CANADIAN
WILDLIFE HEALTH
COOPERATIVE

GOT BATS?

HOW TO MANAGE BATS IN BUILDINGS IN NEWFOUNDLAND AND LABRADOR

October 2018

Tessa McBurney

CREATING A WORLD
THAT IS SAFE AND SUSTAINABLE
FOR WILDLIFE AND SOCIETY

Acknowledgements

Cover Photo by Jordi Segers

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Section 1. Bat Basics

1.1 Ecological Services and Bats

Ecosystem services are the worldwide benefits that are provided to humans by the natural environment, including wildlife. Bats provide many ecosystem services including: insect control, pollination, and seed dispersal. The roles of bats in pollinating crops and agricultural insect pest control result in huge economic savings (1). It has been estimated that **insectivorous** bats (*i.e.*, insect-eating bats) save the global corn industry more than one billion U.S. dollars (USD) annually (2). In southern Texas alone, the insect pest consumption of the Mexican free-tail bat population is worth between $121,000 and $1,725,000 USD per year to the cotton production industry (3). The ecological services of bats are estimated to be valued at somewhere between $3.7 and $53 billion for the U.S. agricultural industry each year (4). Although estimates are not available for the Canadian agricultural sector, the ecological services of bats likely amount to a similar economic value for this sector of the economy. Little brown myotis (*Myotis lucifugus*), one of the resident bat species in Newfoundland and Labrador (NL), can each eat 4 to 8 grams (g) of insects per night throughout the spring and summer (4). Insectivorous bats, which include all Canadian bat species, eat a variety of insects including: flies, caterpillars, moths, midges, beetles, and mosquitoes, some of which are significant agricultural pests (5). This can be important for NL farmers, who lose millions of dollars to crop pests each year; for example, the vegetable and forage crop farmers who lost $2.5 million to armyworms (*Mythimna unipuncta*, Lepidoptera [moths and butterflies]) in 2012 alone (6). The cabbage maggot (*Delia radicum*, Diptera [true flies]) is responsible for damaging cruciferous vegetables (i.e., cole crops; *Brassica oleracea* varieties including: broccoli, Brussels sprouts, cabbage, cauliflower, and kale) throughout NL (7). The top four pests to cranberry crops in NL are all moth species (Lepidoptera spp.) (8). A study in New Hampshire found that Lepidoptera spp. were involved in little brown myotis diets 85.5% of the time (9). For juvenile little brown myotis in Nova Scotia (NS), 7.7% of their diet is Diptera spp. and 15.9% is Lepidoptera spp. (10). In southwestern Ontario, 63% of the early season diet of the little brown myotis is comprised of Diptera spp. (11). The ecological services of bats are also helpful to property owners with vegetable gardens, or simply people who want fewer mosquitoes or moths in their yards.

Figure 1. Bats save the agricultural industry billions of dollars per year.

Figure 2. Broccoli, a common cole crop, is susceptible to many moths and flies, which bats eat.

1.2 Bat Mythconceptions

1. Bats will fly into your hair.

This myth reaches around the world but does not have a single known origin. It likely stems from the fact that bats will often circle low overhead, eating the insects that are attracted to people. Bats do not fly into hair; why would they? Many bat species use a sophisticated **echolocation** system to help them fly in the dark, which allows them to avoid obstacles and locate insects. Those obstacles certainly include people; they likely want to avoid you at least as much as you want to avoid them.

2. Bats will suck your blood.

All bats in Canada are insectivorous bats and none of them drink blood. Contrary to popular belief, very few bats actually have a diet consisting solely of blood, and while vampire bats do exist, they are not the vampires from folklore. In the southern U.S. and South America there are three species of vampire bats, but they mostly obtain their blood meals from birds or large mammals, rather than humans. Unlike mythological vampires, vampire bats do not kill the animal they feed on; they just make a very tiny incision (not usually on the neck) with their teeth and lap up a small amount of blood.

3. Bats are blind.

All bat species have eyes, and most can see at least as well as humans. However, they do not have strong night vision, which is why they use echolocation to find their prey in the dark. Bats echolocate at different frequencies, but they are all too high to be heard by the human ear. However, by recording bat echolocation using specialised acoustic recorders, it is possible to use a computer program to examine the echolocation calls of a bat and determine what species was echolocating. Bat calls are like bird songs; there are unique songs for different species.

4. Bats are rodents.

Bats and mice are both mammals but bats belong to the order Chiroptera, which is completely separate from the order Rodentia, the group for rodents (*e.g.*, mice [*Mus* spp.], rats [*Rattus* spp.], squirrels [Scuiridae spp.]). While bats may look like mice, and have been given names like “chauve-souris”, or “bald mouse”, they are quite different from rodents. Rodents give birth to many young per litter, but bats only give birth to one or two pups a year and devote a great deal of time and energy into caring for their offspring. Rodents only live a few years, but bats are capable of living up to 40 years. Scientists still do not completely understand how such a small mammal is able to live so long.

Figure 3. *Myotis* sp. infected with bat white-nose syndrome.

1.3 Bat White-nose Syndrome (WNS)

In 2014, three bat species were federally listed as endangered in Canada: the little brown myotis, the northern myotis (*Myotis septentrionalis*), and the tri-colored bat (*Perimyotis subflavus*). These species were all listed after experiencing large population declines from bat white-nose syndrome (WNS) (12). WNS is a disease caused by a cold-resistant fungus called *Pseudogymnoascus destructans* (*Pd*) (5). It is unknown how this fungus reached North America, but the most likely explanation is that it was accidentally introduced to a show cave in upper New York State by a tourist visiting from Europe. In a 2012 study, it was estimated that **at least 5.7 to 6.7 million bats had died from WNS in North America since its introduction in 2006, that number is likely much higher now but total loss is difficult to quantify** (1, 13). WNS is caused by *Pd* infecting and damaging the skin of the muzzle, ears, and wing membranes of bats (1). Once infected, *Pd* appears to lead to rapid dehydration and electrolyte loss in bats, resulting in bats arousing more frequently from hibernation which causes them to burn their limited energy reserves and emerge from hibernation too early (14). However, there are few insects available in winter, even on warm days, so the affected bats often starve to death or die from cold exposure (5).

Figure 4. Bat wing with observable *Pd* (in red circle).

1.4 Bat Species in Newfoundland and Labrador

The only two resident bat species in NL are the little brown myotis and the northern myotis (15). Both species are federally listed as endangered due to the impact of WNS. While the hoary bat (*Lasiurus cinereus*) has also been observed in NL, this is an uncommon occurrence (16). This **migratory** species does not overwinter in the province and is thought to only occasionally pass through during migration periods.

THE ONLY TWO RESIDENT BAT SPECIES IN NEWFOUNDLAND AND LABRADOR ARE THE LITTLE BROWN MYOTIS AND THE NORTHERN MYOTIS.

1.4.1 Little Brown Myotis (Little Brown Bat)

When considering the presence of bats in buildings in NL, this typically refers to the little brown myotis. This bat species is a cavity rooster, and roosts in both natural and human-made **roosts**. While in the winter they typically hibernate in caves and abandoned mines (5, 17), it is possible that little brown myotis may be hibernating in other such areas in NL that provide suitable moisture and temperature conditions, such as rock crevices, old wells, or root cellars. Pups are generally born between late June and mid-July and are able to fly ("become **volant**") after three weeks (5, 17, 18, 19). Little brown myotis are known as "**hawkers**", which means they catch their prey in the air, but they are also "**gleaners**" meaning they can capture insects resting on trees and other surfaces. Little brown myotis often consume half of their body weight in food each night, but lactating females can eat up to 110% of their body weight in a night (5).

Figure 5. Little brown myotis (*Myotis lucifugus*).

1.4.2 Northern Myotis (Northern Long-eared Bat)

The northern myotis generally roosts either solitarily or in small groups, and frequently with other bat species (5, 17). These bats have **synchronous birth**, which means that all of the pups within an area are born within as short a time period as six days (5). Northern myotis are both "hawkers" and "gleaners" (5, 17).

Figure 6. Northern myotis (*Myotis septentrionalis*).

Figure 7. Hoary bat (*Lasiurus cinereus*).

1.4.3 Hoary Bat

The hoary bat is the largest bat in Canada (approximately the size of a song sparrow), and is a migratory species, which means they move north for the summer and south for the winter (5). The few sightings of hoary bats in NL are likely due to exploratory migration (16, 20).

Table 1. Life history characteristics for NL bat species; information from: Maunder 1988; Adams 2003; Cryan 2003; Cryan *et al.* 2004 (21); Broders *et al.* 2006; Naughton 2012; Broders *et al.* 2013; Norquay *et al.* 2013 (22); Canadian Wildlife Health Cooperative, unpublished data.

Species	Roost Sites	Diet	Maternity Colony Starts (pregnant)	Birth Period	Typical # of Pups
Little brown myotis	trees, foliage, caves, rock crevices, under rocks, buildings, wood piles, under metal sheetS, under shingles	midges, mosquitoes, moths, spiders, caddisflies, beetles, lacewings, crane flies, wasps, water boatmen, leaf hoppers	late April or early May	mid-June to mid-July	1
Northern myotis	trees (cavities, crevices, under loose bark), caves	flies, moths, beetles, caddisflies, lacewings, leaf hoppers, spiders, caterpillars	spring	mid-May to mid-July	1
Hoary bat (tree bat)	trees (branches, hollows, bark crevices)	moths, beetles, flies, grasshoppers, dragonflies, wasps, smaller bat species	spring	mid- to late June	2

1.5 Bat Species Identification

Figure 8. Tragus differences between little brown myotis (top) and northern myotis (bottom).

There are several important features that are commonly used to identify a bat species including: fur colouration, and measurements of the body, forearm, and ear. The two *Myotis* spp., **little brown myotis** and **northern myotis**, look very similar. The only way to tell these species apart is by the **tragus**, a small, pointed protrusion inside the ear. The little brown myotis has a relatively short tragus that is rounded at the tip and straight along the edge closest to the face, with a small bump on the outside edge (see red circle in top photo on left). In comparison, the northern myotis has a tragus that is longer and pointier, and shaped like a cone, which is straight along the edge closest to the face and slightly curved on the outside edge (see red circle in bottom photo on left). The identification of these bats cannot be separated when they are in flight, as the tragus cannot be adequately seen. It is not recommended that a non-professional touch or pick up a bat to facilitate identification (23). The forearm length of the little brown myotis is 33-41 mm and the weight is 7-14 g. The forearm length of the northern myotis is 34-40 mm and the weight is 4.5-10.8 g (5).

The **hoary** bat also has a very distinctive appearance due to the colouration of its fur. The fur on its body is a combination of dark brown, black, and grey with light and dark bands which make the fur look frost-tipped ("hoary"). Around the face, its fur is a yellowish-brown colour, and the nose, mouth, and ear edges are very dark, almost black. The hoary bat is the largest bat species in Canada with a forearm length of 54-58 mm and a weight of 25.0-35.7 g (5).

1.6 Types of Bat Roosts in Newfoundland and Labrador

1.6.1 Day Roost

A **day roost** is a normal roost site where bats spend time resting during the day throughout the spring, summer, and fall months. For a female without pups or a male, this often means roosting alone. For the majority of females with pups, their day roost is also their maternity colony. Day roosts typically include: natural sites such as trees, caves, rock crevices, and the underside of rocks, and human-made structures such as buildings, shutters, woodpiles, and under metal sheets and shingles (5, 17).

Figure 9. Day roost (or in this case a maternity colony).

1.6.2 Maternity Colony

A **maternity colony** is a roosting site where predominantly females and their young (once they are born) roost in spring and summer. Females have high fidelity to these sites and most return to them annually. A maternity colony is a type of day roost. Maternity colonies can be found in or outside human-made structures, such as buildings and bridges, and can also occur in natural sites, such as tree cavities, under loose bark, rock crevices in cliffs, and small caves that are warmed by hot springs. For optimal growth of offspring, maternity colonies are typically between 32°C and 36°C (5). If you know of a maternity colony location, please call the toll-free number 1-833-434-BATS (2287), or the Newfoundland and Labrador Forestry and Wildlife Research Division at 709-637-2025.

Figure 10. Shed used as a roost site for a maternity colony.

1.6.3 Night Roost

A **night roost** is where bats temporarily rest and digest between feeding bouts throughout the night in spring, summer, and fall. Night roosts are generally used by solitary bats. Night roosts can be either natural or human-made roost sites, and typically include small spaces that can be quickly warmed by the body heat of the bat. Lactating females do not use night roosts but instead return to the maternity colony during these periods so that they can nurse their young (5).

Figure 11. Hibernating *Myotis* sp.

Figure 12. Bat hibernaculum in an abandoned well.

1.6.4 Hibernaculum

A hibernaculum is a winter roosting site shared by hibernating male and female bats, often of several species. Individual bats have high fidelity for these sites and most return to them annually. Hibernacula can be either natural or human-made roost sites that provide high humidity levels and stable, above-freezing temperatures, and may include: caves, abandoned mines, rock crevices, earthen basements, and hand-dug wells (5, 17, 24). The public is asked to report any potential hibernation site by calling the toll-free number (1-833-434-BATS [2287]) or the Newfoundland and Labrador Forestry and Wildlife Research Division (709-637-2025).

1.6.5 Atypical Roost

An atypical (unusual) roost is a human-made roost site that bats may use in day or night in all seasons. As this is not a high quality roost site, bats do not typically have fidelity to the roost. Examples of an atypical roost include: a curtain or wall inside a house, or in the folds of an umbrella outside a house.

1.7 Human Health Concerns

There are two primary human health concerns associated with bats: rabies virus and histoplasmosis.

1.7.1 Rabies Virus

Rabies is an infectious disease that can occur in any mammalian species and is caused by rabies virus which belongs to the Lyssavirus family. There are several different variants of rabies, including those found in terrestrial mammals (*e.g.*, foxes (*Vulpes* spp.), striped skunks (*Mephitis mephitis*), and common raccoons (*Procyon lotor*)) and those found in bats, and they are named according to their reservoir host species (*i.e.*, the animal that maintains the disease in the wild) (25). Cases of bat variant rabies have been reported in bats and terrestrial wildlife species (*i.e.*, red foxes [*Vulpes vulpes*]) in NL (26). Although they are uncommon, most cases of human rabies in North America from 1950-2007 have been caused by bat rabies variants, and several have been characterised as cryptic cases where the patient's contact with an infected bat has not been able to be determined. Since 1950, there have been only 6 human cases of bat-variant rabies in all of Canada (none of which occurred in NL), and only 50% of these cases occurred when the patient was knowingly bitten or scratched by a bat (27). This highlights the need for caution and appropriate protection when touching or handling live bats because an untreated rabies virus infection generally results in death. Bat variant rabies is transmitted among bats or to other animals, including humans, by the transfer of saliva containing rabies virus from an infected bat through a bite or other wound, or through saliva contamination of the uninfected individual's mucous membranes (eyes, mouth, or nose) (25). You cannot get rabies from exposure to bat guano (droppings) or urine (28). **Rabies prevalence in natural bat populations is approximately 1%** (29). However, bats exhibiting abnormal behaviours such as: lying on the ground, difficulty flying, daytime presence, and aggression, are more likely to have rabies (30).

Figure 13. Never touch or hold a bat with bare hands.

IF THERE HAS BEEN SUSPECTED CONTACT BETWEEN A HUMAN AND A BAT PLEASE CONTACT:

FAMILY DOCTOR OR HOSPITAL EMERGENCY ROOM (ER)

(AND CHIEF VETERINARY OFFICER IF BAT IS AVAILABLE TO SUBMIT FOR RABIES TESTING)

IF THERE HAS BEEN SUSPECTED CONTACT BETWEEN A PET/FARM ANIMAL AND A BAT PLEASE CONTACT:

CHIEF VETERINARY OFFICER
709-729-6879

YOU CAN FIND MORE DETAILS ABOUT THE PROPER STEPS TO TAKE AFTER POTENTIAL EXPOSURE TO BAT VARIANT RABIES AT THE FOLLOWING WEBSITE:

HTTP://WWW.FAA.GOV.NL.CA/AGRIFOODS/ANIMALS/HEALTH/PDF/RABIES_POLICY_MANUAL.PDF

Rabies is a fatal disease. It is important that people take the proper precautions to prevent exposure to this virus. **The simplest and best way to prevent rabies exposure is to never touch or hold a bat with bare hands.** Bats, like other wild animals, are afraid when they are touched and will often bite in self-defense. Therefore, if it is necessary to remove a bat from a property, then it is crucial they are handled wearing thick gloves that cover the hands, and if possible, the forearms. While bats have small teeth, they are quite sharp, so thick gloves must be worn so that the bat cannot bite through the gloves. Wounds caused by bats can be very hard to find because the bite puncture marks are very small (less than 1 mm in diameter) and scratches are generally less than 1 mm long (27). T**hus, if there is any possibility that a human or domestic animal was bitten or scratched by a bat, it is very important that the following departments are contacted in order to assess the situation: provincial health officials (family doctor or hospital ER) and/or the Chief Veterinary Officer with the Animal Health Division (709-729-6879). If a bat bite or scratch does occur, immediately wash the wound for fifteen minutes with soap and water, 70% ethanol, or a povidone-iodine solution, and contact the local health authorities** (31). If a bat bite or scratch is identified, then rabies post-exposure **prophylaxis** (PEP; preventative treatment) will likely be recommended as a course of action (31). **If possible, keep the bat so it can be submitted for rabies testing.**

Figure 14. A bat **necropsy** (non-human autopsy) includes rabies testing.

Figure 15. One case of bat-variant rabies was reported in a fox in NL in 1989.

1.7.2 Histoplasmosis

Histoplasmosis is an infectious fungal disease of humans and animals caused by *Histoplasma capsulatum* (*H. capsulatum*) that most often causes a noncontagious (i.e., cannot be spread from an infected individual to uninfected individuals) pneumonia when spores of the fungus are accidentally inhaled by a susceptible individual (28). There have been no human cases of locally acquired histoplasmosis in NL. However, there has been one case of histoplasmosis in a dog in New Brunswick (NB) that came from a breeder in Ontario (ON), which highlights the possibility that *H. capsulatum* might be present in the Atlantic Region of Canada (32).

This fungus typically grows in soils, but particularly in those enriched by bat guano or bird droppings because of their high nitrogen content. Bat guano and bird droppings can also independently provide a suitable substrate for fungal growth. Therefore, spores of the fungus can be transmitted from one site to another on the bodies of animals and contaminate the soil and droppings found at the roosting sites of both bats and birds. Bats, unlike birds, can become infected with *H. capsulatum* and thus carry the fungus in their intestine and deposit it in their guano without ongoing exposure to contaminated soil. Therefore, when working in areas with large amounts of bat guano, it is possible to breathe in the fungal spores when the guano is disturbed, especially when the guano is dry and spores become airborne. The more spores that are inhaled, the greater the chance is of acquiring histoplasmosis. **Thus, it is strongly recommended that personal protective equipment (PPE), especially a Canadian Centre for Occupational Health and Safety (CCOHS)-approved respirator (TC 84A-XXXX N95), is worn to decrease the chance of inhaling the fungal spores.** The best strategy to reduce the likelihood of an infection is to minimise the dust that becomes airborne while working in areas contaminated with bat guano. One way to do this is to thoroughly dampen the guano by spraying a 10% household bleach solution (1 cup bleach and 9 cups water) on it before it is shovelled or swept. Bleach has not been demonstrated to be effective in killing the *H. capsulatum* spores; however, it can prevent contamination of other micro-organisms. The only suitable disinfectant for *H. capsulatum* is a formaldehyde solution, but it is NOT recommended that this is used due to several adverse health effects caused by formaldehyde exposure. The removed guano should be collected in sealable containers or bags and disposed of immediately by bringing it to a landfill to be disposed of as contractor waste (28). Ultimately, it is recommended that removal of any accumulated bat guano be done by professionals that have the proper equipment and knowledge to minimise the biosafety risk associated with this activity, particularly in relation to the human health of both those living and working in the environment.

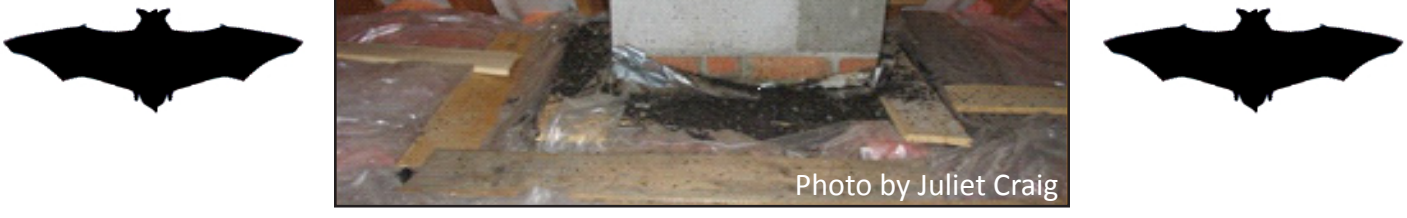


Figure 16. Infected bats can deposit *H. capsulatum* in their guano.

1.7.3 Bat Bugs

Bat bugs are **ectoparasites** of bats in the genus *Cimex*, and are related to *C. lectularius*, the common bed bug. Bat bugs are **temporary parasites**, meaning that they do not remain on their host but rather return to a roost or nest after feeding. The *Cimex* species found on both little brown myotis and big brown bats is *C. adjunctus*, and its range extends across Canada including NL (33). The primary host of bat bugs is bats, but they will feed on alternate hosts if they do not have access to a bat. This means that if bats carrying bat bugs leave a structure, there is a chance that the remaining bat bugs will search elsewhere for a blood meal. A bite from a bat bug is not painful but it may become itchy and develop a small welt due to a common allergic reaction to proteins in bat bug saliva. Bat bug bite swelling is colourless and two to three welts are often found close together. Bat bugs do **NOT** transmit any known human diseases, such as rabies virus or Lyme disease (34). If it is suspected that bat bugs are present in a building, it may be necessary to fumigate with a pyrethrum-based (natural) spray after the bats have left for the season (35).

Figure 17. Bat bug on wing of *Myotis* sp.

Section 2. Options for Managing Bats in Buildings

2.1 Introduction

Buildings can provide ideal roosting conditions for some species of bats. They are usually dry, warm, maintain a constant temperature, and provide shelter from predators (36). They also have an abundance of nooks and crannies that bats prefer to crawl into. While buildings may be the perfect living space for bats, living in a building with bats may be considered a less than ideal situation for some people. The following are the most common reasons why people might want bats removed from their building (37):

1. **Guano (bat droppings)**
2. **Bats entering the living space**
3. **Fear of bats**
4. **Building damage**
5. **Rapid increase in colony size**
6. **Noise**
7. **Smell**
8. **Disease transmission**

These are all valid concerns for an individual to want bats removed from their building. However, many of these issues can be mitigated so that bats can safely remain in their building roost without compromising human safety. Bats also provide many positive benefits to property owners as well, including insect control and a source of organic fertiliser. *The US Centre for Disease Control (CDC) states that "some bats live in buildings and there's no reason to evict them if there is little chance for contact with people"* (38). By ensuring that bats and their guano do not have contact with the occupants of the building, and that all of the building owners' additional concerns are met, it is possible to come up with a solution that is satisfactory for both people and bats. The following discusses the three options available to building owners in regard to roosting bats and includes: leaving bats in an existing roost, excluding bats from an existing roost, and encouraging bats to roost on a property.

Figure 18. Buildings such as these provide important roosting habitat for bats.

2.2 Option 1: Leaving Bats in an Existing Roost

In terms of bat health, the ideal situation would be to leave bats in an existing roost whenever possible. Excluding bats at the wrong time of year can lead to mortality of pups. The effects of excluding bats during the recommended time period have not been studied, but it is likely that this causes undue stress in the affected bats (36). If the bats are roosting in a non-residential building or unused structure, such as an old shed or barn, then the best approach is to leave the bats without any alterations to the structure. Additionally, since exclusions can be costly, it may be preferable to save money by leaving bats where they are. The most important considerations occur when bats are able to enter a living space that is used by humans. The following section provides suggestions for allowing bats to roost in a human-occupied structure while maintaining a safe and healthy environment for both the humans and bats. **It should be noted that ANY structural alterations or improvements should only be made when bats are no longer present.**

Figure 19. Bats roosting in an abandoned house in NL.

2.2.1 Addressing Humans' Concerns

2.2.1.1 Guano (bat droppings)

It is never ideal to have animal faeces of any kind present in a human-occupied living space (*e.g.*, kitchen, bedroom, living room) as it can be a source of organisms that cause significant human diseases. As previously mentioned, there is a potential risk of histoplasmosis for residents when bat guano accumulates in large quantities in an occupied building. Histoplasmosis is not particularly a human-health problem in cases where bats are roosting away from the primary living areas used by the building occupants (*e.g.*, in an attic roost). However, **if the roost space is accessed it is important to take the appropriate precautions** (for more information see *Section 1.7 Human Health Concerns*). This is especially true if the reason for entering the roost is to clean up and remove any accumulated bat guano (28).

Figure 20. Droppings of big brown bats (left) and little brown myotis (right). Small squares are 2 mm²; larger squares are 10 mm².

The guano of some bat species may look similar in appearance to rodent droppings in colour and size, but the guano of little brown myotis and northern myotis, the predominate species in NL, is smaller than rodent droppings and has a dry, crumbly texture composed of shiny insect parts. Additionally, rodent droppings are much harder, and will not fall apart when crushed like bat guano (39). There are methods that can be used to prevent accumulated guano from damaging property. If bats are roosting on the outside of the house and guano is building up on house siding or dropping on to windows or windowsills, then deflector boards can be used to protect the affected areas. Deflector boards are commonly made of wood and can be attached with screws and brackets to window frames or masonry (37), but if unavailable, installation of rain gutters or planters can also be used to deflect or catch guano (36).

Plastic sheeting can be used to protect the floor and stored items and facilitate the removal of guano if it is accumulating inside a building away from an area occupied by residents (37). **However the roosts should be accessed for guano removal only when bats are no longer present** (36). The guano should be removed annually after bats have left for the season, which is between September and May for little brown myotis and northern myotis. Again, a respirator (TC 84A-XXXX N95) should be worn when entering the attic to remove the guano, and a 10% household bleach solution (1 cup bleach and 9 cups water) should be misted to thoroughly dampen the guano so dust will not become airborne (28). Guano and urine stains on walls (usually around roost entrances) can be wiped off after bats have left. Additionally, alterations can be made to facilitate access to the roosting space for clean-ups, and include examples such as adding planks or plywood to the attic floor to improve walking conditions (be careful not to go through the ceiling) and making a large ceiling entrance to the roosting area with pull-down stairs to increase accessibility (36).

If bats are accessing the living space, the entry points for bats to these areas should be sealed to prevent guano-related issues and odours (see *Section 2.2.1.2 Bats entering the living space*) (36). It is important to remember that, while guano can be a nuisance, it is a manageable problem over the few summer months that bats roost (37). The accumulated guano can also be a benefit through its use as an organic, nitrogen-rich fertiliser for gardens, as long as the risk of histoplasmosis is understood and the appropriate PPE is used if necessary (36). **It is NOT recommended that immunocompromised individuals use guano in their gardens.**

Figure 21. Guano below a bat roost.

Figure 22. Plastic sheeting or tarps can be used to collect falling guano.

It is the responsibility of the property owner to ensure that any alterations made to the building are in accordance with the Newfoundland and Labrador Building Standards Act and the National Fire Code of Canada.

2.2.1.2 Bats entering the living space

Direct human-bat contact should be prevented, when possible, to protect human health from diseases such as rabies and histoplasmosis that are known to be associated with bats (discussed in *Section 1.7 Human Health Concerns*). This means that bats found in spaces occupied by humans cannot remain there, and further action will be required to exclude them from these areas. This does not include bats that are roosting in attics that are not accessed regularly or bats that forage outside around the house. Preventing bats from entering a living space can take place at any time of year provided that the area is not part of a maternity colony. Unlike rodents, bats are not looking for food in buildings, so they are not exploring these structures but simply using certain points to enter and exit their roost. If a bat is in a living space, it is likely accidental, either resulting from a fall down a chimney or chute, or from a pup that has lost its way to the roosting area (36).

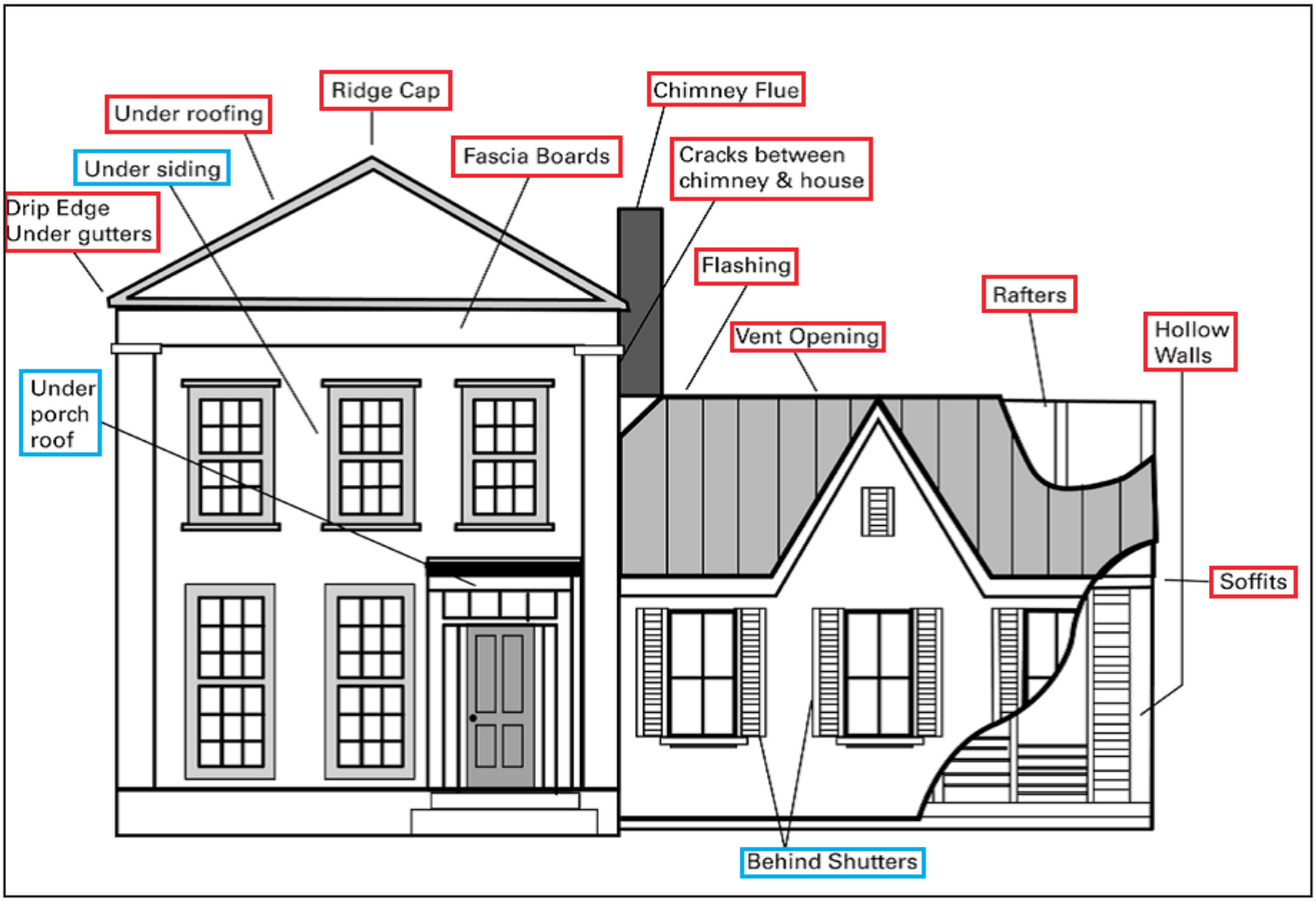


Figure 23. Common roost sites for bats in buildings (general maternity colony roosts are in red and solitary roosts are in blue, although some of these are interchangeable).

Image by Julianne Leekie for the Kootenay Community Bat Project, based on original image by Dr. Stephen C. Frantz, Global Environmental Options, LLC

The first step in bat-proofing the interior of a building is to locate any spaces connecting the living space to the roost site. Provided you do not enter the actual roosting area, this does not disturb the bats and can be performed at any time of year. **Bats can enter or exit a space as small as 15 mm in diameter (which is approximately the size of a dime), or 6 mm wide and 19 mm long (which is close to the size of a small safety pin [Size 000]).** Some common openings may include (36):

Figure 24. Chimneys and fireplaces provide common openings for bats to access the living space.

- the space around the frame of attic hatches and doors
- the flues of chimneys and fireplaces
- the spaces around piping or plumbing
- open windows and doors
- openings in windows, unscreened windows, or loose windowsills
- openings associated with air conditioners, fans, and ducts
- tears or defects in screens
- improperly sealed pet doors

The second step is to seal the openings (36). The spaces can be temporarily sealed using newspapers or rags (37), or the openings can be permanently sealed with wood, flashing, weather stripping (including draft sweeps), screening, copper mesh, or galvanised (steel) wire mesh (36, 39). The galvanised wire mesh can be attached with screws. Copper mesh can be a good option, but it should not come in contact with galvanised metal, as it can cause rapid corrosion of the metal when wet. All types of mesh and screening should have mesh smaller than 1 cm (0.5”). Once in place, the mesh can be covered by a latex (water-based) caulking. Latex caulking is safest for bats, but the sealed openings should be checked periodically as this type of caulking may shrink and crack over time (36, 39). The mesh can also be covered by aerosol foam. **Silicone, polyurethane, or other non-water-based caulking materials should never be used as they often have higher volatile organic compound (VOC) content** (39)**.** Aerosol foam can be used as a sealant or also to cover mesh, however, **it should only be used after bats have left the structure for the season (between mid-to-late October and mid-to-late April). First, ensure bats are not in the space by sticking a long object into the space, such as a stick or a straw. Expandable foam can entomb bats, thus it should NOT be used if there is even a slim possibility that bats are still around and may return to the structure** (39)**.** Backer rod foam insulator can be placed behind the aerosol foam as an extra precaution to prevent any entombment. Aerosol foam also breaks down in heat over time, especially when exposed to weather and UV light, so it may not be the best option for external holes (39). If using aerosol foam, make sure to wear gloves to protect your hands. **When sealing off access points associated with ducts and chutes, it is imperative that they are sealed off at the top of the chute, rather than at the bottom** (36)**.**

Figure 25. Prevent rodents (*e.g.*, squirrels) from chewing through caulking.

Sealing the chutes at the bottom has been found to lead to high bat mortality, because the bats fall down the chute and then are unable to climb up the slippery surface and become trapped. Since bats cannot fly straight up, they rely on their ability to climb rough surfaces to escape ducts and chutes. Not only is the associated bat mortality an issue, but a collection of dead bats in a duct may create odour problems as well (36). If the access point for bats is louvres or covers of ducts that are still functioning, screens that allow for proper air movement but have a mesh size smaller than a bat is able to crawl through can be installed to prevent bats from getting in. **Do NOT place mesh or spark arrestors over fireplace flues that are still in use.** Only certified products tested by a third party should be used with your fireplace to prevent fire hazards. It is possible to purchase certified manufactured flues with caps that meet the CSA standard (*e.g.*, Selkirk models). Outside heating season, it may be possible to close the dampers on fireplaces and flues as long as they are opened prior to use. It is also important to ensure that entry and exit points to the roost site are not affected by any alterations at this time (for more information see *Section 2.3.1.6 Step 6. Exclude the Bats by Sealing the Roost*). While bats are unable to chew through any of the recommended sealants, rodents may be able to accomplish this (especially with aerosol foam) and reopen the entry or exit point. For this reason, if rodents have access to these areas, it would be prudent to layer copper mesh or steel wool between applications of caulking, which hinders their ability to chew through the caulking material (36). Steel wool can be used but it can rust and degrade over time.

2.2.1.3 Fear of bats

There may not be a simple solution to assuaging people's fear of bats. The first step would be to address why they are afraid; if it is due to common misconceptions, these can be easily addressed (see *Section 1.2 Bat Mythconceptions*). However, if the fear lies beyond any general misinformation given about bats, then it may be more difficult to suggest to someone that they continue to allow bats to roost in their building. As always, it is important to emphasise that bats are just a temporary cohabitor, and that they will leave their day roost in the fall (37).

Figure 26. People are generally more scared by what they do not know; take the time to teach people about bats.

2.2.1.4 Building damage

As previously mentioned, the primary damage associated with bats in buildings is due to their guano. However, it is important to highlight that damage caused by the guano is generally related to pre-existing building defects that allow the guano to become wet, and in severe cases, the build-up of wet guano leaks into walls and ceilings, sometimes causing ceilings to collapse. If there is a reasonable concern that this may be an issue, the first line of action would be to address the structural defect that is allowing the guano to get wet. Once this defect has been corrected, there should be no risk of the building being permanently damaged by the guano, and as described above, there are ways to seasonally remove guano from a roost. Some people are concerned that bats also cause serious damage by chewing or scratching like rodents, however, bats do not have teeth that are suitable for gnawing and damage of this type is not reported to be associated with bats (37).

2.2.1.5 Rapid increase in colony size

Another common bat-related concern that people have is that their numbers will keep increasing, so that a bat maternity colony of ten bats in their attic may soon become a hundred bats. This issue can be addressed by the reproductive strategy of bats. Bats are not rodents and do not reproduce rapidly (in high numbers) in the manner that rodents do (37), with most NL bat species only giving birth to one pup per year (5, 17).

A Sweden study on the northern bat (*Eptesicus nilssoni*) from 1982-1986 found that the maternity colony population was stable in number throughout the study period, aside from a decline in number after a particularly long winter. Anywhere from 54-85% of the adult females returned to the maternity colony each year, with 40% of the female pups returning to the colony where they were born (40). These numbers demonstrate the unlikelihood that an established maternity colony's population will rapidly increase in size over a short time period.

Figure 27. *Myotis* sp. roosting.

2.2.1.6 Noise

Bats do not make a lot of noise, and noise generally only becomes a concern when a large number of bats are present in the maternity colony. While bats do echolocate at frequencies beyond the range of human hearing, they also emit squeaks and clicks that we can hear, and this noise is at its loudest both when bats are entering and exiting their roost (36). If noise does become an issue, it can be partially remedied by installing more insulation in the problem area to help muffle the noise (37). Again, these alterations should only be made when bats have left their roost for the season. It is reported that bats roosting in outside walls and chimneys may be louder and more noticeable, which is likely because of their proximity to the living space or because they get disturbed more often in these locations. It can be expensive and challenging to dampen the noise in these situations because it may be necessary to insulate large stretches of wall to reduce the noise. In these cases, it may be necessary to exclude the bats if the noise becomes unbearable (36). However, it is also important to remember that the noise is a temporary issue when bats are using their day roosts during the summer. The noise can be mitigated during these summer months by using ear plugs or white noise to mask the sound (37).

2.2.1.7 Smell

Since guano does not have much of an odour when it is dry, smell is generally only an issue when guano accumulates and becomes wet, which often directly relates to structural defects in the building. As mentioned in *Section 2.2.1.4 Building damage*, this can be remedied by addressing the structural defect directly. Guano may also be more likely to smell strongly in poorly ventilated areas so increasing ventilation with structural alterations may solve the problem. Just ensure that no changes are made to the microclimate (temperature and humidity conditions) of the roosting area. Additionally, annual removal of any accumulated guano will greatly decrease the chances of any guano-related issues (37), but this should be accomplished using appropriate PPE and after the bats have left for the season (28, 36). A build-up of urine can also create odours, especially if left to saturate insulation. As previously mentioned in *Section 2.2.1.1 Guano (bat droppings)*, plastic sheeting can be used to protect insulation from bat excrement and urine (41). Excess urine can be washed off of the plastic outdoors when the guano is removed, or wiped off of the walls after the bats have left their roost for the season. Sealing up spaces connecting the bat roost to the living space will also reduce guano-related odours (see *Section 2.2.1.2 Bats entering the living space*) (36).

Photo by Juliet Craig

Figure 28. Cleaning out guano will prevent odours from becoming an issue with bats.

2.2.1.8 Disease transmission

For more details about bat-related human health concerns, go to *Section 1.7 Human Health Concerns*. Transmission of diseases from bats to humans is a very legitimate concern, but with the appropriate health and safety precautions it can be alleviated. The only known diseases of significance in NL that can be transmitted to humans from bats are rabies and histoplasmosis (36). However, there have never been any human cases of histoplasmosis reported in Atlantic Canada, and if the proper PPE (*i.e.*, respirator [TC 84A-XXXX N95]) is worn while cleaning up guano and the guano is removed properly (see *Section 1.7 Human Health Concerns*), it is highly unlikely that an individual will get histoplasmosis. I**f a person feels ill after exposure to guano, it is important for them to consult a doctor immediately and give them the history of exposure to bat guano** so the physician can take the appropriate steps to diagnose and treat histoplasmosis, if that is indeed the cause of the person's illness (28).

Rabies is a more significant disease because once symptoms appear, there is no effective method of treatment. However, bat variant rabies can only be transmitted to humans by direct contact with a rabid bat (25). **Therefore, it is imperative that bats are NEVER handled unless absolutely necessary, and if they must be handled, that is done while wearing thick gloves and covered arms (*e.g.*, long sleeves). If it is even a remote possibility that a person has been bitten or scratched by a bat, then immediately wash the wound with soap and water for fifteen minutes and without delay contact provincial health authorities (family doctor or hospital ER) to determine the appropriate course of action.** If someone has been bitten or scratched by a bat, they will likely have several courses of rabies post-exposure prophylaxis (PEP) (31).

THE ONLY KNOWN DISEASES OF SIGNIFICANCE IN NL THAT CAN BE TRANSMITTED TO HUMANS FROM BATS ARE RABIES AND HISTOPLASMOSIS.

Figure 29. Bats should never be handled without thick gloves.

Figure 30. A common threat to bats, other small mammals, and birds: outdoor cats.

Figure 31. Bat trapped in a bucket.

2.2.2 Addressing Bats' Concerns

Whether or not you decide to share your building with bats, there are a few things to keep in mind if you want to ensure bats using your property are safe from harm. The following is a list of things to consider if you wish to avoid the accidental death of bats (36):

• **outdoor cats (especially at dawn or dusk)**
As most people know, cats are very successful predators, and even bats are not safe from their claws. Cats are capable of hearing the echolocation calls of bats, and therefore can easily catch them. When you know you have bats on your property, the best solution is to keep cats indoors during those times when bats are present to prevent them from killing bats. Most critically, cats should always be kept indoors from dusk to dawn when bats are feeding and travelling to and from their roost site. This can avert unnecessary bat mortality. Additionally, by stopping your cat from hunting bats, it decreases the risk of its exposure to rabies. Even if your cat is vaccinated against rabies, this does not mean that your cat is adequately protected to prevent a rabies infection.

• **open buckets, garbage bins, tubs, or containers**
If open containers are present within the roost site, or close to roost entry points, then it is possible for bats to accidentally fall into these containers. Bats cannot climb slippery surfaces, and bats are not capable of flying straight up in the air, so they can become trapped in containers. If possible, keep such containers out of roosting areas, or use covered containers that bats will not accidentally get into. If a container must be open, help bats escape by placing something with a rough surface inside that they can use to climb up and get out. Suitable options may include a rough stick, a board, or a ramp.

• anything sticky such as: fly ribbon, glue traps, or tape

Bats can become stuck to these items and often remain trapped. Subsequently, it is very difficult to remove bats from these sticky surfaces without tearing their delicate wing membranes. Therefore, when bats are present on your property, it is best to avoid these products altogether.

• netting

Like sticky objects, netting of any kind (*e.g.*, bird netting) can quickly entangle bats. Once they are ensnared by a net, it can be extremely challenging to remove the bats without causing an injury to the bat or provoking the bat to bite in self-defense. It would be preferable not to use netting when bats are in the area.

• sealing chutes and ducts at the bottom

As previously mentioned, if chutes and ducts are sealed at the bottom, bats may become trapped when they fall to the bottom of the chute with no means of escape. Therefore, if a chute requires sealing, it should be done at the top of the chute after confirming that bats have not already fallen in it.

• open water sources without exit points

Bats use open water sources, such as ponds, water troughs, and rain barrels, for swooping down to drink while flying. Occasionally bats bump into each other when trying to get a drink, which can result in them falling into the water. Bats, like most mammals, are capable swimmers; however, if there is no way for them to climb out of the water they will eventually drown. One remedy is to keep these water sources completely covered so bats cannot fall in. Another solution, which still allows bats to drink, is to provide a way for bats to climb out of the water. This may include logs, boards, or mesh-covered wooden ramps.

Figure 32. Big brown bat caught in a net.

Figure 33. A chute sealed at the bottom instead of the top.

2.3 Option 2: Excluding Bats from an Existing Roost

As previously mentioned, the best option for bats is to leave them in their roost site. However, sometimes this is not possible, either due to one of the human concerns listed above, due to other circumstances (*e.g.*, unoccupied structurally unsound building that needs to be torn down for public safety reasons), or if the bats themselves are consistently put at risk (*e.g.*, if they are under constant threat of predation from a cat). In such cases, it will be necessary to exclude bats from a building. I**n this situation, it is essential to contact your local wildlife division and an appropriate Pest Control Operator (PCO) that has the permit and training to do bat exclusion work.** In consideration of exclusions, it is important to understand the following terminology:

Eviction is removing bats from a building using one-way eviction devices (36).

Exclusion is the process of sealing entry and exit points once bats have left the building, to prevent them from re-entering the roost site (36).

Eviction is removing bats from a building using one-way eviction devices.

Exclusion is the process of sealing entry and exit points once bats have left the building, to prevent them from re-entering the roost site.

2.3.1 Steps for Excluding Bats from Buildings

The following are the steps that should be followed when determining how to exclude bats from a building:

Step 1. Assess the Situation

Step 2. Bat-proof the Human-occupied Living Space

Step 3. Identify the Entry and Exit Points

Step 4. Install a Bat House

Step 5. Evict the Bats

Step 6. Exclude the Bats by Sealing the Roost

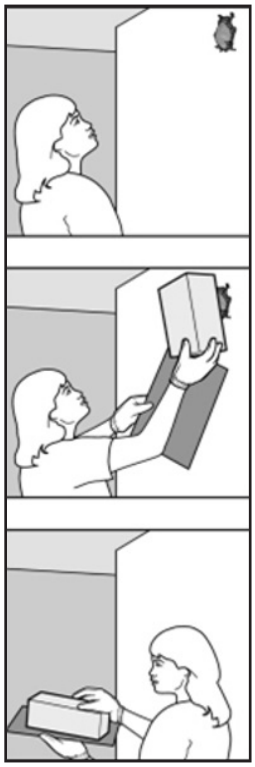
Figure 34. Sometimes human concerns, such as unoccupied structurally unsound buildings that need to be torn down for public safety reasons, do not permit bats to remain in a building.

2.3.1.1 Step 1. Assess the Situation

2.3.1.1.1 Solitary bat or maternity colony?

Determining whether there is a solitary bat or a maternity colony roosting in a building is important because it will result in very different exclusion methods. A **solitary** bat in a human-occupied space of a building should be removed immediately. Solitary bats in other areas away from humans can most often be left until they leave in the fall with little consequence. Entire maternity colonies are quite different because bats are very loyal to these sites, and, if they are removed in a manner that does not prevent re-entry, they have homing abilities that will simply result in their returning to the site in question.

Generally, a solitary bat found in a home is there because it is confused or accidentally gained access. It may be a juvenile that has just learned to fly, or it may be a bat that unintentionally flew in through a window. This bat likely wants to get out of the house just as much as you want it to be gone. So, if you open the windows and doors, it will usually fly out on its own. Make sure to close the doors to other rooms to prevent the bat from going further into the house. Any ceiling fans or fans with open blades should be turned off to avoid bats flying into them and becoming injured. Turning off the room and outside lights will further help the bat find its way out of the house, and **all people and pets should exit the room until the bat leaves**. If the bat does not leave on its own, it may require physical assistance by doing the following (39):



1. Put on thick gloves before attempting to remove a bat from a house. Gloves that cover as much of the forearms as possible are best.

(Leather gloves are a good option; however, any gloves that a bat is not able to bite through can work.)

2. Wait until the bat lands before attempting to capture it, because the delicate wings of the bat are easily damaged if it is caught mid-flight.

3. Once the bat lands, place a small box or other container gently over the bat.

4. Slide a piece of cardboard or a large, stiff piece of paper behind the bat, leaving the box or container in place.

5. Make sure that the bat is not caught between the piece of cardboard and the box or container.

Figure 35. How to remove a solitary bat from a human-occupied space.

Image by J. Scott Altenbach, taken from Bat Conservation International (batcon.org)

Figure 36. Release the bat by allowing it to climb onto a tree limb.

IF THE BAT APPEARS UNABLE TO FLY AFTER AN EXTENDED PERIOD OF TIME, CONTACT:

NEWFOUNDLAND AND LABRADOR FORESTRY AND WILDLIFE RESEARCH DIVISION

709-637-2025

6. Turn the box or container over slowly, keeping the cardboard in place.

7. Bring the box or container outside at night for the bat's release.

Ideally, a bat should not be released outside until it is dark because it can easily be hunted by predators in the daytime. Only if it is not possible to release the bat at night should the bat be released in the day, but make sure that the bat is placed on a tree or somewhere that it can hide from predators. If the bat is captured several hours before dark, small air-holes should be made in the box to allow the bat to breathe. Ensure that the cover fits tightly (**but that it is NOT airtight**), because bats can escape from very small openings.

8. Release the bat outside by placing the box on its side, allowing the bat to climb out onto a tree limb or another elevated position.

The bat species in NL require a drop before they can begin flying, so if you place the bat on the ground, it will NOT be able to fly. However, do NOT throw the bat up into the air to help it fly because it may be injured and unable to fly, and falling on the ground may worsen the injury.

9. Check periodically to make sure that the bat has flown away. If the bat appears unable to fly after an extended period of time, contact the Forestry and Wildlife Research Division (709-637-2025).

If you are uncomfortable or unsure about having to remove a bat on your own, please get in touch with a professional (Pest Control Operator or Conservation Officer [CO]). If it is even a possibility that someone has been bitten, scratched, or touched by a bat in the process of removing it from a building, it is imperative that provincial health officials have been contacted. In this case, the captive bat should NOT be released until a provincial health official has been contacted and it has been determined whether the bat is required for rabies testing. Additionally, if a bat has been found in a room with an unattended child, or a sleeping, mentally impaired, or intoxicated person, the bat should be captured and kept for rabies testing, and provincial health officials should be immediately contacted for further instructions. Please get in touch with a family doctor or hospital ER as soon as possible, and the Chief Veterinary Officer with the Animal Health Division (709-729-6879), if it is necessary to submit the bat for rabies testing.

If you suspect that you have a bat maternity colony in your building, further instructions will be provided below in *Section 2.3.1.2 Step 2. Bat-proof the Human-occupied Living Space*.

2.3.1.1.2 Day roost or night roost?

Day roosts and night roosts were defined previously in *Section 1.6 Types of Bat Roosts*. The key difference is that day roosts are roosting sites where bats spend an extended period of time during daylight hours, mainly during summer and early fall. In contrast, night roosts are temporary resting spots that bats use in the night between feeding excursions. Bats that use night roosts are rarely problematic for people as the bats remain outdoors and have minimal human interaction. However, it is possible that if bats return to the same night roost routinely they could deposit significant amounts of guano around the roost site (42). If possible, it is recommended that night roosting bats are left alone, but if necessary, there are methods to humanely discourage bats from night roosting. As always, it is **NEVER** recommended that bats are directly handled by people. However, there are several options to indirectly discourage bats from night roosting, although **these deterrents must be put in place when bats are NOT present**. Options include (43):

- floating foil balloons in close proximity to the roost location
- pinning strips of boPET (polyester film, *e.g.*, Mylar), tin foil, or curled pieces of ribbon to the roost site so that they can sway in the wind
- taping plastic over the roost site so that the surface is too slippery for the bats to attach to
- placing bright lights around the roost location
- attaching caged fans close by so that they blow air at the roost site

Figure 37. Summer day roost (or maternity colony).

Figure 38. Summer night roost.

Products that should NOT be used include aerosol dog or cat repellants, as they often contain the mildly toxic pesticide methyl nonyl ketone (44). Moth balls are also not suitable as deterrents for bats because in order for them to be effective naphthalene (the active ingredient) would be required in such large quantities it would pose a health hazard to humans (45). Ultrasonic devices are also not recommended as deterrents because they have not been proven to be overly effective (45, 46). **Pesticides, smoke, and other chemical repellents are all dangerous deterrents for bats and are not recommended** (43)**.** While artificial lighting is a suitable deterrent for a night roost, it is not recommended as a deterrent for bats day roosting in a maternity colony because if light is shone at the roost entrance, the bats will not use it and become trapped inside their roost if other exits are not available. **If it is suspected that there is a maternity colony in a building, do not use artificial lighting as a deterrent while excluding bats** (46)**.**

If there is a maternity colony of bats day-roosting in a building and they need to be removed, after the situation is assessed please continue with the following steps to exclude them (42):

2.3.1.2 Step 2. Bat-proof the Human-occupied Living Space

Detailed recommendations for protecting the human living space have already been provided in *Section 2.2.1.2 Bats entering the living space*. General recommendations include the following:

Step 1: locate the spaces that bats may be using to enter the living space from the roost site.

(Bats can enter a space as small as 15 mm round, or 6 mm wide and 19 mm long (36)**.)**

Step 2: seal the gaps temporarily using newspapers or rags (37), or the openings can be permanently sealed with wood, flashing, weather stripping (including draft sweeps), screening, copper mesh, or galvanised (steel) wire mesh (36, 39).

(Only use aerosol foam as a sealant after bats have left for the season.)

(Do NOT use silicone, polyurethane, or other non-water-based caulk materials (39)**.)**

Figure 39. Bats can enter a space as small as 15 mm round, or 6 mm wide and 19 mm long.

Note 1: **When sealing off access points associated with ducts and chutes, it is imperative that they are sealed off at the top of the chute, rather than at the bottom** (36)**.**

Note 2: It is also important to ensure that entry and exit points to the roost site are not affected by the alterations (36).

Note 3: If rodents have access to these areas, it would be prudent to layer steel wool or copper mesh between applications of caulking (36).

2.3.1.3 Step 3. Identify the Entry and Exit Points

When assessing the exterior of buildings, it can be difficult to detect all possible entry and exit points where bats gain access to interior spaces in the building (36). Therefore, the best way to identify these entrances and exits to day roosts in buildings is to conduct an emergence survey at dusk (42).

2.3.2 Emergence Survey

The emergence survey should start fifteen minutes before sunset and continue until at least an hour after sunset to ensure that all bats have left their roost. One person should be placed at every corner of the building so that all sides of the building can be observed at the same time. This is easiest with at least four people but it can still be done with a minimum of two individuals if it is ensured that everyone is positioned so that the entire building can be observed at the same time (47). Each person should stand as close to the building as possible to get a good view, while still making sure that the entire side of the structure is visible. It is best to watch the bats leave their roost at dusk, and if the specific point of access cannot be determined, make note of the general area they are exiting or entering from, and then search the area with a light afterwards or in daylight to identify specific points of access (48). The emergence survey should also be conducted on a night with good weather (*i.e.*, no rain, winds less than 16 km/h, and temperatures higher than 10°C) because in adverse weather conditions bats may not leave their roost. The emergence survey reaches completion a) an hour after sunset if no bats have been observed exiting the building, b) when no bats are observed exiting the building for at least 10 minutes after the last bat emerged, or c) if sufficient light is no longer available to allow observation of bats exiting the building (47).

An emergence survey is also an opportune time to conduct a colony count. This can provide valuable data for bat biologists and also helpful information when excluding bats. To do a colony count, simply count the bats as they emerge from the building. For this activity, it is important to ensure that each observer only watches their own specific area of the building and there is no overlap in these areas; otherwise the same bat may be counted twice by two different people.

Once the emergence survey has concluded, it is imperative to identify the exact entry and exit points that the bats were using. These spots would be where bats were seen entering or leaving the building, or where guano or urine (which will appear as yellow or brown staining) has accumulated on the side of the structure next to a hole or other suitable defect that could be used as an entry space (42).

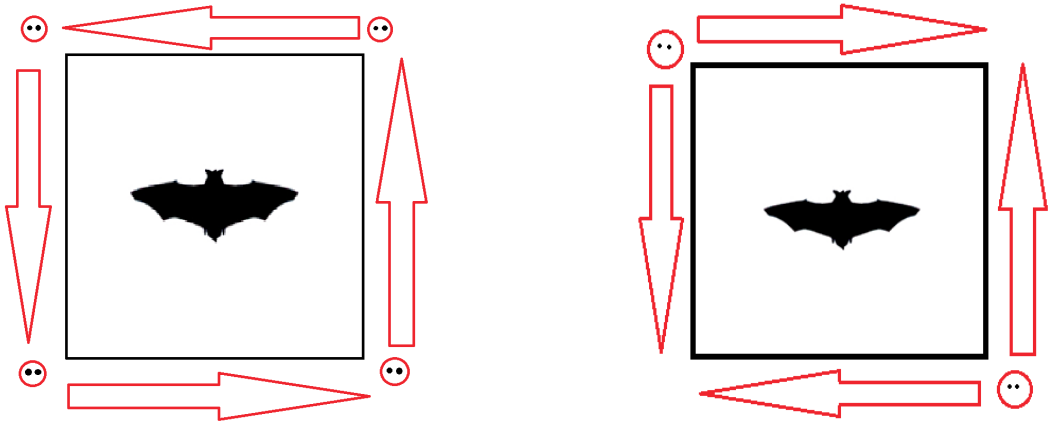


Figure 40. Diagrams of how best to conduct an emergence survey with four people (left; depicted as circles) and two people (right). The arrows are the direction(s) each person is looking.

Image by Tessa McBurney

2.3.1.4 Step 4. Install a Bat House

To provide bats with an alternative, safe roosting space prior to or after exclusion from their original roost, a bat house can be installed nearby. While there is little evidence that bats will choose bat houses over suitable alternative roosting sites, and it may take years for bats to adopt a bat house as a roost (46, 49), it is still recommended to provide these bat houses for bats when they are being excluded from an existing roost. More detailed instructions on using bat houses can be found in *Section 2.4.2 Create a New Roost (Bat Houses)*.

Figure 41. Installing a bat house.

2.3.1.5 Step 5. Evict the Bats

It is crucial to consider timing when evicting bats from a building (42). As previously mentioned, the little brown myotis and the northern myotis give birth between late June and mid-July (18, 19). After birth, it takes approximately three weeks for pups to learn how to fly, or become "volant" (5, 17). Since most aggregations of bats in NL buildings are maternity colonies, if bats are evicted prior to the pups becoming volant and feeding on their own, **the pups will be trapped inside the building without their excluded mothers to feed them, and they will likely die**. Therefore, this should never be done, not just for the conservation of bats, but also to prevent the consequences related to many animals dying in a house (smell, clean-up, etc.) (42). **Bat exclusions should only take place from the beginning of September until the end of April. Bat exclusions should NOT take place from May 1st until August 31st** (36, 39, 42, 46). The best time for exclusion is from mid-to-late October when the young are able to fly, and bats have left their summer residence but are not yet hibernating (42).

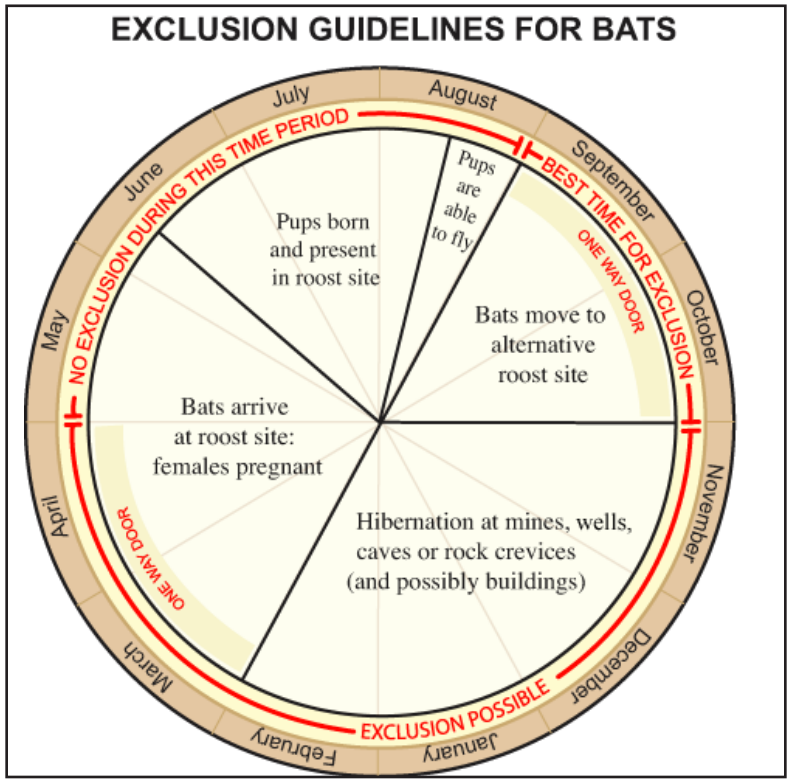


Figure 42. Calendar demonstrating when it is appropriate to exclude bats from a structure and when they should not be excluded.

Image from Craig and Sarell 2016

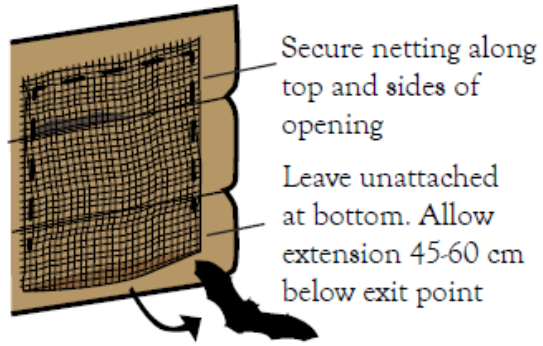


Figure 43. How to position a one-way mesh exit device on a vertical surface. Use lightweight polypropylene netting with mesh smaller than 1.0 cm.

Image from Craig and Sarell 2016

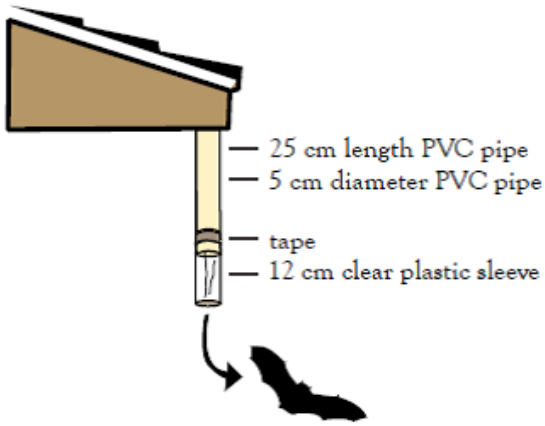


Figure 44. How to position a one-way exclusion tube on a horizontal surface. Use PVC pipe, a clean caulking tube, or flexible tubing.

Image from Craig and Sarell 2016

If the exclusion takes place when bats are still roosting in the building, then it is necessary to use eviction devices that allow bats to exit the structure but prevents them from re-entering. If the bats' absence in the building cannot be confirmed (*i.e.*, the roost site cannot be accessed and checked), then eviction devices should also be used (42).

For an entrance or exit on a vertical surface, like a wall, a one-way exit device can be constructed from lightweight polypropylene netting (bird netting) that has mesh smaller than 1.0 cm (1/2"; 4 x 4 strands per inch) (42). **It is sometimes suggested that plastic sheeting can be used as well; however, this will block ventilation and can alter the temperature and humidity of the roost. It is not recommended to use any methods that result in structural changes that block natural ventilation** (39)**.** The netting should be secured along the top and sides of the opening with the bottom left detached. The bottom should extend 45-60 cm below the exit point. The mesh will prevent the bat from flying back inside the building (42). Flexible exclusion tubes can also be used on vertical surfaces, just ensure that the tube is not so long that it will twist in the wind.

For an entrance or exit point on a horizontal surface, like the edge of a roof, an exclusion tube can be custom-built to act as a one-way exit device. The tube can be made from polyvinyl chloride (PVC) pipe, a caulking tube that has been cleaned out, or flexible tubing (42). If a caulking tube has not been properly cleaned out, the rough surface will allow bats to climb up and re-enter the structure if a plastic sleeve is not used (43). The tube should be at least 5 cm (2") wide and 25 cm (10") long, and placed over the opening. A clear plastic sleeve attached to the end of the pipe will ensure that bats do not re-enter. Bats will leave their roost by sliding down the tube, but they will not be able to re-enter because it is too slippery to climb and too narrow to fly up. Some stores sell "bat cones" that can be used as exclusion tubes (see *Section 4.3.2 Excluding Bats from Buildings*) (42).

It is important to ensure that eviction devices do not have any sharp edges that could potentially injure bats, or spaces where the bat or its limbs may become trapped (42)**.**

Additionally, it is not recommended that eviction devices are attached with duct tape or similar adhesives that have a chance of falling off because bats can become attached to the exposed adhesive or possibly re-enter the building where the tape has fallen off (39)**.**

The one-way eviction devices should remain in place for a minimum of 5-7 nights, with at least 3 consecutive nights of good weather (*i.e.*, temperature above 10°C, winds less than 16 km/h, and no rain). Depending on weather and other factors, bats do not exit their roost to feed every night, so by letting the eviction devices remain for an extended interval, it gives all of the bats sufficient time to leave the building at some point during the eviction period. Bats are unlikely to feed in bad weather conditions and will often remain in their roost, which is why it is important to have at least three consecutive nights of good weather during the eviction process. On the last night the eviction devices are in place conduct a second emergence survey (see *Section 2.3.2 Emergence Survey* for more details). If no bats are observed emerging, it will indicate that all of the bats have been evicted from the building (42). As with the first emergence survey, make sure that this one is conducted on a night with good weather (*i.e.*, no rain, winds less than 16 km/h, and temperatures higher than 10°C) (47). If possible, the bat roost should also be physically checked if it is able to be accessed. Use a flashlight to carefully see if there are any bats still roosting in crevices or cracks (42). If you enter a roost site, proper PPE (*i.e.*, a CCOHS-approved respirator [TC 84A-XXXX N95]) and a Tyvek suit should be worn (28). Ensure that you are always conforming to the necessary safe work practices.

If bats are somehow able to re-enter the building at any point during the exclusion process, then one-way eviction devices need to be re-implemented for another 5-7 nights minimum (with at least 3 consecutive nights of good weather) (42)**.**

If the roosting bats have already left for the season (usually by mid-to-late October in NL) or have not yet returned for the summer (usually by mid-to-late April in NL), then it is not necessary to use eviction devices. However, the roosting area should be carefully checked with a flashlight to ensure that all bats have left the maternity colony (42). Again, make sure all crevices, corners, and cracks are thoroughly examined and wear an approved respirator (TC 84A-XXXX N95) (28, 42).

Ideally if bats are found hibernating in a building in the winter, they can be left for the winter and excluded the following spring before the end of April when the temperature consistently remains above 0°C. Bats produce little guano throughout hibernation and create little disturbance. **It is extremely likely that if a bat is excluded from a building during hibernation, it will either freeze to death or die of starvation.** Please call the toll-free number 1-833-434-BATS (2287) or the Forestry and Wildlife Research Division at 709-637-2025 if you find any bats in the winter.

Figure 45. Hibernating *Myotis* sp.

2.3.1.6 Step 6. Exclude the Bats by Sealing the Roost

Once bats are successfully evicted from a building, it is essential to seal all entry and exit points to prevent re-entry (42). At this time, the one-way eviction devices can be removed, and all entry and exit points can be sealed using wood, flashing, weather stripping (including draft sweeps), screening, copper mesh, or galvanised (steel) wire mesh (36, 39).

(Only use aerosol foam as a sealant after bats have left for the season.)

(Do NOT use silicone, polyurethane, or other non-water-based caulk materials (39)**.)**

To ensure that the exclusion is successful, it is additionally important to seal all other gaps and spaces that bats could use to enter the building. This is ideally also done after the bats have left for their hibernacula in mid-to-late October (42).

REMEMBER THAT UNDER THE NEWFOUNDLAND AND LABRADOR WILD LIFE ACT IT IS ILLEGAL TO KILL BATS WITHOUT A NUISANCE WILDLIFE PERMIT ISSUED BY THE DEPARTMENT OF FISHERIES AND LAND RESOURCES.

After exclusion, the roosting area should be cleaned. If it is possible to access the roosting area, remove the guano and urine-stained insulation (42), address any issues with the vapour barrier, check wood for rot, and reapply insulation. Prior to cleaning, thoroughly dampen the guano with a 10% household bleach solution (1 cup bleach and 9 cups water) and wear an approved respirator (TC 84A-XXXX N95) to prevent histoplasmosis (28). Wear gloves while handling guano-stained materials or dead bats. If any dead bats are found, please submit them directly to the Forestry and Wildlife Research Division (709-637-2025) or contact the Canadian Wildlife Health Cooperative for assistance (1-833-434-2287/902-628-4314). Ensure that if any building alterations are made that they are in accordance with provincial building and fire codes (see *Section 2.2.1.2 Bats entering the living space*).

It may take more than one attempt to successfully exclude bats from a building. **Contact licensed Pest Control Operators or Nuisance Wildlife Control Operators (NWCOs) to be involved with and facilitate the entire exclusion process.** Once bats are evicted from a structure, they may attempt to re-enter the building through new access points, so it might take several attempts before the bats are successfully excluded from a building (42).

Figure 46. To ensure that the exclusion is successful, it is important to seal all other gaps and spaces that bats could use to enter the building.

2.3.3 Decontamination Guide

As previously mentioned, white-nose syndrome (WNS) is a serious threat to both little brown myotis and northern myotis populations. In an effort to mitigate this threat, it is of the utmost importance that further spread of this disease is prevented. This makes it crucial to decontaminate all equipment that will be used for bat evictions and exclusions between roost sites, and that all other disposable materials are discarded properly. The following table outlines the appropriate actions to be taken when decontaminating various kinds of equipment.

Table 2. Recommendations adapted from *Acceptable Management Practices for Bat Control Activities in Structures – A Guide for Nuisance Wildlife Control Operators* by the U.S. White-nose Syndrome Conservation and Recovery Working Group (2015).

Type of Guano Mitigation Equipment	Examples	Action
Disposable personal protective equipment	Tyvek suit, gloves, booties, light duty mask	Dispose of properly following each guano mitigation project or entry into bat roosting areas.
Non-disposable equipment	Clothing, shoes, clipboards	Bag before transport and then decontaminate following WNS guidelines.
Respirators	Typically multiple-use style with removable filters	Dispose of filters after each job, and decontaminate respirator following WNS guidelines.
Vacuums	HEPA vacuums are typically used to remove guano and have two components, the unit itself and the hose/nozzle component	Dispose of vacuum bags after each guano mitigation project and clean hard-surfaced unit, hose, and nozzle following WNS decontamination guidelines.
Lights	Lights, headlamps, and other cursory items used to illuminate the work area in an attic or interior space	Decontaminate according to WNS guidelines.
Cleaning materials	Drop cloths, etc., often removed along with guano and insulation	Dispose of following each guano mitigation project.

For all equipment that can be placed in water, the preferred decontamination technique is to completely submerge gear in water that remains at 55°C for at least 20 minutes. To keep the water at 55°C, it is necessary to add boiling water while stirring throughout the 20 minute period. If the equipment cannot be submerged in water, chemical decontamination is required (50). Disposable equipment and cleaning materials should be immediately sprayed with a suitable chemical decontaminant following use, placed in a garbage bag, and then the exterior of the garbage bag should be wiped down with the decontaminant. Ideally, the garbage bag along with its contents should be incinerated or taken directly to a waste disposal site. If these options are not possible, then the garbage bags can be disposed of in secure, sealed garbage bins. These and other decontamination methods are detailed in the *Canadian National White-nose Syndrome Decontamination Protocol for entering bat hibernacula* (see *Section 4.3.1 Bat White-nose Syndrome*).

Figure 47. Researchers wearing disposable Tyvek suits.

2.4 Option 3: Encouraging Bats to Roost

Figure 48. Say blister beetle (*Lytta sayi*), a plant pest.

If the property owner is receptive to the idea, an additional consideration to the first bat management option that advises how to leave bats safely where they are, is to enhance characteristics of the building's structure that encourage roosting. This should only be done if there are no human health-related concerns associated with the bats in the building and bats are unable to gain access to a human living space (36). This may be a particularly good option in buildings that are not residences, such as sheds or old barns. When possible, this is really the best alternative since the bat species that occur in NL are species-at-risk. The property owner will also have the added benefit of natural insect control right on their property.

Figure 49. Bat in pursuit of prey.

2.4.1 Enhance Current Roosting Conditions

By making roosting conditions more desirable for bats, it can encourage bats to use the building as a roosting site. If bats are currently roosting in the area, ensure none of the alterations will affect the current microclimate conditions (temperature and humidity). While still following building codes and ensuring the structural integrity of the building, this can be accomplished by various techniques including (36):

1. **Enhancing crevices**
2. **Enhancing grip**
3. **Enhancing landing areas**
4. **Increasing darkness**

Figure 50. *Myotis* sp. gripping onto a rough tree branch.

2.4.1.1 Enhancing Crevices

Little brown myotis and northern myotis like to roost in small, narrow spaces where they can huddle together for warmth. By increasing the availability of crevices where bats can roost in the building, it will improve roosting conditions for bats. One way this can be done is by securing pieces of plywood to the rafters to create small spaces in the attic (36).

2.4.1.2 Enhancing Grip

Bats crawl across roosting sites by hanging on with the claws of their thumbs and feet and need a rough surface to facilitate this action. A smooth surface does not provide the attachment for roosting or crawling. Therefore, roughening surfaces enhances roosting and movement by improving bats' gripping ability. This can be accomplished by using sandpaper to roughen a smooth surface, or by carving shallow grooves into wood (36).

2.4.1.3 Enhancing Landing Areas

When accessing a roosting site, bats need to be able to land on the side of a building and crawl through the access point into their roost. With gabled roofs, allowing the gabled ends to remain partially open is a successful technique used to attract bats to roost in the attic space (36).

2.4.1.4 Increasing Darkness

Bats need a dark, quiet area where they can rest undisturbed during the day. If an attic or similar roosting space is exposed to too much light, bats are unlikely to roost in this location. Bats can be encouraged to roost in a particular area by blocking out light using materials to seal holes or cover windows. Another option to reduce light can be the creation of smaller "rooms" in the structure by sectioning off areas using wood or by hanging sections of cloth (36).

2.4.2 Create a New Roost (Bat Houses)

Bat houses should not be used to replace natural roosting sites, such as old trees (51); however, they do provide an ideal alternative roosting site for bats that have been excluded from buildings. Still, there is no guarantee that a bat will choose to use a bat house (46, 49). It is possible to take anywhere from three days to several years before bats choose to live in a bat house (46, 49, 51). However, the longer a bat house is in place, the greater the chance that it will become occupied (51). There is little that can be done to actively attract bats to a bat house (*e.g.*, there is no evidence that placing guano on the bat house will entice bats to roost), but it is possible to construct and install bat houses in ways that promote their use by bats (52). Installing a few different bat houses with diverse temperature and humidity conditions can encourage bats to roost because it supports bats' ability to participate in their natural roost switching behaviour. It is recommended that between 2 and 8 bat houses are placed within a 0.1 km^2 (100 m^2) area. A factor that negatively affects bat house roosting success is increased human disturbance (51), such as loud noises and bright lights near the roost. **Do NOT disturb roosting bats, especially if pups are present.**

Figure 51. Example bat houses.

Figure 52. Bat houses on a pole and an abandoned building.

The best methods for increased likelihood of bat house habitation are to place the bat house in an ideal location and have a bat house with a preferred structure (52).

2.4.2.1 Structure

The best materials for bat houses are a mixture of cedar and exterior-grade plywood or marine grade plywood (52). Wood from the native eastern white cedar (*Thuja occidentalis*) is unsuitable as it is too soft. Eastern larch (also called tamarack or juniper) (*Larex laricina*) may be a viable native alternative, or you can purchase non-native western red cedar (*Thuja plicata*) wood from a store. The plywood should be at least 2 cm (¾") thick with four plies. **Do NOT use pressure-treated wood because its chemical preservatives could be harmful to bats.** Use staples and exterior-grade screws; screws are preferable to nails because screws can join the wood more tightly preventing wind and moisture from entering the bat house (52). Use stainless steel screws to prevent corrosion. Another option would be to glue the bat house joints using a non-toxic water-based wood glue and then strengthen the joints with nails. There are many different structural designs for bat houses, but those that are most common include: single-chambered bat boxes, multi-chambered bat boxes, Kent bat boxes, and rocket boxes (simple or two-chambered). Each structural design serves a unique purpose for bats (52).

2.4.2.1.1 Single-chambered Bat Box

A single-chambered bat box is usually used by females without pups or males (52). There is limited evidence that single-chambered bat boxes may cause bats to overheat in climates with high outdoor temperatures, but it is unlikely that this would be an issue in NL. If desired, single-chambered bat boxes can be used, however, it would be preferable to use multi-chambered bat boxes or rocket boxes that create temperature gradients.

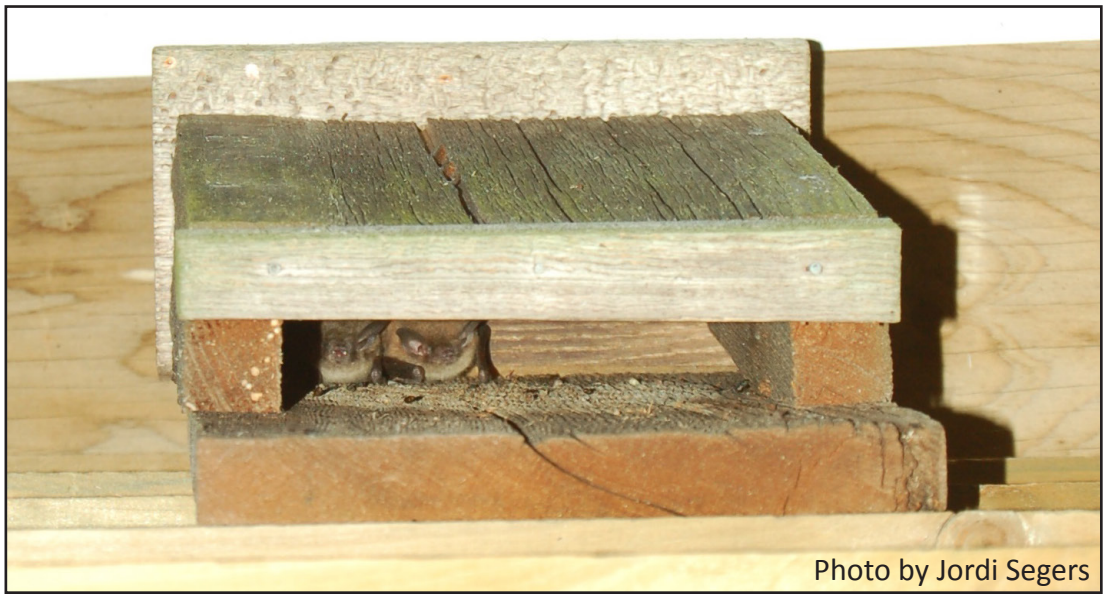


Figure 53. Little brown myotis roosting in a single-chambered bat box.

2.4.2.1.2 Multi-chambered Bat Box

Multi-chambered bat boxes are designed to attract maternity colonies (51), which would generally be the bats that are removed from buildings. These bat houses typically have two to four chambers; however, four chambers are ideal because they provide a greater temperature gradient. Due to this advantage, they are often more successful than the single-chambered bat boxes (52).

The following are some general guidelines for multi-chambered bat boxes (52):

- Bat box size= at least 43.2 cm (17”) wide by 61 cm (24”) tall (total depth depends on number of chambers)
- Landing strip size= approximately 10.16 cm (4”)
- Chamber size= 1.9 (¾”) deep
- Chamber partition width= 1 cm (⅜”)
- Grip surface groove spacing= 0.6-1.3 cm (¼-½”)
- Waterproof
- Dark colour (with non-toxic paint)

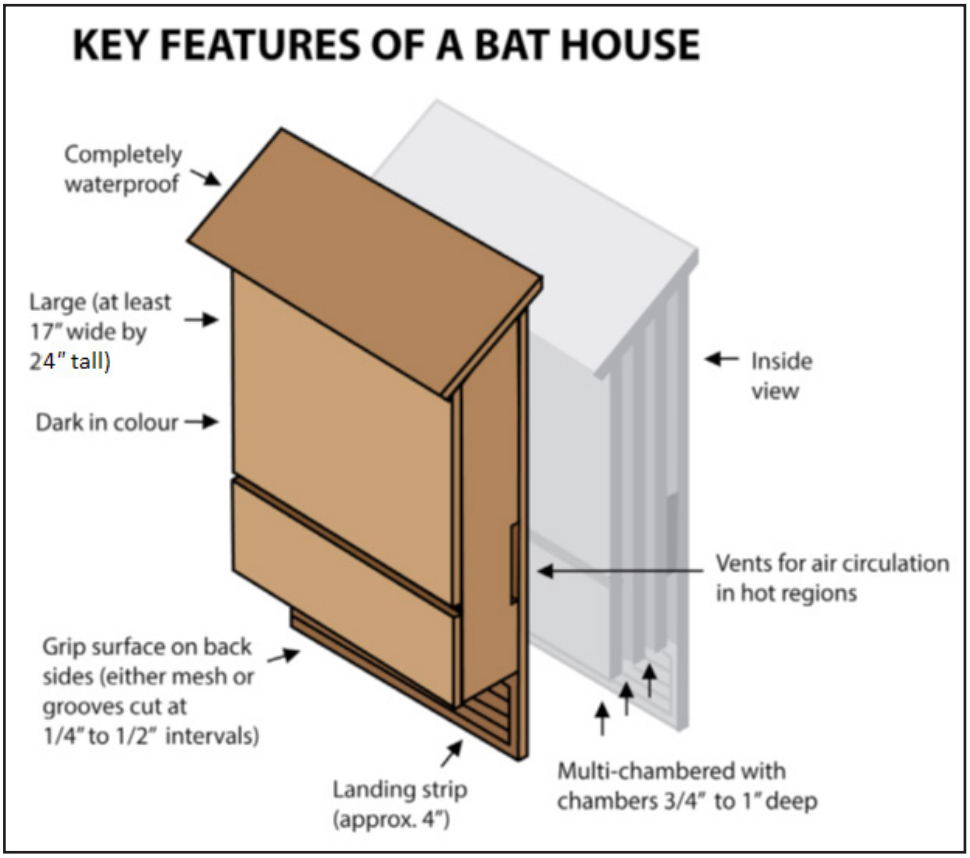
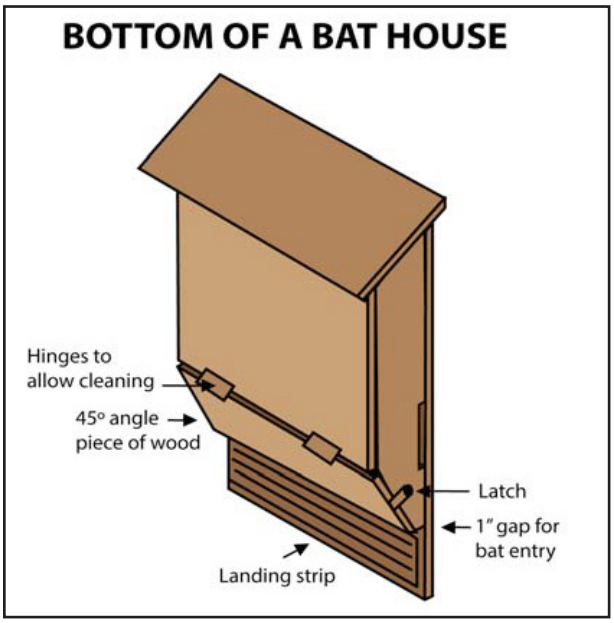


Figure 54. General guidelines for multi-chambered bat boxes.

Image from Craig and Sarell 2016

While the above bat box size is the standard for a small bat box, it is possible to build a larger one. A landing strip is necessary for bats to access the bat box and it requires a rough surface that enables the bats to climb up and into the box. This can be accomplished by scoring grooves in the wood at the recommended groove spacing. The grooves themselves should be 0.08-0.16 cm (0.03-0.06") deep. A naturally rough material, like non-planed cedar lumber, can also be used for a landing strip as long it has grooves that bats can hold on to. Using low-grit sandpaper (*e.g.*, 24-, 40-, or 60-grit) can suitably roughen the surface of the wood as well. Another option is to create a rough surface by mixing a gritty material with non-toxic latex paint. Simply paint the landing strip and then spread ground-up walnut shells, cork, or sand over the surface before applying a second layer of paint. Another possibility is to attach fiberglass mesh (*i.e.*, door screen [18 x 16 strands per inch is standard]) to the landing strip. This can be attached using staples, but it important to make sure that the staples do not corrode over time and break, because then the mesh can lift and bats or guano can get trapped underneath it. Also, ensure that the staples are placed between chamber spacers or on the edges of divider plates so that bats cannot injure themselves on exposed staple tips (52). The fiberglass mesh can alternatively be attached by nailing a thin strip of wood (0.6 cm [¼"] thick) along both sides of the mesh. **Do NOT use metal screen as it has sharp edges that can injure bats, and it corrodes quickly and breaks, potentially leading to bats getting trapped.** To waterproof the bat box caulk all of the seams using latex (water-based) caulking (**do NOT use silicone, polyurethane, or other non-water-based caulk materials**) (39, 52). In NL where the mean maximum July temperature is normally below 29°C, a very dark stain (*e.g.*, black) should be used on the bat box to increase heat absorption. Two to three coats of an outdoor, non-toxic, water-based (latex) paint should be used. **Do NOT use oil-based paint or paints with strong odours or VOCs as these can harm bats or discourage them from roosting in the bat box.** Only the outside of the bat box should be painted and the inside should remain unpainted (52).



A bonus feature that can be used in both single- and multi-chambered bat boxes is a partial bottom that allows better heat retention in the bat box. The bottom should be placed at a downward 45° angle (or greater) facing the back of the box and should leave a 2.5 cm (1") space at the back so that bats can enter the chambers. Attaching the partial bottom with a hinge facilitates the clean-up of any accumulated guano (52).

Figure 55. Optional partial bottom to help with heat retention in a bat house.

Image from Craig 2015

2.4.2.1.3 Kent Bat Box

The Kent bat box is another multi-chambered bat house design, but may not be spacious enough to accommodate a maternity colony depending on the colony size. This bat box was designed by the Kent Bat Group and has had a great deal of success in the UK (53). The box should be made from rough-hewn timber that is 2 cm (⅘") thick. The crevices can be anywhere 1.5-2.5 cm (⅗-1") wide, and other measurements can be approximate with the entire structuring measuring about 48 cm (189/10") in height and 20 cm (79/10") across, and the roof measuring 16 x 25 cm (6⅓ x 9⅘"). It is important to ensure that the bat box is both rainproof and windproof. These directions make a Kent bat box with two crevices, although larger bat boxes can be made with three crevices (54).

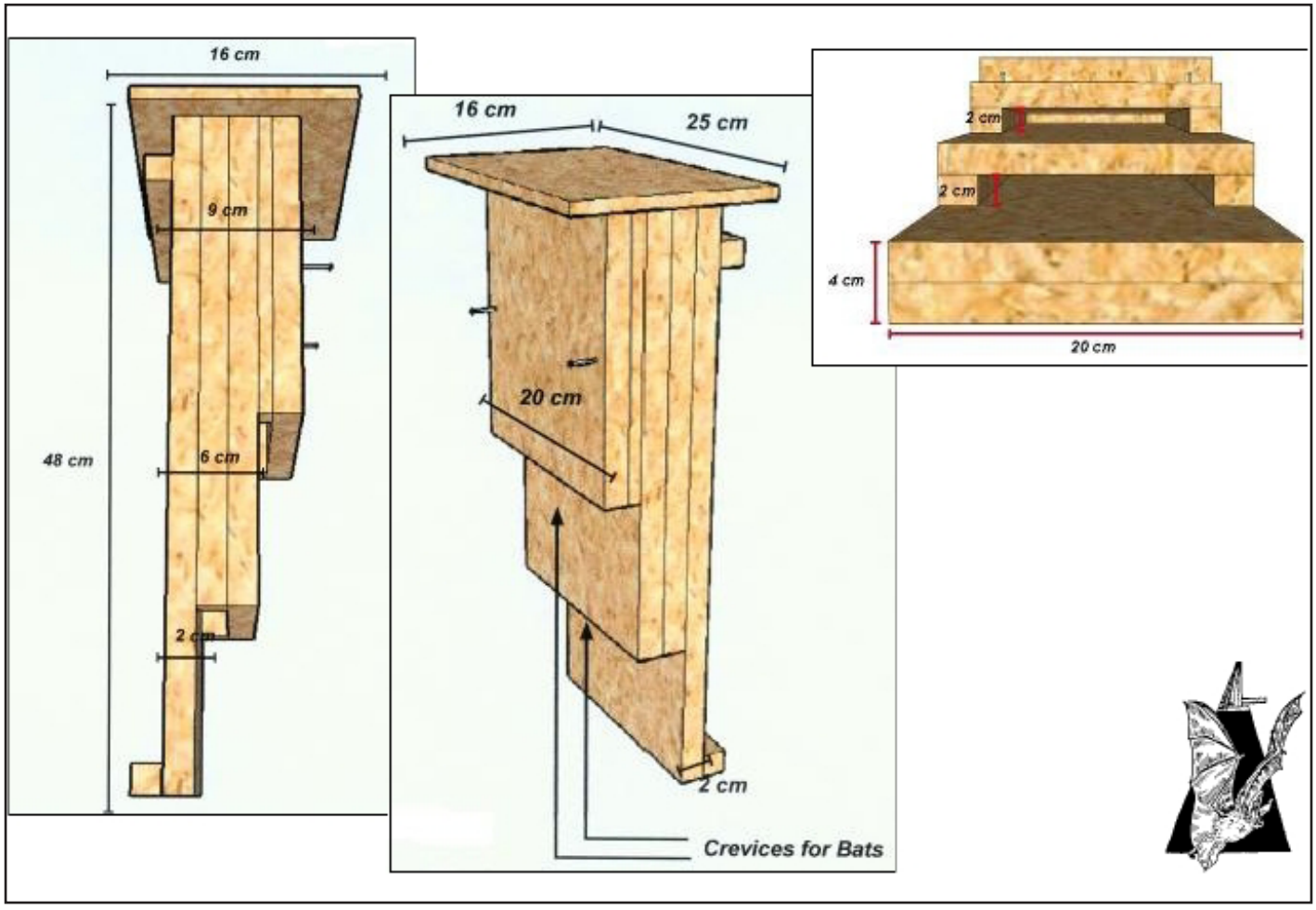


Figure 56. Instructions for building a Kent bat box.

Image from Kent Bat Group 2013

2.4.2.1.4 Rocket Box

Rocket boxes are an effective type of bat house because they face four separate directions which provides a high amount of internal temperature variation that bats can choose from. It is possible to make a simple rocket box just using a post and a plywood box; however, it would likely be less effective than a rocket box with multiple chambers that create different internal temperatures within the structure. A two-chambered rocket box is a cap on a steel pole or wooden post. The pole sleeve (*i.e.*, the innermost square layer that goes around the pole) is made of wood with scored grooves. AC plywood spacer blocks should be positioned in an alternating pattern. An inner shell goes outside the pole sleeve and is made similarly, although grooves are made on both sides of the wood. The inner shell spacer blocks are the same size as the pole sleeve spacer blocks, but are spaced differently. Passage holes are made in the middle of each board of the inner shell. The outer shell only requires grooves on the inside. An inner roof of AC plywood is sealed with water-based caulking. An outer roof of AC plywood is placed over the inner roof, and also caulked with a water-based material (52).

Figure 57. Example rocket box.

Table 3. Measurements for rocket box components; information from *Building Homes for Bats- A Guide for Bat Houses in British Columbia* by Juliet Craig for Community Bat Programs of BC (2015).

component of rocket box	wood thickness (cm)	length x width x height (cm)	depth (cm)	distance from top (cm)
rocket box (entire box)	-	91.4 (3') (high)	-	-
pole/post	-	6.1 (m) (20') (high)	-	-
pole sleeve	-	2.5 x 8.3 x 114.5 (1 x 3¼ x 45")	-	-
pole sleeve grooves	-	-	0.2 ($^{1}/_{10}$")	-
pole sleeve spacer blocks	-	1.9 x 3.8 x 10.2 (¾ x 1½ x 4")	-	12.7 (5")
inner shell	-	2.5 x 15.9 x 106.7 (1 x 6¼ x 42")	-	-
inner shell spacer blocks	-	1.9 x 3.8 x 10.2 (¾ x 1½ x 4")	-	10.2 (4")
passage holes	-	3.81 (1½") (wide)	-	45.7 (18")
outer shell	-	2.5 x 23.5 x 91.4 (1" x 9¼" x 36")	-	-
inner roof	1.9 (¾")	25.4 x 25.4 x 1.9 (10" x 10" x ¾")	-	-
outer roof	1.9 (¾")	30.5 x 30.5 x 1.9 (12" x 12" x ¾")	-	-

The roof should be covered with asphalt shingles or a dark galvanised metal. Use a primer for the first coat then paint the exterior shell three additional times using an outdoor, non-toxic, water-based (latex) paint of a dark colour (52).

Figure 58. The bat house should be painted a dark colour using the recommended type of paint.

A rocket box bonus feature is a special compartment that promotes heat retention in the box. This is accomplished by making a compartment in the upper half of the pole sleeve using a 6.4 cm (2½")-square piece of plywood, filling the compartment with sand, gravel, or dirt, and subsequently sealing the compartment with another piece of plywood over the top (52).

If there is an issue with potential predators climbing the pole (such as cats, squirrels, etc.), a guard can be placed on the bottom of the pole or post; a sheet-metal, cone-shaped guard works well (52).

2.4.2.2 Location

Bats tend to prefer bat houses that are mounted on buildings or similar structures, which is likely due to decreased predation risk and more heat from sunlight exposure compared to roosts in trees (51, 55). Placing a bat house on a building will reduce the change in temperature that occurs from day to night, and keep the temperature in the bat house more stable for the bats (55). If placing a bat house on the side of a building, offsetting the bat house from the structure using a block of wood will prevent guano from dripping down the side of the building. Additionally, bat houses should be placed 6.1-9.1 m from the nearest trees to limit predator access, and it is crucial that the flight path underneath the bat house entrance is free of branches and other obstacles (41, 51, 55). It is recommended that the minimal height for bat houses is 3.1 m (10') above the ground, however, they are more likely to be successfully inhabited when placed 3.7-6.1 m above the ground (12-20') (36, 55). In the temperate climate of NL, the general recommendation is to mount a bat house in an area that receives direct sunlight 6-8hours a day, if only partial sunlight is possible, then morning sunlight is preferable (41). To achieve this, the bat house should be facing between south and east.

2.4.2.3 Maintenance

A build-up of guano inside the bat house can result in bats abandoning the roost site, especially if it blocks the entrance, but this can largely be prevented with an open-bottomed bat house. If a partial bottom is installed to retain heat, it is crucial that any guano accumulation is monitored for any blockages and is removed at the end of the season when bats no longer occupy the roost. It is important to remember that a bat house does not last forever so they should be replaced when they are no longer safe for bats. It is documented that the commonly used wooden bat houses have a life expectancy of approximately 5-10 years (51). Other upkeep includes ensuring that other animals (such as wasps) are not using the bat house (51, 52).

Figure 59. Place the bat house so that the entrance is free of all obstacles.

2.4.2.4 Success?

To check if your bat house is successful, simply place light-coloured material (such as cloth or wood) underneath the bat house to look for guano deposition (52). It is also possible to very briefly use a light to look inside the bat house during the day to determine if bats are roosting, however, it will be difficult to see the bats and this may cause unnecessary disturbance (41). Conducting an emergence survey is another good option to monitor success, and also lets you know the approximate size of the bat colony using the bat house (see *Section 2.3.2 Emergence Survey* for more details) (52). If you conduct an emergence survey, please call the bat hotline at 1-833-434-BATS (2287), or the Newfoundland and Labrador Forestry and Wildlife Research Division at 709-637-2025, to share your results.

Figure 60. Little brown bats roosting in a bat house.

Figure 61. Conducting an emergence survey for two bat houses.

Figure 62. A little brown myotis natural roost in a balsam poplar.

Figure 63. Bats need a water source for drinking.

2.4.3 Enhance Bat Habitat

Besides providing bats with artificial roost sites, such as bat houses, you can also maintain natural roost sites for bats on your property. Both little brown myotis and northern myotis naturally roost in trees, preferring old, dead or dying trees with a large diameter. These types of trees typically have the peeling bark, crevices, and cavities that provide roosting spaces for bats. If you have some of these old trees on your property, and there is no concern about them falling and damaging a house, vehicle, or equipment, or injuring a person, then leave them standing as a natural home for bats. Bats also like to roost in the cracks and fissures of rock formations, so having cliffs or boulders in the yard may attract bats, especially if the rocks are south facing so that they are warmed by the sun. Bats require a water source for drinking and often forage over water as well. Ideal drinking habitat is either a large or small body of water that is clean and free of any obstacles or debris above the water so that bats can drink while flying. Floating plants and algae will deter bats from using a water supply. Every water source should have a suitable exit point so that if a bat accidentally falls in, it will not drown (see *Section 2.2.2 Addressing Bats' Concerns*) (36). Other yard modifications that will attract bats are organic linear features in the landscape, such as hedgerows or tree lines. These will help bats navigate in the dark. Lastly, if you want to encourage bats to use your property, it is important to remove any artificial lighting because it deters bats (56).

2.4.4 Enhance Food Availability

By planting a garden with native plants that attract night-active native insects, you can increase food availability for bats on your property. This does not mean encouraging property owners to attract more mosquitoes to their yards, but rather other insects such as moths. Some general guidelines for bat-friendly gardens include the following (56):

- plant a wide variety of flowers that differ in colour, fragrance, and shape
- to attract insects at dusk when bats are feeding, plant pale flowers that can be seen in low light
- plant single-flowered plants which generally have easier access to pollen and nectar than double-flowered plants (*fl. pl.*)
- attract insects with flowers that provide easy access to pollen and nectar with landing platforms and short florets (plants in the daisy (Asteraceae) and carrot (Apiaceae) families are generally good choices)

Figure 64. Attract native moths like the Virginia ctenucha (*Ctenucha virginica*).

The following is a list of native plants, along with their bloom times and preferred growing conditions, which can be planted to attract insects for bats:

Native Plants	Bloom Times	Growing Conditions
• Mayflower/Trailing arbutus (*Epigaea repens*)	February-May	dry/part shade
• Wild raspberry/Red raspberry (*Rubus idaeus*)	April-May	dry/part shade
• Mountain fly honeysuckle (*Lonicera villosa*)*	May	dry/full sun
• Rhodora (*Rhododendron canadense*)	May	wet/part shade
• Smooth serviceberry (*Amelanchier laevis*)	April-May	moist/full sun
• Wild strawberry (*Fragaria virginiana*)	May-August	dry/part shade
• Blue flag iris (*Iris versicolor*)	June	wet/part shade
• Red osier dogwood (*Cornus sericea*)	June	wet/full sun
• Fireweed (*Chamerion angustifolium*)*	June-August	dry/full sun
• Common evening primrose (*Oenothera biennis*)*	July-September	dry/part shade
• Spotted jewelweed (*Impatiens capensis*)	July-September	wet/part shade
• Spotted Joe-Pye weed (*Eutrochium maculatum*)	July-September	moist/part shade
• White turtlehead (*Chelone glabra*)	July-September	moist/part shade
• Purple-stemmed aster (*Symphyotrichum puniceum*)	August-September	moist/sun
• Rough-stemmed goldenrod (*Solidago rugosa*)	September	moist/part shade

The plants with the "*" are particularly good for attracting moths.

Figure 65. Wild strawberry (*Fragaria virginiana*).

Figure 66. Rough-stemmed goldenrod (*Solidago rugose*).

Section 3. Conservation Measures and Landowner Stewardship

There are opportunities for landowners to get involved in bat conservation in NL. The most important thing for people to do is to **REPORT** any bat sightings by calling the Canadian Wildlife Health Cooperative, Atlantic Region's Bat Conservation Program Technician at 1-833-434-BATS (2287) or e-mailing tmcburney@cwhc-rcsf.ca. Whether a solitary bat is spotted, or there is a maternity colony in a building, it is crucial to identify where bats are hanging out. This is especially important for bat white-nose syndrome (WNS) surveillance season (November 1st-May 31st), and locating maternity colonies in the summer. By providing this information, you are contributing to bat research that is essential in conserving bat populations.

If you have a maternity colony on your property, whether or not you need to have the bats excluded, it is imperative to get a colony count so that researchers can estimate the colony size to help better understand the population status of bats in NL. By calling 1-833-434-BATS (2287), or the Newfoundland and Labrador Forestry and Wildlife Research Division at 709-637-2025, you will be put in touch with researchers that can help you plan your colony count. Colony counts should ideally be done sometime in June, and then again after the pups are volant in August, to get an idea of how many pups were born that summer. The more years you conduct a colony count for a particular colony, the more valuable that data will be to bat conservation. The toll free number can be used to report any bat-related activities you observe on your property as well as to ask any questions you might have in relation to the bats living in your province.

You can help; report your bat sightings to 1-833-434-BATS (2287)!

Figure 67. Report your bat sightings.

Section 4. Resources

Document should be cited as the following:

McBurney, T. 2018. Got bats? How to manage bats in buildings in Newfoundland and Labrador. Tech. Rep. Charlottetown, PE: Canadian Wildlife Health Cooperative, Canadian Wildlife Health Cooperative Atlantic Office. 68 p.

4.1 Definitions

echolocation: emitting sounds out into the environment and then listening for the echoes of these calls as they reflect off of obstacles to create a mental map of the surroundings (a way to “see”)

ectoparasite: a parasite that lives outside of its host (*i.e.*, on the outside of the skin; *e.g.*, ticks)

eviction: removing bats from a building using one-way eviction devices (should only take place from the beginning of September until the end of April)

exclusion: the process of sealing entry and exit points once bats have left the building, to prevent them from re-entering the roost site

gleaner: a bat species that captures prey that is resting on a surface (often plants)

hawker: a bat species that catches prey in the air (on the wing)

insectivorous: insect-eating, , relying on a diet comprised exclusively of insects

migratory: move to different locations between summer and winter

necropsy: an autopsy on a species other than your own (*i.e.*, a non-human autopsy)

Nuisance Wildlife Control Operator (NWCO): someone who relocates, traps, or removes wildlife considered a nuisance

Pest Control Operator (PCO): someone who uses a variety of methods to remove or kill pests or nuisance animals

prophylaxis: measures taken to prevent the spread of a disease (*e.g.*, rabies)

roost: where a bat rests

synchronous birth: when all pregnant females in an area give birth within a short time period ("same time birth")

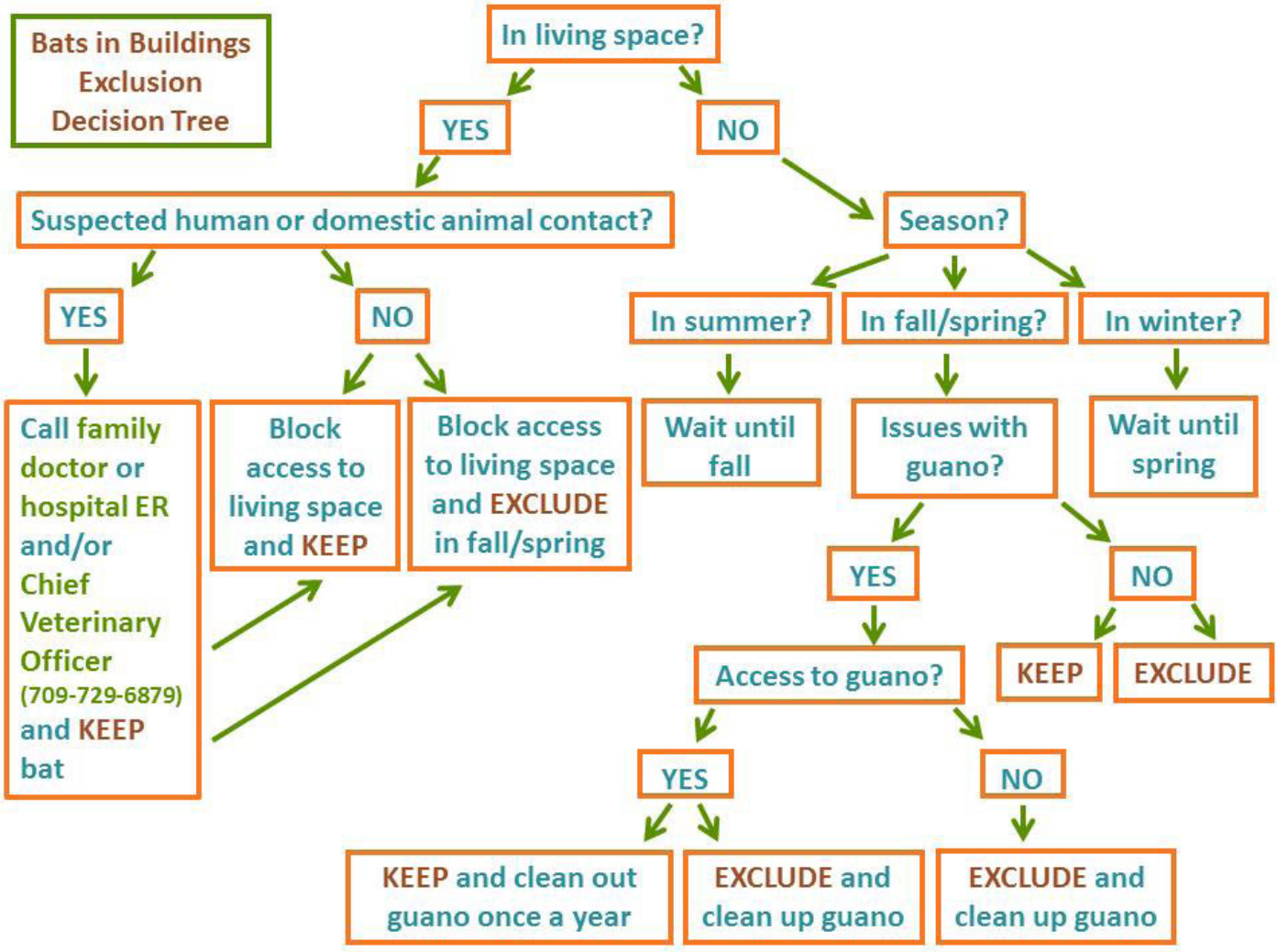
temporary parasite: a parasite that does not remain on its host for its whole life cycle

tragus: a protrusion on the inner side of the external part of the ear

volant: able to fly

Figure 68. Little brown myotis in flight.

4.2 Exclusion Decision Tree



4.3 Helpful Resources

4.3.1 Bat White-nose Syndrome

Canadian Wildlife Health Cooperative

Bat White-nose Syndrome Surveillance:
http://www.cwhc-rcsf.ca/wns.php

B*at White-nose Syndrome Resources*:
http://www.cwhc-rcsf.ca/wns_resources.php

Submission Protocol for White-nose Syndrome Specimens:
http://www.cwhc-rcsf.ca/docs/WNS_Specimen_Submission_Protocol.pdf

Decontamination Protocol for Entering Bat Hibernacula (full):
http://www.cwhc-rcsf.ca/docs/WNS_Decontamination_Protocol-Mar2017.pdf

Decontamination Protocol for Entering Bat Hibernacula (2-pager):
http://www.cwhc-rcsf.ca/docs/BatWhiteNoseSyndrome-DecontaminationBrief-Dec2016.pdf

Canadian National White-nose Syndrome Decontamination Protocol:
https://www.youtube.com/watch?v=kQjALbixJKY

US White-nose Syndrome Conservation and Recovery Working Group

National White-nose Syndrome Decontamination Protocol (US):
https://www.whitenosesyndrome.org/sites/default/files/resource/national_wns_decon_protocol_04.12.2016.pdf

4.3.2 Excluding Bats from Buildings

Alberta Community Bat Program

Got Bats? Alberta Guide for Managing Bats in Buildings:
http://www.albertabats.ca/wp-content/uploads/Alberta_Bats_in_Buildings.pdf
Alberta Community Bat Program- Got Bats?:

Bats and Buildings:
http://www.albertabats.ca/gotbats/

Batcone

Retailer of Bat Eviction Devices:
http://www.batcone.com/

Bat Conservation International

Bat Conservation International- Bats in Buildings:
http://www.batcon.org/resources/for-specific-issues/bats-in-buildings

Community Bat Programs of BC

Got Bats? 7 Steps for Managing Bats in Buildings in British Columbia (BC) (full):
http://www.cwhc-rcsf.ca/docs/7_Steps_for_Managing_Bats_in_Buildings.pdf

Got Bats? 7 Steps for Managing Bats in Buildings in BC (2-pager):
http://www.cwhc-rcsf.ca/docs/7_Steps_for_Managing_Bats_in_Buildings_-_2_pager.pdf

Got Bats? Frequently Asked Questions Regarding Bats in Buildings in BC:
http://bcbats.ca/attachments/bat_FAQ.pdf

US White-nose Syndrome Conservation and Recovery Working Group

Acceptable Management Practices for Bat Control Activities in Structures:
https://www.whitenosesyndrome.org/sites/default/files/resource/wns_nwco_amp_1_april_2015.pdf

4.3.3 Bat Monitoring, Conservation, and Ecology

Canadian Wildlife Federation

Help the Bats Resources:
http://cwf-fcf.org/en/explore-our-work/endangered-species/help-the-bats/

Canadian Wildlife Health Cooperative

Submission Protocol for Wildlife Specimens:
http://www.cwhc-rcsf.ca/forms/cwhc_atlantic_submission_form.pdf

Protocole de soumission pour des spécimens de la faune (en français):
http://www.cwhc-rcsf.ca/forms/formulaire_de_soumission_rcsf_region_de_l'atlantique.pdf

Shipping and Handling Instructions for Wildlife Specimens:
http://www.cwhc-rcsf.ca/docs/CWHC%20Shipping%20and%20Handling%20Instructions.pdf

Merlin Tuttle's Bat Conservation

Worldwide Bat Conservation:
http://www.merlintuttle.com/

Neighbourhood Bat Watch

Citizen Science Bat Monitoring in Canada:
http://batwatch.ca/

Instructions for Bat Colony Counts:
http://batwatch.ca/sites/default/files/pdf/Bat_Colony_Validation.pdf

Nova Scotia Bat Conservation

Report Bat Sightings in Nova Scotia (NS):
http://www.batconservation.ca/index.php?q=node/add/batreport

The Natural History of Canadian Mammals- by Donna Naughton

Newfoundland and Labrador Forestry and Wildlife Research Division

709-637-2025

4.3.4 Bat Houses

Alberta Community Bat Program

Bat House Information for Alberta (including bat house designs):
http://www.albertabats.ca/bathouses/

Building Homes for Bats- Alberta Bat House Guidelines:
http://www.albertabats.ca/wp-content/uploads/ACBP-Bat-Houses-in-Alberta.pdf

Bat Conservation International

The Bat House Researcher- A Decade of Bat House Discovery:
https://www.batcon.org/pdfs/bathouses/ResearchFinal.pdf

Canadian Bat Houses

Canadian Retailer of Bat Houses:
http://canadianbathouses.com/

Community Bat Programs of BC

Building Homes for Bats- A Guide for Bat Houses in British Columbia:
http://www.bcbats.ca/attachments/Bat_houses_in_BC_2015.pdf

Information on Where to Install Bat Houses in BC:
http://www.bcbats.ca/index.php/bat-houses/where-to-install-a-bat-house

The Bat House Builder's Handbook- by Merlin Tuttle

4.3.5 Bat-related Human Health Concerns

Histoplasmosis

Centers for Disease Control and Prevention (CDC)

Histoplasmosis- Protecting Workers at Risk (full):
https://www.cdc.gov/niosh/docs/2005-109/pdfs/2005-109.pdf

Histoplasmosis- Protecting Workers at Risk (2-pager):
https://www.cdc.gov/niosh/docs/2005-109/pdfs/2005-109FS.pdf

NIOSH-approved N95 Particulate Filtering Facepiece Respirators:
https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/n95list1.html

Rabies Virus

Centers for Disease Control and Prevention (CDC)

Compendium of Animal Rabies Prevention and Control:
(Part 1. Rabies Prevention and Control C. Prevention and control methods related to wildlife)
http://nasphv.org/Documents/NASPHVRabiesCompendium.pdf

Newfoundland and Labrador Department of Health and Community Services

Rabies Policy Manual for Newfoundland and Labrador:
http://www.faa.gov.nl.ca/agrifoods/animals/health/pdf/Rabies_policy_manual.pdf

University of Prince Edward Island

Medical Surveillance Plan for Research Involving Biohazardous Materials (rabies safe work practice): http://www.upei.ca/policy/files/policy/Medical%20Surveillance%20Plan%20for%20Research%20Involving%20Biohazardous%20Materials%20-%20admordgnl0012.pdf

Newfoundland and Labrador Animal Health Division

709-729-6879

Newfoundland and Labrador HealthLine

811 (1-888-709-2929)

Newfoundland and Labrador On-call Medical Officer of Health (MOH)

1-866-270-7437

Figure 69. Bat and bat house.

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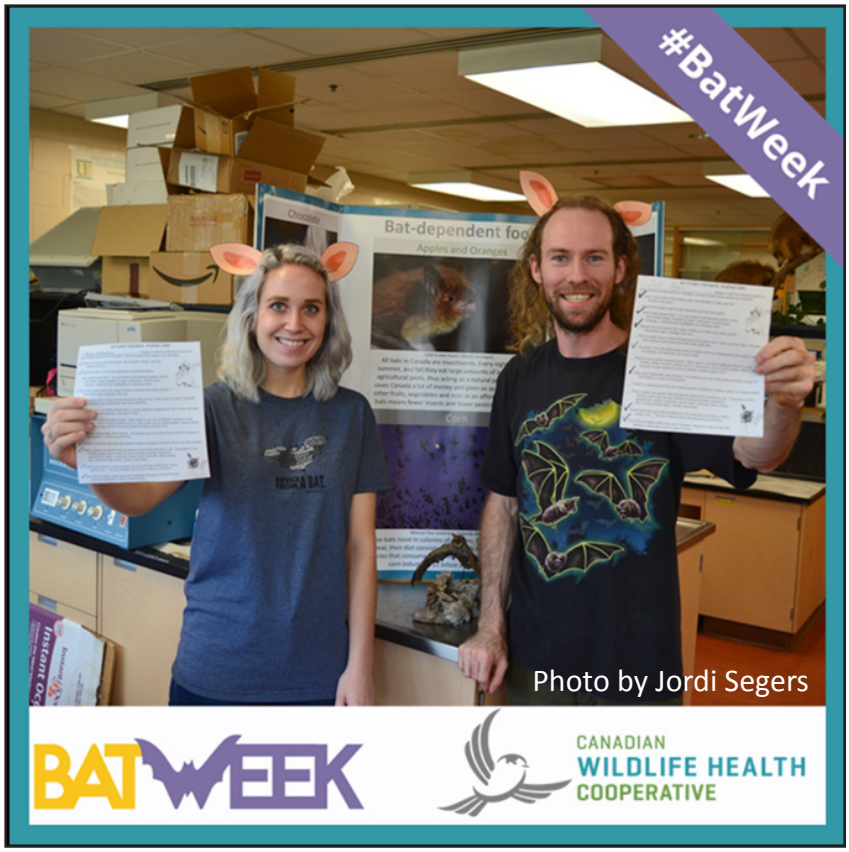

Figure 70. Bat researchers with the Canadian Wildlife Health Cooperative.

CANADIAN
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