NATURAL RESEARCH INFORMATION NOTE 2

FLIGHT HEIGHT IN THE HEN HARRIER *CIRCUS CYANEUS* AND ITS INCORPORATION IN WIND TURBINE COLLISION RISK MODELLING

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ABSTRACT

Potentially, one of the main adverse impacts of terrestrial wind farms on birds is fatality through collision with rotating turbine blades. Hence, a common metric in wind farm studies is to describe flight activity by recording the height at which birds fly above the ground in relation to the height which will be or is swept by the rotating turbine blades.

A brief review of studies of flight behaviour in the hen harrier *Circus cyaneu*s illustrates that a common finding is that height above ground at which harriers fly is typically strongly skewed towards low altitudes with the vast majority of flight activity occurring within 10 or 20 m of the ground.

One of the implications of this trait when recording flight height in studies of wind farm assessment for hen harriers is considered by an illustrative example in which the height bands used for recording flight activity does not match the rotor swept height (RSH) of the proposed turbines. The illustration shows how a method to correct the observed time spent at different flight altitudes under such a scenario, published in Band et al. (2006), can lead to an overestimation of collision mortality in a collision risk model (CRM). A more appropriate correction method is described. Although in most wind farm assessment studies flight height bands should include the RSH as one of those bands, there are several instances in which this may not be possible and such a 'flight-time' correction method would be required.

Finally, we discuss the relative merits of recording avian flight height in 'many narrow height bands' and in 'few broad height bands', and highlight the need for studies of observer error when recording flight height.

INTRODUCTION

Potentially one of the main adverse impacts of terrestrial wind farms on birds is fatality through collision with rotating turbine blades (e.g. Langston & Pullan 2003). Hence, a common metric in wind farm assessment and impact studies is to describe flight activity by recording the height at which birds fly above the ground in relation to the height which will be or is swept by the rotating turbine blades. Hen harriers *Circus cyaneu*s (or northern harriers as the species is known in North America) are well-known to fly mainly at very low elevations as they quarter the ground for prey at slow speed (e.g. Schipper 1977, Watson 1977). Flights at higher elevation usually occur when birds are not hunting, such as when returning to a nest with prey, during display flights, or when simply flying from one place to another (on migration, for example). Speeds during such flights are typically faster (e.g. Madders 1997, Spaar 1997). Although such traits have been known for many years and are obvious to even a casual observer of harriers, it is only fairly recently that flight heights have been quantified, primarily due to the need to record such behaviour as part of wind farm studies. Typically, such studies either record flight height above the ground in 10 m height bands or in broader categories, usually related to the known or anticipated rotor swept heights (RSH) of the existing or proposed wind farm respectively. Recorded flight heights are used to provide an index of 'risk exposure' (e.g. Erickson et al. 2002) or are used in quantifying the flight rate at RSH in collision risk models (CRM: for example, Band et al. 2006), which then take this fundamental activity metric to predict collision mortality.

The purpose of this note is twofold:

1. Collate a sample of available information on hen harrier flight height to discern any common patterns in this trait;
2. Illustrate both the importance of recording flight height in bands appropriate to the RSH and, if this is not done, how crude correction can overestimate collision risk in a CRM.

In collating information on hen harrier flight heights we have assumed that the reader is most familiar with UK studies of harriers at proposed wind farms and so have concentrated on documentation of data from USA studies. Note that all the available data were gathered by 'instantaneous sampling' of behaviour and so, for example, frequency of observed flights at different heights provides a measure of the proportion of flight time at different heights.

For the purposes of brevity, we have also assumed that the reader is familiar with the CRM described in Band et al. (2006) (the 'Band model'). Further background material on this CRM may be found on the Scottish Natural Heritage website (http://www.snh.org.uk/strategy/renewable/sr-we00.asp) and the model has been recently reviewed by Chamberlain et al. (2005). The Band model is in fairly widespread use in UK wind farm assessment studies and is a two-stage process (Band et al. 2006). Stage 1 estimates the number of birds that fly through the rotor swept disc. Stage 2 predicts the proportion of these birds that will be hit by a rotor blade. Combining both stages produces an estimate of collision fatality in the absence of any avoiding action by birds. In practice, birds do avoid flying through rotating blades, and avoidance rates appear to be very high (probably typically >95%) and so an avoidance rate is applied as a final step to the calculations. Whitfield & Madders (2006) have suggested that for the hen harrier an avoidance rate of 99% avoidance is probably most realistic, given the apparently low susceptibility of the species to collision with turbine blades.

FLIGHT HEIGHT IN THE HEN HARRIER

A review of several USA studies of harrier flight height above ground illustrated the strong propensity of harriers to fly at low elevations (Fig. 1). Observations in Scotland conform to the findings from research in the USA. For example, at Arecleoch proposed wind farm in SW Scotland 80% of flights were below 10 m above ground level. Similarly, at Spireslack proposed windfarm in Lanarkshire only 3% of flight observations were at 20-110 m and at the nearby Hagshaw Hill extension only 3% of harrier flights were at 10-100 m, with even less activity above these height bands (refer to relevant Environmental Statements and supplementary information). Foraging harriers at several sites in Argyll also spent very little time flying higher than 5 m above ground (Madders 1997: Fig. 2).

The propensity of hen harriers to fly at low height above ground is therefore probably a ubiquitous trait (at least for birds not actively migrating). In the next section, we illustrate how the strong skew in the frequency distribution of harrier flight heights towards low altitudes is an important consideration when recording flight height and in estimating flight activity or the time spent flying at heights which may lead to collision fatality.

FLIGHT HEIGHT IN COLLISION RISK MODELS

In this hypothetical example, field assessment studies for a proposed wind farm recorded hen harrier flight observations in height bands of <10 m, 10-100 m and > 100m. The proposed turbines have a hub height of 90 m with 90 m diameter rotor sweep (V90 turbines). Thus, the rotor swept height (RSH) is 45 – 135 m. From ornithological observations, 10-100 m was effectively assumed to be the risk height band within which there was a risk of collision. Band et al. (2006) describe a method for correcting the disparity between observed flight height bands and RSH by taking the crude percentage of the 10-100 m limits accounted for by the rotor swept diameter (i.e. in this case 100%, because of 90 m diameter rotor sweep). However, this will tend to overestimate the collision risk for hen harriers due to the marked propensity for hen harriers to fly at low heights (Fig. 1 - 3).

In other words, under the correction method used by Band et al. (2006) a CRM would effectively assume that harriers are immune from collision if they fly lower than 10 m and that flight activity was equally distributed between 10 and 45 m, whereas in reality harriers will be immune from collision if they fly lower than 45 m and flight activity is not equally distributed between 10 and 45 m[1]. As the proportion of time that harriers fly lower than 45 m will be higher than the proportion of time that they fly lower than 10 m and flight activity is not the same between these two heights (illustrated hypothetically in Fig. 3), the CRM will overestimate collision risk under the correction method of Band et al. (2006). The extent of the overestimation will depend on the distribution of flight height utilisation on a site (the severity of the skew towards low flight heights).

A better correction method would be to collect supplementary flight observations at the site using more appropriate height bands which more closely match the proposed turbine dimensions; in the present example, say, <10 m, 10-50 m, 51-100m, > 100m (the

[1] In general, harriers may also be at most at risk of collision in the lower RSH because of flight behaviour and radial differences in blade speed.

rarity of flights at the highest height bands will mean there will be little collision risk estimation error if all flights > 100m are considered as within the risk height). The proportion of flights in the 10-100 m bands that were at 51 – 100 m can then be used as a correction factor applied to the original data, which utilised only three height bands. For example if 20% of all flights at 10-100 m are above 50 m in the supplementary data then the flight time spent at 10 -100 m in the original data should be multiplied by 0.2.

Obviously a similar consideration would be relevant to other situations or species where the frequency distribution of flight height is skewed. While it is also obvious that flight height bands used in avian flight height observations should ideally include a band that matches the RSH of the proposed turbines, there are several scenarios where this may not be possible (and so the above consideration would be relevant), including:

- Rapid technological advances in turbine specifications may mean that when field observations are first undertaken the dimensions of the proposed turbines are smaller than those which are included in the final planning application;
- ‘Repowering’ of a wind farm when old turbines are replaced by larger models.

This illustration may also argue that it is better to record flight height in many narrow height bands (e.g. 10 m height bands) than in fewer broad height bands (this would also make it easier to compare and/or utilise data from other studies): as is apparent (Fig. 1) most studies seem to employ the ‘few broad height bands’ approach. It is easier in the field to record at fewer height bands due to lower processing requirements and another argument against the ‘many narrow height bands’ approach is that observation error (assigning a record to the wrong height band) is more likely than if fewer height bands are used (Band et al. 2006). This seems a reasonable assumption, although what is important in the context of estimating predicted collision risk is the error in assigning records or flight time to the RSH. Thus, when employing ‘few broad height bands’ which match the RSH, all errors are relevant but under the ‘many narrow height bands’ method not all errors are relevant (e.g. it does not matter if most flights at 40 m are incorrectly assigned to a 50-60 m height band if the RSH is 30 – 100 m).

There would be several potential benefits of a study that aims to quantify observation error in flight height estimation (Madders & Whitfield 2006); it would also be useful for such a study to include a contrast in observation error generated by the two 'height bands' methods.

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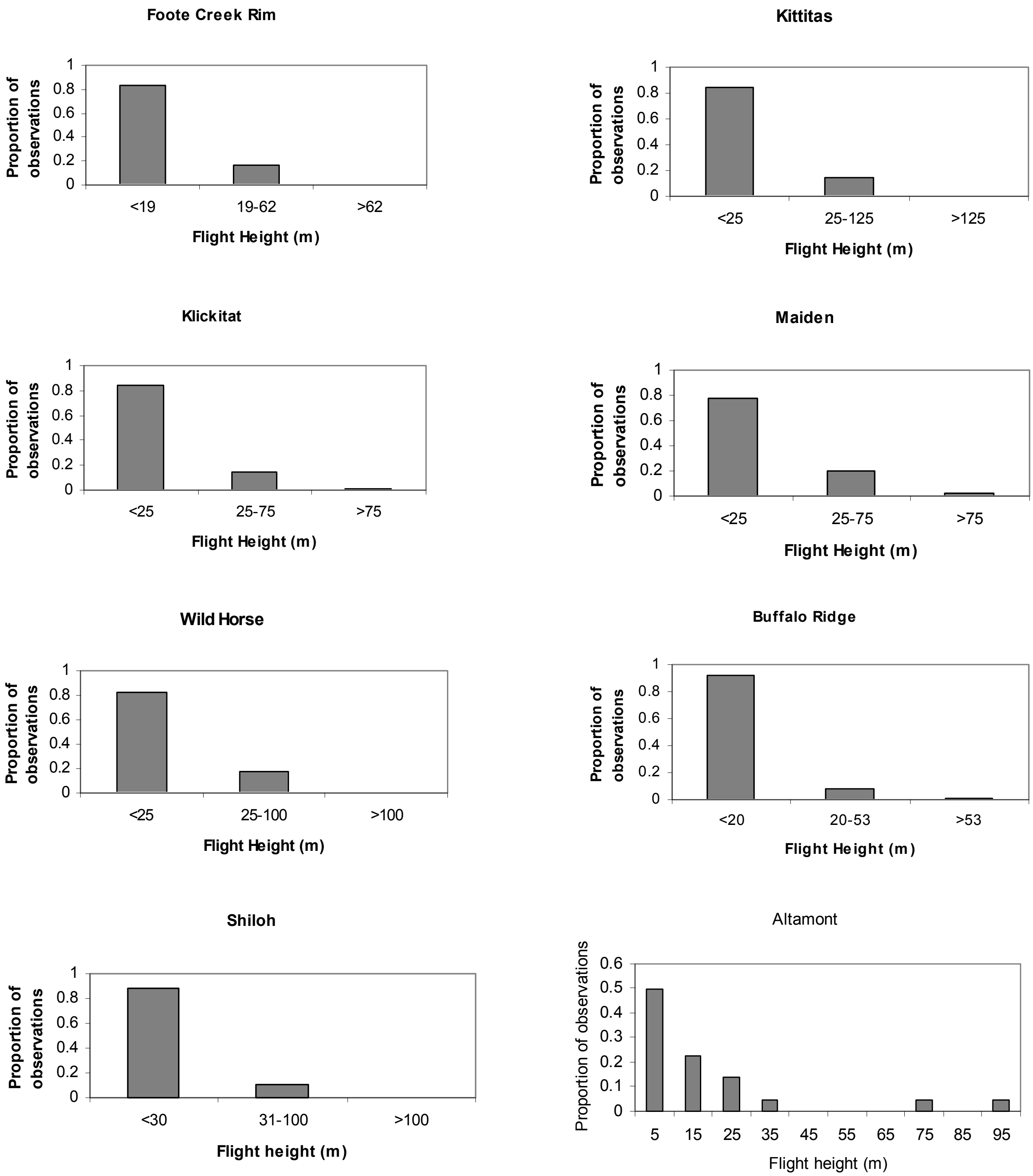


Fig. 1. Frequency distributions of flight heights of hen (northern) harrier at eight proposed or operational windfarm sites in USA. Height bands for recording observations tended to reflect site-specific turbine dimensions. Sources: Erickson et al. (1999, 2003), Johnson et al. (2000a, b), Young & Erickson (2003), Young et al. (2002, 2003), Smallwood & Neher (2004), Kerlinger et al. (2005).

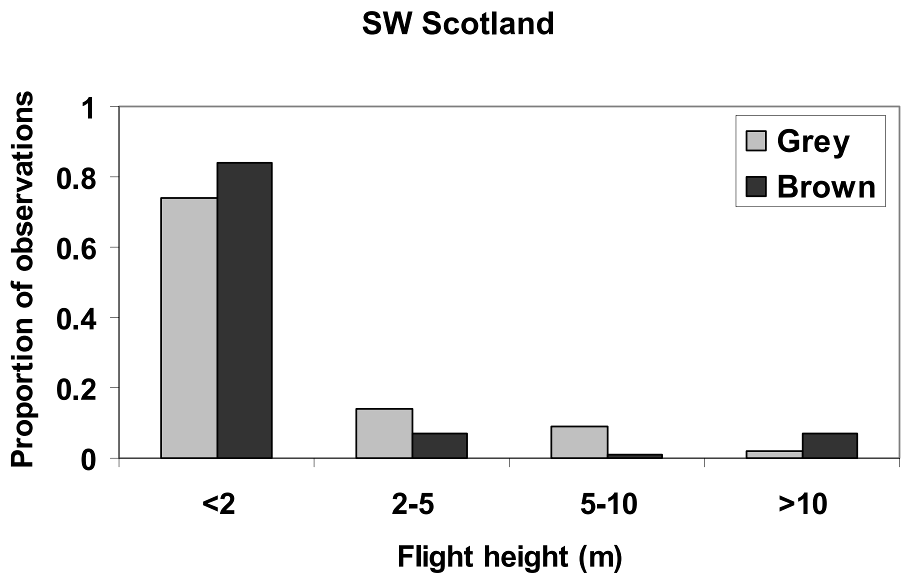
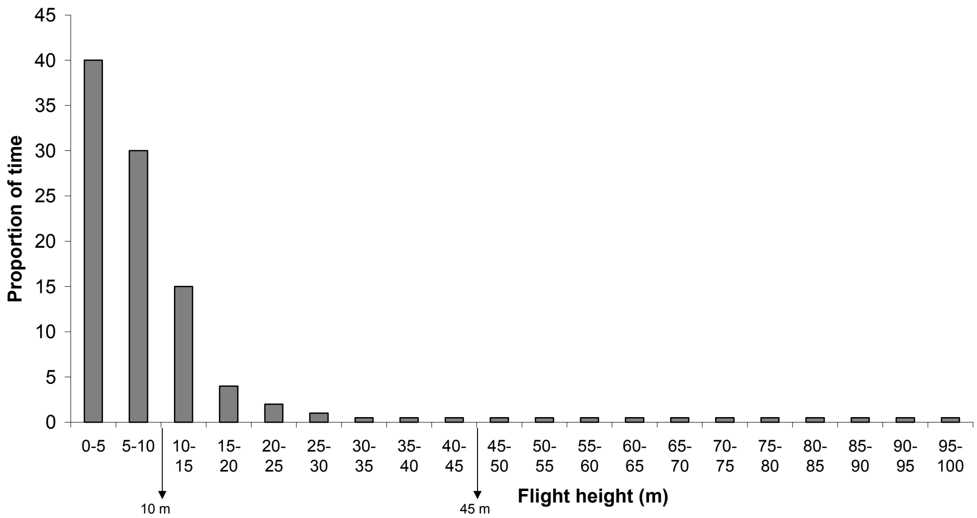


Fig. 2. Frequency distribution of flight heights of foraging hen harriers observed at several sites in Argyll, SW Scotland (after Madders 1997). Birds were categorised as either adult male (grey) or immature male or female (brown).

a)



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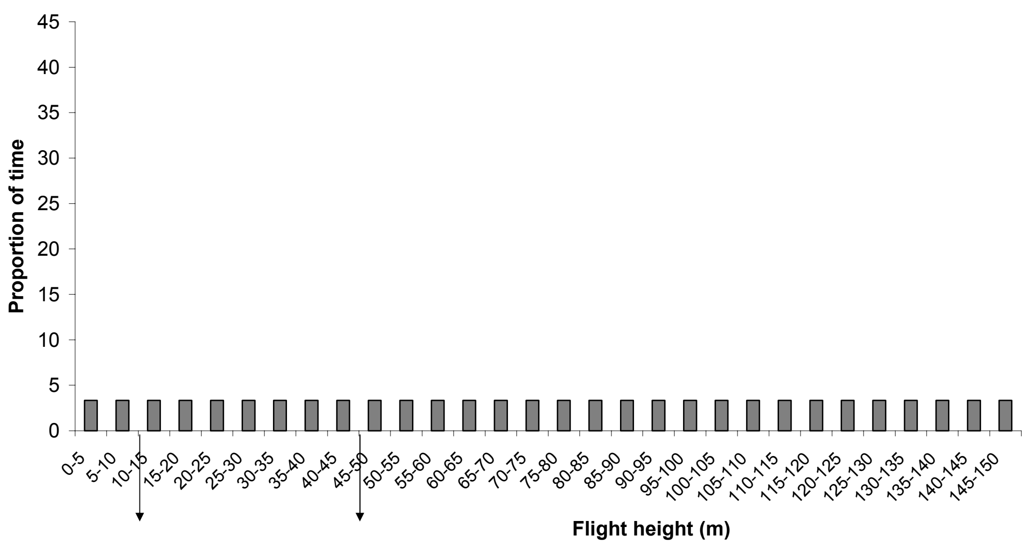

Fig. 2. Two hypothetical frequency distributions of bird activity according to flight height. The band within which flights are 'risky' in reality extends from 45 m to 135 m in altitude, whereas risky heights were presumed during observation to be between 10 m and 100 m. a) Frequency distribution skewed towards flight at lower altitudes and no activity above 100 m altitude (approximating hen harrier flight activity). A 45 m lower height cut-off would estimate that 6.5% of flights were risky (i.e. the accumulated proportion to the right of the 45 m arrow) and a lower cut-off at 10 m altitude would estimate that 30% of flights were risky (i.e. the accumulated proportion to the right of the 10 m arrow). b) Frequency of flights equally distributed according to height and no activity above 150 m altitude. Both 'real' and 'presumed' risk height bands would estimate that 60% of flights were risky.