British Columbia Community Bat Program Annual Bat Roost Counts (2012-2017)

Update: February 2018

Photo: V.Rezniak.

Prepared by

Mandy Kellner

Coordinator, BC Community Bat Program

February 23, 2018

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 (BC) 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 – 2017, is growing each year, and has data on seven bat species at 256 sites.

Key successes of the Annual Bat Count in 2017 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, identification of new large colonies to monitor as sentinel sites, an increased proportion of sites where the species of bat has been identified by genetics or acoustics, and improvements to the Bat Count database.

This report provides a summary of the data available to-date, to identify gaps and prioritize future data collection efforts. Review of the data 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 include:

- research analyses methods and do a power analysis to determine the number of sites required,
- re-assess criteria for sentinel sites,
- improve sample sizes in all regions and for all species. We need to:
    - locate additional sites, especially in regions where WNS is expected to arrive,
    - increase temporal replicates per site, and
    - increase retention of single-year sites into the long-term monitoring program,
- identify species at all sentinel sites,
- gather reports of live or dead pups to confirm if sites are maternity roosts,
- improve retention of interested homeowners and volunteers through communication and outreach, and
- prepare and distribute simple regional summaries for regional coordinators and volunteers.

To achieve current Annual Bat Count objectives and address the recommendations for 2018, 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 acoustic monitoring equipment, acoustic analysis, and DNA 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 must be secured.

Conducting Annual Bat Counts

Table of Contents

List of Tables

List of Figures

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 Bat (*M. septentrionalis*), now listed by the Species at Risk Act (SARA) as endangered in Canada (B.C. Conservation Data Centre 2018). 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 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 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 2017) is beginning to collect data potentially useful for long-term monitoring. In British Columbia (BC), BatWatch has not yet been formally adopted. However, 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 and now spans the province. One facet of the Program is the Annual Bat Count, which are 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 local

Community Bat Project. 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 Counts have 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 field season (Kellner and Dyer 2017).

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 2017 and any recently-available data from 2016 or earlier,
2) assess the success of the program in meeting the recommendations made before the 2017 field season, and
3) continue to provide recommendations to improve the program, in order 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, 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. Finally, the Annual Bat Count could not occur without our many dedicated volunteers, who brave insect swarms and late nights to collect data for the program. We especially thank Juliet Craig and the Kootenay Community Bat Project, who started the Annual Bat Count in BC.

Methods

The Annual Bat Count is a repeated summer emergence count at day roosts in anthropogenic structures (e.g. houses, barns, bat houses). These roost sites are usually identified through the work of the BC Community Bat Program. Regional Coordinators conduct, and promote volunteer participation in, 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 a location, with each site being counted separately and ideally on the same night. For example, an attic roost with 2 bat boxes in the yard would be 1 location with 3 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.

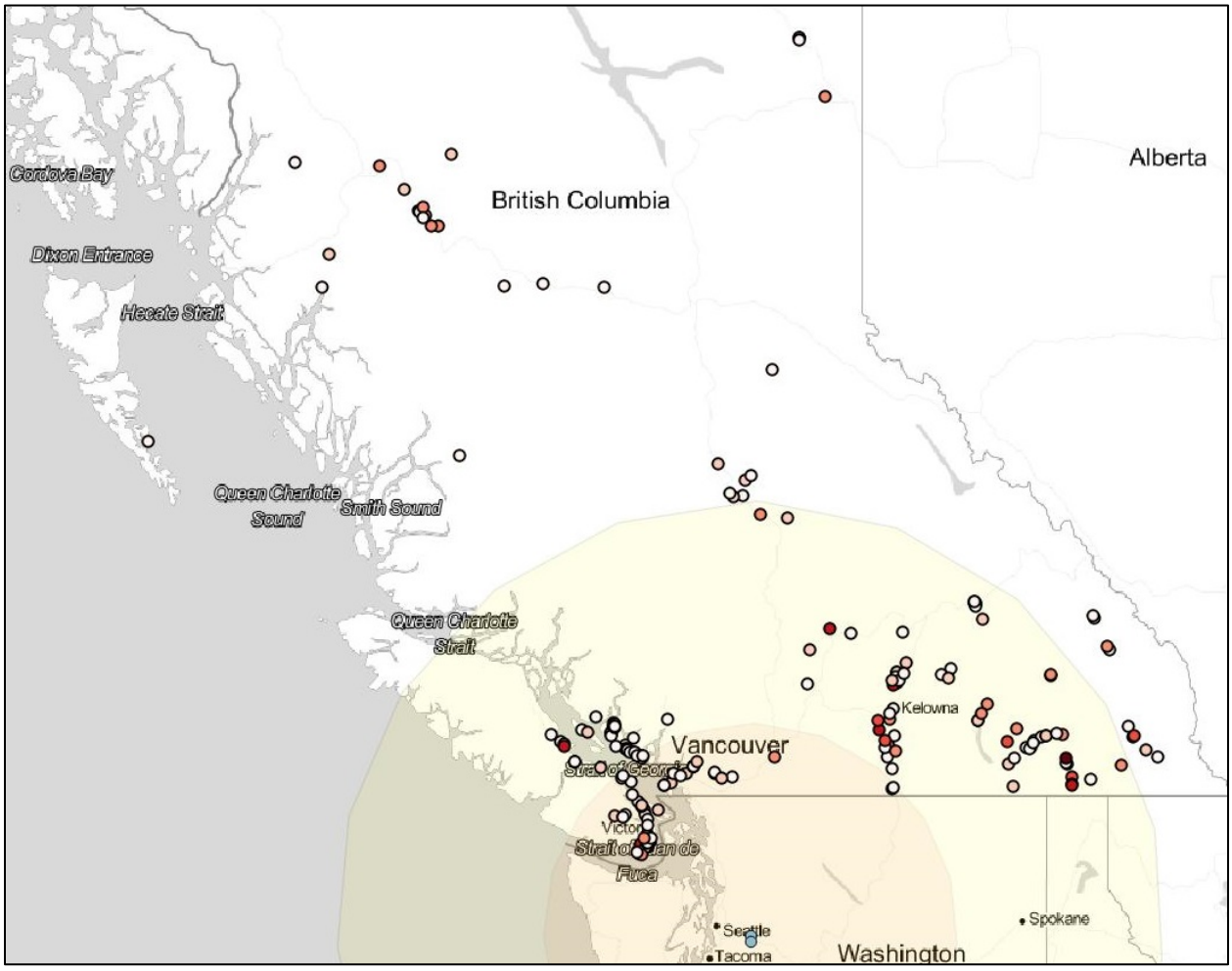

Figure 1. Map of sites sampled in Annual Bat Roost Counts (2012 to 2017). Colour of dot represents the number of years sampled, from white (1 year) to dark red (6 years). The 2016 WNS detection sites in Washington are in blue; within 250 km is shaded orange, within 500 km is shaded yellow.

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 (before pups can fly). These counts are the highest priority, to be consistent with North American Bat Monitoring Program (NABat) protocols. Two more counts are recommended between July 21 and August 15 (when pups are flying and exiting the roost with their mothers). The Annual Bat Count is meant to be repeated yearly, 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 Species Inventory Database (SPI)[1]. Detailed methods can be found on our website[2] .

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. Species identification may also be done by qualified biologists through identification of dead bats or live capture by mist-netting.

The use of a site as a maternity roost can be confirmed by sightings of pups. To-date, this information has not been requested from volunteers and regional coordinators and is not available for the majority of sites. Because we do not have confirmation about roost type from pup observations, we used an alternate method to identify maternity colonies. The maximum counts from pre-pup and post-pup sessions were compared, and sites where the maximum count increased between sessions used to identify potential maternity colonies.

Variation in pre-pup and post-pup counts was investigated by looking at the percent change in the number of bats counted, which considers changes relative to colony size. The formula used for percent change between two counts in a session (either pre-pup or post-pup) was: (count 2 – count 1)/ count 1 *100 %.

In March 2017, we created a list of priority 'sentinel' sites in BC to prioritize monitoring efforts in June 2017 and to promote as long-term monitoring sites (Kellner and Dyer 2017). 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 score, within region. Ranked sites were then reviewed by provincial and regional coordinators to confirm landowner/counter 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 within a session. 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 counters,
- 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).

[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.

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, and 418/470 counts (90%) in 2017. The number of volunteer-nights was a minimum of 465 in 2016 and 430 in 2017.

Number of sites and counts

One thousand, two hundred and eighty-eight (1288) counts were conducted at 257 sites between 2012 - 2017 (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	113
2015	54	75	201
2016	119	152	396
2017 *	106*	142*	470*
Unique locations, sites and counts, all years	203	257	1288

* data is not complete at time of report preparation

Number of sampling years

Sites have been monitored for between one and six years (Table 2), leading to the start of a long-term dataset. As of 2017, twenty-two sites have three years of data, fourteen sites have five years of data, and only one of the 257 Annual Bat Count sites currently has six years of data.

Table 2. The number of roost sites that have from one to six years of count data, and the retention of sites each year.

Number of Years Counted	Number sites counted in 2016	% of total 2016	Number of sites counted in 2017	% of total 2017
1	136	71	156	61
2	34	18	45	17
3	12	6	32	12
4	7	4	9	4
5	1	1	14	5
6			1	1
Total	190		257	

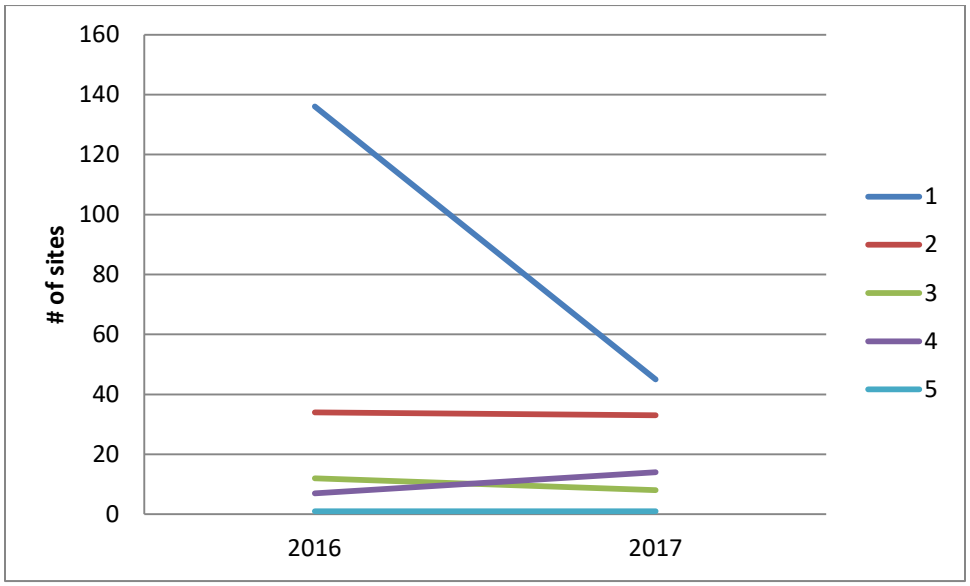

Figure 2. The number of sites monitored for a given number of years (n) in 2016 and n+1 years in 2017, showing the drop in monitoring sites after 1 year of counting.

There is a marked decline in the number of sites monitored for one and two years (Figure 2) – in 2016, there were 136 sites monitored. In 2017, there were only 45 sites that had been counted twice. This suggests that sites counted for one year are rarely retained in the Annual Bat Count and offers an obvious area where improvements can be made. Once a site has been monitored for two years, it appears likely to stay monitored.

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
Cariboo			1	1	9	15
Columbia Shuswap				1	6	7
Fraser Valley/Lower Mainland				1	11	20
Haida Gwaii				1		
Kootenay	10	20	20	31	25	24
Okanagan		3	14	15	26	27
Other					3	1
Peace			1		3	3
Skeena				11	13	8
Southern Vancouver Island/Gulf Islands[1]		7	7	12	22	35
Sunshine Coast					31	
Thompson		1	1	2	3	2
All sites	10	31	44	75	152	142

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

Structure type

Most roost sites were located in occupied houses (123 sites; 48%) and bat boxes or bat condos (90 sites; 35%) (Table 4).

Table 4. Type of structure monitored during the Annual Bat Count, 2012-2017, by region.

Region	Unoccupied house	Occupied house	Outbuilding / barn	Bat box/ bat condo	Other[1]	Unknown	Total
Cariboo	0	7	3	8	0	0	18
Columbia Shuswap	0	3	0	7	0	0	10
Fraser Valley/ Lower Mainland	1	9	5	6	1	0	22
Haida Gwaii	0	0	0	0	1	0	1
Kootenay	4	21	3	24	0	0	52
Okanagan	1	17	7	20	0	0	45
Other	0	2	0	1	0	0	3
Peace	0	1	0	3	0	0	4
Skeena	0	11	1	5	0	0	17
Southern Vancouver Island/Gulf Islands	0	26	2	13	4	5	50
Sunshine Coast	0	25	4	1	1	0	31
Thompson	0	1	1	2	0	0	4
Total	**6**	**123**	**26**	**90**	**7**	**5**	**257**

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

Bat species documented in anthropogenic structures

Annual Bat Counts occur at bat colonies in anthropogenic structures so provide data on bat species that use these structures. Seven species of bat were confirmed as using anthropogenic structures as roosts in BC (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). Little Brown Myotis use artificial structures more than any other bat in BC (Table 6) and occur at 92/168 (55%) of sites with confirmed species identification. They most often roost without other species (51 sites) but commonly co-roost with Yuma Myotis (26 sites) and sometimes co-roost with Big Brown Bat, Californian 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 68/168 (40 %) of sites. They often roost without other species (31 sites) or co-roost with Little Brown Myotis (26 sites) and occasionally co-roost with other species including Big Brown Bat, Californian Myotis and Townsend's Big-eared Bat (Table 6).

Funding from the BC Government in March 2017 and historical DNA results increased the number of sites with species identification compared to 2016 data. As of 2017, 145 (56 %) of 257 sites, counted since 2012, have confirmed species identification, and 23 sites have results pending, for a total of 168 (65 %) of sites with species identification (Table 6). The proportion of sites with species identification has increased from 2016, when species identification was known at 78 (41 %) of the 190 sites sampled. Some sites have not been visited for several years and it is unlikely that the bat species using these sites will ever be determined. At new sites, species identification is necessary to support effective monitoring.

Of the 142 sites sampled in 2017, 103/142 (73 %) have a species identification. This will increase, possibly to 126/142 (89 %), once lab results are received, and we expect the proportion of sites with known species identification to continue to increase in the future as unidentified colonies are targeted for id.

The proportion of sites with confirmed species identification is greater at the high priority sentinel sites identified prior to the 2017 season and targeted for id (Kellner and Dyer 2017). At these locations, 46/50 locations (92 %) have a species identification. For the 60 draft sentinel sites identified for 2018, all but five of the sentinel sites (55/60, 92 %) (77/89, 86 % of roost count sites) already have species id confirmed or pending. The remaining sentinel sites and associated roost sites without species identification should be communicated to regional coordinators and targeted for species confirmation in 2018.

Table 5. Species, number of roosts monitored, and regions found, for bat roost sites in anthropogenic roost structures.

Species	Number of roost sites with confirmed species identification[1]	**Regions**
Little Brown Myotis	92	All
Yuma Myotis	68	Cariboo, Columbia-Shuswap, Fraser Valley / Lower Mainland, Kootenay. Okanagan, Southern Vancouver Island/Gulf Islands, Sunshine Coast, Skeena, Okanagan, Thompson
Big Brown Bat	13	Cariboo, Columbia-Shuswap, Fraser Valley / Lower Mainland, Kootenay, Okanagan, Peace, Skeena, Southern Vancouver Island/Gulf Islands
California Myotis	14	Sunshine Coast, Southern Vancouver Island/ Gulf Islands
Townsend 's Big-eared Bat	7	Fraser Valley / Lower Mainland, Kootenay, Southern Vancouver Island/ Gulf Islands, Sunshine Coast
Long-eared Myotis[2]	2	Skeena, Southern Vancouver Island/Gulf Islands
Long-legged Myotis	2	Cariboo, Southern Vancouver Island/Gulf Islands
Total	198[1]	

[1] Note that more than one species can occupy the same roost site.
[2] These Long-eared Myotis may be Little Brown; re-sampling recommended.

Table 6. Species assemblages and the number of roosts found for each species and species group, at 257 anthropogenic roosts in BC.

Species in roost	Number of roost sites	% of all roost sites
Little Brown Myotis	51	20
Little Brown Myotis / Big Brown Bat	2	< 1
Little Brown Myotis / Long-legged Myotis	1	< 1
Little Brown Myotis / Yuma Myotis	26	10
Little Brown Myotis / Yuma Myotis / Big Brown Bat	3	1
Little Brown Myotis / Yuma Myotis / California Myotis	7	3
Little Brown Myotis /Long-eared Myotis	2	< 1
Yuma Myotis	31	12
Long-eared Myotis	1	< 1
Long-legged Myotis	1	< 1
California Myotis	6	2
California Myotis / Yuma Myotis / Townsend's Big-eared Bat	1	< 1
Townsend's Big-eared Bat	5	2
Townsend's Big-eared Bat / Big Brown Bat	1	< 1
Big Brown Bat	7	3
No ID	89	35

TBD	23	9
Total	257	

Identification of maternity colonies

Pre-pup and post-pup counts were available at 285 year-site combinations, at 162 sites. There were 104/162 (64 %) roost sites that had an increase in maximum counts from pre-pup to post-pup sessions in at least one year, suggesting that 104 these sites are maternity colonies. Maternity colonies were found in all types of structures used as roost sites, with the greatest number in occupied houses (52/104, 50 %) and bat boxes / bat condos (36/104, 35 %) (Table 7).

Fifty-one (51/104, 49%) of these maternity colonies sites were confirmed as Little Brown Myotis alone or a mix with other species; 30 sites have no species identification is missing (19 sites) or pending (10 sites) (Table 8). Little Brown Myotis maternity roosts were mainly in occupied houses (28/51, 55%) but also in bat boxes/ bat condos (14/51, 27%) (Table 8).

Table 7. Summary of roost sites by structure type and colony type for 162 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	Non-maternity	Maternity (# sites)	% of structure type housing a maternity colony	% of all maternity roosts in a given structure type
Unoccupied house	3	1	2	67	2
Occupied house	80	28	52	65	50
Outbuilding /barn	14	5	9	64	9
Bat box/ bat condo[1]	58	22	36	62	35
Other[2]	6	2	4	66	4
Unknown	1	0	1	100	0
Total	162	58	104		
%		**35.8**	**64.2**		**100**

[1] Includes both occupied and unoccupied bat boxes.

[2] 'Other' includes 'Church', 'Tree', and 'Other' categories.

Table 8. The number of sites monitored for each species or species group, by structure type, for 104 maternity colonies. 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	Townsed's	Townsend's / Big Brown	Big Brown	TBD	NoID	Sum	**% of total with Little Brown**
Unoccupied house	**0**	**1**	0	0	0	0	0	1	0	0	0	2	**0**
Occupied house	**18**	**10**	4	2	1	2	0	0	0	4	12	52	**54**
Outbuilding/barn	**2**	**3**	1	0	0	0	2	0	0	0	1	9	**56**
Bat box/ bat condo[1]	**5**	**9**	9	0	0	0	0	0	2	6	5	36	**39**
Other[2]	**1**	**2**	0	0	0	0	1	0	0	0	0	4	**75**
Unknown	**0**	**0**	0	0	0	0	0	0	0	0	1	1	**0**
Total	**26**	**25**	14	2	1	2	3	1	2	10	19	104	**49**

[1] Includes both occupied and unoccupied bat boxes.

[2] 'Other' includes 'Church', 'Tree', and 'Other' categories.

Identification and monitoring of high priority sentinel sites

In 2017, fifty (50) locations were identified as sentinel sites, or highest priority for ongoing monitoring. Many of these locations contain multiple roost sites in close proximity (e.g., Sun-Oka Provincial Park – four bat boxes), so these sentinel sites encompass 90 individual roost count sites. New sentinel sites have been identified in the Fraser Valley/Lower Mainland, Kootenay, Vancouver Island/Gulf Islands, and BC-Other regions (Appendix 1). The total number of sentinel sites is now 60 sentinel sites encompassing 89 roost count sites, used by six species (Table 9). Little Brown Myotis are confirmed at 37 of these sentinel sites, at 60 roost count sites. Yuma Myotis are confirmed at 27 sentinel sites, at 35 roost count sites. Results form 2017 DNA testing will likely increase these numbers.

Thirty-one (31/50, 62%) of the sentinel sites identified in 2017 were successfully monitored in 2017 (Appendix 1). Forty-two (42/60, 70 %) of the sites identified for 2018 were monitored in 2017. Reasons for not monitoring at priority sites included poor timing of monitoring efforts (2 sites) and no response from landowners (17 sites).

Table 9. Number of sentinel sites and associated roost count sites by species.

Species in roost	Sentinel sites	Roost count sites
Townsend 's Big-eared Bat	1	1
Big Brown Bat	2	2
California Myotis	1	1
Little Brown Myotis	22	25
Little Brown / Long-legged	1	1
Little Brown / Yuma	12	16
Little Brown / Yuma / Big Brown	2	2
Long-legged Myotis	1	1
Yuma Myotis	13	17
TBD[1]		11
NoID[1]		12
Total	60[2]	89

[1]TBD – to be determined – samples are currently being tested. No Id – no testing has occurred.
[2]Totals do not add up because sentinel sites may have multiple species identified at component roost sites.

Variability within years

Pre-pup counts

One hundred and ninety-eight (198) unique site/year combinations had multiple counts in the pre-pup sampling period (June) for 2012 to 2017. In total, there were 451 repeated counts done across the 198 site/year combinations. Using the maximum count from each site/year combination,

For the 198 site/year combinations where multiple pre-pup counts were available, the average difference between counts was an increase of 4 bats from the first to the second count. However, there was large variation between the pre-pup counts, with the standard deviation of the difference was +/- 136 bats. Sixty-eight (68, 34%) cases had a decrease in bats between the first and second counts, 27 (14%) were identical (these sites usually had a small number of bats), and 103 (52%) increased. The difference between the first and second counts ranged from a decrease of 740 bats (count 1 = 948, count 2 = 208) to an increase of 526 bats (count 1 = 202, count 2 = 728). Expressed as a percent change of the original count value, to reflect colony size, the average percent change in pre-pup counts was an increase of 158 ± 1023 % (Figure 2).

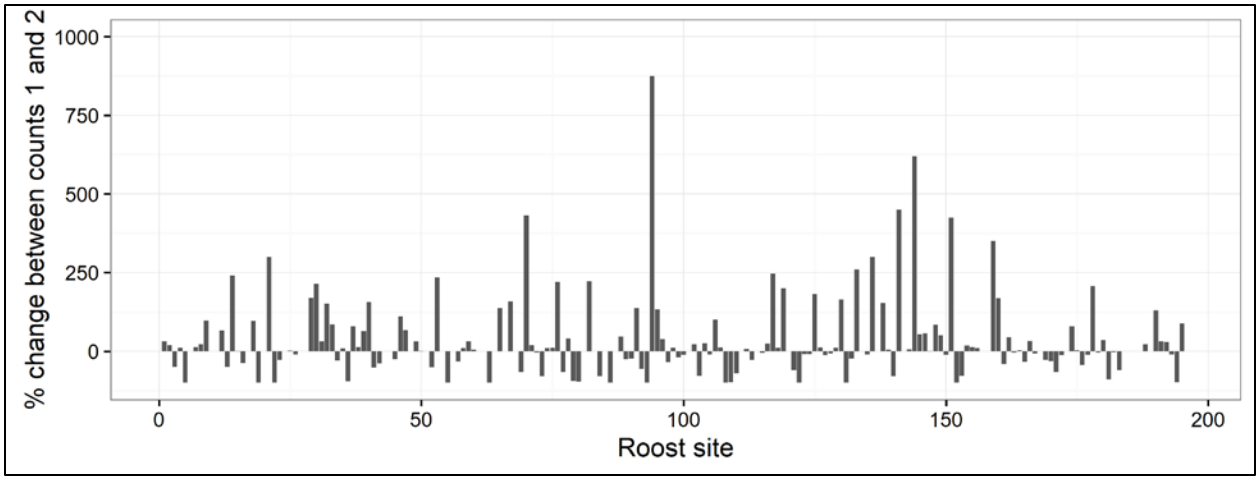

Figure 3. Percent change between the first and second counts in the pre-pup session. Four cases had a % change greater than 1000 % and were excluded from the graph for clarity.

Post-pup counts

Two hundred and one unique (201) unique site/year combinations had multiple counts within a year in the post-pup session (July/August) from 2012 - 2017. There were 483 repeated counts done across these 201 site/year combinations.

For the 201 site/year combinations where multiple post-pup counts were available, the average difference between counts was -40 bats from the first post-pup count to the second post-pup count at a site, in one year. There was larger variation between these repeated post-pup counts than was recorded between pre-pup counts - the standard deviation of the difference was +/- 200 bats. However,because colonies were larger, the average percent change in colony size between post-pup counts was + 4 ± 4 % (Figure 4).

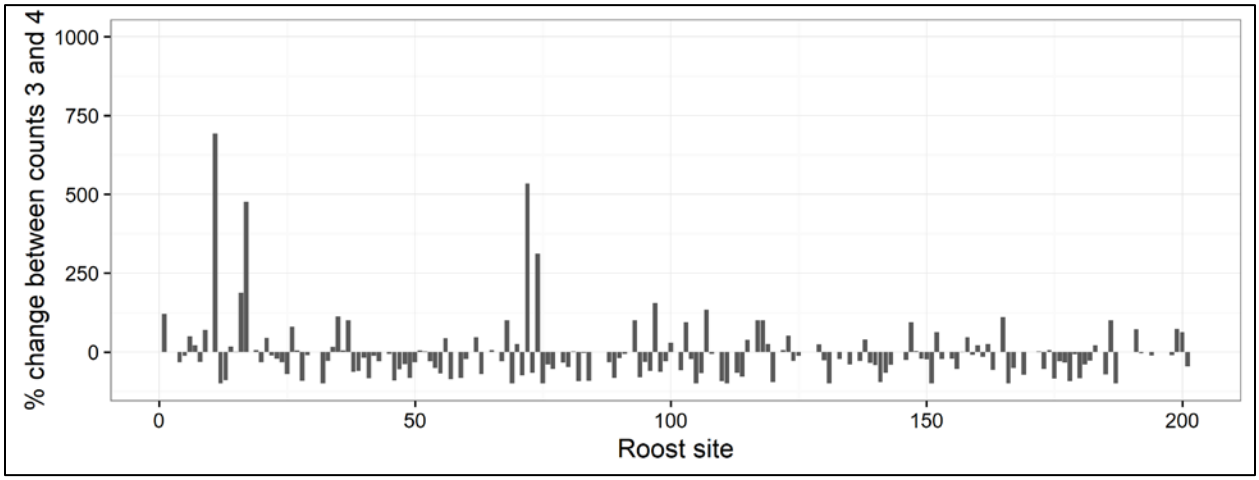

Figure 4. Percent change between the first and second counts in the post-pup session.

Trends across years

Eighty sites now have multiple years of counts. These 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 (e.g., Figure 8, Appendix 2). The Okanagan data on maximum pre-pup counts (Figure 8) showed an increasing number of sites recruited for long-term monitoring and the dropping of one large MYYU colony in 2014 – in this case, this site had an exclusion done and alternate habitat installed and monitored, and no landowner/volunteer follow-up is required. No drastic declines in pre-pup counts are apparent.

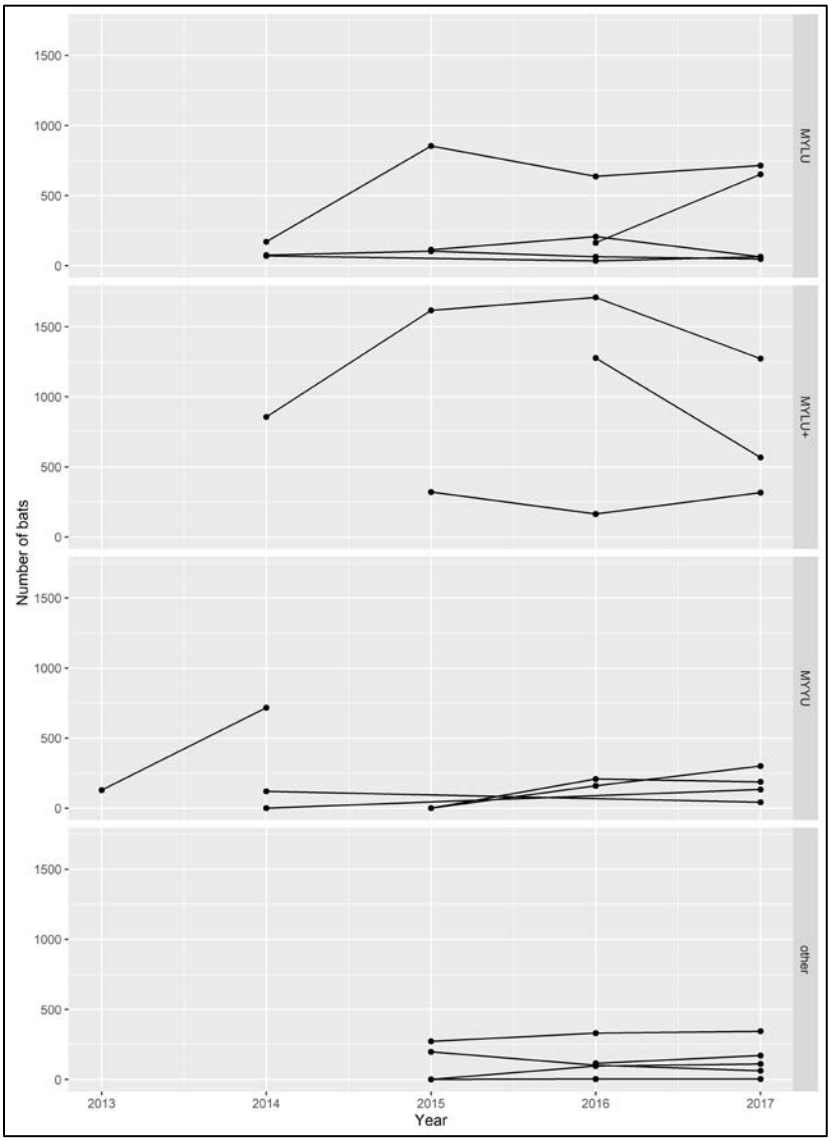

Figure 5. Okanagan Annual Bat Counts. The maximum number of bats counted in the pre-pup session, by year and species, for Annual Bat Count sites in the Okanagan region that have multiple years of data. Each line connects yearly counts at one site for one species. MYLU: Little Brown Myotis; MYLU+: mixed colony with Little Brown Myotis; MYYU: Yuma Myotis and mixed colonies with Yuma Myotis but no Little Brown Myotis; Other: colonies of all other 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. 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 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.

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 2017) (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 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.

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 10). The NABat Monitoring Progam, which uses passive acoustic monitoring at sites or transects, may be more useful for monitoring many of these species. 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 10. 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 (*C. 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

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 168/257 (65 %) of all sites (2012-2017) and 103/142 (73 %) of sites sampled in 2017 now have a species identification completed or pending. At sentinel sites, 77/89 (86 %) of 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. This issue must be considered and addressed carefully if the Annual Bat Count hopes to track potential shifts in species composition in roosts. 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 – DNA analysis uses only one guano pellet per site so will not identify mixed roosts. 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 (sampling strategy with suitable size is needed) 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.

Identification of maternity colonies

Maternity roosts can be identified most confidently by sightings of live or dead pups. Pup observations are not in the database at present. This data gap will be addressed in 2018 by a) getting regional coordinators to review site lists to identify any where there have been observations of pups, and b) ensuring all counters will be asked to look for and report the presence of pups in the post-pup season.

For our purposes, maternity colonies were identified by an increase from pre-pup to post-pup counts. This method could be modified to require an increase of a certain percent in the pre-pup counts to qualify as a maternity colony. Manually reviewing the results identified colonies that are likely maternity colonies but are data-deficient (no pre-pup and post-pup counts within the same year). Sites where the post-pup counts were surprisingly small were also identified. At these sites, the timing for the post-pup counts may be too late, with bats already leaving the site. These sites occur in the Fraser Valley/Lower Mainland, Southern Vancouver Island/Gulf Islands, Thompson, and southern parts of the Kootenay regions. The Okanagan Region already adjusts the date of the post-pup count to promote counts July 11 – August 5, instead of July 22 – August 15, which should be considered for these regions.

Manual review also revealed that some large colonies did not get identified with this method – these may have been sites where non-reproductive individuals left the colony earlier than females that successfully had pups. Earlier count dates or inspection for pups may be useful to confirm that these are maternity colonies.

Identification of sentinel sites

The number of sentinel sites currently identified does not reach the recommend targets of 30-50 sites monitored per year per species (Walsh et al 2001). Little Brown Myotis, for which we have the most data, was confirmed at 31 sentinel sites (60 roost counts sites). However, some of these sites have more than one species and count numbers are not separated by species. For species-specific trends, which are necessary if we suspect WNS will have varying impacts by species, counts for multi-species sites must be separated by species.

For all species, more sentinel sites are therefore required, although perhaps not to detect the large declines expected from WNS. 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. However, adjustment of the criteria for sentinel sites could be beneficial, including lowering the necessary colony size, including maternity colony status, and including all active sites of species of interest (e.g. those known to be susceptible to WNS or to carry Pd). The criteria for identifying sentinel sites, as well as 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

interest in sentinel sites as colonies where in-depth monitoring and research occurs (e.g., Deas Island Heritage House), while the Annual Bat Count list of sentinel sites aims to identify a large number of sites for long-term monitoring.

Monitoring of sentinel sites

In 2017, 31/50 (62 %) of sites identified as high-priority sentinel sites were monitored. Reasons for sites not being monitored in 2017 included primarily lack of volunteer commitment/availability but also incorrect timing of counts. 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. Results in 2017 suggest 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 in 2018. New in 2018 is that coordinators will be provided with a pre-filled datasheet clearly identifying priority sites, and will be reminded to contact landowners individually to provide feedback on past counts and encourage participation.

Non-priority sites will continue to be monitored for community engagement and stewardship promotion. 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.

Variability of counts within a session

The variability between two counts in one session (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. It also emphasizes the importance of conducting multiple counts to get the best possible maximum number of bats in a site. Counts that are extremely different within a session should be individually reviewed to determine possible reasons behind the variation (e.g. count was too early, before bats arrived). Doing more than one count in the pre-pup session (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. 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.

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 reproductive female pipistrelles in buildings (Whitaker 1998) and bat boxes (Bartonička and Řehák 2007), as well as Big Brown Bats 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.

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). 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. Most United Kingdom (U.K.) 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. Methods to analyze repeated count data should be investigated (e.g. program TRIM - Trends and Indices for Monitoring data) 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.

Currently, the maximum number of known roost sites is 257 at 203 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 (ie. 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. Sixty (60) locations with (encompassing 89 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. Additional sentinel sites (tentatively estimated at 25 to 50 sites, based on Walsh *et al.* 2001) need to be established in addition to the 60 existing sentinel sites to establish minimum sample sizes for trends. All of these sites need to be high priorities for continuing counts. Many more samples are required to establish regional trends, and only two species (Little Brown Myotis, Yuma Myotis) have enough sites to potentially provide species-specific trends.

The number of sites required to detect 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 be emphasized in 2018, as it will likely be easier to replicate counts at existing sites than to increase sample sizes.

Program funding and feasibility

The primary source of funding to-date for the Annual Bat Count at the provincial level has been grants from Habitat Conservation Trust Foundation and Habitat Stewardship Program. 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 2018

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 session and between years, and conduct a power analysis to clearly identify sample sizes, duration of counts, etc. needed to monitor bat species in BC.
        - ✓ **Initiated by BC government early 2018; funding application in to HCTF for 2018/2019**
    - This is required to achieve an estimated minimum sampling duration (# years) and sample size (# sites) needed to develop statistically-useful trends by species.
    - 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 session in June**
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 in each region in 2017; this list will be refined in 2018 and monitoring of these sites promoted**
        - ✓**Work to confirm if sites are maternity roosts or not, using increases in counts between sessions or visuals of live or dead pups or juveniles**
        - ✓**Re-assess and update criteria for inclusion as a sentinel site**
    - At these sites, efforts will be made to ensure:
    a. species are confirmed through genetics and/or acoustic means,
        - ✓**species identification is confirmed at 92 % of sentinel sites; consider re-sampling all sites with acoustics or genetics in 2018**
    b. counts continue to occur each year, and

- ✓**62 % of sentinel sites monitored in 2017; ongoing monitoring of sentinel sites is flagged as priority for 2018; volunteer communication and outreach should be emphasized**
- ✓**Summary data on counts on each region should be prepared and provided to regional coordinators and volunteers (e.g. point 9 below)**

c. counts are replicated two or more times annually.

- ✓**58 % of sentinel sites had two or more pre-pup counts in 2017; multiple early counts will be emphasized in 2018 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 2017, 55 sites were monitored in these regions**
     - ✓**Efforts will be made to identify additional sites in 2018**
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.
     - ✓**Work with the province and BCBAT in 2018 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 and species identification has been done at 66 % of all sites monitored (and 73 % of sites monitored in 2017)**
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 2017; efforts are needed in 2018 to retain interested homeowners and trained volunteers, to obtain multi-year samples at sentinel roosts**
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**

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 and 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
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)
10. Seek out new funding sources to support the growing Annual Bat Count.

References

Barlow, K. E., P. A. Briggs, K. A. Haysom, A. M. Hutson, N. L. Lechiara, P. A. Racey, A. L. Walsh, and S. D. Langton. 2015. Citizen science reveals trends in bat populations: the National Bat Monitoring Programme in Great Britain. Biological Conservation 182 (2015): 14-26.

Batwatch 2017. www.Batwatch.ca. Accessed 29 Mar 2017.

B.C. Conservation Data Centre. 2018. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Jan 19, 2018).

Frick, W.F., J.F. Pollock, A.C. Hicks, K.E. Langwig, D.S. Reynolds, G.G. Turner, C.M. Butchkoski, and T.H. Kunz. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science, 329(5992), pp.679-682.

Kasso, M. and M. Balakrishnan. 2013. Ecological and economic importance of bats (Order Chiroptera). ISRN Biodiversity, Article ID 187415, 9 pp doi:10.1155/2013/187415

Kellner, M. and O. Dyer. 2017. British Columbia Community Bat Program Annual Bat Roost Counts (2012-2016). Working report prepared for the BC Ministry of Environment, Penticton.

Kunz, T.H., E. Braun de Torrez, D., Bauer, T. Lobova, and T.H. Fleming. 2011. Ecosystem services provided by bats. *Annals of the New York Academy of Sciences*, *1223*(1), pp.1-38.

Nagorsen, D.W., and R.M. Brigham. 1993. Bats of British Columbia. Royal British Columbia Museum Handbook. Volume 1. The Mammals of British Columbia.

Surveillance and Monitoring Methods for European Bats Agreement on the Conservation of Populations of European Bats (EUROBATS)

Walsh, A., C. Catto, A.M. Hutson, P.A. Racey, P. W. Richardson, and S. Langton. 2001. The UK's National Bat Monitoring Programme – Final report 2001. Bat Conservation Trust, London. DEFRA - DETR Contract No. CR018.

Warren, R.D. and M.S. Witter. 2002. Monitoring trends in bat populations through roost surveys: methods and data from Rhinolophus hipposideros. Biological Conservation 105(2): 255-261.

Lewis, S.E. 1995. Roost fidelity of bats: a review. J. Mammal. 76(2):481-496.

Whitaker Jr, J.O., 1998. Life history and roost switching in six summer colonies of eastern pipistrelles in buildings. J. Mammal. 79(2):651-659.

Bartonička, T. and Řehák, Z., 2007. Influence of the microclimate of bat boxes on their occupation by the soprano pipistrelle *Pipistrellus pygmaeus*: possible cause of roost switching. Acta Chiropterologica, 9(2): 517-526.

Willis, C.K. and Brigham, R.M., 2004. Roost switching, roost sharing and social cohesion: forest-dwelling big brown bats, *Eptesicus fuscus*, conform to the fission–fusion model. Animal Behaviour, 68(3):495-505.

WNS.org. 2017. Bats affected by WNS. https://www.whitenosesyndrome.org/about/bats-affected-wns. Accessed 13-Feb-2018.

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	2017 sites successfully monitored in 2017	Comments 2018	Region	Species	Maximum count
1		Omineca –only site in area	BC – other	MYLU	57
3	Yes		Cariboo	MYLU/MYVO	390
4		Bella Coola – contact by phone	Cariboo	MYYU	202
25	Yes		Cariboo		227
26	Yes		Cariboo	pending	161
27	Yes		Cariboo	MYLU	298
28	Yes		Cariboo	MYLU	114
29	Yes		Columbia Shuswap	EPFU	27
49	Yes		**Fraser Valley / Lower Mainland**	**MYLU/MYYU**	**3340**
53	Yes		**Fraser Valley / Lower Mainland**	**MYLU/MYYU**	**728**
54	Yes		**Fraser Valley / Lower Mainland**	**COTO**	**300**
64		**New**	**Fraser Valley / Lower Mainland**	**MYLU**	**212**
65		**New**	**Fraser Valley / Lower Mainland**	**MYLU**	**160**
66		**New**	**Fraser Valley / Lower Mainland**		**113**
9		Miscommunication 2017? Count too early.	Kootenay	MYYU	3078
10			Kootenay	MYLU	1050
11	Yes		Kootenay	MYLU/MYYU	2113
12			Kootenay	EPFU	36
13	Yes		Kootenay	MYLU/MYYU	1345
32			Kootenay	MYLU	157
33	Yes		Kootenay	MYLU	357
34			Kootenay	MYYU	279
36			Kootenay	MYLU	251
37			Kootenay	MYLU	217
38	Yes		Kootenay	MYLU	199
39			Kootenay	MYLU	170
40			Kootenay	MYYU	282
41			Kootenay	MYLU	126
42	Yes		Kootenay	MYYU	213
43			Kootenay	MYYU	295
44			Kootenay	MYYU	270
45	Yes		Kootenay	MYLU	131
47			Kootenay	MYLU	170
55		New	Kootenay	pending	4000
58		New	Kootenay	MYYU	351
15	Yes		Okanagan	MYLU/MYYU	1708

16	Yes		Okanagan	MYLU/MYYU	1396
17	Yes		Okanagan	MYLU	103
57		New	Okanagan	pending	343
61	Yes		Okanagan	MYLU	651
62	Yes		Okanagan	MYLU/MYYU	1308
63		New	Okanagan	MYLU/MYYU	434
48	Yes		Peace	MYLU	150
22	Yes		Skeena	MYLU	146
23		Original building demolished, condo not counted according to protocols	Skeena	MYYU	1020
24	Yes		Skeena	MYLU	283
52			Skeena	MYLU	267
51			Sunshine Coast	MYCA	170
8	Yes		Thompson	MYLU/MYYU	382
2		Courtenay – only site in area	Vancouver Island / Gulf Islands		198
6	Yes		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**581**
7	Yes		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**980**
14	Yes		**Vancouver Island / Gulf Islands**	**MYVO**	**96**
30	Yes		**Vancouver Island / Gulf Islands**	**MYYU**	**59**
31	Yes		**Vancouver Island / Gulf Islands**	**MYLU/MYYU**	**1120**
46		**Spider Lake – outside of HAT's area**	**Vancouver Island / Gulf Islands**		**573**
50	Yes		Vancouver Island / Gulf Islands	MYLU/EPFU	982
56	Yes		Vancouver Island / Gulf Islands	MYLU/MYYU/EPFU	693
59		New - Nanaimo	Vancouver Island / Gulf Islands	MYLU/MYYU	254
60		**New**	**Vancouver Island / Gulf Islands**	**MYYU**	**541**

Appendix 2. Yearly trends

Maximum bat counts in the pre-pup session, by year, region, and species.

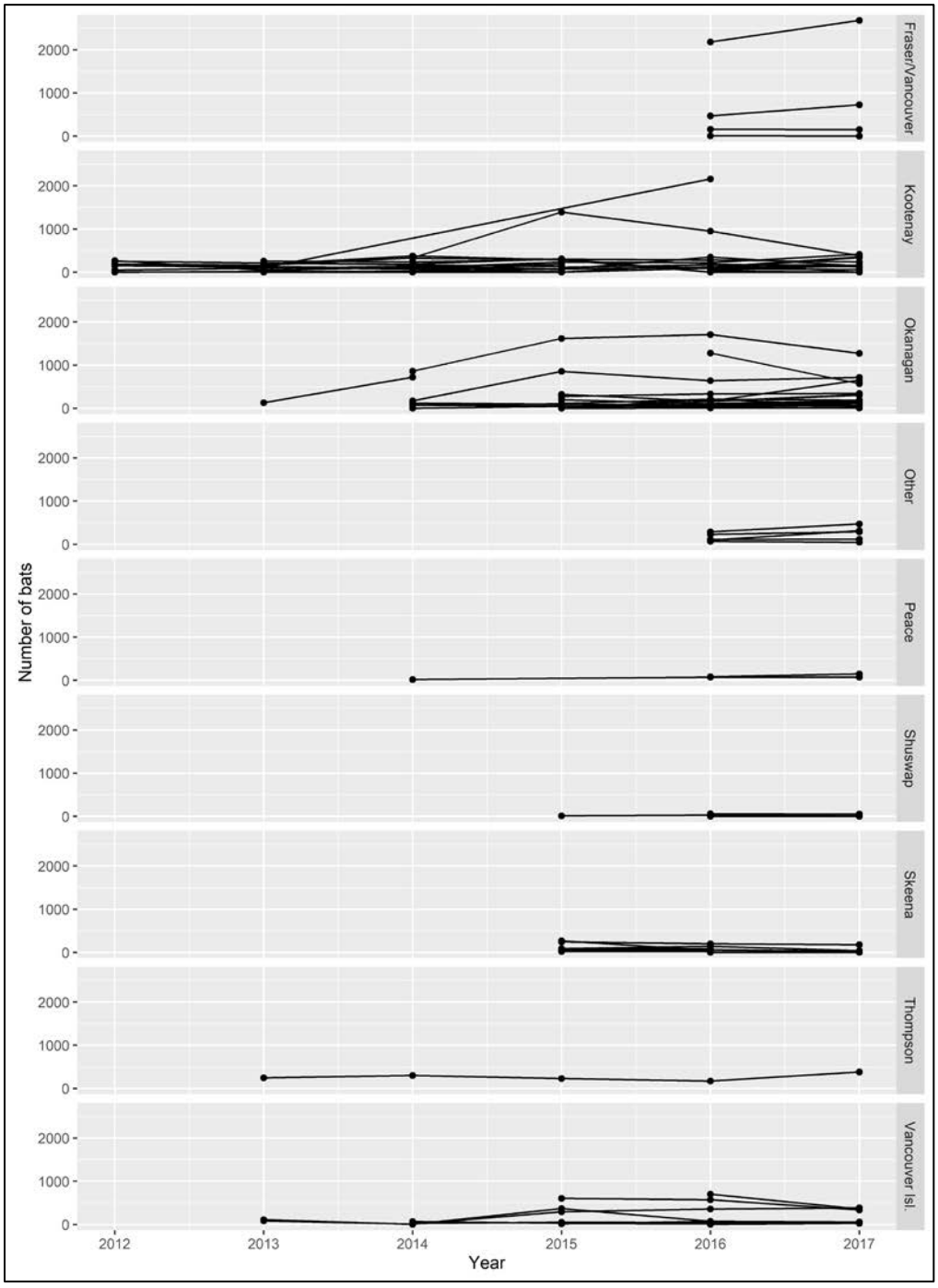

Figure 6. The average number of bats counted in the pre-pup session, by year and region, for the 80 Annual Bat Count sites that have multiple years of data. Each line connects yearly counts at one site within a region. 'Other' includes counts from outside of regions with bat programs, including northern Vancouver Island and Prince George.

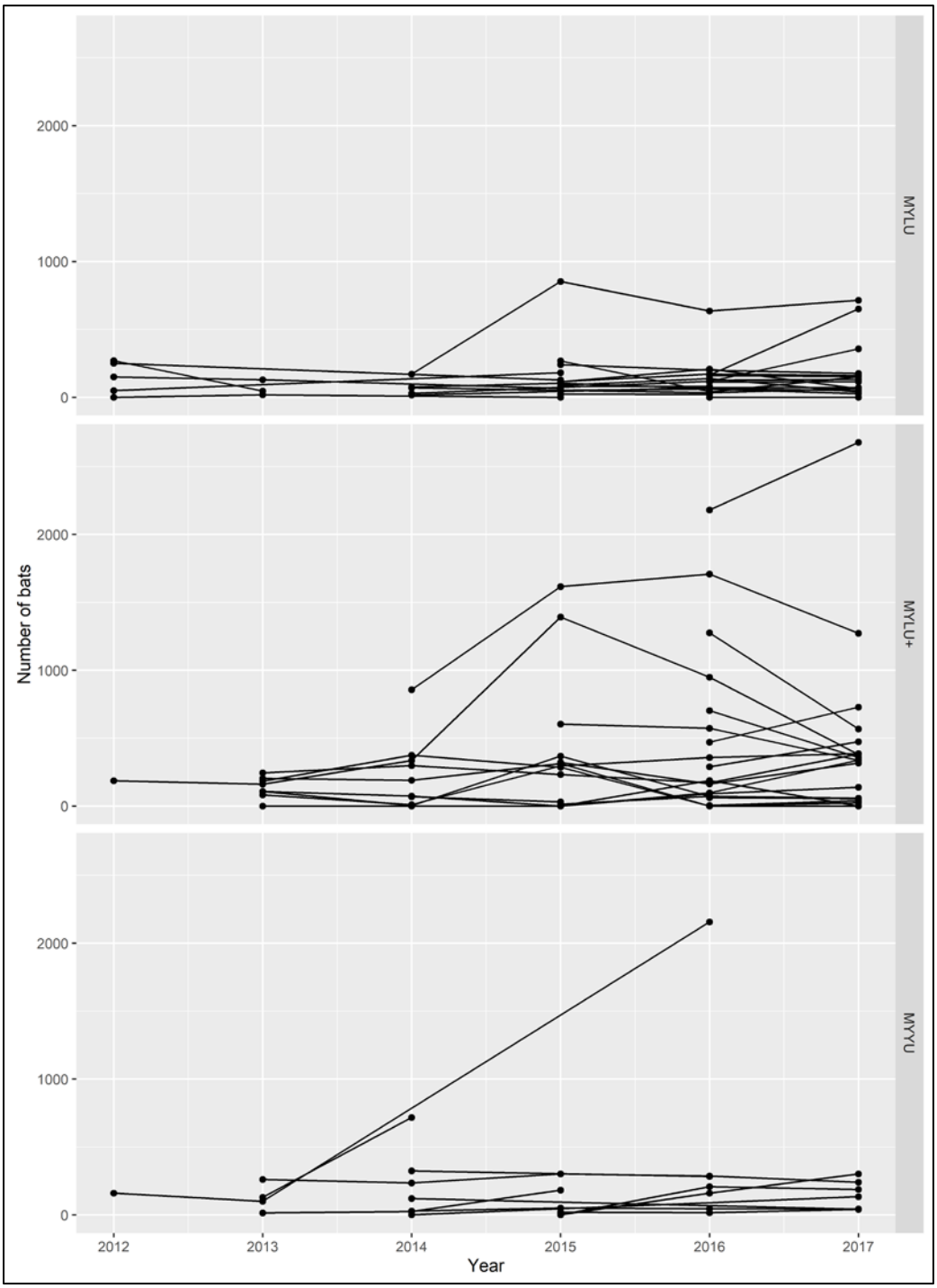

Figure 7. The maximum number of bats counted in the pre-pup session, by year and species, for Annual Bat Count sites that have multiple years of data. Each line connects yearly counts at one site for one species. MYLU: Little Brown Myotis; MYLU+: mixed colony with Little Brown Myotis; MYYU: Yuma Myotis and mixed colonies with Yuma Myotis but no Little Brown Myotis.

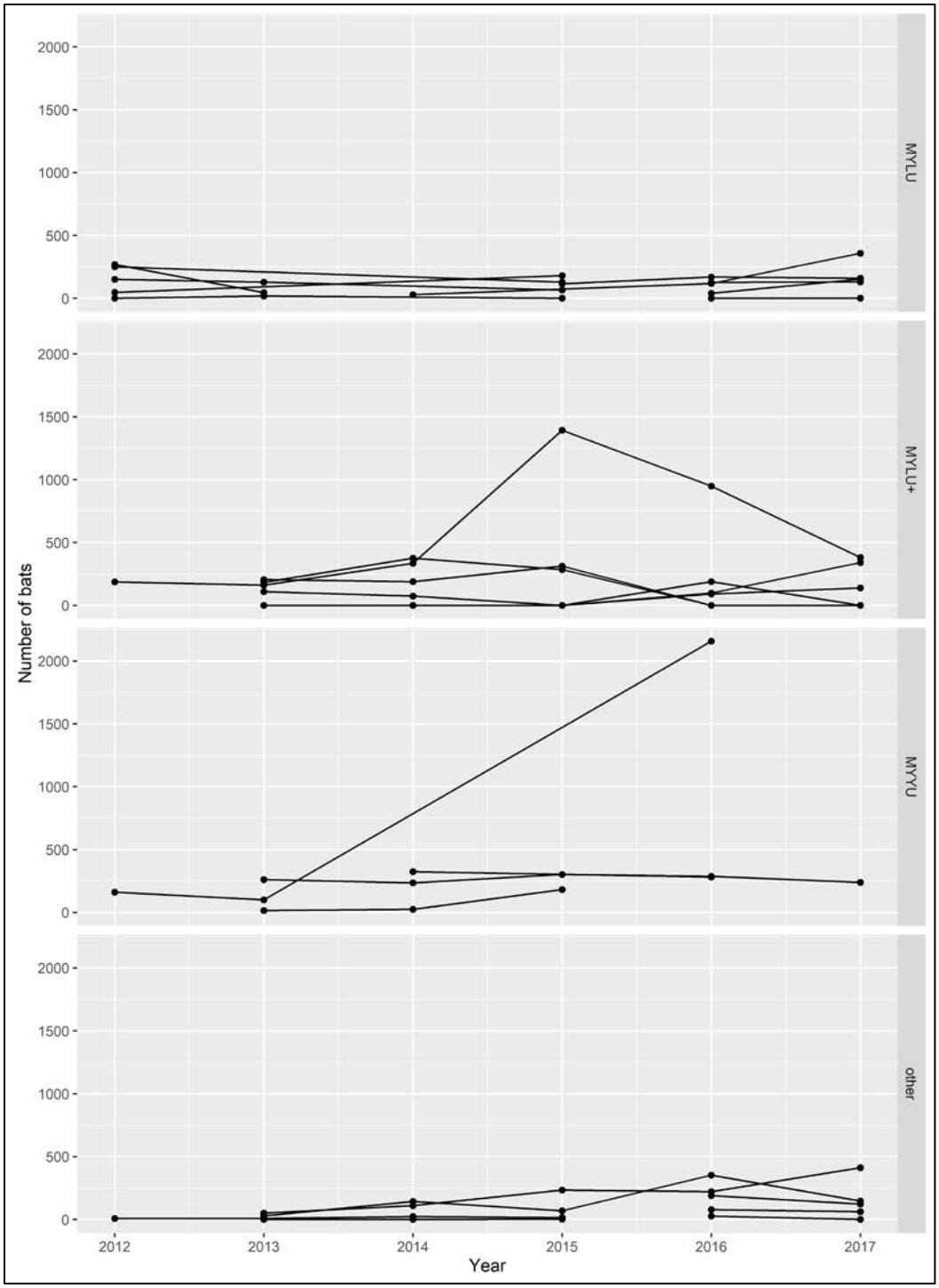

Figure 8. Kootenay Annual Bat Counts. The maximum number of bats counted in the pre-pup session, by year and species, for Annual Bat Count sites in the Kootenay region that have multiple years of data. Each line connects yearly counts at one site for one species. MYLU: Little Brown Myotis; MYLU+: mixed colony with Little Brown Myotis; MYYU: Yuma Myotis and mixed colonies with Yuma Myotis but no Little Brown Myotis; Other: colonies of all other species.