Bat Mitigation Framework for Wind Power Development

Wildlife Land Use Guidelines

Introduction

The role of Alberta Environment and Sustainable Resource Development (ESRD) - Wildlife Branch is to ensure that development of wind power projects includes appropriate consideration and mitigation of potential effects to Alberta's wildlife populations.

Wind power has both direct and indirect effects on wildlife, particularly on bats. Wind power projects may have negative effects on bat populations and bat habitat through:

1) physical changes to habitat associated with project construction;
2) decreased bat populations due to bat fatalities during the operation of a wind turbine; and
3) alterations to bat movement.

Wind energy projects must be appropriately sited and well planned to avoid or minimize bat mortalities. The sites chosen for wind power developments due to favorable local meteorological conditions also appear to coincide with bat migration corridors, with turbine heights and numbers playing a significant role in bat fatalities (Barclay et al. 2007, Baerwald and Barclay 2009).

High rates of bat mortalities are concerning as bats are relatively long-lived with low reproductive output rates, and the majority of bats killed by turbines tend to be reproductive adults.

On average, greater than 80% of bat fatalities currently recorded at wind energy developments in North America involve migratory species (Arnett et al. 2008). Bat fatalities, primarily migratory species, occur through direct collision with blades or indirectly from rapid decompression (barotrauma) near turbines (Baerwald et al. 2008). Hoary bats (*Lasiurus cinereus*), and silver-haired bats (*Lasionycteris noctivagans*) dominate fatalities in Alberta and the highest rate of bat mortalities typically occurs during the late summer and early fall migration period. The provincial status listings for hoary and silver-haired bats were changed to "sensitive" in 2005 (Alberta Sustainable Resource Development 2005), reflecting ongoing concerns with the rates of fatalities for these species due to human activities.

The goal of this framework is to inform both ESRD-Wildlife Branch staff and industrial proponents about the management of bats in relation to wind power generation, and assist in the application of mitigation measures specific to reduce the effect of turbine operation on bats. As our knowledge of both wind turbine technology and bat ecology increases, updated mitigation strategies will be necessary. This adaptive management framework is a 'living document' that will be updated as new information on bats and wind energy becomes available. This document discusses bat fatalities, pre-construction surveys and risk assessment, post-construction monitoring and step-wise bat mitigation strategies.

Bat Fatality Rates

The majority of bats killed at wind power developments in Alberta are migratory species (hoary and silver-haired) that are killed most frequently during fall migration. It is not known why bat fatality rates is not as high during spring migration; it is due perhaps to bats flying at a higher elevation during the spring or using different travel corridors with less wind power facilities when travelling north. Alberta migratory bat species typically roost in treed areas and forage over open country. Wind turbines located in migration corridors between these two habitat types may contribute to high bat fatality rates. In addition, at some wind power developments, the northern-most turbines in a development tend to contribute most to bat fatalities, presumably because bats are migrating south in the fall (Arnett et al. 2008, Baerwald and Barclay 2011). Turbine height is also an important factor, as taller turbines kill more bats (turbines above 65 metres; Barclay et al. 2007). Bat migration seemingly occurs at heights of 60 to 90 metres above ground (Kunz et al 2007, Baerwald and Barclay 2009) and as tall turbines are becoming more common, bat fatalities are expected to be a frequent issue for wind turbines.

Bat activity (measured by recording echolocation passes) is higher at low wind speeds, and reducing turbine activity during low wind periods by increasing the minimum wind cut-in speed of turbines, has resulted in decreased bat fatality (Baerwald and Barclay 2009, Arnett et al. 2010). If bats mimic bird migration, bats may migrate more in conjunction with tail winds (Hedenstrom 2009). This creates an opportunity to minimize risk to bats by adjusting turbine speed during southerly windy conditions.

Pre-Construction Surveys and Risk Assessment

The goal of a pre-construction bat survey is to estimate the relative risk of fatality to bats from wind turbines at proposed sites via a representative sampling of bat activity across a proposed wind power development location. Pre-construction surveys for bats are conducted at all proposed wind power development sites to assess the potential for bat fatalities following the recommendations and protocol of the Alberta Bat Action Team (ABAT) (Lausen et al. 2010). Where significant risk to bat populations have been identified through pre-construction surveys, ongoing bat surveys will be required until an accurate assessment of the effects of the operation of the wind power development on bats can be ascertained.

When assessing pre-construction bat monitoring data, ESRD-Wildlife Branch will be specifically evaluating:

1. Bat Survey Protocol: Follow the recommended practices from ABAT Pre-Construction Protocols for bats (Lausen et al. 2010).

2. Timing of survey: Surveys must occur at times appropriate for detection. Collection of fall bat migration data (August 1 – September 10) must be the priority, as most fatality is associated with migrants traveling south in the fall. Detectors should begin operation at least one half-hour after sunset and end one half-hour before sunrise.

3. Acoustic detectors: Detectors are placed in enough locations to characterize bat movements over the entire area proposed wind power developments, and to capture north-south bat migration movements. An adequate number of detectors need to be placed at heights of 30 metres, as literature suggests detections are significantly higher at that height. Proponents are to refer to the Pre-Construction Protocols (Lausen et al. 2010) regarding the number and placement of detectors. Assessments should be made to assess differences in detection rates between detections at ground level and 30m. Analysis will need to factor differences in detection rates when determining bat activity.

4. Type of detector: Acoustic detectors have been most effective in assessing bat activity. Radar can characterize movement patterns of flying animals but cannot distinguish bats from birds. Radar is not recommended for bat activity evaluation but may be acceptable if used in conjunction with acoustic monitoring.

5. Data: The acoustic data are reported as a mean number and variance of bat passes per detector night, and also as bat passes per megawatt of electricity generated per detector night. Detector night is based on detectors operating a half-hour after sunset to a half hour before sunrise, and between August 1 and September 10. Data are also to be reported as

passes per detector night, and broken down into at least two categories: migratory bat species and non-migratory bat species. Low frequency observations can be grouped with migratory data for conservative estimate of migratory bat passes. Data from individual detector locations are also important. Data are to be entered into the Fish and Wildlife Management Information System (FWMIS) so that the information can be referred to by ESRD-Wildlife Branch staff and others.

A number of acoustic bat detectors are to be used to give a representative sample of bat activity across the wind power development and the various habitat or topographical features. Sampling stations should be distributed geographically throughout the wind power development area such that the perimeter of the proposed area is monitored in addition to the central area, and any likely migratory fly-ways (see Lausen et al. 2010). It is important to note that pre-construction bat activity (passes) based on 30 metre high acoustic data has been related to post-construction fatality, on average at a rate of roughly 1 bat pass per detector-night to 4 bat fatalities per turbine per year (Baerwald and Barclay 2009). Based on this preliminary relationship and using the Precautionary Principle, ESRD -Wildlife Branch views:

- Less than 1 migratory-bat passes* per detector-night as a potentially acceptable risk;
- 1 to 2 migratory-bat passes* per detector-night indicates a potentially moderate risk. Mitigation measures such as siting turbines in alternative locations, reducing turbine height and/or rotor length and other strategies, are to be anticipated and explored;
- Greater than 2 migratory-bat passes* per detector-night indicates that there is a potentially high risk of bat fatalities. Alternative turbine locations are to be considered, and/or operational mitigation will most likely be required (e.g. changing cut-in speeds) to reduce bat fatality to an acceptable level.

Mitigation for moderate to high risk bat activity, through appropriate siting to avoid migration corridors and/or areas of high bat activity, is to be pursued prior to requesting an ESRD-Wildlife Branch wind energy project referral report (sign-off). To date, studies at Alberta wind power developments indicate that migratory species are the dominant bat species killed, but tracking of non-migratory bat species activity and fatality is still required.

* Note: migratory-bat passes refers to total passes for the migratory species combined, not including other resident species. Bat passes is based on detector nights operating Aug 1 – Sept 10.

Post-Construction Surveys and Assessment

Post-construction monitoring requirements will be site-specific and based on an adaptive management approach to local wildlife (bat) issues. Post-construction fatality assessments are to follow the recommendations and protocol of the ABAT. Decisions on how much effort and time are appropriate for post-construction fatality assessments will be based on several considerations. These decisions will be influenced by

- pre-construction survey assessments
- site characteristics
- estimated bat population levels
- number of turbines
- assessed likelihood that the particular development will cause high numbers of bat mortalities

Bat fatality surveys are to include the area within a radius of at least 50 metres from the base of the turbine (Baerwald and Barclay 2009).

Results of fatality surveys are to be reported to ESRD-Wildlife Branch (using FWMIS database) annually in a standardized format, including raw data, quantification of search effort and estimates of sampling efficiency. A bat fatality rate estimate is to be determined and reported as 'fatalities per turbine per year', as well as 'fatalities per MW rated capacity per year'. All fatality data is to be corrected using methods proposed by Huso (2011) to account for carcass removal by predators and searcher efficiency. Additionally, this fatality estimate can be assessed using a web-based Wildlife Fatality Estimator.

Collaborative and adaptive management approaches between wind power developers and ESRD-Wildlife branch are encouraged to reduce the risk to wildlife and help ensure compliance with the Wildlife Act. In areas of high seasonal bat use, or where post-construction monitoring shows a high incidence of bat fatality, adjusting cut-in speeds may be necessary to reduce bat fatality, especially from mid-summer to late fall when fatality peaks (Arnett et al. 2008). This adjustment will be recommended by the ESRD Wildlife Biologist, in consultation with bat experts, as required. Initiation of discussions and consultations between wind power developers and ESRD-Wildlife Branch regarding operational mitigation and adjustments are based on a combination of any of the following:

- Pre-construction surveys indicating "less than 1 migratory-bat passes/detector-night" (equating to less than 4 mortalities per turbine) suggests that bat fatality issues are unlikely; however, post-construction monitoring is required. Also, if bat activity appears to be concentrated in a certain area of the proposed site, then about pre-construction mitigation should occur.

- Pre-construction surveys indicating "1 to 2 migratory-bat passes/detector-night" (equating to 4 to 8 mortalities per turbine) alert both ESRD-Wildlife Branch and the proponent that bat fatality issues may be present and consultation with ESRD-Wildlife Branch is required about pre-siting mitigation, and the types of mitigation that are proposed to manage post-construction fatality.

- Pre-construction surveys indicating "greater than 2 migratory-bat passes/detector night" (equating to greater than 8 mortalities per turbine) alert both Wildlife Branch and the proponent that bat fatality issues are likely and consultation with ESRD-Wildlife Branch is required as described above. If exceptionally high activity is determined in consultation with the Wildlife Biologist, pre-siting mitigation and, depending upon the results of carcass surveys, post-construction mitigation initiated in a stepwise fashion (see Figure 1).

- Locating wind turbines in potential bat migration corridors along southward valley systems (Red Deer River valley and Bow River valleys), and adjacent to continuously treed habitats (e.g. along the Foothills), poses a potential risk of high bat fatality during turbine operations (E. Baerwald pers. comm.). Additionally, locating wind turbines among or between bat roosting habitat (mature mixed wood or riparian forests, river valley coulees and rock crevices) and foraging habitat (wetlands, open meadows) could also pose a risk of high fatality to local bat populations.

- Post-construction surveys indicating a fatality rate of 4 to 8 fatalities (corrected as per Huso 2011) per turbine per year of any combination of migratory bat species (hoary, silver haired and red bats) will lead to consultation with ESRD-Wildlife Branch about possible mitigation and further monitoring. Operational mitigation, although likely, may not be necessary at this point, and discussion should occur to outline approaches available.

- Greater than 8 fatalities per turbine per year are considered a very high risk site to bats. This estimated level of risk has been set, pending further research on bat population estimates, based on the listing of hoary and silver-haired bats as "Sensitive", as well as recommendations from other jurisdictions. Although a fatality rate exceeding 8 fatalities for an individual wind turbine constitutes a high risk site, lower fatality rates among several wind turbines in an area may similarly be considered high risk to bats due to the cumulative fatalities.

- Annual total bat fatalities at a wind power development in the range of 500 bats per development per year is concerning to ESRD-Wildlife Branch. Moreover, because some wind power developments are in close proximity to one another, ESRD-Wildlife Branch will track cumulative bat fatalities due to wind turbine operations in an area and evaluate the need for additional post-construction mitigation. For example, 500 bat mortalities per year at one wind power development will have a similar affect on the bat population as five wind power developments in the same local area, each with 100 bat mortalities per year. Therefore, proximity to other wind power developments, the level of bat fatality at these developments, and the projected level of bat fatality risk at the proposed site based on pre-construction surveys will be factored into discussions regarding siting and mitigation. A new wind power development proposed in close proximity to another wind power development with a high risk of bat fatality is much more likely to require mitigation.

Note: At present, there is no accepted bat fatality threshold (i.e. a rate beyond which fatality is not sustainable to the population). Due to the specific prohibitions about causing harm to wildlife in the Wildlife Act, ESRD-Wildlife Branch has adopted 4 to 8 bat fatalities per turbine per year (estimated fatality based upon 1 to 2 passes per detector) to initiate consultation with wind power applicants regarding possible mitigation. The reason for this risk level is twofold:

1) It is based on the Precautionary Principle, to address turbine-related bat fatalities before it becomes a population level issue. Adopting this principle is particularly important as the bat species most commonly being killed by wind turbines are listed as "Sensitive" and the additional stresses to bat populations due to habitat loss and disease (e.g. white-nose syndrome).

2) Employing a range for the estimated level of risk allows for site-specific conditions to be factored into the discussions. Eight mortalities per turbine exceeds the mean wind-turbine related bat fatality rate across the continent (Barclay, pers. comm.), suggesting that this rate is not unusual; however, it may be too high. Until researchers are able to confidently estimate bat population sizes it is not possible to determine the population-level effects of various levels of turbine-induced fatality. Therefore, this approach is not managing towards an acceptable level of fatality, but rather an acceptable level of risk. Higher levels of risk will require more rigorous review and evaluation of mitigation strategies to maintain the level of benefits that Albertans expect from energy development.

Operational mitigation strategies:

There are relatively few mitigation measures that have proven effective to reduce bat fatality during wind turbine operations. Wind turbines in Alberta generally have a minimum wind cut-in speed around 4 metres per second, meaning that electricity starts to be generated when that wind speed is reached. It has been shown that increasing cut-in speeds to 5.5 metres per second, significantly reduced turbine-related bat fatality, as bat activity is reduced during higher wind speeds (Baerwald et al 2009, Arnett et al 2010).

Additionally, altering the pitch angle of the turbine blades and lowering the required generator speed for electricity production had the same beneficial effect on bat fatalities, as did increasing rotor start-up wind speed (Baerwald et al. 2009). Moreover, some of those mitigation methods may extend the life of the turbines (Baerwald et al. 2009). These operational mitigations have been implemented with small cost impacts to the proponent.

Further, as bats typically migrate during the night, operational mitigation only during night-time operation further reduces costs. Other mitigation, such as warning lighting (Johnson et al. 2003) and application of UV paint (Young et al. 2003) has not been shown to be effective at reducing bat fatalities. Bat fatalities tend to be associated with a group of turbines within a wind power development (such as the northern-most turbines), but not with individual turbines. If a group of turbines was associated with high bat fatality, then mitigation could focus on that area. Otherwise, mitigation recommendations will be for most, or all, of the wind power development.

After reviewing pre-construction acoustic surveys, a mitigation strategy is to be developed by proponents to address the anticipated levels of bat fatalities related to turbine operations. Developing this strategy prior to application for development approval from the Alberta Utilities Commission will ensure efficient implementation of operational mitigation, if required. To ensure that this is understood by all parties, bat activity monitoring, estimates of turbine-related bat fatality and development of an operation mitigation strategy will components of the wind energy project referral report (sign-off) provided by ESRD-Wildlife Branch.

Therefore, recognizing industry considerations, ESRD-Wildlife Branch suggests implementing the following approaches:

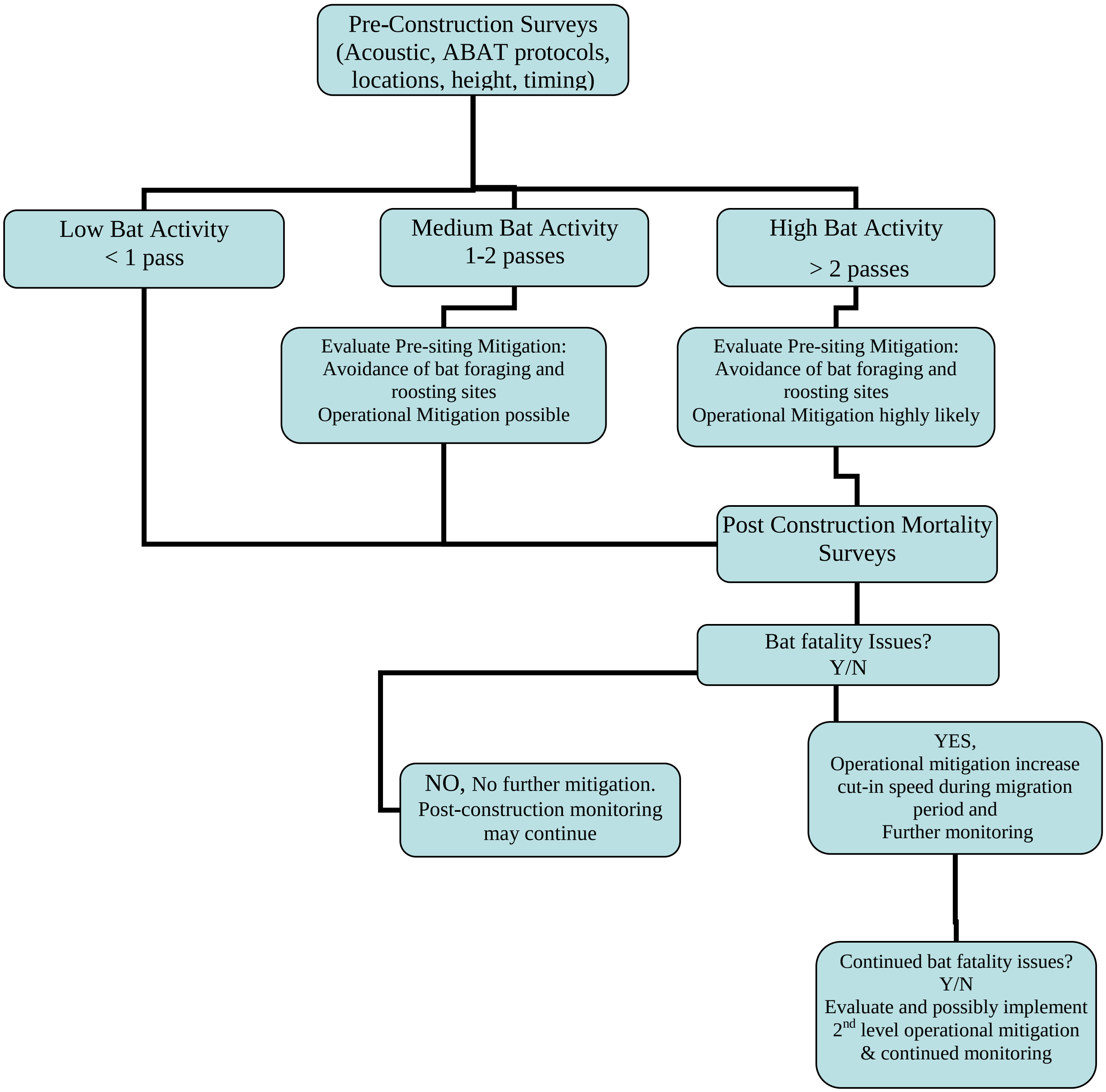
1. Based on post-construction survey results, identify if there are areas of the wind power development where bat fatality is high (e.g., turbines on one edge of the development). If possible, operational mitigation should focus initially on areas causing fatality, and further monitoring used to determine effectiveness of the mitigation implemented. If fatalities occur randomly throughout the wind power development, then mitigation will need to be applied to the entire development.

2. Adjusting the minimum wind cut-in speed to 5.5 metres per second is the first type of operational mitigation to be implemented. Based on the specifications of several turbine manufacturers, this alteration is compatible with turbine operation although the ability to make this alteration must be confirmed prior to installation. Low-speed idle and altering the pitch angle of turbine blades will also be considered as a first level of mitigation.

3. Operational mitigation may be particularly needed during peak bat migration (e.g., August 1 to September 10 Baerwald et al. 2009) or as identified through pre-construction acoustic surveys. Additionally, increasing cut-in speeds only during the night when bats are migrating may provide cost-effective mitigation as compared to mitigation operated for the entire day.

4. In situations where the initial operational mitigation such as increased cut-in speeds has not been effective because the wind power development is experiencing continued high bat mortalities (through post-construction surveys), additional operational mitigation steps may be required. Additional operational mitigation may include ceasing turbine operation at night during the peak bat migration period.

Figure 1: Flowchart for Bat Surveys and Mitigation Approaches



Literature cited:

Alerstam, T., and A. Hedenstrom. 1998. The development of bird migration theory. Journal of Avian Biology 29:343–369.

Alberta Bat Action Team. n.d. ABAT Programs & Publications. Retrieved from http://www.srd.alberta.ca/FishWildlife/WildlifeManagement/AlbertaBatActionTeam/ABATProgramsPublications.aspx

Arnett, E.B., Brown, K., Erickson, W.P., Fiedler, J., Hamilton, B.L., Henry, T.H., Jain, A., Johnson, G.D., Kerns, J., Koford, R.R., Nicholson, C.P., O'Connell, T., Poirkowski, M., and J.R. Tankersly. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72: 61-78

Arnett, E.B., M. MP Huso, M.R. Schirmacher, and J.P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment. 9: 209-214.

Alberta Sustainable Resource Development 2005. The general status of Alberta wild species 2005. Fish and Wildlife Service, Alberta Sustainable Resource Development. Available at: http://www.srd.gov.ab.ca/fishwildlife/wildspecies/

Baerwald, E.F. 2008. Variation in the activity and fatality of migratory bats at wind energy facilities in southern Alberta: causes and consequences. MSc Thesis. University of Calgary, Calgary, AB. 117 pp.

Baerwald, E.F., G.H. D'Amours, B.J. Klug, R.M.R Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18:R695-696.

Baerwald, E. and R.M.R. Barclay. 2009. Geographic Variation in Activity and Fatality of Migratory Bats at Wind Energy Facilities. Journal of Mammology 90: 1341-1349.

Baerwald, E.F., J. Edworthy, M. Holder, and R.M.R. Barclay. 2009. A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities. Journal of Wildlife Management 73: 1077-1081.

Baerwald, E. and R.M.R. Barclay. 2011. Patterns of Activity and Fatalities of Migratory Bats at a Wind Energy Facility in Alberta, Canada. Journal of Wildlife Management 75: 1103-1114.

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

Hedenstrom, A. 2009. Optimal migration strategies in bats. Journal of Mammalogy 90:1298–1309.

Huso, M. M. P. (2011), An estimator of wildlife fatality from observed carcasses. Environmetrics, 22: 318–329.

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

Kunz, T. H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, J.M. Szewczak. 2007a. Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document. Journal of Wildlife Management 71:2449–2486.

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 by ABAT.

Young, D. P., Jr., W. P. Erickson, M. D. Strickland, R. E. Good, and K. J. Sernka. 2003b. Comparison of avian responses to UV-light-reflective paint on wind turbines. National Renewable Energy Laboratory, Golden, Colorado, USA.