Are we properly assessing bird and bat mortality at onshore wind farms?

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Introduction

Wind farms can cause negative impacts on bird and bat communities, such as habitat displacement and direct mortality. To properly assess the impact of wind energy facilities on those populations it is fundamental to conduct post-construction fatality studies and to use standardized methods that provide an accurate estimate of the number of fatalities that occurred at each turbine.

However several factors can influence the reliability of the mortality estimates and therefore must be taken into account during the definition of the experimental design and the selection of the methodologies to adopt. At the same time, due to financial limitations, it is crucial to develop and validate field protocols that reduce the costs without compromising the estimates accuracy and precision.

Carcass searches

At onshore facilities the estimation of bird and bat mortality is generally based on carcass searches around wind turbines. Within a pre-defined plot (that can range between 40 and 120m around the turbine), trained searchers look for carcasses walking, for instance, along parallel transects. Inspections are then repeated over time at regular or irregular intervals, depending on the purpose of the study. However, the number of carcasses found during the searches does not correspond to the real number of birds and bats killed by the wind turbines. This value must be adjusted by carcass removal (e.g. by scavengers or decay) and searcher efficiency rates, which can in turn be influenced by site- and carcass-specific covariates, such as carcass size, season, vegetation cover and orography.

Carcass persistence rates

Current post-construction monitoring protocols accommodate carcass removal trials to assess the carcasses persistence. Trials consist of placing carcasses under the turbines which are then checked for a pre-defined period of time. The experimental design should take into consideration the different factors that can influence the removal rate (such as season and carcass size) and the minimum number of carcasses that must be placed to ensure the statistical robustness of the trials. Additionally, to avoid scavenger swamping, it is important to remember that only a limited number of carcasses should be placed simultaneously (Smallwood 2007).

Once placed, different protocols regarding the frequency and interval between the checks may be adopted to determine the average time of persistence of each carcass. At remote wind farms, frequent checks (e.g. daily) may imply a significant financial effort. Therefore it's essential to fully understand the impact that a reduction on the survey effort may have on the accuracy of the estimated correction factor. Bernardino *et al.* (2011) evaluated the effect of different inspection protocols on the estimation of the carcass persistence rate at 3 Portuguese wind farms. In this study we compared the results of field trials, that consisted in daily checks for a period of 20 days, with 4 other hypothetical scenarios: i) daily checks for 14 days, ii) daily checks for 7 days, iii) checks every other day for 20 days and iv) daily checks in the first 4 days and then in the 7th, 10th, 14th and 20th days. The statistical analysis evidenced significant differences between the removal correction factors whenever the survey effort was reduced. The only exception was when the trial length was reduced from 20 to 14 days (see Bernardino *et al.* 2011, for more details).

This study highlighted not only the impact that field protocols may have on estimates uncertainty but also the importance of selecting the best method to determine the scavenging removal correction factor. Up to that point, it had been determined using either observed proportions or the mean time of removal over a period of time. Yet we have proposed a new statistical approach for the analysis of the time of carcass removal, using parametric survival analysis (Bispo *et al.* 2010). Through this method, different lifetime distributions (e.g. exponential, Weibull, log-logistic and log-normal) may be fitted to data and the model fit analyzed using both adequacy measures (AIC) and graphical analysis. Ultimately carcass persistence rates should be estimated upon the best-fitted model.

Searcher efficiency

Carcass searches are traditionally performed by human observers, whose efficiency is influenced by carcass-specific characteristics (size, coloration and state of decomposition), site-specific characteristics (e.g. vegetation cover, orography, weather conditions) and observer-specific characteristics (e.g. ability to detect, commitment). To assess the carcass detection rate at a particular study area, searcher efficiency trials must be conducted, typically by placing carcasses (or surrogates) under turbines and calculating the average percentage of found carcasses. Depending on the available resources and monitoring objectives, the experimental design of the trials may or may not include covariates.

The trials carried out worldwide evidenced that in some cases human searchers can present low efficiency rates, which may contributes to severe bias in mortality estimates. Thus, the use of dogs and their olfactory capabilities has been suggested as a way to increase carcass detection rates (Homan *et al.* 2001, Arnett *et al.* 2006).

We conducted a study that evidenced the usefulness of using dogs during field surveys to improve bird-strike mortality estimates at wind farms and other anthropogenic structures (Paula *et al.* 2011). During a 3 months period, two dog-handlers teams were trained until dogs were able to stay point and bark in the presence of a bird carcass. After this intensive period of training, trials were performed in order to assess (1) if dogs are more accurate than humans to detect bird carcasses under different vegetation conditions, and (2) if carcass decomposition, weather conditions (temperature and wind speed) and distance to the target affects the search accuracy and efficiency of the working dog. Results showed that while dogs detected 96% of the carcasses placed, human searches only found 9%. Dogs' accuracy was independent of vegetation density and the effects of carcass decomposition state, distances to the carcass and weather conditions on dogs' efficiency were minor.

Fatality estimates

The final purpose of conducting carcass searches and estimating the associated bias correction factors (carcass persistence, detectability rates, among others) is to calculate the number of fatalities per year and single turbine or, alternatively, per MW. Over the years several estimators have been proposed (e.g. Johnson *et al.* 2003, Erickson *et al.* 2004, Kerns *et al.* 2005, Jain *et al.* 2007, Huso 2010, Korner-Nievergelt *et al.* 2011), mainly for wind power facilities but these can be applied to other human infrastructures. However, some of these mortality estimators are complex, requiring, in some cases, a great effort and statistical expertise from the technician who is conducting the data analysis. The same applies to the methods that can be used to estimate the correction factors.

To overcome that we have developed the web-based application "Wildlife Fatality Estimator" (www.wildlifefatalityestimator.com) that helps users to properly apply the existing methodologies to estimate mortality and save time for other data analysis. This totally free web tool is divided in 3 application modules:

- Carcass Persistence - section devoted to the estimation of the carcass persistence probability;
- Search Efficiency - section devoted to the estimation of the detection probability;
- Fatality Estimation - section devoted to the final fatality estimation.

With two of the 3 modules fully developed, users can already fit to their data the survivor function that best describes the time until carcass removal, calculate the associated correction factor and then produce mortality estimates, having available 3 estimators (Jain *et al.* 2007, Huso 2010 and Korner-Nievergelt *et al.* 2011).

Conclusion

In the past years, great efforts have been made to develop the methods and tools to estimate bird and bat mortality. Nevertheless more research on this topic needs to be undertaken, including the development of a universal mortality estimator, i.e., an estimator that produces unbiased estimates under all situations of searcher efficiency or carcass persistence rates. Additionally, further work is required in order to establish better cost/benefit field protocols. The use of dogs instead of human searchers is an example of that situation, since it may not be an option for all study sites, due to logistic and/or financial limitations of the monitoring programs. Only through the combination of optimized field protocols and adequate statistical methods we will be able to fully understand and evaluate the real impact of wind farms on birds and bats communities.

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