**Lecture 6, Series on Wind-Wildlife Interactions**
**Pre-Lecture Readings related to Mitigation**

For the pre-lecture readings for Lecture 6 on examples of mitigation at wind facilities, please look over the following material.

Renewable Energy Wildlife Institute [REWI], 2023, Guide to wind energy & wildlife: Washington, D.C.  Chapter 1. The "Avoid, Minimize, Mitigate" hierarchy. Available at: https://rewi.org/guide/chapters/01-regulatory-context-study-methods-and-development-guidelines/mitigation-hierarchy-avoid-minimize-compensate/

Additional information that may be of interest can be found in additional REWI chapters as well as on the following pages of this document.

Table 1. A summary and brief description of options to avoid, minimize, and compensate for take of Golden Eagles as discussed in the text. Listed references describe use of the options at operating facilities or provide more theoretical support for the application of the option.

| Strategy | Option | Description | References |
|---|---|---|---|
| Avoid | Macro-siting | Avoid siting projects in high-use areas and high-risk topography | Smallwood et al. 2009, Katzner et al. 2012b, Miller et al. 2014 |
| Avoid | Reduce turbine number | Eliminate turbines from high-risk areas and/or reduce exposure | Bay et al. 2016, ICF International 2016 |
| Minimize | Attractant removal | Remove carrion, perches, and attractions for eagle prey | United States vs. Duke Energy Renewables 2013 |
| Minimize | Flight diverters | Install pylons to divert birds around projects or guyed MET towers | U.S.F.W.S. 2013 |
| Minimize | Nest management | Inhibit nest-building; remove or modify nest sites | U.S.F.W.S. 2016b |
| Minimize | Curtailment | Shutdown high-risk turbines or when eagles are at risk of take | De Lucas et al. 2012, Tetra Tech 2012 |
| Minimize | Turbine micro-siting | Use turbine setbacks or avoid high-risk areas | Young et al. 2003, Smallwood et al. 2009, Katzner et al. 2012b, Miller et al. 2014 |
| Minimize | Deterrence | Employ systems that detect and emit acoustic signals intended to alter flight path | May et al. 2012 |
| Compensate | Power pole retrofitting | Replace "problem" poles with APLIC-recommended equipment | U.S.F.W.S. 2013 |
| Compensate | Voluntary lead abatement | Subsidize use of non-lead ammunition or removal of gut piles | Cochrane et al. 2015 |
| Compensate | Roadkill removal | Remove roadkill to reduce vehicle strikes | Tetra Tech 2012 |
| Compensate | Prey habitat improvement | Improve prey habitat to increase eagle productivity | Steenhof et al. 1997 |
| Compensate | Nest-site enhancement | Provide protection or shading for nests | Kochert et al. 2002 |
| Compensate | Rehabilitation | Rehabilitate non-collision injured eagles | Wiemeyer 1981, Martell et al. 1991 |

Allison, T.D., Cochrane, J.F., Lonsdorf, E., and Sanders-Reed, C., 2017, A review of options for mitigating take of Golden Eagles at wind energy facilities: The Journal of Raptor Research, v. 51, no. 3, p. 319–333. [Also available at https://doi.org/10.3356/JRR-16-76.1.]

## Box 6.1 Minimizing collision and electrocution risk through on-site mitigation

### *Turbine collision mitigation options — birds*

- ***Shutdown on-demand:*** The most widely used method involves observers strategically located at vantage points around the WEF implementing shutdown of one or more turbines in response to birds approaching rotor blades. Turbines are restarted once observers determine that birds are no longer at risk (observer-led shutdown on-demand). Shutdowns of this type are typically short (<30 minutes). In some cases, radar is used to assist observers (radar-assisted shutdown on-demand). When WEFs are in areas of intense flight activity (e.g., bird migration corridors), shutdown protocols may allow for a larger proportion of the WEF turbines to be shut down for an extended period (several hours or more) when flight activity is observed or predicted to be particularly high. In addition to observer-initiated shutdown, some automated turbine shutdown systems focused on safeguarding larger bird species have been demonstrated to be effective and may be a good option in some circumstances. The most sophisticated of these systems combine imaging, artificial intelligence, and machine learning to detect target flying bird species and will automatically trigger a shutdown of turbines if a bird approaches within a threshold distance of turbine blades (see McClure et al. 2022).

- ***Livestock management measures*** are required when pastoralism is associated with the WEF site and when vultures or other large scavenging birds are associated with the area, because livestock have the potential to attract these birds, increasing collision risk. Management measures include collaborating with landowners, farmers, municipal authorities, and slaughterhouses to remove livestock carcasses from the WEF and its immediate surroundings; exclude livestock from certain areas during certain times of year; and ensure safe, rapid disposal of carcasses and other material that may attract birds.

- ***Turbine blade painting:*** Increasing the visibility of rotor blades by painting one blade black may reduce turbine collisions for some bird species (Hodos 2003). Blade painting as an effective collision mitigation measure is currently based on a single field study (May et al. 2020), and further research is needed to evaluate its efficacy more fully. At the time of writing, this option is recommended only as a supplementary measure to use in addition to shutdown on-demand.

### *Turbine collision mitigation options — bats*

- ***Blade feathering and curtailment*** is a type of collision minimization measure used mainly for bats that is achieved by slowing or stopping blade rotation (blade feathering) or raising the operational cut-in speed of the turbine (often referred to as curtailment). Curtailment prevents the turbine blades from rotating during periods of low wind speed and high bat activity. Curtailment may be applied to one or more turbines and may be constant for some fixed period of time (blanket curtailment) or vary according to environmental factors and bat activity (smart curtailment). Automated systems designed to curtail turbines in relation to environmental factors and bat activity that are linked to the WEF's (SCADA) systems have also been developed (Hayes et al. 2019).

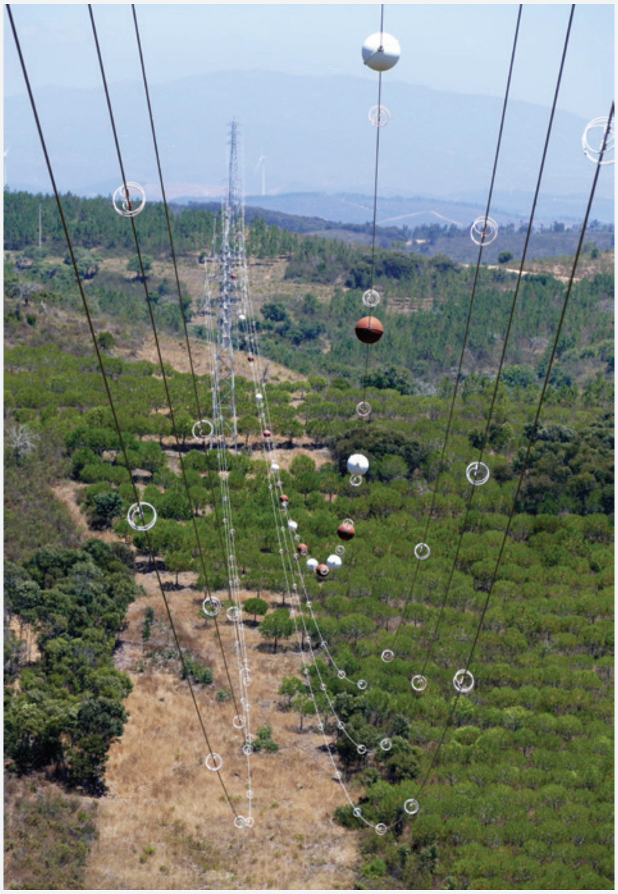
- ***Acoustic deterrents*** involve installation of devices on turbines to deter bats or birds from approaching by emitting noise (for bats, high-frequency sounds within the range of bat call frequencies).

Although acoustic deterrents may be effective for some bat species (e.g., Good et al. 2022; Weaver et al. 2020), evidence is limited, and deployment of this mitigation option is recommended only as a supplementary measure to feathering and curtailment.

### *OHL collision and electrocution mitigation options*

> ***Bird-safe power poles*** can be used with medium-voltage distribution lines, which present a major electrocution hazard for birds, especially medium-sized and large birds, and large bats, such as fruit bats. When it is not possible to bury distribution lines because of geotechnical or other restrictions, bird-safe designs, such as ensuring adequate separation between energized components and between energized and grounded components such that a bird is not able to make simultaneous contact with these components, are essential. For more information, see APLIC (2012), Martín Martín and colleagues (2022), Prinsen and colleagues (2012), and RPS (2021).

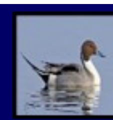
> ***Bird flight diverters*** are designed to increase power line visibility for birds, reducing collision risk. This risk is typically highest on transmission lines, although collisions also occur on distribution lines. A variety of suspended and fixed diverters are available, such as spheres, spirals, and flappers. A risk assessment that considers site conditions, species at risk, power line design, and long-term maintenance requirements, among other things, should be conducted to inform the type installed and their spacing and positioning along the lines. Some bird flight diverters (spirals) can entrap birds, which should also be considered in the selection. For more information, see APLIC (2012), Martín Martín and colleagues (2022), Prinsen and colleagues (2012), and RPS (2021).



Multiple bird flight diverters installed on a transmission line. Algarve region, Portugal. Photo: Alvaro Camiña

> ***Ultraviolet illumination*** of power lines involves projecting ultraviolet light along power lines to increase visibility and reduce collision risk. Although recent studies have demonstrated the effectiveness of this measure, especially for mitigating nocturnal collisions (see Baasch et al. 2022; Dwyer et al. 2019), further research is needed to confirm its effectiveness for a range of collision susceptible species and locations. At the time of writing, this option would be recommended as a supplementary measure to installing flight diverters.

International Finance Corporation. 2023. Post-Construction Bird and Bat Fatality Monitoring for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool. International Finance Corporation, European Bank for Reconstruction and Development, and KfW Group. Box 6.1. [Also available at https://www.ifc.org/en/insights-reports/2023/bird-bat-fatality-monitoring-onshore-wind-energy-facilities.]



Northern Prairie Wildlife Research Center https://usgs.gov/centers/northern-prairie-wildlife-research-center

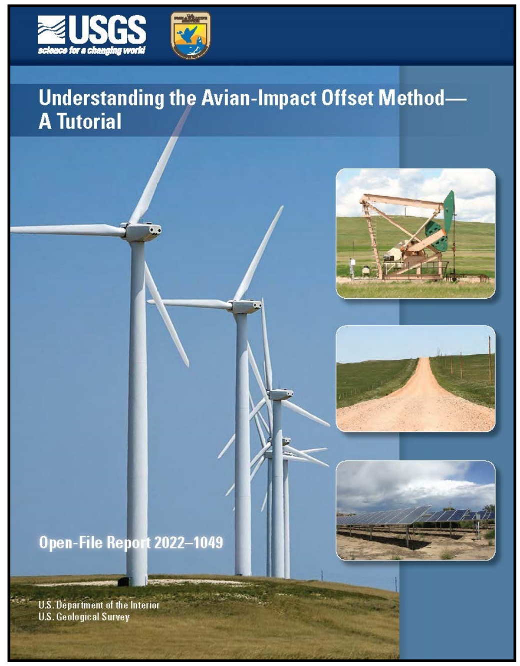
# Compensatory Mitigation Tool for Renewable Energy

## Avian-Impact Offset Method

The U.S. Geological Survey and the U.S. Fish and Wildlife Service Habitat and Population Evaluation Team have developed a tool that enables compensatory mitigation for habitat impacts. The Avian-Impact Offset Method addresses habitat impacts to passerine birds, waterfowl, and shorebirds from renewable-energy development, oil and gas development, and roads.

The Avian-Impact Offset Method quantifies the amount of habitat needed to provide equivalent biological value for birds displaced by energy and transportation infrastructure.

The Avian-Impact Offset Method can be applied to mitigation measures including preserving existing habitat, restoring former habitat, or establishing a conservation bank.




doi.org/10.3133/ofr20221049



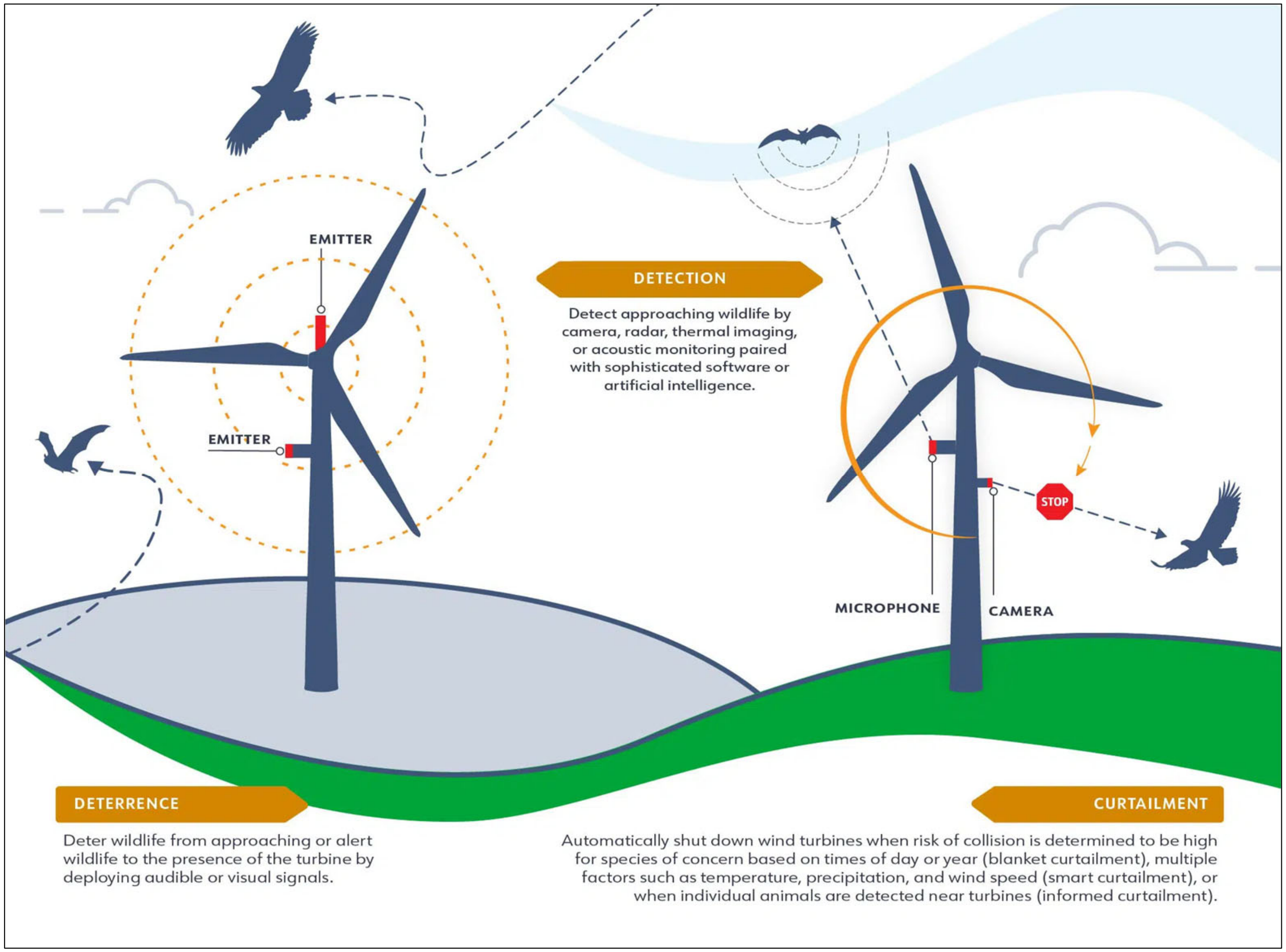

Shaffer, J.A., Loesch, C.R., and Buhl, D.A., 2019, Estimating offsets for avian displacement effects of anthropogenic impacts: Ecological Applications, v. 29, no. 8, p. e01983. [Also available at https://doi.org/10.1002/eap.1983.]

Shaffer, J.A., Loesch, C.R., and Buhl, D.A., 2022, Understanding the Avian-Impact Offset Method—A tutorial: U.S. Geological Survey Open-File Report 2022–1049, 227 p. [Also available at https://doi.org/ 10.3133/ ofr20221049.]

**For more information, contact:**
Jill A. Shaffer
jshaffer@usgs.gov
https://www.usgs.gov/staff-profiles/jill-shaffer
+1-701-253-5547

U.S. Geological Survey, Northern Prairie Wildlife Research Center
8711 37th Street Southeast
Jamestown, North Dakota 58401

Photo credits. Northern Pintail: Paul Hueber, Cornell Lab of Ornithology (CLO); Chestnut-collared Longspur and Upland Sandpiper: Rick Bohn; Blue-winged Teal: Jay McGowan, CLO; Used with permission. Western Meadowlark: Kevin Cole, Creative Commons Attribution 2.0 Generic License.




Renewable Energy Wildlife Institute [REWI], 2023, Guide to wind energy & wildlife: Washington, D.C. Chapter 4. Accessed December 15, 2023 at https://rewi.org/guide/chapters/04-minimizing-collision-risk-to-wildlife-during-operations/.