

The influence of residual tree patch isolation on habitat use by bats in central British Columbia

MICHAEL B. SWYSTUN¹, JENNIFER M. PSYLLAKIS^{1,2}, and R. MARK BRIGHAM¹

¹Department of Biology, University of Regina, Regina, S4S 0A2, Canada; E-mail: swystunm@uregina.ca

²Present address: Faculty of Natural Resources and Environmental Studies, University of Northern British Columbia, Prince George V2N 4Z9, Canada

One forest management practice associated with logging aimed at contributing to the maintenance of biodiversity is to leave residual tree patches within cut blocks. Using Anabat bat-detectors we monitored bat activity along residual tree patch edges and clear-cut edges associated with recent clear-cuts in north-central British Columbia. We tested two hypotheses, (1) relative bat activity would be higher on the clear-cut edge than the residual patch edge, (2) relative bat activity would decrease on the residual patch edge with increasing isolation from the clear-cut edge. We sampled six pairs of edges and found no significant difference in bat activity between patch and clear-cut edges. We found a significant but non-linear relationship between relative bat activity on the patch edge with increasing patch isolation. Bat activity on the residual patch edge was highest at intermediate levels of patch isolation and lower both at patch edges close to, and highly isolated from the clear-cut edge. We postulate that the reason for this relationship is that patches act as windbreaks collecting high densities of insects making them good foraging areas but this benefit is coupled with an increased risk of predation associated with crossing large gaps. At low levels of patch isolation bats may perceive residual patches and adjacent clear-cut edges as a continuous foraging area and thus, bat activity is evenly distributed throughout both habitats. In summary, our data indicate that patches provide localized habitat for foraging bats, however, foraging areas are only one habitat component required by bats and it remains uncertain if patches also offer suitable roosting opportunities.

Key words: Microchiroptera, habitat use, residual tree patch, fragmentation, gap crossing, clear-cut, Anabat

INTRODUCTION

Temperate microchiropteran bats are long lived with non-cyclic populations and low reproductive rates (Findley, 1993). These characteristics are thought to facilitate stable populations in unchanging habitats, but which may become vulnerable through habitat modification (Parker *et al.*, 1996). Currently, habitat alterations are having a large impact on North American landscapes which may be affecting bat populations

(Lowe *et al.*, 1990). Large scale disturbances, such as logging, cause abiotic changes which may affect biotic components of the ecosystem such as availability of prey, interspecific and intraspecific competition or predation rates (Grindal and Brigham, 1998). These factors may in turn influence the suitability of foraging habitat for bats.

Current forest management practices in British Columbia have moved toward harvesting practices which attempt to approximate natural disturbance regimes such as

forest fires (British Columbia Ministry of Forests, 1995). In theory, plants and animals have evolved to cope with the conditions left by these natural disturbances (Bunnell, 1995). One harvesting technique currently used, which is meant to more closely approximate natural disturbance, specifically wildfire, is the retention of residual patches of trees within clear-cuts. This residual vegetation may be left in a patch comprised of live and/or dead trees. We hypothesize these patches may be useful for bats as they could potentially provide roosting and or foraging resources within a clear-cut.

It is well documented that clear-cut edges support increased levels of bat activity (Crampton and Barclay, 1996; Grindal and Brigham, 1998; Verboom and Spoelstra, 1999). However, little or nothing is known about the foraging ecology of bats associated with remnant patches. For the purposes of this study we considered three distinct habitat types created by forest harvesting; harvested areas, clear-cut edges (the border between the clear-cut and intact forest), and residual forest patch edges (the border between the isolated residual patch and the clear-cut). The aim of our study was to investigate the use of residual patch edges by bats relative to clear-cut edges at recently harvested sites. We assumed, given the close proximity of paired study sites (maximum distance 275 m) that environmental factors such as wind direction, temperature (at night) and precipitation would be similar. If both habitat edges provide similar foraging opportunities (i.e. prey abundance and energetic costs) we expected to find a direct correlation between relative bat activity on the patch edge and clear-cut edge. However, if clear-cuts present a barrier to bats due to increased energetic costs, increased risk of predation, or due to a reluctance by bats to venture far from linear landscape elements (Limpens and

Kapteyn, 1991), then we expected that (1) relative bat activity would be higher on the clear-cut edge than the residual patch edge and (2) relative bat activity on the patch edges would decrease with increasing patch isolation.

MATERIALS AND METHODS

The study was conducted between 18 July and 3 August 2000 in the sub-boreal spruce biogeoclimatic zone (Meidinger and Pojar, 1991) near Fort St. James in central British Columbia, Canada (54°10'N–123°45'W). The area is dominated by lodgepole pine (*Pinus contorta*) and hybrid white spruce (*Picea glauca* × *engelmannii*) with interspersed stands of trembling aspen (*Populus tremuloides*) and black spruce (*Picea mariana*). Five bat species are known to occur including: little brown myotis (*Myotis lucifugus*), long-legged myotis (*M. volans*), northern long-eared myotis (*M. septentrionalis*), western long-eared myotis (*M. evotis*), and silver-haired bat (*Lasiurus noctivagans*). Big brown (*Eptesicus fuscus*) and hoary bats (*Lasiurus cinereus*) likely occur in the area but this has not been confirmed (Nagorsen and Brigham, 1993).

We chose six residual patch edges in six different clear-cuts which occurred at distances of 43, 62, 84, 117, 181, and 275 m from the nearest clear-cut edge to evaluate the effect of patch isolation on the behaviour of bats. All patches were between 0.5–2.0 ha in size and found in clear-cuts <5 years old. Clear-cuts ranged in size from 105 to 180 hectares.

We remotely monitored relative levels of bat activity at patch and clear-cut edges by recording echolocation calls using light activated bat detectors and delay switches (Anabat II, Titley Electronics, Ballina, N.S.W., Australia) connected to voice activated, cassette recorders (Texas Instruments, Dallas, Texas, U.S.A.). The system recorded activity from dusk until dawn. We defined a pass as ≥ 2 consecutive pulses (Griffin, 1958). On a sample night, one bat detector was placed on the patch edge and one on the adjacent clear-cut edge at the point where the patch and clear-cut edges were closest. Detectors were placed 1 m off the ground elevated at a 45 degree angle with the microphone parallel to the edge. Both detectors faced the same direction. Nights with rain were excluded from the analysis. Since the sampling period was close in time temporally, climate conditions were similar however, wind speed and direction did fluctuate.

Bat passes were transcribed from recordings using Anabat 5 Bat Call Analysis software (Titley Electronics, Ballina, N.S.W., Australia) with which we could differentiate between *Myotis* spp. and large bats (*E. fuscus*, *L. noctivagans*, and *L. cinereus*). Since we found no significant difference in bat activity between *Myotis* spp. and large bats along patch edges ($t = 2.91$, $d.f. = 5$, $P > 0.10$) and clear-cut edges ($t = 3.76$, $d.f. = 5$, $P > 0.10$) we pooled all passes for our analysis. We used correlation analysis to test for a relationship between bat activity along patch edges and clear-cut edges. We used a paired t -test to compare activity levels between the two habitat types. Regression analysis was used to evaluate bat activity on clear-cut edges as a function of patch isolation. Given our small sample size and the biological significance of improperly rejecting the H_1 hypothesis we set $\alpha = 0.10$.

RESULTS

We recorded a total of 159 bat passes (110 on residual patch edges and 49 on clear-cut edges) over the course of 6 nights. We found no correlation between bat activity along clear-cut edges and patch edges ($r = -0.24$, $d.f. = 6$, $P > 0.10$). There was no significant difference in bat activity between the two habitats ($t = 2.71$, $d.f. = 5$, $P > 0.10$). A second order polynomial function indicated a significant non-linear relationship between bat activity on the patch edge as a function of patch isolation ($y = -17.46 + 0.90x - 0.002x^2$; $r^2 = 0.743$, $d.f. = 3$, $P < 0.05$; Fig. 1).

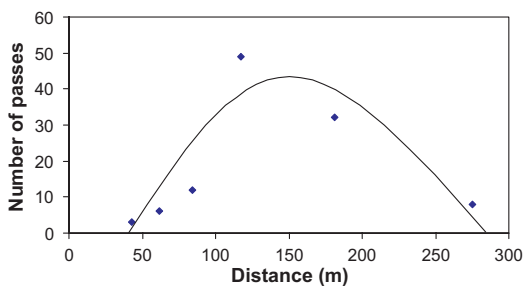


FIG. 1. Non-linear regression of relative bat activity on the residual tree patch edge with varying residual tree patch isolation

DISCUSSION

Our results show that bats are active along residual tree patch edges in recently harvested clear-cuts. In fact, activity was greater along these edges than adjacent clear-cut edges although not significantly so. Although we attempted to select patches which were as similar as possible to each other, there was some variation in tree species composition, patch size, and shape. Those differences may have caused some of the inter-patch variation in the relative bat activity.

We found no correlation between relative bat activity along patch and clear-cut edges. Therefore, other factors must affect the distribution of bats in patchy environments. Ahlén (1983) found that size, isolation, and latitude of island habitats jointly explained as much as 80% of variation in bat activity. Similarly, Ekman and de Jong (1996) noted that a combination of island isolation, area and insect availability affected bat activity in patchy environments. Furthermore, echolocation call structure and the size of bat species may influence their distribution. We found a significant non-linear relationship between bat activity on the patch edge as a function of increasing patch isolation. This non-linear relationship suggests that patch isolation may influence the distribution of bats among residual tree patches in clear-cuts. Since little is known about the use of residual tree patch edges by bats, it is difficult to ascertain the cause of this relationship. Retention tree patches may act as wind breaks collecting insects blown from the surrounding clear-cut. Such an effect has been documented, especially in agricultural landscapes (Lewis, 1965, 1969, 1970). Windbreaks act as landscape elements which collect high densities of insects either as protection from wind and predators, or simply blown in from the surround-

ing open habitat (Lewis, 1970). If residual tree patches are similar to tree patches in agricultural areas, we assume that increased insect densities would attract foraging bats to residual tree patch edges. Fenton (1990) and Whitaker *et al.* (2000) both suggested that prey availability is probably the strongest influence on foraging habitat selection by bats. Whitaker *et al.* (2000) reported that riparian buffer strips act as windbreaks, collecting elevated numbers of airborne insects which facilitates high insectivorous bird densities. Although this hypothesis may explain the increase in bat activity along residual edges at an intermediate distance of isolation, it does not account for the low levels of bat activity among near and also highly isolated residual edges.

At low levels of patch isolation, the close proximity of residual patch and clear-cut edges may be perceived by bats as the same foraging area. Bat activity may be dispersed between the two edges and potentially within the clear-cut causing bat activity to be lower in all habitat types than if they focused on a particular foraging area.

Bat activity at highly isolated patches decreased, consistent with the suggestion that bats may be reluctant to cross large gaps. Decreased activity along patch edges with increased isolation may be due to an increased risk of predation. Speakman (1991) suggested that the risk of predation, mainly by owls, may increase while bats commute through open habitats. Second, there is an increase in energy expenditure however, this is probably not significant since Brigham (1991) suggested that the energetic costs of commuting short distances is trivial with regards to bats total daily energy budget. Third, while commuting through large gaps, exposure to wind and subsequent cooling may lead to an increase in metabolic rate and energy

expenditure of foraging animals (Grubb and Greenwald, 1982).

Due to our small sample size we were unable to analyze large and small bats separately. However, both large and small bats exhibited similar activity trends as the two combined. Since more small bats were recorded than large bats, small bats probably drive the relationship we found.

The highest priorities for further study are to determine insect abundance along residual tree patch edges and whether residual tree patches provide roosting opportunities for bats. The forest practices code of British Columbia mandates that every new clear-cut have a minimum of one residual tree patch a maximum distance of 500 m from the clear-cut edge (British Columbia Ministry of Forests, 1995). Future research should simultaneously investigate bat activity along both the clear-cut edge and residual tree patch edge to determine the influence residual tree patch isolation has on bat activity in both habitats. Rigorous evaluation of the ideal placement of patches in proximity of the clear-cuts is still needed to create favorable habitat for bats and other forest dwelling organisms that require forest habitat to maintain stable populations. Our study indicates that retention tree patches provide foraging habitat for localized bat activity in recently harvested clear-cuts.

ACKNOWLEDGEMENTS

We thank Jennifer Pierre and Ian Scanlan for valuable assistance in the field. We are grateful to Les Peterson for the use of bat detectors, British Columbia Ministry of forests for the use of maps and air photos, and Jim Rusak for statistical assistance. Funding for this project was provided by British Columbia Habitat Conservation Trust Fund.

LITERATURE CITED

AHLÉN, I. 1983. The bat fauna of some isolated islands in Scandinavia. *Oikos*, 41: 352–358.

- BRIGHAM, R. M. 1991. Flexibility in foraging and roosting behavior by the big brown bat (*Eptesicus fuscus*). *Canadian Journal of Zoology*, 69: 117–121.
- BRITISH COLUMBIA MINISTRY OF FORESTS. 1995. Forest practices code of British Columbia: biodiversity guidebook. Queens Printer, Victoria, B.C., 456 pp.
- BUNNELL, F. L. 1995. Forest dwelling vertebrate faunas and natural fire regimes in British Columbia: patterns and implications of conservation. *Conservation Biology*, 9: 636–644.
- CRAMPTON, L. H., and R. M. R. BARCLAY. 1996. Habitat selection by bats in fragmented and unfragmented aspen mixedwood stands of different ages. Pp. 238–259, in *Bats and Forest Symposium* (R. M. R. BARCLAY and R. M. BRIGHAM, eds.). British Columbia Ministry of Forests, Victoria, B.C., 292 pp.
- EKMAN, M., and J. DE JONG. 1996. Local patterns of distribution and resource utilization of four bat species (*Myotis brandti*, *Eptesicus nilssoni*, *Plecotus auritus* and *Pipistrellus pipistrellus*) in patchy and continuous environments. *Journal of the Zoological Society of London*, 238: 571–580.
- FENTON, M. B. 1990. The foraging behaviour and ecology of animal eating bats. *Canadian Journal of Zoology*, 68: 411–422.
- FINDLEY, J. S. 1992. *Bats: a community perspective*. Cambridge University Press, New York, 200 pp.
- GRIFFIN, D. R. 1958. *Listening in the dark*. Cornell University Press, Ithaca, 415 pp.
- GRINDAL, S. D., and R. M. BRIGHAM. 1998. Short-term effects of small-scale habitat disturbance on activity by insectivorous bats. *Journal of Wildlife Management*, 62: 996–1003.
- GRUBB, T. C., and L. GREENWALD. 1982. Sparrows and a brushpile: foraging response to different combinations of predation risk and energy costs. *Animal Behaviour*, 30: 637–640.
- LEWIS, T. 1965. The effects of an artificial windbreak on the aerial distribution of flying insects. *Annals of Applied Biology*, 55: 503–512.
- LEWIS, T. 1969. The distribution of flying insects near a low hedgerow. *Journal of Applied Ecology*, 6: 453–458.
- LEWIS, T. 1970. Patterns of distribution of insects near a windbreak of tall trees. *Annals of Applied Biology*, 65: 213–220.
- LIMPENS, H. J. G. A., and K. KAPTEYN. 1991. Bats, their behavior and linear landscape elements. *Myotis*, 29: 39–47.
- LOWE, D. W., J. R. MATHEWS, and C. J. MOSELEY. 1990. *The official world wildlife fund guide to endangered species of North America*. Beacham Publishing, Washington, D.C., 1: 483–488.
- MEIDINGER, D. V., and J. POJAR. 1991. *Ecosystems of British Columbia*. British Columbia Ministry of Forests, Crown Publications, Victoria, B.C., 330 pp.
- NAGORSEN, D. W., and R. M. BRIGHAM. 1993. *Bats of British Columbia: Royal British Columbia Museum handbook*. UBC Press, Vancouver, 164 pp.
- PARKER, D. I., J. A. COOK, and S. W. LEWIS. 1996. Effects of timber harvest on bat activity in south-eastern Alaska's temperate rainforests. Pp. 277–292, in *Bats and Forest Symposium* (R. M. R. BARCLAY and R. M. BRIGHAM, eds.). British Columbia Ministry of Forests, Victoria, B.C., 292 pp.
- SPEAKMAN, J. R. 1991. Why do insectivorous bats in Britain not fly in daylight more frequently? *Functional Ecology*, 5: 518–524.
- VERBOOM, B., and K. SPOELSTRA. 1999. Effects of food abundance and wind on the use of tree lines by an insectivorous bat, *Pipistrellus pipistrellus*. *Canadian Journal of Zoology*, 77: 1393–1401.
- WHITAKER, D. M., A. L. CARROLL, and W. A. MONTEVECCHI. 2000. Elevated numbers of flying insects and insectivorous birds in riparian buffer strips. *Canadian Journal of Zoology*, 78: 740–746.

Received 3 July 2001, accepted 2 October 2001