Bats of Stanley Park

BCIT Fish, Wildlife, and Recreation Program

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BATS OF STANLEY PARK

BY

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Summary

Bats are important and understudied animals in the ecosystems of British Columbia. The Lower Mainland of BC is known to support up to 10 bat species, yet little research on bats has been conducted in this region. The Bats of Stanley Park project was initiated by the Stanley Park Ecology Society in cooperation with the BCIT Fish, Wildlife and Recreation program to learn more about the bats of the Lower Mainland of BC and raise awareness on their role in the ecosystem. Surveys of bats and their habitat were carried out from summer of 2009 through the spring of 2010 to investigate the presence and distribution of bats in Stanley Park. Acoustic surveys using an ultrasonic bat detector examined bat activity distribution within the park spatially and seasonally. Bat activity was found to be concentrated around freshwater, with the highest levels of activity occurring in the spring and summer. Mist-net trapping was conducted to identify bat species using the park. During the project four bat species were confirmed in the park; the Yuma Myotis (*Myotis yumanensis*), the Little Brown Myotis (*Myotis lucifugus*), the Big Brown Bat (*Eptesicus fuscus*) and the Silver-haired bat (*Lasionycteris noctivagans*). Bat habitat features in the park were also examined using ground-based wildlife tree surveys and Stanley Park map data. Mapping revealed potential roost trees in riparian areas and a diversity of habitat types throughout the park.

Raising awareness on the bats of BC is an important component of the Bats of Stanley Park project. An education module was created to help people understand why protecting bats and enhancing their habitat is positive for the ecosystem as a whole. The curriculum-based BC bat education program for grades 5-7 gives youth a chance to learn about the benefits of bats and potentially become partners in protecting bats in BC. Providing public education and stewardship for bat habitat helps ensure that bats remain an integral part of the ecosystems of BC.

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Acknowledgments

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1.0 Introduction

1.1 Bats and Stanley Park

Bats are a large and diverse group of mammals that are distributed worldwide over a wide range of habitats. By species, bats account for almost a quarter of the world's mammal species, with only rodents outnumbering bats in species diversity (Altringham, 1996). Bats are successful at utilizing a range of habitats and can be found in most environments, from deserts to forests. There are an estimated 19 species of bats that include Canada within their home range (Fenton, 2005). Of these 19 species, 16 are found in British Columbia, eight of which are found in no other province or territory in Canada. Eight of BC's bat species are provincially designated as Red (endangered or threatened) or Blue (special concern) listed species (BC Conservation Data Centre, 2010), with two of these species occurring in the Lower Mainland (Figure 1). Relatively little is known about the bats of British Columbia. Initial studies have examined geographic ranges and habitat needs of the province's bat species, but have focused primarily on the diverse interior ecosystems of the province (Holroyd, et al. 1994; Barclay & Brigham, 1996).

Figure 1. The Lower Mainland region of British Columbia (2) in relation to the other regions of BC (Source: BC Ministry of Environment, 2010).

No formal studies have been conducted on the bat species in Stanley Park. Current information on bats in the park has come from anecdotal observations and distribution range data compiled on bats found in BC. Provincial distribution data indicates ten bat species as possible users of the park. It is not known if all ten bat species with range distribution in the Lower Mainland of BC actually use Stanley Park. Bats have been observed in the park foraging over Beaver Lake and Lost Lagoon. The most commonly sighted bats in Stanley Park are believed to be Yuma Myotis and Little Brown Myotis (VNHS, 2006). Similar to many animals living in seasonal climates, it is assumed that bats in British Columbia are only active through the spring and summer, migrating or hibernating during the fall and winter (Nagorsen & Brigham, 1993). It is unknown if non-migratory bats overwinter in the park.

1.2 Stanley Park Ecology Society and Wildlife Research

Working in partnership with the Vancouver Park Board, the Stanley Park Ecology Society (SPES) is a non-profit organization that takes a lead role in providing environmental education, conducting stewardship activities and carrying out wildlife research in Stanley Park. Started in 1988, SPES operates a public Nature House on Lost Lagoon and engages in stewardship and education programs for school groups and the general public, connecting people with nature (SPES, 2009a). SPES supports the conservation of Stanley Park through the activities of their staff and volunteers and also engages in partnerships with post secondary institutions to carry out research projects on the wildlife and ecosystems of the park. In 2008 SPES initiated the first study of bat species using the park. In 2009 SPES invited the involvement of the BCIT Fish, Wildlife and Recreation program to work collaboratively to conduct additional research on bats in Stanley Park.

1.3 Purpose and Objectives

The purpose of the 2009/2010 Stanley Park Bat Project was to gather data about the bat species utilizing Stanley Park. In addition, the data gathered was used to create new educational materials for classroom and public education and to enhance stewardship for bat habitat in Stanley Park.

The objectives of the Stanley Park Bat Project were to:

1) Conduct presence/not detected surveys to determine what species of bats are found within Stanley Park;
2) Examine habitat use of the bats within Stanley Park and identify available bat habitat by conducting surveys at sites throughout the park;
3) Create an education program about the bats of BC for classroom and public education.

2.0 Bat Species Natural History

Bats are unique flying mammals that play an important role in the ecosystem. Bats, unlike most small mammals, are unique in having long lives, often up to 20 or 30 years, and low reproductive rates, usually one young per year (Findley, 1993). Bats are classified in their own order, Chiroptera, made up of many diverse families. All bats in BC belong to the evening bat family Vespertilionidae, which are nocturnal or crepuscular insectivorous bats that use echolocation to navigate and to locate prey. Being active at night and consuming insects enables evening bats to fill a distinct ecological niche as nutrient cyclers, making them a valuable part of the ecosystem (Fenton, 2005). Bat populations are reliant on access to high quality roosting and foraging sites in their environment (Barclay & Brigham, 1996). While these needs differ between species, most bats found in the Lower Mainland of BC are associated with wildlife trees that provide roosting habitat (Fenger et al. 2006).

Roosting sites are one of the most important features in the environment for bat habitat. Bats require roosts within range of foraging areas to provide cover during their diurnal and nocturnal resting periods (Evelyn et al. 2003). They also need roosts for protection from predators and for thermal regulation, especially during the breeding season when female bats require warmer roosts for rearing young (Nagorsen & Brigham, 1993). While some bats roost alone, many BC bats are colonizing species, where females form large maternity colonies in group roosts to rear young in the spring (Fenton, 2005). Male bats of these species will roost alone or in small groups. Depending on the species, roost sites can be under the loose or rough bark of trees, in tree hollows, on the ends of branches, in rock crevices, in tunnels and caves or in human made structures (Nagorsen & Brigham, 1993).

Bats have developed several adaptations to live in seasonal climates, including torpor, hibernation and migration. These adaptations can differ between sexes and species of bats. Torpor is a hibernation-like state that bats can enter to conserve energy, reducing their heart rate and metabolism while lowering their body temperature to ambient with their surroundings (Altringham, 1996). Male bats enter torpor more often than female bats during breeding season, as female bats need to maintain a steady body temperature for optimal development of their young (Nagorsen & Brigham, 1993). Hibernation is an extended form of torpor, where bats roost in areas that maintain stable temperatures over the winter, rousing occasionally to obtain moisture (Fenton, 1983). Some bat species are migratory and leave their summer range in the fall, flying to other areas where they can hibernate or stay active over the winter. The bat species that live in the Lower Mainland of BC and may be found in Stanley Park are listed in Table 1 (VNHS, 2006, Nagorsen & Brigham, 1993).

Table 1. Bat species found in the Lower Mainland of British Columbia that are believed to use Stanley Park, Vancouver BC and their federal and provincial status as of 2010 (VNHS, 2006, Nagorsen & Brigham, 1993).

Common Name	Species	RISC[1] Code	Provincial[2] Status	Federal[3] Status
Silver-haired Bat	*Lasionycteris noctivagans*	LANO	Yellow	None
Big Brown Bat	*Eptesicus fuscus*	EPFU	Yellow	None
Hoary Bat	*Lasiurus cinereus*	LACI	Yellow	None
Townsend's Big-eared Bat	*Corynorhinus townsendii*	COTO	Blue	None
Keen's Myotis	*Myotis keenii*	MYKE	Red	DD 2003
Little Brown Myotis	*Myotis lucifugus*	MYLU	Yellow	None
Yuma Myotis	*Myotis yumanensis*	MYYU	Yellow	None
California Myotis	*Myotis californicus*	MYCA	Yellow	None
Western Long-eared Myotis	*Myotis evotis*	MYEV	Yellow	None
Long-legged Myotis	*Myotis volans*	MYVO	Yellow	None

[1]Resource Inventory Standards Committee code; all mammals are prefaced with M
[2]Provincial at risk status: Yellow: secure species, Blue: species of special concern, Red: endangered or threatened species (BC Conservation Data Centre, 2010)
[3]Federal at risk status from COSEWIC (Committee on the Status of Endangered Species in Canada). DD 2003: data deficient as of 2003.

2.1 Silver-haired Bat (*Lasionycteris noctivagans*)

Silver-haired Bats are typically associated with coniferous forest and riparian habitats from sea level to 1220m (Nagorsen & Brigham, 1993). Silver-haired Bats typically roost in trees either alone or in small groups of 2-6, with only two small maternity colonies ever found in Canada (Nagorsen & Brigham, 1993). Generally a migratory bat, Silver-haired Bats have been found hibernating under western red cedar (*Thuja plicata*) bark and in coastal Douglas-fir (*Pseudotsuga menziesii*) wildlife trees in BC (Fenger et al. 2006). In Oregon and Alberta, Silver-haired Bats have been found to be associated with old growth forest (Fenger et al. 2006).

2.2 Big Brown Bat (*Eptesicus fuscus*)

Big Brown Bats inhabit a variety of habitats across BC. The range of this species within BC is unknown, however they have been found from Washington to Alaska and the Yukon, therefore it is assumed that their range extends throughout BC (Fenger et al. 2006). Big Brown Bats range in elevation from sea level to 1070m (Nagorsen & Brigham, 1993). They have a strong affinity for human structures and are generally non-migratory, remaining in their natal territory throughout their lives (BC Conservation Data Centre, 2010). In some environments, such as the Okanagan Valley, Big Brown Bats are known to prefer tree roosts such as in ponderosa pine (*Pinus ponderosa*) rather than human structures (Nagorsen & Brigham, 1993).

2.3 Hoary Bat (*Lasiurus cinereus*)

The Hoary Bat is the largest bat in BC. They are commonly associated with both grassland and forest habitats at elevations from sea level to 1250m (Nagorsen & Brigham, 1993). Hoary Bats are migratory and are distributed widely throughout southern BC, however very little is known about their abundance (Nagorsen & Brigham, 1993). Hoary Bats do not colonize but may associate in large groups during migration (BC Conservation Data Centre, 2010). Their roosts are usually located near the ends of branches where they have protection from predators and an unobstructed flight path (Cryan & Brown, 2007). Male Hoary Bats roost alone while the females roost with their young (Fenger et al. 2006).

2.4 Townsend's Big-eared Bat (*Corynorhinus townsendii*)

Townsend's Big-eared Bats are named for their large ears, which are about one half of their body length (Fenton, 2005). They are distributed from sea level to 1070m throughout most of southern BC in a variety of habitats from coastal forests to grasslands (Nagorsen & Brigham, 1993). Townsend's Big-eared Bats roost in caves and human structures, with few recorded maternity colonies found in Canada. One of the few colonies recorded was in the Lower Mainland, in Minnekhada Regional Park, Coquitlam BC (Smyth, 2000). Townsend's Big-eared

Bats maintain small home ranges and will remain in their natal territory, but are sensitive to human disturbance and may abandon a roost once they has been disturbed by humans (Nagorsen & Brigham, 1993).

2.5 Keen's Myotis (*Myotis keenii*)

Limited information is available on the biology of Keen's Myotis. Keen's Myotis is listed as Data Deficient as of 2003 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC, 2009). Much of the information about Keen's Myotis has come from studies conducted on a maternity colony on Hotspring Island located within Gwaii Haanas National Park Reserve of Canada in the Queen Charlotte Islands of BC (Fenton, 1983). They appear to be distributed mainly along the Pacific Northwest coast with most of their population occurring entirely within BC (Nagorsen & Brigham, 1993). Because of the vulnerability of this small population, the species is Red listed (threatened or endangered status) within BC (BC Conservation Data Centre, 2010). Keen's Myotis roost in coastal forest wildlife trees and use caves as winter hibernacula sites (Fenger et al. 2006).

2.6 Little Brown Myotis (*Myotis lucifugus*)

Little Brown Myotis utilize a wide range of habitats, and due to their adaptability are distributed throughout the entire province. Little Brown Myotis have the greatest elevation range of all the bats in the province, with observations recorded from sea level up to 2288m (Nagorsen & Brigham, 1993). Little Brown Myotis use a wide variety of summer roosting sites including loose bark, tree cavities, rock crevices, caves, mines, and buildings (Fenger et al. 2006). Males tend to roost alone or in small groups while females in maternity colonies roost in large groups of hundreds or even thousands (Fenger et al. 2006). Little Brown Myotis have been recorded to live up to 30 years and generally maintain small ranges in the Lower Mainland of BC (BC Conservation Data Centre, 2010).

2.7 Yuma Myotis (*Myotis yumanensis*)

Yuma Myotis are widely distributed throughout southern BC and are locally abundant in the Lower Mainland (BC Conservation Data Centre, 2010). They are commonly associated with coastal Douglas-fir forests, interior ponderosa pine forests, and grassland habitats from sea level to 730m (Nagorsen & Brigham, 1993). Yuma Myotis utilize wildlife trees, caves, rock crevices, and human structures as roosting habitat. They are one of the few bat species in BC that forage over both marine and fresh water and are closely associated with open water access (Fenger et al. 2006).

2.8 California Myotis (*Myotis californicus*)

California Myotis are found along the west coast and throughout most of southern BC (Eder & Pattie, 2001). They are distributed on most of the islands along the Pacific Coast including Vancouver Island and the Queen Charlotte Islands and have an elevation range of sea level to 1300m (Nagorsen & Brigham, 1993). California Myotis forage mostly over the surface of lakes but have also been known to hunt over the tree canopy (Fenger et al. 2006). They do not form large maternity colonies and roost in caves, rock crevices, and human structures (BC Conservation Data Centre, 2010). Wildlife trees have been found to be important for providing roosting locations for this species in BC (Fenger et al. 2006).

2.9 Western Long-eared Myotis (*Myotis evotis*)

Western Long-eared Myotis are well distributed throughout the Lower Mainland and Vancouver Island. They are more tolerant of high, cool elevations than other bats, and sustain breeding populations up to 1220 m (Fenger et al. 2006). They are adaptable in their choice of roosting habitat but prefer coastal forests with rocky outcroppings and interior riparian forests (BC Conservation Data Centre, 2010). This species can forage in a variety of habitats, including heavy foliage (Fenger et al. 2006).

2.10 Long-legged Myotis (*Myotis volans*)

Long-legged Myotis, one of the largest Myotis species in BC, is well distributed across the province and is one of the most common bats found in the western United States (Fenger et al. 2006). Long-legged Myotis are associated with coniferous forest as well as riparian and desert environments (Nagorsen & Brigham, 1993). They are flexible hunters and will forage for prey over water, in clearings and through vegetation, often for sustained long distances (Nagorsen & Brigham, 1993).

3.0 Study Area

Stanley Park is a 404.9 ha urban park located adjacent to the downtown core of Vancouver (Figure 2). The park is situated on the end of a peninsula surrounded by Burrard Inlet to the east and English Bay to the west. The land has been inhabited by humans for thousands of years, with the park area originally used by Coast Salish First Nations as a seasonal community and resource harvesting site. Development of what is now Stanley Park was largely prevented through the British military use of the land (Parks Canada, 2002). Logging of the park area occurred during the 1800s, resulting in the second growth forest found throughout most of the park today. The park became a protected area in 1888, with the land base of the park owned by the Canadian Federal government and leased to the City of Vancouver for use as a municipal park (Parks Canada, 2002).

Figure 2. Stanley Park peninsula adjacent to the downtown core of Vancouver British Columbia. Inset map: Stanley Park (2009).

Several major developments have shaped Stanley Park. The creation of the Lions Gate Bridge in 1938 changed the topography of the park, linking the downtown core of Vancouver to the North Shore across Burrard Inlet (Davis, 2004). In order to control erosion around the park periphery a seawall was constructed, eventually being developed into a continuous trail connecting the park to adjoining areas. Much of Stanley Park has been developed to provide recreational opportunities and has a range of facilities such as playing fields, water-parks and playgrounds. The park is managed for both recreation and conservation, with extensive managed forests remaining since the 1800s (SPES, 2009a). Management of the park is the responsibility of the City of Vancouver, through the elected Vancouver Park Board. Stanley Park is a designated National Historic Site of Canada and a major tourism draw, receiving an estimated eight million visitors per year (VBPR, 2009).

Stanley Park has two major waterbodies, Beaver Lake in the interior of the park and Lost Lagoon on the southern perimeter (Figure 3). Lost Lagoon is a mostly freshwater brackish lake formed by the creation of the Stanley Park Causeway in 1916, which cut off the tidal lagoon from Coal Harbour (Davis, 2004). This changed the shallow saltwater lagoon into a freshwater lake which is now connected to the municipal water system to ensure stable water levels (VNHS, 2006). Beaver Lake is a marshy, natural lake which has also been affected by the causeway development and is fed partially by the municipal water system (Worcester, 2010). Beaver Lake is in the process of infilling and is largely covered by plant growth, including introduced pond lilies. Beaver Creek is fed by Beaver Lake and is one of the few free flowing salmon bearing streams in Vancouver (Figure 3). Beaver Creek connects Beaver Lake to Burrard Inlet and provides estuarine habitat where the creek meets the ocean.

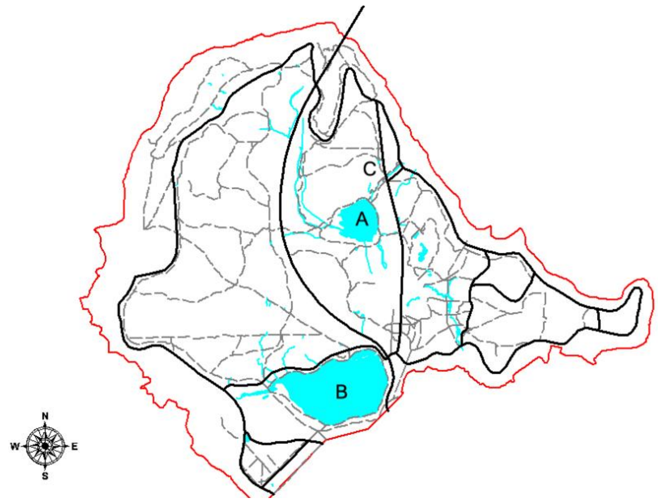

Figure 3.The two major water bodies in Stanley Park: Beaver Lake (A) and Lost Lagoon (B). Beaver Creek (C) is fed by Beaver Lake.

Stanley Park provides important habitat for many wildlife species, both resident and migratory. Much of the most productive wildlife habitat in the park is concentrated around Lost Lagoon and Beaver Lake. Lost Lagoon is especially important for migrating and local bird resting and feeding habitat. The smaller Beaver Lake forms the majority of high quality wetland habitat in the park. Many mammal species including Striped Skunks (*Mephtis mephitis)*, Raccoons (*Procyon lotor*) and introduced Eastern Grey Squirrels (*Sciurus carolinensis*) have significant populations within Stanley Park (SPES, 2010). Both waterbodies provide crucial foraging habitat and freshwater access for the bat community of the park.

Stanley Park is located in the dry maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (Green & Klinka, 1994). Exhibiting the coniferous forest typical to the climax stage of this zone, the dominant tree species in Stanley Park are western hemlock (*Tsuga heterophylla*)*,* coastal Douglas-fir, and western red-cedar (VNHS, 2006). This temperate zone has warm, dry summers and moist, mild winters with little snowfall.

On December 15, 2006 through early January 2007 major windstorms caused extensive blowdown damage throughout Stanley Park (Figure 4), with the most apparent damage focused on Prospect Point (SPES, 2009b). The entire area was affected, with approximately 10,000 trees blown down in the park (VBPR, 2009). The windstorms created a mosaic of open spaces within what was previously mature second growth forest habitat. While the damage and subsequent removal of fallen trees changed the habitat values of the mature forests affected, the subsequent renewal of the forest created new wildlife habitat in the park. The blowdown areas were intensively restored for aesthetic values with 15,000 trees and shrubs planted by the Vancouver Park Board (VBPR, 2009).

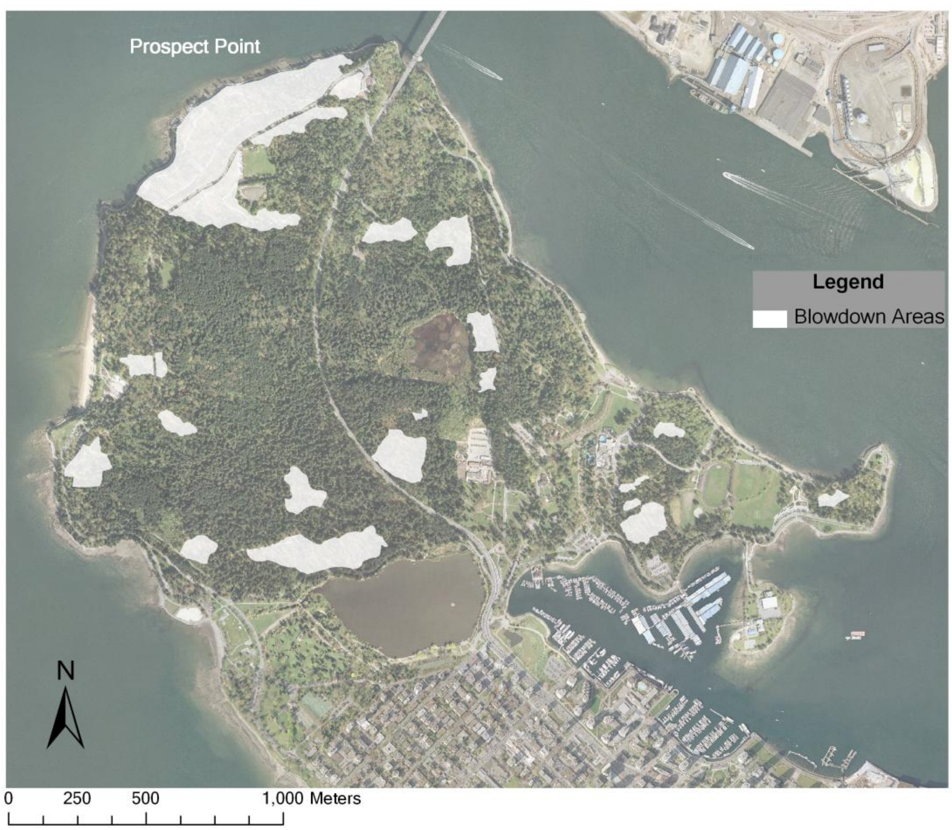

Figure 4. Stanley Park blowdown affected areas following the major December 2006 windstorm.

4.0 Methods

4.1 Colony Emergence Count

Three colony emergence counts were conducted on August 15, 18, and 20, 2009. The counts were performed at an identified maternity colony site at the Stanley Park Dining Pavilion. A visual count of bat emergences was made starting approximately 30 minutes before sunset. Each bat was counted as it emerged by carefully monitoring the colony entrance.

4.2 Acoustic Monitoring

Two series of acoustic surveys were conducted for the Stanley Park Bat Survey. The first series was conducted in summer from August 15 to September 19 2009. The second series was conducted from October 27 2009 until April 14 2010.

The acoustic survey was a presence/not-detected survey carried out according to guidelines from the Resource Inventory Standards Committee (RISC) Inventory Methods for Bats (Ministry of Environment, 1998). The survey was conducted using a Batbox III heterodyne bat detector to acoustically monitor feeding and travelling activity. Most echolocation bursts, produced when bats are navigating or homing in on prey, are inaudible to humans. Heterodyne bat detectors convert the ultrasonic sound into frequencies audible to the human ear. The behaviours of the bats can be ascertained by listening to the regularity of the sound. Bats emit different sounds depending on their activity. While navigating, the echolocation bursts have a relatively slow rate, resembling a regular 'put', 'tick' or 'chirp' sound. These slower echolocation pulses are called 'passes'. During feeding activity the echolocation pulses speed up to resemble a 'buzzing' sound. These are called 'feeding buzzes' or 'buzzes' (Ministry of Environment, 1998). A 'tonal chirp' sound recoded while monitoring bat navigating pass activity was recorded as a pass on the first survey. Starting with the second summer survey session, 'chirp' sounds were recorded

in their own category due to a noticeable acoustic difference from other navigating 'passes' noted while surveying.

The acoustic monitoring procedure, as outlined in RISC, requires monitoring the 20, 30 and 40 kHz range of frequencies. This is necessary to monitor the range of echolocation frequencies used by the different bat species believed to be in the area, as many species echolocate at unique frequencies (Ministry of Environment, 1998). At every monitoring site the 20 kHz frequency was monitored for a 5 minute period after which the frequency was increased by 10 kHz until all three frequencies had been monitored. The detector was then returned to 20 kHz and the monitoring cycle repeated for a total monitoring period of 30 minutes. All of the acoustic monitoring sessions were conducted at night, from after sunset to 01:00.

4.2.1 Summer Acoustic Monitoring

From August 15 to September 19 2009 a total of fourteen acoustic surveys were carried out. Each of the fourteen sites was monitored once for two monitoring cycles, for a total of 30 minutes. Each of the fourteen sites was chosen to represent the range of habitats available to bats within the park (Figure 5). Site selection was conducted according to RISC standards, which recommends selecting sites based on the identified habitat preferences of bats. Freshwater and marine shoreline habitats are known to be preferred feeding sites, as well as clearings near water (Nagorsen & Brigham, 1993). The sites chosen for the acoustic survey focused on areas where the habitat provided potential roosting sites and water access within close proximity. Trails were also identified as possible travel corridors for monitoring.

Figure 5. The 14 acoustic monitoring sites used for the 2009/2010 Stanley Park Bat Survey.

4.2.2 Winter Acoustic Monitoring

From October 27 2009 to April 14 2010 a total of 11 acoustic surveys were carried out. Each site was monitored for 2 monitoring cycles, for a total of 30 minutes. All winter monitoring was conducted at two of the fourteen monitoring sites, Lost Lagoon (Site 2) and Beaver Lake (Site 5). Throughout the winter, monitoring frequency was reduced to once a month, or as weather conditions allowed. Monitoring in winter was focused on the Lost Lagoon and Beaver Lake sites due to their proximity to water and optimal foraging habitat. By conducting monitoring at sites with high quality habitat the probability of detecting low levels of bat activity during the winter was increased. Winter monitoring sessions were carried out just after sunset.

4.3 Mist-Net Trapping

Nine net nights of live mist-net trapping were carried out over four work nights on August 30, 31 and September 13, 21 2009. A set of three 38mm mesh, 2.6m x 9m mist nets were used. The

mist-net trapping focused on areas over water as most bats use open water for drinking and foraging. Reconnaissance surveys were conducted to determine productive areas over or near water to employ the mist-nets. Mist-net arrays of 1 to 3 mist nets were used at each site. Mist-nets were set up over land to block travel corridors, with nets set over water deployed with a minimal clearance over the water surface to effectively capture bats. Bats were also captured at the entrance to the colony roost with a single hand-held net, providing an opportunity to examine the bats emerging from the roost site.

Upon capture the bats were placed into labelled cotton bags and retained for one hour to allow the complete digestion and elimination of any food in the gut that could potentially affect the weight of the animals. Cotton bags were used to prevent injury or suffocation during the holding period (Wilson, et al.1996). After the holding period each bat was weighed and sexed, a description of the bat's fur colour and behaviour was recorded, and specific measurements of the forearm, ear, and tragus were made (Figure 6). The age class of the bat was determined to be adult or immature by examining the swelling of the finger joint as juvenile bat bones are not fully fused (Figure 7). Species specific features were also examined for identification purposes. These features included the presence of a fringe on the tail (Figure 8 A and B), whether the calcar was keeled (Figure 8 C and D) or if the area around the eyes was bald. All the bats were examined by order of capture, ensuring the bats were processed as quickly as possible as prolonged holding can cause extra stress to bats (Wilson, et al.1996).

Figure 6. Features used to identify bat species on the 2009/2010 Stanley Park Bat Survey: Forearm measurement (FA). Ear measurement (E). Tragus measurement (TR) (Source: Nagorsen & Brigham, 1993).

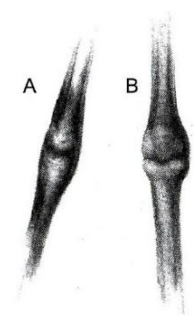

Figure 7. Features used to determine bat maturity on the 2009/2010 Stanley Park Bat Survey: Finger joint of a mature bat (A). Finger joint of an immature bat (B) (Source: Nagorsen & Brigham, 1993).

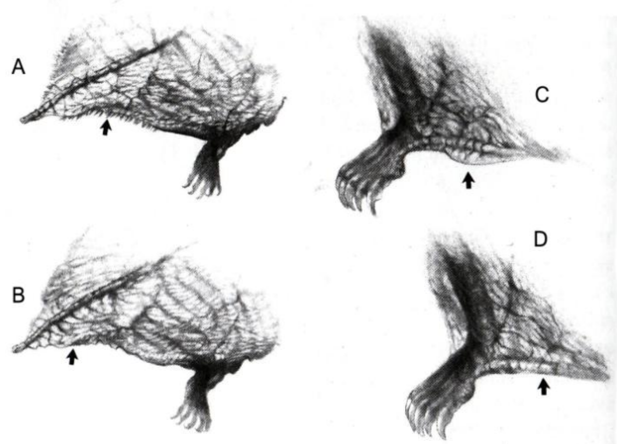

Figure 8. Features used to identify bat species on the 2009/2010 Stanley Park Bat Survey: Tail with fringe present (A) and absent (B). Calcar with keel (C) and unkeeled (D) (Source: Nagorsen & Brigham 1993).

4.4 Habitat Survey

The habitat survey was comprised of two components. The first was to gather information using maps, orthophotos and Geographic Information Systems (GIS) map layers to develop a site description for each monitoring site. The second component was a survey of the potential roost trees in the forested regions within a 50 m radius of Beaver Lake and Lost Lagoon.

Information gathered for each of the fourteen sites included forest stand data and site proximity to habitat features. The forest plantation map of Stanley Park was used to describe the forest age class, year the stand was established, dominant tree species and average height of the stand of each of the monitored sites (Beese & Paris, 1989). ArcMap map data was used to describe the vegetation site association of each monitoring site, as well as the site proximity to freshwater, wetland, trails and roads. The ArcMap linear measurement tool was used to measure the distance from each site to the nearest freshwater, wetland, trail and road in metres. Elevation was not corrected for as the distance was measured as a bat would fly.

The wildlife tree survey was conducted by evaluating all trees in the 50 m riparian region of Beaver Lake and Lost Lagoon for their bat roost habitat value. Potential bat roosts were considered to be wildlife trees, which are large live trees or damaged trees and dead trees. All tree species were included in the survey. Wildlife trees were categorized using RISC guidelines for wildlife tree assessment (Ministry of Environment, 2009). Minimum height and diameter at breast height (DBH) parameters were set based on bat behaviour and habitat needs. Bats prefer tall, large trees that provide security and thermal regulation as roost sites (Arnett & Hayes, 2009). Dead trees were considered wildlife trees if they were 5 m in height or more. Live trees were considered potential roost trees if they were 5 m in height or more with a DBH of 150 cm and over. A DBH of 150 cm was used to select veteran trees within the park, to be consistent with previous veteran tree surveying conducted in Stanley Park by SPES. Tree heights were

visually estimated and DBH measurements taken with a diameter tape. The trees were mapped using a handheld GPS unit to record a UTM point for each tree surveyed.

4.5 Education Module

A bat focused classroom education module was created for Stanley Park Ecology Society's education program department. The module was designed to meet the BC Integrated Resource Package life science curriculum for grades 5-7 (British Columbia Ministry of Education, 2005). This learner range complements the current SPES bat education program intended for grades K-4. The program created for SPES consists of a 45 minute presentation integrating two 10 minute interpretive presentations and two interactive activities. The presentation focuses on the bats of BC and provides an overview of the key aspects of their anatomy, life history, and ecological role. The activities examine the anatomical similarities between humans and bats and demonstrate how echolocation functions. The program incorporates an opportunity for interested educators to participate in an interpretive walk around the school grounds to explore potential bat habitat and discuss the habitat needs of bats. Bat-box building plans are also given to the educator to provide further opportunities for learning.

5.0 Results and Discussion

5.1 Colony Emergence Count

A bat maternity colony was first discovered in the Stanley Park Dining Pavilion in the spring of 2007. A preliminary survey of the colony on August 4, 2009 recorded 163 bats emerging from the colony at dusk (Worcester,Pers. Comm. 2009). Colony emergence counts conducted on August 15, 18 and 20 2009 found a maximum of 9 emerging bats.

The first emergence count of the Dining Pavilion maternity colony for the Stanley Park Bat Survey was conducted on August 15, 2009 from 20:10 until 22:20. The first bats were seen at 20:43. A total of 9 bats were observed. The second emergence count was done on August 18, 2009 from 20:10 until 22:00. No bats were observed. The final emergence count was done on August 20, 2009 from 19:10 until 21:45. The first emergence was at 20:28. A total of 5 bats were observed.

The decrease in numbers of bats observed emerging from the colony over the month of August 2009 reflects the typical rearing period of bats in temperate climates (Nagorsen & Brigham, 1993). Bats mate in late summer or early autumn just before hibernating. Fertilization is delayed until after bats awaken from hibernation, with young born typically in June or July and fledged by late August- early September (Nagorsen & Brigham, 1993). After this period female bats will disband their maternity colonies to mate in preparation for migration or hibernation (Nagorsen & Brigham, 1993). Based on the colony count results the maternity colony in Stanley Park appears to disband in mid-August.

The maternity colony in Stanley Park is believed to be a Yuma Myotis colony as most large maternity colonies found in the Lower Mainland of BC have been identified as Yuma Myotis

(Eder & Pattie, 2001). Mist-netting at the colony site produced a male Big Brown Bat which was captured as it emerged from the maternity colony entrance. Multiple species of bats may share a roost space, however it is unknown if the male and female bats are using the space concurrently as bats usually use sexually segregated roosting sites (Altringham, 1996). However male Big Brown Bats may use the same roost sites as female bats of other species as they have similar thermal requirements to female Yuma Myotis (Lausen & Barclay, 2006).

5.2 Summer Acoustic Monitoring

Acoustic monitoring revealed bat activity of varying levels at all but one of the sites monitored (Table 2). Lost Lagoon (Site 2) had the highest number of feeding buzzes (53) and passes (119), with Beaver Lake (Site 5) having the second largest number of feeding buzzes (16) and passes (71). Sites near the seawall (Sites 7, 8 and 12) had the next highest level of feeding buzz and pass activity. Acoustic monitoring results for the other sites documented activity throughout the park with lower frequency. While monitoring pass activity multiple sounds were identified, however chirp sounds identified during the monitoring session at Lost Lagoon on August 15, 2009 were combined with other pass activity.

Table 2. Acoustic survey summary of bat echolocation activity during the 2009/2010 Stanley Park Bat Survey, Vancouver BC.

Site	Site Description	Date	Site UTM	Total Pass¹	Total Chirp²	Total Buzz³
1	Entrance To Mallard/Brockton Oval Trail	15-Aug-09	0490751 5460730	0	X*	0
2	Lost Lagoon North End	15-Aug-09	0489750 5460498	119	X*	53
3	Prospect Point, Lions Gate Lookout	18-Aug-09	0489634 5462289	9	0	0
4	Hollow Tree, Back End of Field	18-Aug-09	0488909 5461562	6	2	1
5	Beaver Lake, North End	20-Aug-09	0489935 5461401	71	10	16
6	South Creek Trail Entrance	20-Aug-09	0489966 5460704	4	0	0
7	Seawall near Second Beach	22-Aug-09	0489105 5460013	32	21	2
8	Blow-down Area near Second Beach	22-Aug-09	0488896 5460539	24	0	6
9	Junction of Siwash/Merriles Trail	26-Aug-09	0489269 5462122	5	0	0
10	Mini Train Entrance	26-Aug-09	0490276 5460994	4	2	0
11	Brockton Oval Trail Bench	26-Aug-09	0490673 5460709	1	0	0
12	Beaver Creek Bridge/Sea Wall	11-Sep-09	0490134 5461594	29	0	7
13	Bridle Path	19-Sep-09	0489370 5461846	1	0	0
14	Lost Lagoon Under Stone Bridge	19-Sep-09	0489377 5460330	29	1	8

1= Echolocation activity while navigating is noted as a pass
3= Echolocation activity while navigating, but heard as a higher tone, is noted as a chirp
2= Echolocation activity while feeding is noted as a buzz
X*=Tonal chirps heard but not distinguished during the first survey, included in the pass category

The activity levels are represented as high (>30), medium (15-30) and low (<15), by the total number of passes recorded at each site (Figure 9).. All of the high and medium levels of activity were recorded at sites associated with freshwater. Lower incidences of activity were found at the sites farthest from major sources of freshwater, including waterbodies, streams and wetlands. Developments such as bridges, trails and the seawall did not seem to affect activity levels.

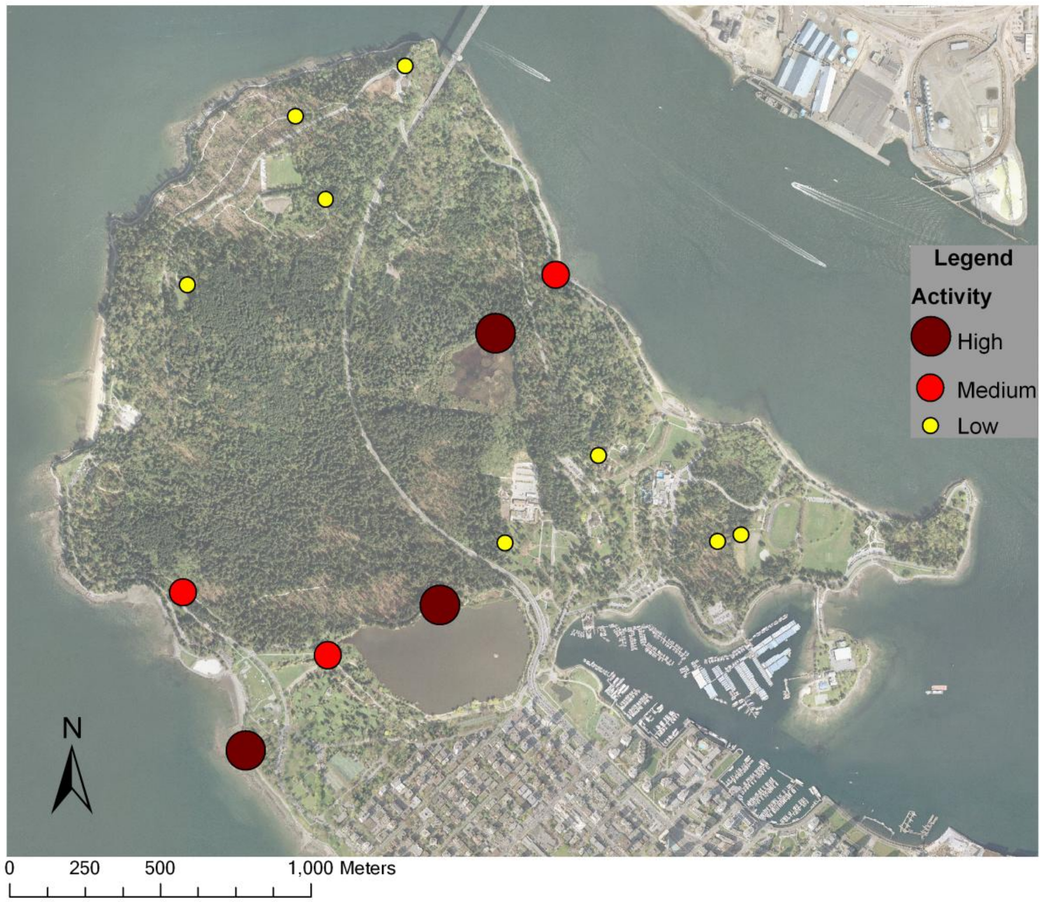

Figure 9. 2009/2010 Stanley Park Bat Survey August-September 2009 acoustic monitoring pass activity by site.

A comparison of pass activity recorded at all fourteen sites during the summer acoustic survey found that the majority of pass activity was recorded while monitoring the 40 kHz frequency with the remainder of the activity split nearly evenly between 20 kHz and 30 kHz. Over 50% of the chirp sounds produced during pass activity was observed in the 20 and 30 kHz range with only a small percentage in the 40 kHz range.

The heterodyne bat detector is limited by not being able to record and analyze echolocation bursts to narrow the identification of individuals to the species level, however the range of frequencies noted during acoustic surveys suggests the presence of multiple bat species. The largest percentage of echolocation activity was noted in the 40 kHz range, which is the frequency used most often by the Myotis genus of bats (Alberta Fish and Wildlife Division, 2000). This correlates with the species captured in the mist-net trapping survey, which were largely Myotis bats. The pass activity with ‘put’ sounds noted at 20-30 kHz could possibly indicate the presence of Big Brown Bats, which were trapped in the mist-net survey, Acoustic data cannot be used to identify species of bats but do suggest a diversity of species use the park. Echolocation frequencies used by bats that are potentially found in Stanley Park are shown in Table 3.

Table 3. Echolocation frequencies of the ten species of bats found in the Lower Mainland of British Columbia when using a heterodyne bat detector (Adapted from RISC 1998).

Common Name	Echolocation Frequency
Silver-haired Bat	25-35 kHz, output a tonal chirp
Big Brown Bat	25-35 kHz, output a "put" sound
Hoary Bat	20 kHz
Townsend's Big-eared Bat	20-90 kHz
Keen’s Myotis	40 kHz, output a sharp "tick"
Little Brown Myotis	40 kHz, output a sharp "tick"
Yuma Myotis	40 kHz, output a sharp "tick"
California Myotis	40 kHz, output a sharp "tick"
Western Long-eared Myotis	40 kHz, output a sharp "tick"
Long-legged Myotis	40 kHz, output a sharp "tick"

The first acoustic monitoring session recorded tonal chirps, which were documented separately in following monitoring sessions to aid in the interpretation of the data. This was important as bats are known to echolocate at a range of frequencies depending on species and different sounds indicate the possibility of different species. Tonal chirps heard at the 20 kHz frequency suggest that species such as Hoary Bats, Townsend's Big-eared Bats or Silver-haired Bats are using habitat within Stanley Park. Following the survey a Silver-haired Bat was captured in Stanley Park in April 2010.

Acoustic monitoring determined the presence of bats at throughout Stanley Park. Bats were detected at all but one of the sites surveyed. Bat activity was distributed throughout the park, with the highest levels recorded in edge habitats close to water (Table 2). A large percentage of bat activity was detected near Lost Lagoon and Beaver Lake. This supports previous research which shows that bats prefer habitat with access to fresh water for drinking and foraging (Arnett, 2007). Supporting the recorded acoustic data, bats were also observed visually engaging in foraging above the surface of waterbodies in the park. Higher insect concentrations around waterbodies may increase bat activity in these areas. The marine environment also showed high levels of use, possibly because Yuma Bats, the most numerous species identified using the park (See Section 5.4), are known to forage over saltwater (Brigham et al. 1992; Nagorsen & Brigham, 1993). Estuarine habitats, where freshwater and marine water are in close proximity have been conjectured to provide good habitat for bats (Nagorsen & Brigham, 1993), which was supported by the high bat use noted at the estuary of Beaver Creek (Site 12).

Open areas are typically preferred for use as travel corridors and feeding areas for bats. Trails and clearings provide habitat structure appropriate for foraging and travel, with insects congregating in clearings and providing foraging opportunities. Most bats are intolerant of cluttered roost sites or travel routes and prefer open access through a site (Cryan & Brown,

2007). Acoustic monitoring results produced passes with little accompanying feeding activity in open areas not in close proximity to freshwater. This suggests that these areas are being used primarily as travel corridors. The open forest structure prevalent in the blow down sites (Sites 3, 5, 11) showed similar levels of activity to those noted in clear areas (Sites 4, 6), indicating that these open areas provide habitat value to bats as foraging sites or possible travel routes to more preferred foraging areas.

5.3 Fall-Winter Acoustic Monitoring

Fall and winter acoustic surveys detected no bat activity from November 2009 until April 2010. Low levels of activity were detected at Beaver Lake (Site 5) on October 27 2009, with no further activity detected throughout the winter monitoring sessions at Beaver Lake or Lost Lagoon (Site 2). Bat echolocation activity was first detected on March 3 2010 at Beaver Lake. Following March 3 2010, all subsequent monitoring sessions at both sites through March and April of 2010 produced bat activity, with a trend toward increasing levels of activity, represented by total passes (chirps, ticks and puts) (Figure 10).

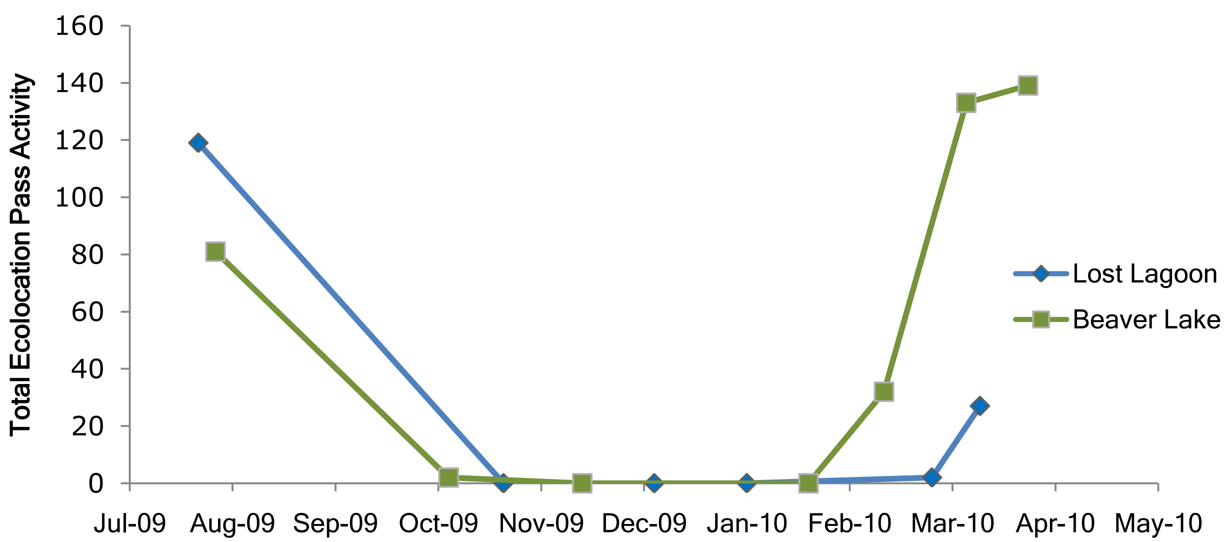

Figure 10. 2009/2010 Stanley Park Bat Survey acoustic monitoring echolocation activity levels at Beaver Lake and Lost Lagoon.

Bat activity is thought to decrease through the fall and winter, as bats in temperate climates generally hibernate or migrate for the winter (Falxa, 2007). In periods of warming temperatures bats may rouse to drink and forage. Periods of lower temperatures require higher energy resources for bats to sustain activity. Cooler weather produces lower insect populations that may not provide bats with sufficient energy resources to maintain regular activity.

5.4 Mist Net Trapping

A total of 20 bats were captured over 9 trap nights in August and September 2009 (Figure 11).Three species were captured over the trapping period: Yuma Myotis, Little Brown Myotis, and Big Brown Bat. Four of the bats captured were not identified to species because the similarity between Myotis species makes positive identification difficult without genetic analysis. Eighteen of the bats captured were male, two were female. Eighteen of the bats captured were mature, two were immature. Both of the female bats were mature adult bats.

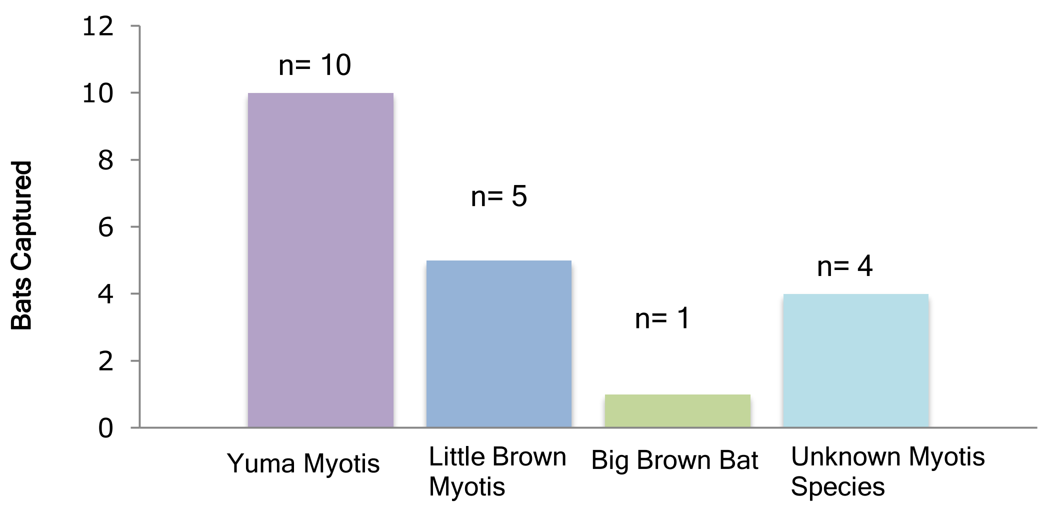

Figure 11. Total numbers of bats captured by species during mist net trapping sessions in August and September 2009 of the 2009/2010 Stanley Park Bat Survey.

Mist-net trapping was productive, with all trap sessions being successful in capturing bats. The most productive trapping sites were the Beaver Creek Bridge/ Seawall and Beaver Lake (Table 4). The largest numbers of bats caught were Yuma Myotis, a species known to be locally abundant in the Lower Mainland of BC that has been previously observed in Stanley Park (VNHS, 2006). The other two species caught, the Little Brown Myotis and the Big Brown Bat are also known to be well distributed in BC (Eder & Pattie, 2001). Mist-net trapping sessions in 2008 produced two Big Brown Bats, two Little Brown Myotis and two unknown Myotis genus. The bats captured in 2008 represent most of the same species as the 2009 mist-net captures.

Mist-net trapping confirmed the presence of bats detected through the acoustic surveying and provided an opportunity to confirm what species of bats are found within the park. This was complementary to the acoustic monitoring, which can reliably detect bats but cannot be used to identify the species of bats. The mist net trapping confirmed the results of the acoustic survey, with almost all of the bats caught belonging to the Myotis genus, the only exception being the Big Brown Bat.

Table 4. Mist-net capture results 2009/2010 Stanley Park Bat Survey, Vancouver BC.

Date	Site	Net	Species	Sex	Age class
Aug-30-09	Beaver Lake North End	1	Yuma Myotis	M	Adult
Aug-30-09	Beaver Lake North End	1	Little Brown Myotis	M	Adult
Aug-30-09	Beaver Lake North End	1	Myotis Species*	M	Adult
Aug-30-09	Beaver Lake North End	1	Yuma Myotis	M	Adult
Aug-30-09	Beaver Lake North End	1	Yuma Myotis	M	Adult
Aug-30-09	Beaver Lake North End	1	Little Brown Myotis	M	Adult
Aug-30-09	Beaver Lake North End	1	Myotis Species*	M	Adult
Aug-30-09	Beaver Lake North End	1	Myotis Species*	M	Adult
Aug-30-09	Beaver Lake North End	2	No Captures		
Aug-31-09	Pavilion Maternity Colony	1	Big Brown Bat	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	1	Yuma Myotis	M	Immature
Sep-13-09	Beaver Creek Bridge/Sea Wall	1	Yuma Myotis	F	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	1	Yuma Myotis	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	1	Yuma Myotis	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	1	Myotis Species*	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	1	Yuma Myotis	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	2	Little Brown Myotis	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	2	Little Brown Myotis	F	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	2	Little Brown Myotis	M	Adult
Sep-13-09	Beaver Creek Bridge/Sea Wall	3	No Captures		
Sep-21-09	Lost Lagoon Stone Bridge	1	Yuma Myotis	M	Immature
Sep-21-09	Lost Lagoon Stone Bridge	1	Yuma Myotis	M	Adult
Sep-21-09	Lost Lagoon Stone Bridge	2	No Captures		
Sep-21-09	Lost Lagoon Stone Bridge	3	No Captures		

Myotis Species*= Positive identification to species not possible without genetic analysis.

The mist-net trapping conducted in August and September 2009 caught primarily male bats. The September 2008 bat mist-netting sessions caught only male bats. The uneven gender ratio in trap captures may reflect the late season dispersal of female bats after the reproductive season. This corresponds with the low number of bats observed during emergence counts made at the maternity colony in August 2009. The mist-net session conducted at the entrance to the Pavilion maternity colony site caught one adult Big Brown Bat male, which suggests that the colony site is utilized by multiple species of bats. The colony is suggested to be made up of female Yuma Myotis during the reproductive season as they are the most common colonizing bat in the Lower Mainland (Eder & Pattie, 2001).

Male Big Brown Bats may use the same roost sites as female Yuma Myotis as they have similar thermal requirements (Lausen & Barclay, 2006).Other bat species are possibly sharing the roost space or moving in after the females move out of the colony site at the end of the reproductive season. The changing thermal needs of the bats could precipitate this movement, as during the early summer reproductive period female bats are in need of a warm space, while most male bats prefer cooler roosts (Nagorsen & Brigham, 1993). Mist-netting and monitoring in the 2009/2010 study took place later in the year (late August – early September) after the reproductive period when the thermal needs of female bats are reduced, possibly allowing other bats to move into the space following the dispersal of the females. Mist net trapping also intercepted two immature bats, indicating that the young of the year had fledged and the reproductive period of the year had been completed.

5.5 Habitat

Stanley Park provides bat habitat throughout the park. The mature coniferous forest, well distributed freshwater sources and riparian corridors maintained within the park are valuable to

many species of bats. In order to examine the distribution of valuable habitat features each monitoring site was described based on habitat data previously collected on digital maps.

5.5.1 Stanley Park Map Survey

Using ArcMap GIS map layers and data from the Stanley Park forest plantation map, habitat data for each of the 14 acoustic monitoring sites was compiled. The forest stand information (Beese & Paris, 1989) and site association for each site is shown in Table 5. The monitoring sites represent the range of stand ages and site associations within Stanley Park currently. The domination of western hemlock in the forest stand tree species make-up reflects the past forestry harvest practices, which preferentially selected western red cedar and Douglas-fir for harvest.

Table 5. Forest vegetation type for the 14 acoustic monitoring sites in the 2009/2010 Stanley Park Bat Survey.

Site #	Forest Age Class	Age/Year Established	Dominant Tree Species*	Average Height	Site Association†
1	Immature	1964	Fd		L-F-S
2	Not Forested				W
3	Immature	1958	Hw > Dr		S-S
4	Immature	1956	Hw > Fd		S-W-F
5	Mature	300 years	Hw Cw >Fd	43 m	D-S
6	Mature	1875	Hw Fd	48 m	L-F-S
7	Not Forested				
8	Immature	1965	Dr		SC
9	Mature	300 years	Hw >Cw >Fd	45 m	F-S
10	Mature	1875	Hw Fd	49 m	None
11	Mature	225 years	Hw >Cw Fd	43 m	L-F-S
12	Mature	300 years	Cw >Hw	45 m	L-F-S
13	Immature	1951	Fd >Hw		F-S
14	Not Forested				W

*RISC Tree Codes: Fd – Douglas-fir, Hw – western hemlock, Cw – western red cedar, Dr – red alder

† Site association: L-F-S = lady fern-foamflower-sword fern
S-S = sword fern-spiny wood fern
S-W-F = sword fern-spiny wood fern-foamflower
D-S = deer fern-salal, F-S = foamflower-sword fern
SC = skunk cabbage W= wetland

Mature and old growth forest stands provide optimum habitat for forest-using bats (Humes et al. 1999). The mix of stand ages in Stanley Park provides open corridors and foraging locations in proximity to available roosting sites. A heterogeneous forest structure is preferred by bats to young forests or predominantly open areas lacking edges for cover (Luszcz, 2004). Stanley Park is extensively managed, with most of the large trees in Stanley Park topped for aesthetic values. This reduces the vertical heterogeneity of the forest and is less favourable for bats, which prefer treetops that extend beyond the forest canopy (Brigham, et al. 1997). The diversity of site associations in Stanley Park provides bats with habitat features that are increasingly less

common in the Lower Mainland. All six site associations present in Stanley Park are represented by the monitoring sites used in the survey. The diversity of available habitat in the park is important for bat populations.

Freshwater and wetlands are beneficial habitat features for bats, providing foraging and drinking opportunities. Stanley Park provides well distributed riparian habitat and freshwater access, creating high-quality bat habitat (Luszcz, 2004). Trails and low use roads may be used as travel corridors for bats, however high use roads pose a risk to bats and may cause negative impacts (Lesinski, 2008). Table 6 shows the proximity of each monitoring site to features that affect habitat quality for bats.

Table 6. Site proximity to habitat features for the 14 acoustic monitoring sites in the 2009/2010 Stanley Park Bat Survey.

Site #	Site	Freshwater Proximity (m)	Wetland Proximity (m)	Trail and Road Proximity (m)
1	Entrance To Mallard/Brockton Oval Trail	950	240	13
2	Lost Lagoon North End	2	72	2
3	Prospect Point, Lions Gate Lookout	975	180	0
4	Hollow Tree, Back End of Field	950	260	90
5	Beaver Lake, North End	5	15	0
6	South Creek Trail Entrance	200	230	0
7	Seawall near Second Beach	0	150	0
8	Blow-down Area near Second Beach	600	19	4
9	Junction of Siwash/Merriles Trail	350	160	0
10	Mini Train Entrance	65	270	0
11	Brockton Oval Trail Bench	920	320	0
12	Beaver Creek Bridge/Sea Wall	0	38	0
13	Bridle Path	54	260	0
14	Lost Lagoon Under Stone Bridge	1	320	0

5.5.2 Wildlife Tree Survey

A total of 82 wildlife trees were counted during potential roost tree surveys around Beaver Lake and Lost Lagoon. Around Beaver Lake 50 trees were counted (Figure 12) while 32 trees were counted around Lost Lagoon (Figure 13). At Beaver Lake four tree species were included in the wildlife tree survey: western red cedar, 32 trees (36%), western hemlock, 32 trees (36%), coastal Douglas-fir, 10 trees (20%), and red alder, 4 trees (8%). At Lost Lagoon four species were included: western red cedar, 23 trees (72%), western hemlock, 5 trees (16%), bitter cherry (*Prunus emarginata,*) 2 trees (6%), and coastal Douglas-fir, 2 trees (6%).

Figure 12. Beaver Lake wildlife tree locations surveyed during the 2009/2010 Stanley Park Bat Survey.

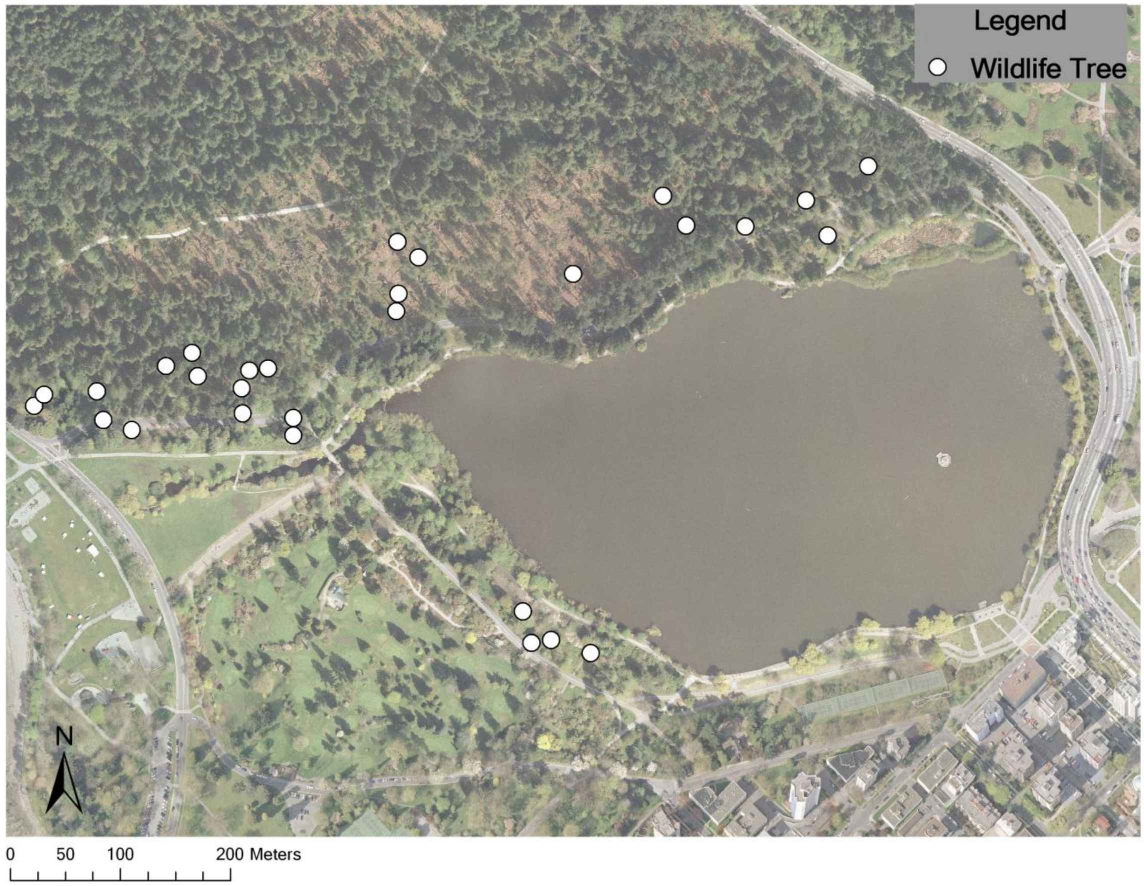

Figure 13. Lost Lagoon wildlife tree locations surveyed during the 2009/2010 Stanley Park Bat Survey.

Proximity to freshwater is important for bat roosting sites, with previous research showing decreased capture rates at potential roosting sites as the distance from foraging sites increased (Luszcz, 2004; Arnett, 2007; Arnett & Hayes, 2009). The distribution of appropriate roosting trees in the riparian areas of both of the major waterbodies in Stanley Park is an indicator of high quality potential bat habitat. Bats use the peeling bark, bark crevices and cavities of trees as roosting habitat. Veteran and dead trees offer bats many crevices and cavities for use as roosting sites.

Previous research has found that the probability of a tree being used by bats as a roost increased as the DBH increased (Arnett, 2007). In one study of Yuma Myotis roost preferences,

conifer trees with a DBH ≥ 115 cm were found to be the most preferred site, with live trees of a smaller diameter used less frequently. (Evelyn et al. 2003). Many trees exceeding this size were found in the riparian surveys, providing roosting habitat for Yuma Myotis as well as other tree roosting bats. Douglas-fir trees appear to be the most important species of tree for tree roosting bats followed by western hemlock and western red cedar (Brigham, et al. 1997; Evelyn et al. 2003; Arnett, 2007; Arnett & Hayes, 2009) Few veteran coastal Douglas-fir trees were found on either survey site, however the mature forest community of the park provides relatively high numbers of veteran western red cedar trees with large cavities and crevices for use as roosts, as well as younger Douglas-fir trees.

6.0 Education Module

The Stanley Park Ecology Society offers BC curricula-focused school programs and public education. A resource package and school group presentation for the SPES education department was created to supplement the existing grades K-4 program, enhancing the life science curriculum offered for grades 5-7 (British Columbia Ministry of Education, 2005). The guidelines and linked subjects are as follows:

Grade 5

- Describe the basic structure and functions of the human respiratory, digestive, circulatory, skeletal, muscular, and nervous systems
- Explain how the different body systems are interconnected

As mammals, bats have many similarities to humans and can be used for comparison to facilitate understanding of the human body. The digestive and nervous systems of bats can also be compared to that of humans, providing insight to their functions. Bats have respiratory and circulatory systems similar to humans, differing from birds while facilitating flight. The muscular

and skeletal systems of bats are based on the same components as humans but are uniquely adapted for flight. An examination of the 'hand-wing' structure of bats is an important feature of bat education and can be used to increase understanding of human skeletal and muscular systems while showing how bats have adapted all of their body parts for an aerial existence.

Grade 6

- Demonstrate the appropriate use of tools to examine living things that cannot be seen with the naked eye
- Analyse how different organisms adapt to their environments
- Distinguish between life forms as single or multi-celled organisms and belonging to one of five kingdoms: Plantae, Animalia, Monera, Protista, Fungi

Echolocation, common to all BC bats, uses high-frequency pulses that cannot usually be perceived by humans. The use of an ultrasonic detector to convert high-frequency pulses into audible sounds is used to detect bats that cannot be seen or heard. Bats are adapted to their environments in several ways that can be explored, including torpor and hibernation. The nocturnal and crepuscular life strategy of bats is also a unique adaption that allows them to fill a specific ecological niche. Bats are excellent examples of animals that adapt to different environments by utilizing a range of habitats.

Grade 7

- Analyse the roles of organisms as part of interconnected food webs, populations, communities, and ecosystems
- Assess survival needs and interactions between organisms and the environment
- Assess the requirements for sustaining healthy local ecosystems
- Evaluate human impacts on local ecosystems

Bats have specific environmental requirements for roosting and foraging habitat. Diverse natural communities provide the secure roosting habitat and foraging opportunities that bats rely on. As nocturnal invertebrate predators, bats fill an essential role in the ecosystem similar to, but uniquely different from that of insectivorous birds. The long lives and low reproductive rate of bats makes bat populations vulnerable to negative human impacts. An environmental interaction currently occurring is White Nose Syndrome, a fungus introduced into caves in the north-eastern USA that is causing high mortality in bat populations that hibernate in caves.

7.0 Conclusion and Recommendations

The Bats of Stanley Park project is an important step in learning more about the bats of the Lower Mainland of BC. The project was successful in identifying four species of bats using the park and examining the distribution of bat activity in the different habitats available in the park. This will facilitate a better understanding of the habitat requirements of bats in Stanley Park and allows for better management of the bat species in the park. Conducting monitoring throughout the year was valuable to gaining a better understanding of the active period for bats in south western BC, and is useful for planning future studies.

Recommendations following this study are that acoustic surveying and mist-net trapping should continue annually. Ideally surveys should be carried out year-round, with greater intensity in the spring and summer. Summer acoustic surveys should be conducted from March to the end of September at least twice a month, with more regular monitoring being optimal. The number of monitoring sites should be increased to gain a better understanding of the distribution of bat in the park. Sites should be monitored multiple times during the survey period, providing a better estimate of bat activity at each site. Winter acoustic surveys should be conducted from October through February and should be carried out once a month on the sites with the highest quality habitat as based on the most up to date data. An Anabat bat detector should be used if possible,

as the acoustic data it records can be used to help identify bats to species. Mist-netting trapping should be conducted beginning in July, although care should be taken to avoid trapping near suspected maternity colony sites as this may impact nursing bats. The identified maternity colony should continue to be monitored using site visits or infrared camera technology to learn more about the bats using the site.

Stewardship of bat habitat is crucial to protecting bats in the park. All wildlife trees and large live trees in the riparian zones of Lost Lagoon and Beaver Lake should be preserved. Development requiring tree removal should be prevented and riparian areas preserved. Installation of bat boxes near Lost Lagoon would be beneficial in enhancing bat habitat in the area and would provide a valuable opportunity for educating the public on the importance of bats in the ecosystem.

Continuing to provide education on bats to the public and to schools is positive in raising awareness and shifting attitudes about bats. Bat box workshops, park interpretive walks and school-based education programs are all components to building support for bats in the community. To ensure that there are healthy bat populations into the future it is essential to educate people and build partnerships for bat conservation.

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9.0 Appendices

Appendix 1 Mist-Net Capture Data

Stanley Park Bat Capture Data

Project:	Stanley Park Bat Survey
Survey date:	Aug 30 2009
Study Area:	Beaver Lake
Study Site:	eaver Lake @ Beaver Cree
Cloud cover:	none
Wind:	none
Precipitation:	none
Temp (start):	22º C
Temp (end):	22º C
Sunset time:	19:58
Surveyors:	SL, RW, ER, DS

Mistnetting survey results:

Net 1 UTM	Over lake from bank
Start time:	20:20
closing time:	20:50
Captures:	8

ID #	Capt #	Capt time	tax code	sex	age class	mass (g)	forearm length (mm)	ear length (mm)	tragus length (mm)	keel	fur colour	fringe	bald eyes	behavior	comments
090830-01	1	20:30	MYYU	M	Adult	7.5	34.9	11.8		no	light brown	no			
090830-02	2	20:40	MYLU	M	Adult	7.3	37.1	12.6	4.7	no	dark brown/ lighter belly	no	no	fiesty	mites
090830-03	4	20:40	MY?	M	Adult	6	36.4	10.6	5.8	no	dark brown/ lighter belly	no	yes	feisty	
090830-04	5	20:40	MYYU	M	Adult	4.5	31.9	15	4.1	no		no	no	calm/ no vocalizations	
090830-05	6	20:45	MYYU	M	Adult	5.2	35	9.3	5.4	no	light brown		yes		
090830-06	7	20:45	MYLU	M	Adult	(e)7.5	33	11.4	6.4	no					
090830-07	8	20:45	MY?	M	Adult	3.5	35.1	10.43	5.2	no	dark brown/ lighter belly		yes		
090830-08	9	20:45	MY?	M	Adult	5.6	36.4	12	4.8	no	dark brown/ lighter belly				

Stanley Park Bat Capture Data

Project:	Stanley Park Bats
Survey date:	31-Aug-09
Study Area:	Stanley Park
Study Site:	Stanley Park Pavillion
Cloud cover:	None
Wind:	None
Precipitation:	None
Temp (start):	21°C
Temp (end):	21°C
Sunset time:	19:56
Surveyors:	SL, RW, ER, DS

Mistnetting survey results:

Net 1 UTM	by gate
Start time:	8:15
closing time:	8:45
Captures:	1

ID #	Capt #	Capt time	tax code	sex	age class	mass (g)	forearm length (mm)	ear length (mm)	tragus length (mm)	keel	fur colour	fringe	bald eyes	behavior	comments
090831-01	1	8:25	EPFU	M	Adult	13.7	47.5	12.95	15.49	N	Dark Brown	N	Y	Vocal/Firm Bite	

Stanley Park Bat Capture Data

Project:	Stanley Park Bats
Survey date:	13-Sep-09
Study Area:	Stanley Park
Study Site:	Stone Bridge@ seawal
Cloud cover:	80%
Wind:	low
Precipitation:	None
Temp (start):	19°C
Temp (end):	18°C
Sunset time:	19:29
Surveyors:	SL, RW, ER, DS

Mistnetting survey results:

Net 1 UTM: Mouth of Creek
Start time:
closing time:
Captures: 6

ID #	Capt #	Capt time	tax code	sex	age class	mass (g)	forearm length (mm)	ear length (mm)	tragus length (mm)	keel	fur colour	fringe	bald eyes	behavior	comments
090913-01	5	9:08	MYYU	M	Immature	7.5	34.29	9.35	5.11	N	Light Brown Pale Under	N	Y	Calm Docile	2nd tier
090913-02	4	9:30	MYYU	F	Adult	7.5	36.32	11.94	5.08	N	Light Brown	N	Y	Docile	Mites, Rich in pc
090913-03	2	9:33	MYYU	M	Adult	7.9	36.1	13.84	6.5	N	Light Brown Pale Under	Y	Y	Feisty	
090913-04	7	9:35	MYYU	M	Adult	6.7	33.45	13.87	5.92	N	Light Brown Pale Under	N	Y	Feisty	4th tier, vocal
090913-05	9	9:49	MY?	M	Adult	X	38.02	12.93	5.94	N	Light Brown Pale Under	N	N		
090913-06	8	9:56	MYYU	M	Adult	6.1	33.35	11.43	5.97	N	Light Brown Pale Under	N	Y		

Net 2 UTM: Top Net
Start time:
closing time:
Captures: 3

ID #	Capt #	Capt time	tax code	sex	age class	mass (g)	forearm length (mm)	ear length (mm)	tragus length (mm)	keel	fur colour	fringe	bald eyes	behavior	comments
090913-07	3	9:30	MYLU	M	Adult	6.6	37.1	10.34	5.74	N	Dark Brown Pale Under	N	Y		
090913-08	1	9:40	MYLU	F	Adult	7.3	37.2	11.99	5.13	N	Dark Brown Pale Under	N	Y		
090913-09	6	9:49	MYLU	M	Adult	8.1	36.83	12.67	5.15	N	Dark Brown Pale Under	Y	Y		

Stanley Park Bat Capture Data

Project:	Stanley Park Bats
Survey date:	21-Sep-09
Study Area:	Stanley Park
Study Site:	Lost Lagoon Bridge
Cloud cover:	5%
Wind:	None
Precipitation:	None
Temp (start):	14°C
Temp (end):	13°C
Sunset time:	19:12
Surveyors:	SL, RW, ER, DS

Mistnetting survey results:

Net 1 UTM	
Start time:	19:30
closing time:	22:10
Captures:	2

Net 2 0 captures
Net 3 0 captures

ID #	Capt #	Capt time	tax code	sex	age class	mass (g)	forearm length (mm)	ear length (mm)	tragus length (mm)	keel	fur colour	fringe	bald eyes	behavior	comments
090921-01	1	20:34	MYYU	M	Immature	5.4	35.1	11.8	5.8	N	Dark Brown	N	Y		
090921-02	2	20:47	MYYU	M	Adult	5.7	33.9	10.4	5.3	N	Dark Brown	N	Y	Vocal	

Appendix 2 Mist-Net Trapping Permit

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

Permit and Authorization Service Bureau
PO Box 9372 Stn Prov Govt
Victoria, BC V8W 9M3
Tel: 1-866-433-7272 or
250-952-0932

PERMIT

78470-25

WILDLIFE ACT

PERMIT SU09-55418

PERMIT HOLDER	Stanley Park Ecology Society - Echo Biology and Communication 5425 Indian River Drive North Vancouver BC V7G 2T7 ATTENTION: Susan Leech PHONE: (604) 904-2478

IS AUTHORIZED UNDER **s. 2(c)(i), 2(j), 2(k)(i), 2(m)** and **2(o)** of the *Permit Regulation*, B.C. Reg. 253/2000,

TO	**Capture and on-site release** up to thirty-(30) **California Myotis** (*Myotis californicus*), **Western Long-eared Myotis** (*Myotis evotis*), **Keen's Long-eared Myotis** (*Myotis keenii*) **Little Brown Myotis** (*Myotis lucifugus*), Long-legged Myotis (*Myotis volans*), **Yuma Myotis** (*Myotis yumanensis*), **Hoary Bat** (*Lasiurus cinereus*), **Silver-haired Bat** (*Lasionycteris noctivagans*), Big Brown Bat (*Eptesicus fuscus*), and **Townsend's Big-eared Bat** (*Plecotus townsendii*) in Lower Mainland Region 2, specifically Beaver Lake and the surrounding forest in Stanley Park for bat monitoring purposes. **Temporarily possess and transport** injured bats to the Vancouver Animal Emergency Care Clinic in Vancouver for the purposes of assessment, rehabilitation or euthanasia. **Release from captivity** (at above point of capture) above named bats. **Possess and dispose** of wildlife parts (above named bats) for scientific purposes.

SUBJECT TO THE FOLLOWING:

TERMS OF PERMIT	The permit holder must comply with the terms in Appendix A.
COMPLIANCE ADVISORY	Failure to comply with any term of this permit is an offence under the *Wildlife Act*, and may result in any or all of prosecution, suspension of the permit, cancellation of the permit, ineligibility for future permits, and denial of future permit requests.
PERIOD OF PERMIT	This permit is only valid from August 15, 2009 to September 30, 2009.
DATE OF ISSUE	July 20, 2009

[signature] **SIGNATURE OF ISSUER**	Jennifer McGuire Regional Manager Recreational Fisheries & Wildlife Programs Lower Mainland Region	**PERMIT FEE** $100.00 **HCTF SURCHARGE** $10.00

Last Updated: June 2, 2009

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Appendix 3 Brilliant Bats Education Program

3.1 Brilliant Bats Lesson Plan

Activity	Objective	Resources	Time Allocated
PowerPoint Presentation	Introduce bats of BC Discuss bat lifecycle and place in the ecosystem Explore bat anatomy and echolocation	Lap-top computer, projector, screen	Two 10 minute sections (Opening and closing presentation)
Anatomy Matching Game	Show comparative anatomy between bats and humans	Bat skeleton poster 2 Sets of 16 human part cut outs 1 set of bat trivia cards	15 minutes
Echolocation Game	Show how bats use echolocation for hunting	Shaker sets with distinct sounds	10 minutes
School Grounds Interpretive Walk (optional)	Explore examples of potential bat habitat on the school grounds	None	10 minutes
Follow-up Activities	Provide resources for teacher use following program	Printouts (crossword puzzle, bat box plans etc.)	N/A

3.2 Brilliant Bats Presentation Script Overview

Presentation breakdown with main goals:

1. **Introduction**
    a. Introduce yourself and your organization
    b. Introduce subject and tell audience how long the presentation will be and what will be covered
    c. Go over rules of conduct and how to ask questions

2. **Bat Species**
    a. Dispel misconceptions about bats (birds, rodents, blindness, caves, vampire bats, rabies)
    b. Describe where bats fit in the taxonomic system
    c. Show pictures of the 16 bat species in BC and mention unique facts

3. **Similarities of Anatomy to Humans**
    a. Flight
        i. Compare bats and birds and bats and humans
        ii. Show the mammalian body system adaptations to flight
        iii. Activity 1: Comparison game
    b. Echolocation
        i. Activity 2: Echolocation game
        ii. Compare bats and humans, explain body systems responsible for echolocation
        iii. Show adaptations for echolocation

4. **Life History**
    a. Discuss the unique lifecycle of bats
        i. Bat life cycle and longevity
        ii. Torpor and hibernation
    b. Diet
    c. Discuss bat habitats and roosting needs

5. **Ecosystem**
    a. Explain unique role as night time predators compare insectivorous birds environmental balance: thousands of insects eaten, unique niche in the environment
    b. Dangers to bats: white-nose, wind-turbines, pest control
    c. How people can help: bat-boxes

6. **Bat Science**
    a. Explain how scientists study bats using ultrasonic detection (bat detectors), night vision, traps
    b. Give examples of the difficulties of studying bats

7. **Review**
    a. Misconceptions
    b. Life cycle, flight, echolocation
    c. Ecology, human impacts
        i. How you can help

3.3 Comparative Bat Anatomy Game

Objectives

To teach the students how bat anatomy is comparable to human anatomy. The activity will focus on comparing 16 parts that are common between bats and humans. This will teach the students that even though the bat and human parts look dissimilar they function in similar ways and evolved from similar ancestral forms.

Materials

2 laminated bat skeleton posters

2 sets of 16 labelled human parts

2 containers for labelled parts (e.g. boxes)

1 set of 40 bat trivia cards

Description

The class will be split into 2 teams. If there are two presenters each presenter will be a team leader for one of the groups. Turn order for the first round should be decided randomly (i.e. coin flip). The team leader will ask one of the bat trivia questions to the students. The students are encouraged to collaborate and discuss answers. If the question is answered incorrectly the team will forfeit their turn. If the question is answered correctly one student will be chosen to match a

human part to its corresponding bat part on the skeleton. After a student places a human part on the skeleton another student will get a chance to place the next one. Play continues until one team has completed their poster. The first team to complete their poster wins.

3.4 Echolocation Game

Objectives

To explore how bats use sensory awareness other than sight to navigate and locate prey. This activity will teach the students predator-prey relationships.

Materials

2 sets of 16 shakers with unique sounds

Description

Using the same teams from the previous activity the class will be split into ‘bats’ and ‘mosquitoes’. The team that won the first activity gets to choose whether they want to be ‘bats’ or ‘mosquitoes’. The shakers are separated beforehand so that each shaker has a match on the opposing team. Each student is given a shaker. The students are not allowed to make any noise other than the shaker or open the shaker. All the students must receive a shaker before the noisemaking can begin. The students will use their shakers to make noise while listening to find their matching one. Once a ‘bat’ has found their matching ‘mosquito’ the ‘mosquito’ is ‘eaten’ and is out. Students continue the activity until everyone has found their matching shaker.

3.5 School Grounds Interpretive Walk

Objective

To give students a chance to explore their school grounds from the point of view of a bat. This demonstrates where bats could potentially roost or forage. This activity shows students the variety of habitats that bats use.

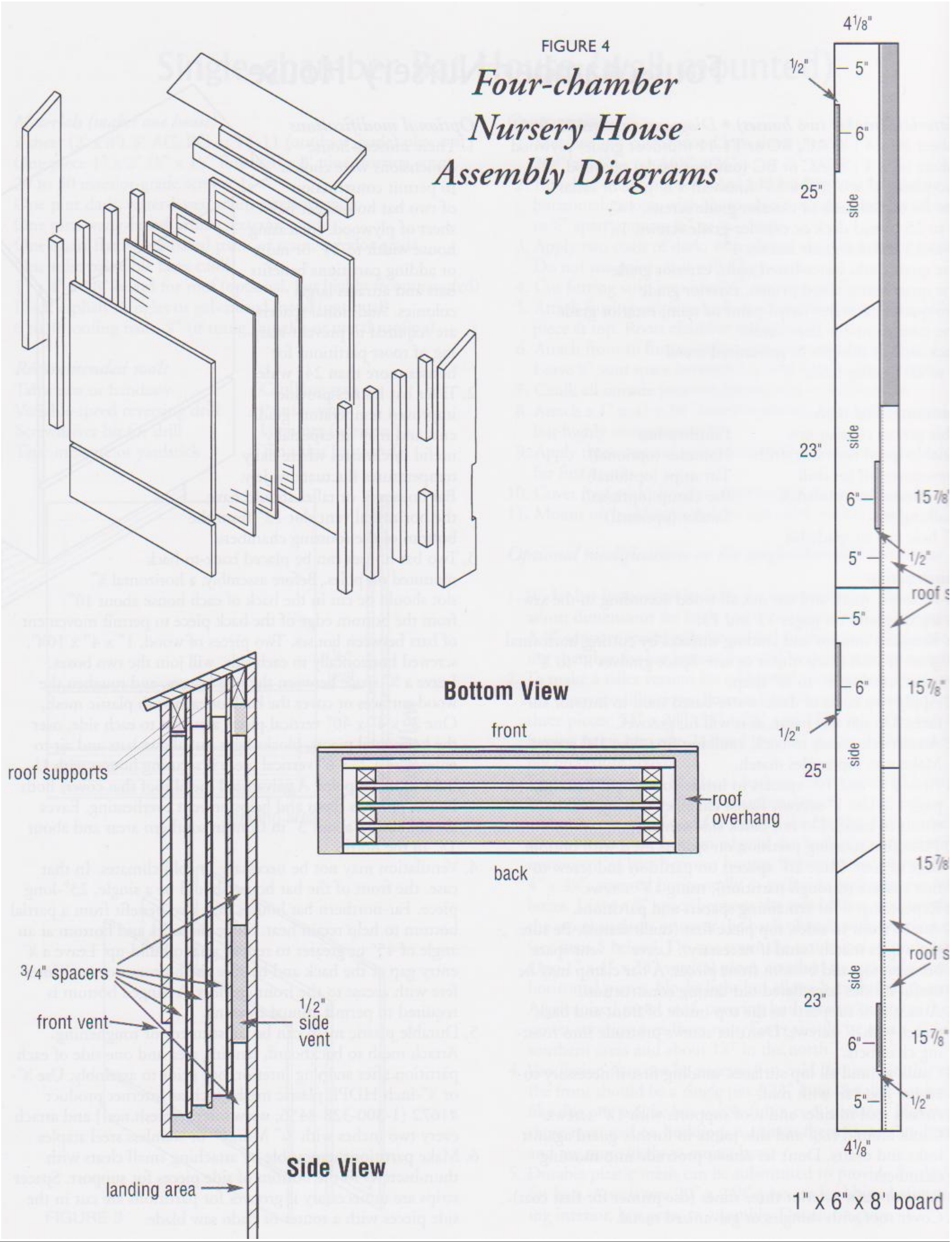
Materials

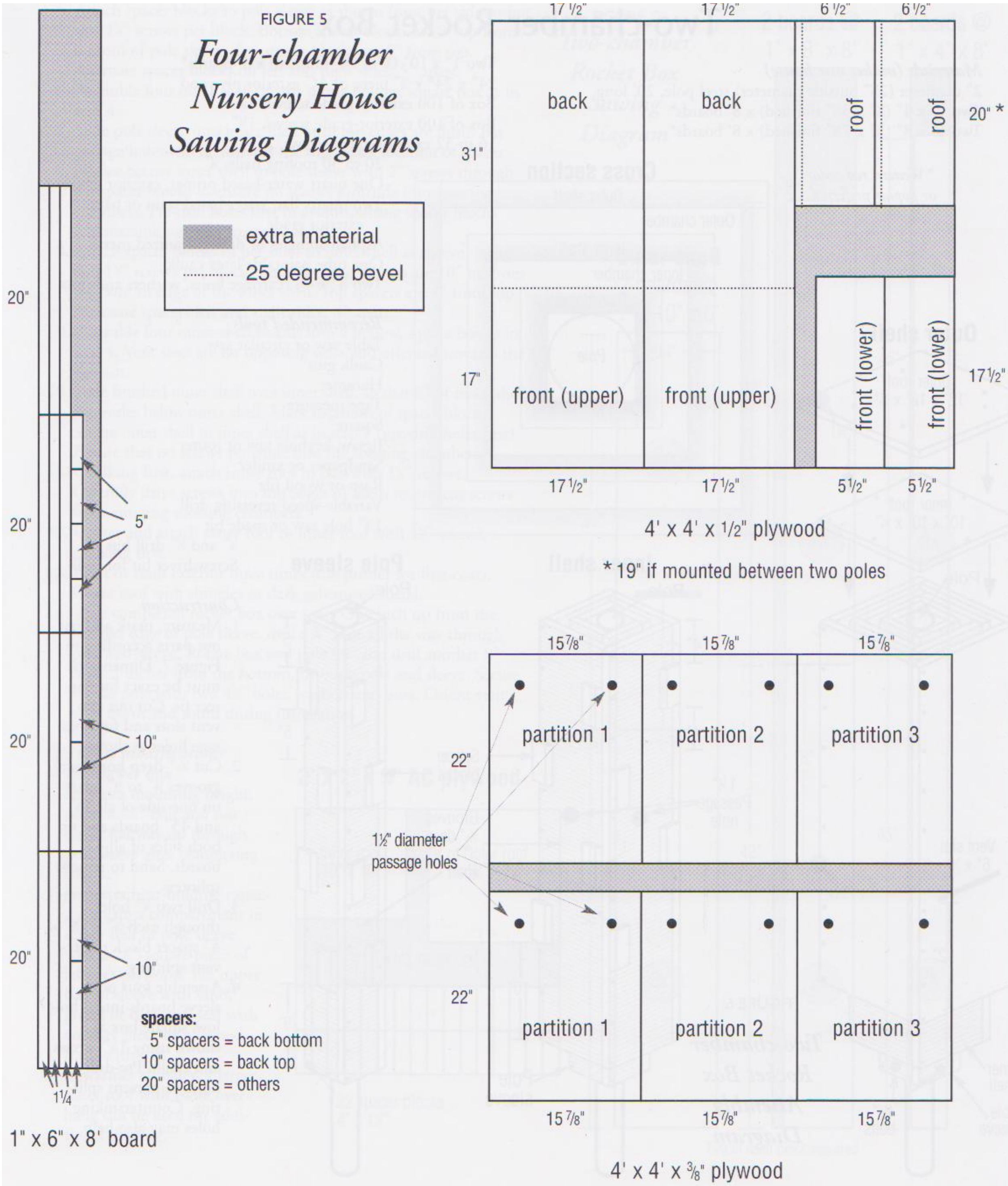
Wildlife and Trees in British Columbia guidebook (Fenger*et al*, 2006)

Description

Walk around with the students, encouraging them to point out areas where bats could roost. Examples are building overhangs, large trees with thick bark, and trees with high branches. Also encourage the students to think of foraging areas for the bats, like nearby ponds or streams. Explain the concept of minimum drop down height to the students, where bats need to drop before they start flapping their wings to fly, like a person hang-gliding!

Appendix 4 Bat Box Building Plan





Source: (Tuttle, Kiser, & Kiser, The Bat House Builder's Handbook, 2004)