RESEARCH BRIEF

November 19, 2021

AWWI Publication Synthesis

Paint it Black: Does Painting Wind Turbine Blades Increase Visibility to Reduce Bird Fatalities?

A 2020 study in Norway investigated the effect of painting one of three blades black on a sample of wind turbines as a strategy to increase the visibility of rotating blades to birds thereby reducing bird collision fatalities at wind energy facilities. This study yielded promising results; however, additional studies should be conducted to determine whether blade painting offers an effective solution for reducing bird fatalities at operational wind energy facilities.

View the full article: Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities

Wind energy is a major component of mitigating climate change, yet like all sources of energy, it has some impacts to wildlife including bird fatalities resulting from collisions with turbine blades. Stakeholders across sectors are working on solutions to minimize these impacts including detection, curtailment, and deterrence strategies. One possible strategy previously explored by researchers is whether increasing the visibility of turbine blades can reduce fatalities by reducing motion smear – the effect where turbine blades are moving at such a high velocity that a transparent blur is produced on the bird's retina such that the bird may not interpret the rotating blades as a hazard and thus may not avoid them.

Previous studies evaluating treatments intended to increase blade visibility were largely inconclusive; however, a study in Norway released in 2020 has resulted in a resurgence in interest in exploring the possibility of reducing collision risk by increasing turbine blade visibility. In this study, researchers tested the hypothesis that painting one of a turbine's three blades black would increase the visibility of the blades to birds thus reducing bird fatalities. The study reported a more than 70% reduction in the annual fatality rate for birds within the study area.

Although these results are encouraging, the small sample size of turbines in the study and the low number of fatalities found limit the inference to the location where the study was conducted. The research does provide insights for future studies that explore outcomes at different locations and with a larger sample size of turbines to determine the generality of these results and potentially evaluate effectiveness among species.

STUDY APPROACH

Researchers conducted their study at the Smøla wind power plant in Norway using a Before and After Control Impact (BACI) design. They painted one of three turbine blades black at four turbines and selected four nearby turbines as unpainted controls. Fatality data collected prior to the study were available for all eight turbines. The Smøla wind-power plant was chosen as a study area in part because of concerns about high levels of white-tailed eagle fatalities and the availability of long-term fatality monitoring data.


Smøla Wind Farm. From May et. al (2020)

Monitoring of bird fatalities at the wind power plant took place from 2006-2016, including 7 ½ years of data collection before and 3 ½ years after the blade painting treatment. At the eight study turbines combined, 1,275 individual searches were performed over the 2006-2016 period using dogs trained to find carcasses and feather clusters. Incidental carcass detections at the site were also recorded. Forty-two fatalities were included in the analysis, with the most common species being white tailed eagle, common snipe, hooded crow, and meadow pipit.

Before the blade painting treatment, seven fatalities were recorded at the control turbines and 11 were recorded at the treatment turbines. After treatment, 18 fatalities were recorded at the control turbines and six were recorded at the treatment turbines. While the number of recorded carcasses increased at the control turbines (7 vs. 18), they decreased at the treated turbines (11 vs. 6). No white-tailed eagle carcasses were recorded after painting at treated or control turbines, compared to six reported at the treatment turbines and one reported at the control turbines before painting. Researchers found no evidence of birds having a higher probability of collision at the neighboring control turbines, indicating that treatment did not result in birds avoiding the treatment turbines and colliding with other turbines nearby.

TAKEAWAYS

Based on the fatalities found, the authors reported the following conclusions :

- Applying black paint to rotor blades resulted in a >70% reduction in annual fatality rate for all birds within the study area.
- Blade painting appears to have reduced fatalities when results were combined for common kestrel and white-tailed eagles, the two raptor species that were previously recorded as fatalities in the study area.
- Annual fatality rates fluctuated substantially among years, highlighting need for long-term study.


Smøla Wind Farm. Statkraft , 2009, Flikr.

Important considerations when interpreting these results include :

- The low numbers of fatalities found both before and after treatment in this study limited inferences about the effects of blade painting on individual species or species groups.
- The low numbers of avian fatalities found over 10 years of monitoring highlight the challenges in robustly evaluating factors that increase collision risk or approaches for reducing that risk at wind energy facilities.
- Because of the low numbers of fatalities found, a reduction or increase of one or two fatalities could have a substantial impact on the analysis.

Although the results are encouraging, further testing is essential before broadly applying this potential mitigation measure.

RECOMMENDED NEXT STEPS

Similar studies at different locations and with a larger sample size of turbines should be conducted to determine the generality of these results and potentially evaluate effectiveness for species. Considerations for future studies include:

- Selecting sites that already have fatality monitoring data to support estimation of the needed turbine sample size and/or years of monitoring needed to detect effects across all species and species of interest, e.g., eagles and other raptors.
- Potentially conducting post-treatment monitoring over a longer time-period to reduce the limitations of low sample sizes.
- Incorporating findings from current studies on raptor perception and visual cues to inform selection of paint colors for treated turbine blades.

Additional practical considerations that researchers may need to address when developing future studies include:

- Cost and labor associated with treatments for a larger turbine sample size applied to an operating wind facility.
- The effects of increased heat absorption, or "thermal loading," to turbines in hotter regions as a result of dark colored paint.
- In the U.S., Federal Aviation Administration (FAA) regulations restrict turbine blade color.

SUPPORTING AND RELATED RESEARCH

Previous studies have investigated the effectiveness of passive visual cues in reducing motion smearing while other, related studies have investigated the relationship between blade visibility and the impact on occurrence of avian fatalities. One study, published in 2002 with support from the National Renewable Energy Laboratory, *Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines Period of Performance,*[1] tested the effect of motion smear at blade tips. Numerous blade patterns and colors were tested on American kestrels in a laboratory setting. The study found that a single black blade was twice as visible as three blank blades. Additionally, seven color options were tested with no significant differences in results found between colors. An insight that better informed understanding of the effect of motion smear revealed that the physiology of the avian retina is overwhelmed by the velocity of a blade sweeping, giving the appearance of transparency which could be especially true at the blade tip where the velocity is the highest.

An additional study, published in 2000, *Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines,*[2] was conducted to describe and compare avian use and mortality between turbines with UV-reflective paint and those with conventional paint. This study was intended to expand upon previous research that concluded birds could detect wavelengths outside the human range including UV,[3] with a specific focus on the impact on golden eagles. The study did not provide any strong evidence that there is a difference in bird use, mortality, or risk between turbine blades painted with UV-reflective or conventional paint.

A later study reiterated the conclusion that golden eagles and other raptors were not responsive to UV.[4] Additionally, genome sequence analyses were executed in another study that determined golden eagles possess a violet-tuned vision system rather than ultraviolet, reiterating the ineffectiveness of using UV-reflective paint to prevent collisions.[5]

In a 2020 study,[6] Purdue University researchers measured the auditory and visual physiology of golden and bald eagles to inform the design of potential deterrent strategies to reduce eagle collisions with wind turbines. The first phase of the study was collection and analysis of visual and auditory information from golden and bald eagles in rehab centers. The second phase presented these stimuli to both species to identify which stimuli would be the most effective in changing the behavior of the eagles.

Phase one indicated that the visual system of the golden eagle absorbs UV light, making it likely that golden eagles do not detect UV light, but likely that bald eagles do. A significant finding from the study was a blind spot above the head of both species which results in eagles' inability to see an obstacle when their heads are pointed down in flight. Both species' auditory systems responded strongly to tones across a wide range of frequencies; however, bald eagles were better at processing rapid changing sounds.

Researchers identified candidate light and sound stimuli that both eagle species are highly sensitive to for phase two trials. Golden eagles especially exhibited visual behavior with flashing blue light stimuli and all sound stimuli. However, both eagle species showed lower rates of behavior over the course of the experience. Researchers suggest using these stimuli in field-testing of deterrent systems.

Future studies can build on this reinvigorated body of research and the results of the "Paint it Black" study to better determine whether blade painting offers an effective solution for reducing bird fatalities at operational wind energy facilities.

RESEARCH BRIEF

November 19, 2021

CITATION

May et al. (2020). Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. *Ecology and Evolution*, 10: 8927– 8935. https://doi.org/10.1002/ece3.6592

REFERENCES

[1] Hodos W. (2003). Minimization of Motion Smear: Reducing Avian Collision with Wind Turbines; Period of Performance: July 12, 1999 -- August 31, 2002 (NREL/SR--500-33249). United States. https://www.nrel.gov/docs/fy03osti/33249.pdf

[2] Young D P Jr., Erickson W P, Strickland M D, Good R E, & Sernka K J. (2003). Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines: Subcontract Report, July 1999--December 2000. United States. https://doi.org/10.2172/15003047

[3] Jacobs G. (1992). Ultraviolet Vision in Vertebrates. *Integrative and Comparative Biology*, 32(4):544-554. https://doi.org/10.1093/icb/32.4.544

[4] Hunt W G, McClure C, & Allison T. (2015). Do raptors react to ultraviolet light? *Journal of Raptor Research*, 49 (3), 342-343. https://doi.org/10.3356/JRR-14-71.1

[5] Doyle J M, Katzner T E, Bloom P H, Ji Y, Wijayawardena B K, & DeWoody J A. (2014). The genome sequence of a widespread apex predator, the golden eagle (Aquila chrysaetos). *PLoS ONE*, *9*(4). https://doi.org/10.1371/journal.pone.0095599

[6] Fernandez-Juricic E, Lucas J, & Katzner T. (2020). Understanding the Golden Eagle and Bald Eagle Sensory Worlds to Enhance Detection and Response to Wind Turbines. Final technical report submitted to DOE EERE. https://tethys.pnnl.gov/sites/default/files/publications/Purdue-2020-DE-EE0007882.pdf

This work was supported by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the DOE Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.