APPENDIX 5. *Bats and Wind Turbines. Pre-siting and pre-construction survey protocols.* May 2006

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This document has been reviewed and endorsed by the Alberta Bat Action Team (http://www3.gov.ab.ca/srd/fw/bats/ABAT.html), and is an Appendix to the following:
Vonhof, M. 2002. Handbook of Inventory Methods and Standard Protocols for Surveying Bats in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, Alberta. Revised 2005.

Introduction

Recent studies indicate that at some wind-energy installations in North America, bats are being struck and killed by moving wind turbine blades (Johnson et al. 2003, 2004, Arnett. 2005). Relatively little is known about the causes or consequences of such mortalities, but based on the following information, pre-siting surveys for bats should be conducted at all proposed wind-energy sites to assess the potential for bat mortalities. As new information is obtained, recommendations and requirements will be revised and thus this should be considered a "living document".

Over 90% of bat mortalities currently recorded at wind energy developments involve migratory species, while only a small proportion of year-round residents are killed. Depending on the location, hoary bats (*Lasiurus cinereus*), eastern red bats (*Lasiurus borealis*), and silver-haired bats (*Lasionycteris noctivagans*) dominate mortalities. All three species migrate north in spring, females bear their young during the summer, and individuals migrate back south in late summer or early autumn. Little is known about the migratory behaviour of any of these species (but see Cryan 2003, Barclay 1984), especially at smaller geographic scales. For unknown reasons, current records of mortalities at wind energy developments occur almost exclusively during fall migration (Johnson et al. 2003, 2004, Arnett et al. 2005). Both adults and juveniles (young-of-the-year) of both sexes are involved. Mortalities vary among wind energy developments, and from night to night, again for unknown reasons. There are some data suggesting that mortality rates are higher on nights with lower wind speeds (Arnett et al. 2005), but correlation with landscape features and weather remain to be determined.

In Alberta, issues regarding bats and wind turbines appear to be similar to those found elsewhere in North America. Mortalities involve primarily hoary and silver-haired bats during fall migration, although red bats have the potential to be of concern, due to their migratory behaviour. Mortalities vary from site to site. While mortalities of non-migratory species in Alberta have been relatively few to date, only a few studies have been conducted. Until further studies have been conducted, activity of all species at proposed wind energy developments should be monitored.

Site Selection

The potential impact on bat populations should be considered during selection of sites for wind-energy installations. In forested areas, this means avoiding forest edges and ridge tops. In general, bats tend to be detected in higher concentrations around bodies of water and in well-vegetated areas, and migratory movement may be along natural corridors, such as valleys, streams, and cutlines. Therefore, wind energy developments should not be placed in these areas. In particular, effort should be made to avoid north-south valleys and natural corridors. Ideally, turbines should be positioned in open, flat areas at least 500m from bodies of water, riparian habitats, and forest edges. However, because bat migration is poorly understood in Alberta, all proposed wind energy development locations should be monitored for bats using a pre-construction survey. Wind energy developments should not be located within 1 km of known bat hibernacula.

Pre-Construction Survey

Goal
The goal of the pre-construction survey is to achieve a representative sampling of bat activity across a proposed wind energy development location. This will facilitate estimates of the relative risk to bats from wind turbines at proposed sites, but cannot guarantee that sites with low levels of activity will result in fewer deaths than sites with higher levels of activity. In addition, monitoring data collected from various locations across the province should be pooled so that a better understanding of the landscape-scale patterns of bat migration can be assessed.

Specifically, the recommended surveys are designed to determine:
- Species occurrence and diversity
- Activity levels (e.g., relative abundance, seasonal timing, daily timing)
- Potential migration routes

Deposition of all data (acoustic, capture, radar, meteorological) with SRD, Fish and Wildlife Division, will provide a foundation upon which to evaluate future survey data, and will eventually facilitate an understanding of patterns that may lead to better site selection and mitigation techniques.

Timing
Bats in Alberta shift habitat with the seasons, making late summer and early autumn monitoring of bat activity optimal. At a minimum, bat activity during the entire month of August should be measured; because silver-haired bats have been shown to move through an area later than hoary bats, if possible, the first two weeks of September should be also be monitored. Ideally, monitoring should be done for two years to account for year-to-year variation. If potential hibernacula (i.e. caves, abandoned mines, badlands topographical features) of non-migratory species are located nearby, late autumn (October) surveys should be conducted in addition to the August survey. Survey options include mistnetting, acoustic detection, and radar tracking.

Methods
To meet the above goals, three sampling techniques are recommended:

1. Acoustic detection (to determine relative abundance, activity patterns, and species or species group identification)
2. Radar tracking (to determine relative abundance, and general migration behaviour, including flight height, timing and location)
3. Mistnetting (to confirm species identification)

Each of the above sampling techniques has limitations, as discussed below. However, when used in combination, these techniques should provide information on:

- the relative abundance of the most susceptible species
- the location of potential migration routes

Acoustic detection. Because bats generally echolocate as they fly, microphones sensitive to the frequency of sounds that bats use (ultrasound) can provide a measure of bat activity in an area. Although there are a variety of bat detectors available on the market, currently only one type allows for high capacity storage of echolocation data required for the prolonged monitoring recommended in this protocol. AnaBat with a Compact Flash Storage Zero Crossings Analysis Interface Module (CF-ZCAIM; Chris Corben, www.hoarybat.com; Titley Electronics, Australia; refer to Appendix 4) digitally records echolocation sequences (refer to Section 1.4.2 in the Handbook). When 1 – 5 turbines are proposed, an AnaBat system placed at each proposed turbine location is recommended. When more than 5 turbines are proposed, positioning at least one AnaBat detector at each of the north, east, south, and west peripheries of the proposed area, and one in the centre is recommended. In a linear array, all 5 AnaBats would be positioned equidistant along the proposed linear area. If the proposed area encompasses a geographically, geologically or ecologically diverse terrain, then using more AnaBats may be necessary.

Because mortality occurs in the rotor-swept area, AnaBat microphones should be placed at least 30 m above the ground. All AnaBats at a site need to be at a consistent height so that data are comparable. Existing meteorological towers or temporary towers can be used to allow the microphone to be hoisted into the air. If the microphone is to be placed at the top of a turbine or other tower, the addition of an extension cable running from the microphone to the AnaBat will necessitate the use of a specialized Model Hi-microphone rather than a "standard" Model STI-microphone (Titley Electronics). Microphone cables exceeding 60m in length should be avoided as they can interfere with proper signal transmission. Microphones at heights of 30 m or more above the ground should be oriented parallel to the ground or at a slight upwards incline. Alternatively they may be face downwards if a reflective shield positioned on an angle below the microphone is used (reflective shields and custom AnaBat accessories available from Tracy Allen, www.emesystems.com). Because wind and rain can interfere with ultrasound collection, microphones should be pointed away from the prevailing winds, and a shielding system should be used that minimizes rain exposure, but does not interfere with ultrasound collection. Microphone heads that have a discoloured gold colour have less sensitivity and should be replaced. Sensitivity of the AnaBats can be adjusted, and we recommend a level of 8. If this generates too many extraneous “noise” files (see below), sensitivity can be lowered, but this compromises detection range. All AnaBats in the survey area should be set at the same sensitivity setting, and this sensitivity should be provided with data submission. To best detect the range of bat species in Alberta, a division ratio of 16 on the Anabat should be used.

The AnaBat (with the timer function “on”) together with the CF-ZCAIM draw little power, and will operate properly for 2 weeks or more running on an external 24 amp-hour 12-volt battery. However, because AnaBat sensitivity decreases as battery power decreases, the battery should be monitored and recharged as necessary. Alternatively, a solar panel can be installed to keep the external battery charged. The AnaBat, CF-ZCAIM and battery need to be stored in a semi-waterproof container to ensure rain does not come in contact with the electronics. If the microphone is in the container attached to the AnaBat, the head can be positioned up to a sufficiently large hole in the container, otherwise, an extension cable leading to an externally located microphone will extend through a small hole in the container.

Even though the number of bat passes in a monitored area may be small, use of a high capacity (512 MB or larger) flash card is recommended, because wind noise and other types of interference often trigger the system, resulting in a large number of “noise” files being stored on the card. The software (CFRead) necessary to program the flashcard and CF-ZCAIM, and to retrieve the data file from the flashcard, comes with the AnaBat unit when purchased from Titley Electronics. The retrieved data file needs to be “interpreted” to generate individual echolocation sequence files. Interpretation will automatically occur if this option is selected in the CFRead menu. Alternatively, the data file can be interpreted at a later time. Each echolocation sequence is represented as a unique file, with year, date, and time of the bat pass comprising the file name. Each sequence can be viewed using AnaLook software, which is also included with the AnaBat system if purchased from Titley Electronics, or freely downloadable from the AnaLook author’s webpage (http://users.lmi.net/corben/WinAnalook.htm). Proper analysis of these files requires significant experience in species identification. Discussion of the identification process and the difficulties of accurate species identification using acoustic monitoring is beyond the scope of this protocol (but see Barclay 1999, Fenton 2000).

Minimally, acoustic data should be presented as total bat passes and mean passes per detector-night (excluding nights with measurable precipitation). To allow comparison with other studies where continuous monitoring may not have been achieved, data should also be presented as mean passes per detector-hour; to provide data for potential future mitigation and ongoing research in this field, number of passes in each 60 minute period after sunset should also be presented. With sufficient experience, a breakdown indicating passes by the following four groups of bats: big brown (*Eptesicus fuscus*)/silver-haired (*Lasionycteris noctivagans*), hoary (*Lasiurus cinereus*), red (*Lasiurus borealis*), and *Myotis* species, will also be beneficial.

Acoustic detection of bats is far less expensive than radar (one AnaBat system ~$2000; refer to Appendix 3), and because detection is through echolocation, rather than visualization, it is not biased by the presence of birds. However, this type of survey makes the assumption that most bats are echolocating as they move through the area. While at least some bats flying at wind turbine heights echolocate, it is not yet known whether all do so, and thus, measurements of activity can currently only be used as an index of the number of bats flying past the bat detector. In addition, not all species of bats are easily identified via their echolocation calls.

Radar tracking. Radar represents an alternative to acoustic monitoring, albeit an expensive one. Using radar, bats can be visualized in a large volume of space with a radius of up to several kilometers. Currently, distinguishing bats from birds using radar is difficult, but better algorithms are being developed. Bat species cannot be differentiated. Radar equipment, and an experienced technician to operate the equipment and interpret data, at present, are not readily available, making this technique limiting. Western EcoSystems Technology, Inc. (Cheyenne, Wyoming) and EchoTrack (R. Millikin, Ottawa, Ontario) are the two companies currently offering bat surveys using radar. Using radar, the number of bats flying through the proposed wind energy development area should be counted throughout the entire month of August, at minimum, with monitoring continuing until mid-September when possible. As with acoustic data, total and mean numbers of bats per night and per detector-hour (excluding nights with measurable rainfall) should be calculated. In addition, the proportion of bats flying within the rotor-swept height should be calculated.

Mistnetting. Although mistnetting is the typical survey method for bats, not all wind energy development sites offer conditions conducive to netting. Mistnetting should only be carried out by qualified personnel (i.e. with experience using mistnets for bats and identifying bats) with pre-exposure rabies vaccinations. Because many bats fly above practical mistnet height, surveying for bats from the ground is not the best way of determining a wind energy development's potential impact on bats. Similarly, most mortalities occur when the turbine blades strike bats flying at heights >20m. For these reasons, mistnetting alone is inappropriate for assessing bat activity at proposed wind-energy installations, and should be considered a low priority method for establishing the type of baseline data needed for pre-construction surveys. If the area around the proposed turbines is conducive to mistnetting, data should be collected according to the suggested standards for bat research in Alberta (Vonhof 2002). Because capture success can be affected by moonlight and weather conditions, continuous sampling is usually not possible. Periodic sampling in areas conducive to netting, in appropriate conditions, should take place in late July, throughout August and early September. Mistnetting data complement acoustic and radar data (Kuenzi and Morrison 1999), providing unequivocal identification of species. Species identification, sex, age (adult or juvenile), mass, and forearm measurements should be recorded for each capture. Refer to the Handbook for appropriate netting protocol.

Other Considerations. Meteorological data may be used to correlate estimates of bat abundance and activity to variation in weather, and can be used to explain variation in activity across nights and/or among sites. Minimally, temperature, wind speed and direction, and rainfall should be recorded every 30 minutes while conducting surveys, and incorporated into the analysis. Additionally, rapid changes in barometric pressure may signal incoming weather fronts, and may correlate with passing waves of migratory species. Meteorological data may be available from MET towers in the proposed wind energy development area; otherwise, meteorological variables should be recorded with data loggers or portable weather stations (e.g. available at Forestry Suppliers Inc., Onset Computer Corp., etc.).

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For information on other suppliers, see Appendix 3.

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