Appendix I

Bat Population Study (2007)

Bat Species Composition and Activity at the Proposed Dalhousie Mountain Wind Development Site, Nova Scotia

Final Report

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Introduction and Background

Wind generated energy is a relatively new addition to the commercial energy market that is displaying phenomenal growth on a global scale. During the last decade, global wind energy capacity has doubled every three years, about a 30% increase annually (CanWEA 2006). Contrary to past perceptions of the industry, wind power is now modeled as a stable, cost-competitive sector that can substantially contribute to future power generation portfolios. This new stability has come from technological advancements, making the industry more economically competitive, and also from the continuing global demand for renewable energy sources (Andersen & Jensen 2000; Menz & Vachon 2006). In Canada the trend continues with expectations of 10,000 megawatts of wind capacity to be installed by 2010 (CanWEA 2001).

The Atlantic Provinces are poised to substantially contribute to the growth of wind energy in Canada. Objectives for installed capacity in the region are to reach 1,130 megawatts by 2015 (Hornung 2006). In Nova Scotia, wind energy will take a leading role in achieving the requirement for new renewable energy sources to comprise 5% of electricity by 2010 (Hornung 2006). Clearly as wind energy expands in the province, the role of identifying and selecting wind power sites which meet criteria set by government, industry and the public will become increasingly important.

Wind power is commonly cited as a model of an ‘environmentally friendly’ renewable resource because it does not contribute direct atmospheric emissions, has minimal economic expenditure following decommission and uses limited land area for operation (Andersen & Jensen 2000). Despite these environmental advantages, bird and bat mortalities have been documented for several wind generation facilities across the globe (Ahlén 2003; Johnson et al. 2003b; Johnson et al. 2004; Kerns & Kerlinger 2004; Osborn et al. 2000; Young et al. 2003). In comparison to avian fatalities, the documentation and analysis of bat fatalities at wind facilities is relatively recent and is gaining considerable attention.

Bat mortality as a result of collisions with man-made structures is not unique to wind turbines, with reports of bats colliding with such structures as lighthouses, communication towers and buildings dating as far back as 1930 (Johnson et al. 2004). Bat collision mortality from wind turbines first made its way into the media in North America following a large bat kill at a West Virginia wind farm in 2003 (Williams 2003 in Johnson et al. 2004). Since that time there has been many documented bat fatalities at wind development sites. Estimates of bat fatalities are highly variable ranging from less than 3 bats/turbine/year (Johnson et al. 2003a; Johnson et al. 2004) to 20-50 bats/turbine/year (Jain et al. 2007; Kerns et al. 2005; Nicholson 2003). Species composition of collision fatalities is typically comprised of hoary bats (*Lasiurus cinereus*), silver-haired bats (*Lasionycteris noctivagans*), eastern red bats (*Lasiurus borealis*), and big brown bats (*Eptesicus fuscus*), with smaller numbers of eastern pipistrelles (*Perimyotis subflavus*), northern long-eared (*Myotis septentrionalis*) and little brown bats (*Myotis lucifugus*) predominantly in eastern North America.

Occurrence records exist for seven species of bats in Nova Scotia, the same seven species with documentations of fatalities at wind turbine sites listed above (Broders et al. 2003a; van Zyll de Jong 1985). Nova Scotia is close to the northern periphery of the current known range for each of these species, with the exceptions of the northern long-eared and the little brown bat (van Zyll de Jong 1985). These two species, as well as the eastern pipistrelle, are the only bat species with significant populations in Nova Scotia (Broders et al. 2003a; Farrow 2007).

The eastern pipistrelle is a non-migratory bat species found throughout the eastern forests of North America (Fujita & Kunz 1984; Veilleux et al. 2004). This species occurs in very low numbers in southern coastal New Brunswick (Broders et al. 2001) and in 2001, Broders (2003a) discovered the first concentration of eastern pipistrelles in Nova Scotia at Kejimkujik National Park. Subsequent ultrasonic monitoring throughout mainland Nova Scotia confirmed the presence of a significant population of this species in the province, yet indicated restriction of the population to southwest Nova Scotia in the summer (Farrow 2007; Rockwell 2005). The restriction of this population to southwest Nova Scotia suggests that the population of eastern pipistrelles is disjunct, at least during the summer (Broders et al. 2003b; Farrow 2007).

Only the northern long-eared and little brown bat are common in Nova Scotia (Broders et al. 2003a) and they both have distributional ranges that extend into Newfoundland (Grindal & Brigham 1999; van Zyll de Jong 1985). They are therefore likely ubiquitous throughout the province (Broders et al. 2003a). The northern long-eared bat is a forest interior species (Broders et al. 2003a; Henderson 2007; Jung et al. 2004), while the little brown bats is more of a generalist species, associated with forests, as well as human-dominated environments (Barclay 1982; Jung et al. 1999). Both species are year-round residents in the province with over-wintering documented at a number of hibernacula located throughout central Nova Scotia (Garroway 2004; Moseley 2007; Tutty 2006).

The hoary bat, silver-haired bat and eastern red bat, are all migratory species with extensive distributional ranges in North America (van Zyll de Jong 1985). Historically, there have been few occurrence records for these species in Nova Scotia, though several reports of these species flying ashore in Massachusetts and aboard ships off the coast of Nova Scotia in the fall, suggest the possibility of a migratory movement across the Gulf of Maine (Broders et al. 2003a). In 2001, Broders et al. (2003a) recorded greater than 30,000 echolocation sequences from May to September at Kejimkujik National Park and Brier Island, yet fewer than fifteen of these, all in September, were attributed to any of the migratory species. Therefore, it was suggested that there are no significant migratory movements of these species through Nova Scotia and the incidence of individuals of these species during the summer are low (Farrow 2007; Rockwell 2005; Garroway and Broders unpublished data)

Localized over-wintering and reproduction records have been recorded for big brown bats in New Brunswick in low numbers, where their presence was associated with buildings. McAlpine *et al*. (2002) subsequently suggested that the species may exist in that province in low numbers where it is closely associated with human occupied buildings. Taylor (1997) identified 3 big brown bats hibernating in a hibernaculum in Nova Scotia. These findings indicate that the conditions may exist for year round-residency of the species in the province. However, a general lack of evidence for their presence given the increased research effort since Taylor's work suggests that if the species is present in Nova Scotia they are very localized and in very low numbers.

Echolocation is the primary sensory means by which all of these microchiropteran bat species orient themselves and hunt for prey (Fenton 1997; Fenton & Griffin 1997), where they emit vocalizations and analyze the returning echoes created when these sounds encounter objects (Fenton 2003). Instruments sensitive to these frequencies are referred to as bat detectors and allow investigators to record, hear, and even visualize the otherwise inaudible echolocation calls of bats (O'Farrell et al. 1999). Detectors permit identification of many bat species by their calls (Fenton & Bell 1981; O'Farrell et al. 1999; Thomas et al. 1987), assessment of activity patterns, and studies of behavior and habitat relationships of many species of echolocating bats (Fenton 1997). Bat detectors often permit investigators to sample a much larger area than conventional capture techniques and generally yield a more complete inventory of bat species than captures alone (O'Farrell & Gannon 1999).

Project Objective

It is likely that local resident bats will be impacted by the clearing of land to make room for turbines via the loss of roosting and foraging areas. However, it seems likely that if there will be significant direct mortality of bats associated with this project it will occur during the fall migration period (from mid-August until late September/early October); this project was designed to assess this. Therefore, the goal of this study was to provide local data that could be used to make inference on the potential for a wind development at Dalhousie Mountain to cause unacceptable levels of bat mortality. Specifically the objectives were to:

1) Document species composition

2) Determine whether there are abnormally high levels of bat activity at the site. It there is abnormally high bat activity it might indicate that the area represents a migration corridor and warrants further investigation.

Study Area

The proposed Dalhousie turbine site is approximately 340 m in elevation located near the community of Brookland, Pictou County, Nova Scotia. Dalhousie Mountain is situated in the Cobequid Hills ecodistrict theme region and the upland forest cover is primarily composed of sugar maple, yellow birch and American beech and can be intermixed with balsam fir, red spruce and black spruce (Davis & Browne 1996).

Methods

We used Anabat II detection systems to sample the echolocation calls of bats. Each system was deployed at ground level and consisted of an ultrasonic Anabat II detector interfaced to a CF Storage ZCAIM (Titley Electronics Ltd., NSW Australia). The seasonal timing of the sampling period likely corresponded to fall migration activity by migratory species and movement by resident species to local hibernacula. Activity was monitored at three locations (Location 1, 504290 E 5043190 N, Location 2, 503946 E 5049736 N and Location 3, 503810 E 5042461 N; UTM NAD83 Zone 20 format). Detectors were placed along forest edges or forested trails to maximize recordings of bats commuting or foraging in the area. Monitoring began on the evening of 08 August 2007 and was completed on the morning of 7 September 2007 (Location 1: 8 to 16 August; Location 2: 17 to 29 August; Location 3: 31 August to 7 September).

Identification of many bat species is possible because of the distinctive nature of their echolocation calls (Fenton & Bell 1981; O'Farrell et al. 1999). Species were qualitatively identified from echolocation sequences by comparison with known echolocation sequences recorded in this and other geographic regions. In the case of species in the genus Myotis (northern long-eared and little brown bat), we did not identify sequences to the species level, as their calls are too similar to be separated. The calls of silver-haired bats and big brown bats are also very similar and therefore we also grouped these two species together. Identifications were accomplished using frequency-time graphs in ANALOOK software (C. Corben, www.hoarybat.com). An anabat echolocation file that approximates a call sequence, defined as a continuous series of greater than two calls (Johnson et al. 2004), was used as the unit of activity.

Results

A total of 461 bat echolocation call sequences were recorded over thirty detector nights at the three sample locations (Table 1). All of the recorded sequences except for one were attributable to *Myotis* species, with a single recorded call sequence that was consistent with characteristics of a big brown bat or silver-haired bat (recorded at 02:17 AM at location 2 on the evening beginning on 17th August). Only 12 of the *Myotis* call sequences were recorded at location 3 and 80 of the call sequences were recorded at location 1. The remaining 368 Myotis echolocation sequences and the single big brown sequence were recorded at location 2. The average number of sequences per night at Dalhousie Mountain (all locations) was 16 (SD = 20) during the sampling period. For context, in 129 nights of monitoring along 5 forested edges from June-August 1999 in the

Greater Fundy National Park Ecosystem the average number of sequences per night was 27 (SD = 44) (Broders unpublished data). The level of activity found at Dalhousie Mountain was less than the average nightly activity level found during the summer in southern New Brunswick.

Although we did not distinguish the calls of Myotis species, the majority of the Myotis sequences recorded at both locations likely represent the little brown bat for at least two reasons. First, the northern long-eared has low intensity calls and is thus not recorded as well as the little brown bat (Broders et al. 2004). Secondly, the northern long-eared bat is a recognized forest interior species (Broders et al. 2006; Jung et al. 1999; Lacki & Hutchinson 1999; Sasse & Pekins 1996) and is less likely to use open areas for foraging and commuting (Henderson 2007).

Discussion

The majority of the recorded echolocation sequences at the proposed Dalhousie Mountain wind development site were calls of the two Myotis species known to occur in Nova Scotia, the little brown bat and the northern long-eared bat. This was expected as these two species are the most common species in the province and are two of only three species of bats with significant populations in Nova Scotia (Broders *et al.* 2003b). We recorded only one call sequence of a species other than a Myotis (either a big brown bat or a silver-haired bat) both of which are rarely encountered in Nova Scotia (Broders et al. 2003a; Taylor 1997) and therefore, it was expected that these species would not be well represented in this survey. The majority of the Myotis calls are likely attributable to the little brown bat because it has calls that are more easily recorded (higher intensity;

Broders *et al.* 2004, Miller and Treat 1993) and is a generalist species that forages in a variety of habitats, including open areas and over water (Anthony & Kunz 1977; Lacki & Hutchinson 1999). Both species may be potentially impacted by the loss of roost sites (tree cavities) and foraging areas when sites are cleared of forest cover for developments if suitable roost trees were situated in the area.

Myotis bats are relatively new to the list of bat fatalities at wind turbine sites. The first large scale wind developments were located in western North America typically in agricultural and open prairie landscapes (reviewed in Johnson 2005). Fatalities of these non-migratory species were largely absent from these sites. It is likely that this reflects the location of these wind development sites in open non-forested landscapes. These species may be under represented in the Chiropteran fauna in these open areas due to an association with forested landscapes. More recently, evidence of Myotis fatalities from collisions with wind turbines have been noted at sites in forested areas in eastern North America (Jain et al. 2007; Johnson 2005; Kerns & Kerlinger 2004).

Another explanation for the paucity of Myotis species from fatalities is that they tend to fly close to the ground (Broders 2003), and thus are less impacted by the rotating blades. A study of bat activity at potential turbine sites prior to construction is currently in progress in the eastern United States where bat activity is being monitored at three heights, ground level (1.5 m), 22m and 44m (Arnett et al. 2006). Preliminary results from this study show that Myotis activity is greater at ground level compared with activity at heights of 22 and 44 m. These findings may lend support to the suggestion that Myotis bats tend to fly lower to the ground but do not account for the relatively high numbers of Myotis fatalities found at wind turbine sites on forested ridges.

To date, very little is known about the real implications of wind developments on populations of small, non-migratory bat species. Little is known about the flight behaviour and dynamics of movements (e.g., height agl of travel and travel routes) of bats to/from hibernacula sites during their regional migration in the fall and spring, and their behavior once they arrive at the hibernacula but before they begin to hibernate. Further, bats arrive at hibernacula 1-2 months before the onset of hibernation when courtship and copulation is believed to occur (Fenton 1969). Exploratory research in Nova Scotia in 2006 indicates that bats are moving significant distances in the fall during swarming (reproductive period) (Poissant and Broders, unpublished data). During this time the majority of bats present during swarming activity at night did not roost in the hibernacula during the day. Additionally, the incidence of recapture was exceptionally low (<1%) and 4 bats with radio transmitters could not be located after release suggesting they moved significant distances from the hibernacula where they were captured. Movement data in other areas of eastern North America indicate bats moved in excess of 200 km between hibernacula within a year and up to 500 km between years (Davis & Hitchcock 1965; Fenton 1969) which demonstrates large scale movements by resident hibernating species.

With data lacking on the activities and movements of regional hibernators like the little brown and northern long-eared bat, it is difficult to predict the specific effects that a wind development will have on local populations of these bats. The high number of fatalities of non-migratory bats at turbine locations on forested ridges in eastern North America suggests that it is an important issue requiring continued research attention and monitoring in the future.

No calls were recorded for the other migratory species (hoary or eastern red bats) at any of the detector sites. Location records for all of these migratory species in the province are patchy with off-shore accounts suggesting only occasional migratory movements through the province (Broders et al. 2003b; van Zyll de Jong 1985). Thus, the lack of recorded call sequences from migratory species was not unexpected. Although the survey did not take place over the entire migratory period, it was approximately 4-weeks long and it is therefore expected that if the area was an important migration corridor we should have detected it.

Recently it has been hypothesized that the size (height) of wind turbines plays a key role in bat fatalities. An on-going study by Arnett *et al.* (2006) that is assessing the height of recorded bat activity at sites prior to construction of turbines, has found that migratory bat species are flying at the highest sampled heights (44m and above). These heights put these species at the greatest risk of collision with rotor blades and may explain high mortality at certain sites. In another study, Barclay *et al.* (2007) compiled data from published and unpublished reports regarding bat (migratory and year-round resident species) and bird mortality at 33 wind energy sites in North America. They provided evidence that suggests that the increased size of new turbines at installations (i.e. height of turbines has increased) may be impacting the number of bat mortalities. Turbines with towers exceeding 60 m potentially resulted in a disproportionately high number of mortalities compared to towers shorter than 60 m. However, the authors noted that turbine height (and therefore size) alone does not explain all of the documented differences in the number and composition of bat species mortalities.

We only used ground based echolocation sampling which may have affected our ability to detect calls by high-flying species if they did move through the area. The range of detection of the systems is dependent on a number of factors, including the frequency and orientation of the call source. However, at its maximum range for an intense, low-frequency call it likely does not exceed 15 to 20 m. Some migratory bats may be flying at heights that exceed 100 m, outside of the range of our ability to detect them but within the area that puts them at risk of collisions. However, our expectation is that if there were any significant numbers of long distance migrants moving through the area we would detect a portion of them with our sampling design. Given the results of other research we have been doing in the region (which suggests few individuals of these species are present), and the fact that we recorded only one echolocation sequence with characteristics consistent with one of the long-distance migrants in this survey it is unlikely that there was any significant amount of activity of these species in the study area.

It is likely that many design and site-level differences determine fatality events as well as various aspects of bat behaviour and movements during the fall swarming and migration period although information on these phenomena are poorly understood (Holland 2007). For example, it is not known if bats actively echolocate when migrating (either locally or long-distance) and the role of landmarks (natural or artificial) as visual cues for swarming and/or migration are also not understood (Cryan & Brown 2007). It is also not known if certain bat species routinely and predictably migrate at certain heights and routes (specific to a region or site) nor is it known if there is large variation in the number of migrants passing through an area from year to year (Barclay et al. 2007;

Johnson et al. 2003a). Stochastic weather factors that vary spatially (regionally from topography) and temporally (in frequency) may also contribute to bat fatality events in an unpredictable manner. In particular, low barometric pressure, low relative humidity and low wind velocities (conditions associated with the passing of storm fronts in an area) have been shown to be associated with high bat mortality events (Erickson et al. 2003; Kerns et al. 2005). Therefore pre-construction activity surveys may be limited in their ability to detect and predict migrating bats moving through an area and thus unexpected mortalities may be found once turbines have been installed and are on-line.

Conclusions

Migratory species of bats have received the greatest attention because they make up the large majority of fatalities at existing wind turbine developments. Past evidence (Broders et al. 2003b), as well as the results of this survey, suggest that there is likely no significant movements of migratory bats species (hoary, red, silver-haired bats) and big brown bats through the region. Although we cannot rule out the possibility that there will be mortality events associated with this development, we have found no evidence with our study that the proposed structures will indeed cause significant direct mortality of long distance migrants, and this is supported by other research in the region that suggests that the abundance and distribution of these species in the province is small.

Bat activity recorded at the proposed site was dominated by Myotis species (little brown bat and northern long-eared), which typically forage at heights below the level of turbine blades. Because the proposed Dalhousie wind development is located in a forested area and bat mortalities have recently been noted at other forested wind developments in eastern North America, their may be a risk of mortality of Myotis bats at this site. Little is known, however, about how these bats interact with turbines and the impact of turbines on their populations may become of concern in the future.

There are a number of significant hibernacula in northeastern Nova Scotia where thousands of bats congregate for courtship and spend the winter months. We know little about the dynamics of the spatial and temporal movement patterns of bats from summering areas to hibernacula and among hibernacula (e.g. are they following specific corridors? Are spatio-temporal aspects of movements in response to particular weather patterns? etc.). Without this information it is difficult to be certain that the development will not impact bats during this time. With our study we have found no evidence to suggest that significant numbers of bats are moving through this area during the migratory period (i.e., no evidence that it is a migration corridor). Therefore, although we cannot rule out the possibility that there will be significant direct mortality associated with the development, we found no evidence to suggest there would be.

To date, there is no established link between pre-construction surveys and post-installation mortalities. Presently there are a number of studies aimed at determining the impacts of wind turbines on bats (e.g. Baerwald and Barclay in southern Alberta) and others are trying to link pre-construction activity with resulting bat mortalities following construction in order to predict relative risk of installation at sites as well as potential fatalities. In response to these concerns, we are making the following recommendations for this proposed project.

Recommendations

- Conduct post-construction fatality searches, ideally for an entire season (April to October), but especially during the fall migration season from mid-August to late-September to fully understand temporal patterns of fatalities. Standardized methods for these searches, including the necessary corrections for scavenging losses and searcher efficiency, can be found in the literature. These data are essential for assessing potential risks at future developments in the region.
- Remain up to date with current research on bats and wind energy developments. There is presently an abundance of research aimed at determining the impacts of wind energy developments on populations of bats. Studies focus on a number of potential mitigation methods, including the effects of weather on activity patterns and collisions, various mitigation treatments (such as turning off turbines when wind speeds are low) or possible deterrents (including acoustic and radar emissions).

Appendix A

Table 1. Number of echolocation call sequences by species group recorded per night at three locations at the proposed Dalhousie Mountain Wind Development Site, Pictou County, Nova Scotia.

	Myotis*				BBB/SHB**	Total for
Evening of	Loc. 1	Loc. 2	Loc. 3	Total	Loc. 2	all species
8-Aug-07	2	n/a	n/a	2	0	2
9-Aug-07	8	n/a	n/a	8	0	8
10-Aug-07	5	n/a	n/a	5	0	5
11-Aug-07	4	n/a	n/a	4	0	4
12-Aug-07	13	n/a	n/a	13	0	13
13-Aug-07	9	n/a	n/a	9	0	9
14-Aug-07	2	n/a	n/a	2	0	2
15-Aug-07	15	n/a	n/a	15	0	15
16-Aug-07	22	n/a	n/a	22	0	22
17-Aug-07	n/a	17	n/a	17	1	18
19-Aug-07	n/a	93	n/a	93	n/a	93
20-Aug-07	n/a	29	n/a	29	n/a	29
21-Aug-07	n/a	30	n/a	30	n/a	30
22-Aug-07	n/a	45	n/a	45	n/a	45
23-Aug-07	n/a	30	n/a	30	n/a	30
24-Aug-07	n/a	2	n/a	2	n/a	2
25-Aug-07	n/a	23	n/a	23	n/a	23
26-Aug-07	n/a	15	n/a	15	n/a	15
27-Aug-07	n/a	42	n/a	42	n/a	42
28-Aug-07	n/a	32	n/a	32	n/a	32
29-Aug-07	n/a	10	n/a	10	n/a	10
30-Aug-07	n/a	n/a	2	2	n/a	2
31-Aug-07	n/a	n/a	1	1	n/a	1
1-Sep-07	n/a	n/a	4	4	n/a	4
2-Sep-07	n/a	n/a	2	2	n/a	2
3-Sep-07	n/a	n/a	1	1	n/a	1
04-Sep-07	n/a	n/a	0	0	n/a	0
05-Sep-07	n/a	n/a	0	0	n/a	0
06-Sep-07	n/a	n/a	2	2	n/a	2
Total	80	368	12	460	1	461

* Includes the little brown bat (*Myotis lucifugus*) and the northern long-eared bat (*M. septentrionalis*).
**BBB/SHB is big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctavigans*)
n/a are nights not monitored at a location for bat activity

Literature Cited

Ahlén, I. 2003. Wind turbines and bats - a pilot study. Page 5p. Sveriges Lantbruks Universitetet, Uppsala, Sweden.

Andersen, P. D., and P. H. Jensen. 2000. Wind energy today and in the 21st century. International Journal of Global Energy Issues **13**:145-158.

Anthony, E. L. P., and T. H. Kunz. 1977. Feeding strategies of the little brown bat, *Myotis lucifugus*, in southern New Hampshire. Ecology **58**:775-786.

Arnett, E., D. Redell, J. Hayes, and M. Huso. 2006. Patterns of pre-construction of bat activity at proposed wind energy facilities. Presentation and Abstract. 36th Annual North American Symposium on Bat Research, Wilmington, North Carolina.

Barclay, R. M. R. 1982. Night roosting behavior of little brown bat, *Myotis lucifugus*. Journal of Mammalogy **63**:464-474.

Barclay, R. M. R., E. F. Baerwald, and J. C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology **85**:381-387.

Broders, H., G. Quinn, and G. Forbes. 2003a. Species status, and the spatial and temporal patterns of activity of bats in southwest Nova Scotia, Canada. Northeastern Naturalist **10**:383-398.

Broders, H. G. 2003. Summer roosting and foraging behaviour of sympatric *Myotis septentrionalis* and *M. lucifugus*. Page 192. Ph.D Dissertation. University of New Brunswick, Fredericton, NB.

Broders, H. G., C. S. Findlay, and L. Zheng. 2004. Effects of clutter on echolocation call structure of *Myotis septentrionalis* and *M. lucifugus*. Journal of Mammalogy **85**:273-281.

Broders, H. G., G. J. Forbes, S. Woodley, and I. D. Thompson. 2006. Range extent and stand selection for forest-dwelling northern long-eared and little brown bats in New Brunswick. Journal of Wildlife Management **70**:1174-1184.

Broders, H. G., D. F. McAlpine, and G. Forbes. 2001. Status of the eastern pipistrelle (*Pipistrellus subflavus*) (Chiroptera:Vespertilionidae) in New Brunswick. Northeastern Naturalist **8**:331-336.

Broders, H. G., G. M. Quinn, and G. J. Forbes. 2003b. Species status, and the spatial and temporal patterns of activity of bats in southwest Nova Scotia, Canada. Northeastern Naturalist **10**:383-398.

CanWEA. 2001. Wind Vision for Canada (10x10): Recommendations for achieving Canada's wind energy potential. Page 9p. The Canadian Wind Energy Association, Calgary, Alberta.

CanWEA. 2006. The Wind Energy Industry: The business of wind. Canadian Wind Energy Association Fact Sheets.

Cryan, P. M., and A. C. Brown. 2007. Migration of bats past a remote island offers clues toward the probelm of bat fatalities at wind turbines. Biological Conservation **139**:1-11.

Davis, D. S., and S. Browne, editors. 1996. The Natural History of Nova Scotia: Theme Regions. Nimbus Publishing and the Nova Scotia Museum, Halifax, Nova Scotia.

Davis, W. H., and H. B. Hitchcock. 1965. Biology and migration of the bat, *Myotis lucifugus*, in New England. Journal of Mammalogy **46**:296-313.

Erickson, W. P., J. Jeffrey, K. Kronner, and K. Bay. 2003. Stateline Wind Project Wildlife Monitoring Annual Report, Results for the period July 2001- December 2002. . Technical report submitted to FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee.

Farrow, L. J. 2007. Distribution of the eastern pipistrelle (*Perimyotis subflavus*) in southwest Nova Scotia relative to landscape factors. MSc thesis. Saint Mary's University, Halifax, Nova Scotia.

Fenton, M. 1997. Science and the conservation of bats. Journal of Mammalogy **78**:1-14.

Fenton, M. 2003. Eavesdropping on the echolocation and social calls of bats. Mammal Review **33**:193-204.

Fenton, M., and G. Bell. 1981. Recognition of species of insectivorous bats by their echolocation calls. Journal of Mammalogy **62**:233-234.

Fenton, M. B. 1969. Summer activity of *Myotis lucifugus* (Chiroptera:Vespertilionidae) at hibernacula in Ontario and Quebec. Canadian Journal of Zoology **47**:597-602.

Fenton, M. B., and D. R. Griffin. 1997. High-altitude pursuit of insects by echolocating bats. Journal of Mammalogy **78**:247-250.

Fujita, M., and T. Kunz. 1984. *Pipistrellus subflavus*. Mammalian Species **228**:1-6.

Garroway, C. J. 2004. Inter- and intra-specific temporal variation in the activity of bats at two Nova Scotia hibernacula. Honours thesis, Department of Biology. Saint Mary's University, Halifax, Nova Scotia.

Grindal, S. D., and R. M. Brigham. 1999. Impacts of forest harvesting on habitat use by foraging insectivorous bats at different spatial scales. Ecoscience **6**:25-34.

Henderson, L. E. 2007. The effects of forest fragmentation on the forest-dependent northern long-eared bat (*Myotis septentrionalis*). MSc thesis. Saint Mary's University, Halifax, Nova Scotia, Canada.

Holland, R. A. 2007. Orientation and navigation in bats: known unkonwns or unknown unknowns? Behavioral Ecology and Sociobiology **61**:653-660.

Hornung, R. 2006. Status report on wind energy supply and demand in Atlantic Canada. Canadian Wind Energy Association, Calgary, AB.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual report for the Maple Ridge Wind Power Project Postconstruction bird and bat fatality study - 2006. Curry and Kerlinger, LLC, Syracuse, NY.

Johnson, G., W. P. Erickson, J. White, and R. McKinney. 2003a. Avian and bat mortality during the first year of operations at the Klondike Phase I Wind Project, Sherman County, Oregon, Goldendale, WA, USA.

Johnson, G. D. 2005. A review of bat mortality at wind-energy developments in the United States. Bat Research News **46**:45-50.

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, and D. A. Shepherd. 2003b. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. American Midland Naturalist **150**:332-342.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin **32**:1278-1288.

Jung, T. S., I. D. Thompson, and R. D. Titman. 2004. Roost site selection by forest-dwelling male Myotis in central Ontario, Canada. Forest Ecology and Management **202**:325-335.

Jung, T. S., I. D. Thompson, R. D. Titman, and A. P. Applejohn. 1999. Habitat selection by forest bats in relation to mixed-wood stand types and structure in central Ontario. Journal of Wildlife Management **63**:1306-1319.

Kerns, J., W. P. Erickson, and E. B. Arnett. 2005. Bat and Bird Fatality at Wind Energy Facilities in Pennsylvania and West Virginia. in E. B. Arnett, editor. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, TX, USA.

Kerns, J., and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003. Prepared by Curry & Kerlinger, LLC.

Lacki, M. J., and J. T. Hutchinson. 1999. Communities of bats (Chiroptera) in the Grayson Lake Region, Northeastern Kentucky. Journal of the Kentucky Academy of Science **60**:9-14.

McAlpine, D. F., F. Muldoon, G. Forbes, A. I. Wandeler, S. Makepeace, H. G. Broders, and J. P. Goltz. 2002. Over-wintering and reproduction by the big brown bat, *Eptesicus fuscus*, in New Brunswick. Canadian Field-Naturalist **116**:645-647.

Menz, F. C., and S. Vachon. 2006. The effectiveness of different policy regimes for promoting wind power: Experiences from the states. Energy Policy **34**:1786-1796.

Moseley, M. 2007. Records of bats (Chiroptera) at caves and mines in Nova Scotia. Curatorial Report # 99, Nova Scotia Museum, Halifax, Canada.

Nicholson, C. P. 2003. Buffalo Mountain windfarm bird and bat mortality monitoring report, Knoxville, Tennessee.

O'Farrell, M., and W. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy **80**:24-30.

O'Farrell, M., B. Miller, and W. Gannon. 1999. Qualitative identification of free-flying bats using the Anabat detector. Journal of Mammalogy **80**:11-23.

Osborn, R. G., K. F. Higgins, R. E. Usgaard, C. D. Dieter, and R. D. Neiger. 2000. Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. American Midland Naturalist **143**:41-52.

Rockwell, L. 2005. Species diversity and geographic distribution of bats in Mainland Nova Scotia. Honours thesis. Saint Mary's University, Halifax.

Sasse, D. B., and P. J. Pekins. 1996. Summer roosting ecology of northern long-eared bats (*Myotis septentrionalis*) in the White Mountain National Forest. Pages 91-101 in R. Barclay, and R. Brigham, editors. Proceedings of the Bats and Forests Symposium of the British Columbia Ministry of Forests, Victoria, B.C., Canada.

Taylor, J. 1997. The development of a conservation strategy for hibernating bats of Nova Scotia. Honours thesis. Dalhousie University, Halifax, Nova Scotia.

Thomas, D. W., G. P. Bell, and M. B. Fenton. 1987. Variation in echolocation call frequencies recorded from North American Vespertilionid bats: A cautionary note. Journal of Mammalogy **68**:842-847.

Tutty, B. R. 2006. Temporal variation in bat activity at two hibernacula in Nova Scotia: Spring emergence, fall immergence and management concerns. Honours thesis. Saint Mary's University, Halifax, Nova Scotia.

van Zyll de Jong, C. G. 1985. Handbook of Canadian Mammals. Vol 2 (Bats) National Museums of Canada, Ottawa, Ontario.

Veilleux, J. P., J. O. Whitaker, Jr, and S. L. Veilleux. 2004. Reproductive stage influences roost use by tree roosting female eastern pipistrelles, *Pipistrellus subflavus*. Ecoscience **11**:249-256.

Young, D. P. J., W. P. Erickson, R. E. Good, M. D. Strickland, and G. D. Johnson. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming. Western EcoSystems Technology, Inc. (WEST, Inc.).