



Use of artificial roost boxes by bats in British Columbia – update to 2023

Prepared by
Mandy Kellner, BC WLRS Bat Conservation Coordinator /
In partnership with the BC Community Bat Program

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Executive Summary

Bat conservation in BC has tended to include or even emphasize using bat boxes as habitat enhancement and mitigation. Multiple bat box projects have deployed hundreds of boxes across the province. A provincial-level evaluation of outcomes, including use by bats, bat species in boxes, and relative use of different box types, is necessary. This should include an assessment of the value of boxes in exclusion situations, because installing bat boxes prior to exclusion is a recommended component of bat-friendly exclusions and is a widely promoted practice. Additionally, there are increasing concerns about the potential for bat boxes to inadvertently harm bats and the breadth of this problem should be investigated.

To begin to address these questions about the effectiveness of bat boxes as a conservation tool, in 2019 we began to compile data on bat boxes in BC including their location, type, installation, and occupancy information. In 2019-20, we had records of 626 bat boxes. By November 2023, the number of bat boxes included in the database has grown to 1062. While data is often not complete for each box, this large dataset provides insights into how boxes are used in BC and can provide a base from which to further investigate effectiveness of boxes and to contribute to updated Best Management Practices specific to BC.

Bat boxes were used by five species of bats, but the majority of boxes were occupied by Little Brown Myotis and/or Yuma Myotis. Also present were Big Brown Bats, and rarely California Myotis and Long-legged Myotis.

A considerable proportion of the boxes were occupied (60 %), and box usage occurred across BC. Occupancy rate varied by box type. Maternity boxes had a higher occupancy rate (62 % occupied) than rocket boxes (55 %) or single chamber boxes (48 %). Maternity boxes and rocket boxes had larger median colony sizes (30 bats) than single chamber boxes (5 bats). The large bat condo was used by a large colony, and three of ten mini-condos were consistently occupied.

Approximately half (45 %) of the boxes installed as mitigation during exclusions from human structures were used by bats, providing habitat for excluded colonies. Bat boxes should continue to be installed prior to exclusions. Mitigations should follow current best management practices, and include the installation of multiple boxes per site, confirmation of species, and counts of colony size before and after exclusions.

We collated reports of mortalities at bat boxes in BC from 2015 - 2023. Each year, there were from zero to four events reported with mortalities of greater than five bats. Mortality rates are estimated as 2 – 14 % for involved colonies. Although heat or humidity may have been a factor in some mortalities, the majority of events are unexplained. There is no existing information on mortality rates of bats in BC. The data to-date provide a valuable first step in monitoring and understanding mortality.

Finally, we reviewed and assessed box tracking and reporting methods to identify how we could improve the dataset. Promoting online registration, then sending seasonal email prompts to landowners to encourage monitoring, could be useful to increase the number of boxes that are monitored. Landowners who installed boxes as part of an exclusion should be re-contacted directly by regional

projects to encourage monitoring. The 2019 Best Management Practices for Bat Boxes should be updated as needed, and be widely promoted. We believe that raising awareness about the need for monitoring, combined with targeted requests for information about exclusions, will lead to a more complete dataset. This in turn will increase our understanding of bat box use and aid in further assessing the effectiveness of bat boxes for bat conservation.

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Acknowledgements

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Cover photos: Top, left to right: Habitat Acquisition Trust, Salt Spring Bat Project / P. Ommundsen, Habitat Acquisition Trust, M. Kellner, Okanagan Bat Project / R. Kroondijk. Bottom: Cariboo Bat Project / V. Reznicek.

Background

Urban and rural development, coupled with forestry and other industrial development, has led to the loss and/or degradation of roosting habitat for many of the 15 bat species in British Columbia (BC BAT 2016). Several of our bat species have adapted to roosting in human structures such as attics, barns, and siding, and in artificial bat roost structures, or bat boxes (Kellner and Rodriguez de la Vega 2023). Bat boxes predominantly target bat species that prefer to roost in crevices. Boxes are usually made of wood and contain one to hundreds of crevices, and are intended to provide summer roosting habitat.

There are many reasons people install bat boxes, including habitat enhancement in areas with limited or no natural roosting habitat, attracting bats for mosquito control, mitigation for an exclusion from a known roost, and as a focus for education. Funding agencies often support “on-the-ground” habitat enhancement projects including bat box installations.

It is, however, difficult to assess if bat boxes are meeting the goals of funding agencies, conservation groups, and private landowners because studies and monitoring on the use of boxes by bats are lacking. It is also difficult to provide current, data-based recommendations on ideal box types and placement with having data on which to base guidance. Additionally, there are increasing concerns about the potential for bat boxes to negatively impact bats through providing dangerous thermal conditions.

In an effort to address these deficiencies, we reviewed known bat box programs delivered in association with the BC Community Bat Program. We gathered bat box records from Community Bat Programs in BC, to examine use of boxes and ultimately identify factors that contribute to use by bats. This work was initially done in 2019 and resulted in discussions about bat boxes with the BC bat community, including the Bat Matters May 2019 Conference in Peachland and the BC Bat Action Team September 2019 meeting at Blue Lake. The review of regional bat box projects, plus input from these discussions, was incorporated into the development of the [Best Management Practices for Bat Boxes in BC](#) (Dec 2019). The BMPs were reviewed by key BC bat biologists working on bat boxes, distributed to regional Community Bat Program Coordinators, and made available on the bcbats.ca website at <https://www.bcbats.ca/attachments/BMPS-for-Bat-Boxes-in-BC-2019.pdf>. BMPs are included as Appendix 1. Finally, there was increased emphasis on reporting bat boxes through enhancement of the [online bat box reporting portal](#) on bcbats.ca, and promotion of this portal to regional coordinators and private landowners with bat boxes <https://www.bcbats.ca/index.php/bat-houses/register-your-bat-house>.

Collection of bat box data has been ongoing. This report is to update the original finding with all available BC data to 2023 to better understand bat box use in BC and to provide updated recommendations where appropriate.

Methods

Data on bat boxes and occupancy was obtained from three sources: the BC Annual Bat Count database (BC Community Bat Program, Kellner and Rodriguez de la Vega 2023), the www.bcbats.ca online

registration form (<https://bcbats.ca/bat-boxes/register-your-bat-box/>), and regional databases maintained by regional bat projects (to 2019). Databases were from the Kootenay Community Bat Project, Okanagan Community Bat Project, Sunshine Coast Wildlife Project, South Coast Bat Conservation Society, and Habitat Acquisition Trust.

‘Bat boxes’ in this report include all artificial bat roosts made of wood as well a small number of artificial bark roosts where data was reported to the BC Community Bat Program. Not included are the majority of data from other artificial roost projects in the province that use artificial bark (e.g., Wildlife Conservation Society Tree Roost Project <https://wcsbats.ca/Our-work-to-save-bats/Tree-Enhancement-and-Roost-Mitigation-Project>) and concrete (Andrusiak and Sarrell 2019). For this report, artificial roosts were classified as (Figure 1):

- Single chamber – one single roost chamber in a rectangular box,
- Maternity – two or more (usually 3-4) chambers in a rectangular box, including back-to-back maternity boxes on one pole/post,
- Rocket box – one or two concentric chambers around a central pole,
- Bark – synthetic bark-mimic that wraps around a pole to create a single chamber (not shown in Figure 1),
- Mini-condo – a 4’x4’x4’ structure holding many maternity box-type baffles/chambers, and
- Condo – an 8’x8’x8’ structure holding many maternity box-type baffles/chambers.

Bat species in boxes were confirmed through capture, genetic testing of guano (Wildlife Genetics International, Nelson), and/or acoustically. Detailed methods are in Kellner and Rodriguez de la Vega (2023).

Data were collected on box installation type (heated building, outbuilding, pole, chimney), aspect (for maternity and single chamber boxes), colour, and height. There were a range of box colours reported. For analysis, colours were grouped. Green, brown, and black were considered ‘Dark’, while white, beige, tan, and natural wood were considered ‘Light’.

Data on mortality events was requested from roost stewards in summers from 2018 to 2023. The online bat box registration form and the Annual Bat Count form requested information on dead bats, and the BC Community Bat Program Sick/Dead Bat Protocol instructed regional coordinators on bat collection.

When possible, dead bats from roost sites were collected as per the Sick/Dead Bat Protocol and directions from members of the BC Bat Action Team investigating bat boxes and possible heat stress (Cori Lausen (WCSC), Susan Dulc (TRU)).



Figure 1. Bat box types. Clockwise from upper left: Maternity box mounted on barn, looking up into back-to-back 4-chamber maternity boxes, rocket box on pole, mini-condo, condo. The single chamber box is not pictured. Photos: HAT, D Dagenais, J Balke, M Kellner, KCBP.

Results

Distribution and occupancy of bat boxes

We know of 1062 bat boxes installed across the province (Table 1). Of these, 844 (79 %) have been monitored and have occupancy information, where bats were either confirmed or were looked for and not see. For boxes these 844 boxes that were monitored and results reported, sixty percent (505/844, 60 %) of bat boxes were occupied. Bat counts, available for 360 of the boxes, show that a minimum of 48,760 bats are housed in these structures.

There were 218 boxes/1062 boxes that were never monitored, to our knowledge, and so had no occupancy information. The majority of these (159/218, 73%) are listed in regional databases but no successful follow-up has been conducted.

Table 1. Occupancy of bat boxes documented in different data sources.

Data source	Occupied	Vacant	Unknown	Total
BC Annual Bat Count	313	47	0	360
Regional database	100	87	159	346
Online registration	92	205	59	356
All sources	505	339	218	1062

The three data sources are expected to have different biases in reporting bat occupancy. Participants in the BC Annual Bat Count and online registrations are more likely to have colonies/ less likely to report on empty boxes. Online registration, more heavily promoted as of 2019, is encouraged when boxes are first installed, leading to many reports of no occupancy because the box is newly installed and no follow up has yet occurred. We subjectively decided to pool data from all three sources for analyses, acknowledging likely skew in each type of data collection method.

There are 751 boxes with location data, and 616 of these that also have data on if they were occupied or not (occupancy data). Occupied boxes are distributed across BC (Figure 2).

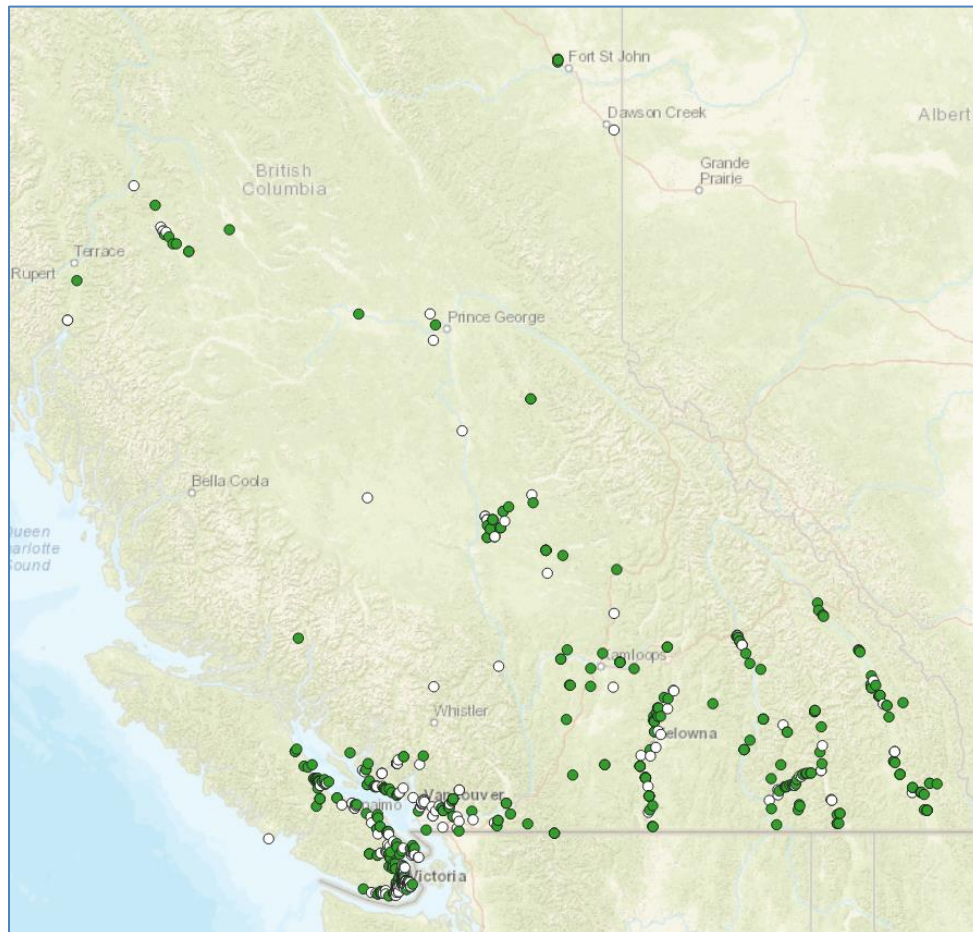


Figure 2. Location of bat boxes that are occupied by bats (green circles) or vacant (white circles).

Bat box type

Box type was reported for 774 of the 844 bat boxes where occupancy (presence/believed absence) was known (Table 2). There were 70 monitored boxes of unknown type. Occupancy varied with box type, and ranged from 30 -100 % for the known box types. For the two most common box types, the maternity boxes were more frequently occupied than rocket boxes (62 versus 55 %, Figure 3). Single chamber boxes were occupied less (38 %). There is one full-sized condo near Creston, which has had an increasing number of bats since installation in 2014. There are ten mini-condos currently monitored in BC; seven have not been occupied to-date (30 % occupancy). One mini-condo in Vancouver was occupied in the third summer after installation (BC Community Bat Program 2023) and one mini-condo in Kikomun Creek Provincial Park was occupied within the same year as installation (A Weber-Roy pers comm).

Table 2. Occupancy rate by bat box type for 844 bat boxes across BC.

Box type	Occupied	Occupied %	Vacant	Vacant %	Total
Maternity	338	62	211	38	549
Rocket Box	71	55	59	45	130
Single	38	48	41	52	79
Mini-condo	3	30	7	70	10
Condo	1	100	0	0	1
Artificial bark	5	100	0	0	5
Unknown	49	70	21	30	70
All boxes	505	60	339	40	844

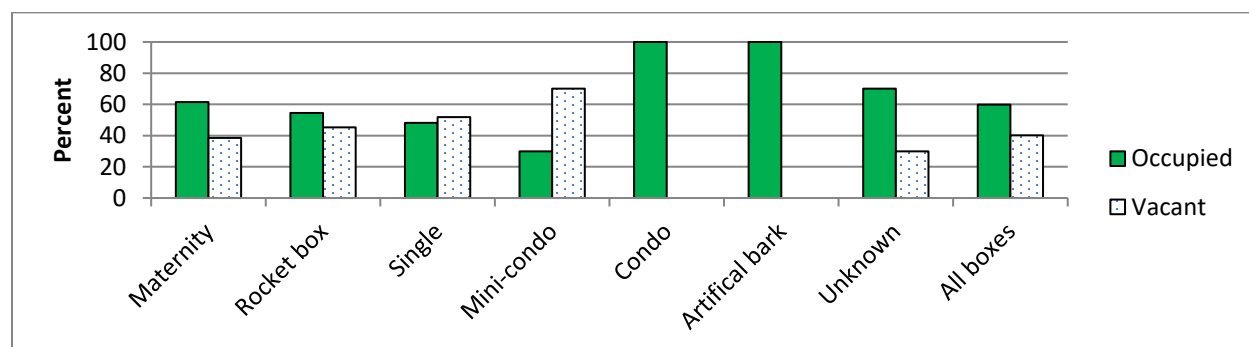


Figure 3. Percent occupancy by box type. See Table 2 for sample sizes.

There are 130 rocket boxes with location information and occupancy monitoring. This style of box has been deployed on southern Vancouver Island and Gulf Islands (82 boxes), Lower Mainland (3 boxes), Sunshine Coast (5 boxes), Okanagan (7 boxes), Cariboo (4 boxes), and Kootenay (29 boxes) regions. Rocket boxes are occupied in all regions where they have been installed (Figure 4).

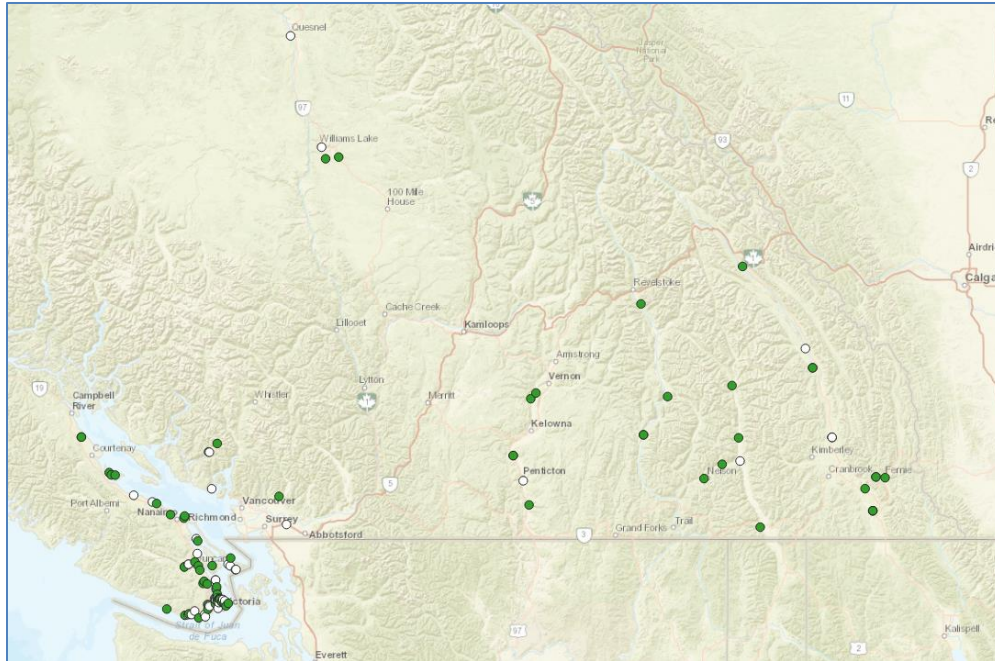


Figure 4. Distribution and occupancy of 130 rocket boxes in BC. Green circles are occupied rocket boxes; white circles are unoccupied rocket boxes.

Colony size

Colony size varies with bat box type (Table 3, Figure 5). Maternity boxes (including back-to-back maternity boxes) house larger colonies than rocket boxes or single chamber bat boxes, although the median number of bats is the same (50) for maternity and rocket boxes.

Table 3. Median, mean, and maximum number of bats by bat box type, for occupied bat boxes.

Box type	Number of boxes	Median # bats	Mean # bats	Maximum # bats
Maternity box	293	30	104	1300
Rocket box	55	30	93	581
Single chamber	30	5	34	316
Mini-condo	3	133	547	1433
Condo	1	5878	5878	5878
Bark	5	2	3.6	11
Unknown	48	64	129	1050

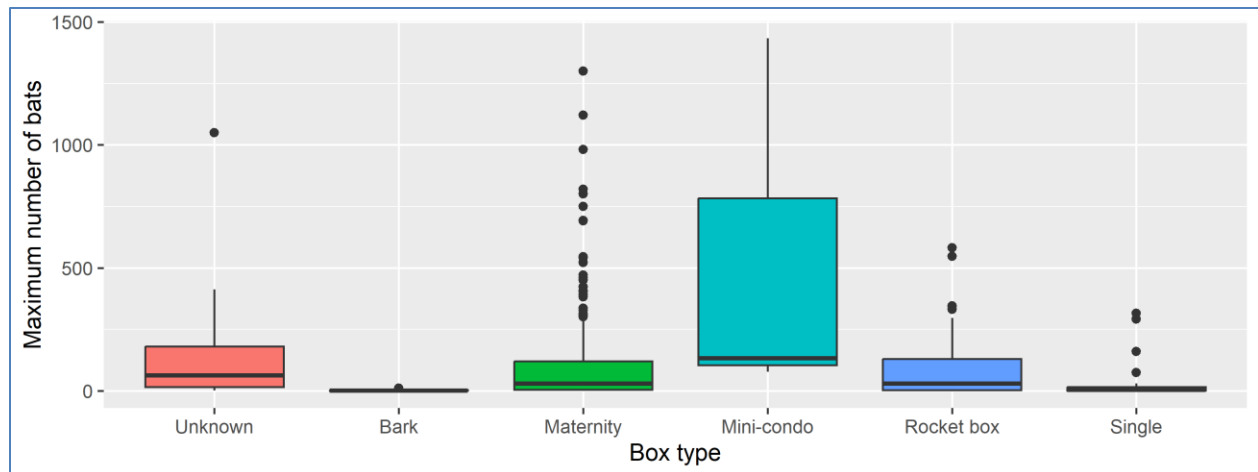


Figure 5. Colony size by bat box type for occupied bat boxes excluding the one Condo. Bat box types are: Unknown (n = 48), Bark (n=5), maternity boxes (n = 293), rocket boxes (n = 55), and single chamber boxes (n = 13).

Bat species

There were 180 bat boxes where species or species group had been identified through DNA in guano, capture, and/or acoustics. Five species were confirmed to be using boxes, including Little Brown Myotis, Yuma Myotis, Big Brown Bats, Californian Myotis, and Long-legged Myotis (Table 4, Figure 6). There is some uncertainty around the identity of a few Little Brown /Long-eared Myotis samples; these are considered Little Brown Myotis for this report.

Little Brown and Yuma Myotis were the most common species in bat boxes. When there were multiple species in a box, groups always included Little Brown Myotis with one or two of the other species, except for one box reported to house Yuma/ California Myotis. Big Brown Bats were in bat boxes in the Cariboo (2 boxes), Vancouver Island and Gulf Islands (4 boxes), Okanagan (3 boxes, 1 with Yuma Myotis), Thompson (2 boxes), Lower Mainland (2 boxes), Sunshine Coast (1 box) and Skeena (1 box, with Little Brown Myotis) regions. All Big Brown roosts were in maternity boxes.

Californian Myotis were reported in boxes in the Okanagan (1 rocket box), Sunshine Coast (3 maternity boxes and 2 unidentified boxes), and Vancouver Island and Gulf Islands (5 maternity boxes, 2 rocket boxes, and 1 unidentified box).

Long-legged Myotis were in the Okanagan (1 box), Kootenay (1 box), Metro Vancouver (1 maternity box) and Skeena (1 maternity box) regions.

Table 4. Species and species groups in bat boxes in BC.

Species /species mix	Number of bat boxes	% of boxes with known species ID
Little Brown Myotis	83	46
Yuma Myotis	46	26
Big Brown Bat	13	7
Little Brown/Yuma Myotis	12	7
Californian Myotis	12	7
Long-legged Myotis	4	2
Little Brown/Yuma/Californian Myotis	2	1
Little Brown Myotis/ Big Brown Bat	1	1
Yuma Myotis/ Big Brown Bat	1	1
Myotis spp.	6	3
All species	180	100

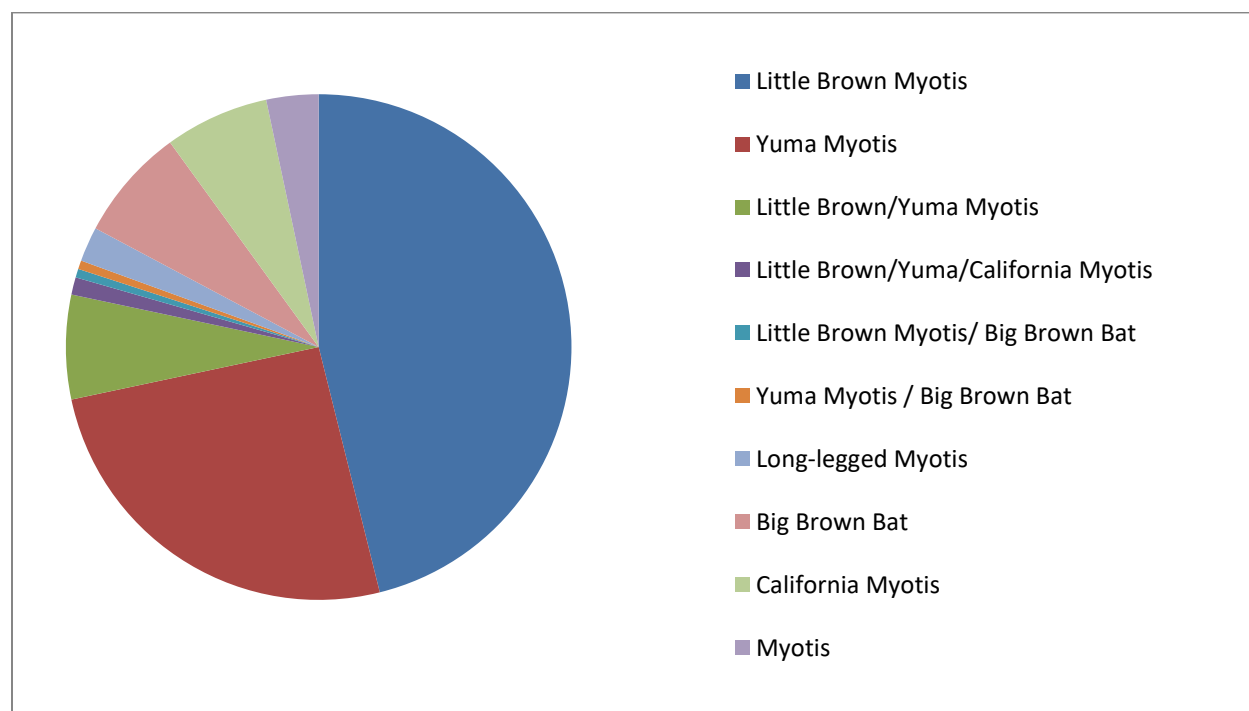


Figure 6. Species of bats in 180 bat boxes in BC. The majority of boxes (78 %) were occupied by Little Brown Myotis, Yuma Myotis, or a mix of these two species.

Species and box type

There were 159 boxes where species and box type were known (Table 5). Little brown Myotis, alone or in mixed species colonies, were found in 90 boxes. Of these, 69 (77 %) were in maternity boxes, 16 (18 %) were in rocket boxes, three (3 %) in single chamber boxes, and two in bark (2 %).

Table 5. Type of bat box used by different species/species groups.

Species/species group	Maternity box	Rocket box	Single chamber	Mini-condo	Condo	Bark	Total
Little Brown Myotis	57	13	3	0	0	2	75
Yuma Myotis	32	5	1	1	1	0	40
Big Brown Bat	13	0	0	0	0	0	13
Little Brown / Yuma Myotis	10	2	0	0	0	0	12
Californian Myotis	7	2	0	0	0	0	9
Long-legged Myotis	2	0	0	0	0	0	2
Little Brown / Yuma / Californian Myotis	1	1	0	0	0	0	2
Little Brown Myotis / Big Brown Bat	1	0	0	0	0	0	1
Yuma Myotis / Big Brown Bat	1	0	0	0	0	0	1
Myotis	2	0	2	0	0	0	4
All species	126	23	6	1	1	2	159

Colour

The majority of bat boxes deployed in BC are dark in colour (Table 6). There are only 91 lighter boxes with monitoring data; the majority of these are in the Kootenay (26/91), Okanagan (13/91), Southern Vancouver Island (12/91), and Metro Van (11/91) regions. There appears to be a difference in occupancy between dark and light boxes $\chi^2 (1, N = 354) = 4.2, p < 0.05$. There were insufficient records to allow regionally-specific analyses for colour or aspect.

Table 6. Colour and occupancy of 354 bat boxes.

Colour	Occupied	Occupied %	Vacant	Vacant %	All
Dark	116	44	147	56	263
Light	29	32	62	68	91
All colours	145	76	209	124	354

Install type

Installation affected occupancy of 432 bat boxes with installation and occupancy data (Figure 7). Rocket boxes, min-condos, and condos are usually only mounted on poles and were not included in this dataset. Occupancy varied with installation type. Boxes had higher occupancy when on chimneys (85%, 11/13), heated buildings (62%, 79/128), and unheated/outbuildings (68%, 58/85). Occupancy rates were lower for boxes mounted on poles (49%, 71/146) and trees (23%, 14/60).

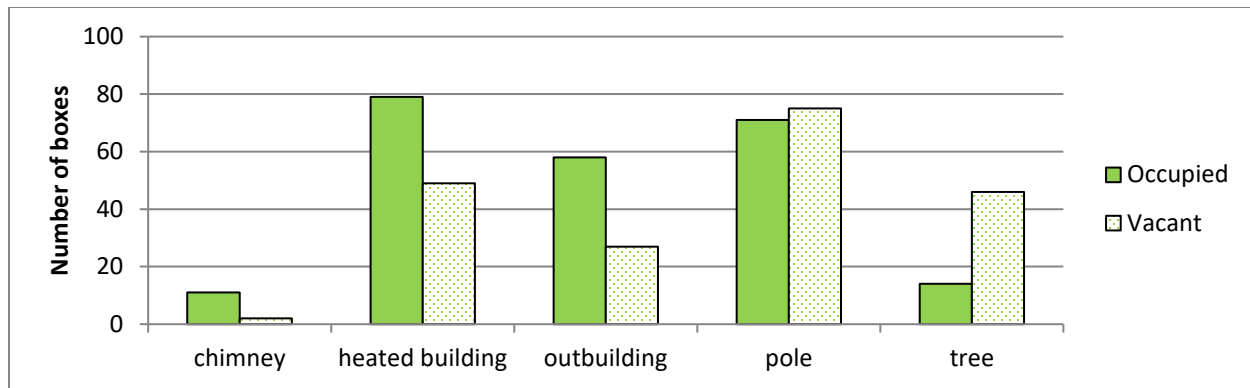


Figure 7. Occupied and vacant bat boxes by install type, for 432 bat boxes. Samples sizes are chimney n = 13, heated building n = 128, outbuilding n = 85, pole n = 146, and tree n = 60.

Bat boxes as mitigation

Reason for installation was reported for 443 boxes (Table 7). Of these, 353 also had occupancy monitoring at some time.

Boxes installed when landowners had bats and wanted to provide additional habitat were most likely to be monitored (99/112; 88% monitored). Boxes installed as part of an effort to attract bats and provide habitat and attract bats were slightly less likely to be monitored (169/201; 84 %). Of the 130 boxes installed as part of an exclusion, only 85 (65%) were monitored. Boxes installed as part of an exclusion had the highest occupancy rate (45 %), followed by boxes to attract bats (41%). Least successful were boxes added to provide additional habitat when bats were already present (30% occupancy).

Colony sizes in bat boxes at exclusion sites appeared larger than those at other boxes with known reason for installation (Table 8, Figure 8).

Table 7. Monitoring rate and occupancy of boxes based on reason for installation.

Reason for install	All boxes	Boxes without monitoring	Boxes with monitoring	Occupied	Occupied %	Vacant	Vacant %
Attract bats	201	32	169	69	41	100	59
Excluding bats	130	45	85	38	45	47	55
Have bats; provide additional habitat	112	13	99	30	30	69	70
All boxes	443	90	353	137	39	216	61

Table 8. Median, mean, and maximum number of bats by bat box type, from BC Annual Bat Count data for occupied bat boxes with Bat Counts of 1 or more at any time.

Reason for installation	Number of boxes	Median # bats	Mean # bats	Maximum # bats
Unknown	322	40	115	1433
Attract	58	10	67	545
Exclude	30	43	301	5878
Have bats	25	8	16	78
All boxes with bat counts > 0	435			

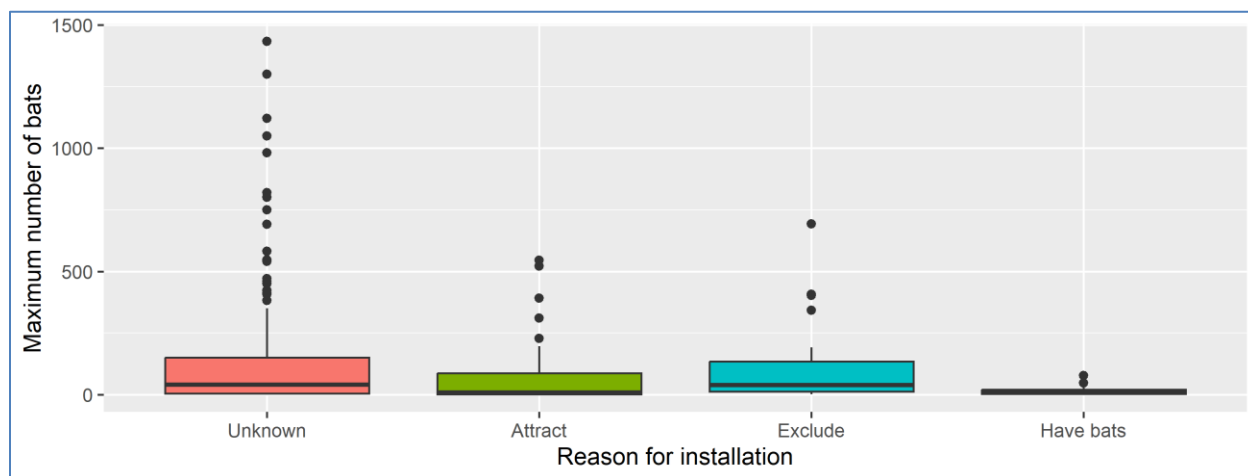


Figure 8. Colony size by reason for installation, for occupied bat boxes with bat counts. Reasons for installation are Unknown (n = 322), Attract bats (n = 58), excluding bats from another structure (n = 30), and because landowners have bats and wish to provide additional habitat (n = 25).

Mortality events at bat boxes

There were 27 events (24 mortality events and three non-lethal events) at boxes from 2015 to 2023. These were reported by roost stewards, regional community bat projects, and bat researchers. Reports were summarized in a Google Sheet and shared online. Eleven events involved 0 - 3 bats, and sixteen involved > 5 bats (9 -506 bats).

There were two to four reported mortality events of five or more bats each year from 2016 to 2019 (Table 9). The percent mortality, based on very rough estimates of colony size, ranges from < 1- 14 %.

The Annual Bat Count can be used as a conservative estimate of the number of boxes monitored in a year. In 2019, there were 121 boxes monitored, housing 5700 bats. If all mortalities happened at Annual Bat Count sites (they did not), this would mean 3.3 % of sites (4/121 sites) had mortality events involving 9.8 % (559/5700) of the bats censused. Excluding one exceptionally large mortality event at a large colony, 2.4 % (3/121) of sites had events involving only 2.4 % (53/2200) of bats censused.

Table 9. Summary of reported mortality events at bat boxes, 2015 – 2023.

Year	Total # events	# mortality events of > 5 bats	Total # dead bats (reported)	Range in % mortality of colonies, when colony size was known
2015	0	0	0	0
2016	4	3	76	2 – 7
2017	3	2	26	3 – 5
2018	6	4	144	3 – 13
2019	3	3	559	2 – 14
2020	3	1	38	7
2021	4	0	3	
2022	3	2	25	6
2023	1	1	6	2
All years	31	13	857	1 – 14

Discussion

This study pulls together data from various projects across the province and forms a starting point for future targeted data collection and analyses. Although sample sizes are small, the dataset provided preliminary insights on species using bat boxes, use of different box types in BC, and colony size in different box types. Of particular interest are the occupancy rates and range of colony sizes in boxes of different types. However, there are likely interactions between installation factors (e.g. colour, mounting type, aspect, location in province) that may influence occupancy. A larger, more complete dataset is required to tease apart the influence of multiple factors on occupancy and investigate variation in box use across the province.

Bat boxes and exclusions

Boxes installed during exclusions were occupied about half of the time (45 % occupancy), which is slightly lower than the average occupancy rate (60 %). However, these boxes were providing habitat for bats, and the limited count data suggests that colony sizes in these boxes are similar to those in other bat boxes. To avoid concerns about overheating, and provide a range of conditions for excluded bats, multiple boxes with different thermal properties should be installed at these sites following current Best Management Practices (BC Community Bat Program 2019).

The dataset did not include colony size or species identification before/ after exclusion. Determining what proportion of a colony actually moves into boxes placed for mitigation is an important next step. Research into the effectiveness of boxes as mitigation for exclusion is underway in the Kootenays (contact LeighAnne.Isaac@gov.bc.ca).

Bat boxes installed as part of exclusion are not well-monitored compared to boxes installed for other reasons. To accurately assess the utility of bat boxes as alternate habitat, we need to improve data collection with this group of landowners who may be less interested in monitoring than people who install boxes to increase habitat or attract bats. A dedicated effort should be made to continue to gather

information on occupancy, particularly after exclusions, to determine efficacy of boxes at providing mitigation habitat.

Bat boxes and mortalities

There were a limited number of mortality events reported at bat boxes from 2015 - 2023. Although there are a total of 1062 bat boxes that have been monitored in BC, it is unknown what proportion of these are monitored each year. At the time of writing, cat predation was by far the most common cause for bat mortality in summer (Beattie et al. 2022), often without the bat box owners knowing a cat was involved. However, there are other factors that may cause mortality including disease and overheating. Overheating is known to contribute to mortality in bat boxes in some cases (Flaquer et al. 2014, Lausen 2020), and is likely responsible for bats gathering at the entrance to bat boxes (bulging) during high heat. There are, however, also multiple mortality events recorded in BC where comments indicate temperatures were low and that heat or humidity were unlikely to be factors. Ongoing research into bat box microclimates, mortality events, and movement between boxes will be helpful in determining the extent that overheating plays in these mortality events.

Gathering data and collecting samples when there are mass mortalities at bat boxes and other human roost structures continues to be important, to increase our understanding of normal rates of mortality at BC bat colonies, and allow investigation into possible causes of unusual mass mortality events. Data should be shared with researchers investigating bat box temperature and humidity and impacts on bat survival. The BC government and BC Community Bat Program will continue to encourage reporting of any dead bats near roost sites, as well as unusual behaviour that may indicate overheating, such as bats bulging from the bottom of a box or taking flight during the daytime.

Recommendations

To improve the database and our understanding of how bats use bat boxes in BC, suggestions include:

- identify locations of the boxes at unknown sites,
- compare use of boxes across regions,
- look at colony size by species using boxes,
- evaluate proportion of boxes that are mixed-species roosts,
- following up on occupancy of bat boxes, particularly those installed as part of evictions,
- encourage participation of box owners in the BC Annual Bat Count,
- develop a BC Annual Bat Count online app to streamline data capture, and
- continue to support studies on temperature and humidity of bat boxes throughout the province, including sharing data with the Canadian Bat Box project.

Lessons learned

Valuable lessons were learned through this project. Specifically, we realized that when project requires multiple steps, we need to identify and address barriers at each step. Steps to be considered in this project, and actions to improve completion of each step, are:

Steps for roost stewards	BC Community Bat Program actions to improve outcomes
If excluding, gather data prior to exclusion	• Provide DNA collection instructions to confirm species ID • Ensure at least one bat count is completed to estimate colony size; provide count directions and datasheet (or links to online versions)
Install a bat box and capture details about box type and installation	• Promote online registration immediately
Monitor bat box for use and number of bats	• Promote monitoring by sending mass email reminder to all bat box registrants. ALSO emphasize regional outreach efforts. • Ensure roost stewards know how to monitor a bat box, either through ○ having a guano catcher/sheet (best for occasional or seasonal use, or to confirm initial use), ○ looking in, or ○ exit counts (best for determining number of bats, and good for stable colonies that can regularly be observed)
Submit data, even if box is vacant	• Prompt landowners for reporting by sending emails. • Ensure data entry is easy – consider new options (e.g., online app)

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Appendix 1. Best Management Practices for Bat Boxes in British Columbia. Dec 2019.

Best Management Practices for Bat Boxes in British Columbia



BC Community Bat Program December 2019



Summary

- Bat boxes can be valuable for bat conservation, but reasons to install boxes should be carefully considered, and attention to construction, installation, monitoring, and maintenance are essential.
- Determine if bat boxes are necessary or appropriate prior to construction and installation.
- Not all bat species use bat boxes. Boxes are used primarily by the two species which commonly inhabit buildings (Little Brown Myotis and Yuma Myotis).
- Bat boxes may increase the number of roost sites available for some species but do not mitigate the loss of complex natural habitats.
- Bat boxes may be valuable in the following situations:
 1. mitigation for exclusion from a known roost,
 2. mitigation for loss of natural roosting habitat,
 3. education, or
 4. pest control.
- Prior to any exclusion, do exit counts to determine bat numbers and install enough bat boxes to support the excluded colony.
- Install well-built, multi-chamber boxes, not single chamber boxes.
- Install multiple boxes in locations with varying amounts of sun exposure, ideally three or more.
- Follow regionally-appropriate recommendations for colour and amount of sun exposure.
- Register your bat boxes with the BC Community Bat Program.
- Monitor your bat boxes and report any mortality.
- Maintain your bat boxes annually.

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Considerations for use of bat boxes

Bat boxes can provide safe, secure roost sites for several species of bats in British Columbia. They are commonly used by Little Brown Myotis, Yuma Myotis, and Big Brown Bats, and occasionally used by California Myotis, Long-legged Myotis, and Long-eared Myotis. Detailed construction and installation information is provided in [Building Homes for Bats](#) and from [Community Bat Program Regional Coordinators](#).

Bat boxes can be an essential part of managing bats and providing habitat in urban and rural areas. However, before installing a bat box, it is important to consider if a bat box is necessary or appropriate in the situation. Bat boxes are likely not necessary in undisturbed areas where natural roost sites are available (e.g. patches of old cottonwood, aspen, conifers with sloughing bark or cavities, cliffs and rock outcrops with deep cracks, barns or outbuildings). For an overview of considerations on how and when bat boxes may best be employed to contribute to bat conservation, watch the Wildlife Conservation Society Canada webinar '[Roosts for Tomorrow](#)'.

- Do not install bat boxes in undisturbed habitat (e.g. undisturbed, older forest with cavities and sloughing bark), where roosts are likely available. This will avoid concerns about potentially increasing the few bat species that use boxes to the detriment of other bat species.
- Bat boxes may be valuable in the following situations:
 1. mitigation for exclusion from a known roost,
 2. mitigation for loss of natural roosting habitat,
 3. education, or
 4. pest control.

See below for best practices specific to each of these situations.

1. Mitigation for exclusion from a known roost (e.g. building, tree, bridge)

- If possible, retain and preserve the original roost to avoid negative impacts and potentially decreased reproductive success in the colony.
 - Follow detailed guidance in [Managing Bats in Buildings](#) and examples from [Living with Bats](#).
- If exclusion is required, conduct exit counts before exclusion. Conduct a minimum of two pre-pup (June 1-21) and two post-pup (July 11 - August 5) colony counts, using the BC [Annual Bat Count protocol](#), and submit data to the [BC Community Bat Program](#) to:
 - determine the size of the colony and calculate the minimum number of bat boxes required to support the colony after exclusion, keeping in mind not all boxes will be occupied so additional boxes are needed.
 - One multi-chamber nursery box or rocket box may house 200-300 bats, while a mini-condo may house 1000 +.
 - determine if it is a maternity roost (i.e. is there a large increase in numbers between pre-pup and post-pup counts).
 - facilitate effectiveness monitoring (e.g. the proportion of colony that re-locates to bat boxes).
 - identify the main access points are for repair/renovation work during exclusion.

- Install a minimum of two (ideally 3+) four-chambered maternity boxes and/or rocket boxes. Multiple bat boxes should be installed, to provide a range of temperature options at a site and account for unoccupied boxes.
- Identify the species at the roost through acoustics or guano pellets (DNA). Contact BC Community Bat Program for guidance and analysis.
- Installation should occur at least one summer season prior to exclusion to allow time for bats to find and occupy the new boxes. Ideally, install in April or May and conduct exclusion in fall (see exclusion timing).
- If the owners of the exclusion site cannot or do not install enough bat boxes to support the colony, use a community stewardship model (e.g. install boxes within 500 m in the neighbourhood or at local parks).

Bat-friendly exclusions: If you are working with landowners to facilitate a bat-friendly exclusion in fall, encourage the landowners to help gather information about the utility of bat boxes: encourage multiple bat counts AND installation of bat boxes prior to exclusion, plus bat counts at the bat boxes in future.

2. Mitigation for loss of natural roosting habitat (e.g. old trees)

Urban and rural areas such as the Okanagan Valley have documented a 50% decrease in low-elevation roosting habitat, suggesting a role for habitat enhancement in ensuring continued presence of bat species. You can learn more about natural bat habitat in the [Bat-friendly Communities](#) guidance document. Before installing bat boxes as habitat enhancement, consider that:

- Areas with currently suitable tree roosting habitat should not be considered for bat boxes.
- Only six (6) of BC's 16 bat species use bat boxes and buildings. The majority of structures are used by only two species.
- Bat boxes are not effective mitigation for loss of complex natural habitats that provide abundant natural roosts and foraging habitat, so restore natural habitats where possible.
- Bat boxes may benefit some species by increasing the availability of safe roost options in an area that already has key elements to support those species (food and water) but lacks roosting habitat for crevice roosting bats due to human impacts.
- Bat boxes may provide temporary roost sites while forested habitats regenerate to a stage where they can provide natural roost sites. Habitat restoration benefits many species, not just bats and should be a priority over providing a few crevice roosts (e.g. bat boxes), whenever possible.

Species that use bat boxes: In BC, 89 % of bat boxes are used by only two species (Little Brown Myotis and Yuma Myotis).

3. As a focal point for public education

Public education can be another reason to consider installing a bat box. Well-situated bat boxes with interpretive materials can provide an opportunity to learn about bats and their habitat requirements, an accessible location to watch bats and increase public participation and support for bat stewardship. Before installing bat boxes for the purpose of public education, consider that:

- Multiple box sizes and designs, and varied installations, should be used to maximize usefulness of the boxes and minimize disappointment. See [Building Homes for Bats](#).
- Boxes should be installed in suitable areas to maximize both educational value and benefits to bats, rather than focusing solely on education.
- An interpretive sign should be installed. A sign design is available through the BC Community Bat Program.
- Signs last a long time. Take care to ensure contact information on the sign is also long duration.
- Ensure that a plan is in place that outlines responsibility for long term care, maintenance, and monitoring of the boxes.

4. Natural control of insect pests

Many people wish to install bat boxes to encourage bats on their property for pest control (mosquitoes, crop pests). If installing bat boxes to encourage bat presence for pest control, consider:

- Bats do eat mosquitoes and a variety of forest, agricultural, and orchard pests.
- Install bat boxes only if natural roosts are lacking but other habitat requirements are present (foraging areas, a water source within 5 km). See the [Bat-friendly Communities Guide](#) for more information on habitat essentials.
- Install a minimum of two, four-chambered, maternity boxes and/or rocket boxes. Multiple bat boxes should be installed, to provide a range of temperature options at a site and account for unoccupied boxes. If boxes are used by bats, consider adding more boxes.
- If you are installing boxes in an agricultural or orchard landscape, guano may be valuable for confirming prey items eaten by bats. Contact the [BC Community Bat Program](#) to find out more.

Construction – recommended approaches for organizations

Construction of high-quality, multi-chamber, bat boxes is time-consuming. Several approaches are recommended, based on experiences across the province.

- Use experienced woodworkers: Consider partnering with an individual, organization, or institution with construction or woodwork experience, who can build bat boxes for distribution (e.g., prison, disabled woodworker business, high-school woodworking programs, keen community volunteers with woodworking shops, rod and gun clubs).
- Volunteers or students: If volunteers are interested in building bat boxes, ensure they have the necessary carpentry skills or can acquire them (e.g. in a high-school woodworking class) to build high-quality bat boxes. Poorly constructed boxes have less likelihood of occupancy and don't last as long, so are not an optimal use of resources. As a result, most Community Bat Programs have moved away from volunteer, bat house building workshops and use experienced carpenters instead.
- Supply builders with optimal plans or [links to plans](#) online. Some boxes, such as small, single chamber boxes are not recommended. However, do install a variety of boxes if possible, including deep and shallow boxes, wide and narrow chambered boxes, etc. as this will provide varying microclimates and appeal to bats of different stages in reproduction, different sexes, and different species. All boxes need standard components including a long rough landing platform, and ways for bats to move between chambers inside the box without having to exit the box.
- Consider partnering with local hardware stores when possible, for material cost-reduction and wood-cutting options.

- Consider sourcing funds for bat house materials from local conservation funds, [TD Friends of the Environment](#) (not for private land), Fish and Wildlife Compensation Program's (FWCP) [Community Engagement grants](#), or Public Conservation Assistance Fund ([PCAF](#)).
- Bat-box building workshops: These are a LOT of work and are rarely done as we now recommend only multi-chamber bat boxes constructed by experienced carpenters. If you are doing a workshop, due to the length of time to make a multi-chamber box, do as much preparation as possible (e.g., pre-cutting and roughening all pieces) to ensure projects can be completed in the allotted time. Combine a workshop with an educational presentation and provide instructions on installation and monitoring. Example presentations are available from the BC Community Bat Program.

Bat box style and construction details (what kind of bat box and how many?)

Details on bat box construction and installation are provided in the [Building Homes for Bats](#) guide. Regional adaptations are best discussed with the [Community Bat Program Regional Coordinator](#) for your area. Key points:

- Promote multi-chamber maternity boxes (> 60 cm / 24" tall, > 50 cm / 20 " wide) or rocket boxes found in [Building Homes for Bats](#). These offer a range of temperatures to roosting bats, are most likely to be occupied, and are most likely to house maternity colonies (highest conservation impact). Costs range from ~ \$50 - \$100 per box, plus installation costs.
 - Single-chamber houses are not recommended. They are much easier to build, but may have more chance of overheating, to the detriment and perhaps death of bats inside, and will not support maternity colonies. These boxes should only be installed in shaded or north-facing areas, if used.
- Bat condos (2.5 m (8') wide and high) and mini-condos (1.2 m (4') wide and high) are larger and can be built to provide a complex set of microclimates. They are more expensive (~\$7000 minimum) and may take years to become occupied, although structures do get occupied by a small number of bats in the first season. For mitigations where bats need a home quickly, ensure the condos offer ample roosting opportunities under siding and roofing. Standard bat condo plans may require site-specific modifications to be warm enough to support maternity colonies in BC or cool enough to avoid heat stress in hot areas of BC. Contact the [BC Community Bat Program](#) for details.
- Install a temperature and humidity monitoring device, if possible, to contribute temperature data to research projects and allow for adaptive management (see Monitoring, below). If temperatures are too hot or cold, modifications can be made, including stain colour, opening vents, closing gaps, etc.
- Ensure houses are correctly built or they will not last and are less likely to be used, including:
 - secure caulking and roofing. Leaky houses will not attract bats and are a waste of resources.
 - appropriate venting (as per designs in [Building Homes for Bats](#)).
 - all interior surfaces are roughened (roughened wood provides a "foothold" and is preferred over screen; if screen is used, ensure all staples are flush to avoid damaging wings)
 - landing pad of sufficient length (10 cm (4")) and roughness below the chambers, for bats to land on then crawl into chambers
 - colour of the exterior of the box should be based on location to increase or decrease heat – see temperature maps in [Building Homes for Bats](#)

- use of odour-free, water-based stains, and only stain the OUTSIDE of the box.
- Consider your target species when constructing boxes.
 - Most species that use bat boxes (e.g. Little Brown, Yuma, and California Myotis) use 1.9 cm / ¾" crevices or spaces between bat box chambers.
 - Big Brown Bats, which are larger, may prefer larger (2.5 cm / 1") crevices and may be less likely to use a 1.9 cm spaced box.
 - Townsend's Big-eared Bats require open, barn-like structures. Use of artificial roost structures in BC by this species is poorly understood, with only one successful Townsend's artificial roost in BC (condo, not box). If you build a structure for this species, ensure plans for the structure and monitoring results are shared with the BC Community Bat Program and the Province of BC.
 - Other bat species not mentioned are less likely to use boxes made of plywood or milled wood.
- Artificial bark can be bought (e.g. Brandenbark) or constructed (e.g. cedar shakes) and may provide habitat for a variety of Myotis species, including Northern Myotis, that do not use buildings or boxes. Use in Canada is unknown but bark trialled in BC has received immediate use (species to be determined).

Distribution (who gets a bat box and how to distribute bat boxes)

- Boxes given away for free are less likely to be installed, installed correctly and monitored. This can be a large drain on limited budgets and reduce effectiveness of the program. Consider
 - A refundable deposit, returned after installation and/or three years of monitoring (proof of installation and/or occupancy count data required). If unoccupied, move the box.
 - Pricing that covers materials and installation costs.
 - Pricing that contributes funds to the bat project.
- Prioritize who will receive bat boxes (e.g., eviction is planned, landowners can commit to do annual bat counts and/or that are centrally located for volunteers to do roost counts and guano collections).
- Hand-deliver bat boxes if possible, and review installation criteria, select a site, and promote monitoring. Ideally include installation by a trained person.
- Maintain a contact list of all bat house recipient and/or workshop participants and obtain permission to share data for research purposes, and/or ensure recipients all register bat boxes on www.bcbats.ca
- Ensure that installation, maintenance, and monitoring advice is provided to all bat house recipients, regardless of how the boxes are built/sourced.

Installation

Bat boxes in full sun will get hot. Heat appeals to maternity colonies of bats in spring when heat is critical to advance gestation. There is, however, concern that boxes could get too hot and/or humid and contribute to mortality later in the season, particularly during sudden temperature fluctuations. To be effective, bat houses must be installed according to the guidelines in [Building Homes for Bats](#), with regionally-appropriate amount of direct sunlight, on a heated building/outbuilding/pole, and at least 10 feet high and away from clutter. Bat boxes can be placed on de-limbed trees, but live branches may cause shading and clutter.

- Promote installation of multiple boxes (minimum of two, ideally three or more), in positions that receive varying amounts of solar heating. Sites with multiple houses offer a range of roost temperatures and are more likely to be occupied by maternity colonies. Bats will move between boxes. To facilitate movement when pups are unable to fly, place some boxes back-to-back, with a roughened tunnel between them. Use variation in staining, solar exposure, and/or awnings to create different microclimates across the structures.
- Ensure bat boxes get installed. Many donated (free) bat houses do not get installed, or may be installed in suboptimal locations. Maximize effectiveness of bat boxes by ensuring that boxes are sited in optimal locations. Consider:
 - Site visits to assist with siting and installation by trained staff/ volunteers.
 - Financial incentives to encourage installation by homeowners (e.g., a deposit returned after installation).
 - A fee-for-service model including a site visit, bat boxes, and install.
- Provide a regional instruction sheet, including recommended colour of bat box, facts about local bats, maintenance recommendations, and your contact information (Appendix 1).
- Record details on installation and submit online – see Tracking below.
- Install houses at least one summer season before an exclusion, to allow bats time to locate the new roost site.
- Bat houses not occupied after three or more years should be relocated to a site with more or less direct sunlight.

Tracking bat houses

- Encourage bat box owners to [register their bat house online](http://www.bcbats.ca) at www.bcbats.ca
- Keep a list of all contacts who receive or build or install a house for follow up.
- Confirm if bat box owners give permission for data on their bat house (location, box characteristics, and installation information) to be shared provincially for research.
- Always collect standard information on bat house characteristics and installation details, to aid in determining bat preferences. This should include:
 - Type and size (e.g. nursery box, rocket box, Wisconsin mini-condo)
 - Number of chambers
 - Colour
 - Aspect
 - Mounting surface (pole, wall).
- During site visits, record basic characteristics of successful and unsuccessful bat houses (e.g. evidence of use, location, bat box type, mounting method, height, aspect, colour). All data should be reported online through the [Bat House Registration link](#).

Monitoring and maintenance

Providing effective artificial roosting habitat is a long-term commitment. Bat boxes should be maintained and monitored yearly (at a minimum).

- Maintenance must be carried out for boxes to be effective. Ensure box recipients know to
 - Scrape out wasp nests.
 - Scrape out any large guano accumulations.
 - Recaulk joints and repair roofs if needed.
- Monitoring approaches could include:

- A monitoring agreement signed by bat box recipient to encourage monitoring.
- Funded or volunteer monitoring team with an identified team leader.
- Recruiting dedicated volunteer groups.
- Provide an easy and clear monitoring protocol. At least one count (ideally four) during the BC Annual Bat Count is recommended, even if no bats are observed.
- Promote visual checks throughout the summer, to confirm occupancy.
- Remember that bats may occupy bat boxes intermittently and perhaps for only part of the season. These boxes are still providing important habitat!
- Use a guano catcher or place plastic sheeting or cardboard on the ground to best monitor for intermittent use. Bat guano looks like mouse droppings – dark and elongated pellets. Bat guano is easily crushed, and contains insect fragments.
- Encourage reporting of all unused boxes as well as used boxes, to improve future installation advice.
- Encourage box owners to regularly inspect the ground under the bat boxes in late June and early July, to check for dead pups or adults. Report these immediately to the [BC Community Bat Program](#).
- Consider installing a shade cloth/sheet over the bat box if bats appear too hot and are hanging around the entrance of the box.
- If mortalities are observed, install a nearby or adjoining box that is cooler, through shading, aspect, or venting. This will provide a safe escape from occasional overly-hot (e.g., > 42 °C) temperatures in the main box.
- Provide feedback to bat box owners and monitors to enforce value of monitoring and retain monitors.
- Expect to have to re-contact box owners with reminders to monitor boxes. At a minimum – March/April – reminder to install new boxes, ensure older boxes are clean and in condition. June/July – reminder to monitor for occupancy/Annual bat count, and to check for dead pups.
- Encourage monitoring of temperature and occupancy in bat boxes, to determine maximum tolerable temperature for bats and situations that create high temperatures. Contact the BC Community Bat Program for more information.

Guano collection and distribution

- Ensure appropriate respiratory protection is used when collecting guano from enclosed spaces.
- As with the handling of any animal feces, ensure gloves are used.
- Guano is an excellent fertilizer but should not be transported away from the roost site, due to the possible persistence and transport of Pd, the fungus responsible for WNS, in guano.
- Promote using guano as fertilizer ONLY in the immediate surroundings (<20 km from source).

Acknowledgements

This document was based on the recommendations developed in the Kootenay Community Bat Project report (Craig and Isaac 2018), information from Habitat Acquisition Trust (Erickson-McGee 2019) and communications with bat biologists, bat advocates, and BC Community Bat Program regional coordinators across the province. Their experiences and findings are invaluable in helping direct future mitigation and enhancement efforts.

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Appendix 1. Example of regional installation information handout (South Coast)



South Coast Bat Conservation Society
Bat research, conversation and education



Installing a Bat Box

Bat boxes are an excellent way to enhance bat habitat in your neighbourhood. Female bats may use these roosts from April to October to raise their pup; however, occupancy time varies with species (3 wk- 5 mo). Bat boxes require very little maintenance. As a caretaker of a bat box, we encourage you to join the Community Bat Programs Annual BC Bat Count. This province-wide program only requires a total of 4 hrs of observations every summer, and allows you to directly help us monitor, protect, and manage bats.

There are numerous types of bat boxes, two successful designs are the Rocket Box and 4-chambered Nursery House (aka bat house). Be cautious of marketed boxes as they may not be suitable. Visit SCBats website for designs, to purchase a kit or box, or to book a bat house building workshop.

Bat boxes should have/be:

- ☑ Three or more chambers connected internally
- ☑ All internal surfaces grooved or scoured
- ☑ Partitions with ¾ inch spacing
- ☑ Unobstructed landing strip 3" or taller
- ☑ Roof with lateral and forward overhang
- ☑ Watertight
- ☑ Hung in a location that receives a large amount of sunlight (S or SE exposure in Vancouver)
- ☑ Hung a minimum of 12 ft (4 m) above the ground, and 20 ft (6 m) from surrounding obstacles (i.e. wires, branches)
- ☑ Hung within 400 m of freshwater
- ☑ Hung on a building near the roof or mounted on posts
- ☑ Avoid chemicals, metal or hard mesh materials that can harm bats



Rocket box

For a successful bat house in the Vancouver and surrounding areas:

- ☑ Install the box before April or 1 year prior to exclusion.
- ☑ Install 2 or more to compare and assess conditions and/or designs.
- ☑ Keep cats inside at sunset and sunrise to reduce predation on bats.
- ☑ Minimize disturbance. Do not tap or bump the box and only shine a light up inside for minimal periods of less than 10 seconds to check occupancy.



4-chambered nursery house

If your bat house is not occupied after 2-3 summers check for drafts and gaps. Monitor your property for bat activity and move it to a new location based on your observations. Or try painting it a different colour. Contact SCBats of the BC Community Bat program for guidance and learn about the Annual BC Bat Count.