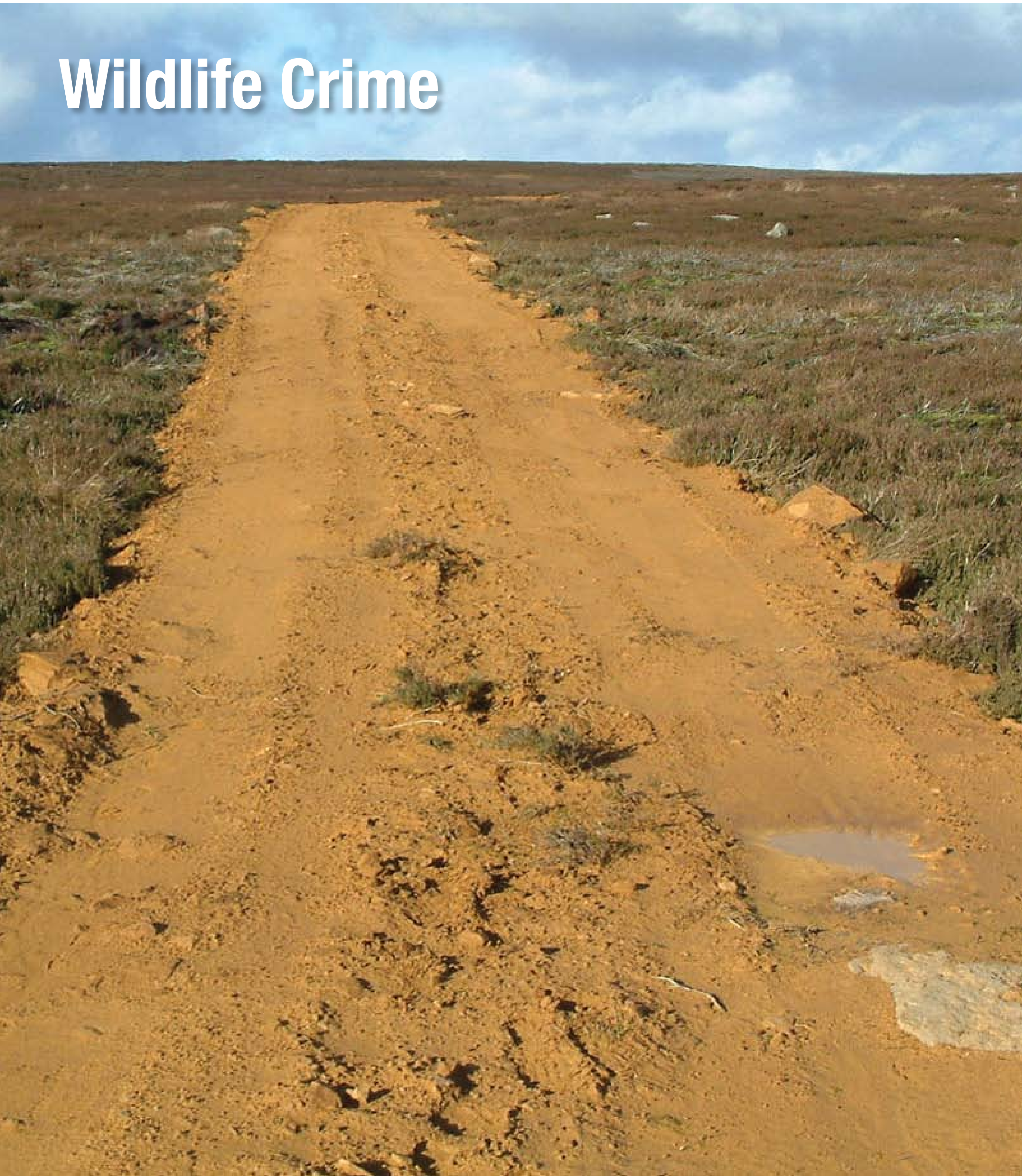
Number 64 • June 2009

In Practice

Bulletin of the Institute of Ecology and Environmental Management

Wildlife Crime



Bats and Onshore Wind Farms: Site-by-Site Assessment and Post-Construction Monitoring Protocols

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The publication of Eurobats guidance for onshore wind farms (Rodrigues *et al.* 2008) has led to a wider awareness of the potential impacts of these developments on bats. This has culminated in the development of the current Natural England (NE) interim guidance (Mitchell-Jones and Carlin 2009). This guidance, adopted by Scottish Natural Heritage (SNH) and the Countryside Council for Wales (CCW), has led to the requirement for stringent surveys and assessments for any wind farm proposal before planning consent can be granted by planning authorities and government ministers. However, unlike birds, where detailed pre-construction survey and post-construction monitoring guidance is available, there is no methodological wind farm specific guidance for bats (Anon 2005, Anon 2009). It is hoped that this article will contribute towards developing national survey and post-construction monitoring methodology appropriate to all proposed and consented onshore wind farms.

Introduction

Wind farms are becoming an important source of power generation, and this is likely to increase in the future as the UK commits to lower carbon emissions. However, it is essential that potential ecological impacts are assessed before consenting to a new wind farm development. Impacts on most animals and habitats are generally considered to be synonymous with those associated with most other types of development. However, due to flight and associated behaviours, wind farms pose particular risks to birds and bats in addition to traditional impacts (*e.g.* habitat loss, disturbance, *etc.*). Assessment of impacts on birds has been based upon standardised and rigorous survey methods for a number of years, and post-construction monitoring guidelines were issued earlier this year (Anon 2005, Anon 2009). Although afforded enhanced statutory protection as European Protected Species, there are no national guidelines outlining standardised survey methods and post-construction monitoring techniques for bats at onshore wind farm sites, despite increasing evidence of negative effects and the mounting body of international academic publications discussing the causative mechanisms.

European guidance on assessing impacts and post-construction monitoring has been published by EUROBATS (Rodrigues *et al.* 2008). However, the methods suggested in this document are appropriate to continental scenarios, where bat activity levels may be particularly high. This is due to the occurrence of more diverse species and behaviours, including the potential for long-distance migration routes and higher swarming risks. Although the behaviour of bats in the UK has not been subject to the same level of research as in mainland Europe, major migration routes are not currently known to occur within Britain.

NE produced an interim guidance document which presented a pragmatic interpretation of EUROBATS recommendations as applied to the UK in May 2008, updated in February 2009 (Anon 2008, Mitchell-Jones and Carlin 2009). This document presents loose methods for assigning risk to sites and collision risk to different bat species, but does not offer guidance on levels of survey effort. Survey methods follow Bat Conservation Trust (BCT) generic best practice guidelines, but these are not written with the unique effects of wind turbines in mind (Parsons *et al.* 2007). While the survey methods described are transferable, the level of effort suggested is not sufficient to inform a robust assessment of wind farm impacts.

Cook *et al.* (2008) proposed a generic survey methodology for the specific purpose of assessing the potential impacts of wind farms on bats. This methodology took a step towards a standardised protocol for ecologists undertaking these studies. However, there is a risk that this methodology could be interpreted as required for all sites, regardless of situation. It is essential that standardised methodologies allow ecologists to design a survey approach suited to the particular conditions of the site. Indeed, there are many locations in the UK where such intensive surveys would be disproportionate, needlessly dangerous (*e.g.* extensive sites in upland bog habitats in Scotland) and impossible (*e.g.* dense plantation woodland).

Post-construction monitoring is essential for gaining a greater understanding of the effects of wind farms on bats. Although NE guidance welcomes such monitoring, and recognises the necessity of standardised methods, little detail is provided. This article proposes a standardised methodology, developed as a pragmatic interpretation of EUROBATS guidance as applied to the UK (Mitchell-Jones and Carlin 2009, Rodrigues *et al.* 2008). These methods are presented for discussion, and it is hoped that they may contribute towards a national standardised methodology.

Site-by-Site Pre-Construction Survey Methods

Summary of General Approach

Cook *et al.* (2008) presented a detailed outline of survey methods to be employed for the assessment of potential impacts of wind turbines on bats. These methods present an excellent approach, and are considered here to be appropriate to wind farm developments. However, it is critical to ensure flexibility within the design, allowing ecologists to employ survey effort as appropriate to the site. It is proposed that surveys should involve the following stages:

1. identify survey area (200 m + rotor radius from proposed turbine locations [see Box 1] or potential development area if locations are not yet known);

Table 1. Criteria for assessing potential site risk.

Feature	Feature Risk Level		
	Low	**Medium**	**High**
Location	North Scotland	Central/South Scotland, North England and North Wales	South England and South Wales
Elevation	High elevation (>500 m)	Moderate elevation (200-500 m)	Low elevation (<200 m)
Situation	Exposed – high winds	Moderate winds	Sheltered – low winds
Habitat	Exposed upland habitats (*e.g.* bog habitats) Commercial forestry >100 m from suitable habitat features*	Exposed habitats (*e.g.* bog habitats, large scale farming) >50 m from suitable habitat features*	Suitable habitat features* within or adjacent to wind farm footprint
Roosts	No major hibernacula, breeding or maternity roosts within >500 m of turbine locations or potential development area	Major hibernacula, breeding or maternity roosts within 500 m of site, but not on or within 50 m of turbine locations or potential development area	Major hibernacula, breeding or maternity roosts on or within 50 m of turbine locations or potential development area
Species present**	*Myotis* spp. Long-eared bats Horseshoe bats	Common pipistrelle Soprano pipistrelle Barbastelle	Noctule Leisler's bat Nathusius' pipistrelle

Suitable habitat features include, but are not restricted to woodland edges, deciduous or mixed woodland, waterbodies and linear features (woodland edges, hedgerows, treelines or rivers).
*****As published in NE interim guidance, based upon existing information concerning species specific behaviour and characteristics (Mitchell-Jones and Carlin 2009).***

2. desktop survey (noctule records within 20 km, all other bat records within 5 km);
3. habitat assessment (ideally extended Phase 1 Habitat Survey, but at least a site walkover to identify all potential commuting routes, foraging and roosting habitat);
4. identify roosts (within 500 m + rotor radius of proposed turbine locations [see Box 1] or potential development area, following BCT good practice guidelines (Parsons *et al.* 2007));
5. assess potential site risk; and
6. design and conduct automated, manual and targeted activity surveys (methods as described by Cook *et al.* (2008), survey effort as identified in stage 5).

This approach is largely identical to that described by Cook *et al.* (2008).

Minor differences include the suggestion that the desk study be extended to include all noctule records within 20 km (as opposed to 15 km recommended previously). This is based upon experience gained in south Scotland, where noctules are poorly recorded, but thought to be rare. When assessing potential impacts on this species in these areas, consultees have requested that even very low levels of activity are placed in to the context of a 20 km radius, based upon historical records. Similarly, it is recommended that roosts are identified within 500 m of proposed turbine locations, placing the bat activity onsite in to a wider local context.

Box 1 – Calculating buffer distance between turbines and habitat features

NE interim guidance presents a formula for calculating the distance between turbines and habitat features (Mitchell-Jones and Carlin 2009). However, it may be difficult to obtain accurate height information for all habitat features, and features such as trees will change over the operational life of the wind farm (particularly fast growing conifers providing woodland edge habitat). In addition, wind farm designs inherently follow an iterative design process, through which constraints are taken in to account as they are discovered. Therefore, completing this calculation for each iteration would be onerous, and of limited value to any assessment. Instead, it is recommended here that the buffer simply extend from the rotor radius limit. This will always over-estimate any buffer from features shorter than a turbine, and is considered to be an appropriate and precautionary approach.

Ideally, an extended Phase 1 Habitat Survey would be conducted prior to bat surveys. This would allow the identification of features providing potential commuting routes, foraging and roosting habitat. In practice, it is likely that bat surveys will be commissioned before a Phase 1 Habitat Survey has been undertaken. In this case, reference to aerial photographs and an initial site walkover should identify these features, allowing an assessment of site risk to be completed.

Activity surveys should include automated surveys (elevated to as near rotor height as possible, or angled appropriately), walked manual transects, and targeted surveys. Surveyors should aim to come within 200 m of all potential turbine locations within the site during walked manual transects. Where a site consists of mature commercial forestry, it may be more appropriate to design transects that follow woodland edges, allowing assessment of effects of keyholing turbines (which effectively creates new woodland edge habitat). Targeted surveys would include commuting route surveys, as described by Cook *et al.* (2008), but may also include driven transects to cover wider areas. Such transects may be required to identify noctule lek sites, where this is suspected to be associated with observed, regular flight behaviour. It is important to ensure that regular behaviour is assessed in the context of sunrise and sunset times.

The only major difference is the addition of stage 5, where potential site risk is assessed prior to designing activity surveys. This stage allows survey effort to be appropriately tailored based upon the likely risk to bats at that particular site.

Table 2. Activity survey effort appropriate to site risk levels.

Survey design	Site risk level		
	Low	Medium	High
	Walked manual activity transects		
Frequency+	Three (Spring, Summer, Autumn)	Monthly (dusk or dawn)	Monthly (dusk or dawn alternating with bimonthly back-to-back dusk and dawn visits)
Number of sample points / ha	10	10	20
	Automated activity surveys		
Frequency of three day survey periods	Three (Spring, Summer, Autumn)	Three (Spring, Summer, Autumn)	Three (Spring, Summer, Autumn)
Number of sample locations / km^{2}++	2	2	5

+Frequency of surveys during appropriate bat activity period. In most cases this will be April to October, but this activity season will be reduced further north. For example, May to September may be more appropriate for most Scottish sites.
++See Box 2.

Assessing Potential Site Risk

NE interim guidance presents a basic method with which sites may be assessed as either 'high' or 'low' risk for bats based upon various features. However, the guidance states that in reality, most sites are likely to lie between these two extreme risk levels. Furthermore, guidance does not suggest appropriate levels of survey effort for different risk levels. Table 1 provides a more detailed aid to assigning risk levels to sites. The results of data searches, site walkover and identification of roosts (or, at minimum, potential roosts) inform this assessment. Therefore, it is important that these are completed at as early a stage as possible.

It must be stressed that this table is only intended as an aid. In the absence of a realistic risk index that adequately considers all potential factors, the ultimate assessment of risk for a site relies upon the expert professional judgment of the ecologist and relevant statutory body. Species and high population densities will also affect the decision as to the level of survey effort required. NE guidance identifies which species are of particular risk of collision with wind turbines. It is suggested that these categories are used when deciding levels of activity survey effort, and not the rarity of the species themselves. Rare species that are less susceptible to mortality through the pathways unique to wind turbines will be fully assessed in terms of loss of habitat and/or roost locations. However, as small numbers of collisions may constitute a significant impact on small populations, it may be necessary to determine use of important habitat through targeted surveys where rare species are present in significant numbers.

Site size has not been included within the risk assessment criteria, as the size of a site does not have any bearing on the presence or absent of suitable habitat features for bats. An expansive site in the Highlands may have no suitable habitat features for bats, while a small site in southern England may offer many suitable features. However, the size of a site, and presence of suitable features within the site will clearly be considered when developing surveys, following potential site risk assessment.

Determining Appropriate Levels of Survey Effort

Using the criteria described above, an ecologist may assess the overall likelihood of a wind farm at a particular site presenting a risk to bats, using the same categories (*i.e.* low, medium and high). Although species specific surveys will be dependent upon species present, these risk categories can be used for determining the level of effort required for general activity surveys. Table 2 presents a guide for survey effort considered appropriate for the different risk levels.

Post-Construction Monitoring

There is currently a great level of uncertainty regarding assessments of impacts of wind farms on bats, due to a lack of research at existing developments in the UK. Increased understanding of the impacts through post-construction monitoring would allow for a greater level of certainty when assessing the potential impacts of future developments, and lead to more detailed and informed pre-construction survey guidelines. 'Experimental' mitigation methods are often proposed to offset potential impacts – for example by creating rich foraging habitats (*e.g.* manure piles or ponds) so as to attract bats offsite. Without monitoring and research, there is no way to know that any mitigation measures are effective. Therefore, post-construction bat monitoring should be an encouraged component of any wind farm Habitat Management and Monitoring Plan (HMMP) where impacts on bats have been identified, and required wherever mitigation measures are proposed.

The following proposed post-construction survey methodology was developed by the authors, and has been accepted for proposed wind farm sites in England. NE have also requested that other proposed wind farms incorporate bat monitoring in HMMPs and have referred to this methodology as submitted for previous developments.

It is proposed that monitoring surveys would be repeated during years 1, 2, 3, 5, 10 and 15 of the operational life of the wind farm. This would coincide with post-construction bird monitoring, in accordance with current SNH guidance. By conducting ecological post-construction monitoring concurrently, surveys and reports may be completed efficiently, and an overall picture of ecological impacts may be clearer.

Corpse Searches

Mortality data should be collected at four periods during the year, coinciding with different stages in bat lifecycles. These visits should be made during the following times:

- Spring – emergence from hibernation. Females in particular feed intensely in preparation for breeding;
- Early Summer – active maternity roosts;
- Mid-late Summer – mothers suckling; and
- Autumn – young fledge, and *Mytotis* spp. exhibit swarming behaviour, during which they may be at particular risk of collision with turbines.

The precise timing of surveys would be dependent upon the latitude of the site, concurrent with activity survey periods.

Although noctule bats are not known to migrate in the UK, the spring and autumn mortality searches would ensure that the migration periods are covered should further research discover that this does occur at some level.

Each visit should involve searching for dead bats under turbines. For small developments or those in areas of high importance to bat populations or rare species, all turbines should be included within the search. Where developments are large, and sited in areas assessed as being of low importance to bats, a subset of turbines may be selected for search. In this case, an intelligent sample design would be preferable, targeting areas where bat activity was found to be or is likely to be higher. For example, turbines close to features thought to be of high value to bats should be chosen, as well as random turbines located in poor quality bat habitat.

A square search plot with sides equal to the maximum blade tip height should be marked around the base of each turbine (*e.g.* 100 m x 100 m for 100 m tip height). This plot will then be systematically searched for bat corpses by following defined transect routes or by using dogs trained to detect dead bats.

Any bat corpses should be collected and a post-mortem conducted to determine the cause of death. These data will contribute towards research exploring the mechanisms resulting in bat fatalities at wind farm sites.

Turbine number, bat species, age, evidence of barotrauma and/ or evidence of collision and cause of death should be recorded for each bat corpse detected.

Calibration of detection rate will be required, and should follow SNH bird monitoring guidance methods, as applied to bats (Anon 2009).

Activity Monitoring

Monitoring of bat activity within the wind farm site may also be beneficial – particularly at locations where the risk of impacts on bats is considered to be of concern. Such monitoring may involve the utilization of automated bat detectors and manual activity transects. Automated detectors' locations and transect routes would preferably be synonymous with those used in the pre-construction survey, to allow a comparison to this baseline. A control site, of similar altitude and habitat composition should also be monitored, using identical methods.

Roost Monitoring

Where roosts have been located within 500 m of turbine locations, these should be checked during post-construction monitoring, employing the same methods as used for the pre-construction assessment.

Other Monitoring Methods

Other methods, such as infrared cameras and radar, have been suggested. For logistical reasons, it is impractical to use these at most wind farm sites and so it is not recommended that these form part of a standardised methodology. However, such techniques may be appropriate for sites where particular potential impacts have been identified and more detailed, targeted monitoring is required.

Conclusions

The nature and magnitude of potential impacts of wind turbines on bats are poorly understood. However, increasing evidence from around the world indicates that poorly sited wind turbines have the potential to cause significant negative effects through pathways unique to these developments. It is therefore important that assessments follow standardised and robust methods that can be tailored to the particular site, while allowing direct comparisons between sites by decision makers and for cumulative assessments. Furthermore, standardised post-construction monitoring is essential so as to inform research in to the particular effects of wind farms on bats in the UK. It is hoped that the methods suggested in this article will promote discussion and move closer to national methods.

Box 2 – Designing automated bat survey detector locations

Cook *et al.* (2008) suggest that automated bat survey locations should be based upon turbine positions. This is not considered appropriate, as layouts may not be available and are likely to change as new constraints are discovered throughout the Environmental Impact Assessment (EIA) process. Therefore, an approach that samples the proposed development area is recommended here, and is dependent upon the size of the potential development area and the risk level of the site.

Acknowledgements

The authors wish to thank Mike Armitage, Kirsty Cathrine, Jonathan Fairbairn, Claudia Gebhardt, Chris Pendlebury, Chris Robinson and Simon Zisman for their valuable contributions.

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