Sightings of pups can be used to confidently confirm a site as a maternity roost. However, confirmed pup sightings are not available for the majority of sites. Alternatively, the maximum counts from pre-pup and post-pup periods were compared, and sites where the maximum count increased between periods was used to identify potential maternity colonies.

However, with increasing anecdotal reports about the movement of bats between roost sites in early summer, and rapid dispersion of colonies from roost sites in July and August (within the post-pup count period), we trialed a count-based definition of a maternity site. This was based on the expected different behaviour and roost selection of females and males during the maternity season (June through early August). Female temperate zone bats generally cluster and use warm sites during the maternity season, presumably to reduce their use of torpor and increase the rate of fetal development and juvenile growth

[1] http://a100.gov.bc.ca/pub/siwe/search_reset.do
[2] http://www.bcbats.ca/index.php/get-involved/participate-in-the-bc-bat-count.

(Kunz 1982). The majority of male bat species are solitary during summer months (Safi and Kerth 2007). Little Brown Myotis and Big Brown Bat, two of the species commonly found in anthropogenic structures, may roost in the same structures as females (Kurta and Kunz 1988) or in small groups (Safi and Kerth 2007) during the maternity season. Little Brown Myotis males may also form a small proportion of individuals in a maternity colony (e.g. ~6% males, Davis and Hitchcock 1965). However, reports of large congregations of males are lacking. Therefore, we assumed that any large group of bats in July is likely to be composed primarily of reproductive females and young. We therefore propose to identify maternity colonies as any colony with 20 + bats, at any period from May through August. This cut-off number was determined in discussion with BCBAT biologists (Lausen 2018, Mitchell 2018). This technique also flags possible maternity colonies that do not have pre and post pup count pairs.

Potential maternity sites were identified using all three methods, if available, and sites were manually reviewed to ensure that maternity colonies were correctly identified.

Sentinel sites

In March 2017, we created a list of priority 'sentinel' sites in BC to prioritize monitoring efforts in June 2017 and to promote and prioritize long-term monitoring sites (Kellner and Dyer 2017). These sites were chosen to be large, secure colonies with sufficient volunteer or coordinator resources to be counted regularly. To establish the list of sentinel sites, sites were assigned a rank of zero or one for each of the criteria below and all ranks were added to provide a total score. The score was sorted to prioritize sites by high score, within each region. High ranked sites were then reviewed by provincial and regional coordinators to confirm landowner/volunteer interest and identify other sites that could be prioritized (e.g., large Little Brown colony not counted recently and requires follow-up with a landowner). Criteria used for the initial ranking of sites were:

- LARGE: colony size greater than 150 bats in at least one count; larger colonies theoretically will have less % variation between counts. Large colonies are also more likely to be maternity colonies,
- ACTIVE: counted in the last 2 years, indicating recent access to the site and availability of volunteers,
- WITHIN YEAR REPLICATION: multiple counts available within a year,
- BETWEEN YEAR REPLICATION: counts are available from more than one year,
- COSEWIC: are COSEWIC-listed species present (Little Brown Myotis), and
- KEEN: homeowner/community support (if a landowner is known to be very keen to count and submit data over the long term).

Results

Volunteer involvement

Volunteer involvement is essential to the Annual Bat Count, providing many or most of the bat counts in some regions. Volunteers either assist regional coordinators or conducted counts on their own.

Volunteers may have assisted at more than one count, and many counts required multiple volunteers to ensure all exits were monitored, so the number of unique volunteers is unknown. Volunteers participated in a minimum of 338/396 counts (85%) in 2016, 418/535 counts (78%) in 2017, and 540/755 (71%). The number of volunteer-nights was a minimum of 465 in 2016 and 430 in 2017, and 613 in 2018.

Number of sites and counts

Two thousand, one hundred and seven (2107) counts were conducted at 389 sites between 2012 -2018 (Figure 1; Table 1). Each site is usually counted from one to four times per year, although a few sites were counted more frequently. Sites sampled in one year may not have been sampled in subsequent years, and sites counted for multiple years were often but not always counted in consecutive years. The number of sites has increased with the expansion of the Community Bat Program across the province and increased efforts by coordinators to establish count sites and gather baseline pre-WNS data.

Table 1. Number of locations, roost sites, and counts per year. Not all sites from a year were counted in successive years.

Year	Locations	Roost sites	Counts
2012	10	10	26
2013	24	31	82
2014	37	44	112
2015	54	75	201
2016	119	152	396
2017	145	186	535
2018	173	214	755
Unique locations, roost sites and counts, all years	317	389	2107

Number of sampling years

Sites have been monitored for between one and seven years (Table 2), leading to the start of a long-term dataset. As of 2018, 219 sites have one year of data, 93 sites have two years of data, 35 sites have three years of data, 21 sites have four years of data, nine sites have five years of data, 11 sites have six years of data, and one of the 389 Annual Bat Count sites currently has seven years of data.

Sites that have been monitored for two or more years can be used in trend analysis using the methods employed in UK's National Bat Monitoring Programme (Bat Conservation Trust 2018). As of 2018 in BC, there are 170 /389 locations (44 %) with two or more years of data.

Table 2. Number of roost sites that have from one to seven years of count data, and the percentage of sites sampled two or more years. Sites with two or more years of data can be used in trend analysis (Bat Conservation Trust 2018).

Number of years counted	Number of sites as of 2016	Number of sites as of 2017	Number of sites as of 2018
1	136	156	219
2	34	45	93
3	12	32	35
4	7	9	21
5	1	14	9
6		1	11
7			1
Total	190	257	389
Percent with 2+ years	28	39	44

Distribution of sites

Roost count sites are distributed throughout B.C. but are focused in areas of higher human habitation and where Community Bat Programs have been established for longer times (Table 3, Figure 1).

Table 3. Distribution of roost sites counted in the Annual Bat Count, by region and year

Region	2012	2013	2014	2015	2016	2017	2018
Sunshine Coast					31	41	49
Southern Vancouver Island/Gulf Islands[1]		7	7	12	22	35	44
Okanagan		3	14	15	26	27	36
Fraser Valley/Lower Mainland				1	11	21	27
Kootenay	10	20	20	31	25	26	21
Cariboo			1	1	9	14	18
Skeena				11	13	8	6
Columbia Shuswap				1	6	8	4
Peace			1		3	3	
Thompson		1	1	2	3	2	3
Haida Gwaii				1			
Other[2]					3	1	6
All sites	10	31	44	75	152	186	214

[1]Includes data from bat programs on Salt Spring, Thetis, Mayne, Gabriola, Denman/Hornby, and Texada Islands

[2] Other includes sites in Northern Vancouver Island and the Omineca/Prince George area

Structure type

Most roost sites were located in occupied houses (200 sites; 51%) and bat boxes or bat condos (127 sites; 33%) (Table 4).

Table 4. Type of structure monitored during the Annual Bat Count, 2012-2018, by region.

Region	Unoccupied house	Occupied house	Outbuilding / barn	Bat box / bat condo	Other[1]	Total
Sunshine Coast	5	65	9	13	6	98
Southern Vancouver Isl./Gulf Isl.	1	45	4	18	2	70
Kootenay	4	28	3	27	0	62
Okanagan	2	21	9	25	1	58
Fraser Valley/ Lower Mainland	1	13	6	11	1	32
Skeena	0	12	1	5	0	18
Cariboo	1	7	3	11	0	22
Columbia Shuswap	0	4	0	7	0	11
Other	0	2	1	5	0	8
Thompson	0	2	1	2	0	5
Peace	0	1	0	3	0	4
Haida Gwaii	0	0	0	0	1	1
Total	**14**	**200**	**37**	**127**	**11**	**389**

[1] 'Other' includes 'Tree' and 'Other' categories.

Bat species

There are seven species of bats recorded roosting in anthropogenic structures in the Annual Bat Count data. These are Little Brown Myotis (*Myotis lucifugus*), Yuma Myotis (*M. yumanensis*), Big Brown Bat (*Eptesicus fuscus*), Californian Myotis (*M. californicus*), Long-legged Myotis (*M. volans*), Long-eared Myotis (*M. evotis*), and Townsend's Big-eared Bat (*Corynorhinus townsendii*) (Table 5).

For species identification at all sites across years, there are 192/ 389 (49 %) sites that have a species id, with an additional nine sites classified as Myotis species. There are 26 sites with samples submitted and genetic results pending. If all samples are successful, there will be 227/389 (58 %) sites with species id. Many of the unidentified sites have not been visited for several years and it is unlikely that the bat species using these sites will ever be determined.

For the 214 roost sites sampled in 2018, 107 (50 %) have a species ID. There are 26 samples from 2018 pending analysis, for a total of 133/214 (62%) sites with id. Nineteen sites had a count of 0 bats, so no identification is possible. However, many new sites were added in 2018 that did not yet have any information on species. At these sites, species identification will be necessary to support effective monitoring, and determination of species at count sites will again be emphasized in 2019, through recording with acoustic detectors and collecting guano samples.

Table 5. Species, number of roosts monitored, and regions monitored by the Annual Bat Count.

Species	Number of roost sites with confirmed species identification[1]	Regions
Little Brown Myotis	112 (58%)	All
Yuma Myotis	82 (43%)	Cariboo, Columbia-Shuswap, Fraser Valley / Lower Mainland, Kootenay, Okanagan, Skeena, Southern Vancouver Island/Gulf Islands, Sunshine Coast, Thompson
Big Brown Bat	20 (10%)	Cariboo, Columbia-Shuswap, Fraser Valley / Lower Mainland, Kootenay, Okanagan, Peace, Skeena, Southern Vancouver Island/Gulf Islands
California Myotis	18 (9%)	Sunshine Coast, Southern Vancouver Island/ Gulf Islands
Townsend 's Big-eared Bat	8 (4%)	Fraser Valley / Lower Mainland, Kootenay, Southern Vancouver Island/ Gulf Islands, Sunshine Coast
Long-eared Myotis	5 (3%)	Haida Gwaii, Skeena, Southern Vancouver Island/Gulf Islands, Sunshine Coast
Long-legged Myotis	2 (1%)	Cariboo, Southern Vancouver Island/Gulf Islands
Total	192[1]	

[1] Note that more than one species can occupy the same roost site.

Little Brown Myotis are more commonly found in artificial structures than any other bat in BC (Table 6) and occur at 112/192 (58%) of sites with confirmed species identification. When multiple species are identified at a roost, Little Brown Myotis and Yuma Myotis are commonly found with Yuma Myotis, and sometimes co-roost with Big Brown Bat, California Myotis, Long-legged Myotis or Long-eared Myotis (Table 6).

Yuma Myotis are the second most common bat in anthropogenic structures and are confirmed at 82/192 (43 %) of sites. They often are found in roosts with Little Brown Myotis and occasionally co-roost with other species including Big Brown Bat, California Myotis and Townsend's Big-eared Bat (Table 6).

There are five sites identified as having Long-eared Myotis. Two of the sites are bat boxes (Kootenay and Skeena regions), one is a cave, and two are occupied houses. Long-eared Myotis were confirmed genetically at the bat box roost in the Skeena Region in 2015. However, the DNA analysis procedure at the time did not include testing for a gene (muc-11) to positively differentiate Long-eared Myotis from a coastal genotype of Little Brown Myotis. Improved testing from 2016 onwards allowed differentiation of these species. The Kootenay bat box site was confirmed genetically in 2017, after the testing method for MYEV was improved. Confirmation of species in the other three cases involved in-hand identification and acoustics. A maternity colony in a cave in Haida Gwaii was identified through capture as a mixed colony of Long-eared Myotis (formerly Keen's Myotis) and Little Brown Myotis. A dead bat on-site, paired with acoustics, identified Long-eared Myotis in a mixed colony in a house on the Sunshine Coast. Acoustic identification was used in 2017 to identify Long-eared Myotis in a mixed colony at a house on Southern Vancouver Island.

Table 6. Species assemblages and the number of roosts found for each species and species group, at 389 anthropogenic roosts in BC.

Species in roost	Number of roost sites	% of all roost sites
Little Brown Myotis	70	18
Little Brown Myotis / Yuma Myotis	28	7
Little Brown Myotis / Yuma Myotis / Big Brown Bat	2	< 1
Little Brown Myotis / Yuma Myotis / California Myotis	7	2
Little Brown Myotis / Big Brown Bat	1	< 1
Little Brown Myotis / Long-legged Myotis	1	< 1
Little Brown Myotis /Long-eared Myotis	2	< 1
Little Brown Myotis /Long-eared Myotis / Big Brown Bat	1	< 1
Yuma Myotis	44	11
Yuma Myotis/ California Myotis / Long-eared Myotis	1	< 1
Long-eared Myotis	1	< 1
Long-legged Myotis	1	< 1
California Myotis	10	2.5
Townsend's Big-eared Bat	7	2
Townsend's Big-eared Bat / Big Brown Bat	1	< 1
Big Brown Bat	15	4
Myotis spp.	9	2
No ID	162	42
TBD	26	6
Total	389	

California Myotis was identified in occupied houses, barns, and bat boxes. Long-legged Myotis was genetically confirmed at two building roosts, one in the Gulf Islands (an occupied house), and one site in the Cariboo (a barn). DNA identification analyses only one pellet per site so species that rarely use structures or are a small percentage of the bats using the site are likely under-represented in our data, especially at sites with large numbers of bats.

Identification of maternity colonies

Pre-pup and post-pup counts were available at 432 year-site combinations, at 234 sites. There were 145/234 (62 % of sites with pre- and post-pup counts) roost sites that had an increase in maximum counts from pre-pup to post-pup periods in at least one year, suggesting that these 145 sites are maternity colonies. However, sites with multiple years of monitoring did not always consistently increase between pre- and post-pup counts each year. For example, one large colony of 800 + bats in the Okanagan increased in one year from June to August (pre-post pup counts), but in two subsequent years showed a decrease. Using a cut-off number of 20+ bats to define a maternity colony results in the identification of 105 additional maternity colonies totalling 250/389 sites (64 % of all sites). Using either criteria, almost 2/3 of sites monitored are maternity colonies.

Maternity colonies were found in all types of structures used as roost sites (Figure 2). The majority of maternity colonies were found in occupied houses (73/145 maternity colonies, 50 %) and bat boxes /

bat condos (51/145, 35 %) (Table 7). These results are similar using a 20+ cut-off criteria, and very similar to those for all roost sites monitored (including the sites not flagged as possible maternity roosts (e.g. 51% in occupied houses, 33 % in bat boxes; see Structure type above).

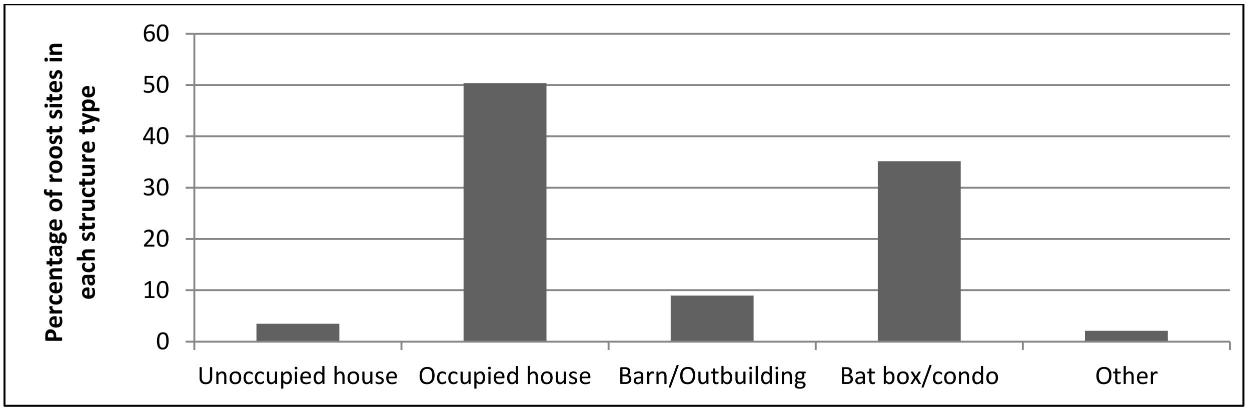

Figure 2. The distribution of 145 maternity roosts by structure type. Maternity roosts were identified through an increase in counts from pre- to post-pup periods.

Table 7. Summary of roost sites by structure type and colony type for 234 sites with pre-pup and post-pup counts in the same year. Maternity colonies were identified based on an increase in numbers from pre-pup to post-pup counts.

Structure type	Total sites	Maternity sites	% of structure type housing a maternity colony	% of all maternity roosts in a given structure type
Unoccupied house	7	5	71	4
Occupied house	121	73	60	50
Outbuilding /barn	21	13	62	9
Bat box/ bat condo[1]	80	51	64	35
Other[2]	5	3	60	2
Total	234	145	62	100

[1] Monitoring at bat boxes includes both occupied and unoccupied bat boxes. The % structure housing a colony is therefore an underestimate for this structure type.
[2] 'Other' includes 'Tree' and 'Other' categories.

Fifty-one (66/145, 46%) of these maternity colonies sites were confirmed as Little Brown Myotis, either alone or with other species (Table 8). Little Brown Myotis maternity roosts were mainly in occupied houses (36/66, 55%) but also in bat boxes/ bat condos (22/66, 33%) (Table 8). Forty-six percent (46%) of all maternity colonies include Little Brown Myotis.

Table 8. Number of maternity colonies by species and structure type. Maternity colonies were identified based on an increase in numbers from pre-pup to post-pup counts.

Species	**Little Brown**	**Little Brown mix**	Yuma	Myotis mix, no Little Brown	Long-legged	California	Townsend's	Townsend's / Big Brown	Big Brown	TBD	Myotis spp.	NoID	Sum	**% of total with Little Brown**
Unoccupied house	**0**	**1**	0	0	0	0	0	1	0	1	1	1	5	**20**
Occupied house	**22**	**14**	6	1	1	5	1	0	1	4	1	17	73	**49**
Outbuilding/barn	**4**	**3**	2	0	0	0	3	0	0	0	0	1	13	**54**
Bat box/ bat condo	**11**	**11**	12	0	0	0	0	0	4	3	0	10	51	**43**
Other[1]	**0**	**0**	0	0	0	0	0	0	0	1	0	2	3	**0**
Total	**37**	**29**	20	1	1	5	4	1	5	9	2	31	145	**46**

[1] 'Other' includes 'Tree', and 'Other' categories.

Identification and monitoring of high priority sentinel sites

Sentinel sites, with highest priority for ongoing monitoring, were identified in 2017 and 2018 (see Methods for sentinel sites). The list of sentinel sites was re-evaluated for 2019 (Appendix 1). Sixteen previously-identified priority sites at 13 locations were dropped, due to lack of interest or participation by landowners (12 locations) or demolition of the roost (1 location). Several new sentinel sites were added. For 2019, there are now 78 flagged priority sites, at 49 locations, for targeting in 2019.

In 2018, 60 sentinel sites at 37 locations (37/60, 62%) were monitored and data submitted. Other sentinel sites were known to have been monitored but data was not submitted before reporting, while some volunteers reported that they were still interested but did not get a count done in 2018.

Six species of bat were confirmed at 67/78 (86%) of these sentinel sites (Table 9). One site has a sample underway at the lab, and 11 have no ID (five of these are requested from spring guano samples submitted through the BC Government WNS surveillance program). Little Brown Myotis were confirmed at 47 sentinel roosts. Yuma Myotis are confirmed at 35 sentinel roosts.

Table 9. Number of sentinel roost sites by species.

Species in roost	Sentinel roost sites
Townsend 's Big-eared Bat	1
Big Brown Bat	1
California Myotis	1
Little Brown Myotis	27
Little Brown / Long-legged	1
Little Brown / Yuma	18
Little Brown / Yuma / Big Brown	1
Long-legged Myotis	1
Yuma Myotis	16
TBD[1]	1
NoID[2]	10
Total	78

[1]TBD – to be determined – samples are currently being tested.
[2]NoID – no testing has occurred.

Variability within count periods

There are four sites where more than the recommended four counts (two pre-pup and two post-pup counts) were conducted (Figure 3). There is large variation in counts within designated count periods, and variation between years in the timing of when colonies reach maximum size and then begin to decline.

Pre-pup counts

For cases where multiple pre-pup counts at one site in one year were available (316 cases), differences between count 1 and count 2 were calculated (Table 10). Differences ranged from a minimum of 0 (counts 1 and 2 were the same) to 1257 (count 2 had 1257 more bats than count 1). The average of this difference between counts was small (an increase of 6 bats from the first to the second count), but the differences were variable, as would be expected with roosts of differing size, with a standard deviation of 161 bats. The majority of sites (152/316, 48 %) showed in an in number of bats between first and second pre-pup counts, 125 sites (40 %) had a decrease and 39 sites (12%) had the same number of bats. Sixteen of the sites that remained the same had no bats present in either count. The observed variability emphasizes the importance of doing at least two counts, to better estimate maximum number of bats in the roost and to be able to estimate variability for that site.

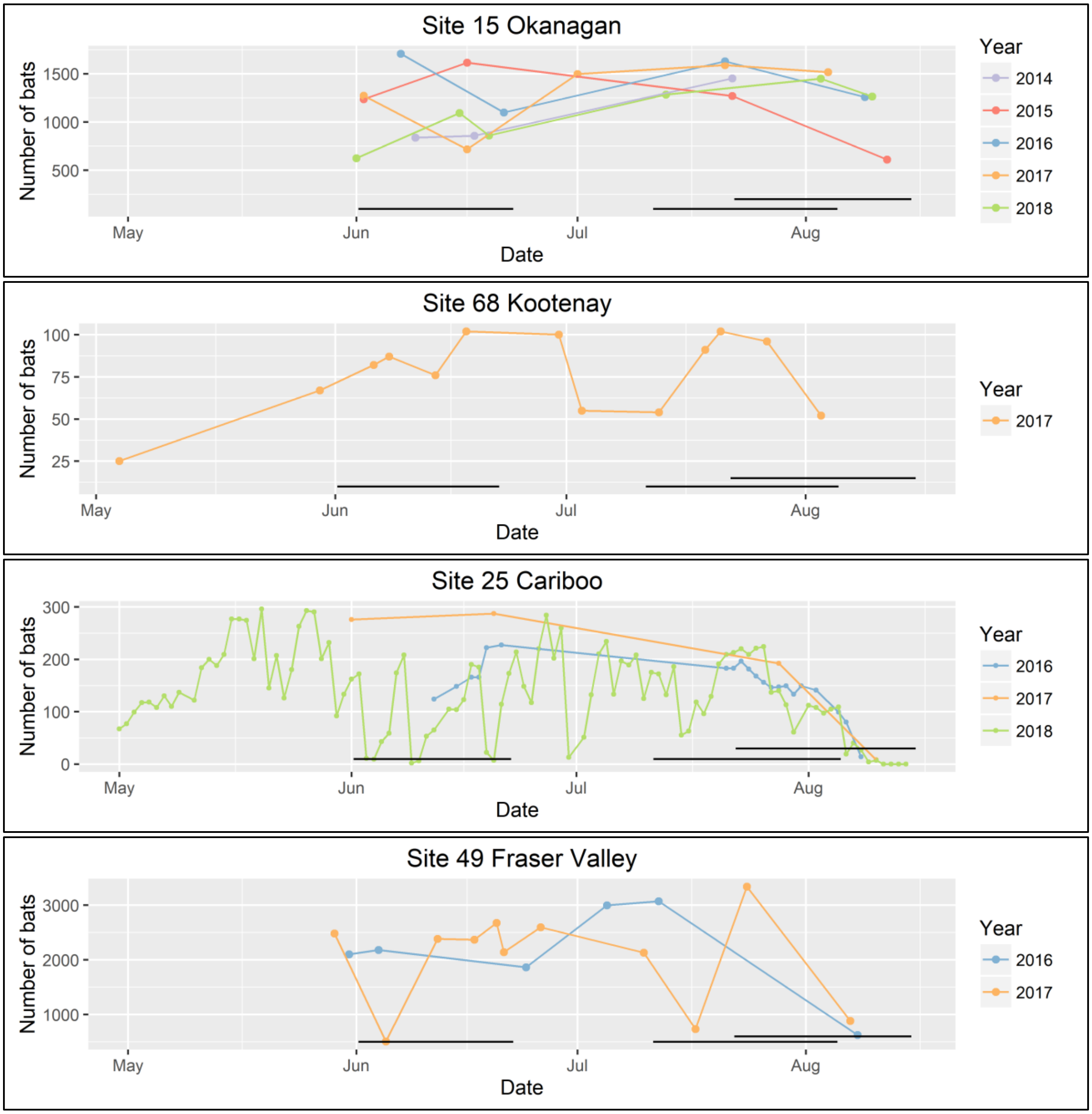

Figure 3. Counts for four sites with more than four counts in a year, showing nightly and yearly variation in count numbers. Horizontal lines indicate Bat Count periods in the pre-pup (Jun 1-22) and post-pup (Jul 22- Aug 15 (pre-2018) / Jul 11- Aug 5 (2018) count periods

Table 10. Variation within a count period, calculated from the differences between count results at a site in the same count period in the same year.

Measure	Count period Pre-pup (Jun 1 -22)	 Post-pup (Jul 11 – Aug 4)
Number of cases with two counts in a count period in the same year	316	320
Minimum difference between counts at a site in a count period	0	0
Maximum difference between counts at a site in a count period	1257	2000
Average of the difference between counts at a site, across all cases	+6 bats /	-22 bats
Average % difference between counts at a site, across all cases	+ 146 %	-49 %
Standard deviation of the difference between counts at a site, across all cases	± 161 bats	± 212 bats
Standard deviation of the % difference between counts at a site, across all cases	± 932 %	± 678 %

Post-pup counts

For cases where multiple post-pup counts at one site in one year were available (320 cases), differences between count 1 and count 2 were calculated (Table 10). Differences ranged from a minimum of 0 (counts 1 and 2 were the same) to 2000 (count 2 had 2000 more bats than count 1). The average of this difference between counts was small (a decrease of 22 bats from the first to the second count), but the differences had a standard deviation of 161 bats. The majority of sites (163/320, 51 %) had a decrease between the first and second count in the post-pup period, while 50 (16 %) stayed the same and 107 (33%) increased. Sites that stayed the same are mostly sites with no bats (26 counts) or small numbers of bats.

The tendency for sites to decrease suggests that post-pup counts often include counts when bats have begun to leave colonies. The post-pup count in 2018 was done in an earlier time to try and reduce the chances of bats having left roosts before the count. This change did not noticeably decrease variation in the results from this count period (standard deviation of the difference +/- 227 bats). The change also did not affect the direction of the difference between counts - prior to 2018, site/year combinations showed a 53 % decrease, 16 % stable, and 31% increase in number of bats from the first to second post-pup count. In 2018, there was a 48 % decrease, 15 % stable, and 37 % increase in the number of bats from the first to second post-pup count.

Dates of first pups

Observations of first pups of the year were obtained from several intensely-monitored roost sites (Table 10). These observations show yearly variability in the start of parturition. These dates also suggest that any counts prior to ~ July 9 would not include volant pups (assuming around three weeks until pups begin flying). The current pre-pup count period is June 1 – 22 and therefore prior to volancy of pups. The current post-pup count period is July 11 – August 4.

Table 11. Dates of first pup observed, by Region, for three intensely-monitored roosts.

Region	Species	Year	Date
Okanagan	MYLU/MYYU	2017	Jun 26
Okanagan	MYLU/MYYU	2018	Jun 21
Peace	MYLU	2017	Jun 30
Peace	MYLU	2018	Jun 21
Cariboo	MYLU	2018	Jun 18

Trends across years

One hundred and thirty-one (131) sites have two or more years of count data. Although no formal analyses have been done yet, these counts can be graphed by region and species and to identify areas to focus on to improve sample sizes, as well as to provide feedback to coordinators and volunteers (Appendix 2). Changes in maximum pre-pup counts between years must be considered in context of the large variation within count periods in a year (see Variability within count periods , above). Sites showing declines are investigated individually to determine if there are obvious factors at play (excessive heat, exclusion, new roost sites nearby, large amount of variation normally at the site, etc).

As an example, the Okanagan pre-pup counts (Figure 4) showed an increasing number of sites recruited for long-term monitoring, and illustrate the yearly variability within sites and among years. Several sites show declines and require further investigation.

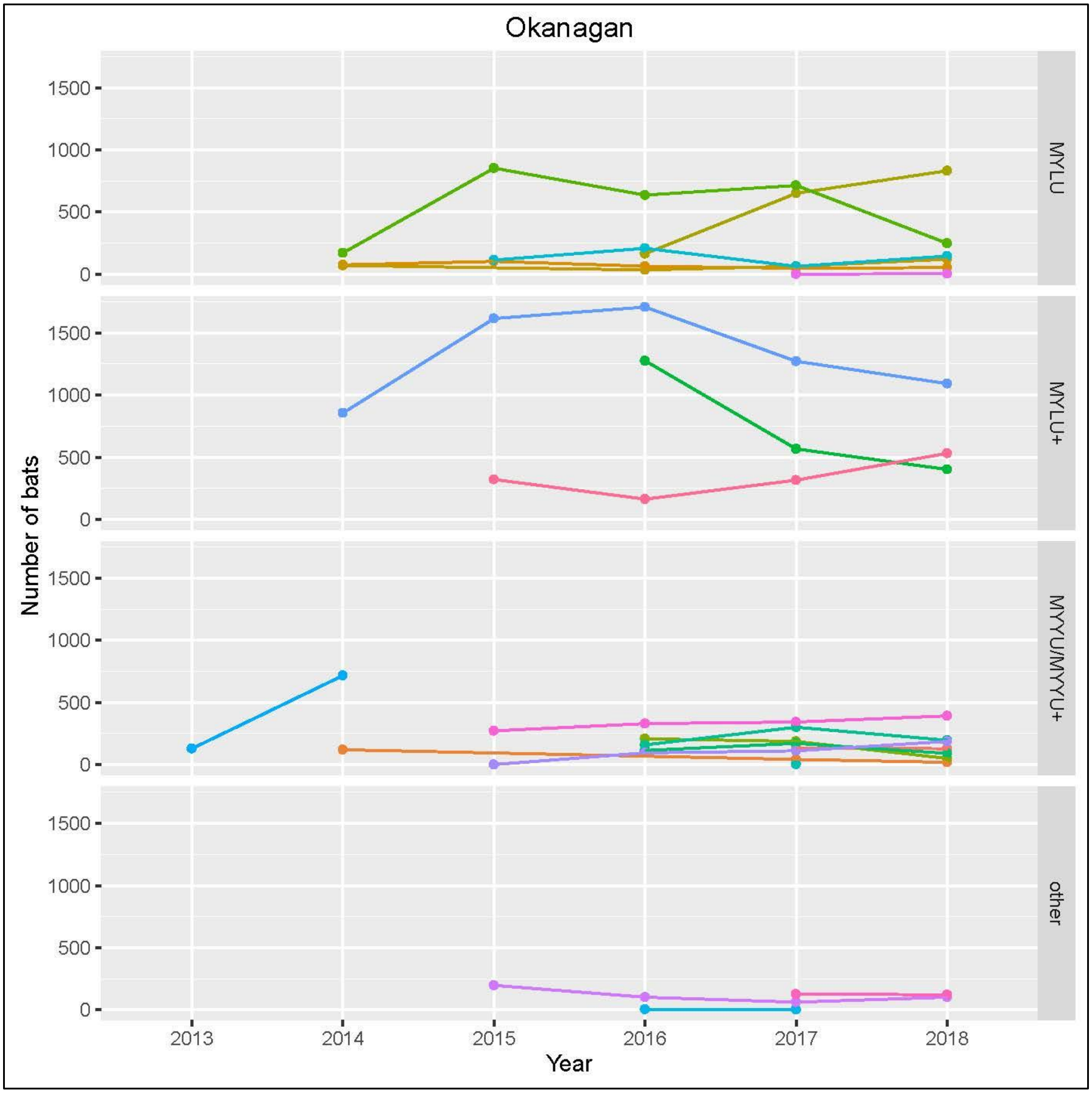

Figure 4. Okanagan Annual Bat Count data. The maximum number of bats counted in the pre-pup period, by year and species, for Annual Bat Count sites in the Okanagan region that have multiple years of data. Each coloured line connects yearly counts (dots) at one site. MYLU: Little Brown Myotis; MYLU+: mixed colony with Little Brown Myotis; MYYU/MYYU+: Yuma Myotis and mixed colonies with Yuma Myotis but no Little Brown Myotis; Other: colonies of all other species or unknown species.

Discussion

Participation and support

Interest in the Annual Bat Count has been increasing, with more sites and increasing volunteer participation each year. The number of counts done by volunteers has increased each year.

There are huge benefits of volunteer involvement, including increasing the number of counts done, increasing the geographic scope of the project, and increased local awareness and stewardship. However, this dramatically increases the number of hours, and associated cost, invested by regional coordinators to train, coordinate, and follow-up with volunteers.

Increased financial support for Annual Bat Count provincial and regional coordinators is needed to ensure that priority sentinel roost sites are counted yearly. Coordination is required at the provincial level to set program priorities and goals, monitor progress, analyze results and ensure that the results are available to guide species monitoring and recovery actions. Regional coordinators need to have time to review data, contribute to or modify the priority site list generated at the provincial-level, organize volunteers and landowners, assist in conducting counts, and enter data. Without adequate time for planning and coordinating the many volunteers, sampling is left in the hands of volunteers who may or may not participate in the program, and it is unlikely that all targeted sites will be counted.

Success of the monitoring program depends on recruiting and retaining volunteers. The program currently recruits new colonies and volunteer counters through community presentations, press releases, and our website. To-date, regional coordinators have been responsible for retaining volunteers. Efforts should be made in both these areas; discussions with volunteers and coordinators in 2017 highlighted the need for follow-up and information return to keep volunteers engaged. Given funding constraints, coordinators may need to focus efforts on retaining volunteers for sentinel sites, ignoring lower-priority sites. It would be beneficial to provide training or develop guidance on how to engage and retain volunteers; a written document could be provided in the yearly information package given to regional coordinators. Small tokens of appreciation (e.g. pencils, stickers) were well-received in 2018 and should be widely provided in 2019. A summary of findings to-date has been prepared and will be emailed to volunteers in late winter/spring 2019, following the recommendations made in 2018 (Appendix 3).

An option that may reduce the demand on volunteers and coordinators is the calibration of counts by human observers with numbers of calls or files recorded by passive acoustic detectors, to facilitate monitoring purely using passive detectors. This research project is currently beyond the scope of the Community Bat Program but may be of interest to students.

Target species

Bats appear to have different vulnerabilities to WNS, based on patterns of mortality in affected species (WNS.org 2019) so species specific trends are needed to monitor impacts and recovery. The Annual Bat Count is focussed on anthropogenic structures so will only be useful for monitoring the seven BC species that regularly use structures. The Annual Bat Count has good potential to monitor population trends for at least two species. The Little Brown Myotis has now been detected at 91 sites; and Yuma Myotis at 65 sites; both are known to be susceptible to WNS.

Roost counts may also have potential to monitor additional species, if sample sizes can be increased. This is expected to occur as the Community Bat Program continues to spread and more volunteer counters are recruited. Annual Roost Counts likely will not contribute to population monitoring for the bat species which never/rarely use anthropogenic structures or are rarely documented in the province (Table 11). This includes Silver-haired Bats - there is only one report of a Silver-haired Bat in an outbuilding in summer (Craig and Isaac 2018), so this species cannot be monitored with the Annual Bat Count. Alternative approaches, such as passive acoustic monitoring at sites or mobile transects may be more useful for monitoring many of these species (Loeb et al 2015, Bat Conservation Trust 2018). Other options include expanding the roost count program to include cliff roosts for Pallid and Spotted Bats and large stable tree roosts for some other species.

Table 12. Bat species in BC and their potential for monitoring using existing Annual Bat Count protocols.

Can be effectively monitored with Annual Bat Count	Can potentially be monitored with Annual Bat Count	Not regularly in anthropogenic structures – not monitored with Annual Bat Count
Little Brown Myotis (*M. lucifugus*)	Big Brown Bat (*E. fuscus*)	Northern Myotis (*M. septentrionalis*)
Yuma Myotis (*M. yumanensis*)	California Myotis (*M. californicus*)	Western Small-footed Myotis (*M. ciliolabrum*)
	Long-legged Myotis (*M. volans*)	Silver-haired Bat (*Lasionycteris noctivagans*)
	Long-eared/Keen’s Myotis (*M. evotis*)	Hoary Bat (*Lasiurus cinereus*)
	Townsend’s Big-eared Bat (*Corynorhinus townsendii*)	Western Red Bat (*Lasiurus blossevillii*)
	*Spotted Bat (*Euderma maculatum*)	Eastern Red Bat (*Lasiurus borealis*)
	*Pallid Bat (*Antrozous pallidus*)	Canyon Bat (*Parastrellus hesperus)*
		Mexican free-tailed Bat (*Tadarida brasiliensis*)

*These species do not roost in anthropogenic structures, but could potentially be monitored at cliff sites using a similar protocol

Species identification

One ongoing recommendation to improve the Bat Count data has been to increase the number of sites with species identification. The percentage of sites with species identification has increased greatly. In 2016, only 82/190 (43%) of Annual Bat Count sites had confirmation of the species being counted, and this short-coming was identified as a significant gap in the program. Efforts were made in 2017 to incorporate older genetic and acoustic information into the database, to include information on type of data used for identification and the year the identification was made, as well as to collect and analyze guano and acoustic samples for all new sites. As a result, of 218/389 (56 %) of all sites (2012-2018) and 133/214 (62 %) of the sites sampled in 2018 now have a species identification completed or pending. At sentinel sites, 67/78 (86 %) roost sites have species identification.

It is important to note that species identification at a roost may change between years, and ideally species should be confirmed annually. Determining species from DNA in guano likely under-represents some species in multi-species roosts, especially species that represent a small percentage of bats at a roost. DNA analysis uses only one guano pellet per site so will not identify mixed roosts. This issue must be considered and addressed carefully if the Annual Bat Count hopes to track potential shifts in species composition in roosts related to WNS. Change of species may reflect a real shift in species composition but may also be a consequence of the sampling technique used to determine species. Remedies include submission and analysis of multiple guano samples per site, with associated increase in costs, and/or acoustic monitoring at the site to reveal the presence of multiple species. If multiple species are detected acoustically, multiple DNA samples could be collected in an effort to genetically confirm this conclusion and differentiate between acoustically-similar species, if necessary. Costs differ between these methods of species identification, which will factor into the approach used going forwards. Development of an eDNA-type method to confirm presence of multiple species would be beneficial.

Identification of maternity colonies

Because of the high value of conserving maternity roosts and of monitoring at these colonies, a recommendation for the program was to identify which colonies were maternity colonies, to allow focussing on these sites. We explored several methods to confirm which Annual Bat Count sites housed maternity colonies.

Maternity roosts can obviously be confirmed by sightings of live or dead pups. Pup observations are not in the database at present, and although initially optimistic about obtaining this information, few sightings of pups have been reported. The datasheet will include a ‘pups seen’ checkbox in 2019 to try and solicit reports, and roost monitors will be reminded to check below roosts for pups in late June through July.

In the absence of pup sightings, we initially proposed to identify maternity colonies by an increase from pre-pup to post-pup counts. Difficulties with this method are becoming increasingly apparent, as we gain information about frequent movements between roost sites and the rapid dispersion of colonies in July, whether from changing roost conditions or dispersion of females that failed to reproduce or were done lactating.

We hypothesized that the timing for the post-pup counts has been too late in previous years (July 22 – August 15), with bats already leaving sites in the Fraser Valley/Lower Mainland, Southern Vancouver Island/Gulf Islands, Thompson, and southern parts of the Kootenay regions. The Okanagan Region adjusted the date of the post-pup count in 2017 to promote counts earlier in July, from July 11 – August 5, instead of July 22 – August 15. This was to increase the chance that counts happen before the colony disperses. In 2018, this earlier sampling period was used across BC to try and reduce variability in counts. The change to an earlier count period made no obvious difference, with many colonies still recording decreasing counts in the post-pup period, likely due to colony movement or dispersal throughout July and August.

We also explored using a numerical cut-off of 20+ bats to define potential maternity colonies. This method resulted in a similar proportion of roosts identified as maternity colonies (62-64 %) as the pre-post pup count method, but obviously includes all large colonies in the province. The types and proportions of roost structures used were also similar between the two methods. Therefore, a numerical cut-off may be an alternate way to identify potential maternity colonies in the absence of pup sightings, and flag these colonies as potential sentinel sites to emphasize for long-term monitoring.

Potential for monitoring population trends

Population trend data is important for monitoring population changes that are expected from white-nose syndrome. Detection of statistically reliable trends depends on a number of factors including time frame, sample size, annual replicates, annual variation, etc. (Walsh et al. 2001). Variation within and between years depends in part on the degree of roost fidelity/switching by that species, with more roost switching leading to more variable data and a larger number of sites required. In the UK, knowledge of the ecology of a species is used to identify which of several survey techniques will produce the most reliable trend (Bat Conservation Trust 2018). In BC, we know very little about intra-species behavioural differences, but this knowledge would likely enhance our population monitoring efforts.

Walsh et al. (2001) recommended a minimum of five years of monitoring for trend information for United Kingdom bats due to annual variations in counts. Two years of monitoring is the minimum for using sites in trend monitoring analyses (Bat Conservation Trust 2018). Most United Kingdom (UK) bat species required between five and nine years of counts at 100 sites to detect population changes of 5% per year (26.2% change over 5 years). Roost counts for the Greater Horseshoe Bat (*Rhinolophus hipposideros*) in the United Kingdom required a sample size of around 25 roost counts and seven years to detect a population change of 5% per year but 100 roost counts to detect a change of 2.73% per year. Bat counts at hibernacula of some species in eastern North America declined by 30 – 99 % yearly after WNS arrived (Frick et al. 2010). Substantial declines, such as these, likely can be detected with shorter term monitoring and lower numbers of sample sites. Recovery rates will obviously be slower, and as in the UK, will require many sites and a long sampling duration to detect trends with high confidence.

Currently, the maximum number of known roost sites is 389 at 317 locations, with additional sites expected to be located in regions new to the program. This suggests there may be enough sites to select a suitable sample size for providing reliable long-term trend data for some bat species. However, not all sites are likely to be stable (i.e. bats may be excluded from some buildings) or accessible (i.e. if future owners choose not to participate) and some have very small counts (e.g. 2 or 6 bats) that likely are too low to contribute.

The number of sites required for detecting a trend increases substantially when there is no replication and only one count is done per year at a site. For example, *Pipistrellus* species in the United Kingdom required an additional 72 sites sample size, if only one count per year was done, compared to two counts per year, to have the same statistical power to detect change (Walsh et al. 2001). Many BC sites continue to have only one count per year; replication should continue to be emphasized in 2019, as it will likely be easier to replicate counts at existing sites than to increase sample sizes.

Methods to analyze repeated count data should be investigated (e.g. program TRIM - Trends and Indices for Monitoring data (van Strien et al 2004), Generalized Additive Models (Bat Conservation Trust 2018). and power analyses should be run to determine if counts have power to detect a pre-determined level of change. This level of change should be determined in consultation with provincial biologists and after considering the normal variation seen in counts pre-WNS.

Utility of post-pup counts in trend analysis

Examination of bat count methodology in other jurisdictions suggests that only in the UK has statistical analysis been done on count data, and that this was done using only pre-pup counts. The UK National Bat Monitoring Programme requires two pre-pup counts yearly, and emphasizes counting 2+ years to make data useful (Bat Conservation Trust 2018).

Nova Scotia bat counts promote one pre-and one post-pup count (McNeil 2014). No trend analysis has been done on the Nova Scotia data, but graphical results from a single intensely-monitored site suggest that post-pupping, counts decline very rapidly (Toms 2019). The date that colonies begin to decrease in size is variable amongst years, beginning July 9th to 20th in the 3 years monitored (Toms 2019), making it difficult to identify a standard count period that would capture the post-pup peak in numbers.

Ohio promotes one pre-pup (last week of May to third week in June) and one post-pup count (fourth week of June to end of July) (Hazelton 2018). This program began in 2017 with no analysis underway at present (Stankavich 2019).

In Wisconsin, there are two pre-pup counts in June 1 -30, and two post-pup counts mid-July to mid-August. Maximum counts at a site are used to graph trends for each site (Kaarakka 2018), but no information on statistical analysis was available. Wisconsin also promotes the Great Wisconsin Bat Count, on the first weekend in June and last weekend in July (one pre- and one post-pup count, at a very specific time).

Based on the UK model, one option for BC is to drop the post-pup count entirely, due to its variability and the difficulty in adequately capturing counts that reflect parturition and an increase in size of maternity colonies. Changing the bat count protocol to request only two counts in June will:

- Match established data collection protocols used successfully for trend analysis in the UK
- Use resources more effectively, because conducting two counts instead of four each year still achieves the goals of generating data for trend analysis, plus engagement of bat counters and roost stewards

- Allow keen counters to invest time in counting more than two times in June

Retaining both the pre-pup and post-pup counts in BC, for a total of four counts yearly, will:

- Possibly assist in identifying maternity colonies (only somewhat useful)
- Provide an enjoyable count experience, with late summer often being a nicer time to count,
- Facilitate participation of children, because they are out of school in July/August and emergence is earlier in the evening
- Reduces changes in the program, as many volunteers do not like change
- Maintain the current data set until initial analyses can be done, which may show utility of these counts.

At this time, we recommend continuing to emphasize the two pre-pup counts as priorities, while also requesting two post-pup counts if possible (see Participate in the BC Bat Count for recommendations).

Sentinel sites

Forty-nine (49) locations (encompassing 78 roost count sites) currently meet most of the criteria for establishing reliable trends and are identified as 'sentinel sites'. This total number of sentinel sites may not provide enough samples for determining a provincial trend, as it does not reach the recommend targets of 30-50 sites monitored per year per species (Walsh et al 2001). Additional sentinel sites (tentatively estimated at 25 to 50 sites, based on Walsh *et al.* 2001) need to be established in addition to the 49 existing sentinel sites to establish trends - perhaps not to detect the large declines expected from WNS, but certainly to monitor recovery. Efforts should be continued to increase the number of sentinel sites in the Fraser Valley/Lower Mainland and Sunshine Coast Regions, as regions likely to be impacted first by WNS.

Only two species (Little Brown Myotis, Yuma Myotis) may have enough sites to potentially provide species-specific trends. Little Brown Myotis, for which we have the most data, was confirmed at 47 sentinel roost sites) and Yuma Myotis at 35 sentinel roost count sites. However, some of these sites have more than one species. For species-specific trends, which are necessary if we suspect WNS will have varying impacts by species, counts at multi-species sites would ideally be able to be separated by species. Of course, if all species in a multi-species roost are expected to suffer the same mortality rate, this is not a concern. At this time, mortality rates due to WNS of Little Brown Myotis and Yuma Myotis in western North America, which commonly roost together, are unknown. With the exception of several sites where captured samples are used to estimate the proportion of each species at a site, we have no simple way to count species in multi-species sites. BC MoE initiated the development of an acoustic protocol, but the Community Bat Program does not have resources to further develop this protocol at this time.

The criteria for identifying sentinel sites (species of interest, importance of confirmation as maternity site), and methods for effectively monitoring mixed colonies (such as monitoring the proportion of each species in capture samples or in acoustic recordings) should be discussed provincially. There is also interest in sentinel sites for in-depth monitoring and research (e.g., Deas Island Burvilla Heritage House), and coordination of Annual Bat Count and other research projects would be mutually beneficial.

In 2018, 37/49 (75 %) of sites identified as high-priority sentinel sites were monitored. Reasons for sites not being monitored in 2018 included primarily lack of volunteer commitment/availability. Because the Annual Bat Count depends not only on locating roost sites but also on the participation of many homeowners and volunteers, success for long-term monitoring will require training and retaining homeowners and volunteers. As in past years, this suggests that efforts must be made in this area to improve within-year and between-year monitoring. Increased involvement by regional coordinators (including contacting landowners and/or coordinating volunteers as needed) is necessary to ensure counts occur. Coordinators are provided with a pre-filled datasheet clearly identifying priority sites, and will again be reminded to contact landowners individually to provide feedback on past counts and encourage participation.

The importance of monitoring and identification of species at sentinel sites will continue to be a target in 2019. Monitoring of priority sites can be promoted by reviewing the Bat Count goals with regional coordinators and emphasizing the need to communicate with and engage volunteers to ensure counts happen at these locations. Sites identified as lower priority/not sentinel sites will continue to be monitored for community engagement and stewardship promotion.

Variability and timing of counts

The variability between two counts in one period (either pre-pup or post-pup) emphasizes the need to conduct counts under the best possible weather conditions, to maximize bat activity and the ability of human observers to detect bats. Variation in counts may also result from bats switching roosts. It is unknown how common roost-switching is for colonies in buildings in BC. In general, building roosts are considered stable roost sites (Lewis 1995), but roost switching has been recorded for various species roosting in buildings (Whitaker 1998), bat boxes (Bartonička and Řehák 2007), and natural roosts in forests (Willis and Brigham 2004). The degree of switching may depend on species, roost structure, proximity of other roost sites, parasite loading, and environmental factors. The observed variation emphasizes the importance of conducting multiple counts to get the best possible maximum number of bats in a site.

At a provincial level, determining the timing of pre- and post-pup count periods needs to consider variation in the timing of parturition across the province and proving a long-enough period that volunteers can accomplish the counts, while restricting the count periods to times when bat numbers should be at their peak.

Variability in count results and dates of parturition were reviewed, to assess if the variability could be reduced by changing or restricting the dates of count periods. Doing more than one count in the pre-pup count period (May/June) often resulted in an increase in the number of bats observed, likely leading to a better estimate of the minimum colony size and suggesting that some of the initial counts may have occurred before all bats had returned to the roost site for the summer. The pre-pup count, from June 1 -

22, is undoubtedly before pups are volant. With parturition dates ranging from June 18 – 30, and pups seen in a roost as late as July 30, it is possible to delay this count to end in late June without potentially counting volant pups. Advantages would be ensuring that bats have returned to maternity roosts before counting; a disadvantage is that there may be a decrease in activity around parturition. As such, this count should remain June 1 -22.

The post-pup count encompasses a time when colonies begin to rapidly decrease in size, based on comparison of post-pup counts at sites and on the detailed data from sites monitored frequently (Figure 3). When two or more counts were done in the post-pup count period (July/August), numbers usually decreased between these counts, suggesting that the final count was sometimes after bats had begun departing the roost. Truncating the post-pup count to be only 2 weeks long (July 11 - 25) appears to be one option to avoid capturing the decrease in colony size, and thereby decrease variation in these counts. However, based on sightings of pups, early pups should be volant beginning July 12-20 but pups born later may not be. Truncating the count may actually miss counting volant pups, so this period should likely remain as-is (July 11 – August 4).

Program funding and feasibility

The primary source of funding to-date for the Annual Bat Count at the provincial level has been funding from Habitat Conservation Trust Foundation / Forest Enhancement Society of BC, the BC Ministry of Environment and Climate Change Strategy, and the Habitat Stewardship Program for Species at Risk. Regional bat projects may apply for and access other funds to support additional counts. As the program has expanded across the province and new sites are sought out and added to the long-term monitoring program, funding levels for this aspect of the Community Bat Program have not increased accordingly. Future growth of the program will likely be hampered by available funding. We need to secure alternate funds at the provincial level, plus encourage and support regions to apply for regionally-specific grants.

Recommendations for 2017 to 2022, progress to-date, and priorities for 2019

1. Establish a 5-year strategic monitoring program to track select bat populations in relation to the expected arrival of WNS in BC.
   - Research statistical methods for trend analysis, analyse the variation within a count period and between years, and conduct a power analysis to clearly identify sample sizes, duration of counts, etc. needed to monitor bat species in BC.
     - ✓ **Power analysis discussions initiated by BC government early 2018; ongoing discussion with BC and US FWS / NABat**
   - This is required to achieve an estimated minimum sampling duration (# years) and sample size (# sites) needed to develop statistically-useful trends by species.
   - **Discuss methods (e.g. % decrease in yearly prep-pup counts) that can be used to flag sites with declining counts**

- Modify Annual Bat Count protocols if needed to ensure counts and replicates occur in the ideal time periods
  - ✓ **Directions were modified in 2017 to prioritize obtaining two counts in the pre-pup period in June**
  - ✓ **Modification of the timing of post-pup counts in 2018 did not lead to reduced variation in counts**
  - ✓ **CBP recommends retaining all four counts until initial analyses are complete**
  - ✓ **The utility of continuing post-pup counts should be discussed provincially**

2. Ensure that sentinel sites are monitored for a minimum 5-year period, with 2 or more annual replicates, to assess population trends.
   - Sentinel sites have high numbers of bats (e.g. >150) and/or contain maternity roosts, have a high probability of long term presence (i.e. aren't likely to be destroyed) and contribute to species-specific population monitoring on a regional basis.
     - ✓ **Sentinel sites were identified as of 2017 and the list refined yearly; monitoring of these sites will be promoted**
     - ✓ **Re-assess and update criteria for inclusion as a sentinel site**
     - ✓ **Confirmation of a roost as a maternity roost is difficult; continue to seek out information on presence of pups but consider colony size as adequate surrogate**
     - ✓ **Include a check-box for 'pups see' and date on the 2019 data sheet**
   - At these sites, efforts will be made to ensure:
   a. species are confirmed through genetics and/or acoustic means,
      - ✓ **species identification is confirmed at 86 % of sentinel sites; consider re-sampling all sites with acoustics or genetics in 2019**
   b. counts continue to occur each year, and
      - ✓ **62 % of sentinel sites were monitored in 2018**
      - ✓ **volunteer communication and outreach should be emphasized to increase monitoring**
      - ✓ **in 2019, create and distribute guidelines to coordinators on how to recruit, train, and retain volunteers**
      - ✓ **Summary data on counts on each region should be prepared and provided to regional coordinators and volunteers (see point 9 below)**
   c. counts are replicated two or more times annually.
      - ✓ **early counts will be emphasized in 2019 through outreach to volunteers**

3. Increase the number of sites monitored in the Fraser Valley/ Lower Mainland (Vancouver to Hope), Sunshine Coast, and Southern Vancouver Island/ Gulf Islands regions (ideally to 30 to 40 sites per region year, if possible).
   - These are the first areas in BC that are likely to be impacted by WNS.
     - ✓ **In 2018, 120 sites were monitored in these regions, an increase from 97 in 2017**
     - ✓ **Efforts will be made to re-sample sites and identify additional sites in 2019**

4. Identify species of bats at all roost sites, particularly sites with high counts and those identified as sentinel sites, and update database.
    - This can be done by genetic sampling of guano, and/or passive or active acoustic monitoring (e.g., using RoostLoggers (Titley) or EchoMeter Touch (Wildlife Acoustics) bat detectors).
    - Acoustic sampling can identify if multiple species are present and differentiate Little Brown/Long-legged from Yuma/California Myotis. We need to confirm if acoustic recordings from passive RoostLogger deployments would be of sufficient quality to distinguish between these groups.
        - ✓**The BC government began investigating a procedure for monitoring at multi-species roosts. In 2019, continue work with the province and BCBAT to develop standard methodology for monitoring multi-species roosts**
    - Review and enter all existing DNA and acoustic data into database by year, with an identifier for 'source' of species identification
        - ✓**DNA and acoustic information has been entered into the CBP database; discussions are underway about incorporating this information into the BC WSI database**
5. Promote continuing roost counts at sites with strong volunteer support, to encourage stewardship, increase the number of multi-year samples to support detection of statistical trends, and scan for significant colonies.
        - ✓ **The number of roosts and volunteer involvement increased in 2018; ongoing efforts are needed in 2019 to retain interested homeowners and trained volunteers, to obtain multi-year samples at sentinel roosts**
        - ✓**Emphasize re-contact with an info summary, email reminders before June, and tokens of gratitude (pencils, stickers)**
6. Coordinate with broader-scale bat monitoring programs.
    - We have an ongoing dialog with the BC coordinators of the North American Bat (NABat) monitoring program (Cori Lausen and Jason Rae, Wildlife Conservation Society Canada) about including the data in NABat. Additionally, the federal BatWatch program is expanding westward. BC and/or the BC Community Bat Program should consider submitting data to the BatWatch program to allow data to contribute to national monitoring.
        - ✓**We continue to discuss merging with BatWatch**
        - ✓**Ongoing discussions with NABat biologists**
7. Establish long-term acoustic monitoring at a sub-set of sentinel sites.
    - This will increase our understanding of colony composition for mixed colonies and provide information on timing of arrival and departure of bats to guide recommendations on exclusions or renovations for other homeowners in BC
        - ✓**Will require funding and partners to develop an effective program**
8. Develop and distribute questions to bat count participants to determine the effect of participation in bat counts on their intent and actions to protect roost habitat for bats

- Questions can be easily incorporated as part of the data form used for monitoring
    - ✓**Questions may be incorporated into an updated data form for 2019**

9. Prepare outreach-quality, simple regional summaries about the topics presented here at the provincial level, for use by regional coordinators and distribution to volunteers and landowners. These may already be available for the Kootenay and Okanagan regions. Topics should include:
    a. level of volunteer involvement
    b. number of counts and for which species, to identify regions that require more roost counts for effective species monitoring
    c. # of sampling years per site, level of recruitment of sites into a multi-year monitoring program
    d. multi-year trends by species to identify sites where data has not been continuously collected and may require extra attention (e.g. landowner follow-up, recruitment or organization of volunteers)
        - ✓**A provincial summary has been completed; regional summaries and trends will be provided in future versions**
        - ✓**Improve tracking of volunteer effort in 2019 for more accurate reporting - add a space on datasheet to indicate number of volunteers involved**
10. Seek out new funding sources to support the growing Annual Bat Count.

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Appendix 1. Sentinel sites for ongoing monitoring

See Methods for criteria for listing as a Sentinel Site. Sites in bold font are within 250 km of the 2016 and 2017 WNS detection sites.

Sentinel Site ID	Monitored in 2018	Comments 2018	Region	Species	Maximum count
1		Dropped – not monitored since 2016, no landowner interest	BC – other	MYLU	57
67	**yes**	**New in 2018**	**BC – other**		**2474**
3	Yes		Cariboo	MYLU/MYVO	651
4	yes	Bella Coola – contact by phone	Cariboo	MYYU	213
25	Yes		Cariboo	MYLU	293
26	Yes		Cariboo	MYLU	301
27			Cariboo	MYLU	298
28	Yes		Cariboo	MYLU	114
29	Yes		Columbia Shuswap	EPFU	27
49	Yes	**No data submitted as of Dec 2018**	**Fraser Valley / Lower Mainland**	**MYLU/MYYU**	**3340**
53	Yes		**Fraser Valley / Lower Mainland**	**MYLU/MYYU**	**820**
54	Yes		**Fraser Valley / Lower Mainland**	**COTO**	**414**
64	**Yes**		**Fraser Valley / Lower Mainland**	**MYLU**	**273**
65	**Yes**		**Fraser Valley / Lower Mainland**	**MYLU**	**160**
66	**Yes**		**Fraser Valley / Lower Mainland**		**1006**
9	Yes	Population boom 2018	Kootenay	MYYU	5878
10		Dropped – not monitored since 2015, no landowner interest	Kootenay	MYLU	1050
11	Yes		Kootenay	MYLU/MYYU	2113
12		Dropped – not monitored since 2015, no landowner interest	Kootenay	EPFU	36
13	Yes		Kootenay	MYLU/MYYU	1345
32		Dropped – not monitored since 2015, no landowner interest	Kootenay	MYLU	157
33	Yes		Kootenay	MYLU	357
34		Dropped – not monitored since 2015, no landowner interest	Kootenay	MYYU	279
36		Dropped – not monitored since 2015, no landowner interest	Kootenay	MYLU	251
37		Dropped – not monitored since 2015, no landowner interest	Kootenay	MYLU	217
38			Kootenay	MYLU	199
39			Kootenay	MYLU	170
40		Dropped – not monitored since 2016, no landowner interest	Kootenay	MYYU	282
41	Yes		Kootenay	MYLU	191
42			Kootenay	MYYU	213
43		Dropped – not monitored since 2015, no landowner interest	Kootenay	MYYU	295
44		Dropped – not monitored since 2013, no landowner interest	Kootenay	MYYU	270
45			Kootenay	MYLU	131
47			Kootenay	MYLU	170

55	Yes		Kootenay	MYLU	4500
58			Kootenay	MYLU/MYYU	351
15	Yes		Okanagan	MYLU/MYYU	1708
16	Yes		Okanagan	MYLU/MYYU	1396
17	Yes		Okanagan	MYLU	103
57	Yes		Okanagan	MYLU/MYYU	343
61	Yes		Okanagan	MYLU	832
62	Yes		Okanagan	MYLU/MYYU	423
63	Yes		Okanagan	MYLU/MYYU	532
48			Peace	MYLU	150
22	Yes		Skeena	MYLU	146
23		Original building demolished, condo not counted according to protocols	Skeena	MYYU	1020
24			Skeena	MYLU	283
52			Skeena	MYLU	267
51	Yes		Sunshine Coast	MYCA	170
8	Yes		Thompson	MYLU/MYYU	382
2		Dropped – Courtenay, not monitored since 2016	Vancouver Island / Gulf Islands		198
6	Yes		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**581**
7	Yes		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**1195**
14	Yes		**Vancouver Island / Gulf Islands**	**MYVO**	**115**
30	Yes		**Vancouver Island / Gulf Islands**	**MYYU**	**62**
31	Yes		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**1120**
46		**Dropped – at Spider Lake, outside of HAT's area, not monitored since 2016**	**Vancouver Island / Gulf Islands**		**573**
50	**Yes**		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**1117**
56	**Yes**		**Vancouver Island / Gulf Islands**	**MYLU/MYYU /EPFU**	**731**
59	Yes	Nanaimo	Vancouver Island / Gulf Islands	MYLU/MYYU	356
60			**Vancouver Island / Gulf Islands**	**MYYU**	**541**

Appendix 2. Yearly trends

Maximum bat counts in the pre-pup period, by year, region, and species. Colours represent different roost sites; dots are counts and lines connect counts across years. 'Other' includes counts from Northern Vancouver Island, Skagit, and Prince George.

Species categories are: MYLU (colonies with Little Brown Myotis), MYLU+ (colonies with Little Brown Myotis and other species, usually Yuma Myotis), MYYU/MYYU+ (colonies with Yuma Myotis or Yuma Myotis and other species but NOT Little Brown Myotis), and Other (colonies with other species, other mixed species, and where species is unknown).

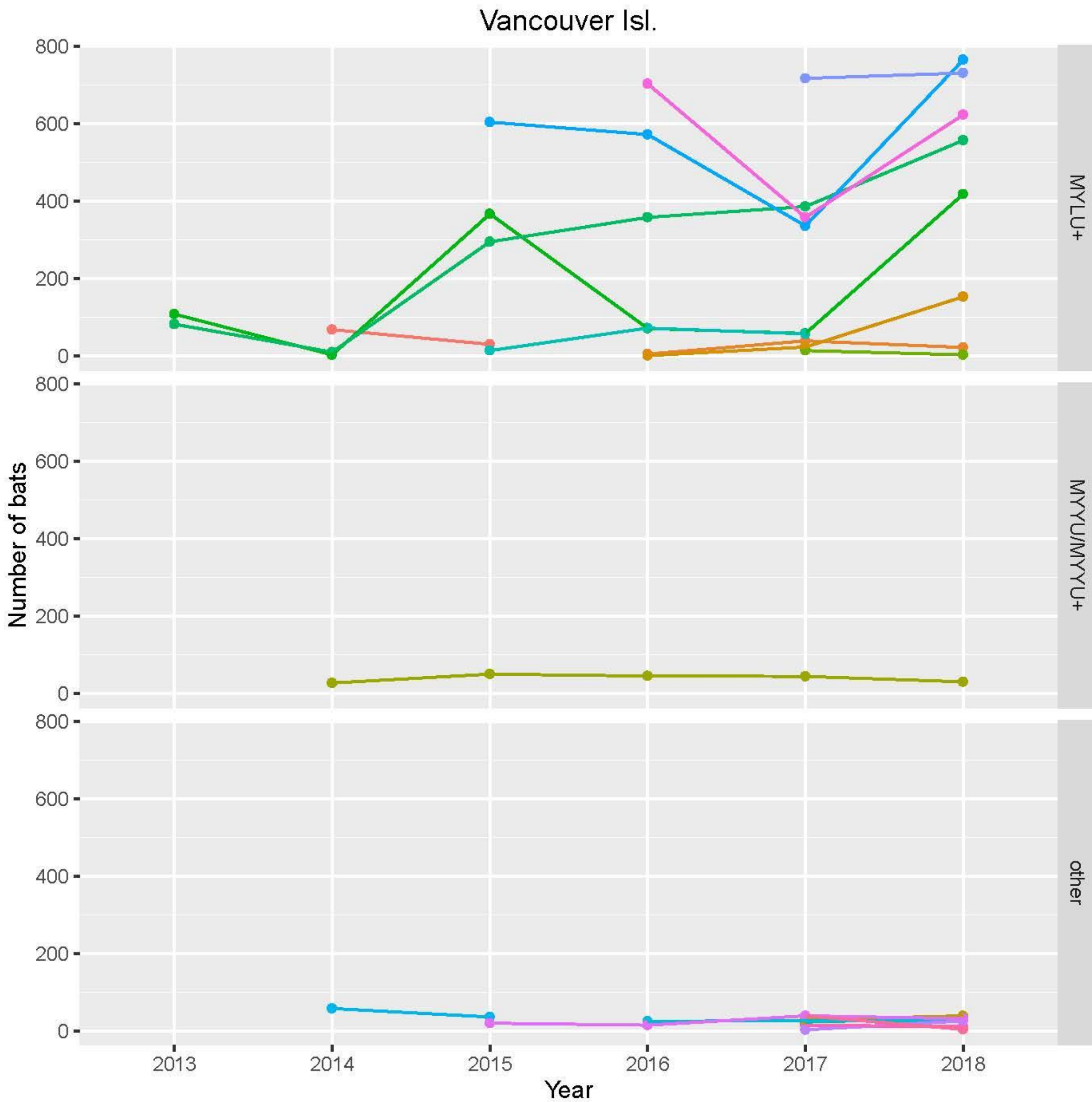


Figure 5. Vancouver Island Region trends in maximum pre-pup counts.

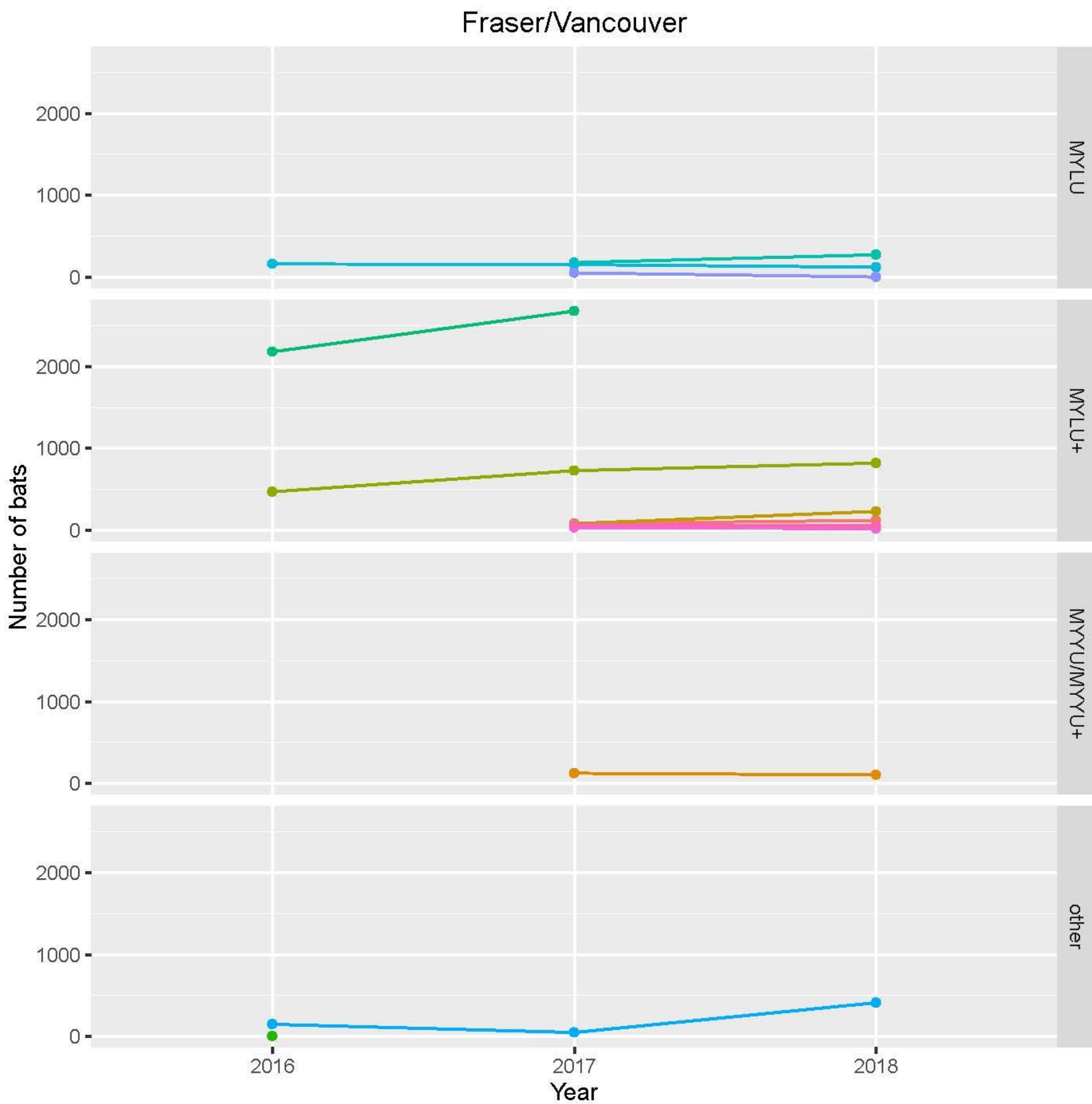


Figure 6. Fraser Valley/Vancouver Region trends in maximum pre-pup counts.

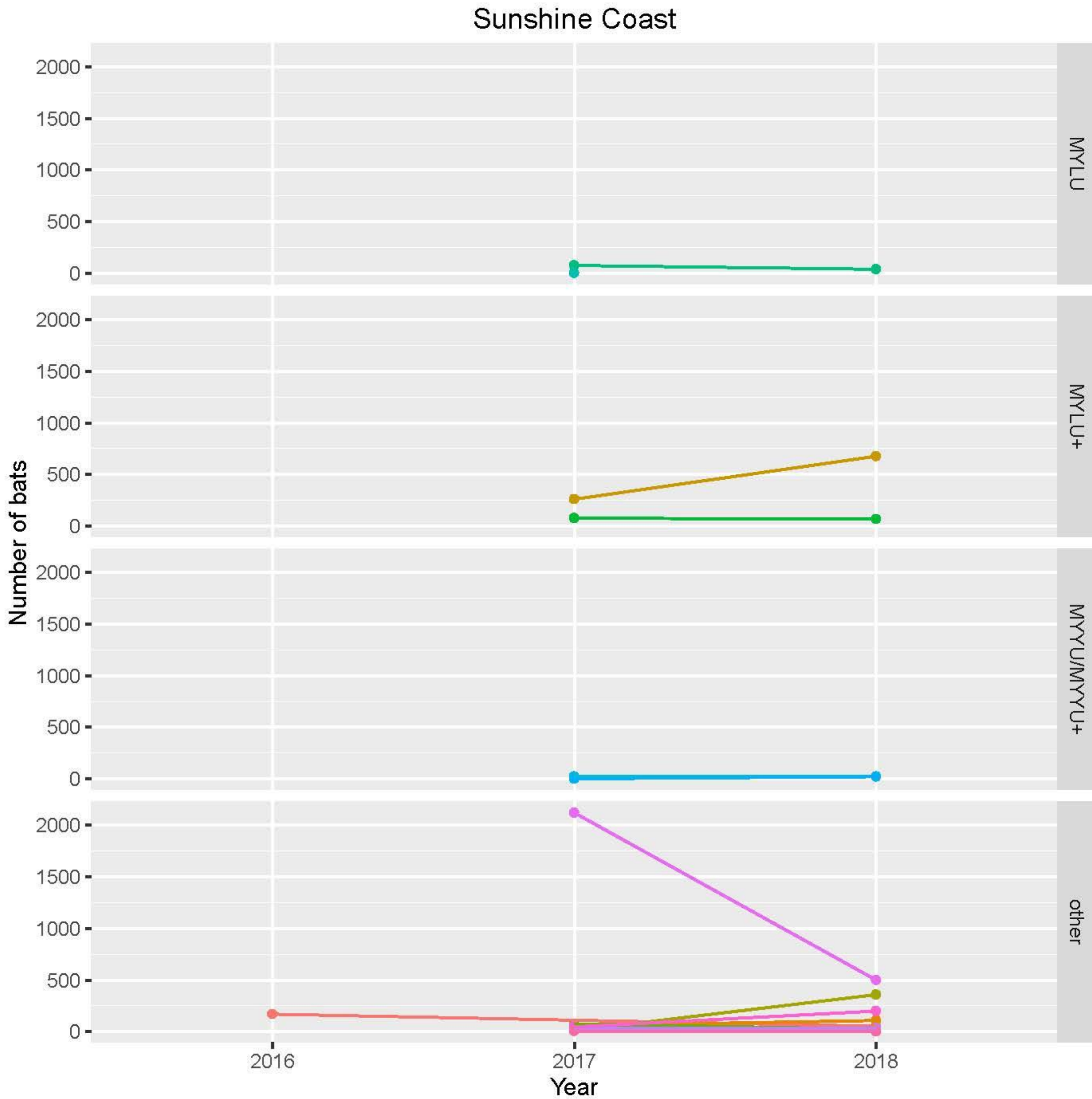


Figure 7. Sunshine Coast Region trends in maximum pre-pup counts.

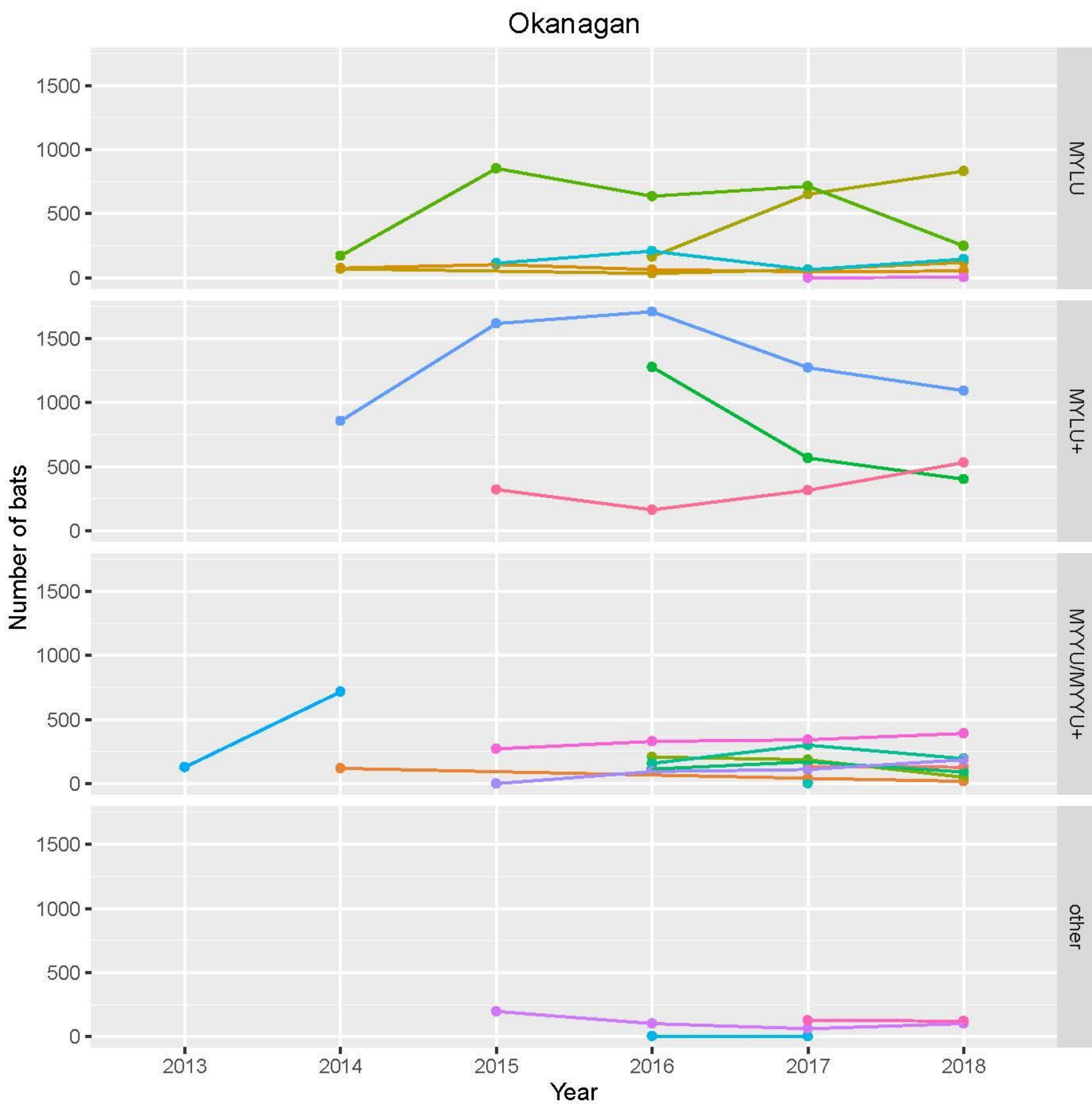


Figure 8. Okanagan Region trends in maximum pre-pup counts.

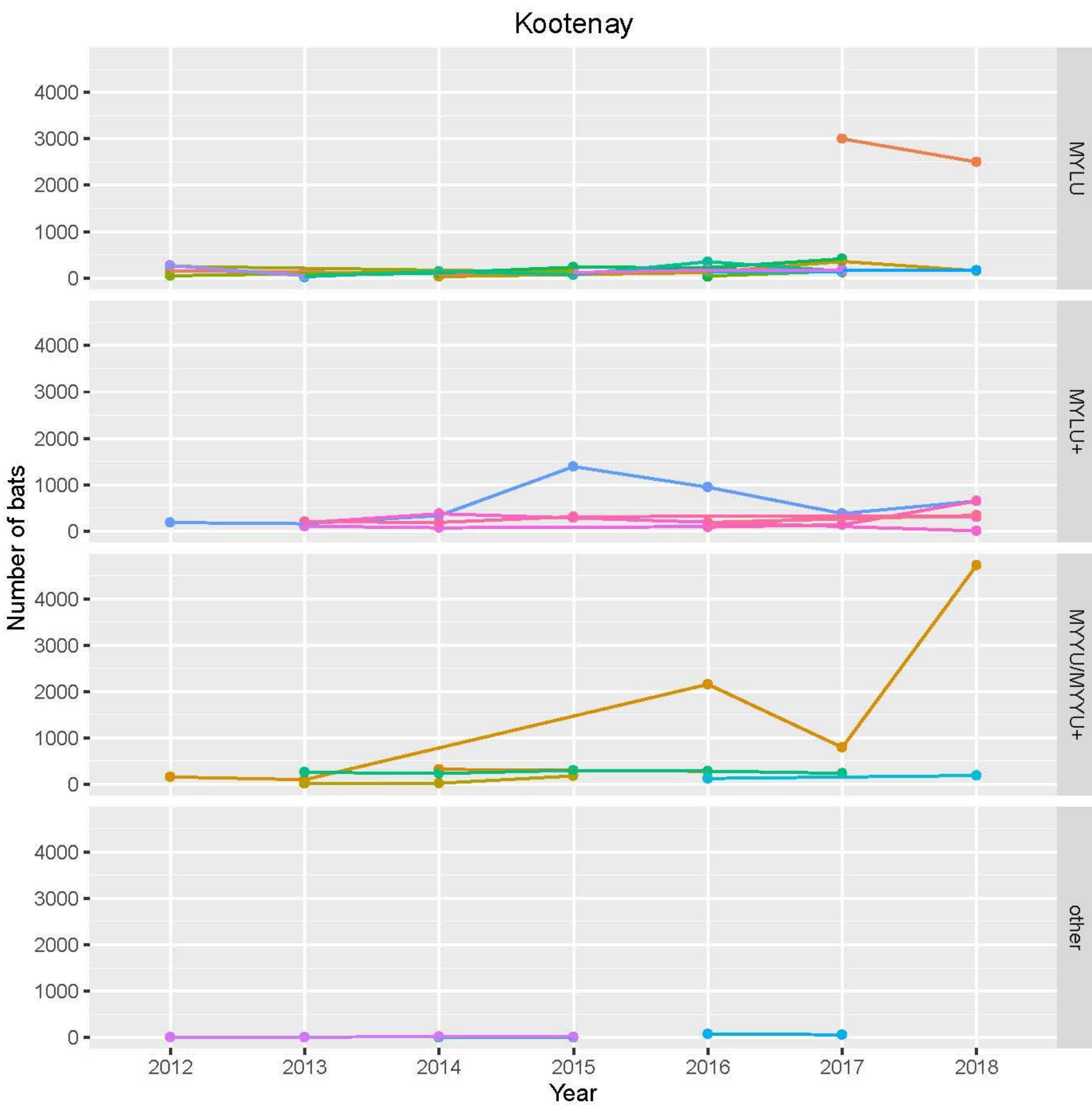


Figure 9. Kootenay Region trends in maximum pre-pup counts.

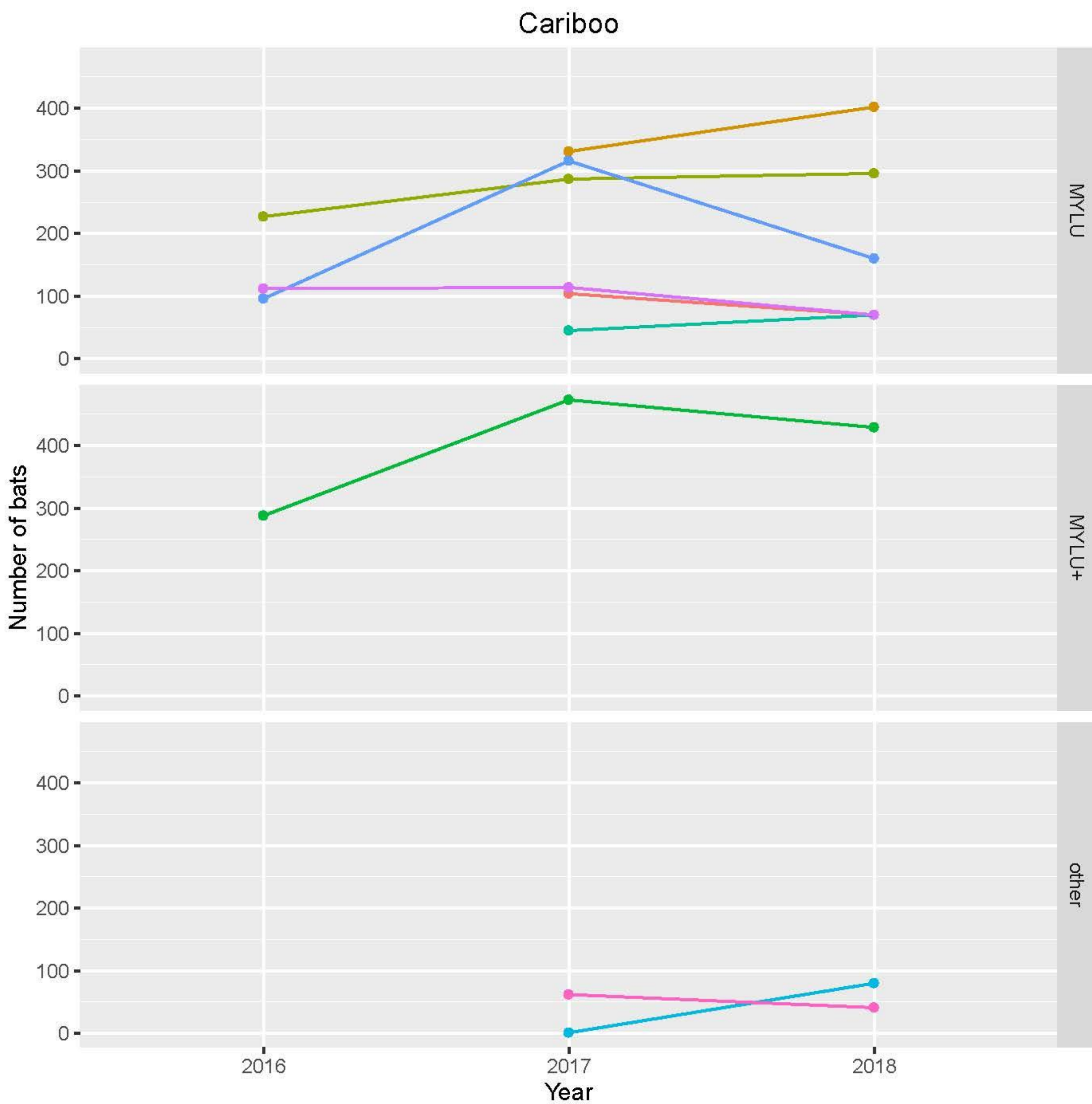


Figure 10. Cariboo Region trends in maximum pre-pup counts.

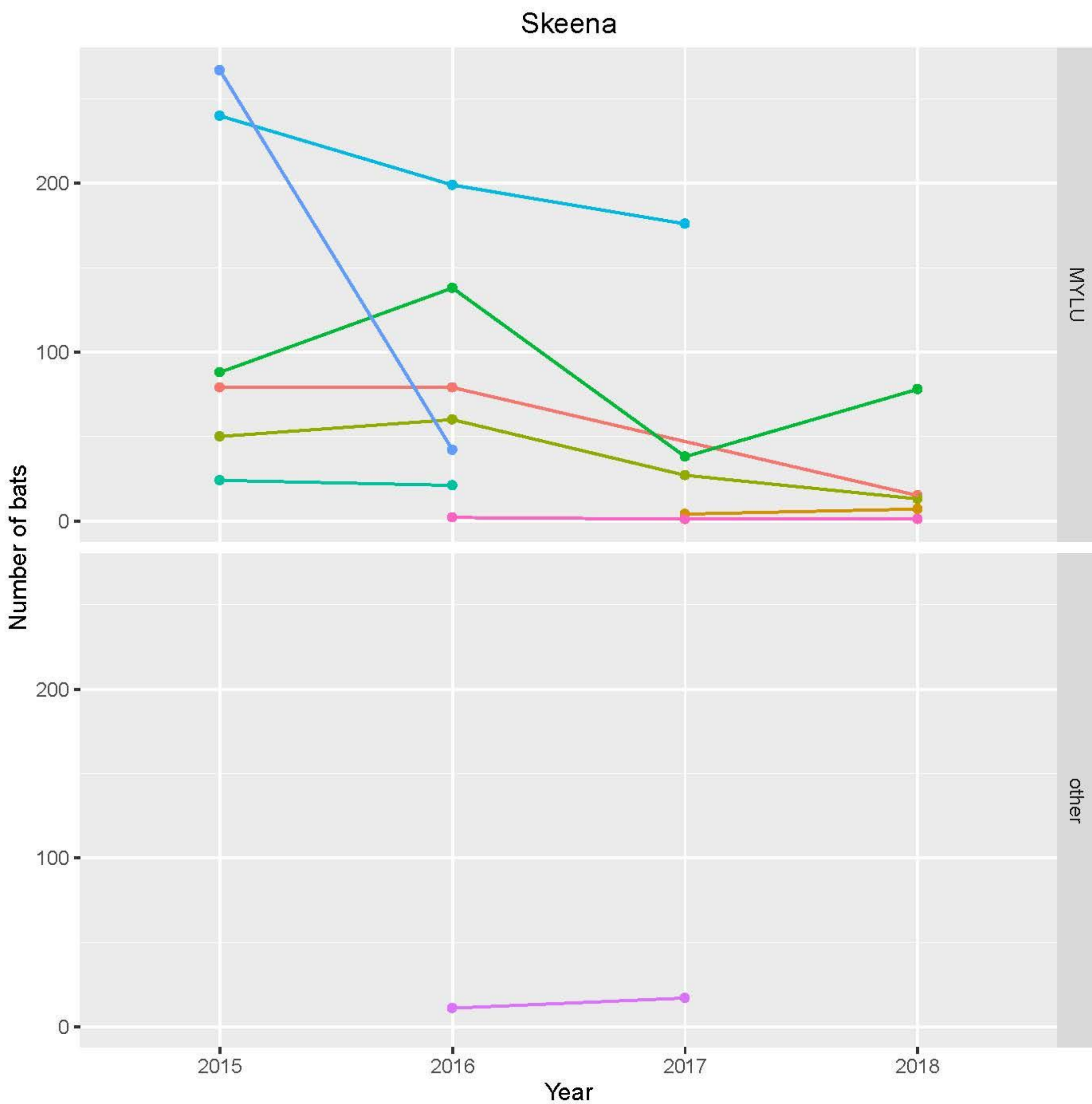


Figure 11. Skeena Region trends in maximum pre-pup counts.

Note: The olive green line and the dark green line are both bat houses at the same location – decreases in one site (Olive Green line) may reflect increases at the other site (Dark Green).

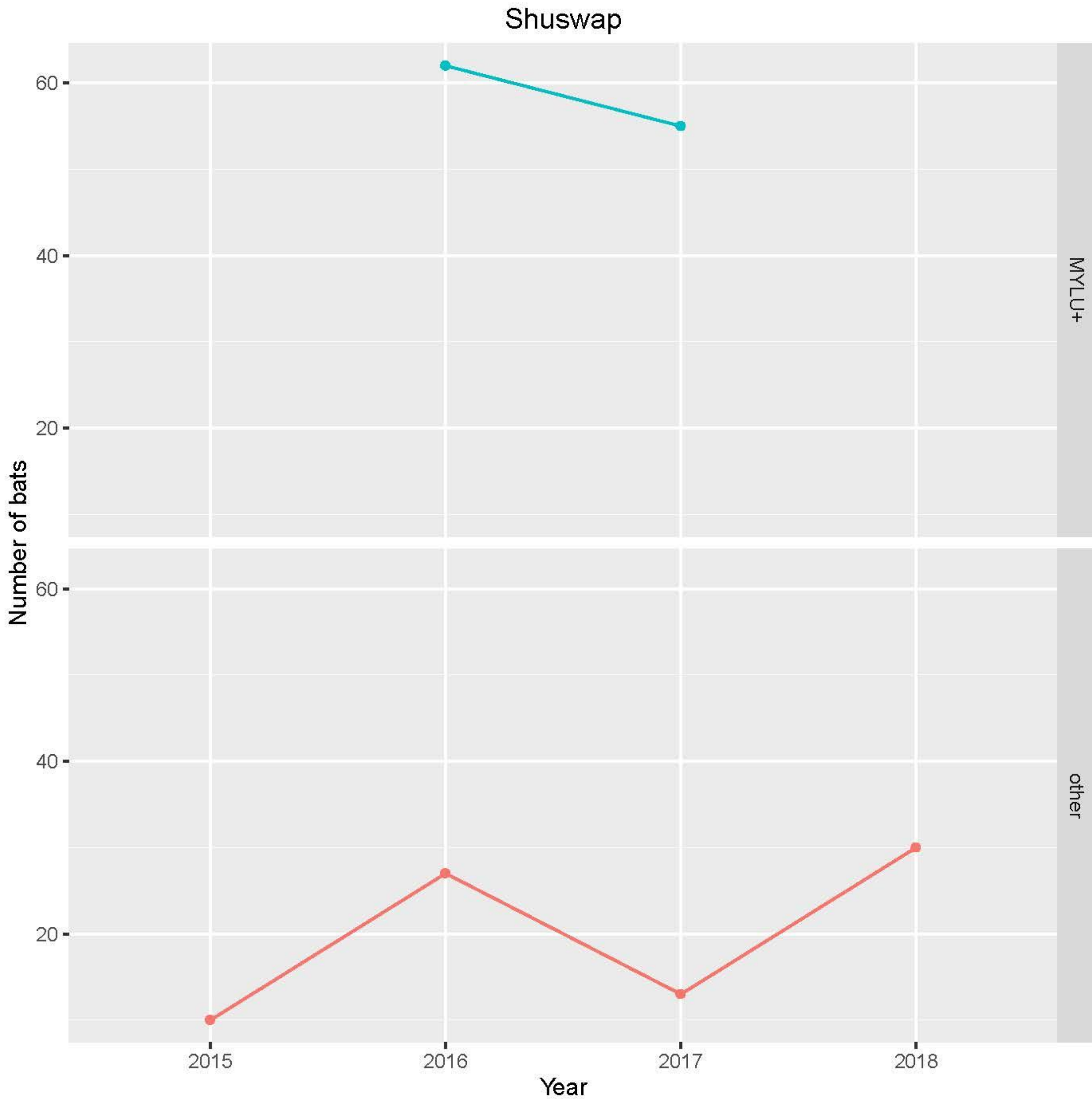


Figure 12. Shuswap Region trends in maximum pre-pup counts.

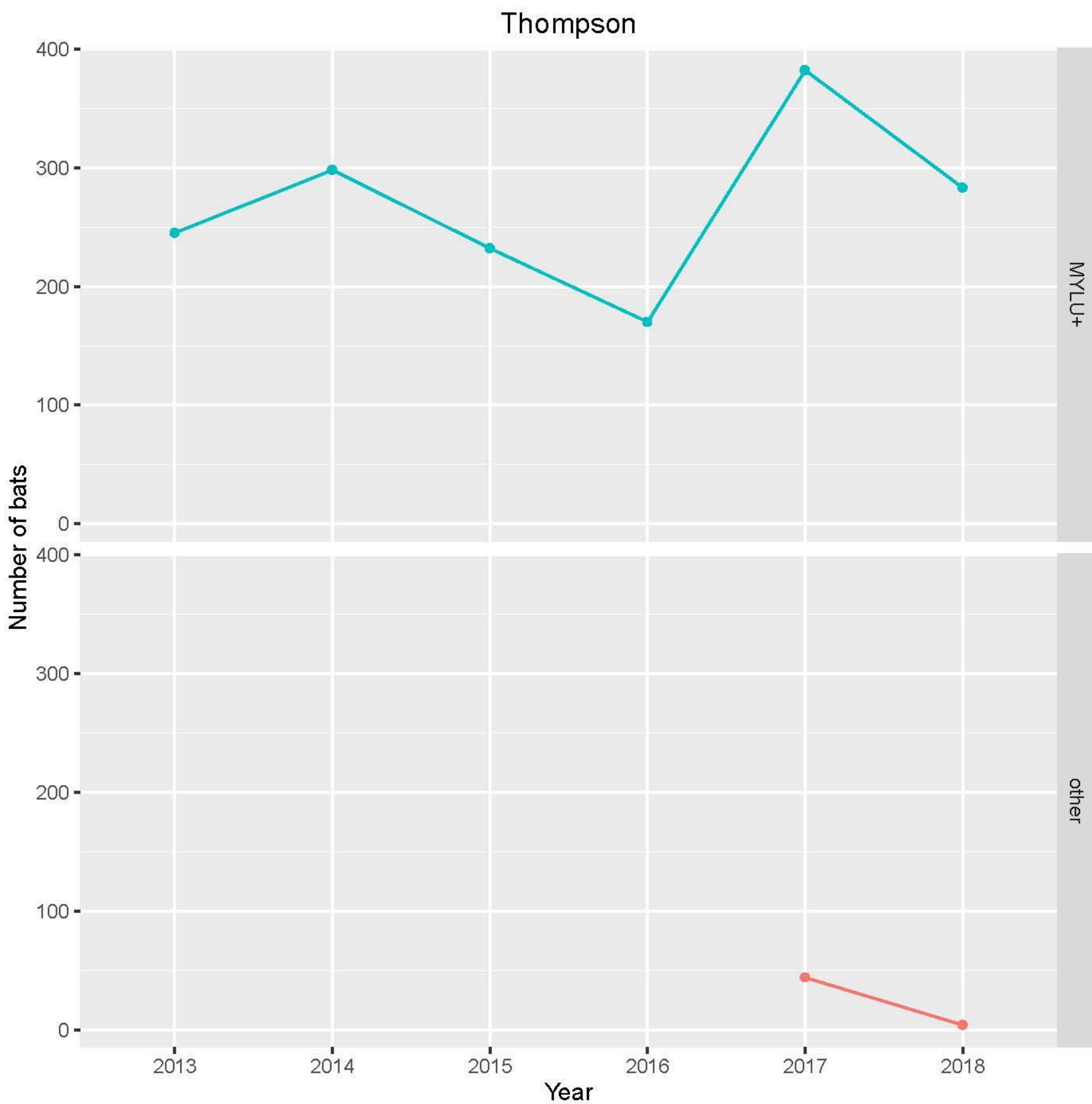


Figure 13. Thompson Region trends in maximum pre-pup counts.

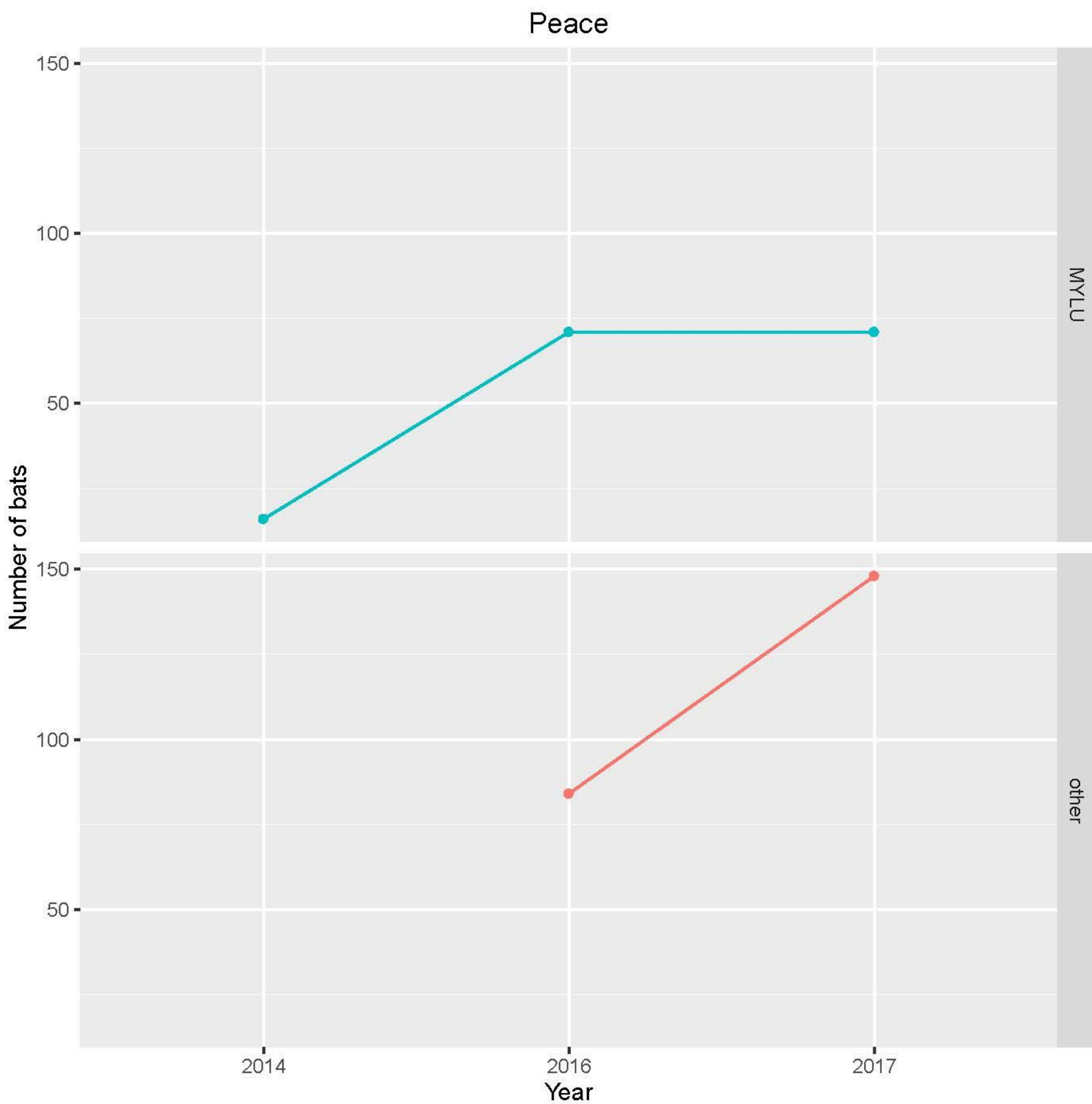


Figure 14. Peace Region trends in maximum pre-pup counts.

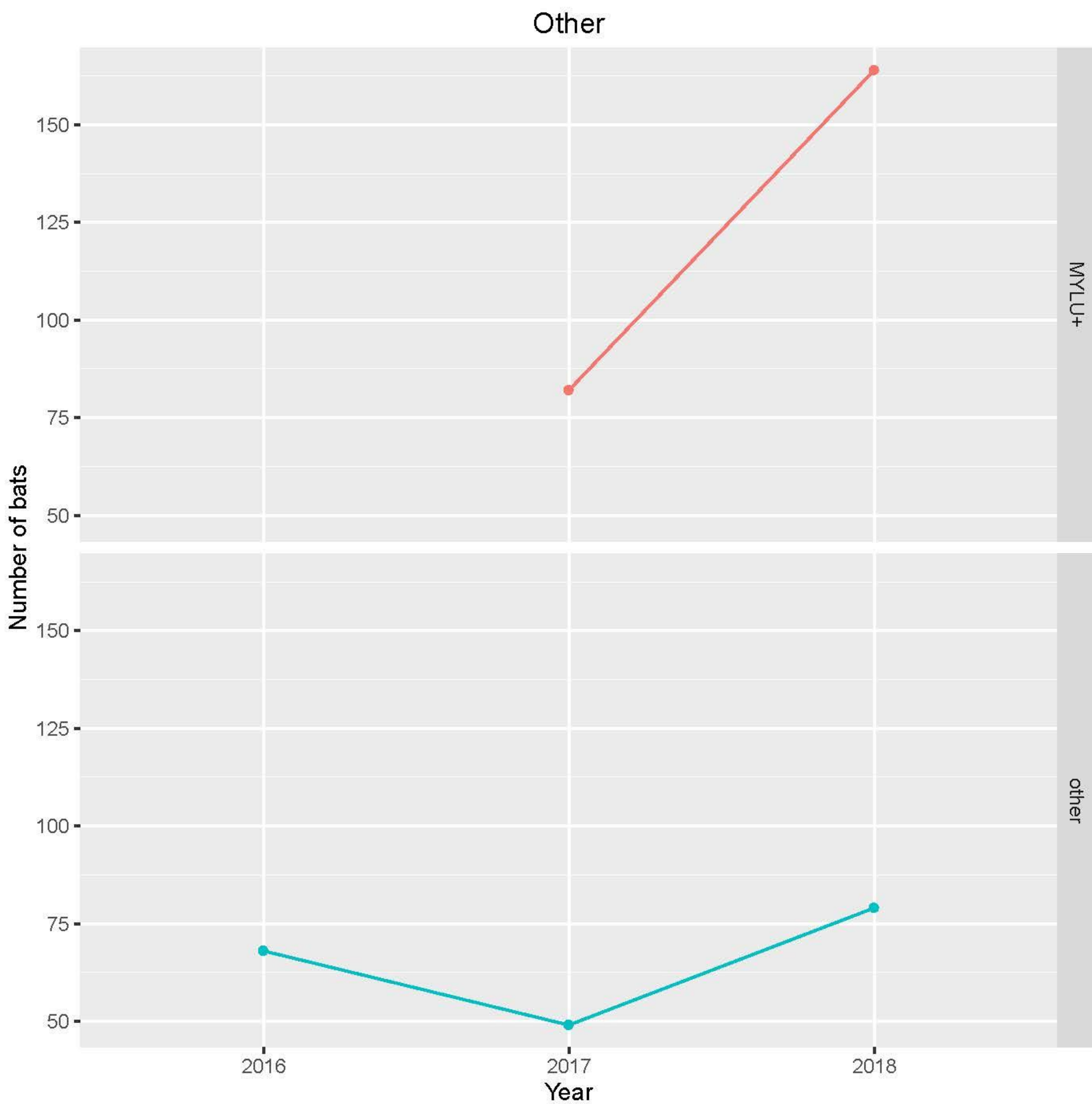


Figure 15. Other Region trends for maximum pre-pup counts.

Appendix 3. Summary for volunteers

BC COMMUNITY BAT PROGRAM

BC Annual Bat Count Summary 2018

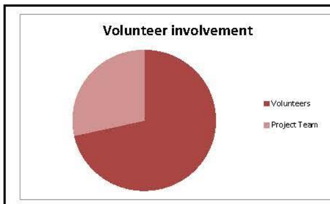
Why counting bats is important

The BC Annual Bat Count is a summer emergence count of bats at day roosts in human-made structures (e.g. houses, barns, bat houses). Begun in 2012, we now have data on seven bat species at 389 sites around the province.

Annual Bat Count data is a key part of our provincial bat monitoring program. It is important to monitor bats because bats face a wide variety of threats, including habitat loss, increasing severity of fires, and wide-scale mortality from White-nose Syndrome. Human activities have large potential to cause declines or to support bat populations. Monitoring will inform our policies and actions to protect and conserve our bats. No private landowner information is passed along when the count results are shared.

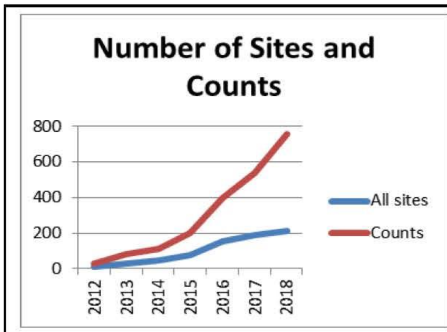
Number of volunteers

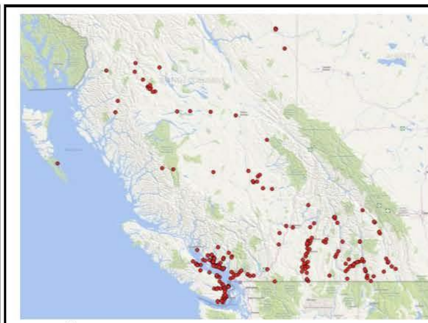
The BC Annual Bat Count continues to grow! In 2018, volunteers donated **613 volunteer-nights**, participating in **540 bat counts**. In fact, the majority of the counts were done by volunteers across the province.



Number of sites

In 2018, there were a total of 755 counts done at 389 roost sites.

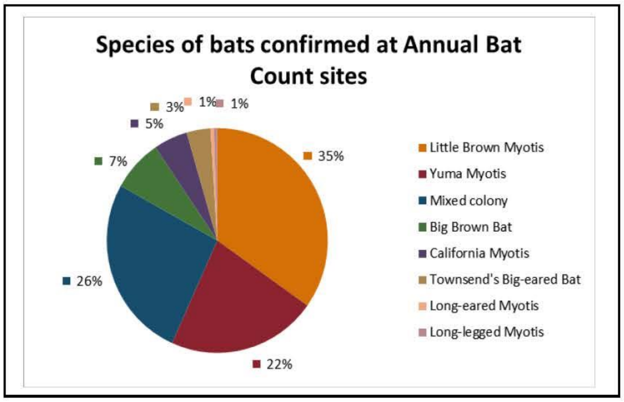




Annual Bat Count sites across BC

Species of bats

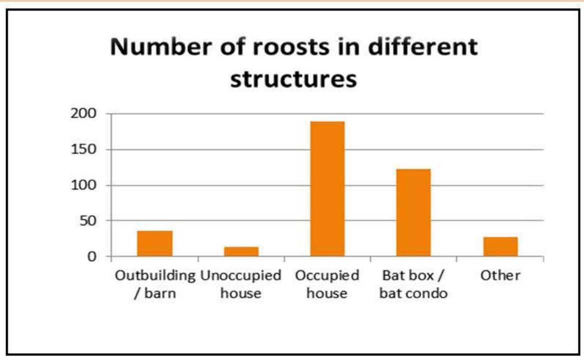
Seven species have been identified at sites counted in the Annual Bat Count. Most common are the Little Brown Myotis and Yuma Myotis. Mixed colonies, with more than one species present, are also common. More information about these species can be found on our website or in the Bat-friendly Communities Guide.



There are 201 sites where we know the species of bat living there. If you have a roost and do not know what species of bat lives there, you can submit a guano sample following the directions on our Bat Count page, or contact the BC Community Bat Program Coordinator.

Structures used by bats

Most roost sites are located in occupied houses (189 sites; 49%) and bat boxes or bat condos (123 sites; 32%). Bat colonies are also monitored in outbuildings/barns, unoccupied houses, and other structures (churches and bridges).



Trends at count sites

While not statistically analyzed yet, the Annual Bat Count data set can illustrate trends in populations. Stay tuned for information on how bat colonies in your region are doing.

Thank-you for counting! We look forwards to your 2019 results!
Visit: www.bcbats.ca Annual Bat Count

HABITAT CONSERVATION TRUST FOUNDATION
FESBC Forest Enhancement Society of British Columbia
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British Columbia Conservation Foundation
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