Biological Conservation 224 (2018) 26–33

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Short communication

Automated monitoring for birds in flight: Proof of concept with eagles at a wind power facility

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ARTICLE INFO

Keywords:
Golden eagle
Bald eagle
Wind power
Wind farm
Bird monitoring
Renewable energy

ABSTRACT

Automated surveys for wildlife have the potential to improve data collection while averting mortality of animals. Collisions of eagles at wind power facilities are particularly of concern and therefore an automated system that could detect birds, determine if they are eagles, and track their movement, might aid in curtailing wind turbines before collisions occur. Here, we use human observers and photographs to test the ability of a camera-based monitoring system, called IdentiFlight, to detect, classify, and track birds. IdentiFlight detected 96% of the bird flights detected by observers and detected 562% more birds than did observers. The discrepancy between observers and IdentiFlight seemed to be because the ability of observers to detect birds declined sharply by distance and toward the west. We reviewed photographs taken by IdentiFlight and determined that IdentiFlight misclassified nine of 149 eagles as non-eagles for a false negative rate of 6%, and 287 of 1013 non-eagles as eagles for a false positive rate of 28%. The median distance at classification for birds classified as eagles was 793 m and the median time from detection till classification was 0.4 s. Collectively, our results suggest that automated cameras can be effective means of detecting birds in flight and identifying eagles.

1. Introduction

Wildlife management often requires assessing distribution, abundance, or movement of animals through space and time (Anderson et al., 2017; Williams et al., 2002). Such monitoring can be aided by automated technology, allowing researchers and managers to collect large amounts of data accurately and efficiently (Arts et al., 2015; August et al., 2015). For example, acoustic recordings are often used to monitor vocalizing birds (Shonfield and Bayne, 2017), and researchers can deploy camera traps to monitor a variety of taxa (Burton et al., 2015). Likewise, radar can be used to track migrating birds (Gauthreaux and Belser, 2003) and assess bird collision risk (e.g., Desholm and Kahlert, 2005; Gerringer et al., 2016; Jenkins et al., 2018).

The use of automated technology in applied ecology is increasing (Arts et al., 2015; August et al., 2015) alongside the need to detect and identify birds in flight. Collisions between birds and aircraft cause human fatalities and billions of dollars of damage each year (Allan and Orosz, 2001; Anderson et al., 2015; Sodhi, 2002), highlighting the importance of detecting and tracking birds to avoid collisions near airports (Gerringer et al., 2016). Bird collisions at wind power facilities are also a concern (Drewitt and Langston, 2006; Johnson et al., 2016; Loss et al., 2013; Smallwood, 2013; Watson et al., 2018), especially because fatalities may involve Bald (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*), which are legally protected within the US (Bald and Golden Eagle Protection Act, 1940). Some wind power facilities employ people who watch for eagles from observation towers or other vantage points and order certain turbines to be powered down if eagles are deemed at risk of collision. The wind power industry might therefore benefit from an automated monitoring system that could detect, identify, and track eagles.

Past studies have used data collected by human observers (hereafter 'observers') to test the ability of acoustic recording units (Alquezar and Machado, 2015; Campos-Cerqueira and Aide, 2016; Leach et al., 2016) and radar (Dokter et al., 2013; Gerringer et al., 2016) to detect birds. These studies assume the automated system is useful if it detected a substantial proportion of birds detected by observers. Here, we use observers and photographs classified by an independent team of experts to test the ability of a camera-based monitoring system to detect birds in flight and determine whether they are eagles. We specifically examined the proportions of birds detected by one survey system (human or camera-based) but missed by the other. We also determined and

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https://doi.org/10.1016/j.biocon.2018.04.041
Received 17 November 2017; Received in revised form 23 April 2018; Accepted 28 April 2018

compared the rates at which each system correctly classified birds as eagles or non-eagles. Finally, we calculated the distance at which the camera system detects birds and the time it required to determine if a bird is an eagle.

2. Methods

2.1. Study site

Duke Energy Renewable's Top of the World Windpower Project is a 200 MW project located ~14 km northeast of the town of Glenrock, Wyoming on ~17,000 acres of land. Top of the World Windpower Project is composed of 44 Siemens 2.3 MW, 101-meter rotor diameter wind turbines and 66 General Electric 1.5 MW, 82.5-meter rotor diameter wind turbines. All wind turbines at Top of the World have a hub height of 80 m above ground level. Activity of golden and bald eagles is high at Top of the World, and Duke Energy has been investing in strategies to reduce collision risk as part of its settlement agreement resulting from prosecution by the US Department of Justice (United States of America v. Duke Energy Renewables, 2013). Duke Energy installed four IdentiFlight units and asked the American Wind Wildlife Institute to provide an independent evaluation of the technology. Other bird species common within the study site that are of interest to airports and wind power facilities include Turkey Vultures (*Cathartes aura*), Red-tailed Hawks (*Buteo jamaicensis*), and Common Ravens (*Corvus corax*).

2.2. Field data collection

2.2.1. IdentiFlight

The IdentiFlight system (hereafter, IdentiFlight; Boulder Imaging, Boulder, Colorado) was developed to detect eagles at sufficient distance from wind turbines to determine in real-time whether any specific turbine or turbines should be shut down or prevented from starting. IdentiFlight is designed as a network of tower-mounted camera systems seven to 10-m-high. Each camera system (hereafter: 'IdentiFlight unit') consists of a ring of eight fixed Wide Field of View (WFOV) cameras and a High Resolution Stereo Camera (HRSC) mounted on a Pan and Tilt Unit (Fig. 1A). The WFOV cameras detect moving objects in the environment and begin to track them. Once a moving object is detected, the HRSC is pointed at the object. The HRSC estimates the line-of-sight distance to the object and takes photographs (Fig. 1C, D) every 200 ms (5/s) to gather the data necessary to classify the object as an eagle or non-eagle. Each IdentiFlight unit uses an algorithm to detect and classify objects within a 1000 m radius. See online appendix for further details of the classification algorithm and visual coverage of a given IdentiFlight camera system.

For this study, four tower mounted IdentiFlight units were deployed in a network along the northern ridgeline of Top of the World (Fig. 1B), a location within the project footprint that is known for eagle flight activity. Note that IdentiFlight units were not mounted on wind turbines, but on separate towers. The IdentiFlight towers were spaced between 530 and 630 m apart allowing for sufficient overlapping visual coverage (see online appendix, Fig. 1B).

2.2.2. Observers

Observers followed a point count survey methodology (i.e., point-based recording of activity) modified from Appendix C of USFWS (2013). On weekdays from 08 August–09 September 2016, observers conducted four 105-min point counts daily, with breaks between counts. The four counts occurred from 9:00–10:45, 11:00–12:45, 13:15–15:00, and 15:15–17:00 MST during all safe weather conditions and when visibility was > 800 m.

During each count, observers recorded all birds the size of an American Kestrel (*Falco sparverius*), or larger, seen within the defined 1000-m survey area, the time each individual bird entered and left their view or the survey area, and traced the path of the birds on an aerial map. Observers also estimated the height of the bird relative to themselves at detection and at its lowest and highest points. Whenever an observer lost sight of a bird (behind clouds, hills, etc.) then later appeared to regain sight of it, they would not count it as a different bird unless more than ~1 min had passed. We paired observers with IdentiFlight units so that each observer independently surveyed the same area covered by the associated unit. There were thus four concurrent surveys being conducted for each count period. Observers were rotated after each count to control for differences in observer skill. Surveys were conducted from vantage points where visibility was similar to that of the associated IdentiFlight unit. All observers were experienced in surveying for eagles.

2.3. Data processing

Our study design therefore consisted of four humans and four IdentiFlight units, each individually attempting to detect birds flying within a 1000-m radius. We combined the individual efforts of the IdentiFlight units and observers into composite records of all birds seen by each method during survey periods. The IdentiFlight output we examined for this study consisted of one image per second, along with bird spatial location coordinates, and the percent confidence in the classification decision (see online appendix for details) for each instance of an IdentiFlight unit detecting and tracking a bird. Because more than one IdentiFlight unit can detect and track the same individual bird, we combined records of flight paths if the start, end, or mid-point of any two flight paths from different IdentiFlight units were within 1 min in time and within 120 m in linear distance from each other. We chose the one-minute criterion to match the observer methods. The 120-m criterion was determined by IdentiFlight engineers as the maximum distance apart at which two flight paths might be considered the same bird. The primary intent was to minimize over-counting of individual birds, with the trade-off that birds flying close together in space and time would be under-counted.

To facilitate the processing of millions of images and data points, the manufacturer (Boulder Imaging) examined output from the IdentiFlight units and observers to pair the two datasets. For each bird detected by observers, Boulder Imaging determined whether the timing and flight path recorded by the observer overlapped flight paths recorded by IdentiFlight units (see online appendix for details). Boulder Imaging further determined which birds were detected by observers but did not correspond with any birds recorded by IdentiFlight, and vice versa.

We only report results for the 4-unit IdentiFlight system, as a whole, not for individual units because curtailment decisions will most likely be made based on the entire system and not individual units. We considered a bird to be classified by IdentiFlight as eagle or non-eagle based on the detection record from whichever IdentiFlight unit had the highest percent confidence in classification. If the highest-confidence detection was classified as an eagle, we considered the bird to be classified as an eagle. Likewise, if there were ties between detections for highest confidence, we deferred to detections classified as eagles. We further considered a bird to be identified as an eagle by observers if any observer classified the bird as an eagle.

We determined the accuracy with which IdentiFlight classified birds as eagles or non-eagles using the 1224 birds closer than 1000 m that were by both the observers and IdentiFlight. We contracted experienced raptor biologists to examine photographs associated with each of these birds and classified each bird as either eagle or non-eagle. Two raptor biologists scored each bird flight as either containing pictures of an eagle, or not. Where the two raptor experts differed in classification, a third biologist examined photographs to break the tie. Given the limited resources available to examine photographs, we did not examine photographs for birds that were not detected by humans.

We calculated time from detection until classification as the elapsed