THERYA, 2015, Vol. 6 (3): 505-513 DOI: 10.12933/therya-15-330, ISSN 2007-3364

Letter to the editor

La gestión de la convivencia entre los murciélagos y las turbinas eólicas

Managing coexistence for bats and wind turbines

The human enterprise continuously faces the need for increased energy, particularly electrical. The main sources for electricity production, until a few years ago, have been fossil fuels or hydroelectric dams. In recent times generation from other renewable sources has increased, among which wind energy production has become increasingly important (GWSC 2014). In contrast to fossil fuels, energy produced by wind turbines entails no CO_2 production or any other type of air pollution (Fthenakis and Kim 2009). Therefore, in this time of global warming, a massive increase in wind farms is expected to contribute to a cleaner energy future (GWSC 2011), along with other renewable energy sources (IPCC 2007). Projections are that wind energy production will increase exponentially from 6.1 gigawatts (GW) per year in 1996 and 318.1 GW in 2013 (GWSC 2014). See Table 1 for projections of the growth of the industry to 2030.

Recent studies have hypothesized that wind farm facilities can have a highly negative impact on the local community of bats (Rydell et al. 2010; Arnett and Baerwald 2013; Hayes 2013; Medellín *et al.* 2014). The tree roosting bat species seem to be those that have high fatalities by the turbines (Cryan *et al.* 2014). Two of these studies have been very controversial. The first of these (Subramanian 2012) reported that 18,000 wind turbines in Spain may be killing between 6 to 18 million birds and bats annually. The second one (Hayes 2013) has analyzed 22 published estimates of bat mortality at wind farms in the United States which ranged from 0.2 to 53.5 fatalities per megawatt (MW) generated per year with a mean of 13.4. At the 2012 rate of 51,000 MW per year, he suggests that over 600,000 bats would have been killed in that year. The reliability of these mortality extrapolations has been criticized on statistical methodology grounds (Huso and Dalthorp 2014), but what is important here is that these and other studies have shown that significant numbers of bat fatalities are caused by wind turbines in the United States alone. Moreover, we must keep in mind that mortally injured bats can fly away only to die later causing underestimation of mortality rates (Grodsky *et al.* 2011). Some data show that bats are more vulnerable to die by wind turbines than birds (Smallwood 2013).

This non-trivial impact on bat mortality carries potentially substantial ecological and agricultural costs. Bats are abundant in temperate to tropical regions, including semi-arid biomes. They are known to have major impacts in controlling insect pests of agriculture at least in some regions (Boyles *et al.* 2011; Maine and Boyles 2015). Furthermore, frugivores are often important seed dispersers and significant pollinators as well. There is also the potential for bats killed by wind turbines to spread rabies to scavengers (Grodsky *et al.* 2011). This conflict between the needs for clean electricity production and the needs for bat conservation must be addressed promptly.

Given that wind power generation is a necessary component of our future power supply, that bats are major contributors to ecosystem services that support human civilizations, and that bats are at risk for significant negative impacts by wind turbines, we must give serious attention to how we can design wind farms so as to minimize their negative environmental impacts. Here we discuss aspects of wind farm design that should be considered as routine procedures inherent in plans to establish a wind farm and to improve management of existing facilities. In doing this, serious attention needs to be directed to the unique nature of each potential site and its local bat fauna. We divide these considerations into biological and technological aspects. Of course, attention to bat mortality needs to be integrated with concerns for improving energy production efficiency and reducing bird fatalities as well (Hutchins 2014). Wind farms have been recorded to have a strong effect on mortality of birds (Erickson *et al*. 2014; American Wind Wildlife Institute 2015).

Biological Aspects of Wind Farm Management

Of primary importance, whenever and wherever a site is being considered for wind farm development, it is essential to make an accurate inventory of the bat species found in the area. For each species, its food niche must be determined. This information provides not only its main type of food, but also its foraging and flight behaviors (Giannini and Kalko 2004). Bat feeding guilds include insectivory (actually arthropodivory), nectar-feeding, fish-eating, fruit eating, frog-eating, and sanguivory (Wilson 1973). Various combinations are also possible. Information on the feeding guilds is critical, because such data can inform planners about the height that particular species habitually forage. Foraging below the heights of the turbine blades or above them can reduce risk of blade collisions. Moreover, if bats forage within dense foliage or high above the upper edge of the vegetation, they will probably reduce their exposure to being struck by the blades. Among the various feeding guilds, it is the insectivores that seem generally to be at greatest risk, although relatively little is known about risks for tropical species. It is estimated that worldwide about 75 % of species and 50 % of the genera of bats have diets based exclusively or largely on arthropods (Hutson and Mickleburgh 2001). Even among insectivores, however, foraging styles are diverse. Some species capture insects from the ground or low-lying plants or over open fields. Others feed within low lying foliage or high above the tree canopy. These behaviors may reduce vulnerability to wind turbine blades. On the other hand, feeding in and around tree canopies is considered to increase vulnerability to blade impacts, because of similar heights of tree canopies and turbine blades. There is also evidence that some bats are actually attracted to turning blades, mainly on nights with bright moon illumination (Baerwald and Barclay 2011; Cryan *et al.* 2014). In such cases, risk can be reduced by discovering how to make turning blades less attractive. Another factor that needs to be assessed is the complexity of the habitat where bats forage (Denzinger and Schnitzler 2013). Is the vegetation continuous or are there patches of different vegetation types generating associated edges? These factors are strongly suspected to be important in judging bat vulnerabilities.

Bat mortality has also been shown to vary considerably in relation to the land use in the vicinity of the wind farm facility. For example, Rydell *et al.* (2010) report that annual per turbine kill rates in northwestern Europe were lowest on flat open farmland, higher in more complex agriculture, and highest at the coast and in forests. Site assessment must also recognize that most species of bats fly daily between roost and foraging locations. Roosts may be caves, fissures in rocks or cliffs, abandoned mine shafts, hollow tree cavities, or within foliage in tree canopies. In tropical regions, roosts may be shelters made by space under loose bark, by partially severing a leaf blade to make a "tent", or even by hiding in pitcher plants (*Nepenthes*; Schöner and Schöner 2012). Such daily travels may be 40 or more km each way (Fleming 2001). Travel routes may follow ridge tops, vegetation edges, or water courses. Much more information on this aspect of bat behavior is badly needed. Nevertheless, wind farm planning should be aware of the potential causes of collisions with blades. Sometimes, single shelters are used by thousands of bats (Vargas-Contreras *et al*. 2012). Travel to foraging locations from such sites is often in groups (Fleming 2001), which might increase the

Table 1. Projections of the cumulative changes in a) the global increase in wind power capacity from 2012 to 2030, b) corresponding increases in the share of wind power in overall electricity demand, and c) the corresponding reduction in CO2 emissions (GWSC 2011). Low, Moderate and High refer to three scenarios of world electricity demand and wind power growth up to the year 2030.

	2010	2015	2020	2030
Global cumulative wind power capacity (Gigawatts)				
Low	185.2	295.7	415.4	572.7
Moderate	198.7	460.3	832.2	1,777.5
High	201.6	533.2	1,071.4	2,341.9
Wind power share of global electricity demand (in percentage)				
Low	2.3	-	4.5	4.9
Moderate	2.4	-	8.9	15.1
High	2.5	-	11.5	18.8
CO_2 reduction per year (Millions of tons)				
Low	243	435	611	843
Moderate	261	678	1,225	2,616
High	265	785	1,577	3,257

probability of large numbers being impacted. However, currently available data, mostly from non-tropical areas, suggest that solitary species are most often killed (Arnett *et al.* 2009; Rydell *et al.* 2010).

Two other landscape elements that need to be assessed in planning for wind farms are the proximity to agricultural crops and water bodies. These are usually associated with large numbers of insects and are attractive places for bats for foraging and drinking. It is recommended that these features be evaluated in planning potential sites. Limited information currently available indicates that adjacent crop fields are not associated with high bat mortality (Rydell *et al.* 2010). Of course such generalized risks may be impossible to avoid completely. It seems likely that future research will show that bat fatality rates will depend on the proximity of turbines to travel routes, agricultural fields, and water bodies, but that there will be much variation in these impacts.

Bat mortality rates can also vary seasonally and regionally. Such data would enable species-specific and locally relevant mitigation measures to be included in wind farm planning. Available data from temperate climates suggest that highest mortality rates occur in late summer (Trapp *et al.* 2002; Kerns and Kerlinger 2004; Arnett *et al.* 2009), and mainly impact tree roosting bat species (Cryan *et al.* 2014). These species of bats may be attracted to wind turbines (Cryan and Barclay 2009), or perhaps simply do not avoid them because they are aerial foragers in uncluttered forest areas (Schnitzler and Kalko 2001) and may not be able to discriminate wind turbines from trees (Kunz *et al*. 2007). However, unlike for birds, this kind of behavioral data is often unknown for bats. In many cases, we do not even know if a particular species is migratory or not.

Although currently available information allows us to make better predictions about bat feeding and movement behaviors in some well-studied species, such data are scarce or absent for most species likely to be vulnerable (mainly insectivores) to wind turbine blades. Much new research is urgently needed, especially for species most likely to be impacted.

Over all, the biological aspects of wind farm-bat interactions are badly in need of additional research. We know enough, however, to realize that the problem is too serious to be ignored. For some regions, we have sufficient understanding for initial management planning, but in general it is time to be proactive in pursuing the basic research in bat natural history that will clearly be needed.

Technological aspects of Wind Farm Management

In addition to the various aspects of bat species life histories, there are many technological issues that need to be addressed in siting wind farms and in attempting to reduce the mortality of bats that can be otherwise anticipated. One issue is to determine the anticipated wind speeds at various heights and compare them with bat flight activity. Wind speeds will affect the foraging efficiency of bats as well as the energy demands of flying. It may also influence the activity and hence the availability of prey. Wind speed may also influence the height that various prey species are using, and this in turn might make them more or less available to foraging bats. In a Pennsylvania wind farm, bat mortality was reduced when minimum operational wind speeds (the wind speed below which blade rotation is stopped, or "cut-in speed") were set at 5.0 m s^{-1} or higher (Arnett *et al.* 2011).

An additional unanticipated threat to bats has been suggested by Kunz *et al*. (2007) and Grodsky *et al.* (2011). These authors claim that injuries to bats can occur from low pressure vortices at the tips of spinning blades. This "barotrauma" can reportedly cause lung and inner ear damage resulting in delayed mortality. This would also likely be disorienting to the bats, increasing the likelihood of collisions with the blades. Grodsky *et al.* (2011) autopsied bats killed by windmills and found evidence of barotrauma or direct collision, and in fact reported that 50 % of all the bats autopsied had significant damage to their inner ears. However, Rollins *et al.* (2012) report that specimens with ruptured ear drums (evidence of barotrauma) occur only in very low numbers.

Recently, it has been suggested that the hue of the windmill blades could be an important issue that needs further study (Long *et al.* 2010). Their color and the ultraviolet spectrum elicited may affect the attraction of insects to the blades. Moreover, it is known that some insects show a preference for certain colors, and this could attract them to the blades with foraging bats following them, although this may be applicable only for crepuscular feeding bats. Also blades painted white will reflect moon light, and may attract insects along with foraging bats, much as street lights do.

Another important issue that needs to be explored is the sound environment of the spinning blades (Georgiakakis *et al.* 2012). Much is known about the frequency range of echolocation signals in many species of bats (Orozco-Lugo *et al.* 2013). However, this remains unstudied in most species. It may be possible to find sound frequencies that would repel bats from spinning turbines (Arnett *et al*. 2013a). A more feasible approach might be to have the revolving blades emit sounds that the bats could hear, even if not repellent. The current broadband ultrasound broadcasts can mitigate bat fatalities. However, these occur only at low frequencies, and further experimentation is needed (Arnett *et al.* 2013a).

Where feasible, the siting of wind farms along sea coasts both in the littoral zone and in adjacent off shore areas may greatly reduce, but not eliminate, their impact on bats, but perhaps not on birds. However, on the coastlines of Sweden, Germany, and France bat mortality is higher than in inland areas (Rydell *et al.* 2010). Other situations that need to be avoided are those near peninsulas and between the mainland and islands that could be flyways (Traxler *et al.* 2004). Coastal areas also have strong and reliable winds for electricity generation. In the United States, the coasts of North Carolina on the Atlantic Ocean and San Francisco on the Pacific Ocean are considered to be between "outstanding" and "superb" for wind farms (NREL 2007). Denmark is also making extensive use of coastal sites for placement of wind turbines. Where possible, coastal placement of wind farms should avoid known migration routes for bats and birds.

Another technical recommendation is to support policies that would encourage or require wind farm operators to install available improvements in their equipment that result in enhanced electricity generation and that also have a repellent system that reduces bat fatalities. Such combinations would allow fewer wind turbines to generate the same or more power. If these improvements also required fewer blades per turbine, wind farms could become less dangerous for bats and birds as there would be fewer lethal collisions per unit of power generated. Additionally, such efficiency improvements would compensate for any required reductions in power production instigated to reduce negative impacts on bats and birds. Current efforts to improve power production at slow wind speeds will have the disadvantage of reducing incentives for increased wind speed cut-off rates.

With all of the uncertainties inherent in new technologies, it is essential that once a wind farm has been put into operation, it should be regarded as an adaptive management project. That is, various monitoring routines need to be established in order to steadily improve the service provided. For any given site it is necessary to know how variables such as air temperature, wind speed, moonlight, and bat activity levels are related. Such knowledge can then be used to reduce bat mortalities. Amorim *et al.* (2012) demonstrate how air temperature can be used in this way in Portugal. Towers with anemometers need to be placed at various heights (such as 15, 30, and 60 meters) that can monitor height-related wind speeds at various locations within the farm and over the seasons of the year. Simultaneously, ultrasound detectors could be placed at the same heights to record bat activity levels. Then it would be possible to relate bat activity levels with wind speeds as well as season, height above the ground, and various topographic and vegetation variations within the site. There may very well be wind speeds, seasons, or blade heights that would dictate shutting down particular wind turbines at times of heightened bat activities. These data need to be used for this purpose. Moreover, such data would also be very helpful if a wind farm were to be expanded, or new sites developed nearby.

A critically important form of monitoring is the recording of mortalities caused by collisions with the wind turbine blades. We recommend that an independent investigator, not someone from the wind farm administration, conduct regular episodes of intensive monitoring, perhaps with trained dogs (Mathews *et al.* 2013) to search for corpses of different vertebrate species that have been killed by the blades. The suggested methodology is to follow a path removing all existing corpses from the census area, and then conduct a multiday survey. Ideally, each survey would be performed two times per day. The first, made at sunrise, to locate the corpses that were killed in the nocturnal period (mainly bats). The second would be carried out at sunset to determine those killed during the day (especially birds). Performing these two surveys daily is intended to access the corpses before the scavenger species (mammals, birds and insects) remove them. Such a protocol of intense monitoring could then be repeated monthly for a few days or at various seasons when bats are active in the area.

Because adaptive management efforts require knowing the identity of the species killed, we suggest that the corpses found within the wind farm area that cannot be identified confidently to species be identified by using genetic methods such as the barcode of life (Álvarez-Castañeda *et al.* 2012). We propose this technique because it is available in many institutions, and only needs a very small fragment of the corpse to make a species identification. Moreover, genetic identification is fast, low cost, and reliable for identification of small fragments in poor condition, and they are not dependent on the availability of multiple specialists for different taxonomic groups. Of course if wind farm management has access to someone skilled in local bat identification, this would make genetic methods unnecessary except in problematic cases.

In this relatively early stage of wind power electricity generation, but with the signs of concomitant serious impacts on bat populations already being clear, it is imperative that this is the time to incorporate bat protection into wind farm design and placement. While we aim to reduce bat fatalities, other objectives such as increasing the efficiency of power generation and reducing bird mortality must be addressed as well. Massive growth in the use of wind power to help meet the needs of humans for electricity is about to happen. With any growth scenario, it is obvious that the installed capacity of wind farms will increase significantly worldwide (Table 1). As a consequence the same proportional increase in bat fatalities can be anticipated if mitigation measures are not widely adopted. In addition, we must consider the effects of other human causes of bat mortality, such as closing abandoned mines, disturbance to caves, forest fires, pesticides, domestic cats, road kills, white-nose syndrome, etc. Now is the time to seriously research methods for mitigation of the direct negative effects of wind farms on bats (and birds), with their inevitable indirect influences on ecosystem services important to humans. To achieve improved coexistence we need to address these problems with the skills of the engineer, ecologist, and bat biologist, and in general to acquire a better understanding of the life histories of bats throughout the world. This is a formidable undertaking, which is all the more reason to not delay our efforts. Highest priorities should be given to determining the local bat community at each wind farm site, and to monitoring fatalities in relation to associated data on season, weather, and local vegetation features.

References

Álvarez-Castañeda, S. T., C. Lorenzo, M. Elias, P. Cortés-Calva, E. Rios, J. Ortega, and F. A. Cervantes. 2012. DNA barcoding of mammals in Mexico: implications for biodiversity. Open Zoology 5:18-26.

American Wind Wildlife Institute (AWWI). 2015. Wind turbine interactions with wildlife and their habitats: a summary of research results and priority questions. Viewed September 4, 2015 at https://awwi.org/resources/summary-of-wind-wildlife-interactions-2/#section-summary-of-windwildlife-interactions.

Amorim, F., H. Rebelo, and L. Rodrigues. 2012. Factors influencing bat activity and mortality at a wind farm in the mediterranean region. Acta Chiropterologica 14:439-457.

Arnett, E. B., M. Schirmacher, M. Huso, and J. P. Hayes. 2009. Patterns of bat fatalities at the Casselman Wind Project in south-central Pennsylvania. Annual report to the bats and wind energy cooperative and the Pennsylvania Game Commission. Bat Conservation International, Austin, TX. http://www.batsandwind.org/pdf/2008%20patbatfatal.pdf.

Arnett, E. B., M. M. P. 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.

Arnett, E. B., C. D. Hein, M. R. Schirmacher, M. M. P. Huso, and J. M. Szewczak. 2013a. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. PLoS ONE 8(6): e65794. doi:10.1371/journal.pone.0065794.

Arnett, E. B., and E. F. Baerwald. 2013. Impacts of wind energy development on bats: implications for conservation. Pp. 435-456 in Bat evolution, ecology, and conservation (Pederson, A. R. ed.). Springer Science Press. New York, EE.UU.

Arnett, E. B., R. M. R. Barclay, and C. D. Hein. 2013b. Thresholds for bats killed by wind turbines. Frontiers in Ecology and the Environment 11:171.

Baerwald, E. F., and R. M. R. Barclay. 2011. Patterns of activity and fatality of migratory bats at a wind energy facility in Alberta, Canada. Journal of Wildlife Management 75:1103-14.

Boyles, J. G., P. M. Cryan, G. F. McCracken, and T. H. Kunz. 2011. Economic importance of bats in agriculture. Science 332:41-42.

Cryan, P. M., and R. M. R. Barclay. 2009. Causes of bat fatalities at wind turbines: Hypotheses and predictions. Journal of Mammalogy 90:1330–1340.

Cryan, P. M., P. M. Gorresen, C. D. Hein, M. R. Schirmacher, R. H. Diehl, M. M. Huso, D. T. S. Hayman, P. D. Fricker, F. J. Bonaccorso, D. H. Johnson, K. Heist, and D. C. Dalton. 2014. Behavior of bats at wind turbines. PNAS 111:15126-15131.

Denzinger, A., and H. U. Schnitzler. 2013. Bat guilds, a concept to classify the highly diverse foraging and echolocation behaviors of microchiropteran bats. Frontiers in Physiology 4:1-15.

Erickson, W. P., M. M. Wolfe, K. J. Bay, D. H. Johnson, J. L. Gehring. 2014. A Comprehensive Analysis of Small-Passerine Fatalities from Collision with Turbines at Wind Energy Facilities. PLoS ONE 9(9): e107491. doi:10.1371/journal.pone.0107491.

Fleming, T. H. 2001. Bats and columnar cacti: coevolutions partners. Pp. 780-781 in Encyclopedia of mammals (MacDonald, edit.). Andromeda Press. London, United Kindom.

Fthenakis, V., and H. C. Kim. 2009. Land use and electricity generation: A life-cycle analysis. Renewal Sustentable Energy Review 13:1465-1474.

Georgiakakis, P., E. Kret, B. Carcamo, B. Doutau, A. Kafkaletou-Diez, D. Vasilakis, and E. Papadatou. 2012. Bat fatalities at wind farms in north-eastern Greece. Acta Chiropterologica, 14:459–468.

Giannini, N. P., and K. V. Kalko. 2004. Trophic structure in a large assemblage of phyllostomid bats in Panama. Oikos 105:209-220.

Global Wind Energy Council (GWSC). 2011. Global Wind Energy Outlook 2010. http://www.gwec.net/wp-content/uploads/2012/06/GWEO-2010-final.pdf

Global Wind Energy Council (GWSC). 2014. Global Wind statistics 2013. Brussels, Belgium.

Grodsky, S. M., M. J. Behr, A. Gendler, D. Drake, B. D. Dieterle, R. J. Rudd, and N. L. Walrath. 2011. Investigating the cause of death for wind turbines-associated bat fatalities. Journal of Mammalogy 92:917-925.

Hayes, M. A. 2013. Bats killed in large numbers at United States wind energy facilities. BioScience 63:975–979.

Huso, M. M. P., and D. Dalthorp. 2014. A comment on "Bats killed in large numbers at United States wind energy facilities". BioScience 64:546-547.

Hutchins, M. 2014. Five myths about wind power and birds. Bird Conservation 2014:22-25

Hutson, A. M., and S. P. Mickleburgh. 2001. Microchiropteran bats: global status survey and conservation action plan. IUCN 56.

Intergovernmental Panel on Climate Change. 2007. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Pachauri, R. K., and A. Reisinger, eds.). Intergovernmental Panel on Climate Change. Geneva, Switzerland.

Kerns, S. 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 to FPL Energy and Mountaineer Wind Energy Center Technical Review Committee. http://www.wvhighlands.org/Birds/Mountaineer FinalAvianRpt-%203-15-04PKJK.pdf.

Kunz, T. H., E. B. Arnett, W. P. Erikson, A. P. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5:315-324.

Long, C., J. Flint, and P. Lepper. 2010. Insect attraction to wind turbines: does colour play a role? European Journal of Wildlife Research 57:323-331.

Maine, J. J., and J G. Boyles. 2015. Bats initiate vital agroecological interactions in corn. Proceeding of the National Academy of Sciences 112: on line doi:10.1073/pnas.1505413112

Mathews, F., M. Swindells, R. Goodhead, and 4 others. 2013. Effectiveness of search dogs compared to human observers in locating bat carcasses at wind turbine sites: a blinded randomized trial. Wildlife Society Bulletin 37:34-40.

Medellín, R. A., D. J. Melnick, and M. C. Pearl. 2014. Protect our bats. New York Times, May 12, 2014, p. A23. New York, EE. UU.

National Renewable Energy Laboratory (NREL). 2007. Map showing estimated wind resources and existing power transmission lines for the United States. Department of Energy. http://www.nrel.gov/gis/pdfs/windsmodel4pub1-1-9base200904enh.pdf.

Orozco-Lugo, L. A. Guillén-Servent, D. Valenzuela-Galván, and H. T. Arita. 2012. Descripción de los pulsos de ecolocalización de once especies de murciélagos insectívoros aéreos de una selva baja caducifolia en Morelos, México. Therya 4:33-46.

Rollins, K. E., D. K. Meyerholz, G. D. Johnson, A. P. Capparella, and S. S. Loew. 2012. A forensic investigation into the etiology of bat mortality at a wind farm—Barotrauma or traumatic injury? Veterinary Pathology 49:362-371.

Rydell, J., L. Bach, M. Dubourg-Savage, M. Green, L. Rodrigues, and A. Hedenström. 2010. Bat mortality at wind turbines in northwestern Europe. Acta Chiropterologica 12:261–274.

Schnitzler, H. U., and K. V. Kalko. 2001. Echolocation by insect-eating bats. Bioscience 51:557–569.

Schöner, C. R., and M. G. Schöner. 2012. Living inside a deadly trap; woolly bats use carnivorous pitcher plants as roosts. Bats (Bat Conservation International) 30:2-3.

Smallwood, K. S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37:19–33.

Subramanian, M. 2012. An ill wind, with turbines threatening some bird and bat populations, researchers are seeking ways to keep the skies safe for wildlife. Nature 486:310-311.

Trapp, H., D. Fabian, F. Förster, and O. Zinke. 2002. Fleder mausverluste im eimen Windpark der Oberlausitz. Natur schutzarbeit in Sachsen 44:53–56.

Traxler, A., S. Wegleitner, and H. Jaklitsch. 2004. Vogelschlag, Meideverhalten & Habitatnutzung an bestehenden Wind kraftanlagen Prellenkirchen — Obersdorf — Stein berg/Prinzendorf. Report for WWS Ökoenergie, WEB Windenergie, evn Naturkraft, IG Windkraft und dem Amt der Niederösterreischen Landesregierung. http://www.igwindkraft.at/redsystem/mmedia/2005.04.15/1113566866.pdf.

Vargas-Contreras, J. A., G. Escalona-Segura, J. Arroyo-Cabrales, J. Rendon Von Osten, and L. Navarro. 2012. Conservación de Murciélagos en Campeche. Therya 3:53-66.

Wilson, D. E. 1973. Bat faunas: a trophic comparison. Systematic Zoology 22:14-29.

Sergio Ticul Alvarez-Castañeda[1,] and William Z. Lidicker, Jr. [2]

[1] Centro de Investigaciones Biológicas del Noroeste S.C. La Paz 23096, BCS, México. Email: sticul@cibnor.mx (STA-C).

[2] Museum of Vertebrate Zoology, University of California, Berkeley, CA 94720, USA. Email: wlidicker@berkeley.edu (WZL).