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Topographic factors in avian electrocution risk: A framework to integrate pole location into risk mapping.

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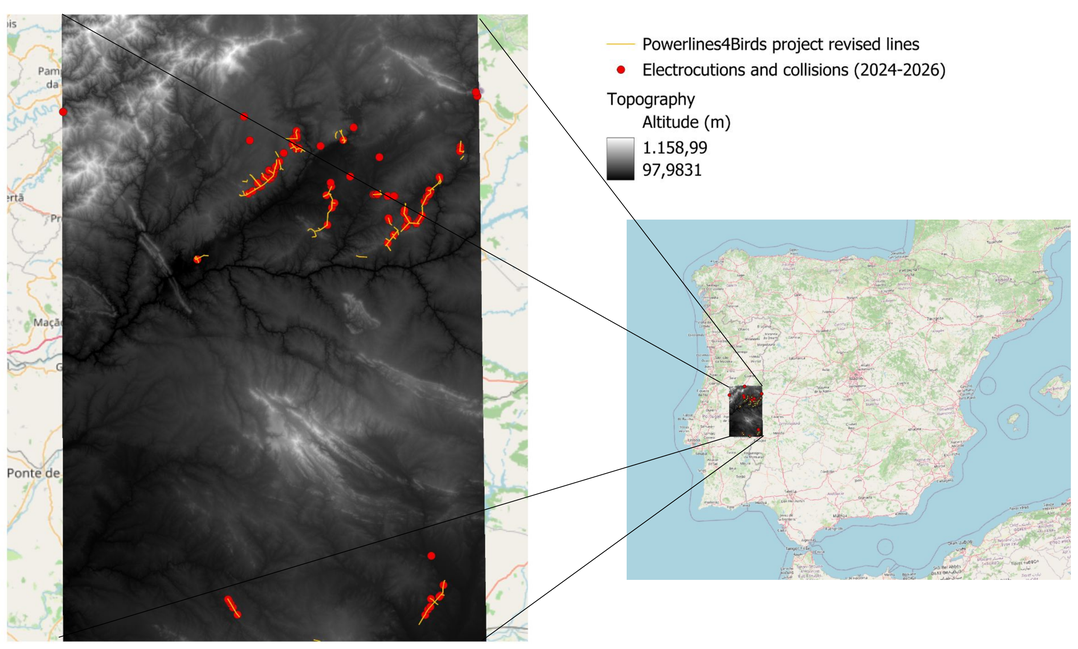
Introduction

- **Project Context:** The LIFE Powerlines4Birds project (2023–2027) aims to reduce power line impacts on threatened bird species in Spain and Portugal, covering Special Protection Areas (SPAs) within the Natura 2000 network.
- **Field Monitoring:** Periodic seasonal monitoring along **40 km of power lines** to record collision and electrocution events.
- **Research Problem:** Official risk maps evaluate avifauna at a global, macro-spatial scale, ignoring local microtopographic variables.
- **Objective:** To evaluate how the topographic position of power line poles (Valley, Mid-slope, Ridge/Crest) influences electrocution risk across functional guilds, identifying limitations in current risk models.

Methods

1. **Study Area & Dataset (2024–2026):**
   a. Avian mortality monitoring across a network of 1,531 power line poles in Portugal.
   b. Total sample of N = 110 confirmed events (78 electrocutions and 32 collisions) compiled by the NGO Quercus.
2. **Microtopography & GIS Analysis:**
   a. Topographic categorization of the pole network in QGIS using Digital Elevation Models (DEM) and Topographic Position Index (TPI).
   b. Poles were classified into three terrain units: Ridge / Crest (36.6%), Mid-slope (29.0%), and Valley / Low (34.4%).
3. **Statistical Modelling in R:**
   a. Global Chi-square test on electrocution events (N = 78) vs. topographic position.
   b. Guild-specific Chi-square test across ecological guilds (raptors, soaring birds, storks, corvids, etc.) to evaluate perch selection and sampling effort-weighted mortality rates.



Results

Multi-Year Sample (2024–2026): N = 110 recorded mortalities compiled by Quercus (78 electrocutions and 32 collisions). Collisions were distributed independently of relief, being primarily associated with flat areas and valleys.

The "Masking Effect":

- **Global Analysis:** The global Chi-square test was not statistically significant ($X^2 = 1.53$, $p = 0.4655$). Grouping all birds (14 species) as a homogeneous set hides the real risk.
- **Guild Analysis:** Functional segregation revealed a highly significant association ($X^2 = 19.43$, $p = 0.0351$), confirming that mortality depends on the flight ecology of each group.

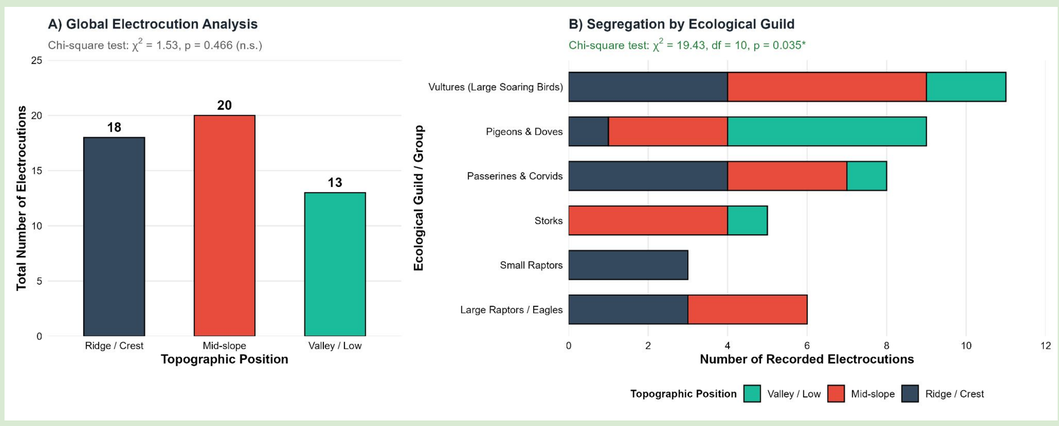


Figure 1. Topographic distribution of avian electrocutions. **(A)** Global mortality analysis showing no overall spatial preference across landscape units. **(B)** Functional segregation by ecological guild, revealing how electrocution risk concentrates on elevated topographies for soaring birds and large raptors.

Slope Independence: Local slope inclination showed no significant differences across guilds ($H = 8.65$, $p = 0.1238$). The key risk factor is topographic elevation (being on the ridge crest) rather than slope gradient.

Topographic Position	Total Poles (N)	% Network (Availability)	Large Raptor Casualties (n)	% Recorded Casualties	Mortality Rate / Pole (%)
Ridge / Crest	560	36.60	6	40.00	**1.07**
Mid-slope	444	29.00	7	46.70	**1.58**
Valley / Low	527	34.40	2	13.30	**0.38**

Table 1. Topographic exposure and electrocution risk for large raptors (n = 15). Mortality rates highlight disproportionate risk on ridges and mid-slopes compared to network availability.

Applied Management: 86.7% of raptor mortalities occur on mid-slopes and ridges, with mortality risk peaking on mid-slope poles (4 times higher than in valleys).

Conclusions

- **Bias in Official Models:** Current predictive risk maps underestimate black spots in mountainous areas by relying on macro-spatial metrics and ignoring local microtopography.
- **Perch Selection:** Large raptors preferentially select power line poles located on drainage divides and ridges to optimize thermal soaring and territory scanning, multiplying their exposure to electrocution risk.
- **Management Implications:** Incorporating local microtopographic metrics—such as the Topographic Position Index a(TPI)—into official risk mapping algorithms is imperative.
- **Budget Prioritization:** Corrective actions and preventive insulation measures must prioritize poles located on ridges and upper slopes to maximize the cost-effectiveness of conservation investments.

References

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