Conservation of Bats and their Habitat in Clowhom Watershed

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Executive Summary

Bats are one of the most threatened wildlife groups, impacted by multiple factors including habitat loss and degradation, declines in insect populations, mortality at wind turbines, chemical pollution, and accidental and deliberate human disturbance. An even larger threat looms with the specter of White-nose Syndrome (WNS), a deadly introduced fungal disease which kills up to 95% of bats in affected colonies and is now spreading within Washington State. The purpose of this project is to help ensure the survival of bats and their habitat in Clowhom watershed and surrounding communities on the Lower Sunshine Coast.

This report summarizes work during the first year of a three-year project. Our objectives in 2019-2020 were: (1) To improve and increase bat roosting habitat; (2) To increase the number of protected maternity roosts and hibernacula; (3) To undertake White-nose Syndrome surveillance; (4) To provide scientific information to guide conservation of bats; and (5) To undertake public outreach and engagement.

To improve bat roosting habitat, we repaired damaged roosting boxes and worked with community members to build and install additional bat houses. To identify and protect bat roosts, we surveyed buildings and bat houses in Clowhom, met with stakeholders and residents in the watershed, and reached out to citizens in the wider Sunshine Coast community. To undertake White-nose Syndrome surveillance, we collected records of dead and winter-flying bats, submitted bat carcasses for health testing, and carried out roost emergence counts. To provide scientific data, we conducted acoustic surveys and roost counts, collected guano samples, monitored bat house occupancy, and installed temperature loggers in key bat houses. To engage community members in bat conservation, we carried out diverse outreach activities.

In all, we documented 74 newly identified bat roosts in 2019, including one maternity colony supporting over 400 bats, and worked with landowners to protect and maintain these sites. Together with community volunteers, we built and installed 45 bat houses, assessed occupancy of 33 bat boxes, and carried out 159 emergence counts at 106 bat roost sites, including 5 sites in Clowhom watershed and 101 in surrounding areas of the Sunshine Coast. Engagement activities included 7 bat house workshops, 8 outreach tables, 6 school programs, and 11 media articles.

Clowhom is home to two of the three largest known bat roosts on the Lower Sunshine Coast. One is in an abandoned building (Clowhom Lake Cabin) and the other in a set of bat boxes mounted back-to-back on posts (Maternity Box Cluster). Both of these regionally significant roosts house maternity colonies including both Yuma Myotis (*Myotis yumanensis*) and the federally endangered species, Little Brown Myotis (*Myotis lucifugus*). Our 2019 roost emergence counts confirmed the presence of over 600 bats at the Maternity Box Cluster and over 1000 bats using the Clowhom Lake Cabin.

A key activity this project year was to undertake necessary repairs and improvements to the Clowhom Maternity Box Cluster. By replacing broken posts, repairing damaged boxes, and adding extra boxes, we have increased the quantity and diversity of available roosting habitat at the site and ensured that this important structure will stand for several more decades. By installing internal and external temperature loggers we will be able to monitor temperature conditions in this important roost.

Two BC Hydro buildings in Clowhom, the Pump House and the Auxiliary Building, both appear to support large numbers of bats at certain times of the year. In contrast to previous years when hundreds of bats were present, very few bats were seen at the Pump House in 2019. No bats were observed in the Auxiliary Building during the single visit in September 2019, but substantial bat guano was present. Further surveys are required to understand the timing and nature of bat use of these two buildings. Smaller bat roosts were documented in other structures in the watershed, including privately-owned cabins and a warehouse.

Clowhom watershed is home to at least eight bat species. During acoustic surveys in 2019, the most commonly recorded bats were Yuma Myotis and Little Brown Myotis, along with the tree-roosting species Silver-haired Bat (*Lasionycteris noctivagans*). Silver-haired bats accounted for most calls recorded in the early spring and late fall, while the other two species contributed the most calls in summer recordings. Overall numbers of bat calls were low in the late fall.

This project is addressing three Priority Level 1 actions identified in the Clowhom Watershed Plan (2020). Our surveys are helping to identify and protect bat roosts and hibernacula (Action 16) while our bat house surveys are helping to assess effectiveness of bat enhancement and mitigation efforts (Action 21). We are implementing priority species- and habitat-related conservation actions identified in recovery and management plans for species at risk (Action 13). Specifically, we are undertaking priority actions identified in the BC Bat Action Plan in Response to White-Nose Syndrome (BC Bat Action Team 2019), and the federal Recovery Strategy for Little Brown Myotis (ECCC 2018).

By undertaking White-nose Syndrome surveillance, we are helping to provide for early detection of the arrival of the disease in British Columbia to enable a rapid conservation response. Our roost emergence counts at Clowhom maternity colonies are providing pre-WNS baseline relative abundance data, against which future WNS declines can be measured to assess impacts. By working with landowners and stakeholders to conserve bat maternity roosts in Clowhom and beyond, we are helping to keep bat populations healthy prior to the arrival of the disease and ensuring that habitat is maintained to support recovery post-WNS. Our community outreach and engagement activities are helping to dispel negative myths about bats and increase stakeholder support for, and participation in, bat habitat and species stewardship efforts.

Bats play a crucial ecological role as major consumers of forest pests, eating up to their body weight in insects each night (Environment Canada 2015). They also play a role in nutrient cycles, moving nitrogen from aquatic ecosystems, like wetlands and riparian areas where they consume their insect prey, to upland forest ecosystems where their droppings fertilize trees (Duchamp et al. 2010). Thus, helping bats will help maintain the overall health of ecosystems in the Clowhom watershed.

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1. Introduction

BC bats face many threats, including habitat loss and degradation, accidental and deliberate human disturbance, mortality at wind turbines, and declines in populations of insect prey (Frick et al. 2019). On top of all these challenges, bats are now confronting a deadly new threat in White-nose Syndrome (WNS). This devastating disease is caused by a cold-loving invasive fungus, *Pseudogymnoascus destructans* (Pd), that attacks the exposed skin of hibernating bats causing them to rouse frequently and deplete vital energy reserves. Infected bats experience a cascade of physiological disturbances leading to death (Verant et al. 2014). Because most bats produce only one young per year and juvenile survival rates are low, high adult mortality caused by WNS can have devastating impacts on bat populations (Frick et al. 2010).

First introduced to North America in 2006, White-nose Syndrome was estimated to have killed over six million bats in the first six years (USGS 2012). As of October 2020, WNS had been detected in 39 states and seven provinces (White-nose Syndrome Action Team 2020). The disease had been spreading steadily westward from its introduction site in New York at a rate of roughly 200-250 km per year, when in 2016 it suddenly and unexpectedly appeared near Seattle, a jump of over 2000 km, likely a result of human activity (Lorch et al. 2016). As of October 2020, the Pd fungus had been detected in nine counties within Washington State. It is expected to arrive imminently in British Columbia. Surveillance is essential to ensure early detection and rapid conservation response.

The Clowhom watershed is located 32 km northeast of Sechelt on the Lower Sunshine Coast. Industrial activity has impacted bat habitat within the watershed. First, bats lost foraging habitat when the installation of BC Hydro's dam in the 1950s flooded the lower Clowhom valley, causing substantial loss of prime foraging habitat in riparian forests and lowland wetlands (FWCP 2020). Since then, ongoing forest harvesting has reduced natural roosting sites in mature trees and snags. Of eight bat species previously documented in Clowhom (Evelyn et al. 2017), five have now been confirmed to be susceptible to WNS infection, and a sixth has tested positive for the Pd fungus without demonstrating signs of disease (WNS Response Team 2020a).

The goal of this project is to help conserve bats and their habitat in the Clowhom watershed and surrounding Sunshine Coast communities. The current work builds on past knowledge gained from a multispecies FWCP project from 2013 to 2017 (Evelyn et al., 2014, 2014, 2015, 2017).

2. Goals and Objectives and Linkage to FWCP Action Plan

The goal of this project is to ensure the survival of bats and their habitat by carrying out high priority actions identified in the Clowhom Watershed Plan (FWCP 2020), the BC Bat Action Plan (BC Bat Action Team 2019), and the federal Recovery Strategy for Little Brown Myotis (ECCC 2018).

Specific project objectives are:

1) Habitat Enhancement: To improve and increase bat roosting habitat.

2) Habitat Protection: To increase the number of protected bat maternity roosts and hibernacula.

3) WNS Surveillance: To evaluate bat abundance at known roosts and provide early detection of the arrival of White-nose Syndrome in BC to facilitate a rapid conservation response.

4) Increasing Knowledge: To provide relevant scientific data to guide conservation of bats.

5) Community Engagement and Promotion of FWCP: To conduct outreach to increase awareness of bats and their habitat, recruit community participation in bat stewardship efforts, and promote the Fish and Wildlife Compensation Program.

Linkage to FWCP Action Plan

Our project is helping to address the following three Priority Level 1 actions identified in the Clowhom Watershed Plan (2020):

Action 13: Implement priority species- and habitat-related conservation actions in Recovery Strategies and Management Plans for species at risk known to be in the watershed (Wetland & Riparian / Upland & Dryland, Habitat-based Actions, Priority 1).

Action 16: Determine presence, identify/protect bat Maternity roosts and winter hibernacula (Ecosystem, Upland and Dryland, Habitat-Based Action, Priority 1)

Action 21: Assess effectiveness of bat enhancement and mitigation efforts (Ecosystem, Upland and Dryland, Monitoring and Evaluation, Priority 1)

3. Study Area

The 390 km^2 Clowhom watershed is situated in a remote location at the head of Salmon Inlet, 32 km northeast of Sechelt on the Lower Sunshine Coast (Figure 1). It falls within the Coastal Western Hemlock biogeoclimatic zone, including moist maritime and very wet maritime subzones (CWH mm and CWH vm). Elevations range from 30 to 2400 m and vegetation classes range from dense forest to alpine.

The Clowhom Dam was built in the 1950s. Construction resulted in loss of 41 ha of riparian habitat, 6 km of mainstem, 3 km of lower tributary channels, and flooding of 430 ha of existing lake, including 17 km of shoreline habitat (FWCP 2020).

In addition to the impacts from BC Hydro operations, bats in the Clowhom watershed are also affected by industrial logging activities (Interfor), along with four independent power producer run-of-the-river operations, BluEarth Renewables' Clowhom Power operations on Clowhom River (previously Veresen Inc.), and Regional Power's Bear Hydro operations on Bear Creek.

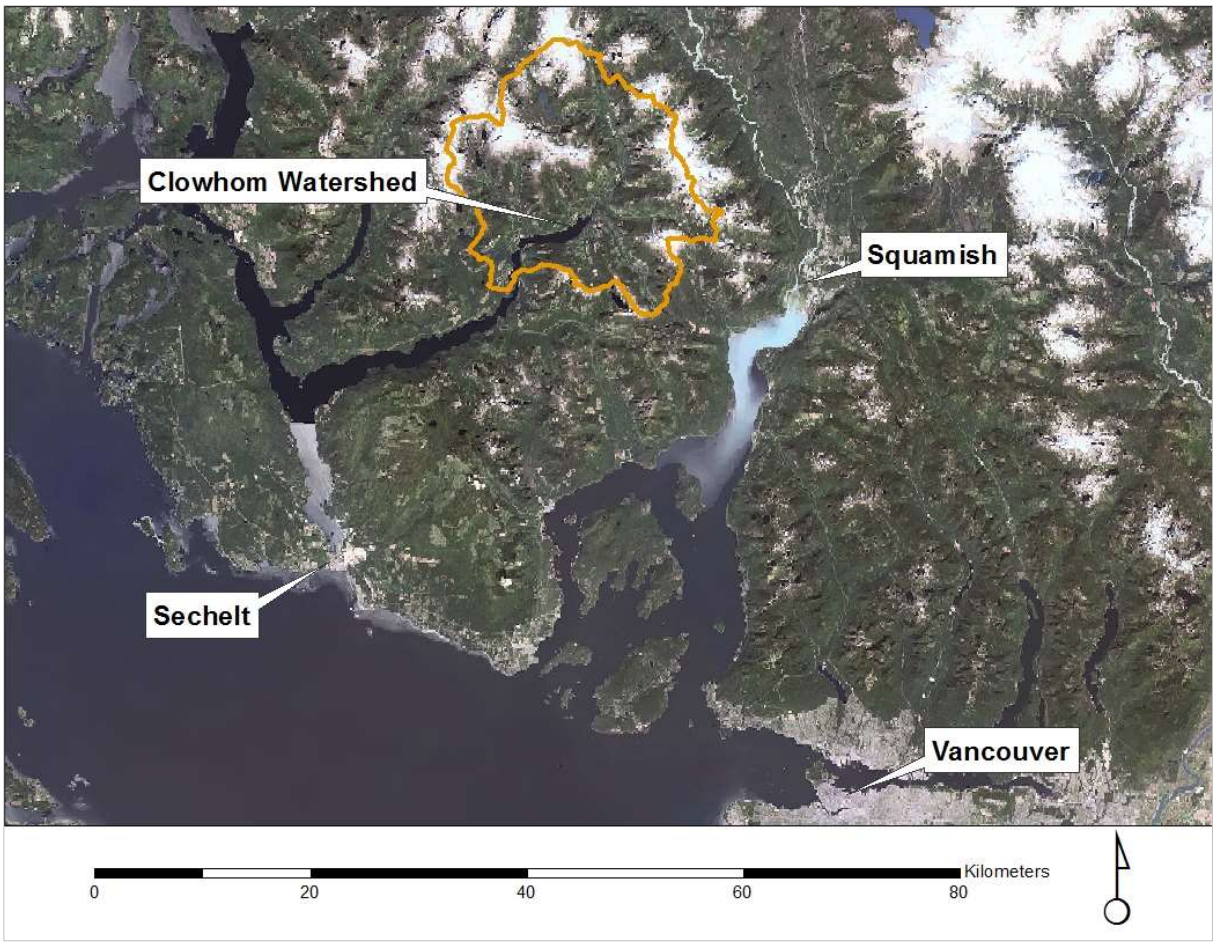


Figure 1. Location of the Clowhom watershed, Sunshine Coast, BC.

4. Methods

4.1 Habitat Enhancement

Repairing and Improving the Clowhom Maternity Box Cluster

Our primary habitat enhancement goal this project year was to undertake essential repairs and enhancements to the Clowhom Maternity Box Cluster (identified in previous reports as "Clowhom Maternity Boxes 1/2/3/4"). This set of bat boxes had been erected by BC Hydro to mitigate for the demolition of a fishing lodge building containing a known Yuma Myotis roost (BC Hydro 2015). The bat boxes were installed in early 2010 and included two pairs of multi-chamber bat houses, mounted back-to-back on 3-meter tall wood posts.

During a previous multi-species wildlife research project from 2013 to 2016, we documented a large maternity colony of Yuma Myotis using the bat boxes. At the end of our study, we warned that the posts supporting the maternity boxes were rotting (Figure 2) (Evelyn et al. 2017). Because the structure was situated in an open area that was susceptible to high winds, we were concerned that the boxes were at risk of falling. Thankfully, the structure remained standing for another three seasons. Once we received funding for this new bat-focused project, we prioritized repairing the Maternity Box Cluster to ensure the long-term integrity of this important roost. When we arrived January 2020 to begin the repairs, we discovered that one of the posts had finally broken and fallen, damaging two of the bat boxes (Figure 2).

Figure 2. Rotten Post Supporting Clowhom Maternity Box Cluster.

Left: Decayed post (July 2017); Right: Fallen post (January 2020)

In January 2020, we dismantled the damaged structure, replaced the posts, and added much stronger crossbeams. We repaired the four original maternity boxes by replacing the outer layers while maintaining the interior chambers to preserve the scent and familiar environment for the colony. We also made improvements to the internal ventilation to reduce the potential risk of excessively high internal temperatures. Finally, we added two additional bat houses to increase capacity and diversity of roosting options. The new boxes were of the Uncle George style, a design preferred by bats in a study in Washington State (Freed and Falxa 2010). The repaired and enhanced roosting structure, with its six bat boxes, was reinstalled in the identical footprint to avoid any disturbance of the soil (Figure 3).

Figure 3. Repairing the Clowhom Maternity Box Cluster.

Repairing Clowhom Rocket Box

We also made repairs to a bat house that had been damaged by woodpeckers. This rocket box style house was installed by BC Hydro near the Clowhom Dam in 2010. In previous years, it had been occupied by dozens of bats. However, woodpeckers had excavated holes in the structure and no bat occupancy had been observed in over two years. In February 2020, we used patches of wood to temporarily repair the holes in the box (Figure 4). However, given the age and degradation of the structure, a complete replacement is recommended.

Building and Installing Bat Boxes

To improve and increase roosting habitat, and to provide focal points for education about bats, we worked with community volunteers and local students to build and install 45 bat boxes at suitable sites throughout the Sunshine Coast, following best practices for bat house design and placement (BC Community Bat Program 2017, 2019).

Figure 4. Clowhom Dam Rocket Box.

4.2 Habitat Protection

Identifying Bat Roosts in Buildings

To identify and protect bat roosts in buildings, between April and July 2019, we examined 20 structures in the Clowhom watershed, looking for signs of bats. Sites examined included abandoned buildings and trailers in the Clowhom village near the dock, buildings owned by the microhydro operators Bear Hydro and BluEarth Renewables, and structures on BC Hydro property (inspected while accompanied by BC Hydro staff). We also conducted outreach to residents in the wider Sunshine Coast community, asking them to report known bat roosts. Where bats were reported, we carried out site visits to assess and document these roosts and talked to the landowners about their concerns and strategies for living with bats.

4.3 White-Nose Syndrome Surveillance

Winter Surveillance

We carried out winter surveillance to document any potential signs of White-nose Syndrome in our region. Because winter arousal can be the first sign of infection, we reached out to the Sunshine Coast community using media and social media articles asking residents to report any sightings of winter flying bats or dead bats. Three carcasses were collected and sent to the Animal Health Centre in Abbotsford for necroscopy and testing for the WNS disease-causing fungus, *Pseudogymnoascus destructans*.

Roost Emergence Counts

Another key component of WNS surveillance is to monitor known roosts through time using emergence counts to detect reductions in colony size that may indicate that the disease is impacting the bats. We conducted roost emergence counts at five bat roosts in the Clowhom watershed. Two of these, the Maternity Box Cluster (Figure 5) and the Clowhom Lake Cabin, have been identified as sentinel roosts in B.C. and are priorities for monitoring due to the large sizes of their colonies. In addition to the counts in Clowhom, we also worked with community members and volunteers to carry out emergence counts at 101 other roosts in surrounding areas of the Sunshine Coast.

Counts took placing during two different time windows: June 1 to 21 (before the bat pups could fly) and July 15 to August 5 (once the pups were anticipated to be volant). Counts took place from 15 minutes before sunset to one hour after sunset and followed Annual BC Bat Count protocols (BC Community Bat Program 2020). Two roosts, the Maternity Box Cluster and the Clowhom Lake Cabin, received full counts four times each, twice during the first counting window and twice during the second counting window. Two other roosts, the Pump House and the Rocket Box, were counted two times each, once during each of the counting windows. A newly discovered roost in a warehouse in Clowhom village was counted during the second window only. To determine which bat species were present, acoustic recordings were made outside each roost and guano was collected for DNA analysis.

Figure 5. Bat emerges from the Clowhom Maternity Box Cluster during emergence count.

4.4 Increasing Knowledge

Acoustic Surveys

To increase knowledge of bat community composition and activity in Clowhom, we conducted acoustic surveys using Anabat Express bat detector units (Figure 6). During the summer breeding season (April-July 2019), detectors were situated near five known roosts to determine which species were present. To evaluate overall bat community composition in the Clowhom watershed, detectors were also deployed at three wetlands that had previously been identified as sites of high bat activity and diversity (Clowhom Wetlands 6, 7 and 8/9). During the late fall (October to November 2019), detectors were placed at three strategic spots spanning the length of the watershed to evaluate activity of migratory species. In all, there were 62 rain-free detector nights of acoustic surveys, including 15 nights in April/May, 18 in June/July, and 29 in October/November.

To identify recorded calls, audio files from the detectors were downloaded into a dedicated computer. Unprocessed files were screened to identify and discard non-bat calls (e.g., insect calls) and ambient noise. The remaining files were then analyzed using the Kaleidoscope Pro 4 Analysis Software (KPro), a suite of analytical tools designed to visualize and identify bat call files. Species identification was executed by running automated routines comparing call-specific characteristics (e.g., frequency, shape, and call pattern) against a proprietary library of bat calls and species-specific classifiers for bats of North America. After the automated identification routines were completed, graphic representations of all bat calls were visually inspected to confirm or discard the automated identification performed by KPro. Because some species have very similar calls, sometimes recordings can only be narrowed to two or more species, grouped together by shared acoustic characteristics into “phonic groups”. Social calls and those that could not be identified to species grouping were excluded from analyses.

Figure 6. Deployment of Anabat Express bat detector.

Monitoring Bat Houses

Manmade bat houses can provide additional roosting habitat in areas where natural habitat is limited. To investigate the efficacy of this mitigation measure, we worked with community members to evaluate the occupancy of 32 bat houses on the Sunshine Coast. In Clowhom, monitoring focused on the two main bat house structures, the Maternity Box Cluster, including its four bat boxes, and the Clowhom Dam Rocket Box (Figure 7).

Figure 7. Bat roost emergence count at the Clowhom Rocket Box.

There have been recent observations from other areas of British Columbia of manmade bat houses becoming too hot, leading to mortality of bats during heat waves (Lausen 2019).

In conjunction with the repairs carried out in January and February 2020, we installed HOBO temperature loggers in the Clowhom Maternity Box Cluster to track both internal bat house temperatures and ambient external conditions (Figure 8).

Figure 8. Temperature logger ready to install in bat box.

4.5 Community Engagement

To engage Sunshine Coast residents in conservation of bats, and to increase awareness of the Fish and Wildlife Compensation Program and its program partners, we carried out a diversity of community engagement activities. We hosted outreach tables at eight public events, providing educational resources, answering questions, and encouraging community members to become wildlife stewards. We offered seven bat box building workshops, provided school programs for six elementary school classes, gave one public presentation about bats, and led a public bat walk (Figure 9). We also published 11 media articles and provided project updates on our website and Facebook page. We were pleased to acknowledge FWCP's support of our wildlife and habitat stewardship efforts both during our public outreach activities, and on our printed outreach materials.

Figure 9. Community members use bat detectors on a guided bat walk in Sargeant Bay Park.

5. Results and Outcomes

5.1 Habitat Enhancement

Repairing the Clowhom Maternity Box Cluster

We successfully repaired and improved the Clowhom Maternity Box Cluster bat roost (Figure 10). Post-installation monitoring in 2020 confirmed that the structure, including the four original maternity boxes as well as the two new Uncle George style boxes, are all being used by bats.

Figure 10. Repaired and Improved Clowhom Maternity Box Cluster.

Above: Before repairs (July 2017); Below: After repairs (Feb 2020)

Building and Installing Bat Boxes

We worked with Sunshine Coast community members to build 45 bat houses for installation in Clowhom watershed, on private properties, and in community parks (Figure 11).

Figure 11. Sunshine Coast residents build bat houses at community workshops.

5.2 Habitat Protection

Identification and Protection of Bat Roosts in Buildings

Of 20 buildings inspected in the Clowhom watershed, five showed signs of bat occupancy in 2019. Details about each of these roosts are provided below.

Clowhom Lake Cabin (Figure 12): This abandoned cabin supports the largest known bat maternity colony in the watershed and sits on a property that is partly privately-owned and partly Crown land. It houses a summer maternity colony that supports over 1,000 mother and baby bats. Acoustic surveys indicate that the roost contains multiple species including Yuma Myotis (*Myotis yumanensis*) and Little Brown Myotis (*M. lucifugus*). The private landowner is committed to protecting this vital roost in the long-term for benefit of the bats.

Figure 12. Hundreds of mother and baby bats inside the Clowhom Lake Cabin (July 2019).

Auxiliary Building (Figure 13): Situated adjacent to the main BC Hydro Generating Station at the end of Salmon Inlet, this abandoned building contains large quantities of guano suggesting that it is an important bat roosting site at least part of the year. During a site visit on September 12, 2019, no bats were observed. The building can only be accessed by our team under supervision of BC Hydro staff. Long-term remote monitoring approaches are being explored to further investigate the timing and nature of bat use of this structure.

Figure 13. The Auxiliary Building contains substantial bat guano.

Warehouse (Figure 14): This large storage building is located in Clowhom village near the dock. A small group of bats roost beneath the light on the exterior of the building. In July 2019, seven bats were observed. Analysis of guano collected beneath the roost indicates that the species present is Yuma Myotis *(Myotis yumanensis)*.

Figure 14. The Clowhom Village Warehouse contains a small bat roost.

Clowhom Private Cabin: Some private landowners have a maternity roost containing dozens of bats in the roof of their cabin in the watershed. Acoustic recordings suggest that this mixed species roost includes Yuma Myotis (*Myotis yumanensis*), Little Brown Myotis (*M. lucifugus*), and Western Long-eared Myotis (*M. evotis*). To date, only Yuma Myotis has been confirmed through DNA.

Pump House (Figure 15): Situated near the base of the Clowhom Dam, right beside the Rocket Box, this small building contains a large amount of guano, indicating that it supports large number of bats at certain times of the year. In the past, bats had been observed roosting both under the metal roof and inside the building. In 2019, emergence counts at the Pump House documented very few bats. Acoustic recordings outside the building were dominated by Little Brown Myotis (*Myotis lucifugus*), with smaller numbers of Yuma Myotis (*M. yumanensis*); the DNA of both species has been confirmed in guano from the building.

Figure 15. The Pump House at the base of the Clowhom Dam supports hundreds of bats.

In addition to the known roosts in Clowhom, in 2019, we also identified 74 new roosts on private properties in Sunshine Coast communities adjacent to the Clowhom watershed. One newly identified site was of regional significance, supporting a maternity colony of close to 400 Yuma Myotis (*Myotis yumanensis*). Another exciting discovery was the second ever recorded sighting of blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) on the Lower Sunshine Coast (Figure 16).

The vast majority of private landowners agreed to maintain the bat roosts in their original condition and were amenable to roost emergence counts to assess the condition of the colonies and monitor bat populations. Where landowners wished to evict bats from their homes, we provided information about best practices and safe timing for exclusion.

Figure 16. Townsend's Big-eared Bat.

5.3 White-Nose Syndrome Surveillance

Winter Surveillance

Between November 2019 and March 2020, we documented five dead bats and two records of winter-flying bats and sent three deceased bats to the Animal Health Lab for necroscopy. We also documented seven hibernating bats, all of which were found roosting singly in wood piles or crawl spaces. As of October 2020, none of the dead bats collected from the Sunshine Coast, nor from any from any other region of British Columbia, have tested positive for Pd fungus.

Bat Roost Counts

In 2019, 159 counts were conducted at 106 different bat roosts on the Sunshine Coast. Most counts occurred during the Annual BC Bat Count window from early June to early August. Within the Clowhom watershed, 15 counts were carried out at five roosts (Table 1).

At the Clowhom Lake Cabin, 386 and 457 bats were detected during two full counts in June, while 836 and 1064 bats were spotted during two counts in July. A third count in June was cut short by rain. Numbers may have been inaccurate during the second counting period because the baby bats were learning to fly and frequently circled nearby and repeatedly re-entered and exited the building.

The Maternity Box Cluster was visually inspected during the day on April 10, 2019 and at least 400 bats were estimated to be present. During two counts in June, 605 and 662 bats were counted; during the second of these counts at least 40 pups were visible in the boxes after the adults had left. Both of the July counts were disrupted by wildlife; however, each of these two partial counts indicated that hundreds of bats were present. A 30-minute partial count on July 29 documented 412 bats, while a 15-minute partial count on July 31 recorded 300 bats.

The Pump House roost, which had housed over 350 bats in June 2018, held only eight bats on June 19, 2019, and only 1 bat on July 29, 2019. No bats were detected in the Rocket Box during either count. In July, seven bats were spotted at the Clowhom Warehouse. Guano was collected in June 2019 from the Maternity Box Cluster, Clowhom Lake Cabin, Pump House, and Warehouse; the DNA from all of these samples was identified as Yuma Myotis (*Myotis yumanensis*).

Table 1. Bat Emergence Counts at Clowhom Roosts, 2019.

ROOST SITE	DATE	NUMBER OF BATS	COMMENTS
Dick Cabin	17-Jun-19	457	
Dick Cabin	18-Jun-19	386	
Dick Cabin	19-Jun-19	144	count cut short by rain
Dick Cabin	29-Jul-19	836	pups learning to fly
Dick Cabin	31-Jul-19	1064	pups learning to fly
Maternity Box Cluster	10-Apr-19	400	daytime inspection
Maternity Box Cluster	17-Jun-19	605	
Maternity Box Cluster	18-Jun-19	662	at least 40 pups left in box
Maternity Box Cluster	29-Jul-19	412	count cut short by wildlife
Maternity Box Cluster	31-Jul-19	300	count cut short by wildlife
Pump House	19-Jun-19	8	count cut short by rain
Pump House	29-Jul-19	1	
Rocket Box	19-Jun-19	0	count cut short by rain
Rocket Box	29-Jul-19	0	
Warehouse	30-Jul-19	7	

5.4 Increasing Knowledge

Assessing Bat Box Occupancy

Of 33 bat boxes evaluated in 2020, 19 (58%) were occupied, with numbers of bats per single box ranging from 1 to hundreds in a single box (one of the four boxes in the Maternity Box Cluster). Outside of the Maternity Box Cluster, of the boxes for which bat numbers were assessed, 90% of bat houses contained fewer than 10 bats.

Acoustic Surveys

Acoustic surveys were used to identify bat species present near known roosts and throughout the watershed. Between April and November 2019, 1730 bat calls were identified on 19 recording nights outside of known roosts, and 390 bat calls were identified on 26 recording nights in Clowhom wetlands. Only 10 calls were detected on 17 nights at other locations in the watershed.

Evaluating bat communities based on acoustic surveys has some limitations. It is impossible to distinguish between several bats passing versus the same individual repeatedly circling. Species producing quieter calls, like Townsends Big-Eared Bat (*Corynorhinus townsendii*) and Western Long-eared Myotis (*Myotis evotis*), may not be detected. Species with similar calls sometimes cannot be distinguished and must be grouped into "phonic groups" containing two possible species. For example, Little Brown Myotis (*M. lucifugus*) and Long-legged Myotis (*M. volans*) cluster together with calls whose frequency bottoms out at 40 kHz, while Yuma Myotis (*M. yumanensis*) and California Myotis (*M. californicus*) cluster together with calls at 50kHz, and Big Brown Bat (*Eptesicus fuscus*) and Silver-haired Bat (*Lasionycteris noctivagans*) cluster together at 25 kHZ. Distinguishing between species with similar frequencies often relies on subtle differences in the shapes of calls. But bat produce different types of calls depending on the situation, and those made when feeding, outside of known roosts, and near clutter, can produce calls that are difficult to distinguish.

In our analysis, recorded calls were generally classified into the following groups:

MYYU:	*Myotis yumanensis*	(Yuma Myotis)
MYCA:	*Myotis californicus*	(California Myotis)
MYLU:	*Myotis lucifugus*	(Little Brown Bat)
MYEV:	*Myotis evotis*	(Western Long-eared Myotis)
LANO:	*Lasionycteris noctivagans*	(Silver-haired Bat)
MYYU/MYCA:	*Myotis yumanensis* or *Myotis californicus*	(Yuma or California Myotis)
MYLU/MYVO:	*Myotis lucifugus* or *Myotis volans*	(Little Brown or Long-legged Myotis)
EPFU/LANO:	*Eptesicus fuscus* or *Lasionycteris noctivagans*	(Big Brown Bat or Silver-haired Bat)

All recordings collected outside of known roost sites were dominated by *Myotis* species (Figure 17). Four of five roosts were dominated by the MYYU/MYCA phonic group, comprising 91% of identified calls near the Maternity Box Cluster, 76% of calls near the Clowhom Lake Cabin, and 62% of calls near both the Warehouse and the Private Cabin. At each of these roosts, the second most commonly recorded calls were those of the MYLU/MYVO phonic group, accounting for 7% at the Maternity Box Cluster, 16% at the Clowhom Lake Cabin, 33% at the Warehouse, and 30% at the Private Cabin. At the Pump House roost, the proportions were reversed with higher numbers of MYLU/MYVO (62%), and MYYU/MYCA (36%) as the second most common. The EPFU/LANO phonic grouping accounted for 2 to 8% of calls recorded outside of known roosts, while the species MYEV accounted for 1% of calls at the private cabin.

In recordings made in Clowhom wetlands, away from known roosts, the most commonly recorded bats included the same three phonic groups found near the roosts: MYYU/MYCA (38%), MYLU/MYVO (22%), and EPFU/LANO (9%), but the species LANO was the second most common at 30% (Figure 18). Calls identified as the species MYLU, MYCA, and MYEV, each accounted for less than 1% of identified calls.

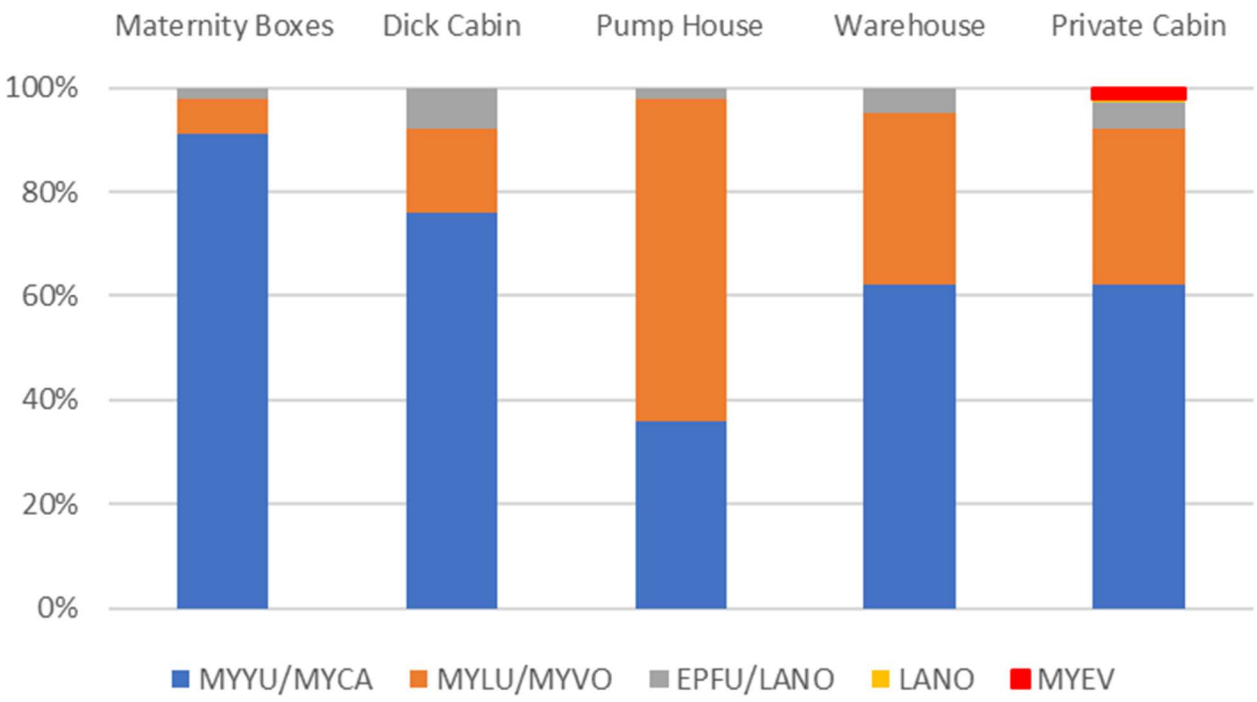


Figure 17. Proportion of identifiable bat calls by species at roost sites, 2019

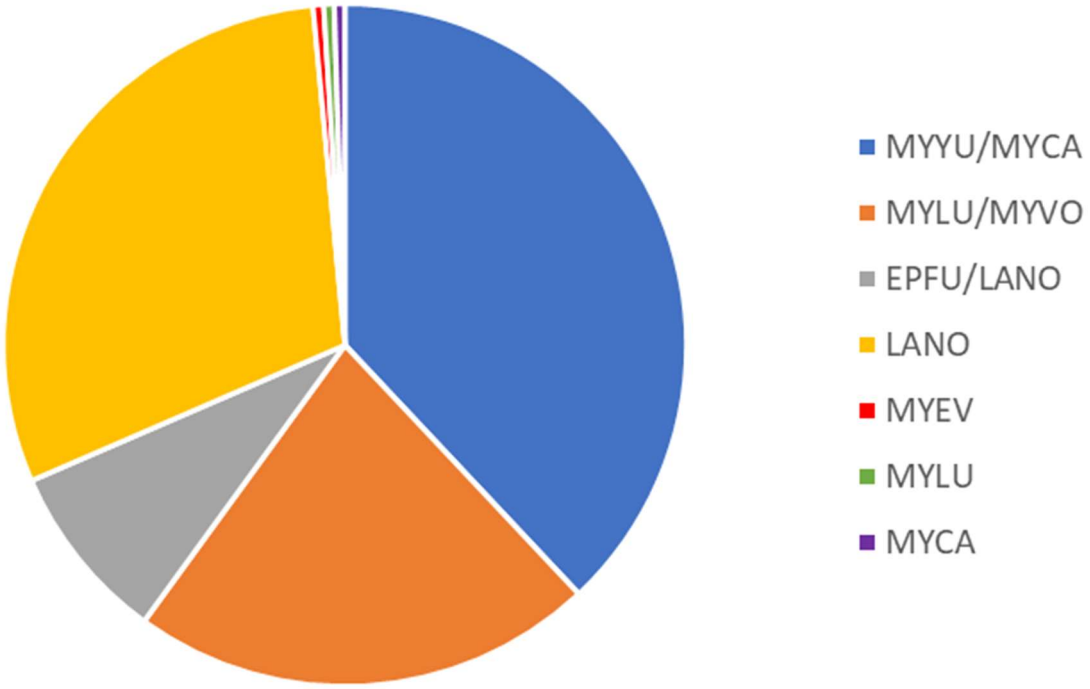


Figure 18. Overall proportion of bat calls by species in Clowhom wetlands, April-November 2019

Away from roosts, LANO *(Lasionycteris noctivagans)* was the most commonly recorded bat in both the spring and fall, accounting for 69% of identified calls in April/May and 58% of calls in October/November (Figure 19). In contrast, during the summer, calls in wetlands were dominated by *Myotis* species, with LANO and EPFU/LANO calls accounting for only 3% of identified calls in June/July.

Bat activity was very low from late October to early November with only 32 total calls detected in 29 nights of sampling. At one of the three fall acoustic survey sites, no calls were recorded in 13 nights. Overall, there were only 0.4 bat calls per recording night in October/November compared with 10.6 in April/May and 12.0 in June/July.

Species detected during the late October to early November sampling period included LANO, MYYU, MYCA, MYLU/MYVO, and MYYU/MYCA.

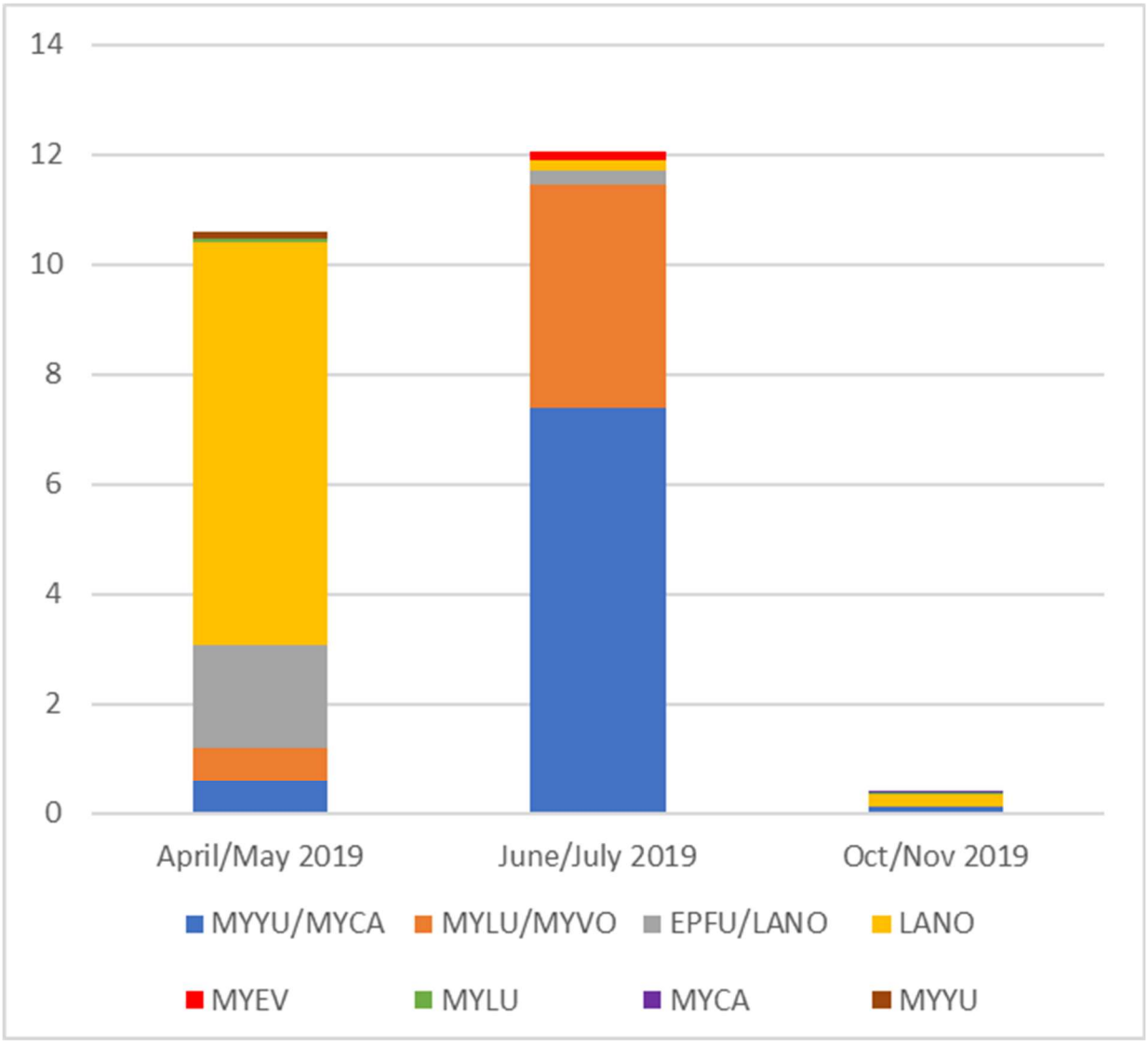


Figure 19. Average number of bat calls per night in Clowhom wetlands at different times of year

5.5 Community Engagement

Between April 2019 and March 2020, we provided 23 community engagement activities, including school programs, outreach tables, bat box building workshops, and bat walks, reaching over 2,000 community members of all ages (Table 2). Over 200 Sunshine Coast residents volunteered on the project by participating in bat roost emergence counts or building bat houses. We published 11 media articles about bats, several of which specifically mentioned Fish and Wildlife Compensation Program support (Table 3).

Table 2. Public Outreach and Engagement Activities, April 2019 – March 2020

DATE	LOCATION	ACTIVITY	AUDIENCE
Apr-19	Earth Day, Roberts Creek	Outreach Table	Community members
May-19	Iris Griffith Centre Nature School	School Program	Grades K-3 students
May-19	May Day, Madeira Park	Outreach Table	Community members
May-19	Pender Harbour Wildlife Society meeting	Presentation	Community members
Jun-19	Oceans Day, Sechelt	Outreach Table	Community members
Jun-19	Sargeant Bay Park	Bat Walk	Community members
2019 Jul-Aug	Gibsons Public Market, Gibsons	Outreach Display	Community members
Jul-19	Conservation Association Youth Program	Box Building Workshop	Grades 4-7 students
Aug-19	Summer Faire, Gambier Island	Outreach Table	Community members
Oct-19	Fall Faire, Pender Harbour	Outreach Table	Community members
Oct-19	Pender Harbour	Box Building Workshop	Community members
Oct-19	Fall Faire, One Straw Society, Roberts Creek	Outreach Table	Community members
Oct-19	Roberts Creek	Box Building Workshop	Community members
Oct-19	Davis Bay NEST Class 1, Davis Bay	School Program	Grades K-3 students
Oct-19	Davis Bay NEST Class 2, Davis Bay	School Program	Grades K-3 students
Oct-19	Langdale Elementary, Langdale	School Program	Grades 3-4 students
Oct-19	Gibsons	Box Building Workshop	Community members
Oct-19	Cedar Grove Elementary, Gibsons	School Program	Grade 4 students
Nov-19	Gibsons Elementary, Gibsons	School Program	Grades 4-5 students
Nov-19	Halfmoon Bay	Box Building Workshop	Community members
Nov-19	Christmas Market, Pender Harbour	Outreach Table	Community members
Nov-19	Pender Harbour	Box Building Workshop	Community members
Feb-20	Professional Day Teachers' Workshop	Outreach Table	Local teachers

Table 3. Media Articles, April 2019 – March 2020

DATE	TITLE	PUBLICATION
May-19	The Status of Swallows and Bats	The Local Weekly
May-19	Protecting Swallows and Bats	Coast Reporter
Jun-19	Report Bat Roosts and Swallow Nests	Coast Reporter
Jun-19	Volunteers Needed to Monitor Local Wildlife	The Harbour Spiel
Jul-19	Report Your Bats	The Local Weekly
Oct-19	Sunshine Coast Wildlife Project	The Harbour Spiel
Oct-19	Help Birds, Bats, and Bees at workshops	Coast Reporter
Oct-19	This is International Bat Week	The Local Weekly
Nov-19	Pender Harbour & Egmont: Christmas Faire this weekend	Coast Reporter
Feb-20	Public Help Essential for Monitoring Bat Disease	Coast Reporter
Mar-20	Bat Watch Bulletin	The Local Weekly

5.6 Outcomes

In summary, Year 1 of this project produced the following specific outputs and outcomes:

Habitat Enhancement

- Repaired and improved the Clowhom Maternity Box Cluster by replacing broken posts, fixing damaged boxes, and adding additional bat houses to provide long-term stable roosting habitat for bats at this important maternity roost.
- Repaired woodpecker damage to the Clowhom Rocket Box to encourage bats to return to this previously occupied roost.
- Worked with community volunteers to build and install 45 new bat houses, helping to mitigate roosting habitat loss, increase available roosting habitat, and raise public awareness about bat conservation.

Habitat Protection

- Together with BC Hydro staff, toured various facilities in Clowhom, including the Pump House, Hydro Station, and Auxiliary Building, to identify any bat roosts in need of protection and monitoring.
- Met with representatives of BluEarth Renewables and Bear Hydro to gain support for bat conservation efforts in the Clowhom watershed. To date, no roosts have been identified in the buildings of microhydro operators but both organizations are amenable to installing bat houses on their properties.
- Consulted with a private landowner about the Clowhom Lake Cabin and confirmed his commitment to ensuring that this important maternity roost can continue to be used by bats.
- Inspected 20 buildings in the Clowhom watershed for evidence of bat occupancy and identified 5 buildings with bats and/or guano present.
- Identified 74 new bat roosts in the wider Sunshine Coast region and worked with landowners to ensure that these roosts are maintained.
- Provided information and assistance to landowners to ensure that when bats are excluded from buildings, mitigation efforts are employed to prevent harm to bats and that suitable bat houses are installed to replace lost roosting habitat.
- By conserving known building roosts, we are helping to keep bat populations as healthy as possible prior to the arrival of White-nose Syndrome.
- Protected bat roosts in buildings will provide habitat to support surviving bats should local populations experience WNS impacts.

White-nose Syndrome Surveillance

- Conducted WNS surveillance to contribute to province-wide efforts to enable early detection when Pd reaches BC, help determine the extent of the disease, and enable a rapid conservation response.

- Conducted 159 roost emergence counts at 106 roosts (5 in Clowhom and 101 in the surrounding communities) to establish pre-WNS baseline abundance data, against which future WNS-related population declines can be measured to assess impacts.

- Documented 5 dead bats during the winter surveillance period and sent 3 carcasses to the Animal Health Lab for testing.

Increasing Knowledge

- Installed temperature loggers in the Clowhom Maternity Box Cluster so conditions in this important roost can be monitored throughout subsequent project years to contribute to broader province-wide efforts to understand temperature conditions in manmade bat houses and evaluate the potential risks of overheating.

- Conducted 62 detector nights of acoustic surveys in Clowhom to inventory bat species present, evaluate seasonal patterns of activity, guide future bat research and mitigation efforts in the watershed, and document migratory bat species occurrence as part of broader international efforts to understand the timing and migratory routes of these threatened species.

- Identified 7 hibernation sites, helping to fill knowledge gaps about where western bats spend the winter.

- Collected guano samples from 6 roosts for DNA analysis to determine the species present.

- Evaluated the occupancy of 33 installed bat boxes on the Sunshine Coast.

Community Engagement

- Carried out diverse outreach activities, including 7 bat house building workshops, 8 outreach tables, 6 school programs, 1 presentation, 1 guided bat walk, and 11 media articles to increase public awareness, decrease human persecution of bats, and recruit community participation in bat stewardship and monitoring activities.

- Facilitated volunteer participation in bat stewardship efforts, including 563 volunteer hours by 204 volunteers who participated in bat counts and building bat houses.

6. Discussion

6.1 Priorities for Bat Conservation in Clowhom

Protecting Roosts in Buildings

Each spring and summer, mother bats gather at maternity roosts to give birth and rear their young. Maternity colonies can range in size from dozens, to hundreds, or even thousands of bats, depending on the species. In British Columbia, Yuma Myotis (*Myotis yumanensis*) and Little Brown Myotis (*M. lucifugus*) are two bat species that often form large roosting aggregations. Because maternity colonies may house most of the breeding females and their offspring from a large area, the destruction of a single roost can have devastating impacts.

Bats originally evolved to roost in natural sites like hollow trees, caves, and crevices, but as humans have transformed landscapes, natural roosting habitat has become more scarce. As a result, bats have increasingly relied on human structures for roosts. Buildings can offer attractive options for pregnant and nursing female bats, providing warm, stable temperatures, protection from predators, and a diversity of microclimatic options within the roost. Bats tend to be very faithful to their maternity roosts in buildings, returning year after year. Therefore, protecting these sites is an essential component of bat conservation.

The Clowhom watershed is home to several known building roosts. The most important of these is the Clowhom Lake Cabin, situated on the shore of the lake and home to the second largest known bat colony on the Lower Sunshine Coast. This abandoned cabin supports more than 1,000 mother and baby bats at peak numbers in mid summer. Species present include both Yuma Myotis and Little Brown Myotis.

Another structure that houses large numbers of bats is the Pump House, a tiny building located near the base of the Clowhom Dam. DNA from guano collected at the site confirms that both Yuma Myotis and Little Brown Myotis use this roost. Bat occupancy appears to be sporadic, with hundreds of bats observed on some nights, and very few on others. It is likely that there is a secondary roost used by the colony nearby. It is unknown whether bats roosting in the Pump House might be part of the colonies using the nearby Clowhom Lake Cabin and/or the manmade bat boxes in the Maternity Box Cluster.

The third site believed to support a large bat colony is the Auxiliary Building, a large, abandoned, empty concrete structure situated next to the main Generating Station at the end of Salmon Inlet. We have yet to confirm the timing and nature of bat roosting activity in this site, but substantial quantities of guano present indicate that large numbers of bats are, or historically have been, present at certain times of year.

Conserving these three building roosts is essential to bat conservation in the Clowhom watershed. At this time, all three of these sites are safe and being protected. BC Hydro has no current plans to disturb, demolish, or renovate either the Pump House or Auxiliary Building (C. Rumbough, pers. comm.).

The Clowhom Lake Cabin is situated partially on Crown Land and partially on private land, and the private landowner is committed to conserving the structure for the bats. However, both the abandoned building itself, and the surrounding property, are in a state of disrepair with substantial debris throughout. A key priority is to work with the landowner, government, and other watershed partners to help clean up this ecologically sensitive location, and to explore options to ensure permanent long-term protection and maintenance of the cabin for the benefit of the bat colony.

Bats may abandon roosts if disturbed (Verts and Carraway 1998), so care should be taken to try to minimize human disturbance to these three known building roost sites. Clowhom is a remote watershed, accessible only by boat, so visitors are rare. Researchers should ensure that they do not bother bats within the roosts during their monitoring visits.

Protecting Roosts in Bat Boxes

Bat boxes are manmade structures designed to provide roosting sites for bats. They may be erected to supplement roosting habitat in areas where suitable natural sites are limited, or employed as a mitigation measure to replace lost habitat where roosts have been demolished or bats have been excluded from buildings. Bat boxes generally contain multiple chambers of narrow crevices in which many bats can roost. Common styles include maternity boxes, rocket boxes, and Uncle George boxes.

One set of manmade bat houses in Clowhom supports a large bat colony. The Maternity Box Cluster includes several bat boxes on posts in a clearing near the end of Salmon Inlet. The structure has supported hundreds of bats every year since our monitoring began in 2016 (Figure 20). In January and February 2020, we undertook necessary repairs to replace broken posts and crossbeams and refurbish damaged boxes. With the addition of two new bat boxes, we have increased the quantity and diversity of roosting habitat within the cluster. There are now six different bat boxes, including maternity and Uncle George style, facing both north and south, providing a variety of roosting options and temperatures for mother bats and their pups.

Another manmade roosting structure known to support bats is the Rocket Box. Situated near the Clowhom Dam, next to the Pump House, this structure once contained a colony of more than 40 bats. However, woodpeckers had damaged the box and bats had ceased using the structure. This year, we patched up the holes but, so far, the bats have not returned. The Rocket Box site offers a potential opportunity to supplement bat roosting habitat by replacing the current box with a larger new roosting structure on the existing pole.

Several other bat houses have been installed at various locations throughout the Clowhom watershed. While monitoring has been limited, to date, we have never observed more than a few individual bats occupying these boxes. Bats roosting in natural habitats, like trees, switch roosts frequently. Installing a variety of bat boxes within restricted areas at suitable sites in the watershed will increase roosting options and accommodate roost-switching behaviour.

Figure 20. Tightly packed bats inside one of the boxes in the Maternity Box Cluster (July 2019)

Maintaining Roosting Habitat in Forests

Although roosts in buildings can be the most obvious, its important to remember that bats originally evolved to roost in natural places like trees, caves, and crevices. Hoary Bats (*Lasiurus cinereus*) and Silver-haired Bats (*Lasionycteris noctivagans*) are two species that exclusively roost in trees, but most BC bat species regularly use dead and dying old trees, and even species like Yuma Myotis (*Myotis yumanensis*) that can form large roosting aggregations in buildings, also commonly use tree roosts (Evelyn et al. 2004).

Suitable roost sites include large diameter decadent or dying trees in early to middle levels of decay that contain loose bark, cavities, or crevices in which the bats can shelter (Hayes and Wiles 2013). Microclimate is key to roost selection; bats seek roosts with warm temperatures to conserve energy and aid in development and growth of offspring (Lausen 2019). Roost trees preferred by bats are larger in diameter, taller than those in the surrounding canopy, farther from neighbouring trees, and in areas of low canopy closure, maximizing solar exposure and heat (Hayes and Wiles 2013).

In watersheds like Clowhom, where significant forest harvesting has occurred, suitable bat roost trees are limited because mature forests have been replaced with younger, denser stands containing fewer snags and old trees. Many large dead and dying trees are knocked down because they pose safety hazards to foresters. Remaining patches of old forest are rare in the Clowhom watershed, especially at low elevations.

To support viable bat populations in Clowhom, it is essential to sustain natural roosting habitat. Forest management practices should seek to maintain and recruit sufficient large trees and snags. It is especially valuable to conserve remnant patches of mature, structurally diverse forest, especially within a few kilometers of water bodies and foraging zones. A variety of potential roost trees should be maintained across all landscape positions and elevations to meet the different seasonal thermoregulatory requirements of bats, from summer maternity roosts to winter hibernation sites.

Forest-roosting bats commonly move from one roost tree to another every few days to decrease parasite loads, maintain social relationships, and seek most suitable thermoregulatory conditions. Therefore, it is desirable to retain patches of snags in high densities (e.g., >40 snags per ha) to provide sufficient suitable roosts to accommodate roost switching behaviour of bats (Baker & Lacki 2006). In younger stands, forest thinning can help accelerate the recruitment of large trees and snags. Girdling and topping may also be used to create snags.

Protecting Foraging and Drinking Habitat

In addition to roosting habitat, bats also require sufficient habitat for feeding and drinking. All British Columbian bats eat insects, but different species vary in their preferred prey and foraging locations. Some, like the Hoary Bat (*Lasiurus cinereus*), feed in open clearings and high above the canopy, while others, like the Western Long-eared Myotis (*Myotis evotis*), can forage within closed forest environments and glean insects from vegetation. Common foraging areas used by many bat species include over water, along forest edges, and in open areas like clearings and meadows.

Wetlands and riparian zones tend to be hotspots of bat activity, providing both drinking water and abundant insect prey. To maintain habitat integrity for bats, it is important to minimize human activities that might damage or degrade these vital ecosystems. One species, in particular, that is strongly associated with aquatic ecosystems is Yuma Myotis (*Myotis yumanensis*); these bats typically forage low over open water, where they feed on emergent aquatic insects like caddisflies and midges.

The areas in Clowhom where we have observed the highest diversity of bats are semi-forested wetlands. As our past surveys have indicated, there are a limited number of small wetlands and ponds within the Clowhom valley (Evelyn et al. 2014). This increases the importance of maintaining the integrity and health of these existing wetlands.

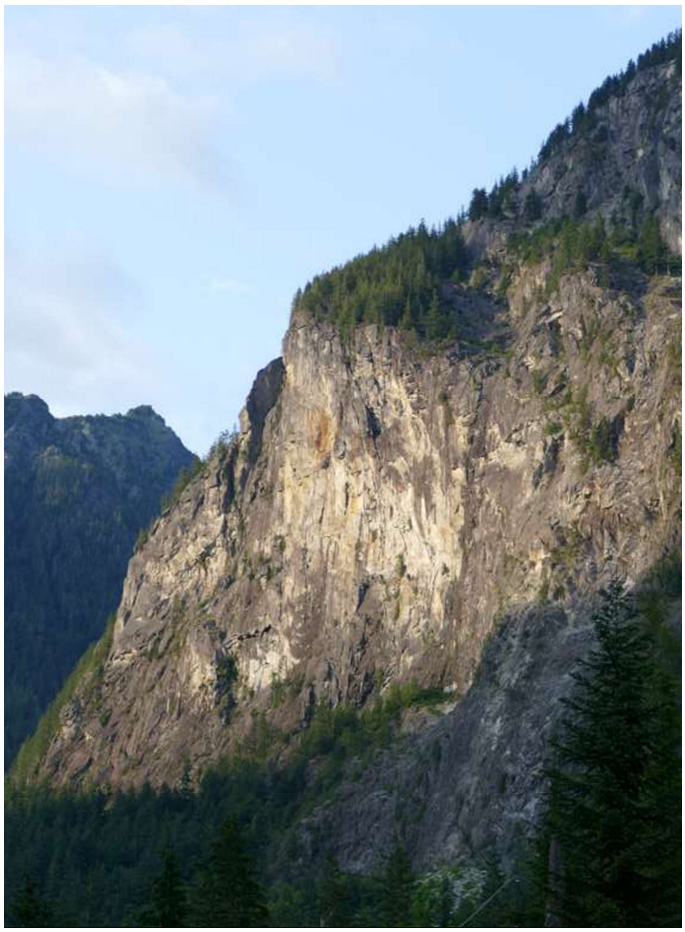
Protecting Hibernation Sites

To minimize energy expenditure over the winter, most bats in British Columbia hibernate or embark on a combination of migration and hibernation to find the ideal conditions. While bats in eastern North America tend to hibernate in large congregations in sites like caves and mines, the hibernation ecology of west coast bats is poorly known. Recent evidence suggests that bats in coastal BC may hibernate alone or in small groups in diverse sites from deep cracks and crevices in rocky outcrops, to beneath tree roots, within tree hollows, or inside buildings or wood piles.

A recent review of over 4,500 winter bat survey records, including 2,888 structures across the western United States, showed that the vast majority of winter bat aggregations were small, with 95% containing fewer than 10 individuals (Weller et al 2018). Apart from a karst cave system on Vancouver Island which houses four species of overwintering *Myotis* bats (Davis et al. 2000), few large hibernacula have been identified in coastal BC.

Here on the Lower Sunshine Coast, our only bat hibernation observations to date are of individual bats roosting alone in crawl spaces, chimneys, sheds, and wood piles. We have yet to identify any winter roosts used by bats in Clowhom. However, the abundant rocky cliffs, crevices, and talus slopes appear to provide many potential hibernation locations (Figure 21).

There are several important conservation implications from the fact that west coast bats appear to hibernate in many different tiny groups at dispersed and inconspicuous locations. The smaller groupings may reduce the impacts of White-nose Syndrome because social clustering behaviour is a risk factor for the disease; bat species most impacted by WNS are those that hibernate in the largest, most social groups (Langwig et al. 2012). However, the small and cryptic hibernation sites on the west coast will also complicate monitoring and disease management efforts. Trying to pinpoint hibernation sites is likely to prove difficult and protecting a single site will have only limited conservation value. Because hibernation sites are hard to find, there is an increased risk that individual bats and their hibernation sites may be inadvertently disturbed or destroyed.



Another difference between west coast bats and those in other parts of Canada, is that several species in British Columbia are active during winter months, periodically emerging from hibernation to drink, forage, or mate. Species that have been observed flying during the winter on the west coast include Yuma Myotis (*Myotis yumanensis*), California Myotis (*M. californicus*), Townsend's Big-eared Bat (*Corynorhinus townsendii*), Big Brown Bat (*Eptesicus fuscus*), and Silver-haired Bat (*Lasionycteris noctivagans*) (Burles et al. 2014, Falxa 2007). These species that naturally undertake regular periods of arousal during winter months may be less susceptible to WNS disease mortality.

Figure 21. Rocky cliff faces and talus slopes in Clowhom

Avoiding the Use of Pesticides and Herbicides

Pesticides and herbicides can have negative impacts on bats for multiple reason. First, they reduce the abundance and diversity of insect prey, such as moths, beetles, and flies, thereby decreasing food availability. In recent years, scientists have observed alarming reductions in insect abundance in various countries around the world, and chemical use has been identified as one of the factors in this "insect apocalypse" (Goulson 2019). This loss of insect prey has been linked to declines in populations of insect-eating wildlife, including bats and other aerial insectivores, like swallows and swifts (Spiller & Dettmers 2019).

Second, bats can be harmed directly when exposed to pesticides through eating, drinking, or contact with contaminated roosting surfaces. Chemicals can bioaccumulate in the bodies of bats, causing damage to their livers, brains, and endocrine and immune systems (Mineau & Callaghan 2018, Oliveira et al. 2020). Bats are especially vulnerable to chemical contaminants because the live for decades, feed high on the food chain, and have high metabolic rates, consuming up to their body weight in insects each day. In addition, the depletion of fat reserves during hibernation can mobilize fat-soluble contaminants into their bloodstreams.

To prevent negative impacts on bats, Clowhom watershed stakeholders should use integrated pest and weed management approaches and avoid the use of chemical pesticides and herbicides whenever possible. Spraying to control forest pests can harm non-target insects that may be important bat prey items. Forestry management prescriptions should be assessed and modified as necessary to ensure that healthy populations of bat prey species remain.

Protecting Bats from Covid19

The global coronavirus pandemic has transformed all aspects of life this year, including bat research. SARS-CoV-2, the virus that causes Covid19, has not yet been found in North American bat species. However, there are theoretical concerns that the virus could be spread from humans to bats. Research is underway to determine if this transmission is possible. In the meantime, out of an abundance of caution, bat biologists are advised to apply the precautionary principle and avoid direct contact with bats in research and monitoring activities to prevent any potential harm to wild bat populations (Canadian Wildlife Health Cooperative 2020, US Geological Survey 2020).

Engaging the Community in Bat Conservation

Community engagement is an essential component of bat conservation efforts in BC. Many residents have bats roosting on their properties, in homes, barns, sheds, bat houses, and trees, and thus can play important roles in protecting bat habitat. Community members may be the first to notice early warning signs of the arrival of White-nose Syndrome, such as dead bats found outside roosts or unusual observations of winter bat activity or bats flying during the day. Landowners can assist with maintenance and enhancement of habitat for bats by installing bat houses in optimal locations and implementing bat friendly practices on their property, such as avoiding the use of chemicals and maintaining old trees and snags.

The Annual BC Bat Count relies heavily on volunteer participation to maximize the number of roost sites that can be monitored each year. By increasing knowledge and awareness of bats among Sunshine Coast community members, we can reduce threats of deliberate persecution, and increase the number of residents participating in bat monitoring and stewardship efforts.

6.2 Priorities for Bat Research and Monitoring in Clowhom

White-nose Syndrome Surveillance

Since 2006, White-nose Syndrome (WNS) has been spreading across North America, having devastating impacts on populations of multiple bat species in eastern and central parts of the continent. In 2016, WNS was suddenly detected near Seattle, an unexpected jump of over 2000 km. By October 2020, the disease-causing fungus, *Pseudogymnoascus destructans* (Pd), had spread to nine counties within Washington State (Washington Department of Fish and Wildlife 2020). The disease is expected to arrive in British Columbia soon.

BC supports the greatest number of bat species of any province in Canada and this tremendous diversity is now at risk from WNS (BC Bat Action Team 2019). In eastern Canada, numerous bat species have been impacted by the disease to varying degrees. One of the worst affected is the Little Brown Myotis (*Myotis lucifugus*). Once one of the country's most common bat species, it received an emergency listing as endangered due to catastrophic WNS-related population declines in the eastern provinces (Environment Canada 2015). Because WNS has only recently arrived on the west coast, it is still uncertain to what extent our west coast species will be impacted. To date, five bat species known to occur in Clowhom have been confirmed to be susceptible. In addition to the Little Brown Myotis, Yuma Myotis (*Myotis yumanensis*), Western Long-eared Myotis (*M. evotis*), Long-legged Myotis (*M. volans*), and Big Brown Bat (*Eptesicus fuscus*) have all been affected by the disease in other regions, while the Silver-haired Bat (*Lasionycteris noctivagans*) has tested positive for the Pd fungus but without characteristic signs of the disease (WNS Response Team 2020a).

WNS surveillance is essential to help determine the spread of the disease and enable a rapid response (BC Bat Action Team 2019). At present, surveillance efforts by biologists across BC include collecting dead bats during winter and spring, documenting reports of winter-flying bats, collecting spring guano samples from beneath known roosts, collecting wing and face swabs, and monitoring colonies to collect baseline population data. The Sunshine Coast is considered a priority area for surveillance in BC due to its proximity to the Washington state border.

Assessing Known Maternity Colonies

Evaluating and monitoring known maternity colonies is essential to bat conservation and WNS surveillance. Clowhom is home to several large and important bat roosts that should continue to be focal points for research and monitoring. Priority sites for study include the Clowhom Lake Cabin, the Maternity Box Cluster, the Pump House, and the Auxiliary Building.

At the Maternity Box Cluster, the priority is to monitor the colony following the repairs and enhancements made to the structure in January and February 2020. This roost is also a focal site for internal and ambient temperature monitoring as part of broader province-wide investigations into temperature conditions in manmade bat boxes.

At the Pump House, the priority is to investigate the year-round pattern of bat occupancy. It appears that bats are only using this roost periodically. We recommend installing a permanent acoustic logger and wildlife camera to collect continuous data from the roost. There may also be a secondary roost site nearby and, to the extent buildings can be accessed in the company of staff, we recommend inspection of nearby structures on BC Hydro property in and around the Clowhom Dam. In future years, radio telemetry could be used to track bats from this colony to determine their movement patterns between the Pump House and other roosts in the watershed.

Year-round monitoring with acoustic detectors and wildlife cameras is also recommended for the Auxiliary Building to determine the species, numbers, and timing of bat use of this building which can only be accessed while accompanied by BC Hydro staff. All bat survey activities at roosts should employ strict protocols to minimize disturbance to bats and avoid the spread of White-nose Syndrome and/or Covid-19.

Acoustic Surveys

Acoustic monitoring can provide valuable information to help us understand bat communities, monitor population trends, and guide and evaluate conservation and management measures. Acoustic surveys can help document seasonal cycles, including timings of arrivals and departures from maternity roosts and patterns of winter bat activity. In addition to providing baseline data on bat populations prior to the arrival of WNS, acoustic monitoring can help with early detection of the disease by documenting unusual daytime flight and changes in summer foraging activity coinciding with the arrival of the illness (Dzal et al. 2010).

Acoustic surveys may be especially important to help with the conservation of migratory bat species. Because they do not hibernate, these bats are not affected by WNS. However, migratory species face a significant threat from wind turbines along migratory routes. Across North America, an estimated 500,000 bats are killed each year at wind farms due to blunt force injuries and barotrauma caused by rapid changes in air pressure. Information about migratory bat behavior in BC, including timing and routes, is lacking and desperately needed. Clowhom is home to two migratory species known to be harmed by wind farms, the Hoary Bat (*Lasiurus cinereus*) and the Silver-haired Bat (*Lasionycteris noctivagans*). Population level declines may soon reach thresholds for official listing of these species. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is currently undertaking assessments of both the Hoary and Silver-haired Bat, with new status reports scheduled for April 2022 (COSEWIC 2020).

To date, acoustic surveys in Clowhom have provided useful inventory information about the composition of the bat community, seasonal patterns, and areas of highest bat activity. However, because of limited available equipment, we have had to move detectors around from site to site. In coming project years, we hope to install permanent monitoring stations that will operate year-round to track population trends through time in key locations, including wetland foraging areas and outside of known roosts. Key roost sites for continuous acoustic monitoring include the Pump House, the Auxiliary Building, the Clowhom Lake Cabin, and the Maternity Box Cluster. Priority wetlands for monitoring bat activity include Wetlands 1, 6, and 8/9.

Monitoring Bat Houses

With the loss of mature forests, natural bat roosting habitat has become less available. Manmade bat houses can be an important conservation tool to supplement roosting habitat or mitigate for the impacts of roost destruction or exclusion, but research is required to evaluate the efficacy of this mitigation method and evaluate the most suitable designs and placements of bat houses. We recommend monitoring as many installed bat houses as possible in Clowhom and surrounding regions of the Sunshine Coast to evaluate occupancy during the spring and summer. Plastic sheets can be placed beneath bat houses to collect any guano to confirm occupancy and provide for identification of species from DNA. Where occupied, daytime inspections can be made, or evening emergence counts conducted, to try and determine how many bats are using each box.

Bats generally select bat houses that are as warm as possible to reduce energy requirements and boost growth of fetuses and developing young. But there is some evidence from other regions that during heat waves exceedingly high temperatures inside bat houses can lead to bat mortality (Lausen 2019). This issue may become even more prevalent under projected climate change scenarios. To date, we have not observed this problem on the Sunshine Coast, but we have installed internal and exterior temperature monitors in the Maternity Box Cluster to track temperatures throughout the season and contribute to province-wide research on this topic. We also recommend installation of temperature loggers within the Clowhom Rocket Box in conjunction with proposed repair or replacement of this structure.

7. Recommendations

The following actions are recommended to help bats in Clowhom and surrounding areas:

Habitat Enhancement

- Undertake necessary site clean-ups at the Clowhom Lake Cabin to prevent contamination of this ecologically sensitive lakeshore location and vital maternity bat roost. Garbage and debris should be removed from inside and outside of the cabin during the winter when bats are absent.

- To increase available roosting habitat for bats, work with community volunteers and students to build and install maternity boxes, Rocket boxes, and Uncle George bat houses at suitable sites in Clowhom and surrounding areas of the Sunshine Coast, following best practices for bat house design and placement.

Habitat Protection

- Continue surveys to identify, protect, and monitor bat roosts in Clowhom.

- To identify other bat roosts, meet with Clowhom industrial users and private cabin owners, along with other Sunshine Coast residents, and work to protect identified bat roosts through written landowner agreements.

- Do not demolish any buildings without checking first for bat occupancy and, if a bat roost is present, follow best practices to prevent harm to bats and mitigate impacts of habitat loss

- If demolition or renovation of any building housing a bat roost is unavoidable, develop a mitigation and habitat replacement plan to ensure that bats are not harmed during exclusion, and that replacement habitat is provided (e.g., through the addition of bat houses and/or condos).

- Maintain and recruit large-diameter dead and dying trees at a variety of elevations and landscape positions to provide sufficient natural roosting sites for bats.

- Conserve remnant patches of mature, structurally diverse forest, especially those within a few kilometers of water bodies and foraging zones.

- Maintain small, forested wetlands within Clowhom watershed to retain prime foraging and drinking habitat for many different bat species.

- Maintain open water with clear flyways into and out of water bodies to provide access for drinking bats.

- Where hibernation sites are identified, avoid disturbing these locations during the winter and seek to protect them by working with relevant landowners and land managers.

- Use integrated weed and pest management approaches and avoid the use of chemical pesticides and herbicides whenever possible. Assess forest management prescriptions, and modify as necessary, to ensure that healthy populations of bat prey species remain.

White-Nose Syndrome Surveillance

- Evaluate bat abundance at known roosts to provide early detection of the arrival of White-nose Syndrome in BC and enable rapid conservation response.
- Take care to minimize disturbance of bats and potential spread of WNS and/or Covid-19 during monitoring activities.
- Collect guano samples from known roosts for possible testing for the presence of the WNS disease causing fungus, *Pseudogymnoascus destructans.*
- Keep records of winter-flying bats, hibernating bats, and daytime flying bats.
- Collect all dead bats during the WNS surveillance window from November to May and ship them to the Animal Health Lab for testing following provincial protocols.

Increasing Knowledge

- Undertake acoustic surveys to document year-round patterns of bat activity, help guide future bat research and WNS mitigation efforts in the Clowhom watershed, and fill knowledge gaps about winter bat activity on the west coast and the timing and movement patterns of migratory species
- Monitor installed bat houses to document occupancy, colony sizes, and species compositions, and to evaluate the efficacy of this mitigation measure.
- Install temperature and humidity loggers in major roosts to assess external and ambient conditions.

Community Engagement

- Conduct outreach activities to increase public awareness of bat ecology, decrease human persecution of bats, and recruit community participation in bat stewardship.
- Request that community members report dead bats, winter-flying bats, hibernating bats, and bats flying during the daytime or behaving strangely.
- Recruit and facilitate community volunteer participation in bat monitoring efforts, including the Annual BC Bat Count and surveys to track occupancy of installed bat houses.
- Provide information and assistance to landowners to ensure that if roost habitat disturbance is necessary, mitigation efforts are implemented to prevent harm to bats and suitable bat houses are installed to provide alternate roosting options

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