Habitat Selection by Bats in Temperate Old-Growth Forests, Clayoquot Sound, British Columbia

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ABSTRACT

Clayoquot Sound on the west coast of Vancouver Island, B.C. is an area of high-profile land-use conflict. In 1995, local scientific and management groups recognized bats as an important component of forest ecosystems. With almost no existing bat information for this area, we began studies of the bat community, with the goal of inventorying the bat community and identifying critical bat habitat at both landscape and stand levels. Identification of the important habitat will provide forest managers with guidelines that may minimize impacts of forest harvesting on bat populations. Over the 3 summers of field study we captured 6 species of bat: *Myotis lucifugus*, *M. yumanensis*, *M. californicus*, *M. evotis*, *M. keenii*, and *Lasionycteris noctivagans*. In addition, we confirmed the presence of *Eptesicus fuscus* through ultrasonic bat detection. From 1996 to 1998, Anabat II bat detectors were used to survey the relative flight and feeding activities of bat species in a variety of forest stands. Significantly higher bat activity was recorded in tall, open forests at lower elevations. In addition, more bat activity was recorded in stands dominated by amabilis fir compared to stands dominated by yellow-cedar. To evaluate the usefulness to bats of buffers around riparian areas, we placed bat detectors 10, 30, and 100 m away from creeks and lakes. There was significantly more foraging activity up to 30 m away from the water's edge, as compared to forest interior sites (>100 m). To assess roost sites as an element of critical habitat, we radio-tracked male and female bats to their roosts. We found 9 bat roosts. Although there are 6 main tree species in Clayoquot Sound, all 5 tree roosts were in large-diameter western redcedar trees, suggesting this is an important species for roosting bats. The remaining 4 roosts were found in cliffs.

Key words: bats, Clayoquot Sound, *Eptesicus fuscus*, habitat selection, *Lasionycteris noctivagans*, *Myotis*, temperate old-growth forest.

Among mammals of their size, bats are unique in having long lives, low reproductive rates, and relatively long periods of infant dependency (Findley 1993). In addition, bats may be dependent on forest attributes that are reduced in managed forests (e.g., large-diameter snags, riparian habitat, etc.; Kunz 1982, Crampton and Barclay 1998). These aspects of life history put forest-dwelling bats at risk of population decline in the presence of habitat alteration. In fact, half of the 16 species of bats found in British Columbia are threatened or endangered (Sarell and Luoma 1994). We know very little about bat habitat requirements for foraging and roosting in relation to old-growth forests (Nagorsen and Brigham 1993) and less still is understood regarding bats in temperate coastal forests. As the major predators of nocturnal flying insects (Rainey et al. 1992), bats play a key ecological role in temperate rain forests, therefore their distribution and habitat requirements are important to understanding and sustaining ecosystems in Clayoquot Sound.

In 1994, the provincial government appointed the Clayoquot Sound Scientific Panel in response to public concern regarding old-growth forest depletion. One recommendation from the panel was "to ensure that particular species known or suspected to be at risk are monitored and their habitats protected" (Clayoquot Sound Scientific Panel 1995). This inventory is a direct result of the panel's concern for the protection of key habitats, in particular for the Red-

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listed Keen's long-eared myotis (*Myotis keenii*). No previous inventory of bats had ever been completed in any of the watersheds of Clayoquot Sound.

Beginning in 1996, efforts were made to sample bat populations of many undeveloped watersheds, with a few additional surveys in partially developed watersheds. Our objectives were to determine species presence and habitat preferences for foraging and roosting. This report summarizes the bats identified in Clayoquot Sound from 1996 through 1998, and presents and discusses habitat preferences of foraging and roosting bats, with greater emphasis placed on the results of 1998. This information is used to formulate our recommendations for managing bat habitat in Clayoquot Sound.

STUDY AREA

The study area is located in Clayoquot Sound on the west coast of Vancouver Island, B.C. (49°00'–49°30'N; 125°20'–126°30'W). The area is a maze of islands, inlets, and coastal temperate rain forest watersheds, and is classified as being in the Coastal Western Hemlock (CWH) biogeoclimatic zone and the Windward Island Mountains ecosection. This is the rainiest zone in British Columbia and is characterized by cool summers and mild winters (Meidinger and Pojar 1991). The area we sampled ranged in elevation from 0 to 730 m, but mountains in the area range up to 1,700 m. The vegetation of Clayoquot Sound consists of dense, coniferous forest with trees up to 60 m or more in height and 3 m or more in diameter. The understory of these forests is characterized by a dense tangle of shrubs, deadfall trees, and moss. The study area spans 3 biogeoclimatic subzone variants in the CWH zone (CWHvh1, vm1, and vm2), from sea-level on the outer coast to 730 m in inland watersheds.

In 1996 and 1997, we sampled in all 3 biogeoclimatic subzone variants. In 1998, we concentrated our sampling effort in the 2 lower-elevation subzone variants, where the most bat activity had been recorded in 1996 and 1997. Within each biogeoclimatic subzone we attempted to sample a range of aspects, habitat types, and forests of varying density and species composition.

MATERIALS AND METHODS

As there are inherent biases associated with different bat sampling methods (Thomas and West 1989), we used 3 methods to evaluate bat diversity and habitat preferences: mist-netting, monitoring of bat activity using bat detectors, and radiotelemetry.

MIST-NETTING

Our mist-net inventory followed the standardized Resources Inventory Committee protocol (RIC 1995). Each survey night from May through August we deployed 4–9 nets nightly for a minimum of 120 minutes post-sunset (the period of highest bat activity [van den Driessche et al. unpubl. observations]).

Bats were identified, weighed, and measured, and then released. In cases where identification was questionable, the 2 species names separated by a slash are used throughout this report (e.g., western/Keen's long-eared myotis).

BAT ACTIVITY

Measuring Bat Activity in Forest Interior Stands

The Vegetation Resource Inventory (VRI) system of maps in Clayoquot Sound is designed to provide a detailed inventory of forest vegetation and stand structure. Map polygon size averages about 8–10 ha. From the results of our work in Clayoquot Sound in 1996 and 1997, we identified 2 forest attributes (dominant canopy species and tree density) to help us "predict" which forest stands would have more bat activity. Based on these results, we selected VRI map polygons dominated by western redcedar (*Thuja plicata*), yellow-cedar (*Chamaecyparis nootkatensis*), western hemlock (*Tsuga heterophylla*), or amabilis fir (*Abies amabilis*), and polygons that varied in tree density in the CWHvh1 and CWHvm1 subzone variants. By placing ultrasonic bat detectors at stations in these polygons, we tested if, in fact, these mapped attributes could be strongly correlated to the amount of bat activity in the forest stand and therefore used as a guide in managing forests for bats.

Comparing Bat Activity in Riparian Stands to Activity in Forest Interior Stands

We wanted to evaluate bat activity in riparian areas with respect to riparian buffers in the Forest Practices Code of British Columbia. To compare bat activity in "riparian" versus "forest interior" sites, we chose sites that were 10 m and 30 m away from water at both lake and creek edges (riparian sites), or >100m away from water (forest interior sites).

Anabat Detector Protocol

For both the forest interior and riparian stations, the inventory technique was identical. We measured the relative abundance of bats using Anabat ultrasonic bat detectors at 42 forest interior stations and 43 riparian stations. We maintained a minimum of 100 m distance between detectors to ensure independence of samples (RIC 1995). Each site was sampled twice, once in May or June, and again in July or August.

Cassette tapes of echolocation calls were analyzed by ear the morning after the survey. As almost all calls recorded were *Myotis* species, we combined all bat species and recorded the total number of echolocation passes per night.

Habitat Plots to Compare Forest Stands

At each Anabat detector station we sampled 20 X 20 m plots to compare actual measures of vegetation and stand characteristics to the VRI map, and also to measure the habitat elements we believed might influence bat activity.

We classified every tree >10 cm DBH (diameter at breast height) in the plot to a standard stratum, and identified species and decay class (British Columbia wildlife tree classification scheme; Vegetation Inventory Working Group 1994). We noted height of canopy, elevation, and slope.

RADIOTELEMETRY TO LOCATE ROOSTS

In 1997 and 1998, we radio-tracked 9 bats (mass >5.7 g) fitted with Holohil LB-2 transmitters and flexible antennae (Holohil Systems Ltd., Carp, ON). To increase efficiency, since much of the terrain is extremely steep and thick with undergrowth, we used a fixed-wing aircraft to establish the general area and then retraced the distance on foot to the bat roost.

Once the roost was found, we took measurements of the roost structure and surrounding habitat. We characterized the forest stand surrounding the tree roost in a 20 X 20 m habitat plot in the same manner as at the Anabat detector sites.

STATISTICAL ANALYSIS

We averaged the number of bat calls per hour to use as a uniform measure of relative abundance (or bat activity) and then did a log transformation to equalize the variance. The number of passes detected per unit time can be considered as an index of the relative use or abundance at different sites and thus as an index of habitat preference (Thomas 1988).

Detector stations were classified as either riparian (at 10 and 30 m from water) or forest interior (>100 m from water) stations. In the analysis of habitat variables (forest density, canopy height, slope, and elevation), we used only forest interior detector sites to remove the compounding effect of riparian habitat from the model.

As we visited each detector station twice, we used a nested (repeated measures) 1-way analysis of variance (ANOVA) to determine if numbers of bat passes/hour varied for class variables such as biogeoclimatic subzone variant, dominant canopy species (measured in the field), and VRI dominant tree species (SAS 1988). We also used the nested (repeated measures) ANOVA to determine if numbers of bat passes differed significantly between stations that were 10 and 30 m from water and stations in the forest interior. To test if habitat variables (e.g., forest density, etc.) differed between stands dominated by different tree species, and between riparian and forest interior sites, we used an ANOVA.

We tested all continuous variables for normality and log-transformed the data to equalize the variance where needed (Zar 1984). If variables could not be normalized, we did not include them in the regression models. We used simple linear regressions to evaluate effects of continuous variables on relative bat abundance. We included a class variable for site in all regression models to account for multiple site visits. As a result of this, there was a large amount of variability inherent in the model and this was reflected in the low R^2 values. We chose to use simple linear regression on the variables rather than a correlation matrix in order to include the variability within each detector site (using both visits to each station) and to reduce the chance of making a Type I error. However, where the variances could not be normalized we used correlations to evaluate relationships (Spearman's rank correlation).

RESULTS

BATS CAPTURED USING MIST-NETS

From 3 July to 27 September 1996, 19 May to 22 August 1997, and 19 May to 30 August 1998, we set 753 mist-nets and caught 118 bats. We caught 1 lactating female western long-eared myotis (*Myotis evotis*; mass outside range of Keen's), 1 male Keen's long-eared myotis (*M. keenii*; from external measurements, Dave Nagorsen, Royal British Columbia Museum, pers. comm.), and 7 other western/Keen's long-eared myotis. Fifteen California myotis (*M. californicus*) were captured. We positively identified 3 Yuma myotis (*M. yumanensis*) and 3 little brown myotis (*M. lucifugus*; based on forearm measurements), and caught 53 little brown/Yuma myotis. In May 1998, we caught 2 silver-haired bats (*Lasionycteris noctivagans*) in an estuarine meadow at Cow Bay, Flores Island. We confirmed presence of reproductive females in the populations of western long-eared myotis, California myotis, Yuma myotis, and little brown myotis. Using ultrasonic detectors we identified an additional species (big brown bat [*Eptesicus fuscus*]), which was not captured in the mist-nets.

COMPARING BAT ACTIVITY IN DIFFERENT FOREST STANDS

We compared bat activity in the 3 biogeoclimatic subzone variants of Clayoquot Sound (CWHvh1, CWHvm1, CWHvm2). Among the 3 subzone variants, significant differences in bat activity were detected (nested ANOVA; df = 2, $F = 6.8$, $p < 0.05$) with significantly more bat activity in CWHvh1 than in CWHvm2 (Scheffe's pairwise comparisons, $p < 0.05$).

We selected VRI polygons dominated by 4 tree species (western redcedar, yellow-cedar, amabilis fir, and western hemlock) and looked for differences in bat activity between them. We found no difference between the 4 mapped stand types (nested ANOVA, df = 3, $F = 1.94$, $p > 0.05$). However, we did find significant differences in activity between stands where the dominant species was determined from our 20 X 20 m habitat plots (nested ANOVA, df = 3, $F = 3.89$, $p < 0.05$). Yellow-cedar stands had significantly less bat activity than amabilis fir stands (Scheffe's test, $p < 0.05$). When we compared the VRI-mapped dominant tree species to the dominant canopy species from habitat plots, they corresponded 50% of the time.

As bat activity was thought to be influenced by stand density and canopy height, we compared these variables between stands that differed in dominant tree species and found stands dominated by yellow-cedar were shorter and more dense than other stands (Table 1). When we compared bat activity with the species' proportion in a plot, we found less bat activity in stands with higher proportions of yellow-cedar (correlation; $n = 43$, $R = -0.34$, $p < 0.05$).

Consistent with results of 1996 and 1997 (linear regression, df = 55, $F = 5.99$, $p < 0.05$), we found bat activity significantly lower in denser forest stands. Variables that best described this relationship were the total number of trees, number of upper subcanopy trees, and canopy height, all of which are measurements that were taken in the field (Table 2). VRI estimates of forest density (number of tree stems/ha and canopy closure) did not exhibit the same negative regression to bat activity. However, when we examined the relationship between measured and VRI-mapped density variables, we found that measured density did not correlate with the VRI estimate of this same attribute ($n = 79$, $r = 0.13$, $p > 0.05$). Results also suggested that height of canopy and elevation were significant factors in determining bat activity.

Comparing Riparian Sites to Forest Interior Sites

In 1997, we compared *Myotis* activity over water to *Myotis* activity in the forest, and found significantly more activity over water (paired t-test, df = 33, $t = 6.6$, $p < 0.0001$). In 1998, we compared bat activity in riparian stands (10 and 30 m from S2 creeks and lakes) and forest interior stands (>100 m from water). Riparian sites had significantly more activity than forest interior sites (nested ANOVA, df = 2, $F = 4.35$, $p < 0.05$). Although there was not significantly more activity at the 10-m sites than the 30-m sites, the mean number of bat passes per hour suggested that bat activity did drop as the detectors moved away from water ($\bar{\chi}_{\text{10m}} = 1.51$, u.c. = 0.39, $\bar{\chi}_{\text{30m}} = 1.38$, u.c. = 0.33, $\bar{\chi}_{\text{Forest Interior}} = 1.00$, u.c. = 0.23).

We investigated differences in stand structure between 10-m riparian, 30-m riparian, and forest interior sites to see if this could provide some insight as to why bats were selecting riparian areas for foraging and flying. We tested variables that had shown a significant relationship to bat activity at forest interior stations (tree density, upper subcanopy, and canopy height) and found no difference in any of these habitat variables (ANOVA, df = 2, $F = 2.25$, 0.88, 0.05, respectively, $p > 0.05$).

Table 1. Comparison of stand density and canopy heights of stands dominated by 4 species of tree. (ANOVA, df = 3, all variables are significant. Scheffe's test is a multiple comparison test that determines which variables are significantly different from others.)

Variable name	F-value	Scheffe's test results[a]
No. of trees in plot	6.84	YC > WRC, WH
No. of upper subcanopy trees	4.00	YC > WRC, WH
Canopy height	10.89	YC < WRC, WH, AF

[a] YC = yellow-cedar; WRC = western redcedar; WH = western hemlock; AF = amabilis fir.

Radiotelemetry to Locate Roost Sites

We located 9 bat roosts. All bats found roosting in trees were found in western redcedars (Table 3). We found tree-roosting bats in large-diameter (115–315 cm DBH) western redcedar trees and most frequently in trees of decay class 2 (4 out of 5 bats). The remaining bats were found in steep, inaccessible rock faces with the exception of 1 *M. lucifugus* male roosting in a shallow pocket of a seacliff just 5 m above the spray zone.

DISCUSSION

Bat Species Diversity in Clayoquot Sound

Prior to 1996, only the Yuma myotis and little brown myotis had been identified in the CWH biogeoclimatic zone of

Table 2. Results of linear regression analysis comparing bat activity to stand characteristics of forest interior stations. Significant regressions and correlations have asterisks. Correlation coefficients for VRI (Vegetation Resource Inventory) canopy height and elevation are Spearman's rank correlations.

Variable class	Independent variable[a]	Degrees of freedom	F-value	Relationship
No. of stems	All trees	42, 1	8.54^{*}	R^2 = 12.4% (-)*
	Canopy trees (L.T.)	42, 1	1.51	
	Upper subcanopy trees (L.T.)	42, 1	7.07^{*}	R^2 = 10.6% (-)*
	Lower subcanopy trees	42, 1	3.44	
	VRI tree density (L.T.)	38, 1	0.76	
Canopy height	Estimated canopy height	36, 1	5.99^{*}	R^2 = 9.9% (+)*
	VRI canopy height	$n = 39$		r_s= 0.24 (-)*
Physical Characteristics	Slope	42, 1	1.91	
	Elevation	$n = 38$		r_s = 0.59 (-)*

[a] L.T. indicates log transformed data.

Table 3. Summary of summer bat roosts found using radiotelemetry in Clayoquot Sound. The first 2 individuals in the table switched roosts and both roosts are listed. All radio-tagged female bats were lactating.

Species[a]	Sex	Elevation (m)	Slope (%)	Aspect (°)	Roost structure[b]	Tree height (m)	Tree diameter (cm)	Wildlife tree class
MYLU/YU	M	30	17	80	WRC	32	220	2
		35	47	230	WRC	35	120	2
MYLU/YU	M	40	20	240	WRC	17	115	2
		0	90	225	sea cliff			
LANO	M	10	0	flat	WRC	26	225	2
MYLU/YU	F	10	0	flat	WRC	37	315	6
MYLU/YU	F	900	sheer	160	cliff			
MYLU/YU	F	600	sheer	225	cliff			
MYLU/YU	M	475	sheer	140	mixed tree/cliff			

[a] MYLU/YU = *Myotis lucifugus/yumanensis*; LANO = *Lasionycteris noctivagans*

[b] WRC = western redcedar; sea cliff = cliff adjacent to ocean, just above spray zone; cliff = cliff located inland or not adjacent to ocean.

Vancouver Island (Firman et al. 1993). Our study confirmed the presence of 5 other species: the endangered Keen's long-eared myotis, western long-eared myotis, California myotis, silver-haired bat, and big brown bat. The presence of pregnant and lactating western long-eared myotis, California myotis, Yuma myotis, and little brown myotis indicates that breeding populations of these species are present in the area.

The presence of the endangered Keen's long-eared myotis in Clayoquot Sound is of special significance as it had been found previously at only 4 other Vancouver Island locations (Nagorsen and Brigham 1993). It is difficult to determine the distribution or population of the species in Clayoquot Sound since mist-netting is biased to low-flying species (Thomas and West 1989). We caught fewer than 8 Keen's long-eared myotis out of 118 bats, which suggests this species is rare; however, further studies using methods more suited to sampling Keen's long-eared myotis are needed to confirm the species is indeed rare in our study area.

COMPARING BAT ACTIVITY IN DIFFERENT FOREST STANDS

Comparison of Biogeoclimatic Variables

Relative numbers of bat passes differed between the 3 CWH subzones. The lowest elevation detector sites on the outer coast of Clayoquot Sound (CWHvh1) had the highest numbers of bat passes, compared to the inland, high-elevation sites in the CWHvm2. Inland and higher elevation sites are exposed to higher amounts of precipitation, longer winters, and greater extremes of daily and annual temperatures (Meidinger and Pojar 1991). We suggest that bats are less abundant, as greater amounts of precipitation and cooler temperatures will significantly affect prey abundance and foraging ability (Grindal et al. 1992).

Comparing Density of Forests

Over 3 years of research we observed a negative relationship between bat passes and stand density, supporting the idea that forest density affects the foraging and flying behaviours of bats and thus their distribution (Fenton 1990). Low-density forests can be viewed as containing fewer obstacles or "clutter." Cluttered habitats are harder for bats to efficiently echolocate within due to multidirectional reflections of their calls, and harder to manoeuvre within due to morphological constraints (Neulweiler 1984, Mackey and Barclay 1989). Forest openings determine forest structure (Arsenault and Bradfield 1995) and may be critical factors in defining bat foraging habitat at the microhabitat scale. The density of the upper subcanopy trees was negatively correlated to bat activity, suggesting that gaps in these forests exist both vertically and horizontally. As bats can fly, this allows movement into different vertical microhabitats by choosing to fly lower or higher (Bradshaw 1996). Forest openings in structurally diverse, old-growth forests represent relatively uncluttered commuting "pathways" and foraging areas, and may be extremely important to bats (Bradshaw 1996, Krusic and Neefus 1996).

Comparing Stands Dominated by Different Canopy Species

We found a significant difference in bat activity between the 4 dominant canopy species measured in a habitat plot. Stands of yellow-cedar had lower bat activity than stands of amabilis fir. We found a positive relationship between yellow-cedar and tree density, and significantly less bat activity in forests with relatively high representation of yellow-cedar. As yellow-cedar-dominated forests are typically denser and shorter, this may explain why we found less bat activity in these forests.

The discrepancy in results between measured (significant) and mapped (nonsignificant) habitat variables was unexpected. However, dominant canopy species of habitat plots were assigned from data collected in a 20 X 20 m plot and the VRI species was based on an 8- to 10-ha polygon area. Therefore, inconsistent results could be due to the different scale of assigning dominance. As bats did appear to respond to dominant canopy species at the 20 X 20 m plot scale, we suggest that site investigations at this scale are preferable for identifying important habitat for bats.

Riparian Areas

Our data suggest riparian areas are extremely important to bats. As the distance increased from water, bat activity decreased. As we looked at habitat characteristics (which limit manoeuvrability and echolocation efficiency) between riparian sites and forest interior sites and found no significant differences, it is probable that bats are selecting riparian areas in response to other factors, such as higher insect abundance. Therefore, bats are selecting to forage in riparian areas for different reasons than they are selecting forest interior habitat, where stand structure did have an influence on their flight paths. The activity patterns of insectivorous bats and insect abundance have been shown in some studies to have a clear relationship (e.g., Rautenbach et al. 1996). Therefore, the 50-m riparian buffer proposed by the Clayoquot Sound Scientific Panel may better protect this habitat than the 30-m Riparian Reserve Zone legislated in the Forest Practices Code.

ROOST SITES IN CLAYOQUOT SOUND

We confirmed the use of cliff bands and large-diameter cedar trees as roosts for both male and female bats. In other studies, bats preferred large-diameter trees for roosting (e.g., Brigham 1991, Crampton and Barclay 1998), and timber harvesting has been associated with a decline in abundance of bats when large-diameter trees are cut (Lunney et al. 1985).

We found 4 of 5 roosting bats in western redcedar trees in a particular stage of decay. Typical tree roosts had dead tops and were in declining health (candelabra cedars in wildlife tree class 2), with extensive cracks leading to interiors decayed by heartrot. As trees beyond wildlife tree class 6 no longer provide suitable roosting habitat for bats (Brigham et al. 1997), preserving large-diameter cedar trees at early stages of decay (class 2) will protect roost sites for bats over a long period, since cedars decay slowly (Parish 1994).

Roost switching has been observed for several species of temperate bats (Brigham 1991, Vonhof and Barclay 1996, Brigham et al. 1997). We documented male bats switching roosts, both between trees and from tree to cliff. Our observations and the literature suggest that preserving a series of potential roost sites may be important for maintaining populations of bats in Clayoquot Sound.

SUMMARY OF MAIN FINDINGS

To maintain populations of bats in Clayoquot Sound, forest managers will need to consider roosting and foraging requirements at the stand and landscape levels. Seven species of bats were confirmed for the area, including the endangered Keen's long-eared myotis, western long-eared myotis, California myotis, Yuma myotis, little brown myotis, silver-haired bat, and big brown bat. The presence of pregnant and lactating western long-eared myotis, California myotis, Yuma myotis, and little brown myotis indicates that breeding populations of these species are present in the area.

AT THE STAND LEVEL

1. We observed a negative relationship between bat passes and stand density, supporting the idea that denser forest is less attractive for foraging and flying bats.
2. We confirmed the use of cliff bands and large cedar snags as roosts for both male and female bats. Tree roosts were predominately located in large-diameter western redcedar trees in early (class 2) decay stages. Thus, preserving these trees will ensure their long-time use as roost sites for bats. We documented male bats switching roosts, both between trees and between tree and cliff. This implies that a series of potential roost sites should be preserved to maintain populations of bats in Clayoquot Sound.
3. We found significantly more bat activity in stands dominated by amabilis fir and less activity in stands of yellow-cedar.

AT THE LANDSCAPE LEVEL

4. Our data suggest riparian areas are extremely important to bats. We found that bat activity at 10 and 30 m from water was significantly more than in forest interior stands (>100 m from water). Current riparian zones legislated in the Forest Practices Code protect a 30-m Riparian Reserve Zone around S2 creeks and 10 m around L1 and L2 lakes. The Clayoquot Sound Scientific Panel recommendations have proposed a 50-m buffer around these same areas. Our data suggest a buffer >30 m on creeks and lakes may better protect this habitat for bats.
5. Bat activity differed between the 3 subzones of the Coastal Western Hemlock biogeoclimatic zone. The lowest-elevation detector sites on the outer coast of Clayoquot Sound (CWHvh1) had the highest numbers of bat passes, compared to the inland, low-elevation sites in the CWHvm1 and the inland, high-elevation sites in the CWHvm2.

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