CENTRE FOR EVIDENCE-BASED CONSERVATION

SYSTEMATIC REVIEW NO. 4

Effects of wind turbines on bird abundance
Summary Report

Reviewers: Stewart, G.B., Pullin, A.S. & Coles, C.F.

Postal Address: Centre for Evidence-Based Conservation,
School of Biosciences,
The University of Birmingham,
Edgbaston,
Birmingham,
B15 2TT,
UK

Email Address: g.b.stewart@bham.ac.uk
Telephone: +44 (0)121 414 4090
Facsimile: +44 (0)121 414 5925

Summary

Background

Wind energy is the fastest growing energy technology in the world, with a yearly growth rate estimated at 30%, reflecting policy commitments in many countries to renewable energy in order to meet greenhouse gas emission targets. Wind energy is seen as a key element of the shift to sustainable energy supplies; however, despite the clean image of wind energy, there is some evidence that wind farm developments may have potentially deleterious environmental impacts. Attention has been brought to the possible impacts on bird populations caused by displacement and direct 'bird strikes'. Here we systematically review the impact of wind turbines on bird population abundance.

Objective

The objective has been to assess the evidence on the positive and negative effects of wind turbines on bird abundance. To achieve this four questions were identified:

1. Do wind turbines effect bird abundance?

2. Are some bird taxon more vulnerable than others?

3. Does the number or power of turbines in a windfarm installation have an impact on the effect of windfarms on bird abundance?

4. Can any other ecological factors or windfarm characteristics be identified which have an impact on the effect of windfarms on bird abundance?

Study Inclusion Criteria

Studies were included if they fulfilled the relevance criteria below.

- *Subjects(s)* studied – any bird species (information was extracted on Falconiformes & Accipitriformes, Anseriformes, Passeriformes and Charadriiformes except *Laridae*).

- *Intervention* used – commercial wind installations in any country: wind farms and turbines.

- *Outcome(s)* – population size or distribution, breeding success, population mortality rate, recruitment rate, turnover rate, immigration rate, emigration rate, demography, dispersal behaviour, collision mortality, displacement disturbance, movement impeded, and habitat loss or damage. (Only information on bird abundance was extracted).

- *Comparator* – appropriate controls (e.g. reference areas) or pre-development comparators

- *Type of study* – any primary studies

Scope of the Search

The following computerised databases were searched: English Nature's "Wildlink, JSTOR, Index to Theses Online (1970 to present), Internet search – Dogpile meta-search engine, SCIRUS, COPAC and ISI Web of Knowledge. In addition, the RSPB library was hand-searched, as were bibliographies. Recognised experts and current practitioners in the fields of applied avian ecology and renewable energy technology were contacted. Foreign language searches were undertaken to ensure that the scope of the review was truly global.

Main results

A total of 124 articles were accepted for full text viewing based upon an initial screening of title and abstract, including foreign language articles. Of these, 15 were of sufficient quality and relevance to meet the inclusion criteria reporting on the results of 19 datasets. Nine of these datasets were complete although three only reported on a limited number species. The remaining 10 datasets were incomplete. Nine did not present variance measures, one did not include turbine characteristics and three of the sites were not independent as they shared the same control.

Random effects weighted mean difference meta-analysis of six complete independent datasets with more than three species produced negative effect sizes, two of which were statistically significant, suggesting that windfarms can have a negative impact on bird abundance. Combination of the complete datasets using Random effects standardised mean difference meta-analysis resulted in a pooled effect size of -0.328 ($P < 0.0001$). The inclusion of incomplete datasets (with down-weighted dummy variances) reduced the size of the effect and its significance (-0.033, $P = 0.002$), whilst including these data with average weighting further reduced the effect size and probability fell beyond the 0.05 significance threshold (-0.022, $P = 0.054$).

Combination of the complete datasets with effect sizes derived from overall means of within-windfarm samples resulted in a negative and significant pooled effect size (-0.712, $P = 0.0001$) which remained with the addition of down-weighted data with dummy variances and non-independent data. (-0.257, $P = 0.023$). Effect sizes were also derived using species as replicates and again the pooled effect size was negative and significant (-0.489, $P = 0.035$) although the significance fell beyond the 0.05 threshold when down-weighted data with dummy variances and non-independent data was added (-0.240, $P = 0.089$).

Meta-regression was used to investigate reasons for heterogeneity in results. Bird taxon had a significant impact on the effect of windfarms on bird abundance ($r = 0.290$, $SE = 0.070$, $P = 0.0001$) with Anseriformes (ducks) experiencing greater declines in abundance than other bird groups, followed by Charadriformes (waders), Falconiformes and Accipitriformes (raptors) and Passeriformes (songbirds).

Turbine number did not have a significant impact on bird abundance whilst turbine power had a very weak but statistically significant effect ($r = 0.002$, $SE = 0.0007$, $P = 0.004$) with low power turbines resulting in greater declines in abundance than high power turbines.

Bird taxon, turbine number and turbine power were combined with habitat type, the migratory nature of the species, latitude, location, size of area, time since operation of windfarm and data quality using multivariate meta-regression. Time since windfarms commenced operation had a significant impact on bird abundance (r = 0 .519, SE = 0.155, P = 0.001) with longer operating times resulting in greater declines in abundance than short operating times. Latitude had a very weak but statistically significant effect (r = -0.099, SE = 0.032, P = 0.002) with high latitudes resulting in greater declines in abundance than low latitudes.

Conclusions

Available evidence suggests that windfarms reduce the abundance of many bird species at the windfarm site. There is some evidence that Anseriformes (ducks) experience greater declines in abundance than other bird groups suggesting that a precautionary approach should be adopted to windfarm developments near aggregations of Anseriformes and to a lesser extent Charadriformes particularly in offshore and coastal locations. There is also some evidence that impact of windfarms on bird abundance becomes more pronounced with time, suggesting that short term bird abundance studies do not provide robust indicators of the potentially deleterious impacts of windfarms on bird abundance.

These results should be interpreted with caution given the small sample sizes and variable quality data. More high quality research and monitoring is required, in particular, long term studies with independent controls and variance data. Pending further research, if impacts on bird abundance are to be avoided, the available evidence suggests that windfarms should not be sited near populations of birds of conservation importance, particularly Anseriformes.