Crouching Tiger, Hidden Danger

Blade patterning reduces avian fatalities at a South African Wind farm

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The blade patterning story started in California's **Altamont Pass 25 y ago**

- Erickson et al. and Smallwood &Thelander found a high fatality rate of birds especially raptors (1300 per year) at the 4930 turbines in Altamont
- National Renewable Energy Lab (NREL) funded two lab studies aimed at testing how to make blades more visible to birds –
- McIsaac (2001)
- Hodos (2003)

Erickson et al. 2001. Avian collisions with wind turbines: a summary of existing studies ….National Wind Coordinating Committee, RESOLVE, Washington, D.C., USA.

Smallwood KS, Thelander C.. 2004. Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission, NREL Sacramento, California, USA

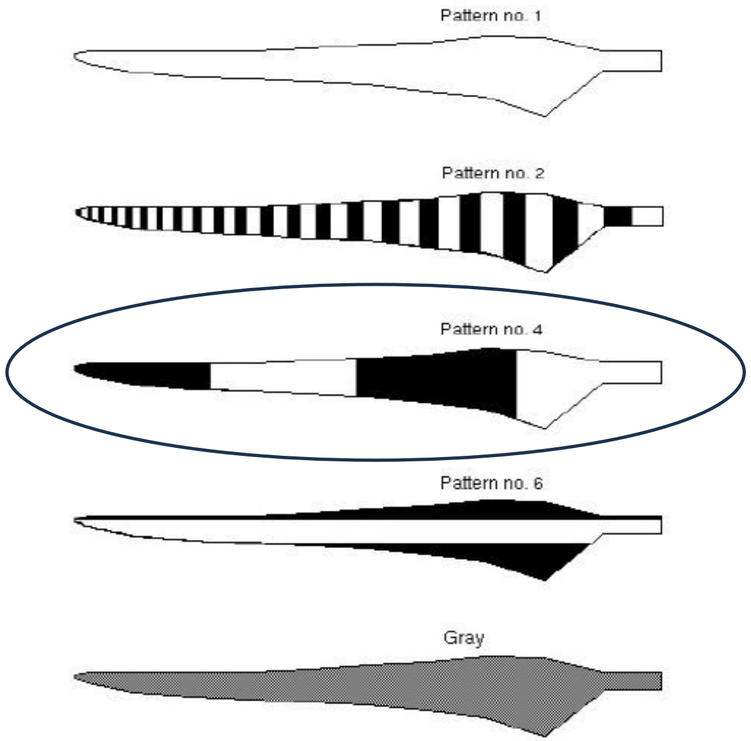
McIsaac HP 2001. Raptor Acuity and Wind Turbine Blade Conspicuity Proceedings of the National Avian-Wind Power Planning Meeting. 4. NREL

Hodos W. 2003. Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines. National Renewable Energy Lab NREL/SR-500-33249

Lab tests of blade patterning to increase visibility to flying birds

McIsaac (2001) tested behaviour responses of American Kestrels in the lab:

- Pattern 4 (two broad black stripes) most conspicuous



Hodos (2003) tested retinal responses of kestrels (reduce *motion-smear*)

- Single black blade most conspicuous

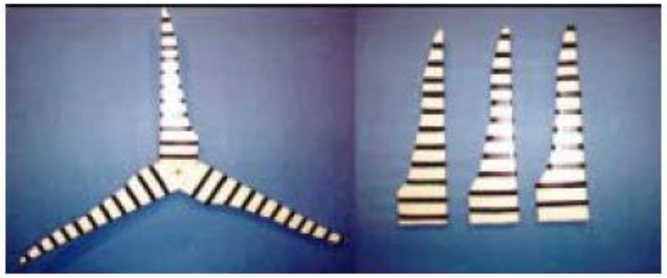


Figure 15. Blade pattern 7. Three blades; staggered thin stripes.

Figure 16. Blade pattern 8. One blade, solid black; two blank blades.

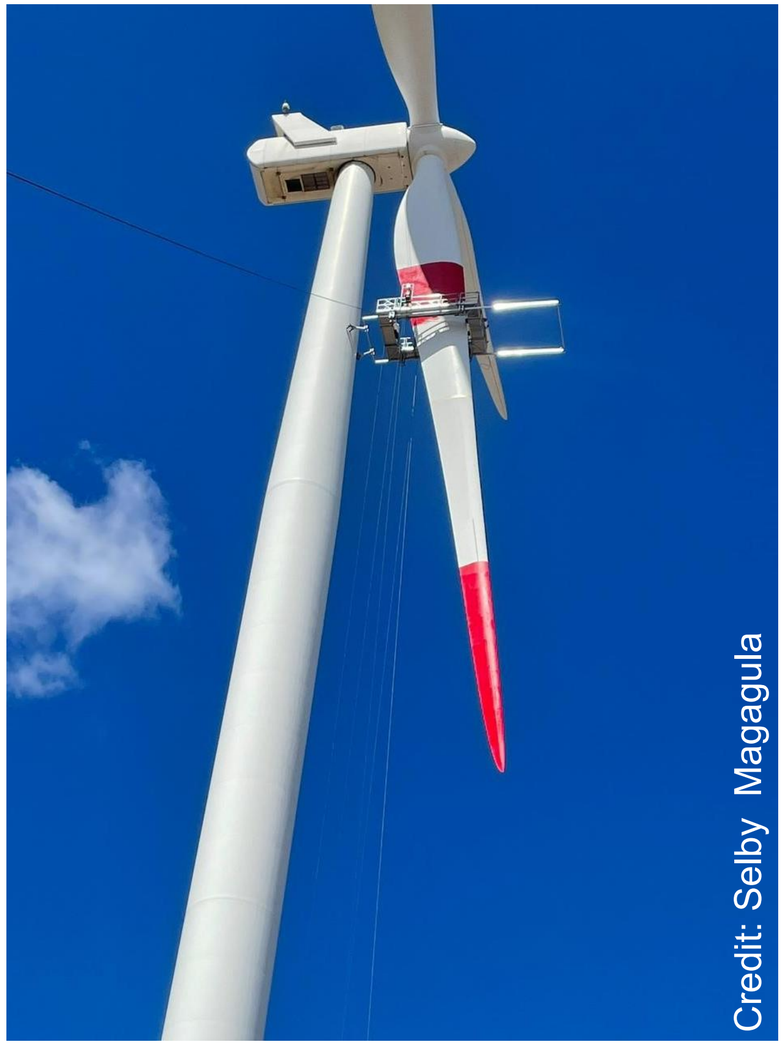
Blade patterning reduces avian fatalities

First field experiment to test the black-blade mitigation at Smøla, Norway

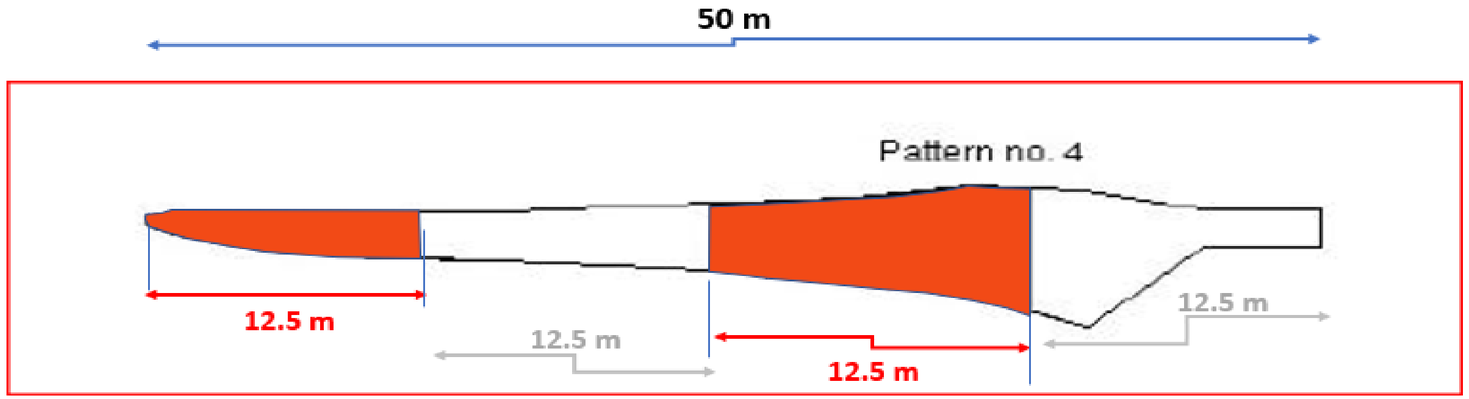
- Aug 2013: NINA black-blade expt to test if they could reduce White-tailed Eagles mortality (Hodos design)
- Fatalities on Smøla, reduced by 72% comparing all birds before (7y) with after (3.5y)
- Eagle fatalities reduced 100% at turbines with a painted blade relative to unpainted controls*

May et al. 2020. Paint it black: Efficacy of increased wind-turbine rotor blade visibility to reduce avian fatalities. *Ecol Evol*. 2020:1–9
*__Stokke et al. 2024__ report no further eagle deaths at the black-blade turbines, but 6 eagles per year at controls 10y on. NINA report 2333

First field experiment with colour-patterned blades at Hopefield, South Africa, 2023

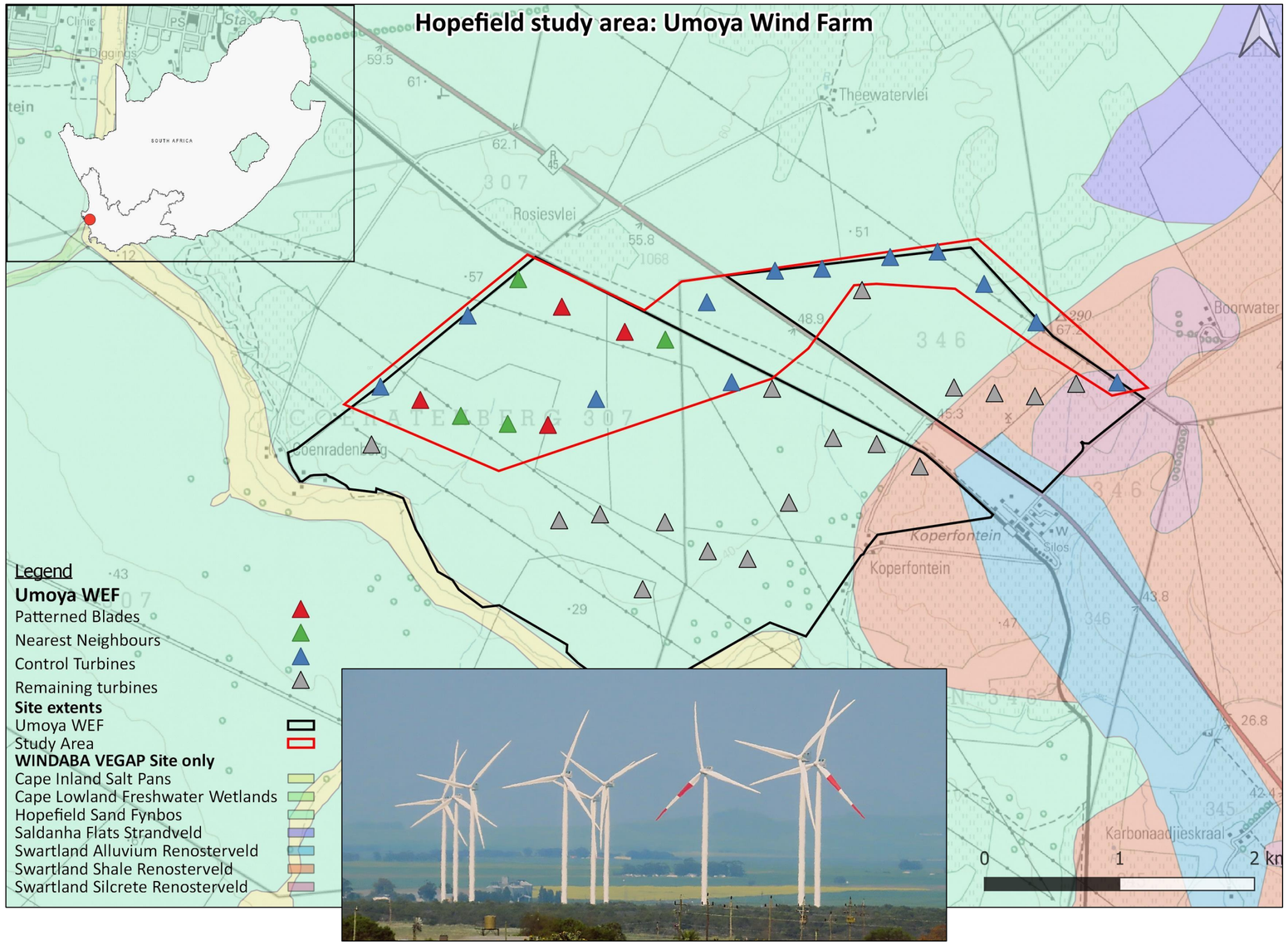


- BBU combined the two most conspicuous patterns: McIsaac's two broad stripes with Hodos's single marked blade to increase likelihood of birds detecting the blades
- August 2022: Umoya received approval from the Civil Aviation Authority to paint white blades with "Signal Red" stripes (black disallowed)
- Jan-March 2023: Umoya painted single blades on four turbines, using aerial platform (costs precluded patterning of 10 turbines)
- Vestas agreed to maintain the warranty "as is" for the patterned blades



Blade patterning reduces avian fatalities

Hopefield study area: Umoya Wind Farm



Umoya wind farm comprises

- 37 Vestas turbines
- 95 m hub height
- 50m blades
- Producing 67 MW

Experimental set up

- 4 high-fatality turbines chosen for treatment
- 4 nearest neighbours and 12 others = controls
- Weekly searches of all 20 turbines for carcasses before (24 mo) and after (26 mo) treatment
- This allowed the powerful BACI analysis

Blade patterning reduces avian fatalities

Live species present **and killed (in bold):**

94 Live Species recorded on site - 14 raptor species

- HARRIER - **Black**, African Marsh
- EAGLES - Martial, **Booted, Black-chested Snake**, African Fish
- BUZZARDS_– **Jackal, Steppe**,
- FALCONS **– Peregrine, Rock Kestrel**
- KITES – **Black-shouldered**, **Yellow-billed**
- OWL **-** Spotted Eagle, **Barn**

Fatalities (all spp):

- Year 1 = 40 birds; year 2 = 35 birds; year 3/4 (patterning) = 35 birds
- Total = 110 birds
- 30% fatalities were raptors (33 of 110)
- 38% of the species killed were raptors (10 of 26)

After patterning at the 4 turbines:

- 7 raptor fatalities (of 6 species) declined to 1 fatality in 26 months
- Based on fatality *rates* we expected 7.6 fatalities in 26 months and found 1 (YBK)
- Thus there has been an [(7.6 – 1)/7.6 =] ~87% reduction in raptors killed

Blade patterning reduces avian fatalities

Effect on fatalities of patterning blades at Hopefield

The following graphs exclude Cape Spurfowl fatalities as tower victims:

Why?

(i) Carcass searchers in all years suggested spurfowl hitting towers
(ii) Majority found next to towers with no major trauma injuries
(iii) Game birds hitting towers found at Smøla and in Spain too

Blade patterning reduces avian fatalities

Effect on fatalities of blade patterning relative to <u>all (16) controls</u>

Effect of blade patterning (left hand graphs) before and after treatment, indicates two fatalities in 26 months after patterning

This could not be explained by a lack of fatalities elsewhere in the wind farm (right hand bars) before and after the treatment for 16 control turbines.

Significantly Different (Barnard's Unconditional Test, Score Statistic = -1.948), p = 0.041

Sophisticated Bayesian GLMs indicated a 10% to 96% (Median 78%) greater reduction in mortality for Patterned relative to All controls after treatment (this a measure of the strength of the effect)

Blade patterning reduces avian fatalities

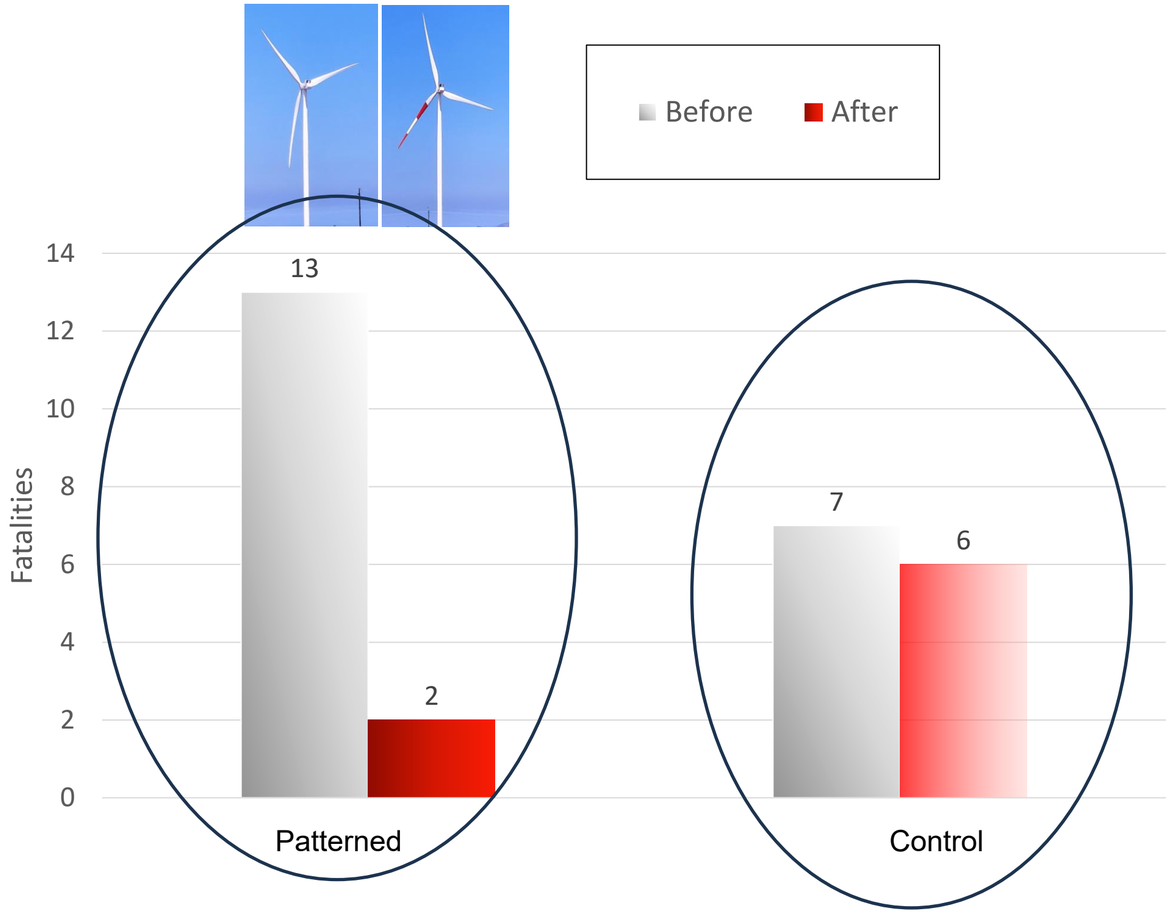
Effect on fatalities of patterning blades relative to nearest neighbour controls

Effect of blade patterning (left hand bars), before and after treatment, show two fatalities in 26 months after treatment

This could not be explained by a decrease in fatalities at the (4) nearest neighbours (right hand bars) before and after the treatment.

Also significantly different (Barnard's Unconditional Test, Score Statistic = -1.917), p = 0.039

The Bayesian GLMs indicated a 5% increase to 97% reduction (median 80% reduction) in fatalities for Patterned in relation to NNC controls after treatment. (a measure of the effect size)



Blade patterning reduces avian fatalities

Does avoidance of patterned turbines increase fatalities at nearest neighbours control?

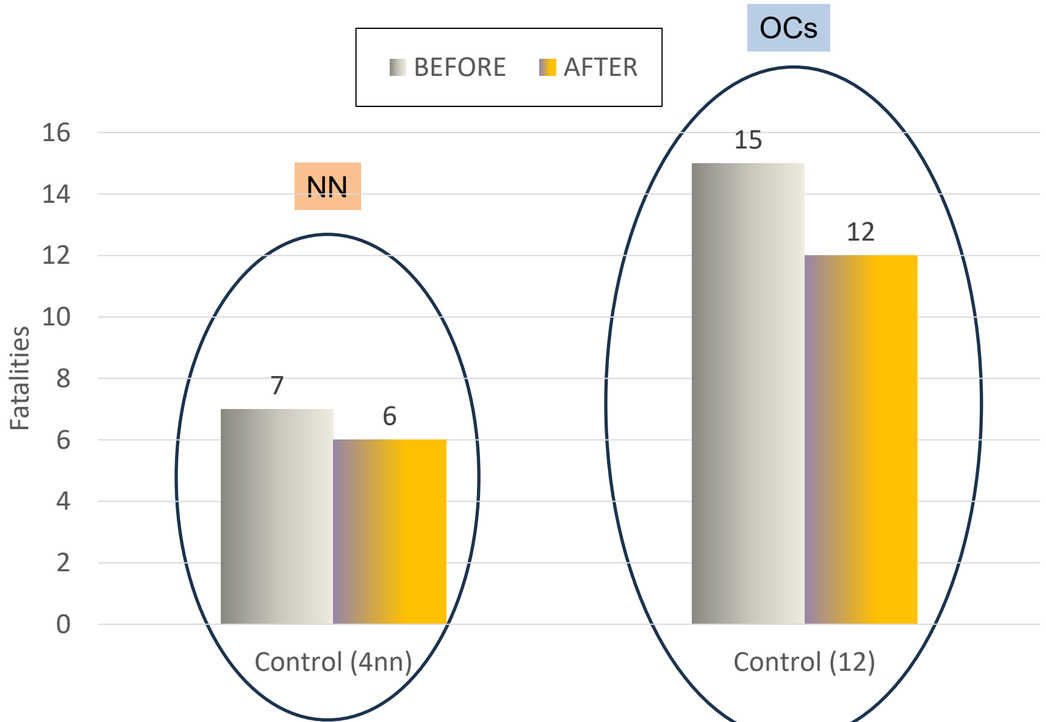
In other words, if birds detect and avoid the patterned turbines, could they be diverted into a nearby control?

If so, we expect increased fatalities at the Nearest Neighbours (NN) relative to Other Controls (OC) further away.

No evidence for increased fatalities at the NN - No significant difference between the two groups (Barnard's, p = 0.51).

According to the GLM there was a 64% reduction to 387% increase in fatalities for NN compared to all remaining controls after treatment (median 32% increase).

Thus, a marginal (non significant) increase but no clear evidence that birds avoiding the Patterned blades are increasing fatalities at the neighbouring turbines.



Summary:

- Umoya wind farm at Hopefield, South Africa is the first facility to field-test colour-patterned blades as a passive mitigation to reduce avian fatalities

- Four single blades were patterned in early 2023 using the optimal combination McIsaac and Hodos

- Comparison of fatalities before and after treatment for patterned and control turbines showed:

  [Effect size]

  - Significant declines in bird strikes for patterned vs all (16) control turbines (p = 0.041) [78%]
  - Significant declines in bird strikes for patterned vs (4) nearest neighbours (p = 0.039) [80%]
  - No significant increase in fatalities for birds veering into the NN (p = 0.51) [32%]

- Raptors deaths (most impacted group) reduced by ~87% at the patterned blades over 26 months

- Lack of fatalities could not be explained by a reduction in overall fatalities because they continued at all control turbines

- These results, despite the small samples, suggest in line with the Smøla results, that increasing blade visibility is a viable [“no regrets investment”] way of decreasing avian fatality rates.

- Call for additional tests in other species-rich environments to test effectiveness with other species (and humbly suggest that all three blades are patterned, not just one)

Blade patterning reduces avian fatalities

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Thank you

Any questions ?

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