A bat fatality risk model at wind farms in Dobrogea, Romania, using a GIS approach

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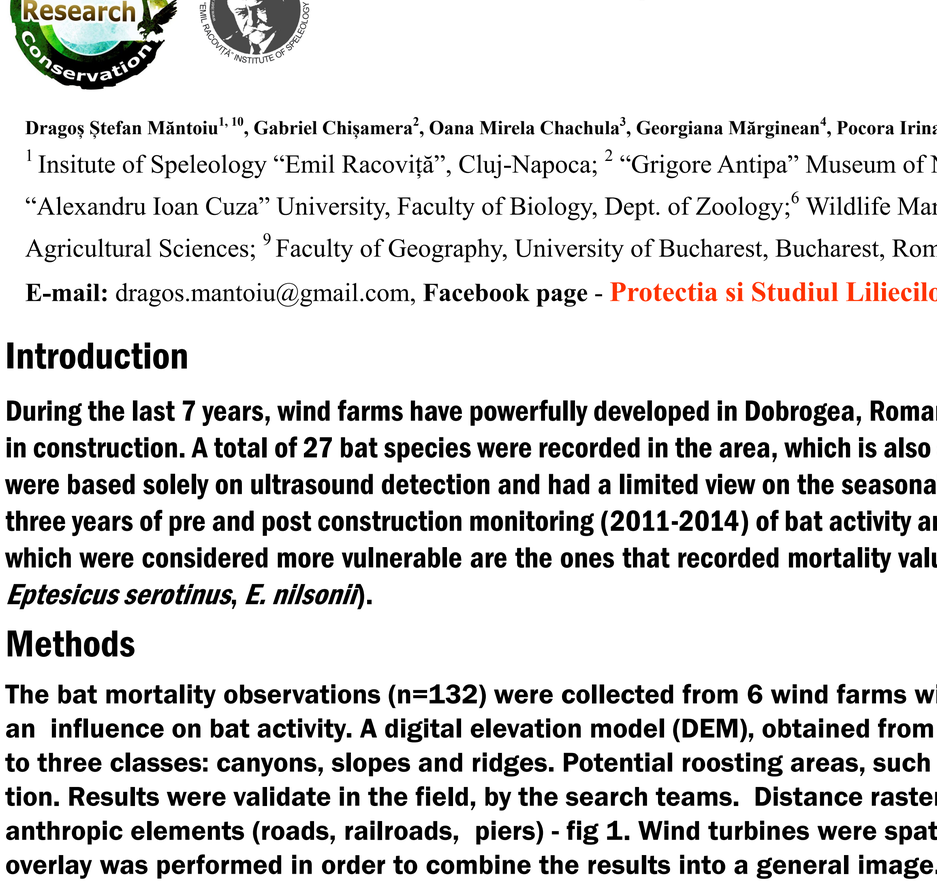
Introduction

During the last 7 years, wind farms have powerfully developed in Dobrogea, Romania, due to low population density and favorable wind conditions, reaching 892 turbines at the beginning of 2014, with several projects still in construction. A total of 27 bat species were recorded in the area, which is also considered a migratory route, due to its proximity to the sea. Environmental impact assessments, conceived in the preconstruction phases, were based solely on ultrasound detection and had a limited view on the seasonal changes in species diversity or key landscape features that may arouse interest for bats. This study compiles the information collected in three years of pre and post construction monitoring (2011-2014) of bat activity and mortality at various wind facilities in the study area, in order to generate a regional GIS model of the potential mortality risk. The species which were considered more vulnerable are the ones that recorded mortality values in the mentioned period (*Pipistrellus nathusii, P. kuhlii*, *P. pipistrellus*, *P. pygmaeus*, *Vespertilio murinus*, *Nyctalus noctula*, *N. leisleri*, *Eptesicus serotinus*, *E. nilsonii*).

Methods

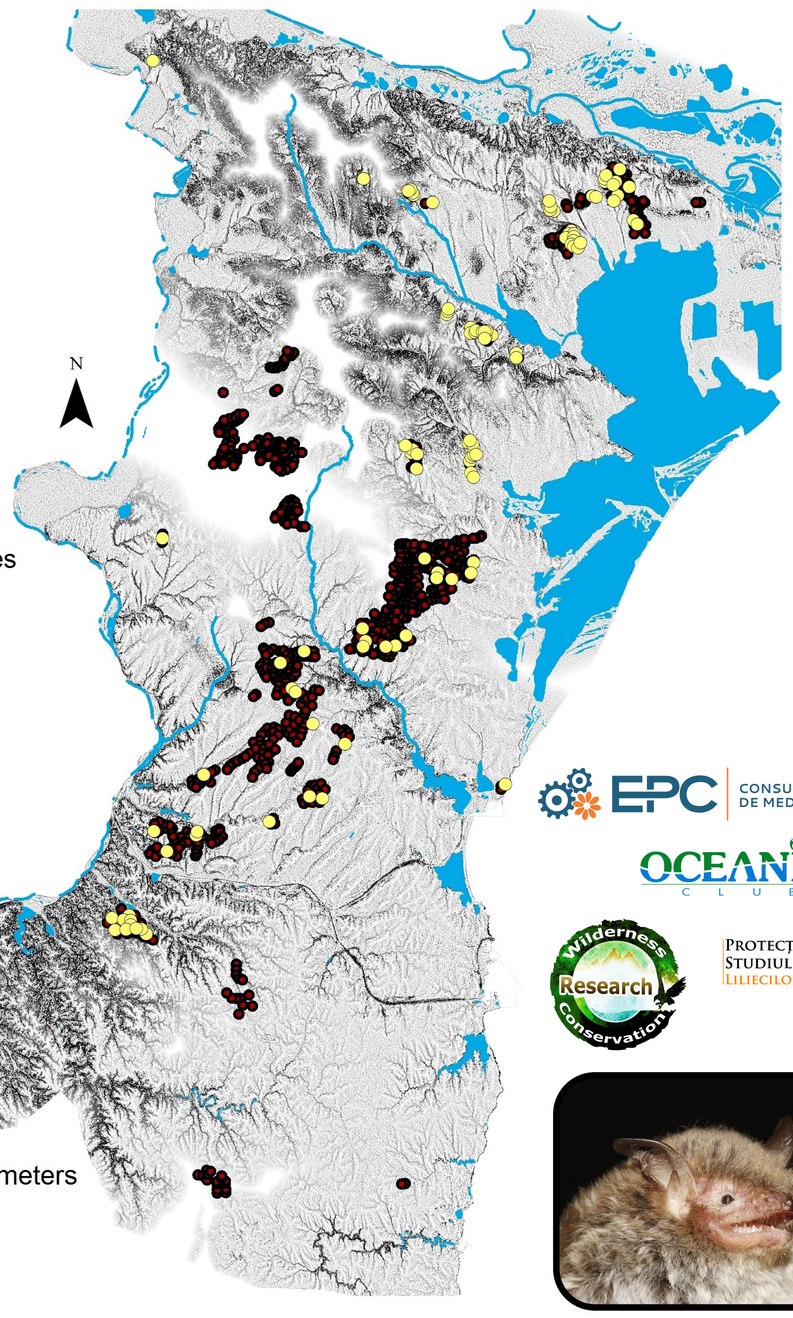
The bat mortality observations (n=132) were collected from 6 wind farms within the study area and were used in order to extract a set of values from multiple environmental layers which are known to have an influence on bat activity. A digital elevation model (DEM), obtained from the Copernicus dataset, was used in order to generate a Topographic Position Index (TPI), which helped classify the landscape into three classes: canyons, slopes and ridges. Potential roosting areas, such as limestone outcrops, forests and anthropic areas, were extracted using Landsat imagery (2014) maximum likelihood classification. Results were validate in the field, by the search teams. Distance raster datasets, corrected via the DEM, were generated in respect to: forests, limestone outcrops, settlements, water bodies and linear anthropic elements (roads, railroads, piers) - fig 1. Wind turbines were spatially extracted using heads up digitizing. A fuzzy membership was generated for each raster dataset using a linear model. A fuzzy overlay was performed in order to combine the results into a general image. The values were extracted via the wind turbine positions in order to generate a classification of the potential negative impact of each turbine, ranging from 0 to 1. The ArcGIS model of the workflow can be seen in figure 2, and the results for each fuzzy membership in figure 3.

Fig. 1 Raw data



Landsat 8 image Fals Color

Fig. 4 Fuzzy overlay model



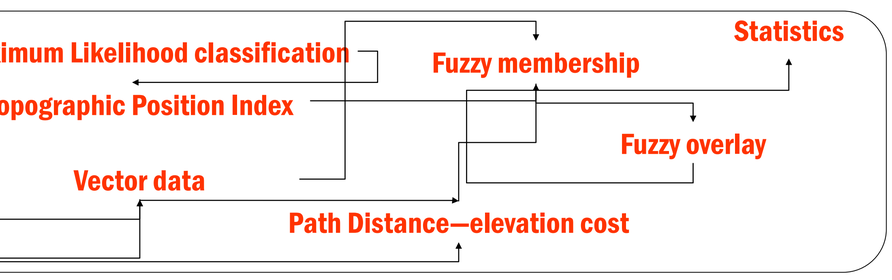


Fig. 2 Workflow model

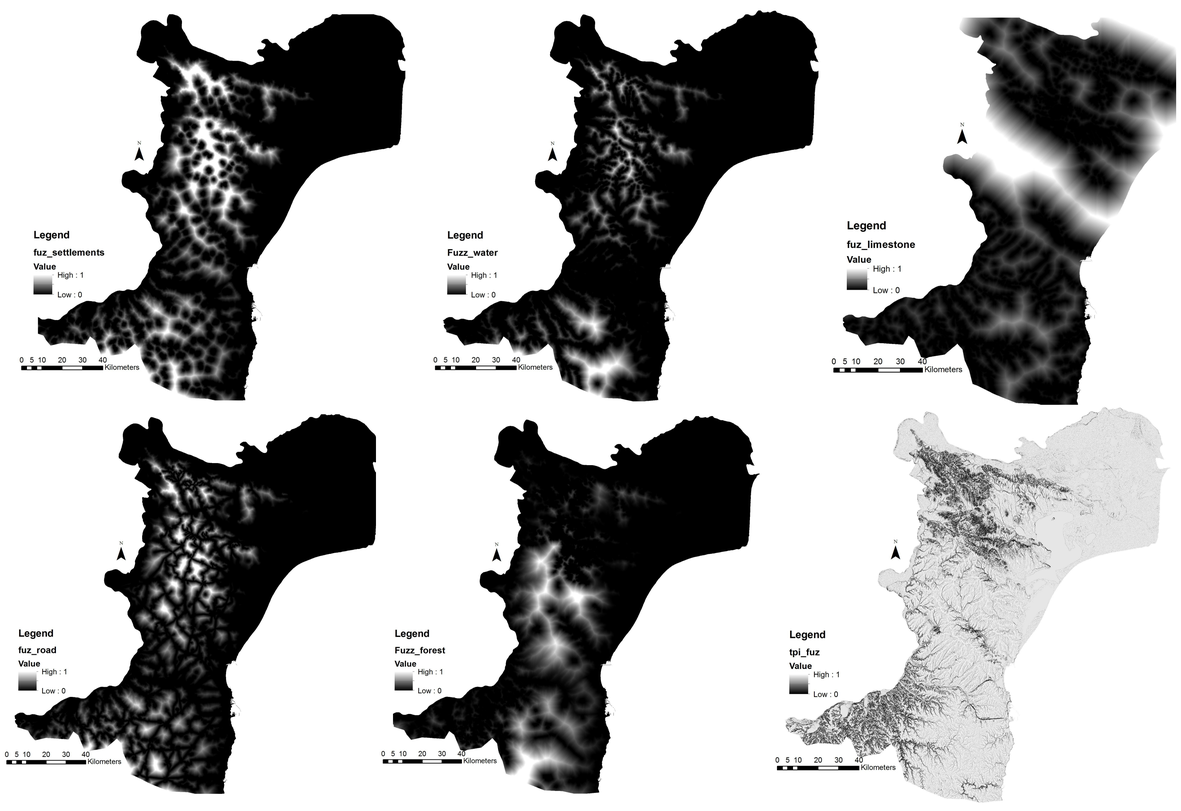


Fig. 3 Fuzzy membership results

Results

A total of 98 wind turbines presented a high value for the fuzzy overlay model (figure 4). These are located near forest edges, close to limestone areas or steep valleys and seem to be uniformly distributed across the study area. The surroundings of the Babadag forest present a higher number of turbines with a greater potential negative impact. Turbines located in open spaces, away from forested areas, limestone outcrops or settlements obtained a very low value in the analysis. A two year case study in the Babadag wind farm (figure 5) shows that higher values are recorded at the end of the summer period. Most of the carcasses in the spring and summer period belong to *Pipistrellus sp.. P. nathusii* has been found in the ultrasound monitoring sessions and the carcass searches from April to November. At the end of the summer period, carcasses of *Nyctalus noctula* start becoming more abundant in the whole Dobrogea area.

Discussions

The approach is powerfully biased by the fact that the observations are influencing the results, without the possibility of a validation, but the method can be seen as an observational guess as to where the potential high impact wind turbines are located. The fact that the specialists have used different search methods, reflects the quality of the data, having a larger number of observations in wind farms where field visits were conducted more often. The turbines which are located in open spaces can be surrounded by agricultural land, making it very hard for specialists to identify bat carcasses when the crops are fully grown. This can influence the model into a false prediction of a very low impact in the area.

Carcasses of *Nyctalus noctula* are recorded mostly at the end of the summer period, indicating a potential migratory route through the area. Fur samples were collected in order to perform a stable isotope analysis

Conclusions

The fuzzy overlay model can be used in order to extract a general image upon the potential negative impact of each wind turbine within a study area, but the results are strongly influenced by the observations and the collection methods. The turbines generate a higher pressure in areas where roosting and feeding habitats are larger, also where linear landscape elements, which can be used as a transit area, are more abundant. *Nyctalus noctula* carcasses have been more abundant at the end of the summer, indicating that Dobrogea can be a migration route for the species.

Fig. 5 Babadag wind farm mortality—2013-2014 compared to the climatic variables