Report Cover Page

Title
Predicting impacts of the Mortlake East windfarm on the Victorian Brolga population
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Summary
This report describes an assessment of the impact of the Mortlake East windfarm proposed by Acciona Energy on the Victorian Brolga population. The assessment is based on the results of a population model that incorporates additional mortality caused by collisions with turbines. The model was age-structured, and a single population was simulated. Demographic and environmental stochasticity was modeled. A model without density dependence and a model with density dependence (Ricker) were used. Density dependence was modeled by assuming survival rates increased as the population size declined. The model was analysed by stochastic simulation in the commercial package RAMAS/GIS with 10,000 iterations. The predicted mortality from the Mortlake East windfarm (<0.11 birds per year) translates to a mortality rate for the Victorian population of <0.018%. This additional mortality causes very little increase in the risk to the Victorian population. The change in risk is smaller than can be reliably discriminated using stochastic simulation with 10,000 iterations, the upper limit imposed by the RAMAS/GIS software.

Applied Environmental Decision Analysis
A Commonwealth Environment Research Facility

Smart science for wise decisions

Predicting impacts of the Mortlake East windfarm on the Victorian Brolga population

Final Report

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Background

Brolgas are listed under the Flora and Fauna Guarantee Act, and are considered vulnerable to extinction. The vast majority of Victoria's Brolgas occur in the south-west. The total number of nesting pairs of Brolgas in Victoria is estimated to be 200-250. Brolgas nest in shallow temporary wetlands. As these wetlands dry out, they move to more permanent wetlands for the summer/autumn period, in some cases forming large flocks. The same nesting and flocking sites tend to be used each year.

Renewed emphasis on renewable energy generation, including significant pending policy changes to favour such technologies, together with excellent wind resources in south-west Victoria, has placed the wind energy industry at the centre of a debate about the magnitude and acceptability of potential impacts on the Brolga population from wind farms.

Government policies provide for detailed assessment of the impacts of wind farms on state and federally-listed threatened species. They also call for cumulative impacts of wind farms to be assessed. To achieve this, a robust scientific framework for assessing impacts of wind farms is required to:

1) estimate the impact of wind farm projects on individual Brolgas;
2) estimate the impact of each project on the Victorian Brolga population; and
3) estimate the effectiveness of mitigation and offset measures to ameliorate any impacts of windfarms.

This consultancy

The University of Melbourne has developed a model of population viability (a PVA model) to assess impacts of windfarms on the Victorian Brolga population. PVA models are systematic, quantitative models that integrate all possible sources of information to predict the population consequences of impact, mitigation and offset scenarios. These models combined estimates of a range of population parameters such as age-specific reproduction and survival rates to predict risks of extinction and population decline more generally over the next 20 years.

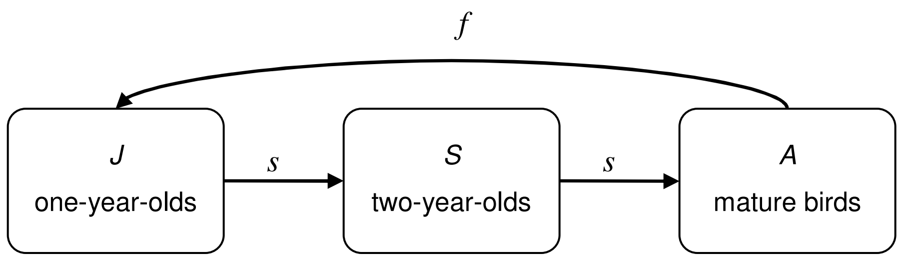
The consultancy used the model of Brolga population dynamics in Victoria to assess impacts of a windfarm at Mortlake East proposed by Acciona Energy on the Brolga population. In particular, the consultancy:

1) Described the population model that was used.
2) Modelled the viability of the Victoria Brolga population without the Mortlake East windfarm.
3) Modelled the viability of the Victoria Brolga population with the Mortlake East windfarm, based on estimates of the additional mortality caused by collisions with turbines.

This report documents the outcomes of the consultancy, describing the model and the results of the analyses. The development of the model and a sensitivity analysis is described in McCarthy (2008). The model was analysed in RAMAS/GIS (Akçakaya & Root 2002).

The model

The model is age-structured, with individuals classified as being one year old birds (juveniles), two year-old birds (sub-adults) and mature birds (adults). Let *J*, *S* and *A* be the abundances in each of these age classes. The per capita fecundity rate (*f*) and survival rate (*s*) define the transitions among these age classes, which can be represented diagrammatically:



These transitions can be defined by a matrix (**M**):

$$\mathbf{M} = \begin{bmatrix} 0 & 0 & f \\ s & 0 & 0 \\ 0 & s & s \end{bmatrix}$$

Estimation of the parameters *s* and *f* is problematic because mark-resighting data are not available. However, estimates can be derived from the observed ratio of immature (one-year-old and two-year-old birds) to mature birds and assumptions about the population trend.

If the population is stable (abundances of each of the age classes are the same from year to year):

$J = f A$,

$S = s J$, and

$A = s (S + A)$.

Solving these equations leads to:

$f = (1 - s) / s^2$, and

$s = \sqrt{(R + 1)} / (R + 1)$,

where *R* equals the ratio of immature to mature birds ($(J + S) / A$). Therefore, if $R = 0.05$, which is approximately the case for contemporary populations in southeastern Australia (Herring 2001), $s = 0.976$ and $f = 0.025$, which are used as the standard set of parameter values. The estimate of *s* can be compared to predictions from an allometric model

(McCarthy et al. 2008, but with additional data on cranes: Bennett and Bennett 1990, Link et al. 2003, Masatomi et al. 2007) that predicts the annual survival rate of adult birds from body mass. Based on a body mass of 6 kg, the predicted annual survival rate of cranes is 0.91 with a 95% credible interval of [0.77, 0.96]. Therefore, the estimate based on age structure is higher than might be expected for a crane of this size but not inconceivably so. Nevertheless, a survival rate less than 0.976 may be possible, and in fact may be likely.

The population growth rate based on the matrix model can be obtained by eigenanalysis of the transition matrix **M**, and is the (real) solution to the cubic equation:

$$\lambda^3 - s\,\lambda^2 - f\,s^2 = 0.$$

A closed form solution can be obtained, but it is unhelpfully complicated (result not shown). However, the solution can be approximated using a first-order Taylor series expansion around the point $f = 0$, leading to $\lambda \approx s + f$. The next term in the expansion is $-f^2/s$, which is small when f is small and s is large. Therefore, $\lambda \approx s + f$ is a good approximation if $f \approx 0$ and $s \approx 1$, which is the case for the brolga. This means that reductions in the population growth rate due to decreased survival of brolgas can be approximately compensated by an increase in fecundity of the same magnitude.

The population growth rate also places limits on how small the annual survival rate may be given that large population declines have apparently not occurred over the last decade or so. If a decline of no greater than 1% per year is possible, then the survival rate must be at least 0.965 given the observed recruitment rate. An annual decline of 2% would permit the annual survival to be as low as 0.955.

Density dependence

Density dependence defines how the population's parameters s and f change as the size of the population changes. The apparent stability of the total population size despite the low levels of recruitment suggests that the annual survival rate may be density dependent. In this case, the recruitment rate would be determined by the availability of suitable breeding sites in a particular year and the hatching and survival rates of any young produced. For the Brolga, this is likely to be influenced by the amount of water in the breeding areas.

In defining the density dependent function, it is necessary to specify how much the population growth rate increases as the population size declines. In practice this is defined by the maximum population growth rate (i.e., the population growth rate achieved as the population size approaches zero, which defines the strength of density dependence) and the function that defines the nature of density dependence (e.g., Beverton-Holt function (Beverton and Holt 1957), Ricker (1975) function, etc; see Burgman et al. 1993). The appropriate function and the strength of density dependence are not known in Brolgas, but different forms gave largely equivalent results, so a Ricker model was used in this report. A model without density dependence in which the population growth rate was 1 (a stable population) was also considered as a baseline scenario. A coefficient of variation of 10% was assumed for fecundity rate and 5% for the survival rate.

Impacts of windfarms

It is assumed that the design and construction of the windfarms will avoid any impacts on the amount of breeding and flocking habitat by ensuring that turbines are placed sufficiently far from these areas and that construction occurs at appropriate times of the year to eliminate disturbance. If this is the case, the only impacts that need to be considered are the mortality events arising from collisions with the turbines and collisions with powerlines associated with the windfarms.

The available evidence suggests that cranes rarely collide with wind turbines, although it remains a possibility. Based on data provided by Ecology Partners and Biosis Research (Aaron Organ, pers. comm.), it is expected that <0.11 Brolgas will be killed annually through collision with turbines at Mortlake East. Based on a Victorian Brolga population of 600, this translates to <0.018% additional mortality per annum.

Cranes are one of the most common bird taxa that collide with powerlines (Morkill and Anderson 1991, Bevanger 1998, Janss and Ferrer 2000 and references therein). Specific instances of Brolgas being killed by powerlines are known (Goldstraw and Du Guesclin 1991), but the rate of mortality is unknown. Impacts of powerlines may be mitigated by marking them to increase visibility (Beaulaurier 1981). This method appears to be partially successful for cranes, with mortality rates approximately halved (Morkill and Anderson 1991, Alonso et al. 1994, Brown and Drewwien 1995), an effect that is consistent with other bird species (Beaulaurier 1981). The risk of powerline collision can be eliminated by placing lines underground, or mitigated by placing existing lines underground in areas frequented by Brolga. It is assumed that any additional risk caused by powerline construction for the Mortlake East windfarm will be either avoided or mitigated, so no additional mortality from powerlines is assumed.

Model predictions

Based on avoidance and mitigation of other impacts, it was assumed that the only impacts of the Mortlake East windfarm on the Brolga population would be additional annual mortality of <0.018% caused by collisions with turbines. Other parameters were held at their standard values (McCarthy 2008), with predictions made using stochastic simulation over a 20 year period. Without the additional mortality, the probability of declining to a population size of 450 birds or fewer at some time within the next 20 years was 0.15. The smallest population size expected within that time frame (EMP, expected minimum population size; McCarthy and Thompson 2001) was 497. The additional mortality of 0.018% would increase the risk of decline, but the increase was not sufficiently large to be detectable within the constraints of precision imposed by stochastic simulation with 10,000 iterations (the upper limit imposed by RAMAS/GIS. Therefore, the increase in the risk of decline to 450 birds or fewer was <0.01.

Increasing fecundity by 0.00018 (from 0.025 to 0.02518) would be sufficient to mitigate the impacts of the windfarm. This translates to an increase of 0.1 birds being recruited annually to the adult population, a small increase that is unlikely to be measured with precision. Equivalently small impacts are predicted using the density-dependent model (Table 1).

Table 1. Results of simulations predicting impacts on Brolgas from the Mortlake East windfarm development.

Scenario	EMP	Probability of decline to or below 450 birds
Baseline (density independent)	497	0.15
Mortality increased by 0.018% (density independent)	497	0.15
Baseline (density dependent)	501	0.10
Mortality increased by 0.018% (density dependent)	501	0.10

Post-construction monitoring

Parameters for the population model of Brolgas were measured indirectly, by using data on age structure and from other crane species. This will add considerable uncertainty to the predictions of the model. In these circumstances, it would be important to ensure that impacts following construction of the model are no larger than predicted and that the effectiveness of mitigation strategies are at least as effective as predicted. This would be most effectively achieved through post-construction monitoring of impacts and mitigation measures.

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