Modelled collision risk for Wedge-tailed Eagles at the proposed Yaloak Wind Farm, Victoria.

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- Brett Lane

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1.0 INTRODUCTION

1.1 Project Background

Biosis Research Pty. Ltd. was engaged in October 2004 by Pacific Hydro Pty. Ltd. to undertake predictive collision risk modelling for the Wedge-tailed Eagle *Aquila audax* at the proposed wind farm site at Yaloak Victoria. The modelling was to use the field data collected by Brett Lane and Associates

1.1.1 Why use a model?

The fundamental objective of modelling of risk is to provide a rigorous process by which probability can be assessed in a manner that can be replicated.

When making predictions of risk, one of the alternatives to using a model is subjective judgement. One of the drawbacks of subjective judgement is that it usually leads to biased predictions of risk, and the biases vary somewhat unpredictably among people (Tversky and Kahneman, 1974; Ayton and Wright, 1994; Gigerenzer and Hoffrage, 1995). The predictions of models tend to be less biased (Brook et al. 2000, McCarthy et al. in press). By using models, the rationale behind the predictions is explicitly stated in the mathematics of the model, which means that the logical consistency of the predictions can be more easily evaluated. Compared to subjective judgement, this makes models more open to analysis, criticism and modification when new information becomes available. Although there might be some arbitrary choices when deciding on the structure and parameters of a model, these choices are stated explicitly when using models but are difficult to disclose when making subjective judgements. Assessments based on subjective judgement can give the illusion that they are not scientifically rigorous (Burgman, 2000), regardless of whether they are or not. The assumptions underlying models can be tested. Models can be used to help design data collection strategies. They can help to resolve and avoid inconsistencies, and the rigorous analysis of data can help to clarify thoughts. Models are often most valuable for their heuristic capacities, by focussing attention on the important processes and parameters when assessing risks (Brook et al., 2002). These benefits are difficult, if not impossible to achieve with subjective judgement.

2.0 METHODS

2.1 Parameters of the model

The model used here is the most recent version of the general avian collision risk model developed by Biosis Research Pty. Ltd. This model has been has been applied here specifically to assess the possible effects of the proposed wind farm at the Yaloak site, on the Wedge-tailed Eagle (WTE).

A number of parameters are incorporated into the model to account for both physical and temporal aspects of the site and proposed wind farm, such as seasonal variation in wind direction and the specifications of turbines proposed to be used. As the model used here is a deterministic model, all of the parameters are fixed and are considered as constants.

Each parameter is detailed below, along with a discussion of the rationale for how each has been derived. Based on these parameters the model generates an annual number of movements (flights) made by birds that are at risk of collision with turbines (Movements at Risk). On the basis of a given local population size for the species, a further series of calculations allows an annual mortality, expressed in the number of individuals, that is predicted to occur.

2.1.1 Number of turbines

The number of turbines are as proposed for the entire wind farm by Pacific Hydro: 70.

2.1.2 Mean turbine area

This represents the mean area [m^2] of each turbine structure that presents a collision risk to WTEs. It has been calculated from specifications for the wind turbine model (NEG Micron NM82) under consideration for the Yaloak wind farm.

The modelling accounts for the fact that the spinning rotors represent a significantly different risk from that presented by the large stationary elements of the tower and nacelle.

The tower and nacelle of turbines are large objects. Towers are 70 to 80 metres tall and approximately four metres in diameter at the base, tapering to a little over two metres in diameter at the top. Nacelles are in the order of 12 to 14 metres long, three to four metres wide and four metres high. All of these components are pale in colour. Under most circumstances it is unlikely that a

Wedge-tailed Eagle would collide fatally with such structures. Rotating generator blades may be less visible under some circumstances and may present the only real collision risk to the birds.

The mean presented areas of turbines are calculated using the following considerations:

The plane of a wind turbine rotor pivots in a 360° horizontal arc around the turbine tower in order to face the wind direction. Hence, the area presenting a collision risk to a bird flying in a particular direction may vary from a maximum, in which the rotor plane is at 90° to the direction in which the bird is travelling, to a minimum, in which the rotor plane is parallel with the travel direction of the bird. Wind direction recorded from the site varies and is summarised by the wind rose data from the site. Calculation of mean turbine areas incorporates appropriate weighting according to this wind rose data. (Note that data for wind direction is provided according to eight compass sectors each of 45°. However, the area of turbine presented to a bird travelling from a given direction and from 180° to that direction is identical. For the purposes of modelling, when a bird is travelling toward a turbine at 90° to the plane of the rotors (from either the 'front' or 'back' of a turbine) the maximum area is presented. When it is travelling toward a turbine parallel to the plane of the rotors, the minimum area is presented. These possibilities account for four of the eight compass sectors. When a bird is travelling toward the turbine from any of the other four compass sectors, it is taken to be travelling at a 45° angle to the rotor plane and hence the area of turbine presented is a corresponding value between the maximum and minimum. Thus the compass sector values for turbine area can realistically be reduced from eight to three.)

Area presented by a turbine also differs according to whether the rotors are stationary or are in motion. When turbines are operational and rotors are in motion, the area swept by the rotors during passage of a bird the size of a Wedge-tailed Eagle is included in calculations of the area presented.

Mean area is thus derived from the sum of the following components:

1. Area presented when turbines are operational (75.8% of time; Daniel Walsh, Pacific Hydro, personal communication). This incorporates the area of turbine plus the area swept by rotor blades (at 14.4 rpm) during passage of a 500mm long bird flying at 60 km/h (this speed is an estimate of the average flight speed of Wedge-tailed Eagles) through the plane of the rotors at maximum presented area. Area presented when turbines are not operational and rotors are braked (24.2% of time). During such times only the minimum area per turbine presents a collision risk. Turbines are switched of when wind speed is below 4 m/sec, when it exceeds 25m/sec, and during maintenance.

2.1.3 Flight height

Data on flight height were provided to us from Brett Lane and Associates. These data were derived from their field-based point counts. The survey sites were located on the edge of the escarpment, with half the survey area for each point comprising edge and plateau, and half valley.

Survey method was fixed points counts, encompassing a horizontal radius of 100m. Each count was undertaken for a total of 15 minutes.

Survey period was for 24 points for a total of 60 minutes per point per season, for four seasons. Total survey time is, therefore: 96 hours (5760 minutes) in total.

Records of the birds included in modelling of collision risk were those that were observed within a 100 metre horizontal radius of an observer and within the following height classes above the ground:

- <35m above ground (i.e. below rotor swept area height);
- between 35 and 110m above ground (i.e. rotor swept area height).

Unfortunately, these height categories do not correspond exactly to the dimensions of the turbines to be used at Yaloak (i.e. swept area height will be 37-119 m above ground). However, this should not make a major difference to the results.

In total, the data includes 27 observations of Wedge-tailed Eagles from below 35 m and 66 observations from above 35 m.

2.1.4 Wedge-tailed Eagle population size

Brett Lane reports that a total of 120 Wedge-tailed Eagles was observed at the 24 sites surveyed at the Yaloak Windfarm site. The maximum number of individuals observed simultaneously was twelve, and we have used this number as an estimate of the local eagle population.

2.1.5 Avoidance by Wedge-tailed Eagles of wind turbines

The use of the term 'avoidance' here refers to how birds respond when they encounter a wind generation turbine, that is, the rate at which birds attempt to avoid colliding with the structures. This should not be confused with what we refer to as 'diversion rate', which is the percentage of birds that alter their flight paths from some distance away to avoid the general wind farm area.

Complete lack of avoidance (0.0) is behaviour that has not been observed in any study of bird interactions with wind turbines and would be analogous to birds flying blindly without responding to any objects within their environments. Absolute avoidance behaviour (1.0) has been documented for some species and may be a reasonable approximation for many species in good conditions, but unlikely for some species in certain conditions.

2.1.5.1 *Avoidance rates in the literature*

Specific avoidance rates measured to date are:

1. Directly observed avoidance rates (i.e. observations of birds passing through a turbine array, but showing active avoidance of collisions):

- 100% - Barnacle, Greylag, White-fronted Geese, Sweden (Percival 1998);
- 100% - range of species (Common Starling, Straw-necked Ibis, Australian Magpie, Australian Raven, Little Raven, *European Goldfinch, White-fronted Chat, *Skylark, Black-shouldered Kite, Brown Goshawk, Richards Pipit, Magpielark, Nankeen Kestrel, White-faced Heron, Brown Songlark, Wedge-tailed Eagle, Swamp Harrier, Brown Falcon, Collared Sparrowhawk, egret sp., White Ibis), Codrington, Victoria (Meredith et al. 2002);
- 99% - migrating birds, Holland (diurnal and nocturnal data) (Winkelman 1992);
- 99.9% - gulls, Belgium (Everaert et al 2002, in Langston & Pullan 2003);
- 99.8% - Common Terns, Belgium (Everaert et al 2002, in Langston & Pullan 2003);
- 99.5% - Common Terns avoiding powerlines (Henderson et al 1996);
- 97.5% - waterfowl and waders, Holland (Winkelman 1992, 1994);
- 87% - waterfowl and waders at night, Holland (Winkelman 1990).

(* introduced species)

2. Calculated avoidance rates (i.e. recorded fatalities compared with measured utilization rates – these are more accurately considered as survival rates of birds passing through a wind farm, but they give an indirect estimate of avoidance rate):

- 100% - waterfowl, Yukon, Canada (Mossop 1997);

- 100% - raptors, Yukon (ibid);
- 99% - Australian Magpie, Skylark, Codrington Victoria (Meredith et al. 2002);
- 99% - waterfowl, waders, cormorants, UK (Percival 2001);
- >95% - Brown Falcon, Victoria [Codrington] (Meredith et al. 2002).

Based on the experience cited above, it is reasonable to conclude that an avoidance rate of 0.99 or greater is typical for birds during daylight and normal weather.

In relation to the WTE, the only directly recorded avoidance rate recorded for this species is 100% at the Codrington wind farm. The avoidance rates for Wedge-tailed Eagles at other sites is unknown as no studies have been conducted. WTE mortality has occurred at both the Woolnorth Wind Farm in NW Tasmania (1 bird) and the Starfish Hill Wind Farm in South Australia (2 birds), but there are insufficient data from Woolnorth to determine the avoidance rate at this site (longer-term data sets will allow an estimation of this figure) and no suitable data from Starfish Hill. There have been no recorded WTE mortality at other Australian wind farm sites that we are aware of.

The only empirical evidence available, therefore, is that supplied above, which indicates that raptors, like other species of birds, have a high avoidance rate. A rate above 98% is realistic. Avoidance rates are likely to be close to 100% during the majority of time, but arguably less during conditions of poor visibility. The incidence of collisions by raptors is related primarily to the amount of time they spend around wind turbines, hence resulting in many more movements per given unit of time. Each of these movements has a high avoidance rate (e.g. 98% and above), even though there are many more movements than other species.

2.1.6 Period eagles are potentially at risk

As the Wedge-tailed Eagle is a diurnal species, the period that it is at potential risk of collision was taken as the annual number of daylight hours at the site's latitude.

2.1.7 Proportion of the population flying through the wind farm

Brett Lane (personal communication) noted that the bird survey points were located on the escarpment edge and that therefore a proportion of the birds recorded would be flying in the zone over the valley, where there were no turbines to collide with. He also noted that some 77% of the Wedge-tailed Eagles they recorded were in this zone.

We have not attempted to use these results in the model, as this would involve a number of assumptions about which we have no information (e.g. some birds over the valley could have been flying towards the turbines and would therefore be at risk, just as some birds seen "inland" of the escarpment may also be outside the risk zone). Such questions could best be addressed by gradient studies, or they could be explored with a stochastic model.

3.0 RESULTS OF MODELLING

3.1 Results

We modelled for five possible avoidance rates (95%, 98%, 99%, 99.5% and 99.8%) for the portion of the generators within the height range swept by rotors. We assumed a constant avoidance rate of 99% for the portion of the turbine tower below rotor height for rotor avoidance rates of 99% or less, and assumed the same avoidance rates for the whole structure for avoidance rates greater then 99%.

Annual Wedge-tailed Eagle movements at risk for four potential avoidance rates are as follows:

Swept area avoidance rate	**Annual movements at risk**
95%	**72.4**
98%	**30.2**
99%	**16.1**
99.5%	**8.1**
99.8%	**3.2**

Using the above results for a population of twelve individual Wedge-tailed Eagles likely to utilise the wind farm area, and hence to interact with the turbine array, the predicted annual mortality is as follows:

Swept area avoidance rate	**Predicted annual Wedge-tailed Eagle mortality**
95%	**11.9**
98%	**11.0**
99%	**8.9**
99.5%	**5.9**
99.8%	**2.8**

3.2 Potential Impacts on Wedge-tailed Eagles

These modelling results indicate the potential for a relatively high impact on WTEs at the Yaloak site from collision with wind turbines. The same model predicts annual collision rates of 0.4, 0.3 and 0.05 respectively for the Woolnorth, Musselroe and Heemskirk wind farm sites in Tasmania (99% avoidance).

If the predicted rate of around 9 birds per year (99% avoidance) was to occur, there would be a major impact on the local and probably regional WTE population.

The utilisation rate for this species at the site recorded by Brett Lane and Associates is very high by comparison to other sites. This could be due to:

- actual very high levels of WTE activity at the site
- differences in survey methodology between other studies and those carried out at Yaloak (there is no *prima facie* evidence that this is the case)
- overestimates of actual site utilisation due to the location of the survey points on the edge of the escarpment.

Discussions with Brett Lane, who collected the data, confirmed that the data had been collected in the standard manner and that we have analysed them and incorporated them into the model in an appropriate manner, so we can discount the second option. Brett Lane noted that his subjective assessment of the site supporting high levels of WTE activity in comparison with other wind farm sites he had worked on was consistent with the numerical data collected, indicating that the first hypothesis above is reasonable.

In relation to the third hypothesis, even if a simple reduction in modelled risk was made using the suggestion by Brett Lane that only 33% of the WTE recorded were actually flying in the risk zone (Brett Lane & Associates draft report, 2004), this would indicate a mortality rate of around three WTEs per year, which is still a high rate.

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