British Columbia Community Bat Program Annual Bat Roost Counts (2012-2016)

Update March 2017

Photos by G.Hucul

By

Mandy Kellner

Coordinator, BC Community Bat Program

and Orville Dyer

BC Ministry of Environment

March 31, 2017

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 is expected 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 population monitoring trends in species of bats such as the federally-endangered Little Brown Myotis (*Myotis lucifugus*) that use human structures for roosting.

The Annual Bat Count is currently the only long-term roost monitoring program in the province, can contribute to the large 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 – 2016, is growing each year, and has data on seven bat species at 190 sites.

Review of the data has highlighted several aspects that can be improved to ensure that the Annual Bat Count develops into a more effective, robust monitoring program. These recommendations include ensuring the program has a 5-year strategic plan, acquires necessary count data for statistical power analysis (i.e. increased number of sites, especially in regions where WNS is expected to arrive; increased temporal replicates per site), and identifies species at priority colonies. To achieve these objectives, the Program needs ongoing provincial-level coordination, data management, analysis and reporting, funding support for regional coordinators, and funds for acoustic monitoring equipment and DNA analysis.

Conducting an Annual Bat Count

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 (COSEWIC 2013)). 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 the 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 known 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 citizen-science 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 with 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 BC Parks staff.

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.

The purposes of this report are to:

1) provide the first summary of available BC Bat roost counts from across the province,
2) outline methodology used for the Annual Bat Count to ensure consistency throughout the province, and
3) 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 programs across the province, and 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 colonies, 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 B.C.

Methods

The Annual Bat Count is a repeated summer emergence count at known 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 the 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 population, or more bat activity (Figure 1).

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 are volant). These counts are the priority, to be consistent with NABat protocols. Two more counts are done 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 or Forests, Lands and Natural Resource Operations staff. Ultimately, count data is entered into the BC Species Inventory Database (SPI)[1]. Details 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 identification of dead bats by experts or live capture by mist-netting.

We created a list of priority ‘Sentinel’ sites in BC to guide monitoring efforts in 2017. This list should assist regional coordinators in meeting our provincial-level goals for number and distribution of monitoring sites. To establish the list, sites were assigned a ranking from 0 - 5 based on:

- colony size (greater than 150 bats in at least one count),
- counted in the last 2 years (indicating recent interest in the site),
- multiple counts available within a year,
- replication between years,
- species present (Little Brown as higher priority), and
- homeowner/community support (if a landowner is known very keen to count and submit data).

Ranked sites were then reviewed by provincial and regional coordinators to ensure sites had more than one count between or within years, making data more useful and confirming landowner/counter interest. When regions had few high-ranking sites, low-priority existing sites were manually reviewed to identify other potential sites. Finally, the list should be considered a draft and other sites will be included based on input from regional coordinators and the discovery of new large roosts.

We looked at the within-season variation of counts in both the ‘early’ and ‘late’ seasons. The difference and direction of difference between paired counts was examined by calculating the percent change as ((count2 / count1) *100%) – 100 %.

Results

Volunteer involvement

Participation data is unavailable prior to 2015, but volunteers assisted regional coordinators, or conducted counts on their own, for 82 counts in 2015 and 196 counts in 2016. Volunteers may have assisted at more than one count, so the actual number of unique volunteers is unknown.

Number of sites and counts

Seven hundred and fifty-one (751) counts were conducted at 190 sites between 2012 -2016 (Figure 1; Table 1). Up to four counts may have been done per site each year. Sites sampled in one year may not

[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.

have been sampled in subsequent years, and sites counted for multiple years were often but not always counted in consecutive years. Counts nearly tripled between 2015 and 2016 because of the growth of the Community Bat Program across the province and increased efforts by coordinators to establish count sites and gather baseline pre-WNS data.

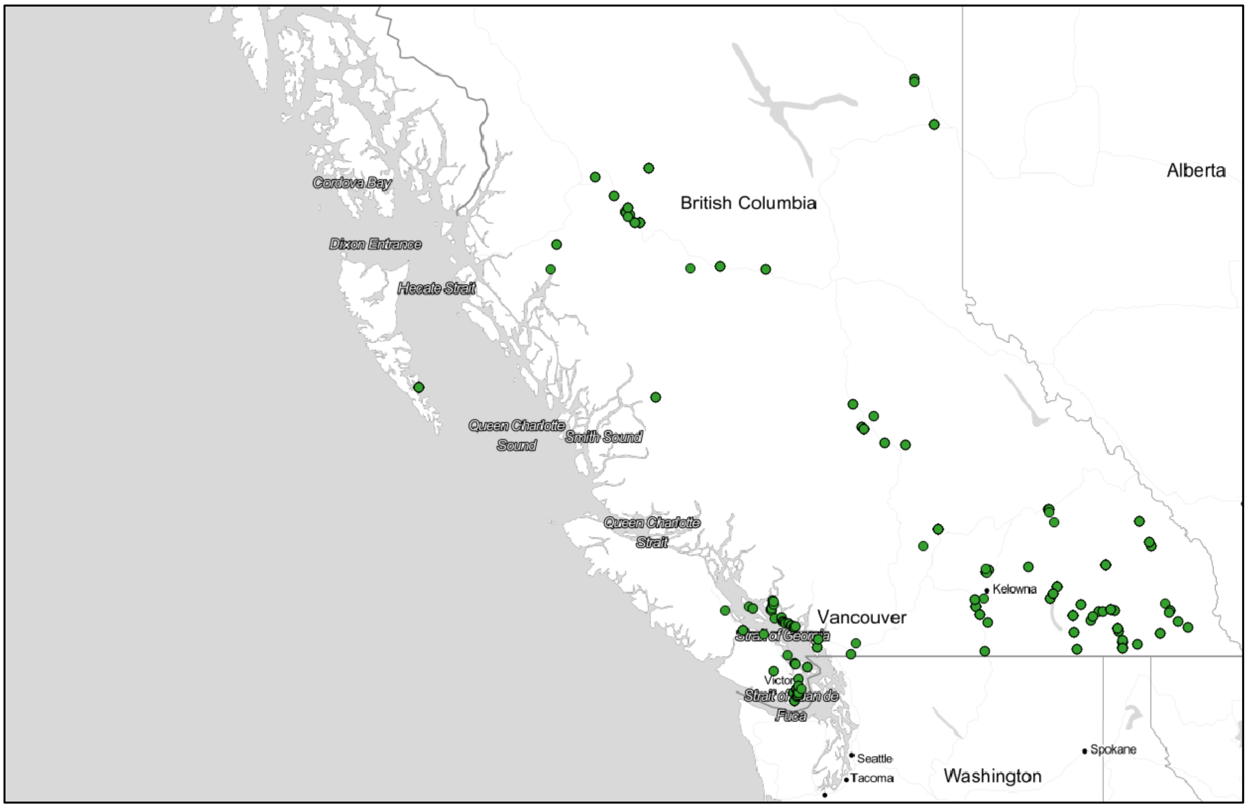

Figure 1 Map of sites sampled in Annual Bat Roost Counts (2012 to 2016)

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

Year	Sites	Counts
2012	10	26
2013	22	72
2014	34	86
2015	64	193
2016	143	374
Unique sites and counts, all years	190	751

Number of sampling years

Sites have been monitored for between one and five years, leading to the start of a long-term dataset (Table 2). As mentioned above, efforts were made to extend the program in 2016 so many sites (136; 71

%) were added that year and have only one year of data. Twenty sites have three or more years of data. Only one of the 190 Annual Bat Count sites currently has five years of data.

Table 2. The number of roost sites that have from one to five years of count data.

Number of Years Counted	Number of Sites	% of Total
1	136	71
2	34	18
3	12	6
4	7	4
5	1	1
	Total 190	

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
Cariboo			1	2	9
Columbia Shuswap					6
Haida Gwaii				1	
Southern Vancouver Island/Gulf Islands		5	6	11	18
Thompson		1	1	1	2
Kootenay	10	13	13	22	19
Okanagan		3	12	15	27
Peace			1		3
Fraser Valley/Lower Mainland				1	13
Skeena				11	13
Sunshine Coast					33
All sites	10	22	34	64	143

Species counted during Annual Bat Counts

Annual Bat Counts occur at bat colonies in anthropogenic structures so provide data only on bat species that use these structures. Guano collection has focused mainly on larger colonies and is not completely analyzed due to funding constraints. As of 2016, 78 (41%) of the 190 sites have identified one or more bat species at the roosts (Table 4). Because species identification may change by year, some sites have multiple species records (i.e. > 75 sites are listed in the table).

Table 4. The species identified in Annual Bat Counts, including the number of sites, range in colony size, and regions found.

Species or species group	# sites where species was identified for at least one year	# bats counted	Regions
Little Brown Myotis	33	8 -1050	many
Little Brown Myotis/Yuma Myotis	9	160 - 2994	Fraser Valley / Lower Mainland, Okanagan
Little Brown Myotis/ Long-legged Myotis	1	261 - 390	Cariboo
Little Brown Myotis/Big Brown Bat	2	40 - 703	Fraser Valley / Lower Mainland
Little Brown Myotis/ Long-eared (Keen's) Myotis	1	4 - 94	Haida Gwaii
Yuma Myotis	22	40 - 3078	Southern Vancouver Island/Gulf Islands, Sunshine Coast, Thompson, Kootenay
Long-legged Myotis	1	15 - 68	Southern Vancouver Island/Gulf Islands
Big Brown Bat	3	10 - 63	Columbia-Shuswap, Kootenay, Southern Vancouver Island/Gulf Islands
California Myotis	6	112 - 390	Okanagan, Sunshine Coast, Cariboo
Townsend's Big-eared Bat/Big Brown Bat	2	33	Southern Vancouver Island/ Gulf Islands
Townsend's Big-eared Bat	3	2 - 23	Kootenay, Fraser Valley / Lower Mainland

Identification of high priority sentinel sites

Fifty-four (54) sentinel sites were identified as high priorities for ongoing monitoring in 2017 (Table 5). For these sites to best contribute to a long-term monitoring program, species identification and an emphasis on obtaining within- and between-year replicates must occur beginning in 2017. Efforts should be made 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. Privacy agreements with landowners prevent listing of actual site names or specific locations in this document but will be provided to regional coordinators. The list will evolve and expand based on discussions with regional coordinators, funding, availability of volunteers, and as new regionally-significant colonies are identified.

Table 5. Draft list of sentinel sites for ongoing monitoring in each region. See Methods for criteria for inclusion and details on 'Priority Score'.

Site ID	Region	Species	Within year reps	Between year reps	Maximum count	Priority Score
1	BC – other		1		57	3
2	BC – other				198	2
3	Cariboo	MYLU/MYVO	1		390	4
4	Cariboo	MYYU	1		202	4
25	Cariboo		1		227	4
26	Cariboo		1		161	3
27	Cariboo		1	1	120	3
28	Cariboo	MYCA	1		112	2
29	Columbia Shuswap	EPFU	1	1	27	3
49	Fraser Valley / Lower Mainland	MYLU/MYYU	1		2994	4
50	Fraser Valley / Lower Mainland	MYLU/EPFU	1		703	4
53	Fraser Valley / Lower Mainland	MYLU/MYYU	1		470	5
54	Fraser Valley / Lower Mainland	COTO	1		300	4
9	Kootenay	MYYU	1	1	3078	4
10	Kootenay	MYLU	1	1	1050	5
11	Kootenay	MYYU	1	1	2113	4
12	Kootenay	EPFU	1	1	36	3
13	Kootenay	MYYU	1	1	1345	4
32	Kootenay	MYLU	1	1	157	4
33	Kootenay		1	1	231	4
34	Kootenay		1	1	279	4
35	Kootenay		1		3078	3
36	Kootenay		1	1	251	4
37	Kootenay	MYLU	1	1	217	5
38	Kootenay		1	1	199	4
39	Kootenay		1		170	3
40	Kootenay		1		282	3
41	Kootenay		1		126	3
42	Kootenay	MYYU	1	1	213	4
43	Kootenay		1		295	3
44	Kootenay	MYYU	1	1	270	3
45	Kootenay	MYLU	1		126	3
47	Kootenay	MYLU	1	1	170	5
15	Okanagan	MYLU/MYYU	1	1	1708	6
16	Okanagan	MYLU/MYYU	1	1	1396	5
17	Okanagan	MYLU	1	1	103	5

Table 5 continued						
Site ID	**Region**	**Species**	**Within year reps**	**Between year reps**	**Maximum count**	**Priority Score**
25	Okanagan	MYLU	1		370	5
26	Okanagan	MYYU	1	1	1308	4
48	Peace	MYLU	1	1	150	4
22	Skeena		1	1	146	3
23	Skeena	MYYU			1020	3
24	Skeena		1	1	283	4
52	Skeena		1	1	267	4
51	Sunshine Coast	MYCA	1		170	3
8	Thompson	MYLU/MYYU	1	1	268	6
6	Vancouver Island / Gulf Islands	MYLU	1	1	504	5
7	Vancouver Island / Gulf Islands	MYLU	1	1	980	5
14	Vancouver Island / Gulf Islands	MYVO	1		68	3
30	Vancouver Island / Gulf Islands	MYYU	1	1	59	4
31	Vancouver Island / Gulf Islands		1	1	1120	4
46	Vancouver Island / Gulf Islands		1		573	3

Variability within years

Early-season counts

Seventy-one sites (41 of which are proposed sentinel sites) had multiple counts in the early sampling period (June) and some of the sites were counted for multiple years. In total, there were 103 samples of repeated count data which could be used to look at variation in counts within sampling periods. The mean count and standard deviation (SD) across the 103 samples was 214 ± 61 bats in a roost.

There was large variation between the two early-period counts (before young fly). The majority of samples showed an increase in the number of bats counted between the first and second count, with an average difference and SD between counts of 36 ± 181 bats (Figure 2). 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 859 bats (count 1 = 1321, count 2 = 2180). When expressed as a percent change of the original count value, to reflect colony size, the average percent change from count 1 to count 2 was an increase of 156 ± 542 % (Figure 3).

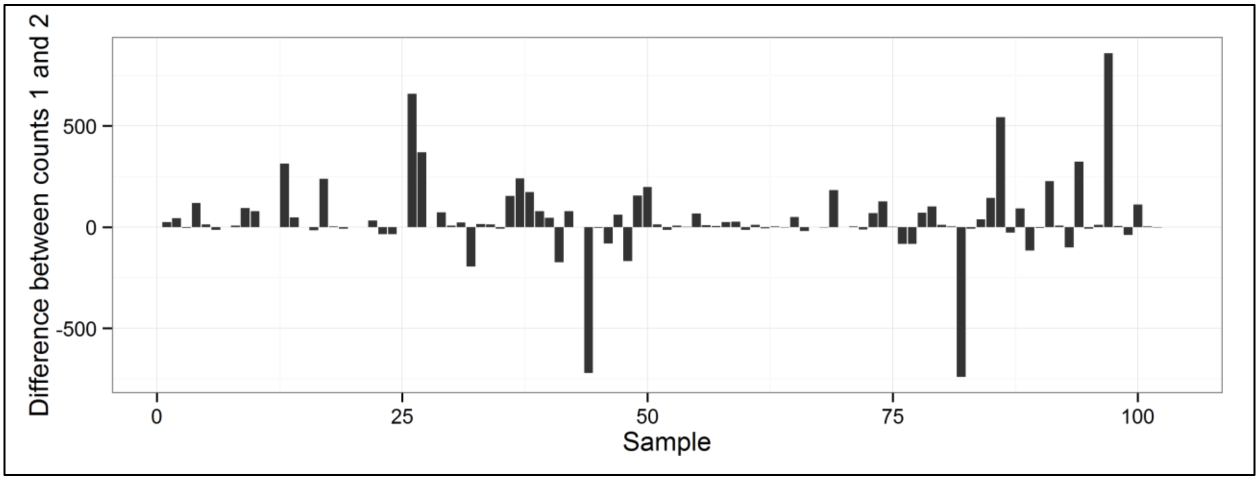

Figure 2. The difference in number of bats counted between counts 1 and 2 in the early season period.

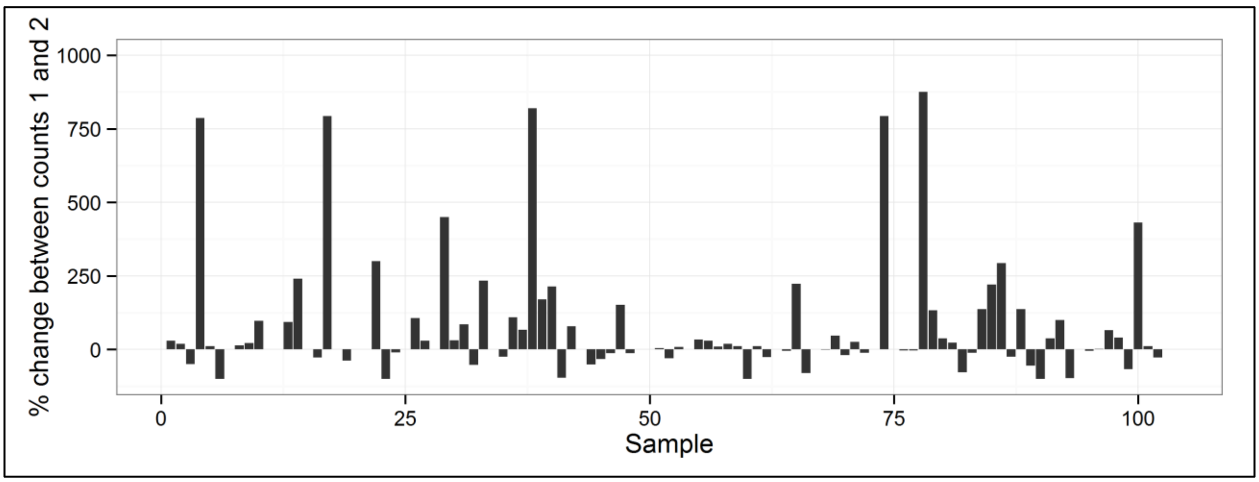

Figure 3. Percent change between early-season counts 1 and 2. Four samples had a % change greater than 1000 % and were excluded from the graph for clarity.

Late-season counts

Eighty-six sites (49 of which are proposed sentinel sites) had multiple counts in the later sampling period (July/August). As with the early counts, some of the sites were counted for multiple years, leading to 119 samples with repeated counts. The average count and SD across the 119 samples was 272 ± 98 bats in a roost. The number of bats counted often decreased between Counts 3 and 4, with an average difference in counts of -66 ± 327 bats (Figure 4). However, several sites had very large percent changes in the number of bats leading to an extremely variable average percent change in counts of + 249 ± 1655 % (Figure 5). These sites went from 2 to 272 bats (13500% increase), 2 to 225 bats (1150 % increase) and 7 to 111 bats (1486 % increase).

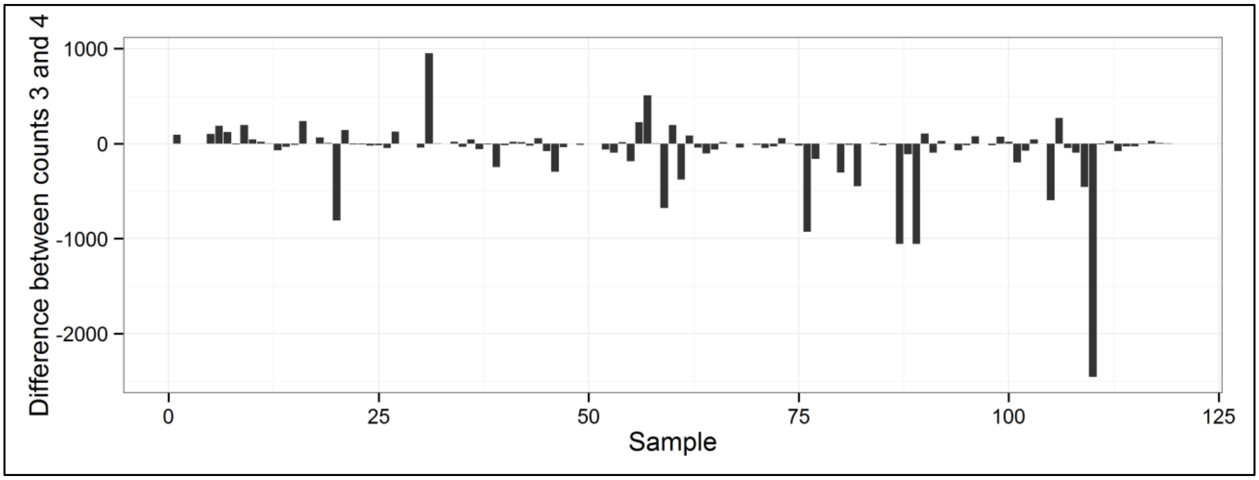

Figure 4. The difference in number of bats counted between counts 3 and 4 in the late season period.

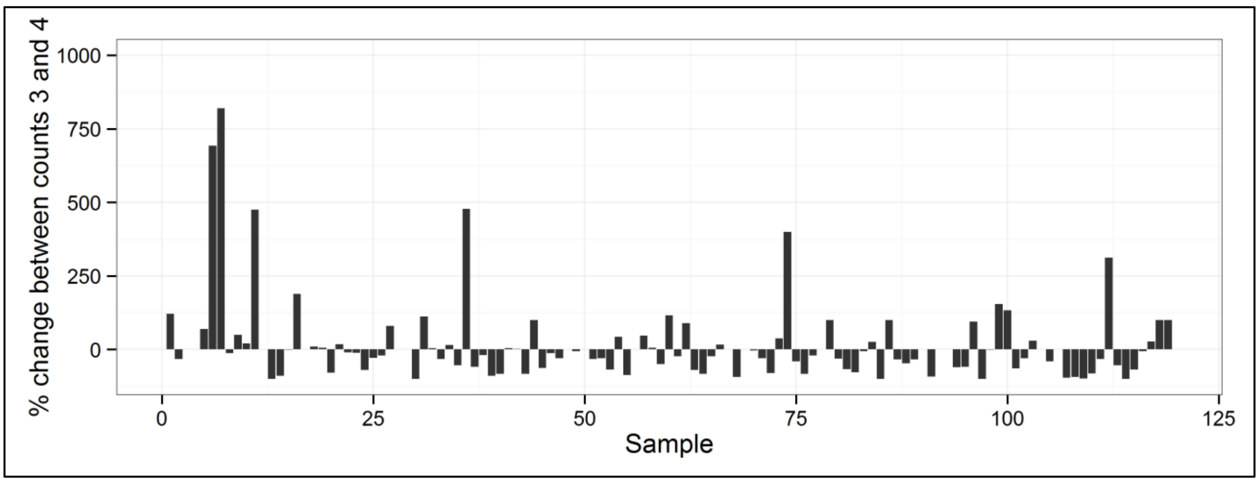

Figure 5. Percent change between late-season counts 3 and 4. Three samples had a % change greater than 1000 % and were excluded from the graph for clarity.

Comparing early- and late-season counts

There were 159 cases where sites were counted in both early and late sessions within a year, allowing comparison of the average number of bats counted between these two periods. The average difference and SD between the sessions was an increase of 61 ± 215 bats in a roost. The majority of sites had a larger average number of bats in the late session (Figure 6).

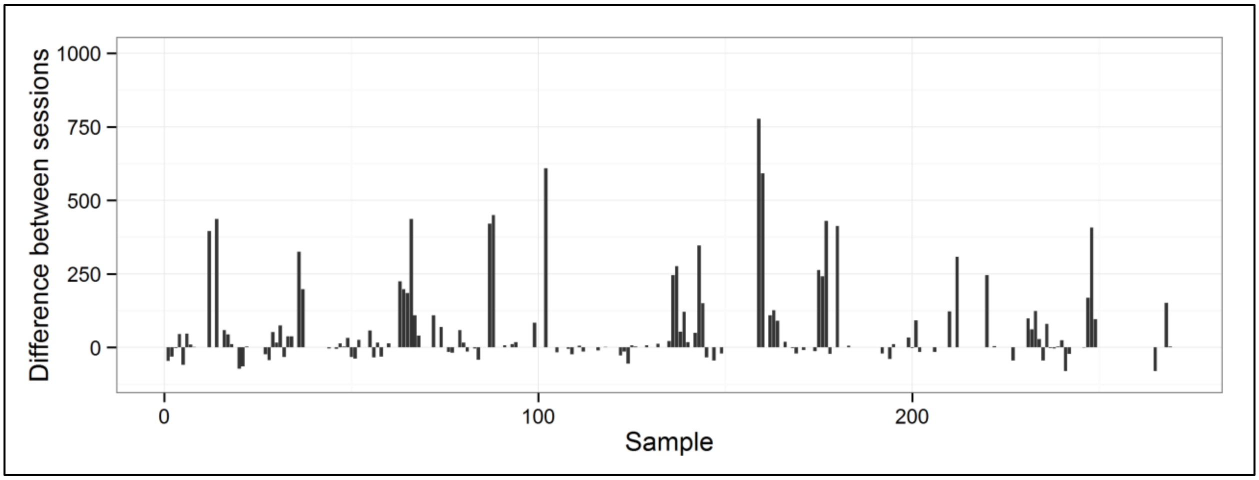

Figure 6. The difference in average number of bats counted in early- versus late-season Annual Bat Counts. Each sample is one site with counts in different sessions in one year.

Variability across years

All sites which had multiple years of early-season counts were graphed by region to view changes over time (Figure 7). This graph is purely exploratory, but offers information on where long-term counts have taken place and what changes have occurred.

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 volunteer-nights increased by 114 from 2015 to 2016. There are huge benefits of volunteer involvement, including increasing the number of counts done and 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 regional coordinators is needed to ensure that priority sentinel roost sites are counted yearly, and that regional coordinators have time to organize volunteers and enter data. Financial support at the provincial coordinator level is needed to set program priorities and goals, monitor progress, analyze results and ensure that the results are available to guide species monitoring and recovery actions.

Target species

Bats appear to have different vulnerabilities to WNS, based on patterns of mortality in affected species (https://www.whitenosesyndrome.org/about/bats-affected-wns), so species specific trends are needed to monitor impacts and recovery. The Annual Bat Count is focussed on anthropogenic structures so will only detect species that use structures. The Annual Bat Count has good potential to monitor population

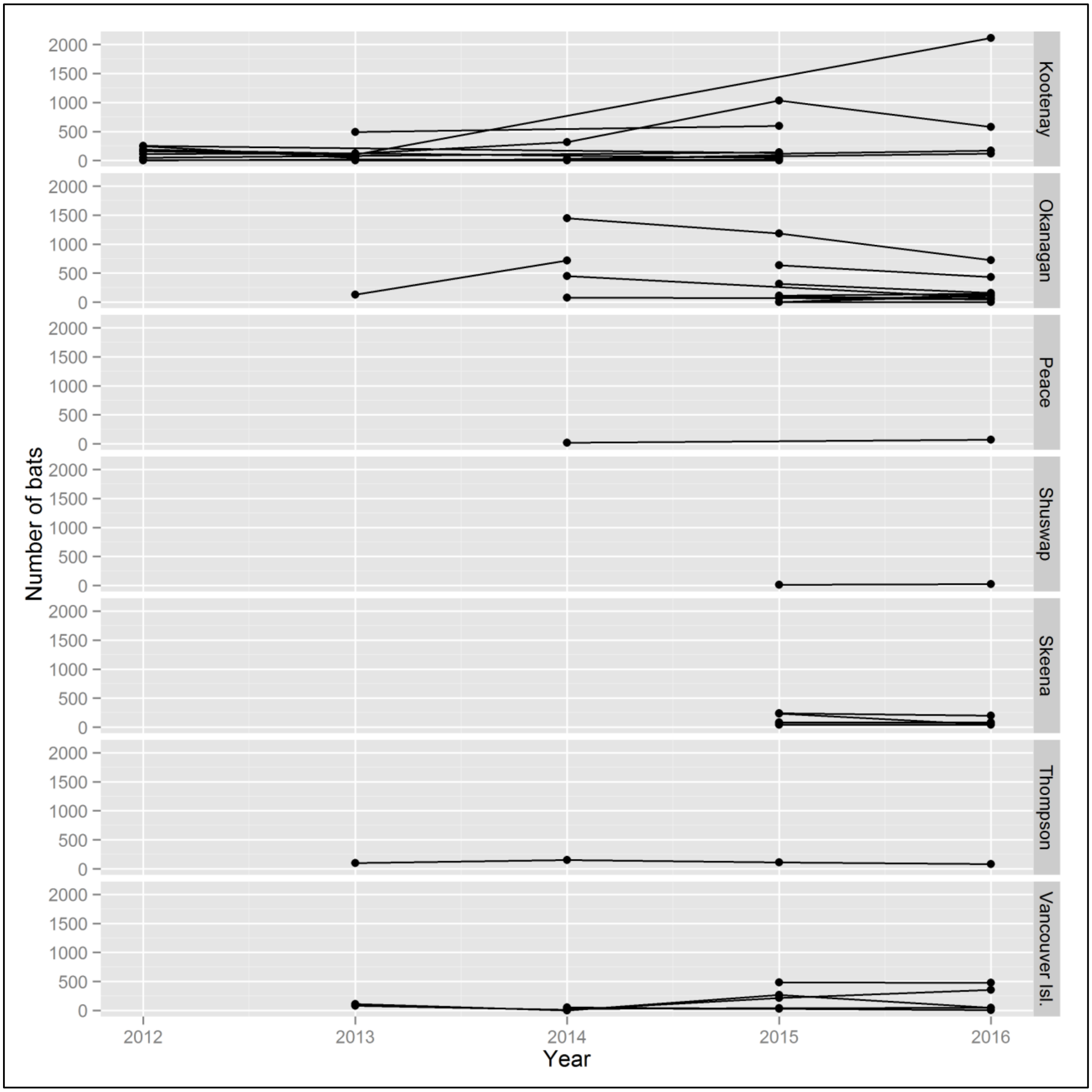

Figure 7. The average number of bats counted in the early-season period, by year, for the 54 Annual Bat Count sites that have multiple years of data. Each line connects yearly counts at one site.

trends for at least two species (Little Brown Myotis detected at 44 sites; Yuma Myotis at 29 sites). Roost counts may also have potential to monitor additional species, if sample sites can be increased. 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 7). The North American Bat Monitoring Program (NABat), 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 6. Bat species in BC and their potential for monitoring using existing Annual Bat Count protocols.

Can be monitored with Annual Bat Count	Potentially 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

Most (108 / 190 = 57 %) Annual Bat Count sites do not have confirmation of the species being counted. It is important to address this knowledge gap as soon as possible to assess options and improve effectiveness of the program in monitoring the impacts of and recovery from WNS. At the very least, sentinel monitoring sites, identified in this report, should have species verified. Species identification can be done by collecting guano for DNA analysis and/or using passive or active acoustic monitors to determine if multiple species are present, and provide insight into the relative proportions of each. The source of the species identification each year should be noted in the database, requiring a review of old DNA results and species assignments.

It is important to note that species identification at a roost may change between years, and ideally species would 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 of more than one guano sample envelope and acoustic monitoring at the site to reveal the presence of multiple species. If multiple species are detected acoustically, multiple DNA submissions should be made in an effort to genetically confirm this conclusion plus differentiate between acoustically-similar species. Costs differ between these methods of species identification, which will factor into the approach used going forwards.

DNA analysis, which is very effective at identifying bats to species, currently costs around $40 per sample (plus $750 set-up fee). Bat detectors are initially expensive and then should function for years, but in some cases also require funds for analysis of recorded bat calls. Acoustic bat detectors come in passive or active forms. Passive detectors can be left in place at a roost, can provide long-term monitoring to capture dates when bats arrive and depart from a roost, but require post-deployment data analysis. Active detectors need to be used by a person and can provide real-time information during a roost count. Both passive and active bat detectors can differentiate species groups, such as 40 kHz Myotis (Little Brown and Long-legged Myotis) from 45-50 kHz Myotis (Yuma and California Myotis), and direct guano sampling efforts if greater than one species is detected. Because of the flexibility inherent in bat calls, genetic analysis is usually warranted to positively confirm species.

Passive detectors range in price from $475 (e.g., RoostLogger, Titley Electronics – small, easy to disinfect, easy to setup, designed for monitoring a small exit space) to $1500 or more (e.g., SM4, Wildlife Acoustics – needs external mic, better call quality, more widely useful (can be used for the NABat Monitoring Program passive sampling)). Active detectors range from $250 (e.g. EMTouch2, Wildlife acoustics – plugs into cell phone, excellent user-friendly visual displays on free app) to $2150 (e.g. Anabat Walkabout, Titley Electronics – self-contained, less intuitive to use, records high-quality calls, can be used in NABat driving transects).

Variability of counts within a season

The variability between two counts in one period (either early or late) 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. Counts that are extremely different within a season 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 early count period (June) generally resulted in an increase in the number of bats observed, likely leading to a better estimate of the minimum colony size. Alternatively, 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 late count period (July/August), numbers usually decreased between these counts, suggesting that the final count was sometimes after bats had begun departing the roost.

The pattern of change in the number of bats at a site may be useful to indicate how the site is being used. Comparing early- and late-season counts at a site may be useful to screen for maternity colonies, as we would expect late-season counts to be approximately double the early-season numbers. Sites that had a very large increase between counts in the late period may not be maternity roosts, but may be post-maternity roost sites used in late summer. These sites add to the variability in this counting period.

They are still useful for long-term monitoring as long as repeated yearly counts occur during the same timeframe (e.g. ensuring counts are made after bats arrive).

The number of sites required to detect a trend increases substantially when only one count is done per year. 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). It is more difficult to increase sample sizes than to increase count replicates. Increasing sample sizes to a statistical target may not be possible for most species. Ensuring that important count sites are replicated within a sampling period can decrease the number of sites needed to detect change, compared to a strategy of having a high number of counts with only one replicate. Many BC sites have only one count per year.

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 190, with more 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 bats. 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. Fifty-four (54) sites currently meet most of the criteria for establishing reliable trends. This total number of sites may not provide enough samples for determining a provincial trend. Additional sites (tentatively estimated at 25 to 50 sites, based on Walsh *et al.* 2001) need to be established in addition to the 54 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 likely are required to establish regional trends.

Species identification is not currently available for 108 sites. Only two species (Little Brown Myotis, Yuma Myotis) have enough sites that potentially could provide species specific trends. In addition, some sites have more than one species and count numbers are not separated by species. If species specific trends are required, species identification is required and counts for multi-species sites must be separated by species.

Recommendations for 2017 to 2022

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 season and between years, and conduct a power analysis to clearly identify sample sizes, duration of counts, etc. needed to monitor bat species in BC.
    - 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
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. At these sites, efforts will be made to ensure a) species are confirmed through genetics and/or acoustic means, b) counts continue to occur each year, and c) counts are replicated two or more times annually.
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 year, if possible).
    - These are the first areas in BC that are likely to be impacted by WNS.
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.
    - Review and enter all existing DNA and acoustic data into database by year, with an identifier for 'source' of species identification

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.
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.
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
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

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.

COSEWIC. 2013. COSEWIC assessment and status report on the Little Brown Myotis (*Myotis lucifugus),* Northern Myotis (*Myotis septentrionalis)* and Tri-colored Bat (*Perimyotis subflavus)* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxiv + 93 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

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

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.