Removing guess in AIA: a cross-continental analysis of fatalities at windfarm

Paulo Cardoso[1*], Joana Ribeiro[1], Helena Coelho[1] & Miguel Mascarenhas[1]

[1]Bioinsight – Ambiente e biodiversidade, Lda., Portugal.

[*]Corresponding author: paulo.c@bioinsight.pt

INTRODUCTION

Windfarms have a negative impact on wildlife (Green et al., 2016). These impacts are well documented on bibliography and one of the most concerning is mortality by collision (Dai et al. 2015; Taber et al. 2019). However, there is still debate on how to quantify the effect of individual removal and the impact at population level. The “effect” and the “impact” of additional mortality are often mistaken or misinterpreted, which leads Environmental Impact Assessment (EIA) reports to focus the analysis of significance using an incomplete view of the problem.

It is increasingly recognised that the focus of impact assessment (IA) should be shifted from individual fatalities to the impact at population level, scaling up the evaluation of significance and allowing an overview on cumulative impacts at landscape level of several wind developments (May et al., 2019). In Europe, the Impact Assessment Directive establishes that the evaluation of the extent of the impact should consider the population size likely to be affected (Directive 2014/52/EU amend to DIRECTIVE 2011/92/EU, Fox et al., 2006) and several international guidelines and good practices suggest the same approach (Conley et al., 2013, IFC 2017, IFC 2019). Yet few, if any, national regulatory instruments have adopted such technical requirements in the EIA process and impact on population is still not fully integrated.

While it may be difficult to assess the impact at population level (May et al., 2019), Population Viability Analysis (PVA) use in conservation and ecology brings insights that could be adopted in EIA. When PVA was used in the context of monitoring the impact of additional fatality at windfarms, a range of species-specific outcomes arose from the evaluation. These outcomes included no significant impact of fatalities at population level for songbirds and bats and inconclusive impact for raptors for one study (Taber et al. 2019), but also the rejection of an offshore project due to unacceptable level of impact (Broadbent & Nixon, 2019).

Overall, the main advantage of PVA is bringing quantitative measures into the assessment. Nonetheless, PVA approach has some drawbacks and it faces many challenges, depending on the location of the projects and the countries’ maturity of the EIA process.

Here, we describe a framework applied in different windfarms in various geographic locations to evaluate fatality impact on population. The aim was to adjust the use of PVA in countries with great disparities among them, bringing the analysis into a common ground. From the results, we derived quantitative measures of the impact on population, namely fraction of the affected population and probability of extinction. We applied this framework to real scenarios of different fatalities of birds at wind turbines in Europe, Africa, and South America.

CASE STUDIES

We had five case studies: Croatia, Brazil, Chile, Portugal, and South Africa. These countries are in different stages of maturation of the EIA process (Figure 1). Croatia is in the Planning phase with a strategic view of the impact of future projects. Brazil is in the Assessment phase, building the baseline of future monitoring programmes centred on observed fatality. Chile is in the Reassessing phase, re-evaluating the predicted impacts at an earlier stage. Lastly, both Portugal and South Africa are in the Adapting stage. Portugal is focused on adaptative management with oriented actions for target species and habitats, while South Africa is starting to evaluate population impacts with PVA to inform future mitigation actions. Besides being in different stages, these countries also have distinct challenges in their EIA process. Croatia, Brazil, and Chile face challenges regarding monitoring programmes and fatality estimates, while Portugal and South Africa face challenges involving quantitative metrics for IA.

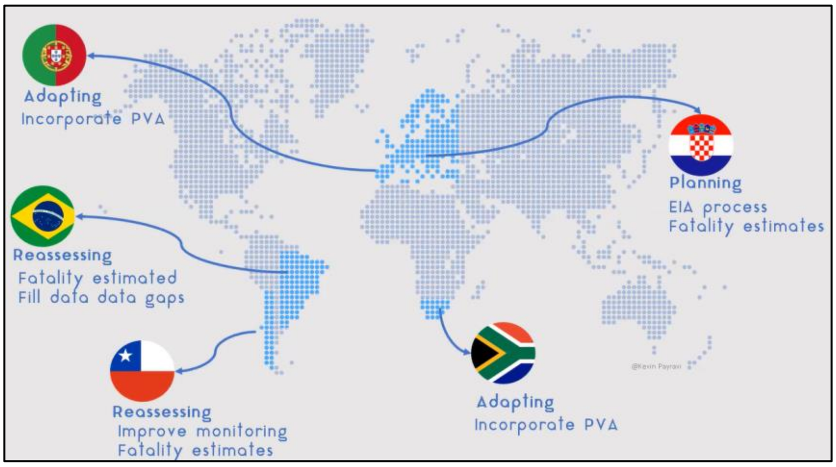

Figure 1 - Case studies and their phases in the EIA process maturing stage.

PVA MODELLING

Models and inputs data

PVA is an analytical process used to evaluate the outcome faced by populations regarding the likelihood of their risk of extinction, decline and chances of recovery. In our analysis, we mainly used a space implicit, age-structured, stochastic model proposed by Borda-de-Água et al. (2014), hereafter referred to Borda-de-Água Model. Additionally, in a particular case study, we used Vortex, a stochastic individual-based simulation model commonly used for modelling population dynamics (Lacy & Pollak, 2020).

PVA is a data demanding procedure and its requirements can be summarised into biological and demographic parameters, and harvesting. Biological parameters refer to species productivity, longevity and survival rate for each age class and sex. Demographic parameters refer to the carrying capacity of the population, which was the same as population size in this study. Different approaches have been proposed to identify the population of interest. In our study, we extrapolated population using densities, after delimiting the area of occupation using expert judgment and literature. Finally, for harvesting we considered the estimated fatality (if available), otherwise we used observed mortality.

In terms of analysed species, for each case study we selected species with high susceptibility to collision and with higher levels of observed mortality.

PVA Results – examples

Both Borda-de-Água Model and Vortex produce slightly different but complementary outputs and metrics to assess the impact of the additional mortality caused by a windfarm. In our approach, with Borda-de-Água Model we obtained the mortality rate applied, population size before and after the impact and probability of extinction. With Vortex, for this particular case, we obtained population size and frequency of extinction.

We present results from two of our five case studies. For Brazil, we modelled population dynamics of the black vulture (*Coragyps atratus)*, one of the most affected species in a particular region. For South Africa, we modelled verreaux's eagle (*Aquila verreauxii)*, a vulnerable species affected by wind farms in the country.

For black vulture, we considered two scenarios of population size affected by the same fatality (Figure 2). The probability of extinction was 0% for both scenarios, with differences in population size after harvesting. The bigger population experienced a mortality rate of less than 1% (rounded to 0%), while the smaller population experienced a mortality rate of about 2%. The larger population had a decline of 5% and the smaller one had a reduction of 31%. This indicates that an increase of 2% in the mortality rate may represent a population decrease 6 times greater for this particular species.

SPECIES	MORT. RATE (%)	N BEFORE IMPACT	N AFTER IMPACT	POP. REDUCT. (%)	PROB. EXTINC.
Coragyps atratus	0% - 2%	13187 - 98578	9039 - 97134	5% - 31%	0%

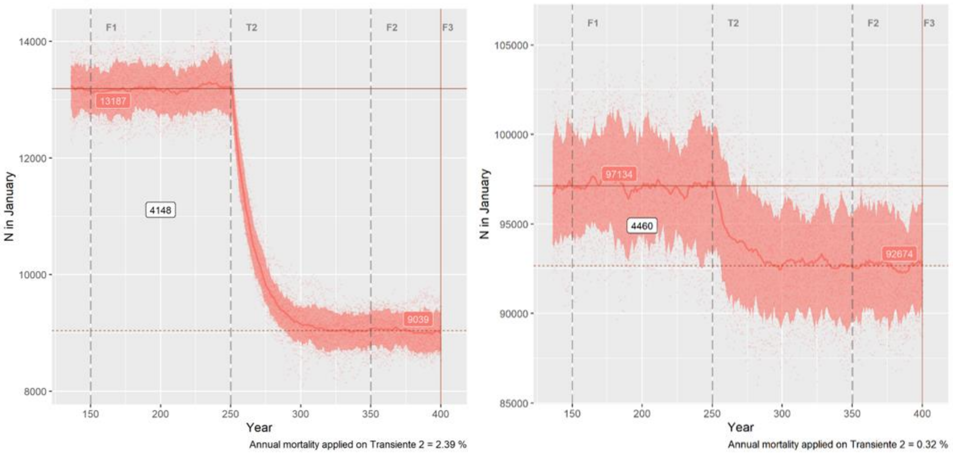

Figure 2 - Outputs for black vulture from Borda-de-Água model

For Verreaux's eagle, we simulated three scenarios: A – population with a negative growth and no additional mortality; B - population with a negative growth and additional mortality; and C - population with a stable positive growth and additional mortality (Figure 3). We observed that considering a slightly positive growth rate, additional fatality caused a decrease in population size but with no extinction during the project lifetime. However, considering a negative growth rate, the expected outcome was the extinction of the population with or without additional mortality. This output is particularly relevant for conservation because it indicates that the developer should implement corrective measures, authorities should be informed and a broader approach should be considered, either regionally or nationally, for this particular species.

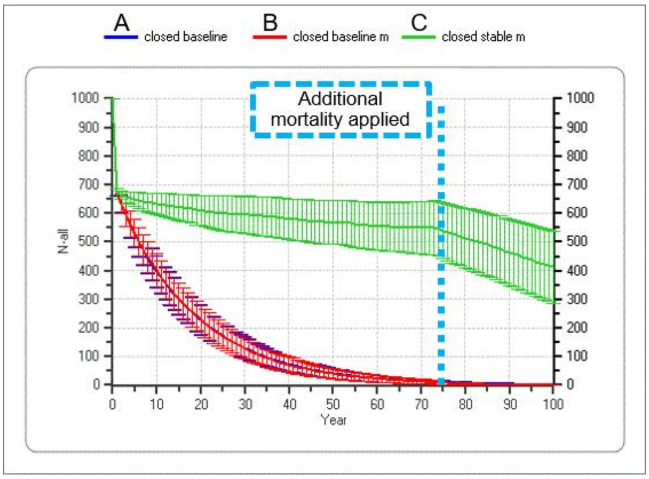

Figure 3 - Outputs for verreaux's eagle from Vortex mode

PVA main challenges

PVA is one of the better known tools to aid an informed decision based on quantitative scenarios and new models are emerging to make it more usable. However, a lot of challenges still remain, particularly related to uncertainty of estimated parameters such as population reduction, one of the referred reasons for the non-use of PVA. Populations are dynamic and complex to model, even accounting natural variability, which is why models require great amounts of input data. This is one of the main challenges and it applies to the three categories of mentioned data (biological, demographic and harvesting). However, challenges should not be an impediment to performing better and more complex analysis. For our case studies we resorted to different kinds of information and sources to obtain all the required inputs.

Life-history parameters of bird species were our main challenges, such as mortality or breeding success. Though quite popular in the last decades, these studies are scarce nowadays, and it is common to find decades old references. Most studies are based on European species and there is a gap of information regarding species from South America, for example. While it is difficult to obtain life-history data, using taxonomic proximity and expert knowledge, such gaps can be reduced. Moreover, investigation efforts should be aimed at collecting biological and demographic data and extending such studies to different geographies.

Another challenge was defining population size. There is high uncertainty around this parameter, but more information is becoming available, particularly for Europe (European Bird Atlas EBBA). Statistical methods for population size estimates based on Citizen Science also provide promising sources of updated data difficult to obtain for bird species. Additionally, many studies provide species densities, which can be used to extrapolate population sizes in specific areas. For all these sources, some degree of uncertainty has to be assumed.

Finally, fatality estimates were a major challenge in the past, but recent unbiased algorithms allow more precise estimates with an associated confidence interval (GenEst). There is a need for implementing adequate monitoring protocols to improve fatality estimates and it is imperative to standardise methodologies and use the best tools available. This is particularly important because it is challenging to compare fatality from different projects and locations when different estimators have been used.

Besides the input data for PVA, it is also important to consider timings as the analysis has to be aligned with the licensing process' timing. Furthermore, not all species are adequate to run this analysis. Impact quantification should be focused on the priority set of impacted species and this should be discussed with local authorities. Finally, it is crucial to consider the uncertainties and accept an educated guess when necessary. Uncertainty should not be seen as a drawback, but rather as something that cannot be avoided but can be minimised. Thus, taking a precautionary approach can ensure that a plausible scenario is incorporated and taken as a reference, instead of only a qualitative guessing.

Despite all these challenges, it is still possible to perform more robust and complex analysis such as PVA. We verified that location was not an impediment as we were able to adapt the analysis to each case, following the best practices protocols in each location and overcome the different challenges presented.

As mentioned, PVA use is still scarce in EIA process. The methodology of PVA is mathematically and statistically complex and data demanding (Lacy 2018) and thus understanding its limitations and boundaries of interpretation is critical when applying it in EIA. Collaborative work is needed to improve the understanding of PVA approach, and also to understand and reduce or control the uncertainty associated with the method.

Our results indicate a general non-significant impact on bird populations, with 0% probability of extinction for all species. However, the effects of the impact still remain and the additional mortality caused population reduction. It is important to not neglect residual impacts and take action to deal with them.

We can deal with PVA challenges at different scales and geographies assuming strong interaction and collaborative work (Figure 4), aiming to reduce the data gap and improve the EIA process. This can be achieved by engaging with industry, consultancy, authorities and the academics, using a collaborative cycle of partnerships and interactions to promote a sustainable development.

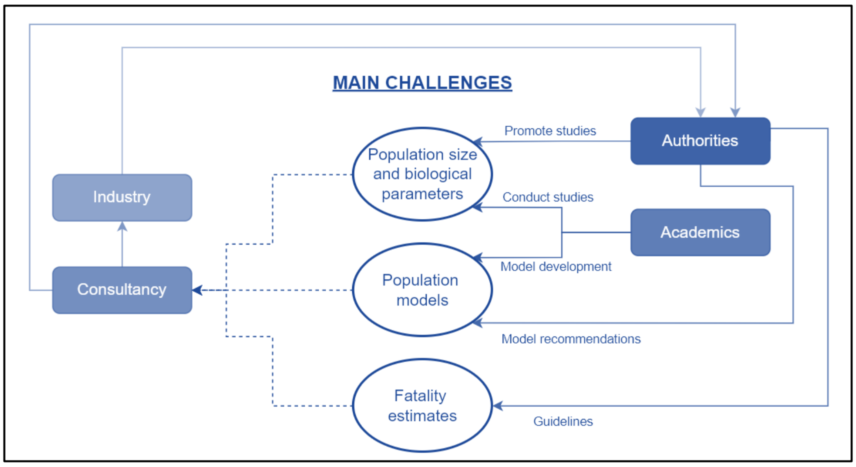

Figure 4 - Knowledge cycle of collaborative work

FINAL CONSIDERATIONS

EIA practices are continuously improved through the PDAC cycle (Plan-Do-Check-Adapt) and the use of PVA should be considered an asset for better quality in decision-making. It can provide information at different stages of the EIA process and, particularly, in the post EIA phase aiding adaptive management decisions.

From our experience, promoting the debate among all stakeholders is the best path for improved decisions and it is also a way to expedite finding the acceptable uncertainty for all stakeholders. In this process, uncertainty should not be seen as an obstacle. Instead, it should be assumed as an intrinsic measure of the decision process. Improving the EIA and post EIA process will require uncertainty to be accounted and minimized. To do so, collaborative work among stakeholders is strikingly important.

REFERENCES

Borda-de-Água, L., Grilo, C., & Pereira, H. M. (2014). Modeling the impact of road mortality on barn owl (Tyto alba) populations using age-structured models. *Ecological Modelling*, 276, 29–37. https://doi.org/10.1016/j.ecolmodel.2013.12.022

Broadbent, I. D., & Nixon, C. L. (2019). Refusal of planning consent for the Docking Shoal offshore wind farm: Stakeholder perspectives and lessons learned. *Marine Policy*, 110, 103529. https://doi.org/10.1016/j.marpol.2019.103529

Conley D., Magagna D., Greaves D., Aires E., Leitao J.C., Witt M., Embling C., Godley B.J., Bicknell A., Saulnier J.B., Simas T., O'Hagan A.M., O'Callaghan J., Holmes B., Sundberg J., Torre-Enciso Y., Marina D. (2013) Report on the analysis of the Environmental Impact Assessment Experience for Wave Energy - Deliverable 3.5 – Work Package 3 Final Report.

Dai, K., Bergot, A., Liang, C., Xiang, W. N., & Huang, Z. (2015) Environmental issues associated with wind energy - a review. *Renewable Energy*, 75, 911-921.

Fox, A.D., Desholm, M., Kahlert, J., Christensen, T.K. & Petersen, I.K. (2006) Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. *Ibis* 148 (supplement): 129-144.

IFC. (2017) Tafila Region Wind Power Projects: Cumulative Effects Assessment. Washington, D.C. International Finance Corporation https://openknowledge.worldbank.org/handle/10986/26322

IFC. (2019) Guía de Buenas Prácticas para el Desarrollo Eólico en Argentina: Gestión de Impactos en Aves y Murciélagos. Washington, D.C. International Finance Corporation. 87p.

Lacy, R.C.,& Pollak, J.P. (2018) Vortex:A Stochastic Simulation of the Extinction Process. Version 10.3.1. Chicago Zoological Society, Brookfield, Illinois, USA.

Lacy, R. C. (2019) Lessons from 30 years of population viability analysis of wildlife populations. Zoo biology, 38(1), 67-77.

Lacy, R. C., & Pollak, J.P. (2020) *Vortex: A Stochastic Simulation of the Extinction Process*. Chicago Zoological Society, Brookfield, Illinois, USA

May, R., Masden, E., Bennet, F., & Perron, M. (2019) Considerations for upscaling individual effects of wind energy development towards population-level impacts on wildlife. *Journal of Environmental Management*, 230, 84-93. https://doi.org/10.1016/j.jenvman.2018.09.062

Taber D. Allison, Jay E. Diffendorfer, Erin F. Baerwald, Julie A. Beston, David Drake, Amanda M. Hale, Cris D. Hein, Manuela M. Huso, Scott R. Loss, Jeffrey E. Lovich, M. Dale Strickland, Kathryn A. Williams, Virginia L. Winder (2019) Impacts to wildlife of wind energy siting and operation in the united states. *Issues in ecology*, Report No. 21, fall 2019.