RENEWABLE ENERGY WILDLIFE RESEARCH FUND

RESULTS SUMMARY

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Flight Characteristics Forecast Entry By Eagles Into Rotor-Swept Zones of Wind Turbines

An empirical study supported by the Wind Wildlife Research Fund testing the thresholds used in automated curtailment and successfully predicting eagle entry into rotor-swept zones at multiple wind energy facilities.

Curtailment is the slowing or stopping of wind turbines in order to minimize avian collision fatalities, but results in reduced power generation. When paired with information on an approaching bird's risk of collision, informed curtailment can help reduce risks for birds while also reducing power loss. IdentiFlight, an automated monitoring systems used to trigger curtailment at wind energy facilities, while better at detecting eagles compared to human observers, can frequently produce false positives where curtailment occurs when no eagle is present. Additionally, with current thresholds for triggering curtailment, about 70% of the curtailments initiated do not result in the eagle entering the rotor-swept zone, thus apparently making curtailment unnecessary. Prior to this study, thresholds used to initiate this process (i.e., flight altitude, distance, relative flight bearing) had not been verified at wind facilities. This study used IdentiFlight eagle data from a single wind energy facility in Wyoming to model eagle collision risk and identify the covariates most important in predicting an eagle's risk of collision after being detected by the system.. The best fit model, which incorporated flight altitude, distance, relative flight bearing, and flight speed, was further tested on a subset of data at the WY facility and on eagle data from a facility in CA with different weather patterns and topography. The model successfully predicted the likelihood of an eagle entering the rotor-swept zone with better accuracy than current automated systems. This model has the potential to be used across many wind energy facilities in order to more accurately minimize protected species mortality while maximizing the amount of wind power generation.

STUDY OBJECTIVES

The primary objective of this study was to create a model for use by automated monitoring systems that better predicted the likelihood of an eagle entering the rotor swept zone. The authors used hierarchical logistic regression models that included occupancy and distance-dependent colonization processes. Data to inform model selection came from IdentiFlight units at Top of the World Wind Power Facility (TW) in Wyoming. Each data point represents a 5-second time segment following an eagle detection by the Identiflight system and provides whether or not the eagle occupies the turbine rotor-swept zone. The authors built models to predict the likelihood that an eagle detected a one-time step would occupy (aka "colonize") the rotor swept zone at the subsequent time step, including the following covariates to inform the models:

1. Altitude (meters above the ground)
2. Approach (relative path bearing towards the nearest turbine)
3. Speed (horizontal velocity)
4. Distance (between the eagle and the nearest turbine)
5. Compass Direction (north and east)

Once the successful model was identified, the authors applied the model to a subset of TOTW data and to data from a different location, Manzana Wind Power Project (Manzana) in California, to further test the reliability of the leading model. This study has shown that a combination of altitude, flight bearing, and flight speed are factors to consider when automating turbine curtailment. While previous thresholds only encompassed flight bearing towards the nearest turbine and altitude, this study has found that the addition of flight speed greatly enhances the predictive probability of automated turbine curtailment.

KEY TAKEAWAYS

- This study is the first to validate thresholds used to inform automated curtailment of wind turbines when a protected species (i.e. eagles) is approaching the rotor-swept zone.
- The authors formulated and validated a model that more accurately forecasts the probability that eagles detected by automated monitoring systems would enter the rotor swept zone

  Eagle collision risk is informed by the following flight characteristics: altitude, distance to nearest tur bine, direction relative to nearest turbine, and speed.
- Eagles flying slowly, presumed to be hunting, specifically hovering or kiting, were at greatest risk of entering rotor-swept zone. Contrarily, eagles flying at fast speeds were far less likely to enter the rotor-swept zone.
- Eagles flying above turbines are unlikely to descend into the rotor swept zone by swooping for prey.
- The model produced from the initial phase of this study at TW was successfully transferred to a second wind energy facility at Manzana. This indicates that this model has the potential of being successfully transferable to multiple wind energy facilities, regardless of weather patterns or topography.

NEXT STEPS

- All data included in the study came from curtailed turbines. It is currently unknown whether curtailment influences eagle behavior. Future studies should investigate whether curtailment affects flight patterns.
- This study supports the current prescribing of curtailment of distance and altitude. The authors suggest adding speed and flight bearing as fast-moving eagles are unlikely to enter the rotor-swept zone.
- Some turbines are more likely to have eagles enter rotor swept zones. This suggests that curtailment criteria can be tailored for each turbine. Future studies should focus on those criteria in an effort to balance collision risk and power generation.
- This model is likely to be transferable across facilities to protect eagles and provides a starting point for an adaptive management process to protect any species when informed over time by species-specific flight characteristics, season, and turbine.

STUDY RESULTS

This study expanded upon and refined the current thresholds used by automated monitoring systems and wind energy facilities. Factors that predict eagle entry to rotor-swept zone:

a. **Altitude -** Eagles that are flying near hub height are more likely to enter the rotor-swept zone, including altitudes that an eagle may dive down towards when hunting. Flying above 200m (above wind turbine height) decreases the likelihood of entering the rotor-swept zone.

b. **Distance -** Eagles more than 202 m away from the nearest turbine were less likely to enter the rotor-swept zone whereas eagles within 150 m of the nearest turbine are more likely to enter the rotor-swept zone. However, eagles that were likely migrating were less likely to enter the rotor-swept zone regardless of distance.

c. **Approach -** Eagles that were flying towards the nearest turbine were more likely to enter the rotor-swept zone. Eagles that were flying away from the turbine were less likely to enter the rotor-swept zone.

d. **Speed -** Eagles flying slowly, presumed to be hunting, specifically hovering or kiting, were at greatest risk of entering rotor-swept zone. Contrarily, eagles flying at fast speeds were far less likely to enter the rotor-swept zone.

Flight bearing (north vs. east) was not significant in informing eagle collision risk. Probability of entering the rotor-swept zone was greatest when eagles were flying near the rotor-swept zone and flew slowly towards the nearest turbine. The leading model predicted the probability an eagle would enter the rotor-swept zone with relatively high certainty at facilities in Wyoming and California, suggesting it may be transferable across a variety of geographic spaces. While this model supports curtailment in response to altitude and distance, the authors recommend the addition of time to collision threshold in response to eagle flight speed.

CITATION

Rolek, B.W., M.A. Braham, T.A. Miller, A.E. Duerr, T.E. Katzner, J.D. McCabe, L. Dunn, C.J.W. McClure. 2022.Flight Characteristics Forecast Entry By Eagles Into Rotor-Swept Zones of Wind Turbines. Ibis. https://doi.org/10.1111/ibi.13076