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Original Articles

The utility of point count surveys to predict wildlife interactions with wind energy facilities: An example focused on golden eagles

Maitreyi Sur[a,*], James R. Belthoff[a], Emily R. Bjerre[b], Brian A. Millsap[c], Todd Katzner[d]

[a] Boise State University, Department of Biological Sciences, 1910 University Drive, Boise, ID 83725, USA
[b] U.S. Fish and Wildlife Service, Division of Migratory Bird Management, PO Box 18, Haleiwa, HI 96712, USA
[c] U.S. Fish and Wildlife Service, Division of Migratory Bird Management, 2105 Osuna NE, Albuquerque, NM 87113, USA
[d] U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 970 Lusk St., Boise, ID 83706, USA

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ABSTRACT

Wind energy development is rapidly expanding in North America, often accompanied by requirements to survey potential facility locations for existing wildlife. Within the USA, golden eagles (*Aquila chrysaetos*) are among the most high-profile species of birds that are at risk from wind turbines. To minimize golden eagle fatalities in areas proposed for wind development, modified point count surveys are usually conducted to estimate use by these birds. However, it is not always clear what drives variation in the relationship between on-site point count data and actual use by eagles of a wind energy project footprint. We used existing GPS-GSM telemetry data, collected at 15 min intervals from 13 golden eagles in 2012 and 2013, to explore the relationship between point count data and eagle use of an entire project footprint. To do this, we overlaid the telemetry data on hypothetical project footprints and simulated a variety of point count sampling strategies for those footprints. We compared the time an eagle was found in the sample plots with the time it was found in the project footprint using a metric we called "error due to sampling". Error due to sampling for individual eagles appeared to be influenced by interactions between the size of the project footprint (20, 40, 90 or 180 km^2) and the sampling type (random, systematic or stratified) and was greatest on 90 km^2 plots. However, use of random sampling resulted in lowest error due to sampling within intermediate sized plots. In addition sampling intensity and sampling frequency both influenced the effectiveness of point count sampling. Although our work focuses on individual eagles (not the eagle populations typically surveyed in the field), our analysis shows both the utility of simulations to identify specific influences on error and also potential improvements to sampling that consider the context-specific manner that point counts are laid out on the landscape.

1. Introduction

Monitoring and surveying are critical for wildlife management and conservation. These processes are designed to estimate wildlife occupancy, abundance and survival, and thus to evaluate existing management practices and compliance with regulatory requirements (Gibbs et al., 2013). However, wildlife monitoring is often confounded by survey error (Yoccoz et al., 2001). For example, most survey methods do not detect all animals in a surveyed area and therefore rely on subsampling and inference to larger areas. These problems are especially relevant to sparsely distributed species for whom detection rate is low and dependent on survey effort and on sampling design (Thompson, 2004).

At large infrastructure facilities, pre-construction wildlife surveys have become integral to risk assessment and conservation efforts. Wind energy development is rapidly expanding in North America. Because wildlife is sometimes negatively affected by these facilities, developers face potential conflict with legally-protected species (Kiesecker et al., 2011). The consequences to wildlife from turbine development are direct, through strike injury or mortality (Hunt, 2002; Drewitt and Langston, 2006; Kunz et al., 2007; Arnett et al., 2008; De Lucas et al., 2008) or indirect, through habitat loss, fragmentation and disturbance (Drewitt and Langston, 2006; Pruett et al., 2009; Kiesecker et al., 2011).

The U.S. Fish and Wildlife Service (USFWS) suggests modified point count surveys to assess use of existing and proposed wind facilities by some species of birds such as golden eagles (*Aquila chrysaetos*) (e.g., Strickland et al., 2011, USFWS, 2013). Point count sampling was originally developed to monitor passerines in terrestrial habitats (Ralph

* Corresponding author.
E-mail addresses: maitreyisur@boisestate.edu (M. Sur), jbeltho@boisestate.edu (J.R. Belthoff), emily_bjerre@fws.gov (E.R. Bjerre), brian_a_millsap@fws.gov (B.A. Millsap), tkatzner@usgs.gov (T. Katzner).

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et al., 1995). The process involves recording the number of individual birds observed or heard within a circular plot. The modified point count approach recommended by the USFWS is used to record the amount of time that eagles spend in a three-dimensional survey plot. These data are then input to an eagle risk model (New et al., 2015) to predict eagle exposure to turbines, collision probability and fatality rates for a proposed wind facility (e.g., Douglas et al., 2012). However, it is not clear how accurately the data collected during these point counts relate to actual use of the project footprint by eagles.

Golden eagles are among the most high-profile species killed at wind facilities (Katzner et al., 2012). Within the USA, golden eagles also have state and national-level regulatory protections (e.g., the Bald and Golden Eagle Protection Act, 16 U.S.C. 668 *et seq*.). Consequently, substantial effort has been dedicated to understand and mitigate threats to this species and, at wind energy facilities, detailed protocols have been designed to predict and manage disturbance and take of golden eagles (New et al., 2015; Strickland et al., 2011; USFWS, 2013). However, golden eagles are not easy to monitor. This is because many aspects of their ecology – low population density, long-distance and often seasonal movements, and avoidance of humans – all combine to make them difficult to detect and count (Fuller and Mosher, 1981). Therefore, as an initial step towards evaluating the utility of point count surveys as suggested by the USFWS, we examined GPS telemetry data from individual eagles tracked in an area well suited to wind energy development and we compared the amount of time a surveyor would have detected the eagles within a point count to the amount of time the eagles actually spent in the project footprint. The telemetry data we used were collected in the Mojave Desert of California with sufficiently short inter-fix intervals to allow us to evaluate the effects of different eagle survey strategies on estimates of actual use of project footprints (Garman et al., 2012).

2. Methods

2.1. Study area

California has some of the highest renewable energy targets in the continental USA (Department of Interior Secretarial Order 3285; Renewable Energy Action Team, 2010) and there are numerous planned and operating wind energy projects in southern California. Much of this development is guided by the Desert Renewable Energy Conservation Plan (DRECP; Fig. 1; California Executive Order S-14-08, Renewable Energy Action Team, 2010). Golden eagles are a conservation priority within the DRECP and there are an estimated 74 occupied golden eagle nesting territories on ~4.5 million hectares of public land in the Mojave and Sonoran Deserts of California (Latta and Thelander, 2013). Although golden eagle territories are sparsely distributed in this region, recent work demonstrates that these eagles use far more space than previously thought (Braham et al., 2015).

2.2. Telemetry data

Seven territorial adults and six fledgling golden eagles in the Mojave Desert were outfitted with solar powered GPS-GSM (global positioning system–global system for mobile communications) telemetry units (Cellular Tracking Technologies, Rio Grande, NJ, USA). Units weighed 80–95 g, < 3% of body weight (Braham et al., 2015) and were affixed as backpacks with Teflon ribbon harnesses (Kenward, 1985). The units collected GPS fixes every 15 min for 9 days and then at 30 s intervals every 10th day. Data from the units were then sent over GSM networks to a remote server where they were available for download. Post processing of the data involved removing data with GPS errors and 2D or low quality fixes (Horizontal dilution of Precision > 10)[1].

2.2.1. Analysis

Our 30 s data were too sparse for most of the detailed analyses we conducted and thus the majority of analyses were conducted on data collected at 15 min intervals. To standardize our data set, we subsampled the 30 s data to 15 min intervals (except for one analysis in which we compared 15 min and 30 s data, see below). We analyzed telemetry-derived GPS data of residential birds collected in two calendar years, 2012 and 2013 (Table 1) within a polygon encompassing part of the Mojave Desert. We note that constraints on sample size here are different than those required if estimating home range (Soanes et al., 2013).

2.3. Eagle survey guidelines

The USFWS Eagle Conservation Plan Guidance (ECPG), derived in part from Strickland et al. (2011), provides recommendations for surveys of golden eagles at potential wind facility locations (USFWS, 2013). These are often used when a project site has been selected but the exact layout of turbines has not yet been determined. A brief outline of the ECPG recommendations for point count surveys is provided in SI1.

2.4. Experimental design

At the time of data collection, there were no operational large-scale wind facilities within our study area. Thus, to evaluate the potential of modified point count surveys to assess individual eagle use of a hypothetical project footprint, we measured the times when the telemetered eagles passed through point count plots and project footprints that we simulated on the landscape. To do this, we first overlaid telemetry data from eagles onto the study area. We then compared the time spent by telemetered eagles within simulated point count plots to time spent in associated simulated project footprints. The process of converting our actual telemetry data to hypothetical survey data is described in the Supplementary information (SI2).

We evaluated the strength of the relationship between use of point count plots and use of project footprints with a metric we called the error due to sampling. To do this, we measured how error due to sampling was influenced by (a) the point count sampling type (the ways in which point count plot locations are distributed within the project footprint); (b) the sampling intensity (the spatial coverage of the project footprint by point count plots); (c) the size of the project footprints; and (d) seasonality (eagle movements and behavior often vary between breeding and non-breeding seasons). We also looked for interactions between these factors. Finally, for a subset of the data, we separately evaluated how error due to sampling was affected by changes in sampling frequency (i.e., if surveys were conducted weekly, bi-weekly, monthly or every 4 months).

The details of our analytical approach were as follows:

1. We simulated project footprints of 20, 40, 90 and 180 km^2 to capture a range of sizes of wind facilities (Fig. 2). A description of the size, shape and placement of footprints in the study area are provided in SI3. Information on number of birds and GPS fixes represented within each simulated project footprint is provided in the results.
2. We simulated modified fixed-radius point count plots within those footprints according to different sampling strategies (SI4 and point 5 below) and calculated the amount of time that telemetered eagles spent in the point count plots and in the simulated footprints (SI2).
3. We compared the amount of time telemetered eagles spent in point

[1] Further details on telemetry systems, their attachment to birds, the data they collect, post-processing of those data, and the interpretation of these data and their relevance to eagle biology are available elsewhere (Lanzone et al., 2012; Duerr et al., 2015; Miller et al., 2014; Braham et al., 2015; Katzner et al., 2015).