University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Bats on Campus:

Living with an Endangered Species

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Executive Summary

In August 2022, a roost of endangered little brown bats (*Myotis lucifugus,* hereafter *M. lucifugus*) was found on UBC Campus, inside the Auditorium Annex Offices. Concerns have been raised by building residents and UBC Facilities about bat activity and bat droppings near the roost. To alleviate these concerns and provide an alternative habitat for these bats, our ENVR 400 project team partnered with UBC SEEDS to help relocate the bats.

M. lucifugus has been an endangered species since 2014 due to a fungal disease known as White Nose Syndrome, which has caused widespread mortality. This is not well known among the public, and there are few groups advocating for the conservation of these bats, despite the fact that *M. lucifugus* prey on insects that harm human health and agricultural productivity, providing desirable ecosystem services in urban environments.

Important factors when determining suitable habitat for *M. lucifugus* include temperature, protection from predators, proximity to water bodies, and density of vegetation. Bat boxes can be a suitable substitute to roosting sites if they are located within suitable habitat.

Our main research objectives were as follows: 1) identify a suitable location for a bat box near the current roost, 2) purchase a bat box that meets the roost's habitat needs, and 3) recommend procedures for protecting the roost and addressing gaps in UBC wildlife conservation policy. To identify suitable habitat, our team first conducted a GIS analysis. This allowed us to weigh different factors relevant to bat habitat suitability, including proximity to water bodies and buildings, density of trees, and density of soft vegetation. Following this, we scouted suitable sites in-person and consulted with various bat experts and UBC staff to understand the benefits and drawbacks of each installation location (Figure 1). One Dual Quad Chamber bat box was obtained after consulting with bat experts to ensure the box met the roost's needs. Finally, the installation process was developed in collaboration with external contractors and UBC Building Operations. The installation location we selected is in a field approximately 120m away from the current roost (Figure 2). Due to the close proximity to the current roost, our group felt this location provided the best opportunity for a successful relocation.

Figure 1. A chart highlighting the key stakeholders we consulted throughout the location selection process. Each group had different insights and concerns about where to place the bat box.

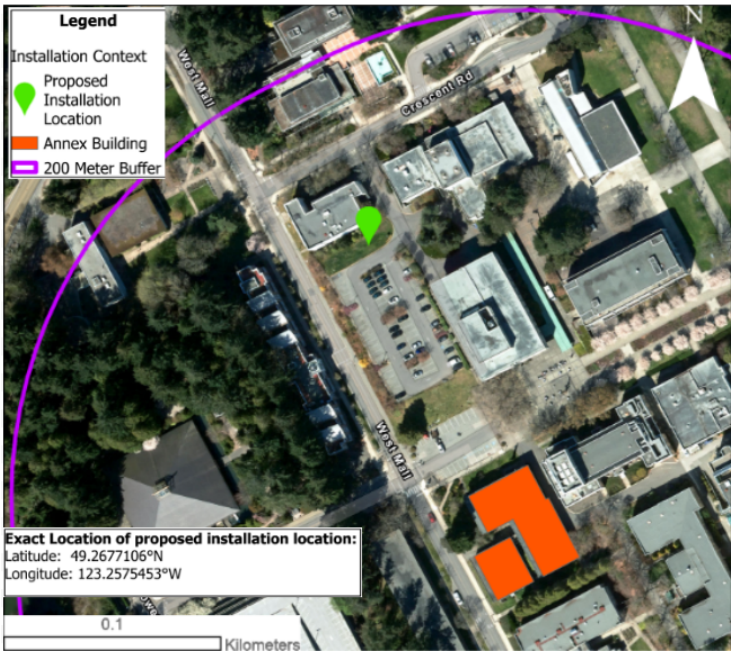

Figure 2. Final proposed installation location for the bat box, represented by the green marker. The location of the building housing the bat roost is shown in red.

As part of the permitting process for our bat box, we developed a Monitoring and Maintenance plan. This plan details the actions required from groups responsible for maintaining the bat box after our team's involvement ends. These groups include student organizations, upper-year undergraduate students, and bat researchers on campus. We have also made recommendations to address gaps in UBC policy regarding biodiversity planning. Our main recommendations are to create a centralized task force explicitly tasked with handling wildlife-related concerns on UBC campus and hire a biodiversity coordinator. Our work helps reduce deleterious human-bat interactions at UBC, provides recommendations that inform procedures for future *M. lucifugus* conservation, and more generally informs future wildlife conservation approaches on campus.

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Author Bios

Philip Bartha is a fifth year student majoring in Environmental Sciences with a focus on ecology and conservation. He was responsible for developing the Monitoring and Maintenance plan, identifying parties to assist with bat box maintenance, and writing conservation recommendations for stakeholders.

Ryan Brehon is a Environmental Science major in his fourth year with a concentration in Land, Air and Water. Through previous work experience, he has installed permanent and temporary structures and has a strong knowledge of various installation techniques. He was responsible for sourcing the materials for installation and creating the installation plan for UBC Building Operations.

Mark Wen is a fourth year student in Environmental Science with a focus on ecology and conservation. He has experience with research and data analysis through the Maldonado Lab. He was responsible for communicating the results from this project in this report and the poster.

Timothy Wong is a fourth year student in Environmental Science with a focus on Sustainability. He is interested in land-use planning related to conservation in urban environments. He was responsible for conducting the GIS analysis and generating the map-based deliverables. He was also responsible for coordinating communications between all the stakeholders involved in this project.

1. Introduction

1.1 Little Brown Bats

Little brown bats (*Myotis lucifugus,* hereafter *M. lucifugus*) have been listed as an endangered species under Schedule 1[1]of the Species at Risk Act (SARA) since 2014 (Environment Canada, 2016). White Nose Syndrome (WNS), a fungal disease that appears as a white fuzz on the noses of bats, is the main cause of the species' decline. Bats are interrupted during hibernation by WNS, causing them to waste energy and die during winter (Frick et al., 2010a). WNS has rapidly spread across North America since it was first observed in 2006. It has already endangered numerous bat species that were previously considered at low risk for extinction, like *M. lucifugus* (Frick et al., 2010a; Hayman et al., 2016). In April 2023, WNS was detected for the first time in British Columbia (CBC News, 2023). Previous reports indicated that WNS had only been observed as far west as Washington (Figure 3). In addition to the threat of WNS, *M. lucifugus* in B.C. are also vulnerable to changing climates. Drier and hotter summers will likely lower insect abundance and diversity, which will decrease prey availability (Frick et al., 2010b).

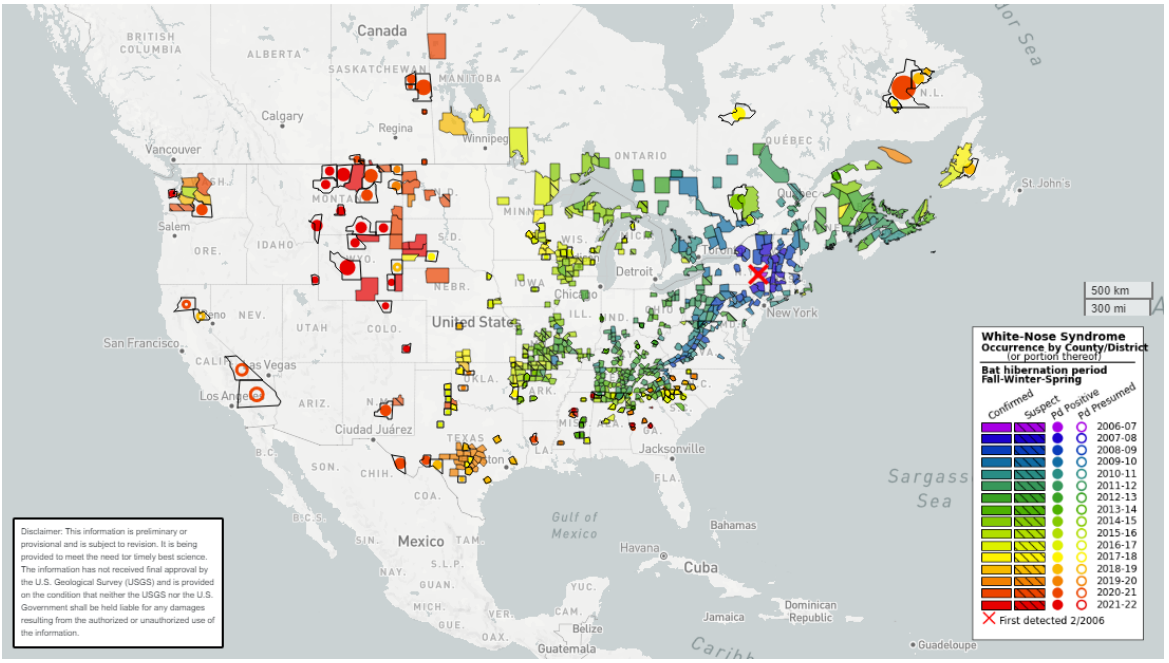


Figure 3. A map of North America showing the annual spread of White Nose Syndrome starting in 2006 and ending in November 2022. Retrieved from White Nose Syndrome Response Team (2022).

The high selection pressure against *M. lucifugus* due to WNS and climate change has major repercussions on the ecosystems they inhabit. This includes human settlements, which have been occupied more frequently by *M. lucifugus* as urbanization has decreased their suitable habitat (Coleman & Barclay, 2011; Frick et al., 2010b; Norquay & Willis, 2014). Bats have always had strong ecological associations with humans ever since we started living in buildings (Voigt et al., 2016). Man-made structures provide bats with shelter, warmth, and protection from predators (Bergeson et al., 2015). In return, bats pollinate and control insect populations (Boyles et al., 2011). Given that individuals can live

[1] Schedule 1 listed wildlife species are officially considered at risk, and are either classified as extirpated, endangered, threatened, or of special concern.

for over 10 years and reproductive females only produce one young per year, their populations are susceptible to rapid decline (BC Bats, 2017; Frick et al., 2010b). The loss of *M. lucifugus* means the loss of the ecological value they provide humans in urban spaces.

1.2 Project Description

In the summer of 2022, a maternity roost of approximately 150 endangered little brown bats was discovered on UBC Vancouver Campus within Auditorium Annex Offices A (Figure 4a-c) (G. Stanley, pers. comm., September 15, 2022). An ongoing analysis of bat guano near the roost has also implied the presence of the Yuma myotis (*Myotis yumanensis*), another bat species (D. Dagenais, pers. comm., February 24, 2023). *M. yumanensis* is commonly found in the same roosts as *M. lucifugus*, and is listed as a threatened species in B.C. This is the first time a roost of endangered and threatened bats has been found inside a UBC building. There are currently no university policies for managing endangered wildlife on campus.

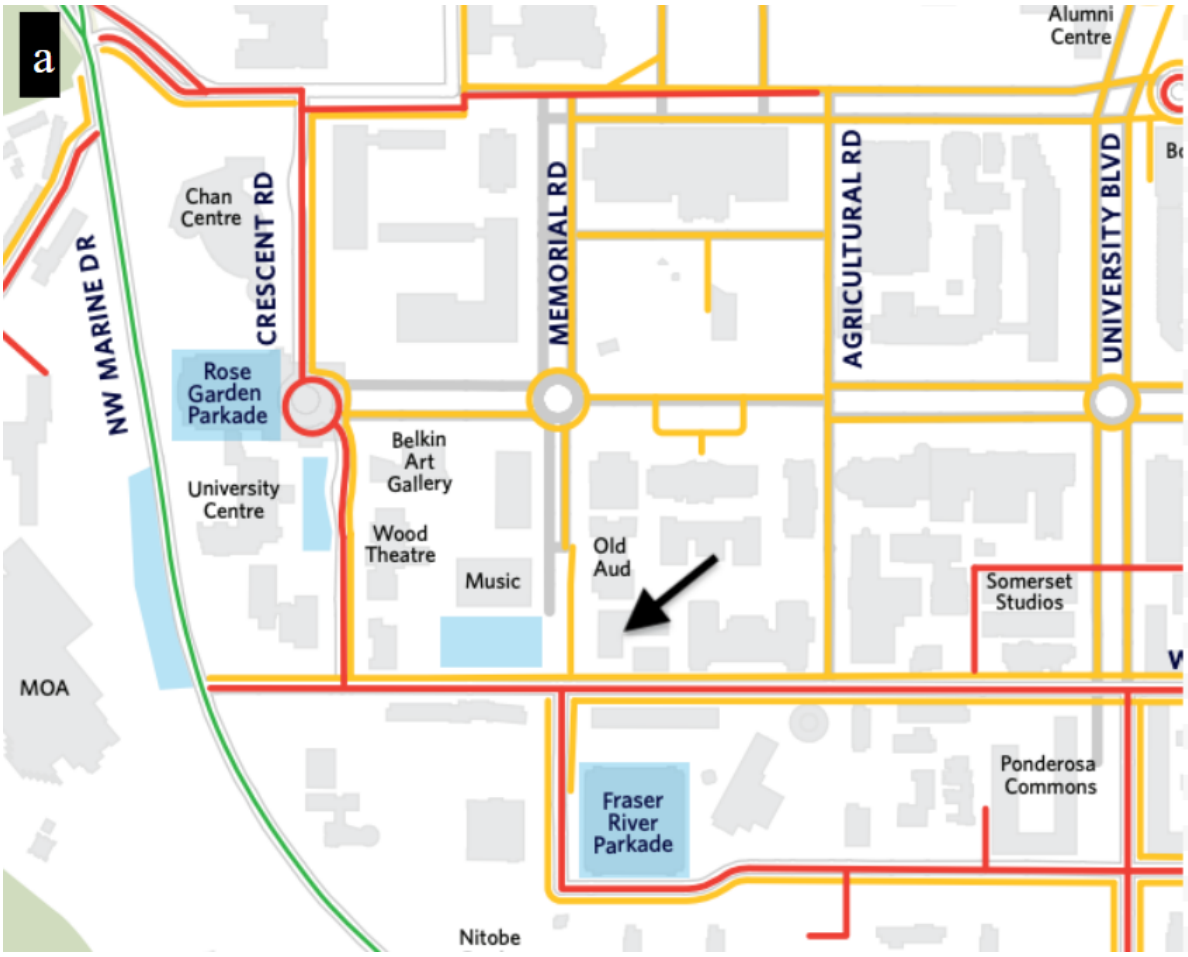


Figure 4. a) Sectioned map from UBC Facilities of UBC Vancouver Campus. The black arrow points to the location of the Auditorium Annex Office building. **b)** A photograph of the exterior of the Auditorium Annex Office building, taken in October 2022 by Timothy Wong. **c)** Gaps between wood panels at the roof edge through which the bats are suspected to have entered, taken in October 2022 by Timothy Wong.

Residents of Auditorium Annex Offices A have voiced several concerns about bat activity, including perceived health risks, such as rabies, and the presence of guano on accessibility railings. Custodial Services are responsible for the pest control contract for UBC Point Grey Campus which includes responding to reports of guano. Bat colonies are a wildlife issue and the responsibility for managing human/wildlife conflict does not fall within UBC Facilities' mandate. Since custodians or streets and landscaping staff do not deal with wildlife control, outside contractors have been hired to clean the guano for the time being. This is not a viable long-term approach due to high costs and inefficiencies from a Facilities management perspective (S. Lynch, pers. comm., November 2, 2022). Although it would be best for the bats to leave the endangered roost alone, there are too many negative interactions between residents and the bats for them to stay. Our team of environmental science students was tasked by the UBC SEEDS Sustainability Program with identifying suitable habitats for *M. lucifugus* on campus, installing bat boxes to help relocate the bats away from the building, and providing a plan to monitor the bats. This project is intended to begin filling in policy gaps at UBC related to wildlife conservation by opening conversations about wildlife conservation among several campus groups. The installation of a bat box will promote biodiversity on campus and pioneer how UBC approaches endangered species conservation.

For this project, we had three objectives:

a. Find an optimal location, given bat habitat and institutional limitations, to install a bat box for the roost of little brown bats (*Myotis lucifugus*) at Auditorium Annex Offices A.
b. Obtain a bat box that is designed to support the Auditorium Annex Offices A bat roost.
c. Provide recommendations to conserve the roost in the future and address current gaps in UBC wildlife conservation policy.

1.3 Bat Relocation

M. lucifugus conservation efforts are complicated by the fact that this species requires different roosts at different times of the year (Figure 5) (Norquay & Willis, 2014; Schorr & Siemers, 2021). *M. lucifugus* reproduce from September to October, before hibernating from early November to March, after which females form maternity roosts to rear their young (Wisconsin Department of Natural Resources, 2013). Pups depend on their mothers for food until early August, when they learn how to fly and forage alone (Frick et al., 2010b). Due to their endangered status, the Auditorium Annex Offices A roost cannot be interfered with from May to September, since this is when pregnant females have pups and are confined to the roost (BC Bats, 2016; Wisconsin Department of Natural Resources, 2013). Under B.C.'s Wildlife Act, wounding endangered or threatened species and capturing wildlife is illegal (BC Wildlife Act, 2023). Thus, harming the roost could have monetary or other legal repercussions for UBC.

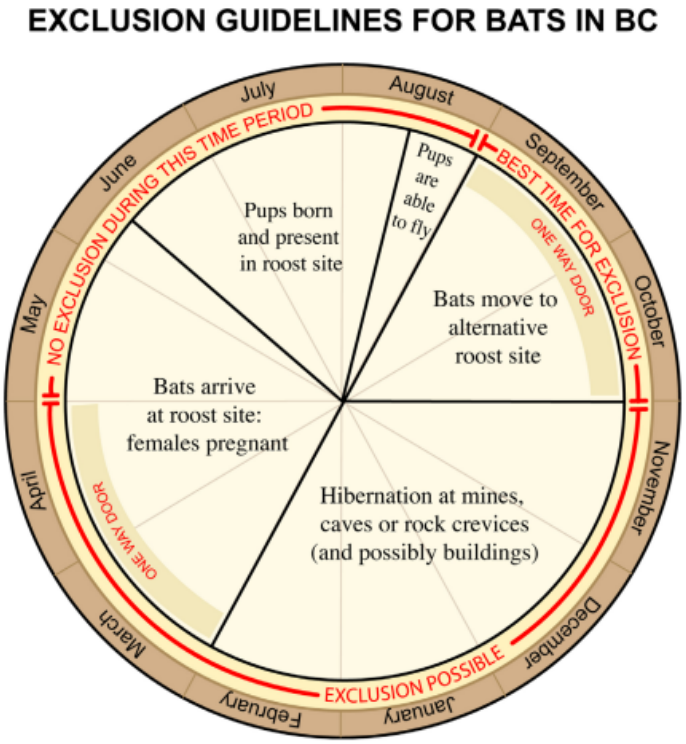


Figure 5. Yearly calendar showing the general timing of bat life stages, shown in black, and timing for excluding bats from buildings in B.C. (BC Bats, 2017).

M. lucifugus choose maternity roosts based on locations that meet certain abiotic requirements, including temperatures ranging from 24 to 34℃, high humidity, and close proximity to water bodies and food sources (Clare et al., 2014; Nelson & Gillam, 2017; Wisconsin Department of Natural Resources, 2013). The best practice for conserving bats inhabiting buildings is to avoid disturbing them, since the bats have moved into a suitable habitat (BC Bats, 2017). Since the bats at UBC are affecting staff and students and UBC Facilities have to hire outside contractors to conduct maintenance, leaving the bats alone is not a viable solution. Ideally, relocating the bats would take place over several years, where bats would be allowed to access their original roost and the installed bat box. Giving the roost time to acclimate to the box will improve the likelihood of a successful relocation. As students and staff have already raised health concerns about the bats, there is no time for an acclimation period. Thus, we recommend that UBC exclude these bats after installing a freestanding dual bat box, which may compensate for their loss of habitat in Auditorium Annex Offices A. Exclusion is the process of sealing off all entry points except for one, waiting until the bats leave their roost (in this case, the building) to forage during the night, and sealing the singular entry point so the bats cannot return. If done properly, this process will not physically harm the bats. Due to logistical complexity and material costs, we will not be conducting exclusion as part of this project, but it may be carried out by other groups in the future.

1.4 UBC's Approach to Wildlife

The discovery of this bat roost marks the first time endangered wildlife have been found living inside a UBC building. Although a team of researchers and staff were mobilized to address this issue, many of them volunteered to help while still fulfilling their regular responsibilities. As mentioned before, Custodial Services is responsible for cleaning up the guano, despite this not falling under their job

description. Similar situations in which people implement temporary solutions are not sustainable in the long-term.

Ultimately, a lack of planning resulted in a situation where the bats were not a priority for any person or group, which delayed action. This reflects a larger issue at UBC. There are no wildlife and biodiversity policies to guide endangered wildlife management. As UBC is not located on federal land, the Species at Risk Act (SARA) does not automatically provide protection for endangered species on campus (SARA, 2002). While the B.C. Wildlife Act penalizes activity that harms endangered species, wildlife conservation still requires significant political and institutional will. Biodiversity is listed as a priority under the Campus 2030 Vision Plan, but no action has been taken to address the shortage of human resources and funding dedicated to wildlife-related concerns (UBC, 2023).

2. Methods and Results

Our first research objective is broken into two parts: 1) identifying suitable habitat for *M. lucifugus* in order to install a bat box that meets the needs of bats and 2) installing a bat box in a location that meets UBC's institutional needs. We conducted an extensive amount of GIS analysis and met with stakeholders to install the bat box in a location that would most likely result in a successful relocation. Additionally, we ensured the bat box was appropriately designed and installed to provide optimal habitat conditions, safety from the elements, and protection from potential predators. The following sections detail the methods used to determine our proposed installation location, as well as the process of selecting the appropriate bat box design and finalizing our installation plan.

2.1 Bat Habitat Selection

The purpose for installing our bat box is to provide bats with alternate habitat that compensates for the loss of their habitat. *M. lucifugus* have high site fidelity, suggesting the bats might return to Auditorium Annex Offices A (Schorr & Siemers, 2021; Wisconsin Department of Natural Resources, 2013). In the event that the bats are excluded from the building, having a bat box nearby would compensate for the loss of their habitat. Since the bats were discovered in the summer, the roost is likely maternal, where multiple females gather to raise their young (BC Bats, 2017). Confined areas in buildings can provide ideal temperature conditions due to heat generated by buildings while also providing protection and shelter from potential predators (BC Bats, 2017; Wisconsin Department of Natural Resources, 2013). By installing a bat box in a suitable location, the box would be able to provide the bats with optimal temperature and predator protection that would help sustain this population.

2.2 GIS Analysis

To determine a suitable installation location, we first identified suitable habitat for *M. lucifigus* on UBC Campus by conducting Geographic Information System (GIS) analysis using ArcGIS Pro (Version 3.1.0). We believed looking for locations in-person would take too much time and likely leave out areas that are less accessible by foot. The methods outlined below were partially developed through consultation with Dr. Brian Klinkenberg, a GIS Professor in the UBC Geography Department.

Since we were undecided about the spatial scope of our study, we used the Habitat Suitability Modeling (HSM) tool to generate suitability maps for the entire campus. Mapping the entire campus would ensure that we would have a reasonable amount of data for our model. If we only used data within a certain radius of the roost, there would not be enough habitat heterogeneity for the model to detect substantial differences in suitability, leading to lower quality results. Based on our background research of bat ecology and the data we were able to procure, we considered four factors when modeling suitability (Table 1).

Table 1. Description of factors used in the habitat suitability analysis, the criteria for determining suitability based on each factor, and the reasoning behind each decision.

Factor	**Suitability Criteria**	**Rationale**
Proximity to water bodies	Higher values (if close to water bodies)	*M. lucifugus* prefer to forage near water where there are more insects.
Proximity to buildings	Lower values (if close to buildings)	We want to minimize human-bat interactions and reduce the chance for bats to inhabit other buildings.
Density of trees	Higher values (if higher density of trees)	A higher density of trees could provide more shelter through increased canopy.
Density of soft vegetation	Higher values (if higher density of vegetation)	More vegetation should support more insects.

The HSM tool creates a map showing relative suitability across a specified area based on an input of different factors that can be weighted and transformed differently. For each of the four factors we considered in our models, we assigned them weightings relative to each other to denote importance. We then transformed the data layers by specifying what criteria we designate as suitable, combined these layers together, and then used the model to find the most suitable locations within a specified radius of the current bat roost (Figure 6). The data used for the GIS analysis was sourced from Campus and Community Planning and GIS Librarians (attributions and full list of datasets can be found within Appendix B).

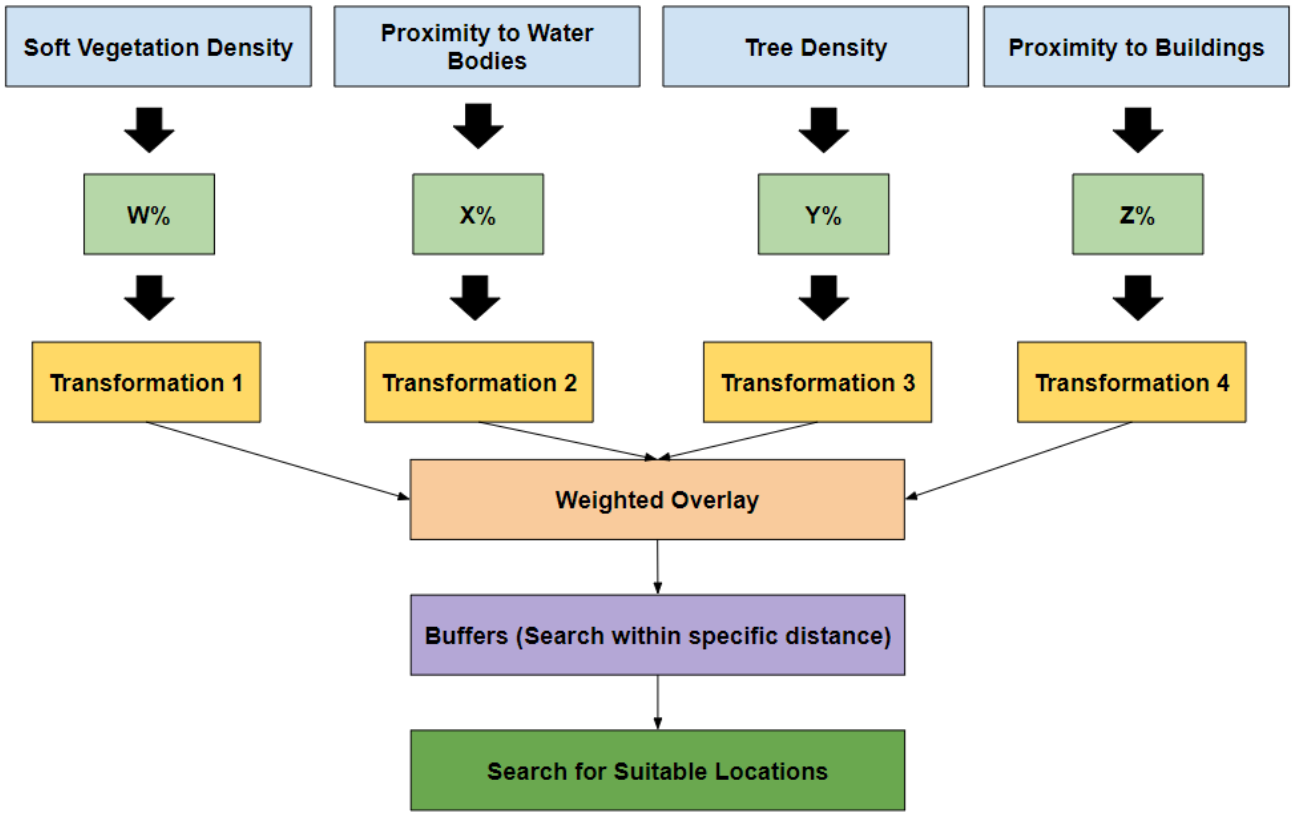


Figure 6. Overview of steps associated with the Habitat Suitability Modeling tool in ArcGIS Pro. Factors (soft vegetation density, proximity to water bodies, tree density, and proximity to buildings) and respective weights, which denote the relative importance of factors, are strictly placeholders (where W + X + Y + Z = 100%). In practice, the weighting was determined using the Analytical Hierarchy Process.

To ensure that we were not basing our decisions off one model, we created three different models to test what happened when we weighed factors differently (Table 2). With the exception of Model 2, close proximity to water bodies is the most important factor, since many sources suggest bats must be able to access suitable foraging areas.

Table 2. Description of all models used to generate *M. lucifugus* habitat suitability maps. All models are based on the same four factors, but the assumptions behind which factors are more important differ. Weightings (relative importance) were determined using the Analytical Hierarchy Process.

Model Number	**Assumptions influencing factor weights**	**Relative importance**
1	High tree density and close proximity to water bodies are more important	Water bodies: 37.5% Trees (high): 37.5% Buildings: 12.5% Soft Vegetation: 12.5%
2	All factors are equally important, high density of trees desired	All factors: 25% each
3	High density of soft vegetation and close proximity to water bodies are more important	Water bodies: 37.5% Soft Vegetation: 37.5% Buildings: 12.5% Trees (high): 12.5%

To run the HSM tool, the data for each factor is transformed so that it reflects suitability across our scale of interest, which is the entire UBC Campus (Figure 7a). We would then indicate how we want suitability to be defined, such as ranking areas of high tree density as more suitable, and giving it a higher score on a scale of 0-100. We repeat this for all factors and the model combines all of them together to generate one weighted overlay map (Figure 7b). After this map is generated, we can identify the most suitable locations within a specified area. We searched for the three most suitable locations within a 500m and 200m radius of Auditorium Annex Offices A (Figure 7c).

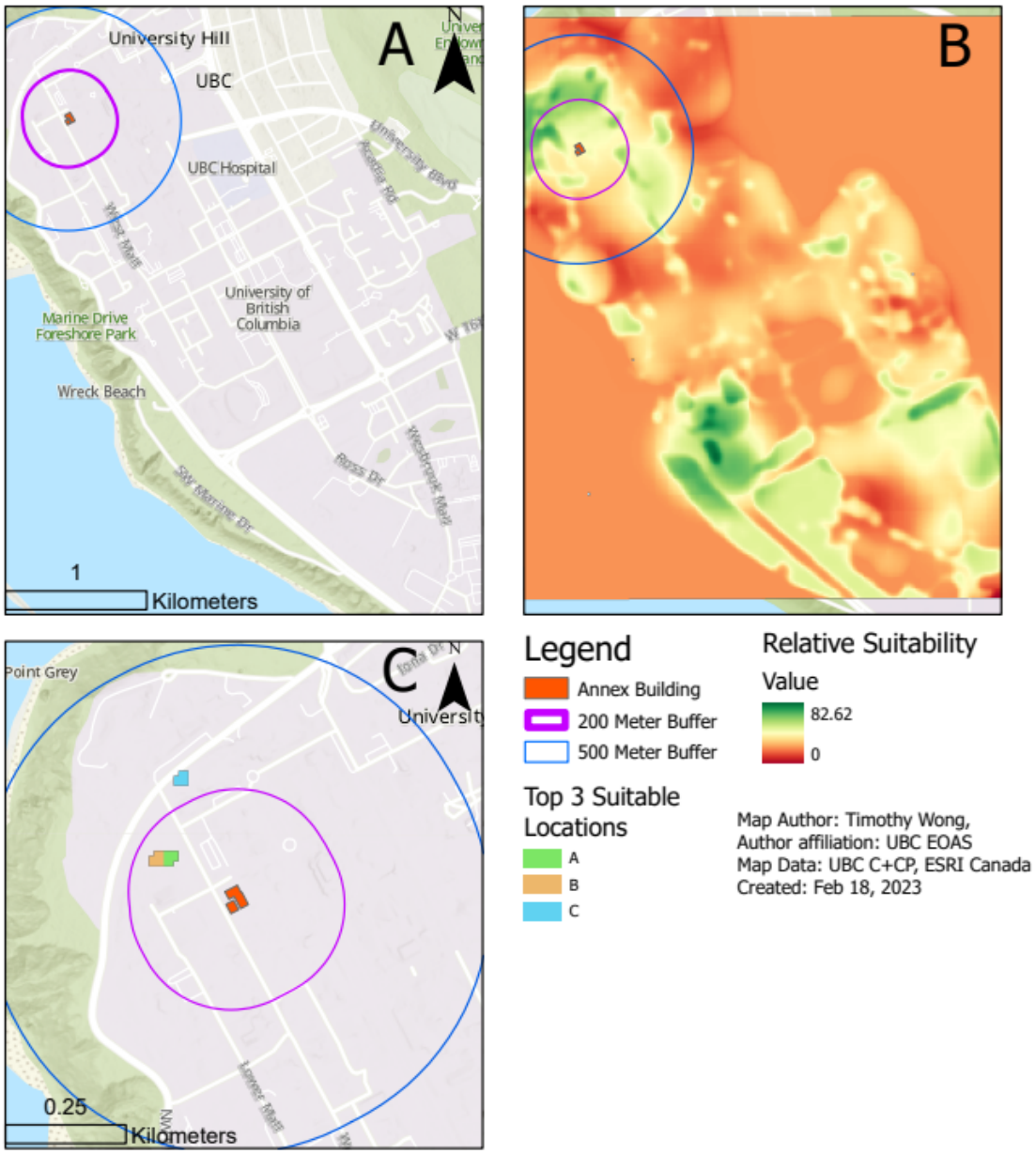


Figure 7a) Map showing the study area of analysis on UBCV Campus. Circles show buffers of radius 200m and 500m centered around Auditorium Annex Offices A, the current location of the bat roost. **7b)** Habitat suitability of little brown bats (*Myotis lucifugus*) on UBCV Campus. The scale, ranging from 0-100, represents habitat suitability (0 = least suitable and 100 = most suitable). Four factors were weighted for the purpose of this analysis (proximity of water bodies, density of trees, density of soft vegetation, and proximity to buildings). The map shows relative suitability values across UBCV Campus assuming equal weighting of all factors, with 0 being least suitable and larger values being more suitable. **7c)** Maps showing the three most suitable locations of little brown bat (*Myotis lucifugus*) habitat within a 500m radius of their current location on UBC Vancouver Campus under the equal weighting evaluation method. Locations are represented by polygons and are not ranked in any particular order. For clarity and concision, only the maps for Model 2 are shown. Maps for all three models can be found in Appendix B.

Several models generated suitable areas in the same location: a clearing in a forested area behind the Liu Institute. We decided to focus our efforts to install a bat box here (Figure 8). We also decided to focus on locations found within 200m radius of the current roost. Ideally, the bat boxes would be located

close to the current roost to decrease the chance that the bats would relocate into another building instead of the box. Many buildings near the current roost have a similar roofing design (i.e. old wood, gaps between wood panels at the roof edge) and are likely suitable habitat for bats.

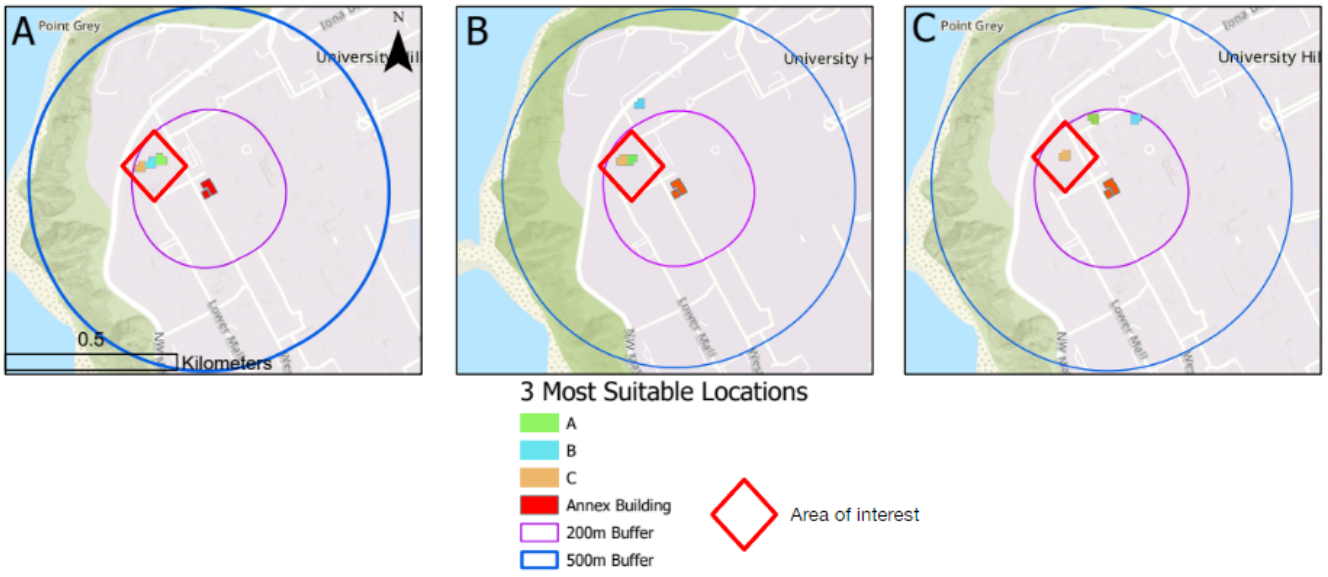


Figure 8a-c) Maps showing the three most suitable locations of little brown bat (*Myotis lucifugus*) habitat within a 500m radius of their current roost under three evaluation methods. Four factors were weighted (proximity to water bodies, density of trees, density of soft vegetation, and proximity to buildings) in three ways: **8a)** preferential weighting of water bodies and trees (Model 1), **8b)** equal weighting of all criteria (Model 2), and **8c)** preferential weighting of water bodies and soft vegetation (Model 3). Locations are represented by polygons and are not in any particular order. The area where overlap was observed between all models is denoted by red diamonds in all figures.
8d) Google Earth layout which shows the initial area of interest, denoted by the yellow pin.

2.2.2 GIS Analysis Limitations

The factors used during the suitability analysis are not an exhaustive list of all factors that influence bat habitat suitability. Notably, temperature, sun exposure, and moisture are all very important abiotic considerations. Human traffic is an additional factor that we did not consider in our GIS analysis. We were unable to obtain data that was detailed enough to represent these factors. Sun exposure is especially difficult to model, since it varies by season and time of day. Additionally, the soft vegetation data does not distinguish between different species of plants. Thus, this would not account for differences in whether plants are maintained (e.g. mowed or sprayed with pesticides) and would not reflect differences in their habitat suitability for insects. For example, the large strip of lawn that runs down Main Mall would be weighted positively, despite it being heavily maintained (e.g. mowed).

2.2.3 Consultations and Ground Truthing

We proposed the location determined above using GIS analysis (i.e. forest clearing near the Liu Institute) to Karen Russell and Renee Lussier of Campus and Community Planning (hereafter C+CP Staff). We also proposed this location to Danielle Dagenais, the Regional Coordinator for BC Bats, who has assisted with past relocation efforts. Through these initial consultations, we found many issues with our proposed location (Table 3).

Table 3. Concerns about the location of bat boxes that arose during consultations with various groups and stakeholders. This is not an exhaustive list, but shows the common concerns raised for multiple locations.

Source of Concern	**Concerns**
Campus and Community Planning	Too close to walking paths/bus stops
	Too close to light fixtures
	Potentially overlaps with utilities
	Proposed location slated for future development
Bat Box Requirements (BC Bats)	Limited sun exposure (shading from trees)
	Less than 20 foot radius of clear space around box
	Further than 100m rom existing roost
	Too close to roads/traffic
Building Managers	Too close to building entrances and walking paths
Arborists	Bat box installation would harm vegetation in the area, especially tree roots
UBC Facilities	Too close to buildings with external structures that bats could enter and occupy

Given the difficulties associated with finding a suitable location solely through GIS, we turned to ground truthing and explored the area surrounding the current roost in person. We found several additional locations that might be suitable (Figure 9) and discussed them with staff from C+CP and BC Bats, while also taking into account the pre-existing concerns raised by UBC Facilities. We soon realized that finding a location that satisfied all requirements would be impossible given that we were consulting with C+CP, BC Bats, UBC Facilities, building managers, and arborists, all whom had their own concerns (Table 3, Table 4).

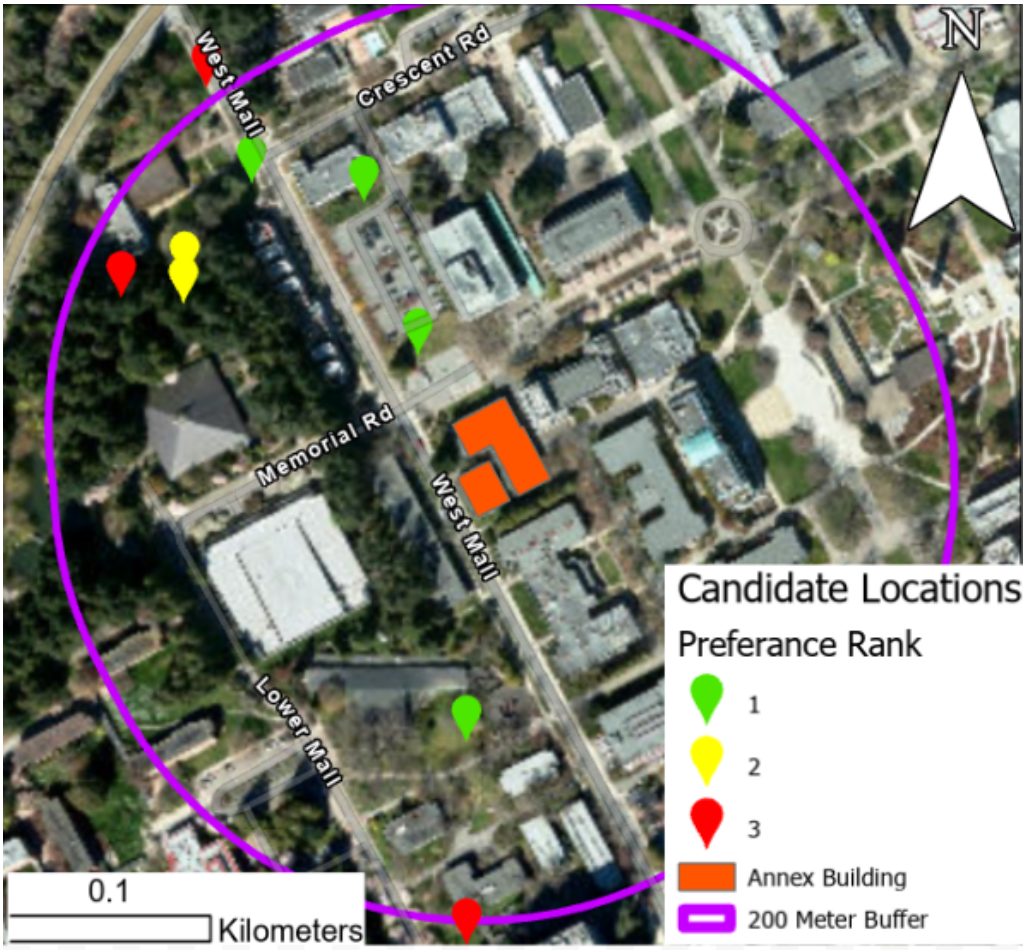


Figure 9. Map displaying eight locations that were identified during our in-person search. The Preference Rank denotes the relative ranking of all locations, with 1 being the most suitable and 3 being the least suitable. Suitability was determined based on the following factors: daily sunlight exposure length, proximity to roads, walking paths, buildings, and existing infrastructure, and obstacles such as branches within a 20 foot radius of the box.

Table 4. Groups/individuals we consulted during the location selection process for the bat box.

Person/Group Contacted	**Reason for Contacting**
Danielle Dagenais: BC Bats	To acquire knowledge about past relocation efforts and best practices for locating bat boxes
Karen Russell and Renee Lussier: Campus and Community Planning	Assistance with submitting a permit to have bat boxes installed and to gain insight on installation requirements/concerns from a planning perspective
Sean Lynch: Custodial Services	To ensure that proposed location would address the needs of UBC Facilities (remove need for reactive guano cleanup outside buildings)
Building Managers (Various)	To inform them of potential bat box installation near their building and to solicit concerns
Arborist	To ensure that installation would not harm any tree roots/other plants in the vicinity

One common concern among candidate locations was the fact that many areas were slated for development. We cross-referenced proposed development projects and found that many locations overlapped future developments. As a compromise, we designed the bat box to be removable, so if construction ever happened, the bat box could be removed beforehand.

After further consideration of concerns and speaking to the bat box builders we were working with, we decided on a location in a patch of grass in an adjacent parking lot approximately 120m away from the current roost (Figure 10). This location still had good sun exposure, as there were no obstacles that blocked sunlight from reaching the location. This was further verified using the Sunlight modeling tool in Google Earth Pro, which shows the historical patterns of sunlight levels at a specific location. Other desirable characteristics of this location were its relatively close proximity to the current roost, the clear space around the box, and the low foot traffic it would receive. We recognized that this location would be close to moving cars (high noise pollution), but ultimately decided this would not be a limiting factor, since the proposed location was no closer to the parking lot than the current roost. Additionally, this location was adjacent to the UBC Graduate School of Journalism, which has a white exterior that would reflect sunlight, providing additional infrared heating for the bat boxes (Figure 11).

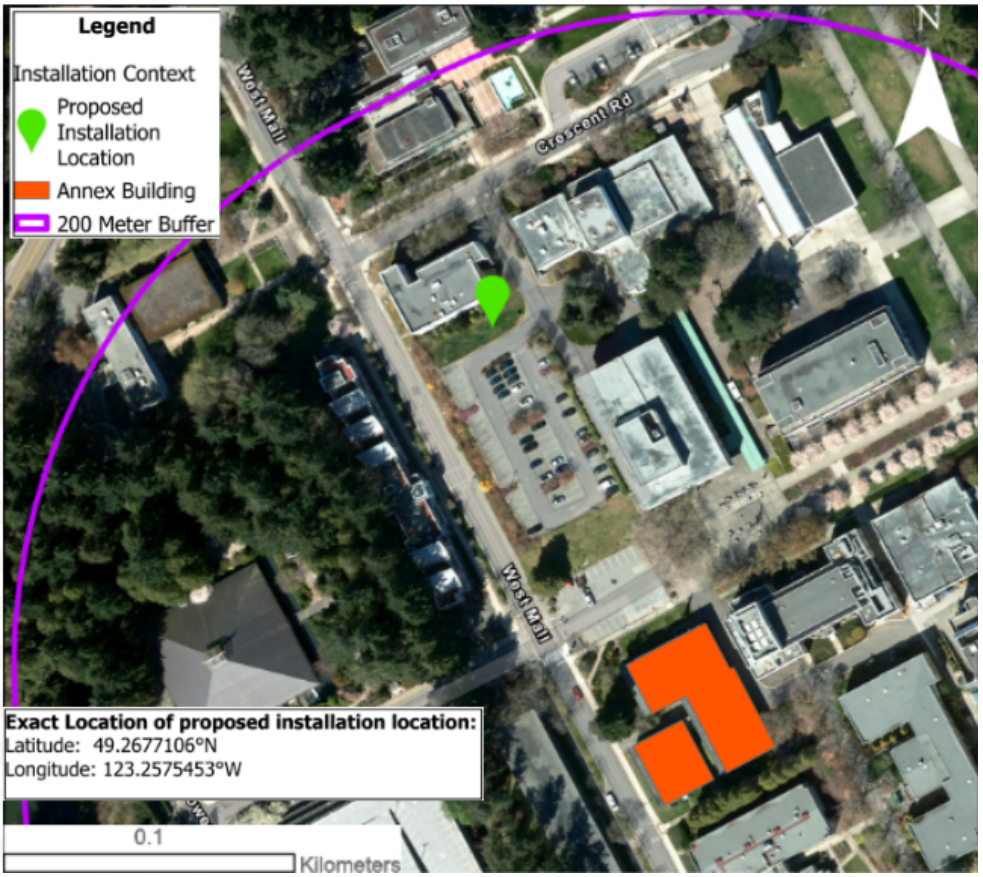


Figure 10. Final proposed installation location for the bat boxes, represented by the green marker.

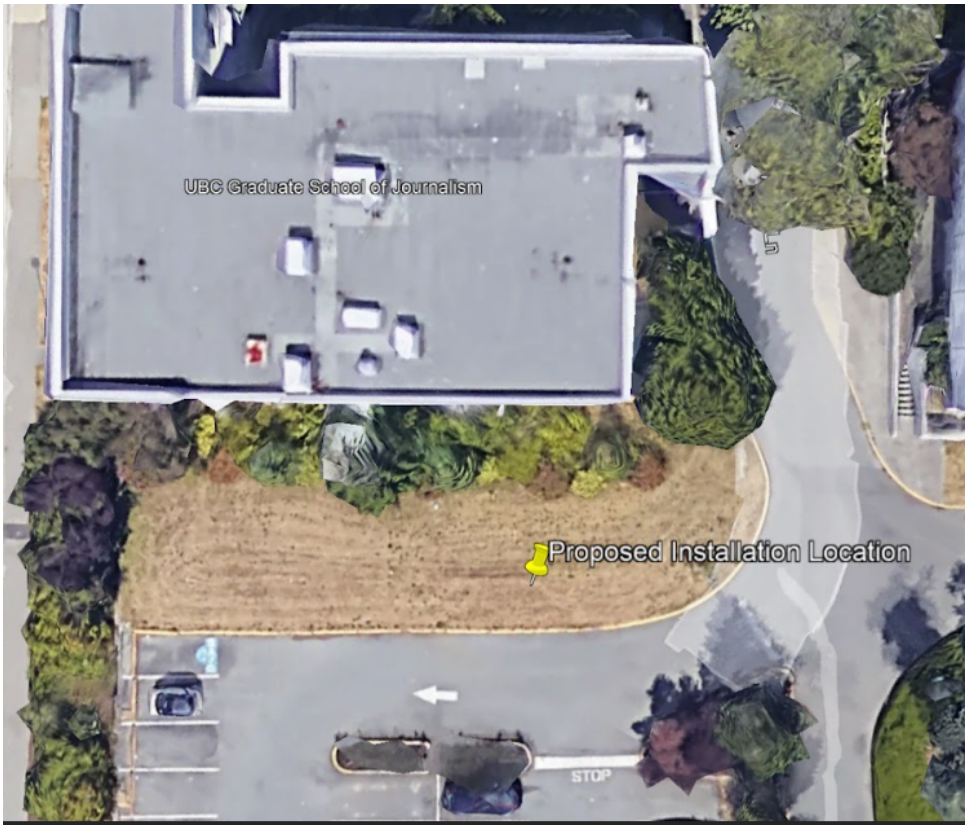


Figure 11. Google Earth layout showing the final proposed installation location for the bat boxes in relation to the UBC Graduate School of Journalism.

2.3 Bat Box Design

To address our second research objective, we had to research and identify the optimal bat box design for the maternity roost. Our research showed that effective bat boxes should be large, multi-chambered, and offer a varying range of temperatures between 24 - 34˚C during the reproductive season (Figure 12) (BC Bats, 2019; Dutch Mammal Society, 2011). Originally, our group planned to install two separate isolated bat boxes. One would face south and be heated by the sun while the other would face the north and remain cool (BC Bats, 2017). However, after sourcing materials, we learned that this was not feasible within our budget.

During our bat box design research, our group contacted Burke Mountain Naturalists, who provided details about the types of boxes they offered. One of their designs was a rocket bat box that would surround a post on all four sides allowing for the roost to move freely in the two chambers. The drawback of this design was the lack of varying microclimates for the roost, since circulating air would create a homogenous temperature in each chamber.

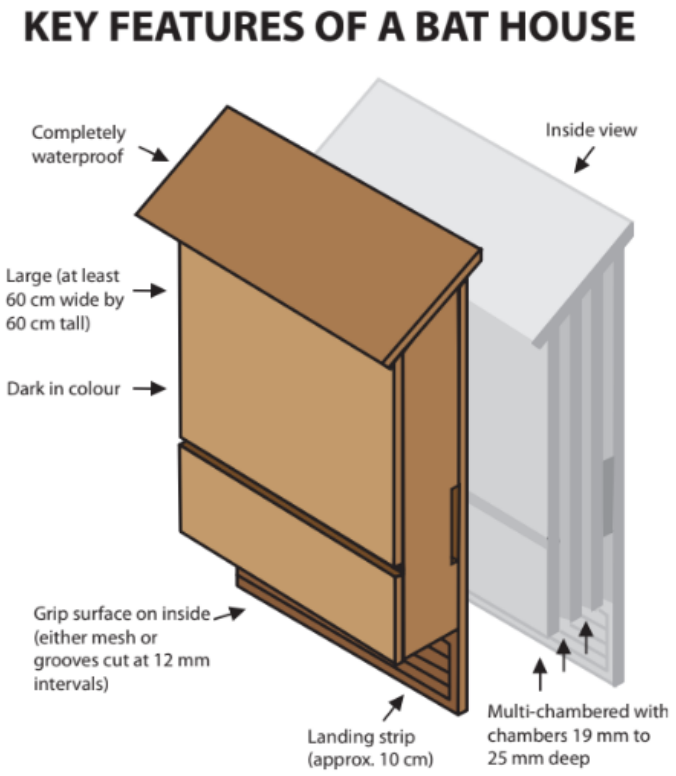


Figure 12. Important bat box design requirements that should be met to ensure bat boxes provide adequate shelter (BC Bats, 2017).

Through contacting Peter Ward and Jim Kneesch from Cascade Bird Box Builders, we sourced our bat box. Their dual design allows the box to face opposite directions, providing multiple microclimates for the bats, while lowering the cost of installation materials. The box also has 4 baffles (chambers) on each side that are roughed up to help the bats grip and hang upside down in the box (Appendix C). The dark stain on the outside of the box will attract heat from the sun, creating a warm environment for the bats. We decided to partner with them and use their bat box design, as it provided the best chances for relocation within our budget.

2.3.1 Material Sourcing and Cost

Lloyd Gauvin from Pitt River Lumber had a 4” x 6” x 18’ untreated cedar post available that met our needs (D. Dagenais, pers. comm., February 23, 2023). Other materials needed for the installation are shown below with the associated cost as well as their source (Table 5).

Table 5. Summary of materials purchased for the bat box installation.

Material	**Cost**	**Source**
Bat Box, Guano Tray and Predator Guard	$340	Cascade Bird Boxes
Cedar Post	$126 + Delivery	Pitt River Lumber (Lloyd Gauvin)
Crushed Rock	6 x $7.19 = $43.14	RONA
TOTAL	**N/A**	**$509.14 + Post Delivery**

2.3.2 Installation Plan

UBC Building Operations will install the bat box with supervision from our team and the Cascade Bird Box Builders team. To make sure the box stays erect for many years, 4’ of the post will be below surface level and approximately 13’ above ground. Having the 4’ underground will ensure that the post is not susceptible to falling over with the weight of the 40 pound box on the top. This leaves the bottom of the bat box 12’ above the ground (Figure 13), following BC Bats’ recommendation that the bat boxes be placed at least 10’ high (BC Bats, 2017).

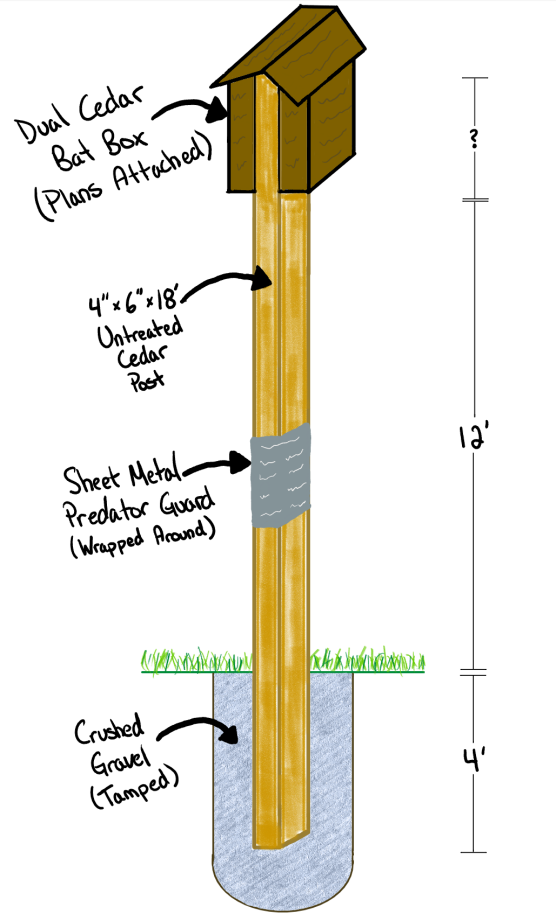


Figure 13. Installation plan for the dual sided bat box, one box facing north and the other facing south to provide different microclimates based on sunlight availability. The untreated cedar post with a predator guard is supported by crushed gravel to make the post removable in the future if necessary.

Originally, we planned to hold the post in place with a ready to mix concrete alongside a post sleeve. This would allow the post to be removed easily if the box had to be removed for any reason. However, the cost of creating a steel sleeve to go around the post was beyond our budget, so we chose to 'cement' the post with crushed gravel instead. Prior to digging the hole for the post, we will review a UBC utilities map to make sure that the chosen location is safe for minor excavations. There are a few double extra strong pipes in the ground beneath our proposed location but we will still be able to install in that area by working around them (Appendix D).

After Building Operations has excavated the hole for the post, the bat box will be mounted to the post before it is stood up vertically. Building Operations will then work with our team to lift up the post and place it into the hole. Alternatively, Building Operations will use a small tractor to hold up the post. The crushed rock will then be added with some water and tamped down to solidify the structure in the ground. While this is happening, a level will be used to make sure the post is perfectly level so that the bat box is not tipping in one direction.

3. Discussion

Choosing the location for our bat box started with GIS analysis, continued with incorporation of feedback based on concerns of UBC groups, and ended by reaching tradeoffs between design, location, and planning requirements. There were multiple factors that were not initially considered and only arose after consultations with relevant groups (Table 3). These include concerns about future development, existing utilities, density of vegetation/wires, sunlight exposure, and presence of tree roots. Resources detailing best practices for locating bat boxes were discovered after reaching out to BC Bats, a local community bat program. Our group benefited greatly from the knowledge and expertise supplied by BC Bats, which suggests that future conservation efforts will greatly benefit from involving local organizations with experience in conserving species. Additionally, previous communication between BC Bats staff and UBC staff about the roost took place, but no known record of this communication exists. This demonstrates the need for a more centralized group that oversees wildlife related issues in order to avoid miscommunications in the future.

Although bats are often portrayed by the media and our culture as pests that spread disease, they are no more likely to carry rabies or fleas than any other wild animal. UBC's integrated pest management guidelines follow policies that define pests broadly as "troublesome living organism[s]" (UBC, 2019). This definition has significant room for interpretation, allowing bats to be considered pests on campus despite being defined as "wildlife" under the B.C. Wildlife Act (BC Wildlife Act, last updated 2023). If people were more comfortable living with bats, UBC would be more motivated to treat bats like wildlife and implement bat-friendly building designs that would allow bats and humans to coexist. One sustainable solution would be installing insulated cavities in existing buildings or new buildings so that bats could live in them with minimal impact on humans. By intentionally considering *M. lucifugus* in building designs, guano would also no longer be an issue, since it can be funneled into one area and composted (D. Dagenais, pers. comm., 2023, Dutch Mammal Society, 2011).

One of the greatest challenges for our project was the lack of wildlife conservation policies on UBC campus. Currently, there is no identifiable body on campus and no funding set aside to address wildlife conservation related concerns. As a result, our team had to reach out to several faculty members, researchers, student clubs, and campus organizations to find people who could help monitor and maintain the bat box. While we secured some sponsors, none could commit to maintaining the box on a long-term basis since that lay outside of their responsibilities. Bat box monitoring and maintenance will be required as long as the bat box is standing (likely at least 10 years). Details about long-term considerations monitoring and maintenance considerations and tasks are included in the Monitoring and Maintenance Plan (Appendix A).

UBC has committed to making biodiversity a bigger priority. In December 2021, the university released its 2030 Climate Action Plan, stating it would "enhance urban biodiversity" and develop a Climate Adaptation, Resiliency, and Biodiversity Strategy (UBC, 2021). UBC's Campus Vision 2050 plan and Green Building Action Plan contain strategies for preserving and supporting biodiversity, such as requiring all new buildings to comply with bird friendly design guidelines (UBC, 2018; UBC, 2023). As a member of the Nature Positive Universities network, UBC has also pledged to halt nature loss and assist species recovery efforts (Nature Positive Universities, 2023). Our project serves as a learning opportunity for policymakers to follow through on promises outlined in biodiversity strategies. UBC cannot continue to rely on UBC Facilities and ad hoc conservation solutions. Well-defined

wildlife-human conflict and endangered species conservation policies are key. This includes identifying any federally or provincially endangered species that currently live on campus. Our methodology also presents a framework for UBC to meet their "Nature Positive" pledge. Collaboration between multiple bodies on campus and consultation with local wildlife experts is essential to improve species recovery efforts.

4. Recommendations

To address our final research objective, we created a list of recommendations for improving bat and wildlife conservation on UBC campus. The sections below outline primary and secondary actions that can be taken by several groups on campus.

Primary Recommendations:

1. Create a Database of Endangered and Threatened Species on UBC Vancouver Campus

- **Why:** To inform any future policies regarding endangered species conservation on campus, UBC should know what threatened and endangered species are currently present. While UBC Okanagan has cataloged endangered species on its campus, UBC Vancouver has not.
- **Who:** Work-learn students and/or environmental consultants.
- **What/How:** As part of a student project, students can collect data through wildlife surveys (i.e. acoustic monitoring), data applications (e.g. iNaturalist), and open-access biodiversity data warehouses (e.g. GBIF). Beaty Biodiversity Museum staff and collections are another excellent on-campus resource. A report can be prepared including each species' name, provincial and federal conservation status, and the areas on campus where it has been observed. Environmental consultants could also be hired to assist with the data collection process.
- **When:** A preliminary endangered species database should be created by mid-2024. This database would inform UBC's Climate Adaptation, Resiliency and Biodiversity Strategy, described in UBC's 2030 Climate Action Plan and set to be completed by the end of 2024 (UBC, 2021).

2. Fix Gaps in Older Buildings and Update Green Building Policy

- **Why:** Gaps in the exterior of Auditorium Annex Offices A provided suitable habitat for the bat roost. Many other buildings within 300m of Auditorium Annex Offices A have similar designs and gaps between panels at the edge of their roofs. This includes the West Mall Annex, other Auditorium Annex Offices, and the Ponderosa Annexes (A-G). Fixing these gaps will decrease the chance bats inhabit these old buildings. Additionally, green building policy can be updated so that new buildings will be suitable for both bats and building residents.
- **Who:** UBC Facilities (Building Operations), UBC Campus and Community Planning
- **What/How:** Identify buildings with existing gaps and caulk gaps. Include insulated cavities in new buildings based on the Dutch Mammal Society's 2011 guide, *Building Bat Friendly*, so that bats are allowed to remain in urban ecosystems.
- **When:** Gaps should ideally be caulked by Winter 2023. This would decrease the chances of bats roosting in buildings in 2024. Updating green building policy may take longer, but should be done before any new buildings near the Auditorium Annex Offices are constructed. These new buildings are a part of UBC's 2050 Campus Vision, and may begin to be built in a couple years.

3. Create Task Force to Address Future Wildlife Concerns

- **Why:** No group on campus is currently responsible for managing wildlife. As a result, responsibility for management has fallen to Custodial Services. A task force would help identify additional wildlife-related concerns, allow responsibility to be shared across departments, and raise the profile of these issues to higher-level individuals. This would motivate the creation of more comprehensive policies for managing endangered species.
- **Who:** UBC SEEDS, UBC Facilities (Custodial Services, Building Operations), UBC Campus and Community Planning, and faculty members.
- **What/How:** Several representatives from each department can meet monthly to discuss concerns and identify responsibilities related to wildlife conservation that can be shared across departments. Key topics of conversation could include streamlining the process of installing wildlife structures (e.g. bat boxes) on campus and identifying areas for collaboration between academics and other campus groups (e.g. UBC Facilities). Long-term planning could also be done to balance construction planning with the need to preserve areas for wildlife conservation.
- **When:** A task force should be created by Summer 2024. This will comply with the timeline of UBC's 2030 Climate Action plan, which aims to increase interdisciplinary collaboration to find biodiversity solutions by 2024 (UBC, 2021).

4. Launch a Bat Awareness Campaign

- **Why:** There is widespread social stigma surrounding bats as carriers of disease, which has only worsened due to the COVID-19 pandemic. Bats provide important ecosystem services in the form of insect control and pollination and the endangered status of certain species of bats within Canada is not well known. There are limited organizations that provide advocacy for the conservation of bats, especially in BC.
- **Who:** UBC SEEDS, UBC bat researchers, the AMS Sustainability Hub, UBC Botanical Gardens, the Beaty Biodiversity Museum, and local bat organizations (e.g. BC Bats)
- **What/How:** To raise awareness about bats, resources about bats can be provided on social media channels, newsletters, and during UBC events. Our project will be showcased as part of the Biodiversity Days celebration in May 2023, a program hosted by UBC Botanical Gardens. Public bat walks, which are also scheduled to take place in May 2023, should continue to be hosted annually by UBC bat researchers. UBC SEEDS can also work with the AMS Sustainability Hub to create media about our bat box. This includes signage and educational materials that can be placed next to our box once it is installed. This will help alleviate concerns from people who might be concerned with the presence of bats, such as building residents or workers.
- **When:** This should be an ongoing process, with promotional material going out regularly on social media channels mentioned above, and ensuring the conversation surrounding wildlife management is brought up in future campus planning initiatives.

5. Hire a Biodiversity Coordinator

- **Why:** A Biodiversity Coordinator can be the first point of contact for biodiversity-related concerns. They will be able to provide resources and contacts that people can use to tackle wildlife issues. They would also build and maintain relationships with local wildlife experts (e.g. BC Bats), while working with campus planners to develop biodiversity planning guidelines, strategic objectives, and conduct risk assessments. Additionally, they might develop a biodiversity baseline

that includes an interactive map showing ongoing wildlife projects and future construction plans to identify where future human-wildlife conflicts might arise.

- **Who:** The Biodiversity Coordinator role could be integrated into an existing organization, such as UBC SEEDS. The candidate would ideally have experience with biodiversity related projects and have experience working for a post-secondary institution.
- **What/How:** The role and responsibilities expected of the Biodiversity Coordinator would have to be carefully scoped and developed while taking into account the current gap in UBC's wildlife related policies. There would also need to be a discussion around which existing organization they would be integrated into, if any.
- **When:** The Biodiversity Coordinator should be hired soon so they fit into the timeline of UBC's 2030 Climate Action plan, which aims to increase interdisciplinary collaboration to find biodiversity solutions by 2024 (UBC, 2021). However, the process should not be rushed in order to find the ideal candidate.

Secondary Recommendations:

1. Update Pest Management Guidelines

UBC's integrated pest management guidelines include a broad definition of "pests" that could be interpreted to include bats (UBC, 2019). Under the B.C. Wildlife Act, wounding or harming threatened or endangered species, including bats, is illegal (BC Wildlife Act, 2023). To avoid liability and protect wildlife, UBC's pest management guidelines should be updated with a more narrow definition. Protocols should be developed by UBC Campus and Community Planning and UBC Facilities so that custodians know what steps to take if they encounter bat roosts. Educational materials can also be developed by bat researchers to help custodians identify the presence of bats.

2. Create Permanent Biodiversity Funding Sources

There is currently no funding set aside to tackle wildlife and biodiversity-related concerns on campus. There are no funds set aside to cover the expense of maintaining the bat box, including purchasing masks to protect bat box caretakers from bat guano. While resources like the AMS Sustainability fund can serve as temporary funding sources, they cannot be relied on permanently. Funding could also be provided to UBC Facilities to help them clean guano without hiring outside contractors.

3. Take Advantage of Research Opportunities

Researchers and students can monitor the bat box after it is installed and examine the health of the population by counting the bats as they leave at dusk. They can report dead bats and collect them to be tested for WNS. This information would be useful for BC Bats, as it informs them on the effectiveness of our chosen bat box design and allows them to stay up to date on any WNS sightings in BC. Surveys of other buildings near the roost can also be conducted to see if there are any new bat roosts. As researchers associated with UBC Farm are also interested in monitoring bat activity, our bat box could be incorporated into a broader bat monitoring program at UBC.

5. Conclusion

Even after determining suitable locations for the bats, coexistence is still difficult to achieve, as many bats are in urban spaces that are constantly under development. There are limited spaces on campus that can be considered a suitable habitat for *Myotis lucifugus*, given factors such as building density, proximity to roads, access to water, and future development. Each stakeholder had different suggestions for how we should weigh these factors. Our attempt to accommodate everyone's suggestions made it extremely difficult to find one location that satisfied all our criteria. Monitoring and maintenance efforts are complicated by the fact that there is no clear responsible body on UBC Campus and no funding set aside to tackle wildlife related concerns, leading to an inability to make decisions. Our bat box is not a sustainable solution because it will eventually need to be moved to accommodate future development.

The larger issue is that UBC Vancouver campus is not as sustainable as it claims. There are no clear policies for managing wildlife, including endangered species. Future development plans do not adequately consider the needs of local wildlife. The most sustainable way for humans to coexist with endangered bats in the future would be to incorporate them into our future building designs. This requires long-term planning and more inclusive conversations about wildlife conservation on campus.

Acknowledgements

Throughout this project, we have had many insightful meetings with groups, organizations and individuals that contributed to the outcome of our project. Georgia Stanley from UBC SEEDS oversaw the entire project, consulted with various stakeholders when necessary and ensured we had the funding for the bat box and installation. Tara Ivanochko provided us with valuable recommendations through bi-monthly consultations and funding to have the post delivered to the installation site. Renée Lussier and Karen Russell from UBC Campus and Community Planning provided additional resources and advice on suitable locations. Danielle Dagenais from BC Bats provided several key resources and frequent guidance. Matthew Mitchell and Aaron Aguirre provided key suggestions during meetings that informed our recommendations. Sean Lynch the UBC Custodial Manager highlighted gaps in UBC faculty and provided significant background about resident concerns with the roost. James Kneesch and Peter Ward of Cascade Bird Box Builders provided the dual bat box at an affordable cost. Patrick Wong, the UBC Facilities Manager, helped us find the final location for installation. Brian Klinkenberg alongside Jose Aparicio, Rachel Wiersma and Evan Thornberry provided ideas and datasets for our GIS analysis. Philip Beck, a UBC Arborist, provided knowledge regarding surrounding vegetation for our initial and final location. Finally, we would like to acknowledge and thank all the other individuals who contributed their valuable time to help us achieve our objectives. We also thank future groups who have volunteered to continue working on the project and oversee maintenance and monitoring of the bat box in the long term.

References

BC Bats. (2016). *White-Nose Syndrome Alert*. Retrieved from Government of BC Website: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/wildlife-health/wildlife-health-documents/white-nose_syndrome_fact_sheet_march_2017.pdf

BC Bats (2017). *A BC Guide for Managing Bats in Buildings*. Retrieved from BC Bats Website: https://www.bcbats.ca/attachments/Bats%20in%20buildings20%20pages_2017_web.pdf

BC Bats. (2019). *Best Management Practices for Bat Boxes in British Columbia.* Retrieved from BC Bats Website: https://www.bcbats.ca/attachments/BMPS-for-Bat-Boxes-in-BC-2019.pdf

BC Wildlife Act. (2023). Retrieved from the Government of British Columbia Website https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/96488_01

Bergeson, S. M., Cate-Carter, T., & Whitby, M. D. (2015). Adaptive roosting gives little brown bats an advantage over endangered Indiana bats. *The American Midland Naturalist, 174*(2), 321-330. 10.1674/0003-0031-174.2.321

Boyles, J. G., Cryan, P. M., McCracken, G. F., & Kunz, T. H. (2011). Economic importance of bats in agriculture. Science, 332(6025), 41-42. 10.1126/science.1201366

CBC News. (2023). *Deadly fungus that has wiped out bat populations detected in B.C.* Retrieved from CBC News Website: https://www.cbc.ca/news/canada/british-columbia/bc-bats-white-nose-syndrome-1.6800262

Clare, E. L., Symondson, W. O. C., Broders, H., Fabianek, F., Fraser, E. E., Mackenzie, A., … Reimer, J. P. (2014). The diet of *Myotis lucifugus* across Canada: Assessing foraging quality and diet variability. *Molecular Ecology*, *23*(15), 3618–3632. doi.org/10.1111/mec.12542

Coleman, J. L., & Barclay, R. M. R. (2011). Influence of urbanization on demography of little brown bats (*Myotis lucifugus*) in the prairies of North America. *PLoS ONE*, *6*(5). doi.org/10.1371/journal.pone.0020483

Dutch Mammal Society. (2011). *Building Bat Friendly.* Retrieved from the Dutch Mammal Society Website: https://www.zoogdiervereniging.nl/sites/default/files/imce/nieuwesite/0verigen/downloads/Building%20bat%20friendly%20-%20Dutch%20Mammal%20Society.pdf

Environment Canada (2016). *Species at Risk Act - Annual Report for 2015*. Retrieved from the Government of Canada Website: https://www.sararegistry.gc.ca/default.asp?lang=En&n=09CB7FDD-1&offset=5

Frick, W. F., Pollock, J., Hicks, A., Langwig, K., Reynolds, D., Turner, G., Butchkoski, C., & Kunz, T. (2010a). An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. *Science*, *329*(5992), 679–682. doi.org/10.1126/science.1188594

Frick, W. F., Reynolds, D. S., & Kunz, T. H. (2010b). Influence of climate and reproductive timing on demography of little brown myotis *Myotis lucifugus*. *Journal of Animal Ecology*, *79*(1), 128–136. doi.org/10.1111/j.1365-2656.2009.01615.x

Government of BC (2023) *Wildlife Act*. RSBC 1996, c488. Retrieved from the Government of British Columbia Website: https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/96488_01#section119

UBC (2018). *Green Building Action Plan.* Retrieved from the University of British Columbia Website: https://planning.ubc.ca/sites/default/files/2019-11/PLAN_UBC_Green_Building_Action_Plan_Full.pdf

UBC (2019). *Pest Control Policy.* Retrieved from the University of British Columbia Website: https://universitycounsel.ubc.ca/files/2022/05/Pest-Control-Policy_UP7.pdf

UBC (2021). *Climate Action Plan.* Retrieved from the University of British Columbia Website: https://planning.ubc.ca/sites/default/files/2021-12/UBCV_CAP2030_FINAL.pdf

UBC (2023). *UBC Campus Vision 2050.* Retrieved from University of British Columbia Website: https://campusvision2050.ubc.ca/

Hayman, D. T. S., Pulliam, J. R. C., Marshall, J. C., Cryan, P. M., & Webb, C. T. (2016). Environment, host, and fungal traits predict continental-scale white-nose syndrome in bats. *Science Advances*, *2*(1). doi.org/10.1126/sciadv.1500831

Nature Positive Universities. (2023). *What is Nature Positive?* Retrieved from the Nature Positive Universities Website: https://laws-lois.justice.gc.ca/eng/acts/s-15.3/page-1.html#h-434603

Nelson, J. J., & Gillam, E. H. (2017). Selection of foraging habitat by female little brown bats (*Myotis lucifugus*). *Journal of Mammalogy*, *98*(1), 222–231. doi.org/10.1093/jmammal/gyw181

Norquay, K. J. O., & Willis, C. K. R. (2014). Hibernation phenology of *Myotis lucifugus*. *Journal of Zoology*, *294*(2), 85–92. doi.org/10.1111/jzo.12155

Schorr, R. A., & Siemers, J. L. (2021). Population dynamics of little brown bats (*Myotis lucifugus*) at summer roosts: Apparent survival, fidelity, abundance, and the influence of winter conditions. *Ecology and Evolution*, *11*(12), 7427–7438.

SARA (Species at Risk Act), S. C. c.29. (2002). Retrieved from https://laws-lois.justice.gc.ca/eng/acts/s-15.3/page-1.html#h-434603

Voigt, C. C., Phelps, K. L., Aguirre, L. F., Corrie Schoeman, M., Vanitharani, J., & Zubaid, A. (2016). Bats and Buildings: The Conservation of Synanthropic Bats. In *Bats in the Anthropocene: Conservation of Bats in a Changing World* (pp. 427–462). Springer International Publishing. doi.org/10.1007/978-3-319-25220-9_14

White Nose Syndrome Response Team. (2022). *Spread Maps: August 30, 2019*. Retrieved from the White Nose Syndrome Response Website:
https://www.whitenosesyndrome.org/static-spread-map/august-30-2019

Wisconsin Department of Natural Resources. (2013). *Little Brown Bat (Myotis lucifugus) Species Guidance* (Report PUB-ER-705). Retrieved from Government of Wisconsin Website:
https://dnr.wi.gov/files/pdf/pubs/er/er0705.pdf

Supporting Endangered Bats on UBC Campus: Bat Box Monitoring and Maintenance Plan

March 8th, 2023

Table of Contents

1 Introduction

1.1 Background

In August 2022, a roost of endangered little brown bats (*Myotis lucifugus*) was discovered in the outer walls of the UBC Auditorium Annex Offices. Building residents and Custodial Services expressed concern about the roost. Building residents with disabilities have also expressed concern about the presence of bat guano on accessibility railings. UBC Facilities has hired outside contractors to pressure wash the guano, but this is not a long-term or cost effective solution. To limit future deleterious bat-human interactions, our team plans to install a Dual Quad Chamber Maternity Bat Box in a patch of grass approximately 120m away from the current roost site (Figure 1). The bat box will serve as an alternative habitat for the roost.

This project is a UBC SEEDS Sustainability Program project that is being completed as part of ENVR 400 with Dr. Tara Ivanochko. Key UBC staff clients involved with the project include Renee Lussier (Landscape Architect), Sean Lynch (Director of Custodial Services), Penny Martyn (Green Building Manager), and Georgia Stanley (SEEDS Climate Response Applied Research Coordinator).

Figure 1. Current roost site and proposed location for Dual Quad Bat box.

1.2 Purpose and Audience

The primary purpose of this document is to outline bat box monitoring and maintenance responsibilities. Performing the outlined responsibilities will increase chances of successful relocation. As bats often take several years to inhabit bat boxes, it may take several years of maintenance before relocation is successful.

The secondary purpose is to address safety concerns. Since many of the bat box caretakers have limited experience monitoring and maintaining bat boxes, clear guidelines are necessary. Poorly maintained bat boxes also pose a danger to bat inhabitants.

The primary audience for this document is the bat box caretakers. This includes UBC SEEDS, Dr. Matthew Mitchell (Research Associate, Land and Food Systems), and several undergraduate students. Dr. Tara Ivanochko (Professor of Teaching, Earth, Ocean, and Atmospheric Sciences) has also agreed to assist with monitoring and maintenance.

This document is also intended for students, researchers, UBC Facilities (including Custodial Services), Campus and Community Planning, and any other UBC staff who may also be involved in monitoring and maintenance.

2 Monitoring Responsibilities

This section details the monitoring responsibilities associated with the bat boxes. The primary purpose of monitoring is to check for the presence of bats. Table 1 shows a monthly timeline of tasks associated with monitoring, which are explained in detail in the following subsections.

Table 1. A month by month breakdown of bat box monitoring responsibilities.

Month	Monitoring Tasks
January	- Collect any dead bats (WNS surveillance period)*
February	- Collect any dead bats (WNS surveillance period)*
March	- Collect any dead bats (WNS surveillance period)*
April	- Occupancy check (biweekly) - Collect any dead bats (WNS surveillance period)
May	- Occupancy check (biweekly) - Check for pups - Collect any dead bats (WNS surveillance period)
June	- Occupancy check (biweekly) - Check for pups - Bat Count (two between June 1 - 21) - Report dead bats
July	- Occupancy check (biweekly) - Check for pups - Bat Count (two between July 11 - August 5) - Report dead bats
August	- Occupancy check (biweekly) - Check for pups - Bat Count (two between July 11 - August 5) - Report dead bats
September	- Occupancy check (biweekly) - Report dead bats
October	- Occupancy check (biweekly)
November	- Collect any dead bats (WNS surveillance period)*
December	- Collect any dead bats (WNS surveillance period)*

*Bats should be away from the roost during this time and in torpor (hibernation). There may be no dead bats to remove.

2.1 Surveys

The main monitoring responsibility of bat box caretakers is checking and recording the presence of bats. Monitoring should **never** involve touching boxes, the bat box pole, or any bats.

2.1.1 Guano Surveys

Guano surveys are one of the most common ways to detect bats. Guano is typically found underneath roosting sites, appears tubular, and is 0.3 - 1.7 cm long (Figure 2). Most of the guano will likely accumulate in guano trays below the box. The presence of guano is a simple but effective indicator of bat presence, although it does not reveal information about population size.

Figure 2. Little brown bat (*Myotis lucifugus*) guano. Photo attributed to Chanel Tom.

2.1.2 Bat Counts

More comprehensive population size estimates can be obtained through bat counts. The ideal time for bat counting is from one hour before to one hour after sunset. This is because bats are most likely to “chatter” and exit the box around sunset for foraging. At least one count during the BC Annual Bat Count is recommended to support local bat research (see Procedural Resources for more details). BC Bats outlines the following procedure for counting bats:

1. Ensure conditions are suitable for bat emergence (>12°C, no rain, low wind speed).
2. Stand a comfortable distance away from bat box exit points. Have multiple people covering all exit points if needed.
3. Record bats as they fly out using a counting app or hand “clicker” to assist with counting.

2.1.3 Other Visual and Audio Surveying Methods

There are a number of other ways to check for bat activity. Caretakers can shine light into the box

and visually check for bats in the box. As bats find artificial light disturbing, experts recommend shining lights on bats for no more than ten seconds.

Another method involves using acoustic monitoring devices near the roost. UBC Researcher Matthew Mitchell has conducted acoustic monitoring at UBC Farm and near the current roost site, and can be contacted regarding this method of monitoring. While it may be difficult to tell which recordings correspond to bats associated with the bat box, acoustic monitoring could provide valuable information about seasonal bat activity levels. If acoustic monitoring occurs, caretakers should collect data from the recorder (approximately once every 2-3 weeks, as battery life can be easily monitored with a smartphone app) and would need to routinely change batteries and SD cards.

2.1.4 Guano Analysis (for species identification)

Ongoing guano analysis suggests that the bat species found in the Auditorium Office Annex building are *Myotis lucifugus* and Yuma myotis (*Myotis yumanensis*). Should there be a need to identify the species residing in the box in the future, guano samples can be collected and submitted for analysis to the BC Community Bat Program. Instructions for collecting and submitting a guano sample can be found under Procedural Resources. Note that the risk of acquiring histoplasmosis from bat guano is minimal but wearing protective equipment (masks and gloves) is essential.

2.2 Dead Bats

An important monitoring responsibility is collecting and reporting dead bats, for the purposes of tracking the spread of a fungal disease known as White Nose Syndrome (WNS). WNS is a fungal disease responsible for major population declines in bat species across North America since the mid 2000s. WNS has been observed in bats in Washington State, Southern Alberta, and B.C. Due to its deadly nature, ongoing testing is important for understanding the spread of this disease. To assist with WNS surveillance, all dead bats should be collected and reported to BC Bats. Note that WNS is not harmful to humans. Detailed information regarding WNS, as well as guidelines for collecting and handling dead bats, are included under Procedural Resources.

2.3 Optional Tasks

Several optional monitoring tasks can be performed to collect more data:

- To check whether the bat box contains a maternity roost (a roost that contains mothers and their babies), the box can be checked for pups after adults emerge at sunset. Seasonal and daily movements of bats between boxes could also be recorded to document roost preferences.
- Temperature can be monitored to identify suitable temperatures for the roost and conditions that create unsuitable temperatures.
- Characteristics of the bat box can be reported to BC Bats to assist with future local installation recommendations (see Procedural Resources). This will contribute to the body of knowledge about local bat box preferences.
- Other buildings near the bat box, including the current roost site, can be routinely checked for evidence of bat activity. If bats are discovered elsewhere, UBC Facilities should be notified immediately.

3 Maintenance Responsibilities

This section details the maintenance responsibilities associated with the bat boxes. The primary purpose of maintenance is to ensure the cleanliness and structural integrity of the bat boxes. Table 2 shows a monthly timeline of tasks associated with monitoring, which are explained in detail in the following subsections.

Table 2. A month by month breakdown of bat box maintenance responsibilities.

Month	Maintenance Tasks
January	- Remove any wasp nests
February	- Remove any wasp nests
March	- Remove any wasp nests - Install any new boxes - Repair and caulk old boxes - Stain boxes
April	N/A
May	- Clean guano trays (once every two weeks)
June	- Clean guano trays (once every two weeks)
July	- Clean guano trays (once every two weeks)
August	- Clean guano trays (once every two weeks)
September	- Clean guano trays (once every two weeks)
October	N/A
November	- Remove any guano inside box
December	- Remove any wasp nests

3.1 Cleaning Guano

To ensure bats continue using the bat box, accumulated guano must be cleaned out of the box and removed from the guano tray. Before cleaning guano, caretakers should wear personal protective equipment, including a N100 respirator mask. Cleaning should primarily take place in the Fall. Panels inside the box can be removed by loosening screws. Guano on the panels should be scraped out using a steel brush before being re-installed. Guano trays can be removed and hosed to remove guano, and any collected guano can be discarded in the garbage. Further instructions on how to clean guano outside the box can be found in the Procedural Resources section.

3.2 General Repairs and Upkeep

Bat boxes should be checked annually for damage, preferably at least a month (January - March) before bats return in the Spring in April. Repairs are essential to prevent leaks and ensure the boxes provide a suitable thermal habitat for the bats. The box should be thoroughly checked for any holes, gaps, or woodpecker damage. Re-caulking joints, repairing roofs, and fixing cracks are all essential. Equipment for these tasks (e.g. exterior-grade screws) should be assessed to ensure they cause no

harm to bats. To prevent rotting, the exterior of bat boxes should be stained using water-based, odorless, animal-friendly paints, like Latex. Dark coloured paints are preferred, as they help the box absorb sunlight and maintain suitable internal temperatures.

3.3 Additional Tasks

Other tasks are important to keep the bat boxes suitable for bat habitation:

- Bat box caretakers have reported the presence of wasp nests inside bat boxes in early Spring. Wasp nests should only be removed when no bats are present. Wasp nets are commonly scraped out of boxes by using a long pole (e.g. broom handle).
- If bats show signs of overheating (e.g. hanging outside of the box), adaptations should be made to reduce the box's internal temperature. This could include staining the box a lighter colour or adding shade.
- Any surrounding obstacles should be kept at least 20 feet from the bat box to prevent collisions.

3.4 Installation of Bat Boxes

In terms of installing the bat boxes, our group would be willing to do the initial installation alongside Building Operations, with additional support from SEEDS and UBC Staff Clients. We are currently in the process of getting in touch with Building Operations and Campus and Community Planning to inquire about acquiring assistance for installation.

4 Long-Term Considerations

One important fact to remember is that bat boxes require patience. According to BC Bats, the average time it takes for a box to be occupied is three years. With that being said, there are several important long-term considerations for monitoring and maintenance.

4.1 Potential Modifications

As bat boxes become more widely used, several potential ways to entice bats to take to them have emerged. If bats continue ignoring the bat box, these strategies could be tested:

- Changing the temperature: To change the temperature of the bat box, a lighter stain could be applied to the outside of the box, shade could be added through additional covering structures, or new ventilation slots could be installed.
- Adding an additional box: Additional boxes can be installed nearby in cooler locations with different designs.
- Raising the bat box: Other unoccupied bat boxes have become successful after being raised a few more feet.
- Guano as an attractant: Another strategy involves covering the bat box with a mixture of water and bat guano. However, there is no strong evidence that scenting the bat box with guano increases chances of occupation.

4.2 Alternative Locations

A more significant modification would be relocating the bat box entirely. Future development plans indicate our bat box may eventually have to be relocated. Through GIS analysis, ground surveys, and consultation with BC Bats, we have identified a handful of other potential locations for the bat box. The details of three other potential locations are presented below. Further discussion with Campus and Community Planning and BC Bats is needed to identify suitable future locations for installation.

Location	Coordinates	Positives	Concerns
Clearing between Liu Institute and C.K. Choi Building	(49.267262, -123.258787)	- Close proximity to trees and forest travel corridor - Close to current roost and water source	- Questionable amount of sunlight
Small clearing near C.K. Choi Building	(49.267801, -123.258326)	- Close to current roost and water source - Decent sunlight exposure	- Close proximity to road and street lights
Field near First Nations Longhouse	(49.265312, -123.256851)	- Decent sunlight exposure - Good distance from roads and surrounding obstacles	- Far from roost and water source - Close proximity to walking path
Field in between parking lots	(49.267035, -123.25719)	- Good sunlight exposure - Very close to current roost - Good distance from surrounding obstacles	- In between two parking lots, concerns about traffic

4.3 Funding

Long-term monitoring and maintenance requires funding. While some of the equipment is available (e.g. acoustic monitoring devices), other materials (e.g. caulk and paints) will need to be purchased. Bat experts and bat box builders have indicated that our box is expected to last for at least ten years. However, it will eventually need to be replaced. Further discussion is needed about potential sources of funding (e.g. Climate Emergency or Sustainability Projects Fund).

4.3.1 Decommissioning the Bat Boxes

If circumstances require the bat houses to be disassembled, the SEEDS Sustainability Program staff will support and fund this process. However, it is important to note that SEEDS Staff and other project sponsors should be contacted before any action is taken. Figure 3 illustrates the annual activity patterns of little brown bats and when decommissioning can occur. Decommissioning the boxes should only occur when there are no bats present, such as in the winter season when they move to alternate roosting sites, or alternatively, they must be excluded from the boxes. See Procedural Resources for more information.

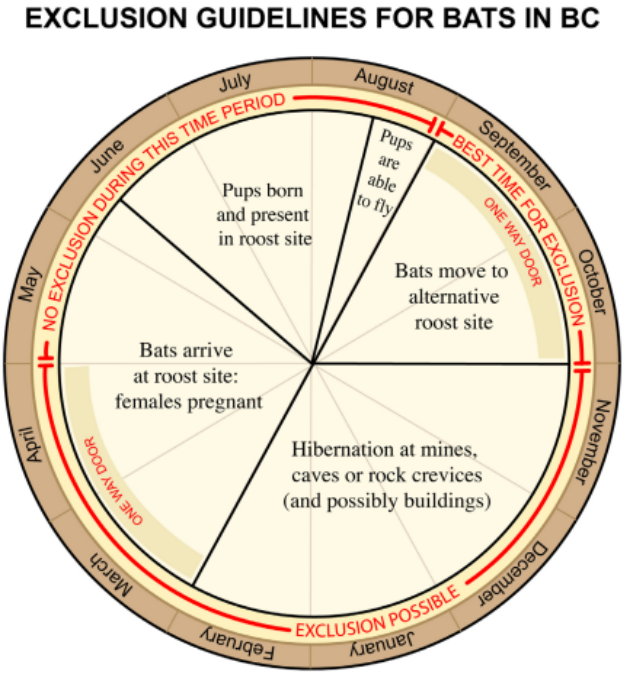


Figure 3. Yearly calendar which shows the general timing of bat life stages, shown in black, and timing for excluding bats from buildings in B.C. (BC Bats, 2017).

4.4 Parties Involved

The key stakeholders listed in the table below should remain informed as monitoring and maintenance progresses. Responsibility for monitoring and maintaining the bat boxes currently lies with UBC SEEDS Sustainability Program (SEEDS). SEEDS and Research Associate Matthew Mitchell would lead monitoring and maintenance this coming summer. Several upper-level undergraduate students and a biodiversity work-learn student have also indicated interest in supporting monitoring and maintenance this summer. Matthew Mitchell and UBC SEEDS's involvement with monitoring and maintenance may continue into Fall 2023, but has yet to be confirmed. A UBC staff or faculty member who can provide guaranteed long-term support has yet to be identified.

Organization / Role	**Contact**
UBC SEEDS Sustainability Program	Georgia Stanley
Research Associate, LFS Faculty Sponsor (Primary)	Matthew Mitchell
EOAS Faculty Sponsor	Tara Ivanochko
UBC Custodial Services Director	Sean Lynch
Facilities Manager (Yellow Zone)	Patrick Wong
UBC Campus and Community Planning	Renée Lussier (Landscape Architect) and Karen Russell (Manager, Development Services)
UBC Arborists	Phillip Beck

BC Bats, Regional Bat Coordinator	Danielle Dagenais
Cascade Bird Box Builders	James Kneesch Peter Ward

5 Project-Specific Resources

5.1 Monitoring and Maintenance Checklists

The following checklists should be consulted before and during every site visit. The monitoring checklist should be consulted during biweekly site visits (May - October). The maintenance checklist should be consulted when bats are vacant from the box (December - March).

Basic Monitoring Checklist (Biweekly - May to October):
1. Are there any dead bats near or around the bat box? (YES/NO)
2. Is there any new guano on or underneath the bat box? (YES/NO)
3. Are bats located at the bottom of the box or hanging outside? (YES/NO)
4. Should acoustic data from the recorder be collected? (YES/NO)
5. Should the batteries or SD cards of acoustic recorders be changed? (YES/NO)
6. Is there any other evidence of bat activity (e.g. chattering, bats exiting roost)? (YES/NO)
7. Are the conditions and timing right to conduct a bat count survey? (YES/NO)
8. Are there any pups present? (YES/NO)
9. Have buildings close to the roost been checked for bat activity? (YES/NO)
10. Are bats moving between boxes and does one box host a higher abundance of bats?
11. Is there any other evidence of bat predation? (YES/NO)

Basic Maintenance Checklist (December - March):
1. Using a flashlight, look into the box from below. Are there any wasp nests inside the box? If YES, contact Phillip Beck (UBC Arborist) or UBC Building Operations to borrow a ladder.
2. Are there any large guano accumulations inside the box? (YES/NO)
3. Are there guano accumulations in the guano tray or underneath the roost that should be removed? (YES/NO)
4. Is there any damage (cracks, woodpecker damage) to the exterior of the box? (YES/NO)
5. Is there any damage to the guano trays or predator guard?
6. Does the box need a new coat of paint? (YES/NO)
7. Have any new obstacles emerged within 20 ft of the box? (New vegetation, new installations, etc.) (YES/NO)

5.2 Equipment

Below is a list of key equipment for monitoring and maintenance. Costs are estimated mostly based on Amazon prices and no items were double-counted. Note that almost all of these items (except masks) would be a one-time purchase.

Activity	**Tools / Equipment**	**Cost ($CAD)**
Guano Surveys and Guano Collection[2]	- N100 respirator masks (x5) - Disposable gloves - Clean tweezers - Pencil / pen*	- Masks = $100 - Gloves = $17 - Tweezers = $3 - Envelopes = $10

[2] Analysis is done for free by the BC Community Bat Program once they receive samples.

	- Paper envelopes - Cotton balls (for storing guano)	- Cotton balls = $7
Bat Counts	- Pencil / pen* - Data sheet* - Flashlight* - Tally counter (phone app)*	$0
Acoustic Monitoring	- Song Meter Mini Wildlife Acoustic Recorder* - SD Cards* - Batteries*	$0
Collecting Dead Bats (see Procedural Resources)	- Paper towel - Disposable gloves - Ziploc bags - iPhone* - Sharpie*	- Paper towel = $5 - Ziploc bags = $11
Cleaning Guano	- Respirator masks (x5) - Steel brush - Screwdriver* - Ladder* - Disposable rubber gloves	- Steel brush = $9
General Repairs	- Caulk - Exterior-grade screws - Ladder*	- Caulk = $12 - Exterior-grade screws = $21
Staining	- Water-based, odorless, animal-friendly paint - Paintbrush*	- Paint = $41
Removing Wasp Nests	- Broom or yardstick* - Ladder* (contact UBC Arborist Phillip Beck)	$0
TOTAL	**N/A**	**$236**

*Can be borrowed from UBC Building Operations or no associated cost.

6 Procedural Resources

Below is a list of key procedural resources that should be referred to when conducting monitoring and maintenance.

1. Counting Bats
- Instructions and BC Bat Count information: https://bcbats.ca/attachments/BC-Bat-Count-instructions-2023.pdf
- Example Data Sheet: https://bcbats.ca/attachments/BC-Annual-Bat-Count-data-form-2023.pdf

2. Collecting and Submitting Guano
- BC Bats: https://bcbats.ca/attachments/DNA-Sampling-Protocol-for-Bat-Guano_Residents_2023.pdf

3. Reporting Presence of Bats or Dead Bats
- BC Bats: https://bcbats.ca/got-bats/report-your-bats/
- BC Ministry of Environment: https://www.bcbats.ca/attachments/wns_april_2016.pdf

4. Cleaning Guano (outside of bat box)
- Quebec Provincial Government:
https://www.quebec.ca/en/homes-and-housing/healthy-living-environment/cleaning-of-an-environment-contaminated-with-bat-droppings

5. Registering Bat Box and Reporting Results
- BC Bats: https://bcbats.ca/bat-boxes/register-your-bat-box/

6. White Nose Syndrome:
- Frick, Puechmaille, & Willis (2016):
https://frick.eeb.ucsc.edu/wp-content/uploads/2013/11/Frick-Puechmaille-Willis-2016.pdf
- Government of BC:
https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/wildlife-health/white-nose-syndrome-wns
- BC Bats: https://bcbats.ca/get-involved/wns-surveillance/
- White Nose Syndrome Response Team (tracks the spread of WNS across North America):
https://www.whitenosesyndrome.org/where-is-wns

7. Exclusion/Decommisioning
- BC Bats: https://bcbats.ca/got-bats/excluding-bats-from-a-building/

7 Additional Resources and References

Bat Conservation International - Bat Gardens & Houses:
https://www.batcon.org/about-bats/bat-gardens-houses/

Bat Conservation International - Extending an Invitation to Bats
https://www.batcon.org/article/extending-an-invitation-to-bats/

Bat Conservation International - The Bat House Builder's Handbook:
https://batweek.org/wp-content/uploads/2018/01/BHBuildersHdbk13_Online.pdf

Bat Conservation Trust - Bat Box Information Pack:
https://cdn.bats.org.uk/uploads/pdf/Bat-Box-Information-Pack-Sept-2020-JF.pdf?v=1600095860

Bat Conservation Trust - Maintaining Your Bat Box:
https://www.bats.org.uk/our-work/buildings-planning-and-development/bat-boxes/maintaining-your-bat-box

BC Community Bat Program - Best Management Practices for Bat Boxes in B.C.
https://www.bcbats.ca/attachments/BMPS-for-Bat-Boxes-in-BC-2019.pdf

BC Community Bat Program - Building Homes for Bats:
https://bcbats.ca/attachments/Building-Homes-for-Bats.pdf

BC Community Bat Program - Where to Install a Bat Box:
https://bcbats.ca/bat-boxes/where-to-install-a-bat-house/

iNaturalist - Little Brown Bat:
https://www.inaturalist.org/guide_taxa/335862

8 Acknowledgements

Several groups, organizations, and individuals contributed significantly to our monitoring and maintenance plan. Danielle Dagenais from BC Bats provided several key resources and frequent

guidance. Renée Lussier and Karen Russell from UBC Campus and Community Planning provided additional resources and advice on suitable locations. Matthew Mitchell and Aaron Aguirre provided key suggestions during meetings. Finally, James Kneesch and Peter Ward of Cascade Bird Box Builders provided helpful insights based on their experience with bat box monitoring and maintenance.

9 Sponsor Signatures

We, the undersigned, confirm that we are willing to take on the responsibility of overseeing the monitoring and maintenance of these boxes after they are installed. We understand we may be contacted if damage occurs to the installed boxes, if concerns are raised about the boxes, and/or if the boxes must be decommissioned or relocated due to legitimate reasons, such as overlapping development plans.

Primary Sponsor:
Name: Matthew Mitchell

Position/Title/Affiliation: Research Associate, Faculty of LFS

Signature: _____ **Date Signed:** _____

Secondary Sponsors

Name: Tara Ivanochko

Position/Title/Affiliation: Professor of Teaching, Faculty of EOAS; Director, ENSC

Signature: _____ **Date Signed:** _____

Name: Georgia Stanley

Position/Title/Affiliation: SEEDS Sustainability Program, Climate Response Applied Research Coordinator

Signature: _____ **Date Signed:** _____

Appendix B: GIS Inputs and Outputs - GIS Datasets, Suitability Maps, Suitable Locations

Table 1. Campus GIS Datasets

Data Description	**Source**
Vegetation Cover	R. Wiersma, Campus and Community Planning
Tree Cover	R. Wiersma, Campus and Community Planning
Roads and Pathways	R. Wiersma, Campus and Community Planning
Water Features	R. Wiersma, Campus and Community Planning
Buildings	R. Wiersma, Campus and Community Planning
Land use planning and boundaries	E. Thornberry, GIS Librarian
LIDAR, UBCV 2021	P. Lesack, GIS Librarian

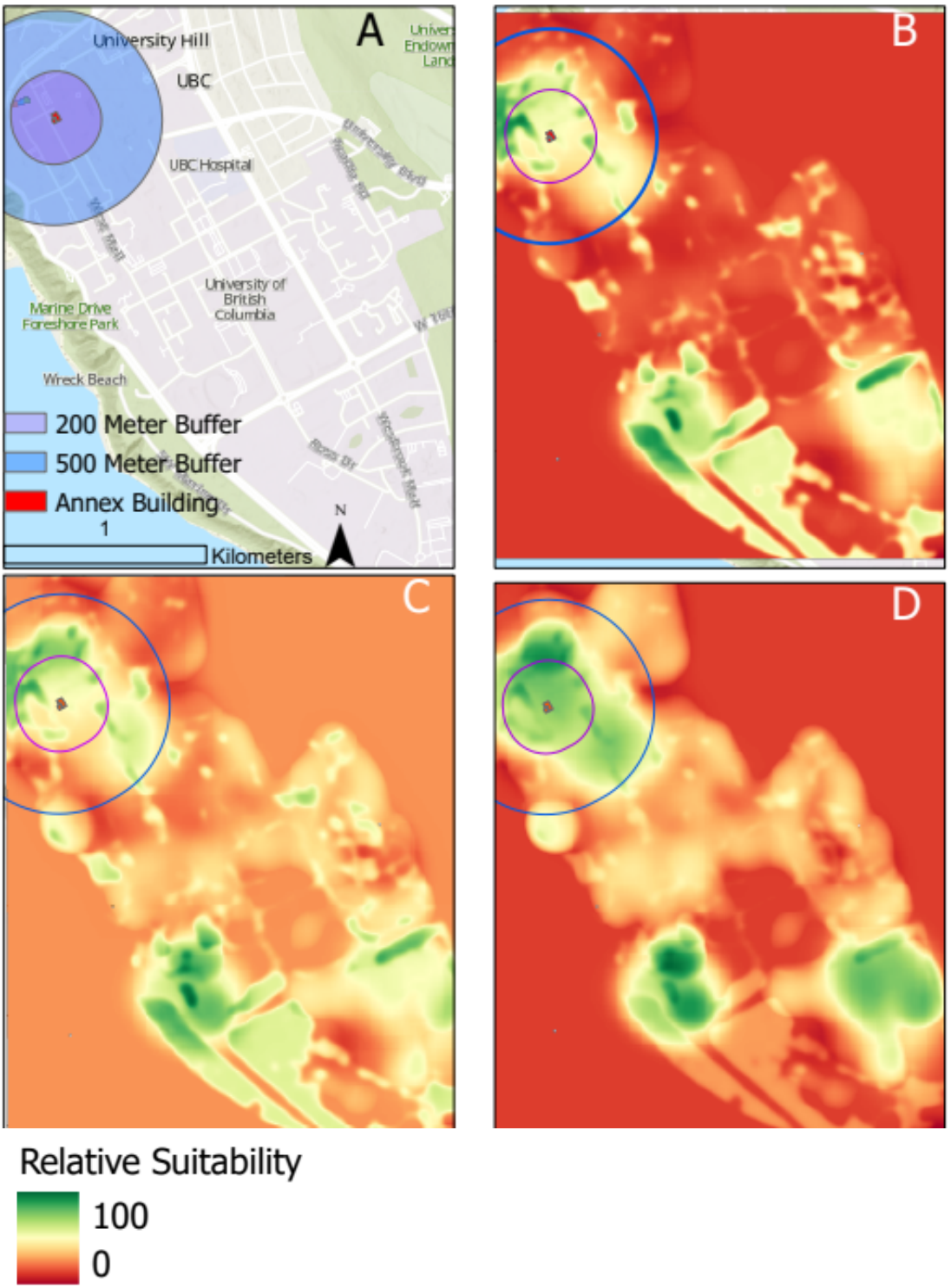
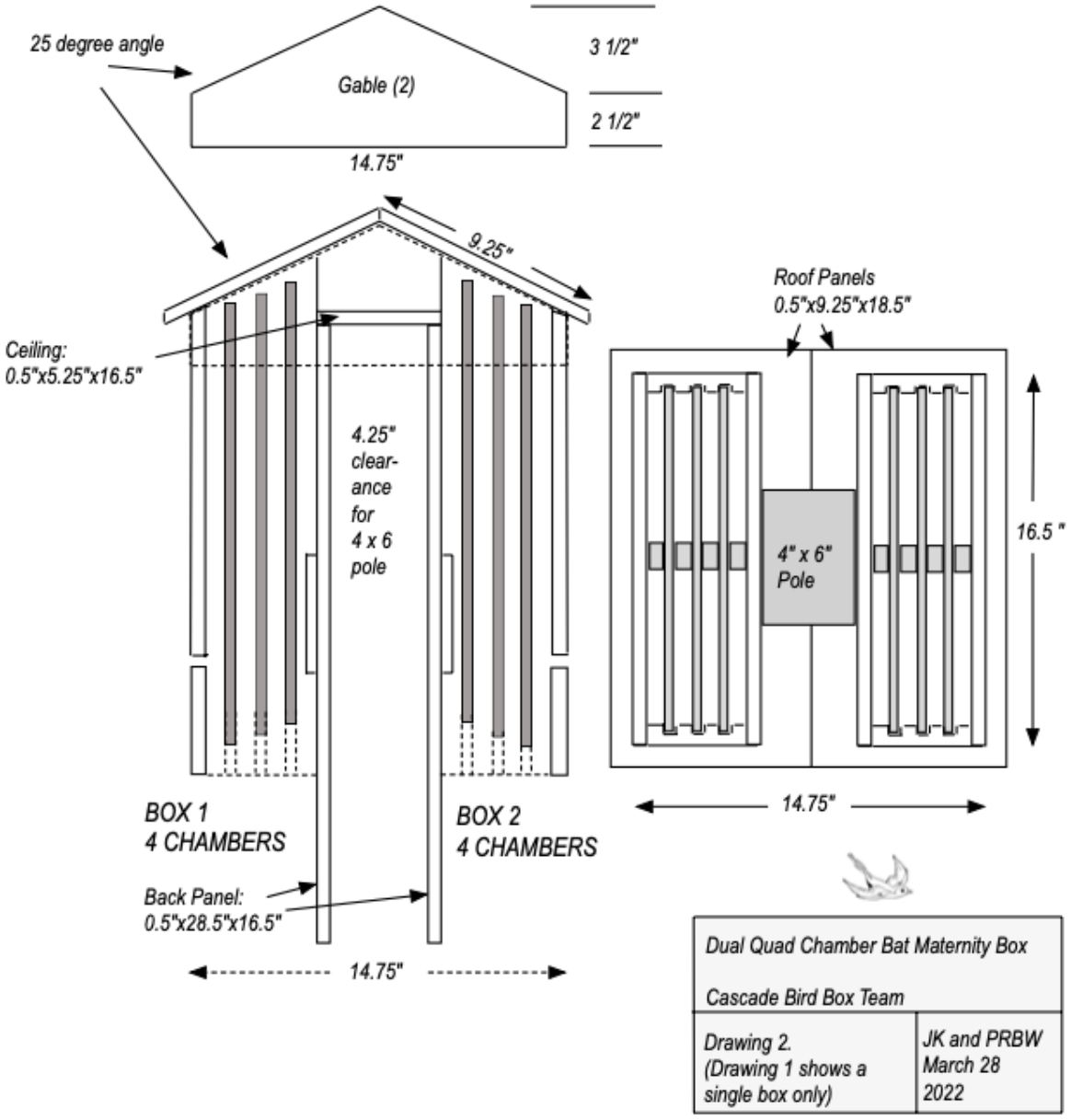
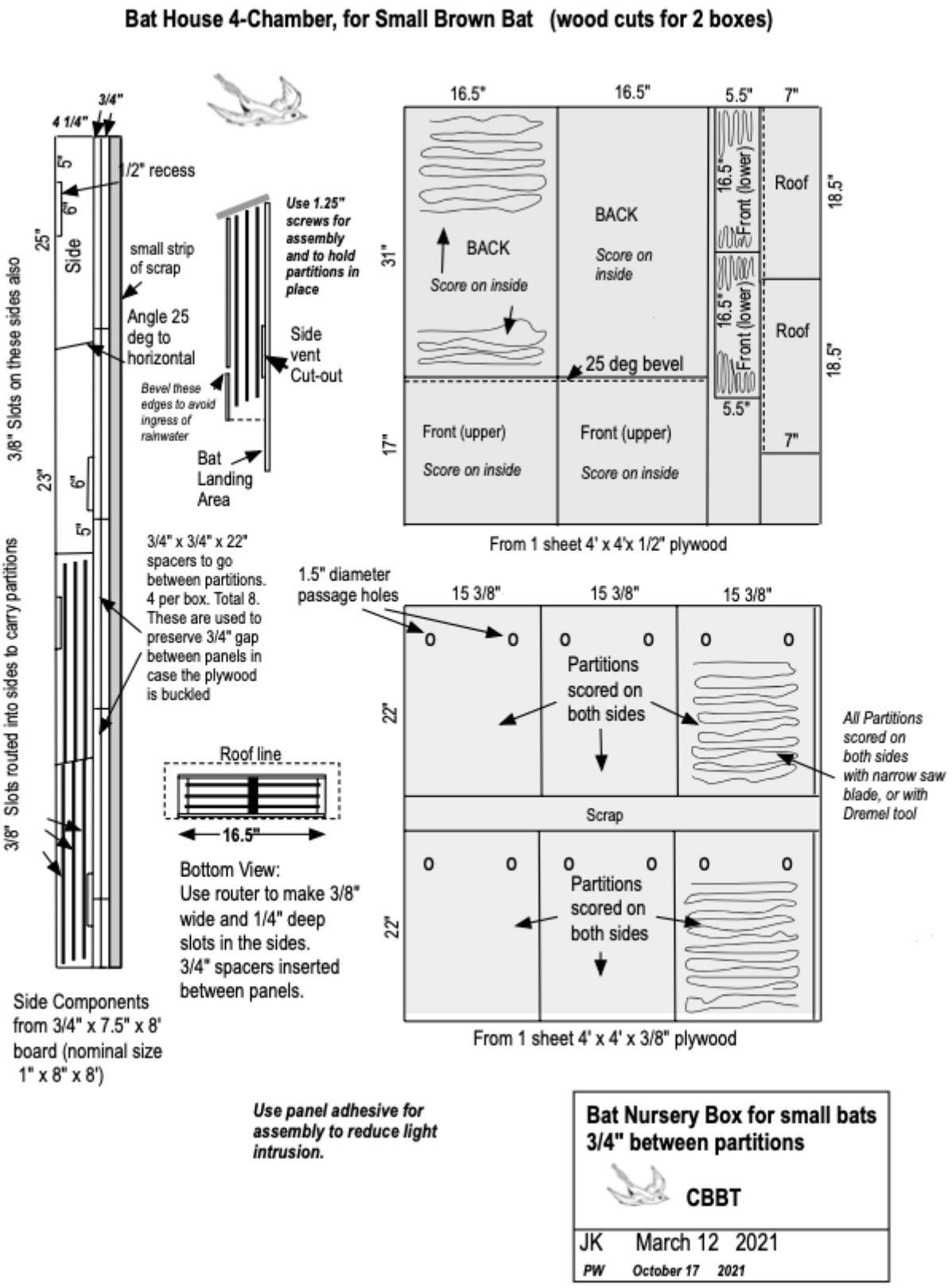


Figure 1a. Map showing the study area of analysis on UBCV Campus. Circles show buffers of radius 200m and 500m centered around the Auditorium Annex Offices, the location of the roost of bats. Figure 1b)-d). Habitat suitability of little brown bats (myotis lucifugus) on UBCV Campus. The scale, ranging from 0-100, represents habitat suitability, 0 being the least suitable, and 100 being the most suitable. Multi Criterion Evaluation was used on four factors (density of water bodies, trees, soft vegetation, and buildings) in three ways: b) preferential weighting of water bodies and trees (Model 1), c) equal weighting of all criteria (Model 2), and d) preferential weighting of water bodies and soft vegetation (Model 3)

Appendix C: Cascade Bird Box Builders Dual Bat Box Design




Bat House 4-Chamber, for Small Brown Bat (wood cuts for 2 boxes)
3/4"
4 1/4"
1/2" recess
5"
6"
25"
Side
small strip of scrap
Angle 25 deg to horizontal
Bevel these edges to avoid ingress of rainwater
Use 1.25" screws for assembly and to hold partitions in place
Side vent Cut-out
Bat Landing Area
23"
6"
5"
3/8" Slots on these sides also
3/8" Slots routed into sides to carry partitions
3/4" x 3/4" x 22" spacers to go between partitions. 4 per box. Total 8. These are used to preserve 3/4" gap between panels in case the plywood is buckled
Roof line
16.5"
Bottom View:
Use router to make 3/8" wide and 1/4" deep slots in the sides.
3/4" spacers inserted between panels.
Side Components from 3/4" x 7.5" x 8' board (nominal size 1" x 8" x 8')
16.5"
16.5"
5.5"
7"
31"
BACK
Score on inside
BACK
Score on inside
16.5" Front (lower)
Roof
18.5"
16.5" Front (lower)
Roof
18.5"
25 deg bevel
5.5"
7"
17"
Front (upper)
Score on inside
Front (upper)
Score on inside
From 1 sheet 4' x 4'x 1/2" plywood
1.5" diameter passage holes
15 3/8"
15 3/8"
15 3/8"
22"
Partitions scored on both sides
All Partitions scored on both sides with narrow saw blade, or with Dremel tool
Scrap
22"
Partitions scored on both sides
From 1 sheet 4' x 4' x 3/8" plywood
Use panel adhesive for assembly to reduce light intrusion.
Bat Nursery Box for small bats
3/4" between partitions
CBBT
JK March 12 2021
PW October 17 2021

Appendix D: Double Extra Strong Pipe Below the Installation Site

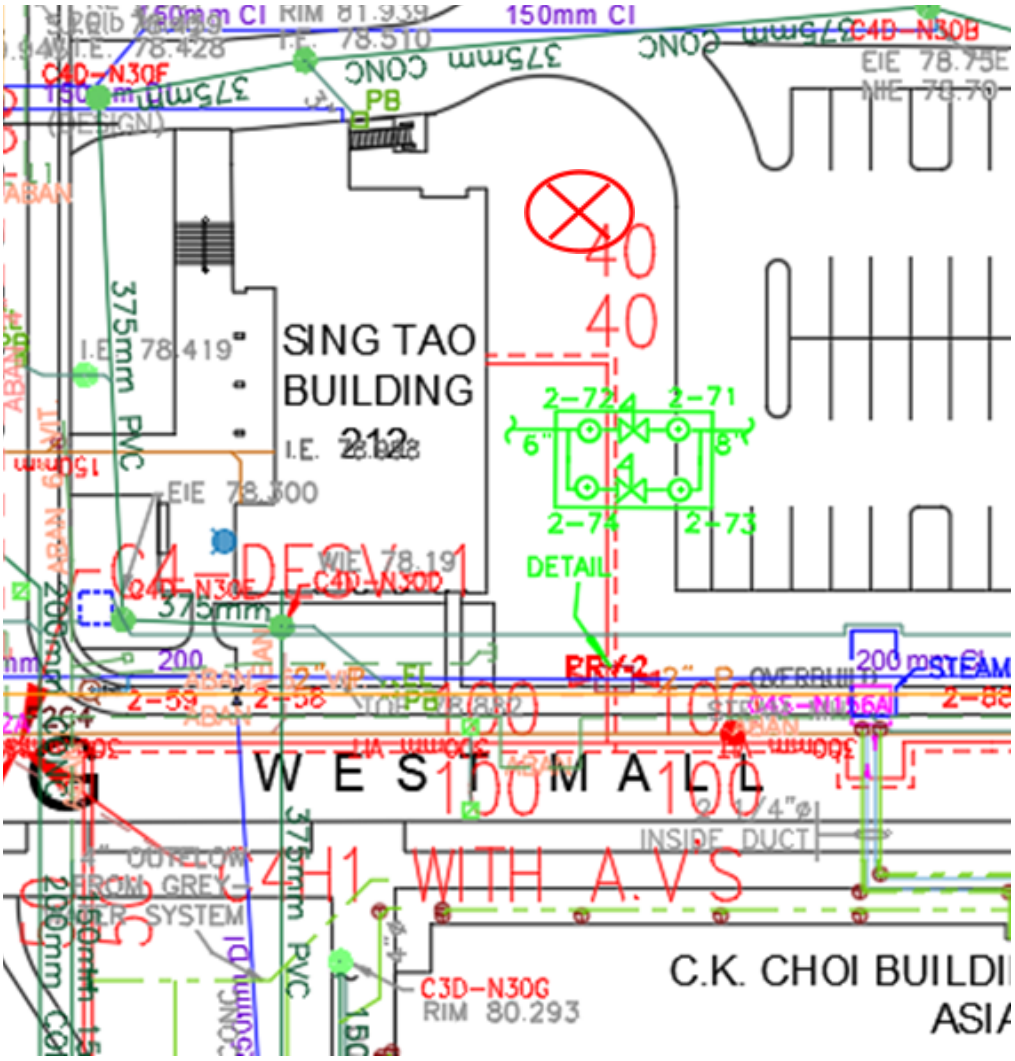


Figure 1. Map of mechanical utilities near the bat box installation site. The red circled “X” marks the installation location.