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September 2019

Arthur Rylah Institute for Environmental Research
Technical Report Series No. 301

Arthur Rylah Institute for environmental research

VICTORIA State Government | Environment, Land, Water and Planning

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Citation: Lumsden, L.F., Moloney, P. and Smales, I. (2019). *Developing a science-based approach to defining key species of birds and bats of concern for wind farm developments in Victoria*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 301. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Front cover photo: A Victorian wind farm (Photo: Lindy Lumsden).

Printed by Melbourne Polytechnic, Preston

Edited by Organic Editing

ISSN 1835-3827 (print)
ISSN 1835-3835 (pdf))
ISBN 978-1-76077-798-2 **(Print)**
ISBN 978-1-76077-799-9 **(pdf/online/MS word)**

Accessibility

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Developing a science-based approach to defining key species of birds and bats of concern for wind farm developments in Victoria

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Acknowledgements

This project was funded through the Energy, Environment and Climate Change Group of the Department of Environment, Land, Water and Planning (DELWP). Support and policy input were provided by Lis Asby, Ruby Campbell-Beschorner, Nick Rintoul, Tracey Taylor and Karen Weaver. Comments on the report were provided by, Chad Browning, Ruby Campbell-Beschorner, Belinda Cant, Richard Hill, Garry Peterson and Nick Rintoul. We also thank Amanda Bush, Daniel Gilmore, Richard Hill, Cindy Hull, Peter Menkhorst, Terry Reardon, Danny Rogers and Mark Venosta for contributing to the expert elicitation process.

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Context:

Assessments of the potential effects of collisions with wind turbines by birds and bats are now a routine component of pre-approval planning processes for commercial-scale wind energy projects in Victoria. However, there is a lack of clear guidance on which species need to be included in these assessments.

Aims:

The aim of this project was to provide a science-based approach to assist in decision-making regarding turbine collision risk for birds and bats in Victoria. There were two components to the project. First, it was necessary to decide which species should form the basis of the investigation, by deriving a list of 'species of interest' based on threatened species status. Second, it was necessary to develop an approach to determine which of those species may be at risk, at a Victorian population level, due to collisions with turbines, to enable a list of 'species of concern' to be compiled.

Methods:

The process for determining which of the 'species of interest' should be considered 'species of concern' entailed a number of steps, including: developing criteria that would adequately reflect collision risks posed by wind turbines to various species; assessing each species against these criteria; developing a method to combine the rankings from these criteria into an ultimate score for each species; and providing a method for evaluating these scores to enable a decision to be made on which species should be considered 'of concern'.

Criteria to reflect collision risk were developed to represent both the *likelihood* and the *consequences* of collisions. Two criteria were used to ascribe the likelihood of risk, using behavioural traits (flight height) and habitat preferences of the species. Four criteria addressed the consequences of risk based on the potential for collision mortalities to affect the Victorian population of each species. These included: whether the population was highly localised or concentrated in certain areas; the demographic capacity of the population to replace individuals lost due to turbine collisions (based on e.g. fecundity, generation time); the size of the Victorian population; and the conservation status in the Department of Environment, Land, Water and Planning (DELWP) threatened species *Advisory List* (DSE 2013), as species with a higher threat status are likely to be more impacted by additional threats than are species with a lower threat status. Using an expert elicitation process, seven bat and six bird experts assessed each 'species of interest' against these criteria using categories of high, medium and low, with guidance provided to them on the interpretation of each category.

The overall likelihood and consequences of collisions were estimated based on a probability distribution, which factored uncertainty into the risk assessment. Using a risk matrix, a modelling approach was used whereby the likelihood that a species was in the category of 'extreme concern', 'concern', 'mild concern' or 'minimal concern' could be estimated. Options for how these resulting estimates could then be used to determine an appropriate 'cut-off' for inclusion of species within a list of 'species of concern' are provided.

Results:

A policy process developed an initial list of 'species of interest'. This list is comprised of species listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988*, in the *Advisory List of Threatened Vertebrate Fauna in Victoria*, or under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* in either the threatened or migratory categories. The 'species of interest' list consists of seven species of bats and 159 species of birds. This list includes species that occur anywhere in Victoria, including offshore, irrespective of whether wind farms are currently located within their distribution, so that the list can still be used if wind energy facilities expand into other areas in the future.

The likelihood of being of extreme concern, concern, mild concern or minimal concern is provided for each of the 166 'species of interest'.

Conclusions and implications:

This project has provided a science-based approach for assessing the level of risk of Victorian species of birds and bats from collisions from wind turbines. The level within the risk matrix that represents an appropriate ‘cut-off’ for inclusion of species within a list of ‘species of concern’ is best evaluated by application of the risk matrix simulator because it offers a quantified mechanism for comparing the results for different species. The selection of an appropriate cut-off, which will determine the list of ‘species of concern’, is based on the level of risk that is considered acceptable, and hence is a policy decision. The final list of ‘species of concern’ will therefore be documented elsewhere.

Wind farm design and turbine technology have been in a state of rapid development over recent years. For example, there have been significant increases in the size and height of turbines. In addition, knowledge about threatened species and their risk factors continues to improve, and the conservation status of individual species may change for multiple reasons. As a result, it is recommended that the status of all ‘species of interest’, including any species that are added to relevant lists of threatened species, should be reviewed every 5 years, using the risk assessment process set out in this report, to re-evaluate the currency of Victorian ‘species of concern’.

1 Background context

Assessment of the potential effects on birds and bats is now a routine component of pre-approval consideration of commercial-scale wind energy projects in Victoria. While the potential for impacts on all aspects of biodiversity are considered, the possibility of collisions with wind turbines is of specific relevance to birds and bats. Such collisions have been documented worldwide, with considerable numbers of mortalities recorded in some areas, but the rate at which they occur is subject to numerous variables (Kunz et al. 2007; Hayes 2013; Lehnert et al. 2014; Arnett et al. 2016; Frick et al. 2017).

The Biodiversity Division of the Department of Environment, Land, Water and Planning (DELWP) is seeking to answer the following question: "What changes are required to the regulatory requirements relating to biodiversity so that data and regulatory advice provided by DELWP related to impacts on birds and bats are more transparent and efficient?" A policy document related to this question was prepared by DELWP's Biodiversity Division in 2017. Following on from this policy framework, the next step is to identify which species need to be considered in planning processes, based on the likely risk faced by their populations from collisions with wind turbines.

It is apparent from the Australian and international experience, that the incidence of turbine collisions varies substantially across species of birds and bats (Baerwald and Barclay 2009; Cryan and Barclay 2009; Hull et al. 2013). As a first step in determining which species should be considered 'species of concern', a decision is required on the baseline suite of species to be investigated, i.e. the 'species of interest', to assess which of these are at a level of potential risk to warrant inclusion.

The aim of this project is to develop an approach that provides an improved basis for decision-making about turbine collision risk for birds and bats in Victoria. This project has developed a framework and mechanism for evaluating which species are likely to be affected by turbine collisions. This assessment is based on information currently available; however, it is recognised that there are substantial knowledge gaps, uncertainties and limitations (see section 6). It is important that future investigations of wind farm collisions are designed to improve understanding of the effects of turbine collisions on species, particularly any effects these might have on the viability of Victorian populations, so that future assessments are based on greater certainty. The risk assessment process set out here should be repeated periodically as new information becomes available (for example, as a result of better monitoring of wind farm impacts, changes to turbine design, improvements in our understanding of the ecology and behaviour of the species, or changes to the conservation status of species of birds and bats).

This report outlines the two-stage approach undertaken to provide a framework for determining which taxa could be considered 'species of concern'.

- The development, from a policy perspective, of criteria for defining 'species of interest' and the provision of this list of species.
- The development and application of criteria and resulting risk matrices that have been designed to reflect the risks to particular taxa due to their ecological and behavioural traits, and conservation status.

These risk matrices can then be used to determine which of the 'species of interest' should be considered 'species of concern'. A range of approaches are discussed for deciding what the appropriate 'cut-off' level of risk is for species to be considered 'of concern'. Ultimately this is a policy decision, based on the level of risk considered acceptable. The publishing of the list of 'species of concern' will be undertaken separately to this report.

2 Policy framework for identifying 'species of interest'

2.1 The issues

Taking a risk-based approach to biodiversity regulation, the focus for consideration of risk due to wind energy facilities is primarily threatened species, or, if relevant, species that may become threatened due to collisions with wind turbines (the latter aspect takes a precautionary approach). However, there are a number of lists of threatened species [i.e. in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the *Fauna and Flora Guarantee Act 1988* (FFG Act) and the *Advisory List of Threatened Vertebrate Fauna in Victoria* ('*Advisory List*') (DSE 2013)], and so it was necessary to first determine which of these would form the basis of the 'species of interest' list.

Additional species that may be of particular concern due to cultural heritage reasons will be subject to further analysis to be undertaken by DELWP. That consideration is outside the scope of the work presented here, which specifically assesses species from a biological perspective.

2.2 The approach

DELWP considers it beneficial to take a forward-looking approach for this project, in regard to both expected changes in the wind energy industry and potential for further additions to threatened species lists, to ensure that the analysis does not become quickly outdated. For instance, there are 21 bird species categorised as Vulnerable, Endangered or Critically Endangered on the *Advisory List* that are not currently FFG-listed but could be in the future. The use of the *Advisory List* is therefore appropriate.

On the basis that the *Advisory List* reflects the current understanding of threatened species, including those considered near threatened and data deficient, it would not be necessary to make a separate determination of species that may become threatened by wind farms. However, to be confident that this was the case, the *Advisory List* would need to be updated sufficiently regularly to ensure that species that have recently become threatened (or near threatened) due to emerging issues are included. It is not clear whether the potential impact of numerous wind farms across the landscape would have been considered in determining the status of bat and bird species when the *Advisory List* was last updated in 2013. Given the pace of development and level of community interest, it is prudent to consider whether there are any species not currently on the *Advisory List* that have the potential to become threatened within the foreseeable future, for any reason, including by wind farm developments.

While species included on the *Advisory List* are considered important to include, any species listed under the FFG Act but not on the *Advisory List* also need to be considered, because the *Ministerial Guidelines for assessment of environment effects under the Environmental Effects Act 1978* (EE Act) (DSE 2006) stipulates that one of the referral criteria under the EE Act is matters listed under the FFG Act. Thus, a wind farm assessed under the EE Act must take account of matters listed under provisions of the FFG Act.

The Victorian Assessment Bilateral Agreement between the Victorian and Federal governments accredits a number of Victorian processes for assessment of actions under the EPBC Act, including under the EE Act and the *Planning and Environment Act 1987* (Vic.). Where an accredited Victorian process is to be used, the Agreement requires Victoria to ensure that assessment documentation is adequate for the Commonwealth Minister to make an approval decision. This includes ensuring that there is a thorough assessment of impact on each relevant Matter of National Environmental Significance listed under provisions of the EPBC Act. Relevant Matters of National Environmental Significance are threatened species listed under section 178 of the Act, and migratory species listed under section 209 of the Act.

2.3 'Species of interest'

The initial list of '**species of interest**' therefore comprises the following:

a. bird and bat species in all categories of threat on the *Advisory List of Threatened Vertebrate Fauna in Victoria*, including the categories Near Threatened and Data Deficient (DSE 2013);

b. bird and bat species listed as threatened under the FFG Act;

c. bird and bat species listed under all categories of threat under the EPBC Act;

d. bird species listed as migratory under the EPBC Act (no species of bats are listed as migratory), that are not listed under a category of threat (a, b or c, above).

e. bird and bat species that the Arthur Rylah Institute for Environmental Research (ARI)-led process considers to have the potential to become threatened (for any reason, using the same assessment methodology outlined in the DELWP *Advisory List*) but that are not currently included on the *Advisory List*.

Species listed under all of the three legislated and policy lists (EPBC Act, FFG Act and DELWP *Advisory List*) are included as 'species of interest', with many species listed under more than one of categories 1a–d.

The following considerations for inclusion or exclusion of taxa are important:

- The method for and evidence informing the determination of species in 'e', above, must be clearly documented, even if the result is that there are no species with the potential to become threatened at the state level by development of wind farms that are not currently on the *Advisory List*, or species that might become threatened for a range of reasons, that are also impacted by wind farms.

- The method and evidence informing any short-listing to determine 'species of concern' be clearly documented.

- Additional species that may be of particular concern due to social or cultural reasons alone fall outside the scope of this work.

To ensure that the analysis does not become quickly outdated, it was considered beneficial to have regard to both foreseeable changes in the wind energy sector, and the potential for additions to threatened species lists as outlined above. Vertebrate fauna specialists at ARI considered the potential for further taxa to be added to an updated *Advisory List* in the future. Three species known to be killed at Victorian wind farms were assessed against the IUCN criteria used to evaluate species for inclusion on the *Advisory List,* based on their entire Victorian population. Although the high mortality rates of White-striped Freetail Bats *Austronomus australis* at some wind farms (Moloney et al. 2019) may have local impacts on population numbers, this was not considered large enough to meet the criteria for listing at the state level for this otherwise common species. The Wedge-tailed Eagle *Aquila audax* was also assessed closely against IUCN criteria. This species has a population structure whereby adult pairs hold long-term breeding territories, with a large number of 'floating' juveniles available to replace any lost territory holders (Olsen 1995). Therefore, although individuals have been recorded killed at wind farms (Moloney et al. 2019) (and elsewhere), this does not necessarily lead to a reduction in the number of breeding adults. Long-term population trends collated by Birdlife Australia suggest there is no evidence of a decline in numbers (represented by reporting rates) of Wedge-tailed Eagles in Victoria from 1999 to 2014 (Birdlife Australia 2015). As a result, it was judged that Wedge-tailed Eagles do not meet the criteria for threatened status listing at a statewide level. Similarly, Little Eagle *Hieraaetus morphnoides* populations appear to be stable in Victoria (Birdlife Australia 2015), and this species also does not meet the criteria. Thus, at the time of publication of this report, it is considered that there are no bird or bat taxa that meet IUCN criteria for addition to the *Advisory List,* and hence there are no 'species of interest' within category 'e' above. As a result, this category is not considered further in this assessment.

There are currently no offshore wind energy facilities in Victoria; however, these are becoming increasingly common overseas. As there is the potential for this to occur in Victoria in the future, to ensure that the analysis does not become quickly outdated, seabirds are also included in the list of 'species of interest'.

The Emu, listed as near threatened on the DELWP *Advisory List*, is not included because it is flightless. It was also noted by species experts, who undertook species rankings (see section 4), that a number of species on an initial list of 'species of interest' are vagrants to Victoria and have been reported extremely

rarely in the state. These are typically on the EPBC lists based on their status in other states. This means that there is no meaningful risk that turbine collisions in Victoria might impact on their populations. Therefore, the species considered to be vagrants in Victoria (listed in Appendix 1) were removed from the assessment.

The final, complete list of 'species of interest' consists of seven species of bats and 159 species of birds (Appendix 2). Of these 166 taxa, 131 are listed in the DELWP *Advisory List*, an additional seven species are listed as threatened species under the EPBC Act, one species is listed on the FFG Act but not on the *Advisory List* or EPBC Act, and the remaining 27 species are listed as migratory, but not threatened, under the EPBC Act.

3 Process and criteria for determining 'species of concern'

3.1 Overview of the process

In developing a list of 'species of concern', the population for consideration of any taxon is the entire Victorian population, and consideration of impacts is considered at that population level.

Monitoring of collisions has been undertaken at various wind farms in Victoria. In parallel with the current project, DELWP has collated all known mortality records from wind turbine collisions at operating wind farms in Victoria and has assessed the utility of the existing post-construction mortality monitoring to reliably estimate annual mortality rates (Moloney et al. 2019). This review showed that the monitoring methods and effort have varied considerably between sites. It is also the case that the distributions of many species do not coincide with where wind farms currently operate in Victoria. As a consequence, the present assessment has been undertaken in the absence of comprehensive, quantified empirical information about collision rates for any Victorian species (see also section 6).

A brief review of key literature outlining methods utilised within various jurisdictions elsewhere to identify key 'species of concern', and of empirical information about characteristics of taxa that are particularly represented among turbine collision fatalities, is summarised in Appendix 5. Although the reviewed literature offered some useful guiding principles, a number of which were incorporated into the process described in this report, none of the methods used elsewhere was considered to be directly applicable to the situation in Victoria. In large measure, this was due to the significant degree of uncertainty and lack of empirical experience about the collision risk for species here.

The potential risks to populations are likely to vary between taxa according to numerous factors, including different flight characteristics and other behaviours; preferred habitats within wind farm environments; broader geographic distribution; and life-history traits such as population size and demographic capacity to replace individuals lost due to turbine collisions.

3.2 Summary of process for ascribing risk ranking to 'species of interest'

The process for determining which of the 'species of interest' should be considered as 'species of concern' entailed determining and implementing the following:

1. criteria that would adequately reflect collision risks posed by wind turbines to various taxa;
2. a mechanism to rank various criteria so as to differentiate variable risks for different taxa;
3. a method to collate the rankings for all criteria into an ultimate rank, or score, for each taxon; and
4. a method to evaluate scores for all taxa to suggest which species are at a level of risk that warrants their inclusion in a list of 'species of concern'.

In July 2017, a workshop was held at ARI to commence the process. Participants in the workshop are listed in Appendix 3. The workshop was concentrated on aspects of points (1) and (2) above. Following the workshop, a set of draft criteria for point (1) was circulated to the participants, and both this and a ranking mechanism for the various criteria were refined over ensuing weeks on the basis of feedback.

Once the criteria and ranking mechanism had been settled, a spreadsheet was developed. It included every 'species of interest' and a total of six criteria to be used for the ranking of the risk for each species. Due to substantial levels of uncertainty for many taxa and for various criteria (see also section 6), a qualitative (low/moderate/high risk) rather than quantitative ranking system was chosen.

The spreadsheet was provided to a group of zoologists with expertise in bird and/or bat ecology. The direct experience of the experts with effects of wind turbines on birds and bats varied considerably, but all had many years of expertise in the ecology of particular groups of birds and/or bats. Each of them was provided

with the explanations of the criteria as set out below, and was asked to apply the rankings for all criteria to taxa within the area of their specialist expertise. The zoologists and the fauna group(s) they ranked are listed in Appendix 3.

Seven specialists provided their rankings against criteria for bats and six provided their rankings for birds. Some specialists did not provide rankings for particular taxa, or groups of taxa of which they did not feel they had sufficient knowledge.

In order to minimise potential for unintentional biases, experts were not given information about the processes that would subsequently be used to determine the overall ranking for each taxon, nor how those might then be used in the risk matrix to evaluate taxa with respect to inclusion on the list of 'species of concern'.

After a number of assessments had been completed, it became apparent that for some criteria there were differences in interpretation of the criteria between assessors. As a result, the criteria were clarified where they were found to be ambiguous, and assessors asked to re-check their earlier assessments. This was to ensure that any differences in scores were due to variation in assessors' understanding of the behaviour of the species, rather than resulting from a different interpretation of the criteria.

The following sections set out an explanation of the criteria and ranking mechanism as provided to the species experts, and the subsequent application of rules and process for using their responses to ascertain a ranked level of risk for each taxon.

3.3 Criteria for determining the relative risk for all 'species of interest'

Commencing with the overall list of 'species of interest', the process of refining it to a list of 'species of concern' is hierarchical and is evaluated against six criteria (A–F). A full explanation of each criterion, as provided to the experts for their elicitation, is presented below. Criteria A and B relate to behavioural traits and habitat preferences within a wind farm environment, which will influence the degree to which individuals of a particular taxon are exposed to collision risk. For this reason, these criteria were used to determine the ***likelihood*** of risk.

Criteria used to ascribe *likelihood* of risk

A	B
Known or likely frequency of flights within rotor-swept height	Habitat preference within general environments of wind farm site. Does taxon frequent open areas coinciding with microenvironments suitable for turbines (on- and offshore)

Criteria C–F are substantially focused on the potential for collision mortalities to affect the Victorian population of each taxon and were used to determine the ***consequence*** of risk.

Criteria used to ascribe *consequence* of risk

C	D	E	F
Highly localised or concentrated population (for whole or part of lifecycle), such that siting of wind farm could have significant consequence to Victorian population	Impact on population relative to demographic capacity to replace fatalities (i.e. generalised combination of dispersal capacity of potential replacements, fecundity and generation time)	Known or estimated size of Victorian population	Listed conservation status as per DELWP *Advisory List* (IUCN criteria for Victorian population)

Each taxon is ranked low, moderate/medium or high relative to the particulars of the criterion. The terms 'moderate' and 'medium' are used where they were considered most appropriate for the particular criterion. They each have the same level as one another in the ranking process.

Section 4 sets out how rankings assigned for the individual criteria were used to contribute to determing an overall ranking of risk for each taxon, and how overall rankings were subsequently used in a risk matrix to ascertain the relative risk level for different taxa.

An explanation of each criterion and the prompts provided to the species experts to be considered when they were ranking species are outlined below.

Criterion F relates to the defined and listed threatened status of all taxa. Ranking of all other criteria requires a degree of informed judgement for almost all taxa.

There is some degree of overlap between the rationale underlying the *Advisory List* conservation status of various taxa (criterion F) and the concepts encompassed by criteria C–E that may lead to some factors being overemphasised in the subsequent output (e.g. the *Advisory List* threat status of each taxon responds to aspects such as its population size and whether its vulnerability is affected by its being highly localised). However, the *Advisory List* threat status of species in Victoria has been assigned considering all the various threats that may impinge upon particular taxa, and to date no taxon has a threat status specifically because of the effects of wind energy developments on its population. Criteria A–E of the present assessment are focused specifically on the risks to a particular taxon associated with turbine collision mortalities. Inclusion of the *Advisory List* status takes the precautionary approach of factoring in that species with a higher threat status are likely to be more impacted by additional changes and threats than are species with a lower threat status. The *Advisory List* status for each relevant species has been determined previously and as a separate exercise from the present consideration of wind turbine collision risk, and thus it was not part of the expert elicitation process. After rankings using all other criteria were ascertained from the expert elicitation process, criterion F was applied as part of the risk-ranking process.

3.3.1 Criterion A (Flight height)

This criterion gives consideration to the potential and frequency of a species to fly within the rotor-swept height zone of modern turbines, which is the primary factor that influences turbine collision risk. The lowest height sweep by rotor tip of current commercial turbines is approximately 25 m above ground level, and wind turbine engineers have advised that, for a range of reasons, the lowest tip height of blades is unlikely to come closer to the ground as technology evolves. The top height varies but may currently exceed 160 m, and, as turbine technology advances, it is generally increasing. These overall dimensions were provided to the species experts undertaking the assessments. A relatively small group of bird species routinely fly or soar up to the top rotor heights swept by current turbines, and species that do so may fly considerably higher and thus remain at risk if larger turbines are used in Victoria. However, the suite of species involved does not appear likely to alter.

There is no substantial body of empirical flight height data for Victoria's birds and bats. Nonetheless, it is evident from general knowledge of behaviour and ecology that flights of some species may be substantially

concentrated below rotor-swept height; some are more routinely within that height zone or, less often, may be above the height of rotors. Ideally, the criterion would use a metric such as the frequency of flights within relevant height zones, but in the general absence of such data, for the great majority of taxa ranking was allocated by expert opinion on the basis of species known behaviours; experience from data collected from Australian wind farm sites; and any information from overseas literature about the same or related taxa.

This criterion relates to the frequency with which animals of the taxon in question are likely to fly within rotor-swept height, specifically when they fly within the types of open environments that are typical locations for wind turbines. Criterion B (below) considers the relative likelihood of use of various habitats, so assessment of the current criterion simply considers the risk of flying within rotor-swept height if, and when the species under consideration flies within relevant open parts of the landscape similar to locations that are suitable for wind turbines.

The ranking used is:

low = species that rarely flies within rotor-swept height;

moderate = species in which a preponderance of flight activity is concentrated below rotor-swept height, but taxon does fly at rotor-swept height during some activities, or this aspect is uncertain; or

high = species in which a high proportion of flight activity is within rotor-swept height.

It has now been well demonstrated that capacity to avoid collisions with wind turbines differs between taxa (e.g. Cook et al. 2012; 2014). However, avoidance capacity has been quantified for only two Australian species (two eagle species in Tasmania) (Hull and Muir 2013), and it is thus not feasible to assign a quantified avoidance rate to taxa in Victoria; nevertheless this criterion can be considered to incorporate some aspects of avoidance behaviour.

3.3.2 Criterion B (Habitat preference)

Criterion B takes account of the general habitat preferences that may substantially influence the likelihood of birds or bats of particular taxa encountering turbines. It is focused on the effect of habitat preference on the exposure to risk of species that inhabit the overall types of locations that are suitable for wind farms, rather than in all habitats used by the species. Some birds and bats rarely move beyond key habitat types, and this may reduce the probability that they will encounter turbines, even if they inhabit a wind farm property. Other species frequent the open landscapes that are most suited to turbines, while another group of species may move through open environments when passing from one patch of preferred habitat to another. The following rankings were applied:

low = species that are quite sedentary and obligate inhabitants of environments unsuitable for wind turbines (for example forests and woodlands), and that are significantly confined to such environments;

medium = species that use both open environments suitable for turbines and other habitats, or preferentially use specific habitats not suitable for turbines, such as large wetlands or forest patches, but may fly through wind farm sites when moving between preferred habitats; or

high = species that are generally resident within open landscapes favoured as sites for turbines, or regularly use these habitats.

Whether or not a site under consideration is within the broader geographic range of particular species will remain an important consideration in statutory planning decision processes for proposed wind farms, so it is not considered necessary to consider the geographic distribution of species within Victoria in the process of determining ‘species of concern’.

It is worth noting that some specific areas of the state are mandatorily excluded from wind energy developments as detailed in *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* (DELWP 2017). These include:

- National Parks and other land subject to the *National Parks Act 1975* (Vic).
- Ramsar wetlands as defined under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

- Yarra Valley and Dandenong Ranges, Bellarine and Mornington Peninsulas, the Great Ocean Road area within 5 km of the high water mark, and Macedon and McHarg Ranges.
- land within 5 km of the high water mark of the Bass Coast, west of Wilsons Promontory.
- all land within 5 km of the high water mark of the coast east of the urban area of Warrnambool.

In addition, wind energy facilities are also prohibited on land within 5 km of major regional cities and centres specified in the Regional Victoria Settlement Framework plan, being: Ararat, Bairnsdale, Ballarat, Bendigo, Benalla, Colac, Echuca, Geelong, Hamilton, Horsham, Mildura, Moe, Morwell, Portland, Shepparton, Swan Hill, Traralgon, Sale, Wangaratta, Warrnambool and Wodonga. These locations are specified in the relevant planning schemes in the schedule to Clause 52.32-2. The 5-km exclusion areas are proposed to be replaced by more specific locations once the future growth planning for these centres has been completed.

Because of their inherent mobility, almost no birds or bats on the list of 'species of interest' can be considered to be entirely confined to any of these specified areas (an exception is the Helmeted Honeyeater (*Lichenostomus melanops cassidix*), which is known only from the exclusion zone of the Yarra Valley). Hence, the application of the *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* in relation to the exclusion of wind energy projects from these areas is not likely to significantly reduce the potential exposure to wind turbines for any species of bird or bat. At present, some taxa (e.g. Black-eared Miner (*Manorina melanotis*), Mallee Emu-wren (*Stipiturus mallee*) and Helmeted Honeyeater) are functionally confined to national parks or other reserves, but conservation efforts are aimed at increasing their distributions, and it does not seem necessary to exclude them from further consideration on the basis of their current distributions.

At the time of writing, no development applications for wind farms in the offshore environment have been lodged for waters off the Victorian coast. However, offshore wind energy facilities are becoming increasingly common in suitable situations overseas, and in view of the potential for that to happen in Victoria's offshore waters, and to ensure that the analysis does not become quickly outdated, seabirds that use offshore environments are included. For example, a wind farm feasibility investigation for waters off the Gippsland coast is understood to be considering a zone out to approximately 30 km offshore. As a consequence, all seabirds on the list of 'species of interest' are considered and no distinction is made between species that routinely use near-shore waters and truly pelagic species.

3.3.3 Criterion C (Geographic population concentration)

This criterion is intended to account for situations where the degree to which a taxon is geographically concentrated may influence the risk posed by the particular location of a wind farm. While the criterion relates to physical or geographic concentration, it does not necessarily mean that a very high density of individuals occurs. It may equally relate to situations where the Victorian population simply occurs in very restricted geographic area(s) or habitat types. Where dense aggregations are involved, the concentration of animals may be for short seasonal periods, but may nonetheless substantially heighten risk to a large portion of the Victorian populations of the species. As with various other criteria, application of rankings for this criterion entailed a degree of judgement, based on the following categories:

low = species that are widely dispersed within areas of suitable habitat and the habitat itself is relatively widely dispersed;

medium = species, such as some shorebirds, that may be more widespread or have greater flexibility in the range of suitable habitat availability, but where a high proportion of the Victorian population is likely to be concentrated at sites where they do occur. Species could also be included in this category if they have highly restricted habitat availability; or

high = bat species that have major aggregations at a few caves, or species of birds that have very restricted distributions or may be seasonally concentrated at very few small locations.

3.3.4 Criterion D (Demographic resilience)

The primary aspect of this criterion relates to the capacity for the relevant population to replace collision victims, especially breeding adults. For the purposes of the assessment, it was not intended that this should

entail a comprehensive demographic analysis. However, basic demographic concepts can be applied to almost all taxa on the basis of general knowledge of life-history traits. The basic drivers of demographic functioning for populations are fecundity, mortality, immigration and emigration. The replacement of collision victims may be different for species in which availability of breeding territories is a key limitation of population size (e.g. many bird species) when compared with species that do not establish defended territories (e.g. colonial roosting bats), in which demographic traits are more direct drivers of population size. The following rankings were applied:

low = species that form breeding territories and that have a reasonable proportion of the population as non-breeding 'floaters' that can rapidly replace breeding territorial adults if lost; species that may or may not form breeding territories and that are short-lived and have high fecundity; species that have capacity for long-range or widespread juvenile or sub-adult dispersal;

medium = species with life-history characteristics that sit between the low and high descriptions here; or

high = species that form breeding territories but where there is limited capacity for a lost breeding adult to be readily replaced; species that do not form breeding territories and that are long-lived and/or have low fecundity; species that may have short-distance juvenile or sub-adult dispersal capacity only.

By way of examples of relevant demographic functioning, dispersal of juveniles/sub-adults by many passerines that subsequently become established in life-long territories can be measured across the distance of a few territories or kilometres, whereas sub-adults of some Australian raptors have been documented to disperse over hundreds of kilometres. The average adult lifespan of many small passerines is in the order of less than 5 years (despite much higher potential lifespans), and this coincides with their capacity to produce multiple clutches per annum. The average lifespan of longer-lived (often larger-bodied) birds may be greater than 10 years, and this often coincides with a single annual clutch and relatively rare survival of juveniles (for example in Brolgas, eagles and owls).

3.3.5 Criterion E (Population size)

This criterion is driven by the concept that the Victorian populations of some taxa are so small or reduced that annual loss of even a very few adults could have serious consequences at the population level. This is apparent based on accepted census information and can be assessed for a number of threatened taxa without the need for population modelling or detailed comparison of aspects like differing effective population size. While population sizes are very much better known for seriously endangered taxa, they are not so well known for more secure taxa. The estimation of population sizes for more secure taxa entailed informed expert assessment. The potential risk for a given taxon was ranked. While the numbers used for these categories are somewhat arbitrary, the extremes represent species with very small populations and those with much more substantial populations.

low = known Victorian population is estimated to number more than 20,000 individuals.

medium = known Victorian population is estimated to number between 1000 and 20,000 individuals.

high = known Victorian population is estimated to number less than 1000 individuals.

3.3.6 Criterion F (Listed conservation status)

The conservation status of each taxon was ranked directly and was not subject to expert opinion. The *Advisory List* uses the *IUCN Red List* approach to allocate threatened status and reflects the Victorian status of the taxon concerned. The *Advisory List* status was used for all taxa listed on it. A few pelagic bird species are listed in a category of threat under the EPBC Act, but are not included on the *Advisory List*. For those species, the EPBC Act conservation status (which is also determined from IUCN criteria) was used. Species that are listed under a category of threat and under provisions of the EPBC Act for migratory species are ranked according to their listed threatened status. Species that are listed as migratory under provisions of the EPBC Act, but have not been assigned a threat status on an official list (1a–c in section 2) are not assigned a rank for this criterion. The ranking used is: low – Near Threatened and Data Deficient; moderate – Vulnerable; and high – Endangered or Critically Endangered.

4 Application of ranked criteria to determine levels of risk

A number of steps are involved in converting the individual expert elicitation values for each criteria of likelihood and consequence risk into an overall assessment of the level of risk for each species, incorporating the uncertainty reflected in these assessment. These steps are outlined below.

4.1 Estimating the probability of each risk category for each element of the likelihood and consequence of collision terms

The individual expert assessments were used to estimate a combined probability distribution for each element of the likelihood and consequence of collision risk, for each species, using the categories of 'Low', 'Medium/Moderate' and 'High'. To illustrate the process, the responses of five experts on Powerful Owls (*Ninox strenua*) are shown in Table 1.

- The experts were divided on criteria A (Flight height), with 'Low' selected by two experts, 'Medium' selected by two experts and 'High' selected by one expert. Therefore, the 'elicited' probability distribution for criteria A for Powerful Owls was 40%, 40% and 20% for 'Low', 'Medium' and 'High', respectively.

- For criteria B (Habitat preference), the experts were split between 'Low' and 'Medium' risk. 'Low' was selected by three experts, 'Medium' was selected by two experts, and no experts selected 'High'. Therefore, the 'elicited' probability distribution for criteria B for Powerful Owls was 60%, 40% and 0% for 'Low', 'Medium' and 'High', respectively.

- The experts were unanimous that risks associated with criterion C (Geographic population concentration) were 'Low'. Therefore, the 'elicited' probability distribution for criteria C for Powerful Owls was 100% for 'Low' and 0% for 'Medium' and 'High'.

- For criteria D (Demographic resilience), the consensus opinion was 'High' risk, with only one expert considering the risk 'Medium'. Therefore the 'elicited' probability distribution for criteria D for Powerful Owls was 0%, 20% and 80% for 'Low', 'Medium' and 'High', respectively.

- The experts were unanimous that risks associated with criterion E (Population size) were 'Medium'. Therefore the 'elicited' probability distribution for criteria E for Powerful Owls was 100% for 'Medium' and 0% for 'Low' and 'High'.

These 'elicited' probability distributions for the five risk elements for Powerful Owls are summarised in Table 2.

The elicited expert opinions for each element for each species was checked for any instances of bi-modal opinions split between low and high, because this could indicate a degree of uncertainty about its true nature. The project double-checked with the expert assessors to ensure that all criteria had been clearly understood and that there was limited likelihood that bi-modal opinions were the result of differing interpretations of the criteria.

Table 1: Elicited expert opinion on the Powerful Owl (*Ninox strenua*) risk categories for each element

Opinion	Flight height	Preferred habitat	Geographic population concentration	Demographic resilience	Population size
Expert A	Medium	Low	Low	High	Medium
Expert B	Low	Medium	Low	High	Medium
Expert C	Low	Low	Low	High	Medium
Expert D	High	Low	Low	Medium	Medium
Expert E	Medium	Medium	Low	High	Medium

Table 2: Elicited probability distribution for the Powerful Owl (*Ninox strenua*) risk categories for each element

Opinion	Flight height	Preferred habitat	Geographic population concentration	Demographic resilience	Population size
Low	40%	60%	100%	0%	0%
Medium	40%	40%	0%	20%	100%
High	20%	0%	0%	80%	0%

4.2 Estimating the overall risk category for the likelihood and consequence of collision

The elements of the likelihood and consequence of collision were combined to form an overall qualitative risk category ('Low'/'Medium'/'High') for the likelihood of collision and the consequence of collision. Likelihood of collision questions (Criterion A and B) and consequence of collision questions (Criterion C to F) were combined in a generally additive process to determine whether the overall likelihood and consequence of collisions was 'Low', 'Moderate' or 'High'. This additive process meant that overall risk was averaged over the relevant criteria, so that no individual criterion could dominate the outcome. In contrast, a multiplicative process allows very high (or low) scores to dominate the outcome, for example, if the maximum risk from the relevant criterion is used. The risks were generally seen as additive, with one exception being the risk associated with criterion C related to localised concentration of a population (see below).

The overall risk associated with the **likelihood** of collision was based on the risks associated with criteria A for flight height and B for habitat preference. For the overall likelihood of collision to be considered 'High', then at least one of these criteria must be considered 'High' and neither criterion could be considered 'Low'. To be considered 'Low', the rank for both of these criteria must have been 'Low'. Everything else was considered 'Moderate'. This approach effectively selected the modal response, with a default to use of the precautionary principle in instances of two adjacent risks, in which case the higher risk was selected.

The overall risk associated with the **consequence** of collision was based on the risk associated with criteria C for localised concentration, D for demographic replacement capacity, and E for Victorian population size. In general, the modal response of rankings across the three criteria was used as the estimate. In cases where the risks were spread across all three levels, 'Low'; 'Medium'/'Moderate' and 'High', a 'Moderate' risk was selected. The exception was in cases where the risk associated with criterion C for localised concentration was 'High'. It was considered that the consequences of high mortality due to wind turbine collisions for species that have a limited distribution and/or are highly concentrated is sufficiently large such that, if a species risk associated with this element was 'High', the consequences of collision should also be set to 'High', irrespective of the risks of the other criteria. This effectively makes this multiplicative for this criterion, rather than additive. For instance, Grey-headed Flying-fox (*Pteropus poliocephalus*) had 'High', 'Medium' and 'Low' risk assessments associated with localisation/concentration, replacement capacity, and

population size, respectively. In general, that should be considered an overall consequence risk of 'Moderate', but the localisation/concentration risk is 'High', so the overall consequence risk defaults to 'High'. This was done because it is considered that the consequences of a wind farm situated too close to a high concentration of the particular taxon would be 'High', irrespective of the other two criteria.

To illustrate the overall risk for the likelihood and consequence of collision, a single simulation for Powerful Owl is used. The 'elicit' probability distribution for Powerful Owls (Table 2) is used to generate a random risk profile for Powerful Owls. Let's assume that the simulated risk levels for criteria A to E were 'Medium', 'Low', 'Low', 'High' and 'Medium', respectively. With risk estimates of 'Medium' and 'Low' for the likelihood elements, the overall risk for the likelihood of collision is moderate. With risk estimates of 'Low', 'High' and 'Medium' for the consequence elements, the overall risk for the consequence of collision (independent of the *Advisory Listing*) is 'Moderate'.

4.3 Inclusion of the DELWP *Advisory List* status in the overall risk category for consequence of collision

Of the 166 taxa included in the list of 'species of interest', 131 are listed under a category of threat on the DELWP *Advisory List*.

The risk assessments to this point did not include any influence from the species status on the DELWP *Advisory List* (criterion F). The rationale for this is that the assessment has been framed explicitly to encapsulate potential risks associated with wind turbines. As noted in section 3, the *Advisory List* allocates categories of threatened status in response to all known threats to each taxon on the basis of *IUCN Red List* criteria. For any given taxon, these include a wide range of non–wind farm–related threats. Nonetheless, there is likely to be some correlation between the *Advisory List* and the overall risk level associated with the consequence of collisions. On balance, the inclusion of *Advisory List* status for each species is considered to provide value, because there are situations where its inclusion adds a more nuanced view of risk and helps to distinguish between species which otherwise might have a similar risk status. Including it is also a precautionary approach, because it recognises that species in a higher threat category are at greater risk of extinction, and that any additional threats could have a greater proportional impact than the same threat might have on a species that is less threatened.

Advisory List status is included as a component in the 'species of concern' risk matrix as part of the **consequences** considerations. The various categories of threat used in the *Advisory List* were converted to a Low, Medium or High risk, as shown in Table 3. Using the same process as applied in other parts of the risk assessment, the modal response for the four consequence elements (the three previous elements plus the *Advisory List* status) was used to estimate the overall risk related to the consequences of collisions. In cases where the risks were bi-modal, the precautionary principle was invoked, and the higher risk was selected. As with other criteria, the exception remains that if the risk associated with criterion C (related to taxa that have a limited distribution and/or are highly concentrated) is high, the risk will default to high.

Table 3: Conversion from DELWP *Advisory List* status to consequence risk

DELWP *Advisory List* status	Consequence risk
Not listed	No ranking
Near Threatened or Data Deficient	Low
Vulnerable	Medium
Endangered or Critically Endangered	High

To illustrate the value of including the *Advisory List* status, we consider two species, the Powerful Owl example mentioned previously and the Greater Sand Plover (*Charadrius leschenaultii*). The overall risk for the likelihood of collision is not affected (remains moderate), as the inclusion of the *Advisory List* status does not influence the likelihood of collision. For the Powerful Owl, the risk simulation for the consequence elements was 'Low', 'High', 'Medium' and 'Medium' (its *Advisory List* status is vulnerable), and the overall risk

for the consequence of collision is moderate, irrespective of whether the *Advisory List* status is included or not. For the Greater Sand Plover, the generated risk levels for criteria A to E were 'Medium', 'Low', 'Medium', 'Medium' and 'High'. Therefore, the likelihood of collision is moderate (from a 'Medium' and 'Low'), and the consequence of collision (independent of the *Advisory List* status) is moderate (from a 'Medium', 'Medium' and 'High'). If the Advisory List status is included (the *Advisory List* status is Critically Endangered), the elements are now two 'Medium' and two 'High', bi-modal, so the precautionary principle means we select the higher risk level. Therefore, the consequence of collision is changed from moderate to high for the Greater Sand Plover.

4.4 Determining the level of concern

Once the overall risk levels for the likelihood and consequence of collision had been calculated for a species, the results were then placed into a 'species of concern' risk matrix to determine the level of concern (Table 4). Four categories of concern were used: 'extreme concern', 'concern', 'mild concern' and 'minimal concern', based on the combination of the scores for likelihood and consequence. Using simulations from the elicited expert opinion, the probability distribution for the level of concern was estimated for each species. That is, the process estimated the probability associated with each cell of the 'species of concern' risk matrix for each species, highlighting the uncertainty about its true risk status.

Table 4: 'Species of concern' risk matrix

		Consequence of collisions		
		Low	**Moderate**	**High**
Likelihood of collisions	**Low**	Minimal concern	Minimal concern	Mild concern
	Moderate	Minimal concern	Mild concern	Concern
	High	Mild concern	Concern	Extreme concern

If a species is at high risk for both likelihood and consequence of collision, then it is considered to be of **extreme concern**. The assessment considers that, if a wind farm operates within an area of the state inhabited by it, there is a high probability that the species will be involved in collisions that will impact the Victorian population. Species that are at high risk for one factor and moderate risk for the other factor were deemed to be of **concern**. Either they are highly likely to be killed by wind turbines in the area, with moderate impact to the species population across Victoria, or they were at moderate risk of being killed by wind turbines in the area, but these mortalities are highly likely to impact the species at the population level across Victoria.

4.5 Modelling 'species of concern' risk matrix using elicited expert opinion

The elicited expert opinion highlighted the fact that there is a level of uncertainty around the actual risk level for each element, and thus for the overall risk. To estimate the probability that a species should be in a particular section of the wind turbine collision risk matrix, a simulation study was conducted.

The 'elicited' probability distributions (generated from the elicited expert opinion as outlined above) were used to generate simulated expert data. That simulated data was then used to calculate the section of the risk matrix that species belonged to in that simulation. The simulation was run 10,000 times for each species. The fraction of times the simulation resulted in the species being in a particular cell (option) was then considered as the estimated probability of that species being in that cell. For instance, the Powerful Owl simulation resulted in 'Low' likelihood and 'Moderate' consequence 2355 times; 'Moderate' likelihood and

'Moderate' consequence 6816 times; and 'High' likelihood and 'Moderate' consequence 829 times. All other options were not encountered in the simulation. The resulting estimated probability for the Powerful Owl collision risk matrix is given in Table 5. Hence, for the Powerful Owl, the most likely option is that there is a 'Moderate' likelihood of collisions with wind turbines and that those collisions would have a 'Moderate' impact on the species at a Victoria-wide scale.

Table 5: Estimated probabilities for cells of the concern risk matrix for the Powerful Owl (*Ninox strenua*)

		Consequence of collisions		
Likelihood of collisions		**Low**	**Moderate**	**High**
	Low	0.0%	23.6%	0.0%
	Moderate	0.0%	68.2%	0.0%
	High	0.0%	8.3%	0.0%

5 ‘Species of concern’ assessment

The risk assessment processes, set out above, have been applied to all ‘species of interest’. A complete list of the risk matrices for the 166 ‘species of interest’ is provided in Appendix 4.

The level within the risk matrix that represents an appropriate ‘cut-off’ for inclusion of taxa within a list of ‘species of concern’ is best evaluated by application of the risk matrix simulator, because it offers a quantified mechanism for comparing the results for different species. The percentage probability levels that should be applied to determine cut-off points are optional, and the following provides an example of the approach but is not intended to recommend particular cut-off values.

Four categories have been provided, based on those shown in Table 4. Where there is both “High” likelihood and consequence, the species is classified as of ‘extreme concern’. Where one category is ‘High’ and the other category ‘Moderate’, it is classified as ‘of ‘concern’. Species of ‘mild concern’ have combinations of ‘High’ and ‘Low’ or ‘Moderate’ and ‘Moderate’. Those species considered to have the least level of concern (i.e. ‘Low’ and ‘Mod’ or ‘Low’ and ‘Low’) are categorised to be of ‘minimal concern’.

Use of just the category of ‘Extreme concern’ allows the focus to be only on species that are highly likely to have collisions, and for which these collisions will have a large impact on the species in Victoria. Including the category of ‘concern’ results in a broader list, which factors in the precautionary principle given that there is uncertainty in the likelihoods and the consequences for all species due to limits in knowledge and data.

The level of (cumulative) probability required in order to include a species on the list of ‘species of concern’ is an arbitrary choice and depends on the risk tolerance. It is worth noting that, while both the individual criteria used and the application of the entire suite of criteria are intended to provide a risk profile specifically in relation to wind farm collisions, there remains a further decision to be made about how ‘acceptable’ the resultant risk may be for the Victorian populations of relevant species. In this report, we have presented two approaches for deciding which species could be considered of concern.

First, we could consider which of the categories (‘extreme concern’, ‘concern’, ‘mild concern’, ‘minimal concern’) is the one most likely to represent the risk to the species. This can be determined from the risk matrices in Appendix 4, by summing the concern groupings as presented in Table 4 (e.g. adding the figures for the two ‘concern’ categories – ‘high–mod’ and ‘mod–high’). As an example, the Australian Bustard (*Ardeotis australis*) is considered to have a 72% chance of it being in the high–high cell and so is of ‘extreme concern’, with the next likely category being ‘concern’ at 28% likelihood. However, not all species are this clear-cut. The Gull-billed Tern (*Gelochelidon nilotica*), for example, has a 10% chance of being of ‘extreme concern’, a 36% chance of being of ‘concern’, a 32% chance of being of ‘mild concern’ and a 21% chance of being of ‘minimal concern’. Therefore, using this approach it would be considered of ‘concern’; however, with this high level of uncertainty it could also conceivably be in one of the other categories. Therefore, although this approach enables each species to be categorised, this may not reflect the true level of either uncertainty or risk to the species.

An alternative approach is to consider what level of risk is acceptable. Thus, for example, while criteria E and F take account of the pre-existing size and status of the Victorian populations of relevant taxa, it is still necessary to determine a level of wind farm collision risk that is tolerable. If we wanted to ensure that a dire outcome was detected, for instance to the point where the species could become regionally extinct in Victoria due to wind farm developments, then erring on the side of caution may be desirable, and a low threshold, say a 1 in 4 (25%) or 1 in 5 (20%), chance of it occurring may be considered appropriate. However, if the outcome is just ‘bad’, for example leading to a decline in the species but not resulting in extinction, then a higher threshold, such as 1 in 2 (50%) chance of it occurring, may be considered appropriate.

If we take an approach that is particularly risk averse, then we might say a species is of concern if it has a reasonable chance of adverse outcomes, such as when the cumulative probability of being of ‘concern’ or ‘extreme concern’ is 20% or greater. However, if we take an approach that is less averse to risk, then we might say a species is of concern only if it is more likely to be of ‘extreme concern’, that is the probability of ‘high–high’ is greater than or equal to 50% and so it is more likely to be of extreme concern than to not be of extreme concern.

6 Uncertainties and limitations

The process of assessing risks to arrive at a list of 'species of concern' encompasses a variety of unavoidable uncertainties and limitations. These include limited information about real-life interactions of birds and bats with wind turbines in Victoria, in addition to limitations and assumptions inherent in the risk assessment process. This section discusses these two broad categories with a view to providing transparency about the process.

It is important that future investigations of wind farm collisions are designed to improve our understanding of the effects of turbine collisions on fauna, particularly any effects they might have on the population viability of Victorian fauna, so that future assessments are based on greater certainty.

6.1 Bird and bat interactions with wind turbines

There is a large and growing international literature about bird and bat collisions with wind turbines, but almost nothing has been published about the experience at Australian sites. The international literature is informative, but the species composition and the physical environment of Victoria differ from anywhere overseas, and it is not appropriate to apply generalities from international experience to Victoria. The study of two Tasmanian wind farms by Hull et al. (2013), remains the sole published Australian study to investigate which avian taxa collided with turbines and to consider possible taxonomic and behavioural factors pre-disposing birds to collisions there.

Investigations carried out to date at a number of operational wind farms in Victoria have documented mortalities of birds and bats due to turbine collisions. The number of documented mortalities at Victoria wind farms is collated in Moloney et al. (2019). However, any consideration of the magnitude or rate of such collisions necessarily must account for uncertainties due to factors such as representative sampling and the influences of searcher efficiency and carcass persistence rates. An analysis of the available data showed that there is a high level of variability in the quality of the data collected and the resulting annual mortality estimates (Moloney et al. 2019). As a consequence, the present assessment has been undertaken without the benefit of comprehensive, quantified empirical information about collision rates for any Victorian species.

There have been few rigorous scientific attempts to ascertain whether mortalities at any one wind farm, or the cumulative mortalities at multiple wind farms, might affect the viability of Victorian populations of threatened species. The species for which this has been most explored is the Brolga (*Antigone rubicunda*), through collision risk modelling and population viability analysis. DELWP has established a process whereby the developer of a wind farm that might have an effect on the Brolga can use population viability analysis to model its likely impact on the Victorian population of the species. The process is detailed in *Interim Guidelines for the Assessment, Avoidance, Mitigation and Offsetting of Potential Wind Farm Impacts on the Victorian Brolga Population 2011, Revision 1* (DSE 2012). On the grounds that the wind farm may have a quantifiable effect, the process is used to determine a level of mitigation sufficient to ensure the wind farm will have no net impact on the population. The intention of this approach for individual wind farms is to ensure that, in combination with other wind farms, there will be no cumulative impact on the Brolga population. For other species, a broad relatively simplistic approach was taken when considering the consequence criteria during the expert elicitation process, with more wind farms within the range of a species considered to be likely to have a greater impact.

Uncertainty also exists about the potential for future impacts on species whose distributions do not coincide with wind farms currently in operation.

These uncertainties about bird and bat interactions with wind turbines are the reason why it was necessary for this project to call on species experts to provide their informed judgement in ranking risk against specified criteria.

6.2 Risk assessment

The risk assessment process set out here also incorporates various assumptions and uncertainties, and the requirement for informed judgements.

The selection and composition of criteria used to rank taxa were informed by the knowledge of specialists, some of whom have worked in the specific field of bird and bat interactions with wind turbines for more than 15 years. However, the criteria incorporate some elements where the cut-off points between categories are arbitrary, such as the categorization of geographic concentration used in Criterion C and of population sizes in Criterion E.

Other than migratory and threat status (pre-determined for the purposes of legislation and the *Advisory List*), the ranking by specialists for all criteria entailed a degree of judgement based on the knowledge and experience of the various people involved. For some taxa about which knowledge is limited and/or there is no available information about how they might behave in the presence of wind turbines, ranking of risk inevitably required decisions based on similar species or general understanding of the wider taxonomic group to which they belong.

The use of a three-tiered qualitative ranking by experts is also somewhat arbitrary, although in light of the uncertainties it was considered to be more appropriate than a quantitative approach. It is also recognised that ranking by additional experts may have provided a ‘smoother’ set of scores as a basis for the evaluation.

Within risk matrices, the application of probability distributions has permitted a more nuanced capacity to evaluate the relative risks for different taxa than would be the case with arbitrary categories of risk. Nonetheless, the number of simulations chosen to be run is also an arbitrary selection, as is the ultimate choice of percentage values used as ‘cut-off’ levels for determining whether the level of risk warrants inclusion in the final list of ‘species of concern’.

We note that many of the uncertainties described here are not unique to the present process, and similar knowledge gaps, assumptions and uncertainties are entailed in processes such the application of *IUCN Red List* criteria used in determining threat status, population viability analyses, and other modelling exercises for wildlife populations.

7 Conclusion and recommendations

7.1 Risk matrix

The level within the risk matrix that represents an appropriate 'cut-off' for inclusion of taxa within a list of 'species of concern' is best evaluated by application of the risk matrix simulator because it offers a quantified mechanism for comparing the results for different species. While an approach to this has been illustrated in this report, a final selection of cut-off levels is a policy decision and will be documented elsewhere.

7.2 Non-threatened species

Species that are not listed as threatened or as migratory are not included in this risk assessment process, due to the definitions used for inclusion in the list of 'species of interest', and because no non-threatened species are currently considered likely to become threatened at the state level due to wind farms. It is conceivable, however, that turbine collisions may have local impacts on species that are not currently listed as threatened. While these local impacts are currently not considered sufficient to have a signficant impact at a state level, this may change in the future as more wind farm developments are constructed. If in the future post-construction mortality monitoring is only undertaken where 'species of concern' are likely to occur, continuing to record the number of mortalities of non-threatened species when they are found, would provide at least some indication of the scale of mortalities. This information could inform future re-assessments of the 'species of concern' list, or trigger additional investigations. It is not proposed that additional sampling would be required, just the documentation of other species located during the targeted sampling. For example, if mortality searches were being undertaken for Southern Bent-wing Bats, and a White-striped Freetail Bat or Wedge-tailed Eagle was found, it would be useful to document these records. It is only through previous similar documentation that we now know that relatively large numbers of both these species are being killed (Moloney et al. 2019).

7.2.1 Recommendation

It is recommended, where investigations are to be undertaken at a wind farm due to the potential for impacts on a 'species of concern', that records of other species found during those searches should also be documented, regardless of their conservation status. All information collected in such investigations should be collated into a central repository for analysis to determine whether the effects of turbine collisions are affecting the conservation status of species currently not considered to be of concern.

7.3 Future review

Wind farm design and turbine technology and specifications have been in a state of rapid development over the past few years. For example, the size and height of turbines has increased very significantly in the past 5 years. In addition, we are continuing to improve our understanding of the ecology, distribution and movement patterns of species, and the conservation status of individual species may change in the future, for multiple reasons.

7.3.1 Recommendation

It is recommended that the status of all 'species of interest', incorporating any species that are added to relevant lists of threatened species, should be reviewed (based on the best available information, using the risk assessment process set out here) every 5 years to re-evaluate the currency of Victorian 'species of concern'.

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9 Appendices

Appendix 1. Species of birds that are vagrant to Victoria and so are not included within the list of 'species of interest'

Table A1.1: Species of birds that are vagrant to Victoria

Common name	Scientific name
Asian Dowitcher	*Limnodromus semipalmatus*
Baird's Sandpiper	*Calidris bairdii*
Barn Swallow	*Hirundo rustica*
Black Bittern	*Ixobrychus flavicollis*
Black Petrel	*Procellaria parkinsoni*
Blue Petrel	*Halobaena caerulea*
Bridled Tern	*Onychoprion anaethetus*
Brown Booby	*Sula leucogaster*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Common Noddy	*Anous stolidus*
Dunlin	*Calidris alpina*
Emerald Dove	*Chalcophaps indica*
Garganey	*Anas querquedula*
Gould's Petrel	*Pterodroma leucoptera*
Great Frigatebird	*Fregata minor*
Grey Petrel	*Procellaria cinerea*
Grey Phalarope	*Phalaropus fulicarius*
Leach's Storm-Petrel	*Hydrobates leucorhoa*
Lesser Frigatebird	*Fregata ariel*
Light-mantled Sooty Albatross	*Phoebetria palpebrata*
Little Curlew	*Numenius minutus*
Little Ringed Plover	*Charadrius dubius*
Northern Shoveler	*Anas clypeata*
Oriental Plover	*Charadrius veredus*
Oriental Pratincole	*Glareola maldivarum*
Pin-tailed Snipe	*Gallinago stenura*
Providence Petrel	*Pterodroma solandri*
Red-tailed Tropicbird	*Phaethon rubricauda*
Ringed Plover	*Charadrius hiaticula*
Soft-plumaged Petrel	*Pterodroma mollis*
Streaked Shearwater	*Calonectris leucomelas*
Swinhoe's Snipe	*Gallinago megala*
Wedge-tailed Shearwater	*Ardenna pacifica*
Westland Petrel	*Procellaria westlandica*
White Wagtail	*Motacilla alba*
White-bellied Storm-Petrel	*Fregetta grallaria grallaria*
White-capped Albatross	*Thalassarche steadi*
White-tailed Tropicbird	*Phaethon lepturus*
Yellow Wagtail	*Motacilla flava*

Appendix 2. Complete list of 'species of interest'

Table A2.1: Complete list of 'species of interest'

EPBC threatened categories – CR Critically Endangered; E Endangered; VU Vulnerable. FFG threatened – L listed. DELWP Advisory List – cr Critically Endangered; en Endangered; vu Vulnerable; nt Near Threatened; dd Data Deficient. EPBC migratory – Mi migrant.

Group	Scientific name	Common name	Conservation status			
			EPBC threatened	FFG threatened	DELWP *Advisory*	EPBC migratory
Bats	*Pteropus poliocephalus*	Grey-headed Flying-fox	VU	L	vu	
Bats	*Nyctophilus corbeni*	South-eastern Long-eared Bat	VU	L	en	
Bats	*Miniopterus orianae bassanii*	Southern Bent-wing Bat	CR	L	cr	
Bats	*Miniopterus orianae oceanensis*	Eastern Bent-wing Bat		L	vu	
Bats	*Rhinolophus megaphyllus*	Eastern Horseshoe Bat		L	vu	
Bats	*Scotorepens greyii*	Little Broad-nosed Bat			nt	
Bats	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail Bat		L	dd	
Pelagic & Coastal Birds	*Ardenna grisea*	Sooty Shearwater				Mi
Pelagic & Coastal Birds	*Ardenna tenuirostris*	Short-tailed Shearwater				Mi
Pelagic & Coastal Birds	*Ardenna carneipes*	Flesh-footed Shearwater				Mi
Pelagic & Coastal Birds	*Oceanites oceanicus*	Wilson's Storm-Petrel				Mi
Pelagic & Coastal Birds	*Pelagodroma marina*	White-faced Storm-Petrel			vu	
Pelagic & Coastal Birds	*Pelecanoides urinatrix*	Common Diving-Petrel			nt	
Pelagic & Coastal Birds	*Procellaria aequinoctialis*	White-chinned Petrel				Mi
Pelagic & Coastal Birds	*Macronectes giganteus*	Southern Giant-Petrel	EN	L	vu	Mi
Pelagic & Coastal Birds	*Macronectes halli*	Northern Giant-Petrel	VU	L	nt	Mi
Pelagic & Coastal Birds	*Diomedea exulans*	Wandering Albatross	VU	L	en	Mi
Pelagic & Coastal Birds	*Thalassarche melanophris*	Black-browed Albatross	VU	I	vu	Mi
Pelagic & Coastal Birds	*Thalassarche chlororhynchos*	Atlantic Yellow-nosed Albatross	VU	L	vu	Mi
Pelagic & Coastal Birds	*Thalassarche chrysostoma*	Grey-headed Albatross	EN	L	vu	Mi
Pelagic & Coastal Birds	*Thalassarche cauta*	Shy Albatross	EN	L	vu	Mi
Pelagic & Coastal Birds	*Phoebetria fusca*	Sooty Albatross	VU	L		Mi
Pelagic & Coastal Birds	*Diomedea gibsoni*	Gibson's Albatross	VU	L		Mi
Pelagic & Coastal Birds	*Diomedea sanfordi*	Northern Royal Albatross	EN			Mi
Pelagic & Coastal Birds	*Thalassarche salvini*	Salvin's Albatross	VU			Mi
Pelagic & Coastal Birds	*Diomedea epomophora*	Southern Royal Albatross	VU	L	vu	Mi
Pelagic & Coastal Birds	*Diomedea antipodensis*	Antipodean Albatross	VU	L		Mi
Pelagic & Coastal Birds	*Thalassarche melanophris impavida*	Campbell Albatross	VU			Mi
Pelagic & Coastal Birds	*Thalassarche bulleri*	Buller's Albatross	VU	L		Mi
Pelagic & Coastal Birds	*Stercorarius longicaudus*	Long-tailed Jaeger				Mi
Pelagic & Coastal Birds	*Stercorarius pomarinus*	Pomarine Jaeger				Mi
Pelagic & Coastal Birds	*Stercorarius parasiticus*	Arctic Jaeger				Mi
Pelagic & Coastal Birds	*Pachyptila turtur*	Fairy Prion			vu	
Pelagic & Coastal Birds	*Stercorarius maccormicki*	South Polar Skua				Mi
Cormorants & Terns	*Phalacrocorax fuscescens*	Black-faced Cormorant			nt	
Cormorants & Terns	*Phalacrocorax varius*	Pied Cormorant			nt	
Cormorants & Terns	*Chlidonias leucopterus*	White-winged Black Tern			nt	Mi
Cormorants & Terns	*Chlidonias hybrida*	Whiskered Tern			nt	
Cormorants & Terns	*Gelochelidon nilotica*	Gull-billed Tern		L	en	Mi
Cormorants & Terns	*Hydroprogne caspia*	Caspian Tern		L	nt	Mi
Cormorants & Terns	*Sterna striata*	White-fronted Tern			nt	
Cormorants & Terns	*Sternula albifrons*	Little Tern		L	vu	Mi
Cormorants & Terns	*Sternula nereis*	Fairy Tern	VU	L	en	

Group	Scientific name	Common name	Conservation status			
			EPBC threatened	FFG threatened	DELWP *Advisory*	EPBC migratory
Cormorants & Terns	*Sterna hirundo*	Common Tern				Mi
Cormorants & Terns	*Larus pacificus*	Pacific Gull		L	nt	
Shorebirds	*Arenaria interpres*	Ruddy Turnstone			vu	Mi
Shorebirds	*Haematopus fuliginosus*	Sooty Oystercatcher			nt	
Shorebirds	*Pluvialis squatarola*	Grey Plover			en	Mi
Shorebirds	*Pluvialis fulva*	Pacific Golden Plover			vu	Mi
Shorebirds	*Thinornis rubricollis*	Hooded Plover	VU	L	vu	
Shorebirds	*Charadrius mongolus*	Lesser Sand Plover	EN		cr	Mi
Shorebirds	*Charadrius bicinctus*	Double-banded Plover				Mi
Shorebirds	*Charadrius leschenaultii*	Greater Sand Plover	VU		cr	Mi
Shorebirds	*Peltohyas australis*	Inland Dotterel			vu	
Shorebirds	*Numenius madagascariensis*	Eastern Curlew	CR	L	vu	Mi
Shorebirds	*Numenius phaeopus*	Whimbrel			vu	Mi
Shorebirds	*Phalaropus lobatus*	Red-necked Phalarope				Mi
Shorebirds	*Limosa limosa*	Black-tailed Godwit			vu	Mi
Shorebirds	*Limosa lapponica*	Bar-tailed Godwit				Mi
Shorebirds	*Tringa glareola*	Wood Sandpiper			vu	Mi
Shorebirds	*Tringa brevipes*	Grey-tailed Tattler		L	cr	Mi
Shorebirds	*Tringa incana*	Wandering Tattler				Mi
Shorebirds	*Actitis hypoleucos*	Common Sandpiper				Mi
Shorebirds	*Tringa nebularia*	Common Greenshank			vu	Mi
Shorebirds	*Tringa stagnatilis*	Marsh Sandpiper			vu	Mi
Shorebirds	*Xenus cinereus*	Terek Sandpiper		L	en	Mi
Shorebirds	*Calidris ferruginea*	Curlew Sandpiper	CR	L	en	Mi
Shorebirds	*Calidris ruficollis*	Red-necked Stint				Mi
Shorebirds	*Calidris subminuta*	Long-toed Stint			nt	Mi
Shorebirds	*Calidris minuta*	Little Stint				Mi
Shorebirds	*Calidris acuminata*	Sharp-tailed Sandpiper				Mi
Shorebirds	*Calidris melanotos*	Pectoral Sandpiper			nt	Mi
Shorebirds	*Calidris canutus*	Red Knot	EN		en	Mi
Shorebirds	*Calidris tenuirostris*	Great Knot	CR	L	en	Mi
Shorebirds	*Calidris alba*	Sanderling			nt	Mi
Shorebirds	*Limicola falcinellus*	Broad-billed Sandpiper				Mi
Shorebirds	*Gallinago hardwickii*	Latham's Snipe			nt	Mi
Shorebirds	*Rostratula australis*	Australian Painted Snipe	EN	L	cr	
Shorebirds	*Stiltia isabella*	Australian Pratincole			nt	
Shorebirds	*Philomachus pugnax*	Ruff				Mi
Waterbirds	*Antigone rubicunda*	Brolga		L	vu	
Waterbirds	*Plegadis falcinellus*	Glossy Ibis			nt	Mi
Waterbirds	*Platalea regia*	Royal Spoonbill			nt	
Waterbirds	*Egretta garzetta*	Little Egret		L	en	
Waterbirds	*Ardea intermedia*	Intermediate Egret		L	en	
Waterbirds	*Ardea modesta*	Eastern Great Egret		L	vu	Mi
Waterbirds	*Egretta sacra*	Eastern Reef Egret				Mi
Waterbirds	*Bubulcus ibis*	Cattle Egret				Mi
Waterbirds	*Nycticorax caledonicus hillii*	Nankeen Night Heron			nt	
Waterbirds	*Ixobrychus minutus dubius*	Australian Little Bittern		L	en	
Waterbirds	*Botaurus poiciloptilus*	Australasian Bittern	EN	L	en	
Waterbirds	*Lewinia pectoralis*	Lewin's Rail		L	vu	
Waterbirds	*Porzana pusilla*	Baillon's Crake		L	vu	
Waterbirds	*Anseranas semipalmata*	Magpie Goose		L	nt	

Group	Scientific name	Common name	Conservation status			
			EPBC threatened	FFG threatened	DELWP *Advisory*	EPBC migratory
Waterbirds	*Anas rhynchotis*	Australasian Shoveler			vu	
Waterbirds	*Stictonetta naevosa*	Freckled Duck		L	en	
Waterbirds	*Aythya australis*	Hardhead			vu	
Waterbirds	*Oxyura australis*	Blue-billed Duck		L	en	
Waterbirds	*Biziura lobata*	Musk Duck			vu	
Raptors, Owls	*Circus assimilis*	Spotted Harrier			nt	
Raptors, Owls	*Accipiter novaehollandiae*	Grey Goshawk		L	vu	
Raptors, Owls	*Haliaeetus leucogaster*	White-bellied Sea-Eagle		L	vu	
Raptors, Owls	*Lophoictinia isura*	Square-tailed Kite		L	vu	
Raptors, Owls	*Falco hypoleucos*	Grey Falcon		L	en	
Raptors, Owls	*Falco subniger*	Black Falcon		L	vu	
Raptors, Owls	*Pandion cristatus*	Eastern Osprey				Mi
Raptors, Owls	*Ninox connivens*	Barking Owl		L	en	
Raptors, Owls	*Ninox strenua*	Powerful Owl		L	vu	
Raptors, Owls	*Tyto novaehollandiae*	Masked Owl		L	en	
Raptors, Owls	*Tyto tenebricosa*	Sooty Owl		L	vu	
Parrots	*Calyptorhynchus banksii graptogyne*	Red-tailed Black-Cockatoo	EN	L	en	
Parrots	*Calyptorhynchus lathami*	Glossy Black-Cockatoo		L	vu	
Parrots	*Lophochroa leadbeateri*	Major Mitchell's Cockatoo		L	vu	
Parrots	*Polytelis swainsonii*	Superb Parrot	VU	L	en	
Parrots	*Polytelis anthopeplus*	Regent Parrot	VU	L	vu	
Parrots	*Neophema pulchella*	Turquoise Parrot		L	nt	
Parrots	*Neophema splendida*	Scarlet-chested Parrot		L	vu	
Parrots	*Neophema chrysogaster*	Orange-bellied Parrot	CR	L	cr	
Parrots	*Neophema elegans*	Elegant Parrot			vu	
Parrots	*Lathamus discolor*	Swift Parrot	CR	L	en	
Parrots	*Pezoporus wallicus*	Ground Parrot		L	en	
Parrots	*Pezoporus occidentalis*	Night Parrot	EN		rx	
Ground dwelling birds	*Leipoa ocellata*	Malleefowl	VU	L	en	
Ground dwelling birds	*Excalfactoria chinensis*	King Quail		L	en	
Ground dwelling birds	*Turnix velox*	Little Button-quail			nt	
Ground dwelling birds	*Turnix pyrrhothorax*	Red-chested Button-quail		L	vu	
Ground dwelling birds	*Ardeotis australis*	Australian Bustard		L	cr	
Ground dwelling birds	*Burhinus grallarius*	Bush Stone-curlew		L	en	
Ground dwelling birds	*Pedionomus torquatus*	Plains-wanderer	CR	L	cr	
Land birds	*Geopelia cuneata*	Diamond Dove		L	nt	
Land birds	*Ceyx azureus*	Azure Kingfisher			nt	
Land birds	*Todiramphus pyrrhopygius*	Red-backed Kingfisher			nt	
Land birds	*Hirundapus caudacutus*	White-throated Needletail		L	vu	Mi
Land birds	*Apus pacificus*	Fork-tailed Swift				Mi
Land birds	*Rhipidura rufifrons*	Rufous Fantail				Mi
Land birds	*Myiagra cyanoleuca*	Satin Flycatcher				Mi
Land birds	*Monarcha melanopsis*	Black-faced Monarch				Mi
Land birds	*Melanodryas cucullata*	Hooded Robin		L	nt	
Land birds	*Pachycephala rufogularis*	Red-lored Whistler	VU	L	en	
Land birds	*Oreoica gutturalis*	Crested Bellbird		L	nt	
Land birds	*Psophodes nigrogularis leucogaster*	Western Whipbird (eastern)	VU	L	cr	
Land birds	*Coracina maxima*	Ground Cuckoo-shrike		L	vu	
Land birds	*Cinclosoma punctatum*	Spotted Quail-thrush			nt	
Land birds	*Cinclosoma castanotum*	Chestnut Quail-thrush			nt	
Land birds	*Pomatostomus temporalis*	Grey-crowned Babbler		L	en	

Group	Scientific name	Common name	Conservation status			
			EPBC threatened	FFG threatened	DELWP *Advisory*	EPBC migratory
Land birds	*Acanthiza iredalei*	Slender-billed Thornbill		L	nt	
Land birds	*Pyrrholaemus brunneus*	Redthroat		L	en	
Land birds	*Calamanthus pyrrhopygia*	Chestnut-rumped Heathwren		L	vu	
Land birds	*Calamanthus campestris*	Rufous Fieldwren			nt	
Land birds	*Chthonicola sagittata*	Speckled Warbler		L	vu	
Land birds	*Amytornis striatus*	Striated Grasswren			nt	
Land birds	*Dasyornis brachypterus*	Eastern Bristlebird	EN	L	en	
Land birds	*Dasyornis broadbenti*	Rufous Bristlebird		L	nt	
Land birds	*Stipiturus mallee*	Mallee Emu-wren	EN	L	en	
Land birds	*Climacteris picumnus victoriae*	Brown Treecreeper (south-eastern ssp.)			nt	
Land birds	*Climacteris affinis*	White-browed Treecreeper		L	vu	
Land birds	*Melithreptus gularis*	Black-chinned Honeyeater			nt	
Land birds	*Grantiella picta*	Painted Honeyeater	VU	L	vu	
Land birds	*Anthochaera phrygia*	Regent Honeyeater	CR	L	cr	
Land birds	*Lichenostomus melanops cassidix*	Helmeted Honeyeater	CR	L	cr	
Land birds	*Lichenostomus cratitius*	Purple-gaped Honeyeater			vu	
Land birds	*Lichenostomus plumulus*	Grey-fronted Honeyeater			vu	
Land birds	*Manorina melanotis*	Black-eared Miner	EN	L	cr	
Land birds	*Stagonopleura guttata*	Diamond Firetail		L	nt	
Land birds	*Struthidea cinerea*	Apostlebird		L		
Land birds	*Ptilonorhynchus maculatus*	Spotted Bowerbird		L	cr	

Appendix 3. Expert elicitation contributors

Table A3.1: Participants in July 2017 workshop

Name	Affiliation
Lis Ashby	DELWP Biodiversity Division
Amanda Bush	DELWP Barwon South West
Kristin Campbell	Biosis
Richard Hill	DELWP Barwon South West
Cindy Hull	Joule Logic
Lindy Lumsden	DELWP Arthur Rylah Institute
Peter Menkhorst	DELWP Arthur Rylah Institute
Paul Moloney	DELWP Arthur Rylah Institute
Ian Smales	Biosis
Tracey Taylor	DELWP Policy and Infrastructure Coordination
Mark Venosta	Biosis
Karen Weaver	DELWP Policy and Infrastructure Coordination

Table A3.2: Specialist participants in ranking 'species of interest'

Name	Affiliation	Taxonomic group
Amanda Bush	DELWP Barwon South West	bats
Daniel Gilmore	Biosis	birds and bats
Richard Hill	DELWP Barwon South West	birds
Cindy Hull	Joule Logic	birds
Lindy Lumsden	DELWP Arthur Rylah Institute	bats
Peter Menkhorst	DELWP Arthur Rylah Institute	birds and bats
Terry Reardon	South Australian Museum	bats
Danny Rogers	DELWP Arthur Rylah Institute	birds
Ian Smales	Biosis	birds and bats
Mark Venosta	Biosis	bats

Appendix 4. Risk matrices showing probability values for each 'species of interest'

This table provides the estimated probability for each cell of the Likelihood–Consequences matrix for all 'species of interest', based on a high, moderate or low probability for each criterion.

Table A4.1: Risk matrices showing probability values for each 'species of interest'

		Consequences		
Species	**Likelihood**	**Low**	**Moderate**	**High**
Antipodean Albatross	Low	2.9%	3.3%	6.2%
	Moderate	12.2%	12.9%	24.9%
	High	9.2%	9.3%	19.1%
Apostlebird	Low	26.9%	21.1%	0.0%
	Moderate	28.3%	23.7%	0.0%
	High	0.0%	0.0%	0.0%
Arctic Jaeger	Low	0.0%	6.7%	0.0%
	Moderate	0.0%	48.9%	0.0%
	High	0.0%	44.4%	0.0%
Atlantic Yellow-nosed Albatross	Low	1.7%	0.0%	4.6%
	Moderate	13.7%	0.0%	42.9%
	High	9.5%	0.0%	27.8%
Australasian Bittern	Low	0.0%	0.0%	24.2%
	Moderate	0.0%	0.0%	59.9%
	High	0.0%	0.0%	15.9%
Australasian Shoveler	Low	0.0%	0.0%	0.0%
	Moderate	13.4%	42.9%	0.0%
	High	10.1%	33.6%	0.0%
Australian Bustard	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	0.0%	27.7%
	High	0.0%	0.0%	72.3%
Australian Little Bittern	Low	0.0%	4.8%	18.6%
	Moderate	0.0%	13.5%	55.2%
	High	0.0%	1.6%	6.3%
Australian Painted Snipe	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	2.9%	69.2%
	High	0.0%	1.2%	26.8%
Australian Pratincole	Low	0.0%	0.0%	0.0%
	Moderate	8.3%	44.2%	0.0%
	High	8.0%	39.5%	0.0%
Azure Kingfisher	Low	41.9%	37.9%	0.7%
	Moderate	10.5%	9.0%	0.1%
	High	0.0%	0.0%	0.0%
Baillon's Crake	Low	4.9%	26.9%	0.0%
	Moderate	10.7%	53.7%	0.0%
	High	0.6%	3.2%	0.0%
Bar-tailed Godwit	Low	0.0%	0.0%	0.0%
	Moderate	3.2%	58.0%	15.1%
	High	1.0%	17.8%	5.0%
Barking Owl	Low	0.5%	3.7%	12.2%
	Moderate	2.4%	15.5%	53.8%
	High	0.4%	2.5%	9.1%
Black-browed Albatross	Low	9.5%	0.0%	6.5%
	Moderate	35.9%	0.0%	23.6%
	High	14.8%	0.0%	9.8%
Black-chinned Honeyeater	Low	19.8%	5.0%	0.0%
	Moderate	60.1%	15.1%	0.0%
	High	0.0%	0.0%	0.0%

Species	Likelihood	Consequences		
		Low	Moderate	High
Black-eared Miner	Low	0.0%	0.0%	60.6%
	Moderate	0.0%	0.0%	39.4%
	High	0.0%	0.0%	0.0%
Black-faced Cormorant	Low	2.4%	19.8%	0.0%
	Moderate	6.5%	54.6%	0.0%
	High	1.8%	14.9%	0.0%
Black-faced Monarch	Low	45.6%	7.4%	7.4%
	Moderate	29.8%	4.8%	5.0%
	High	0.0%	0.0%	0.0%
Black-tailed Godwit	Low	0.0%	0.0%	0.0%
	Moderate	2.9%	73.1%	0.0%
	High	0.9%	23.1%	0.0%
Black Falcon	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	3.3%	0.9%
	High	0.0%	72.5%	23.4%
Blue-billed Duck	Low	0.0%	0.0%	0.0%
	Moderate	9.6%	66.9%	0.0%
	High	2.5%	21.0%	0.0%
Broad-billed Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	79.3%	0.0%
	High	0.0%	20.8%	0.0%
Brolga	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	4.1%	95.9%
Brown Treecreeper (south-eastern ssp.)	Low	53.6%	10.6%	0.0%
	Moderate	30.3%	5.5%	0.0%
	High	0.0%	0.0%	0.0%
Buller's Albatross	Low	0.0%	6.5%	6.2%
	Moderate	0.0%	25.1%	24.8%
	High	0.0%	19.1%	18.3%
Bush Stone-curlew	Low	0.8%	6.6%	24.7%
	Moderate	1.7%	14.0%	52.3%
	High	0.0%	0.0%	0.0%
Campbell Albatross	Low	2.8%	3.2%	6.0%
	Moderate	12.5%	12.5%	25.4%
	High	9.5%	9.2%	18.8%
Caspian Tern	Low	0.0%	0.0%	0.0%
	Moderate	30.2%	34.5%	3.1%
	High	14.0%	16.8%	1.5%
Cattle Egret	Low	0.0%	0.0%	0.0%
	Moderate	16.7%	10.8%	0.0%
	High	43.4%	29.1%	0.0%
Chestnut-rumped Heathwren	Low	43.1%	56.9%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Chestnut Quail-thrush	Low	68.6%	31.4%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Common Diving-Petrel	Low	7.1%	7.2%	2.7%
	Moderate	28.5%	26.9%	11.2%
	High	7.3%	6.8%	2.5%
Common Greenshank	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	71.9%	0.0%
	High	0.0%	28.1%	0.0%
Common Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	79.8%	0.0%
	High	0.0%	20.2%	0.0%

Species	Likelihood	Consequences		
		Low	Moderate	High
Common Tern	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	54.1%	1.9%
	High	0.0%	42.2%	1.8%
Crested Bellbird	Low	80.3%	19.7%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Curlew Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	7.7%	65.1%	0.0%
	High	2.9%	24.3%	0.0%
Diamond Dove	Low	9.5%	2.5%	0.0%
	Moderate	70.2%	17.7%	0.0%
	High	0.0%	0.0%	0.0%
Diamond Firetail	Low	13.5%	18.6%	0.0%
	Moderate	29.8%	38.1%	0.0%
	High	0.0%	0.0%	0.0%
Double-banded Plover	Low	0.0%	0.0%	0.0%
	Moderate	2.9%	68.8%	0.0%
	High	1.0%	27.3%	0.0%
Eastern Bent-wing Bat	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	0.0%	40.8%
	High	0.0%	0.0%	59.2%
Eastern Bristlebird	Low	1.7%	12.6%	85.7%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Eastern Curlew	Low	0.0%	0.0%	0.0%
	Moderate	0.6%	11.2%	60.7%
	High	0.2%	4.1%	23.2%
Eastern Great Egret	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	51.8%	0.0%
	High	0.0%	48.2%	0.0%
Eastern Horseshoe Bat	Low	0.0%	0.0%	74.2%
	Moderate	0.0%	0.0%	25.8%
	High	0.0%	0.0%	0.0%
Eastern Osprey	Low	0.0%	0.0%	0.0%
	Moderate	5.8%	24.9%	33.5%
	High	2.9%	14.1%	18.8%
Eastern Reef Egret	Low	0.0%	12.1%	0.0%
	Moderate	0.0%	67.8%	0.0%
	High	0.0%	20.1%	0.0%
Elegant Parrot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	43.5%	10.8%
	High	0.0%	36.4%	9.3%
Fairy Prion	Low	4.4%	29.5%	2.9%
	Moderate	5.9%	37.4%	3.9%
	High	1.9%	12.8%	1.2%
Fairy Tern	Low	0.0%	0.0%	0.0%
	Moderate	3.1%	5.9%	63.2%
	High	1.3%	2.2%	24.4%
Flesh-footed Shearwater	Low	0.0%	11.7%	0.7%
	Moderate	0.0%	59.5%	3.7%
	High	0.0%	23.1%	1.4%
Fork-tailed Swift	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	29.6%	66.2%	4.2%
Freckled Duck	Low	0.0%	0.0%	0.0%
	Moderate	3.8%	41.8%	9.9%
	High	2.8%	33.5%	8.3%

Species	Likelihood	Consequences		
		Low	Moderate	High
Gibson's Albatross	Low	3.3%	3.1%	6.3%
	Moderate	12.2%	12.4%	25.4%
	High	9.3%	9.1%	18.9%
Glossy Black-Cockatoo	Low	0.0%	7.6%	4.5%
	Moderate	0.0%	43.4%	28.4%
	High	0.0%	9.5%	6.6%
Glossy Ibis	Low	0.0%	0.0%	0.0%
	Moderate	10.6%	33.0%	0.0%
	High	12.9%	43.5%	0.0%
Great Knot	Low	0.0%	0.0%	0.0%
	Moderate	0.8%	12.0%	66.6%
	High	0.2%	3.0%	17.5%
Greater Sand Plover	Low	0.0%	0.0%	0.0%
	Moderate	1.3%	16.1%	58.3%
	High	0.4%	5.0%	19.0%
Grey-crowned Babbler	Low	6.6%	19.0%	21.9%
	Moderate	7.1%	20.9%	24.4%
	High	0.0%	0.0%	0.0%
Grey-fronted Honeyeater	Low	25.1%	22.5%	12.2%
	Moderate	16.6%	15.2%	8.4%
	High	0.0%	0.0%	0.0%
Grey-headed Albatross	Low	0.0%	1.5%	4.5%
	Moderate	0.0%	14.4%	42.5%
	High	0.0%	9.1%	28.1%
Grey-headed Flying-fox	Low	0.0%	0.0%	0.0%
	Moderate	2.0%	4.5%	38.4%
	High	2.6%	5.6%	47.0%
Grey-tailed Tattler	Low	0.0%	0.0%	0.0%
	Moderate	2.6%	32.7%	44.0%
	High	0.7%	8.7%	11.2%
Grey Falcon	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	1.1%	7.1%
	High	0.0%	11.3%	80.5%
Grey Goshawk	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	46.9%	5.8%
	High	0.0%	41.4%	5.9%
Grey Plover	Low	0.0%	0.0%	0.0%
	Moderate	1.5%	18.4%	56.5%
	High	0.4%	6.0%	17.3%
Ground Cuckoo-shrike	Low	23.0%	24.8%	0.0%
	Moderate	20.7%	23.3%	0.0%
	High	4.0%	4.2%	0.0%
Ground Parrot	Low	2.4%	16.9%	29.3%
	Moderate	2.6%	17.7%	31.1%
	High	0.0%	0.0%	0.0%
Gull-billed Tern	Low	1.8%	3.1%	3.4%
	Moderate	16.1%	24.2%	27.6%
	High	5.4%	8.5%	9.9%
Hardhead	Low	0.0%	0.0%	0.0%
	Moderate	19.7%	36.4%	0.0%
	High	15.1%	28.9%	0.0%
Helmeted Honeyeater	Low	0.0%	0.0%	80.0%
	Moderate	0.0%	0.0%	20.0%
	High	0.0%	0.0%	0.0%
Hooded Plover	Low	0.9%	16.2%	0.0%
	Moderate	4.0%	67.6%	0.0%
	High	0.6%	10.7%	0.0%

Species	Likelihood	Consequences		
		Low	Moderate	High
Hooded Robin	Low	46.0%	17.7%	0.0%
	Moderate	26.3%	10.0%	0.0%
	High	0.0%	0.0%	0.0%
Inland Dotterel	Low	0.4%	5.5%	1.5%
	Moderate	2.1%	42.8%	11.0%
	High	1.6%	27.8%	7.4%
Intermediate Egret	Low	0.0%	0.8%	3.2%
	Moderate	0.0%	11.3%	45.0%
	High	0.0%	7.8%	32.0%
King Quail	Low	1.1%	12.2%	46.8%
	Moderate	0.9%	8.5%	30.4%
	High	0.0%	0.0%	0.0%
Latham's Snipe	Low	0.0%	0.0%	0.0%
	Moderate	1.5%	53.9%	0.0%
	High	1.3%	43.4%	0.0%
Lesser Sand Plover	Low	0.8%	3.2%	8.1%
	Moderate	4.8%	18.8%	44.5%
	High	1.3%	5.3%	13.2%
Lewin's Rail	Low	7.6%	40.2%	0.0%
	Moderate	8.3%	43.9%	0.0%
	High	0.0%	0.0%	0.0%
Little Broad-nosed Bat	Low	16.4%	5.6%	0.0%
	Moderate	54.5%	18.0%	0.0%
	High	4.0%	1.5%	0.0%
Little Button-quail	Low	0.0%	0.0%	0.0%
	Moderate	35.1%	17.1%	0.0%
	High	32.5%	15.3%	0.0%
Little Egret	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	30.3%	20.7%
	High	0.0%	29.4%	19.6%
Little Stint	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	79.6%	0.0%
	High	0.0%	20.4%	0.0%
Little Tern	Low	0.0%	0.0%	0.0%
	Moderate	6.9%	44.1%	20.8%
	High	2.5%	17.2%	8.5%
Long-tailed Jaeger	Low	0.0%	12.5%	0.0%
	Moderate	0.0%	50.3%	0.0%
	High	0.0%	37.2%	0.0%
Long-toed Stint	Low	0.0%	0.0%	0.0%
	Moderate	48.4%	31.6%	0.0%
	High	12.1%	7.9%	0.0%
Magpie Goose	Low	0.0%	0.0%	0.0%
	Moderate	1.3%	29.2%	0.0%
	High	3.2%	66.3%	0.0%
Major Mitchell's Cockatoo	Low	1.2%	5.2%	2.0%
	Moderate	10.1%	35.2%	14.1%
	High	5.5%	19.3%	7.4%
Mallee Emu-wren	Low	10.2%	18.2%	71.6%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Malleefowl	Low	0.0%	47.6%	12.6%
	Moderate	0.0%	31.8%	8.0%
	High	0.0%	0.0%	0.0%
Marsh Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	72.2%	0.0%
	High	0.0%	27.8%	0.0%

Species	Likelihood	Consequences		
		Low	Moderate	High
Masked Owl	Low	0.7%	4.5%	12.3%
	Moderate	3.1%	17.5%	45.0%
	High	0.7%	4.9%	11.4%
Musk Duck	Low	0.0%	0.0%	0.0%
	Moderate	11.6%	64.3%	0.0%
	High	3.8%	20.4%	0.0%
Nankeen Night Heron	Low	4.7%	3.4%	0.0%
	Moderate	40.3%	27.0%	0.0%
	High	14.6%	10.0%	0.0%
Night Parrot	Low	0.0%	3.6%	44.8%
	Moderate	0.0%	3.9%	47.8%
	High	0.0%	0.0%	0.0%
Northern Giant-Petrel	Low	1.7%	3.3%	1.5%
	Moderate	13.8%	28.5%	13.9%
	High	9.3%	18.4%	9.8%
Northern Royal Albatross	Low	0.9%	2.1%	9.5%
	Moderate	3.9%	9.1%	37.2%
	High	3.2%	6.0%	28.2%
Orange-bellied Parrot	Low	0.0%	0.0%	2.7%
	Moderate	0.0%	0.0%	49.7%
	High	0.0%	0.0%	47.6%
Pacific Golden Plover	Low	0.2%	5.2%	0.0%
	Moderate	1.9%	70.6%	0.0%
	High	0.6%	21.5%	0.0%
Pacific Gull	Low	7.5%	3.7%	0.0%
	Moderate	34.6%	18.0%	0.3%
	High	24.1%	11.6%	0.2%
Painted Honeyeater	Low	0.0%	0.0%	0.0%
	Moderate	31.2%	68.8%	0.0%
	High	0.0%	0.0%	0.0%
Pectoral Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	34.5%	37.6%	0.0%
	High	13.5%	14.5%	0.0%
Pied Cormorant	Low	1.0%	4.7%	0.0%
	Moderate	11.6%	59.8%	0.0%
	High	3.9%	19.0%	0.0%
Plains-wanderer	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	4.1%	48.5%
	High	0.0%	4.0%	43.4%
Pomarine Jaeger	Low	0.0%	6.3%	0.0%
	Moderate	0.0%	49.8%	0.0%
	High	0.0%	43.9%	0.0%
Powerful Owl	Low	0.0%	23.6%	0.0%
	Moderate	0.0%	68.2%	0.0%
	High	0.0%	8.3%	0.0%
Purple-gaped Honeyeater	Low	19.1%	17.1%	0.0%
	Moderate	34.4%	29.4%	0.0%
	High	0.0%	0.0%	0.0%
Red-backed Kingfisher	Low	28.1%	7.6%	0.0%
	Moderate	44.4%	11.5%	0.0%
	High	6.8%	1.7%	0.0%
Red-chested Button-quail	Low	3.8%	4.3%	0.0%
	Moderate	25.8%	29.7%	0.0%
	High	17.7%	18.8%	0.0%
Red-lored Whistler	Low	14.5%	43.1%	42.4%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%

Species	Likelihood	Consequences		
		Low	Moderate	High
Red-necked Phalarope	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	79.8%	0.0%
	High	0.0%	20.2%	0.0%
Red-necked Stint	Low	0.0%	0.0%	0.0%
	Moderate	17.3%	54.8%	0.0%
	High	6.7%	21.1%	0.0%
Red-tailed Black-Cockatoo	Low	0.0%	0.6%	3.4%
	Moderate	0.0%	8.2%	48.3%
	High	0.0%	5.8%	33.7%
Red Knot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	40.8%	38.9%
	High	0.0%	11.0%	9.3%
Redthroat	Low	6.4%	12.4%	60.9%
	Moderate	1.5%	3.3%	15.5%
	High	0.0%	0.0%	0.0%
Regent Honeyeater	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	12.0%	88.0%
	High	0.0%	0.0%	0.0%
Regent Parrot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	80.1%	0.0%
	High	0.0%	19.9%	0.0%
Royal Spoonbill	Low	0.0%	0.0%	0.0%
	Moderate	5.7%	42.8%	0.0%
	High	6.0%	45.6%	0.0%
Ruddy Turnstone	Low	0.0%	0.0%	0.0%
	Moderate	6.0%	66.4%	0.0%
	High	2.2%	25.4%	0.0%
Ruff	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	75.8%	0.0%
	High	0.0%	24.2%	0.0%
Rufous Bristlebird	Low	9.2%	50.5%	40.3%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Rufous Fantail	Low	30.3%	8.0%	1.7%
	Moderate	45.8%	12.0%	2.2%
	High	0.0%	0.0%	0.0%
Rufous Fieldwren	Low	36.8%	11.3%	12.1%
	Moderate	23.7%	8.2%	7.9%
	High	0.0%	0.0%	0.0%
Salvin's Albatross	Low	3.4%	3.2%	5.6%
	Moderate	12.4%	12.6%	25.3%
	High	9.5%	9.4%	18.6%
Sanderling	Low	0.0%	0.0%	0.0%
	Moderate	9.3%	70.9%	0.0%
	High	2.5%	17.4%	0.0%
Satin Flycatcher	Low	30.8%	7.7%	1.5%
	Moderate	45.8%	12.0%	2.2%
	High	0.0%	0.0%	0.0%
Scarlet-chested Parrot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	80.2%	19.9%
	High	0.0%	0.0%	0.0%
Sharp-tailed Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	8.6%	63.5%	0.0%
	High	3.4%	24.5%	0.0%
Short-tailed Shearwater	Low	5.1%	1.6%	1.7%
	Moderate	32.8%	11.2%	11.2%
	High	21.6%	7.3%	7.6%

Species	Likelihood	Consequences		
		Low	Moderate	High
Shy Albatross	Low	1.2%	3.2%	2.0%
	Moderate	9.2%	27.5%	19.3%
	High	6.4%	19.0%	12.3%
Slender-billed Thornbill	Low	34.8%	29.3%	0.0%
	Moderate	16.8%	15.0%	0.0%
	High	2.2%	2.0%	0.0%
Sooty Albatross	Low	0.0%	3.1%	2.9%
	Moderate	0.0%	27.6%	28.1%
	High	0.0%	19.0%	19.3%
Sooty Owl	Low	0.0%	30.1%	9.4%
	Moderate	0.0%	44.9%	15.5%
	High	0.0%	0.0%	0.0%
Sooty Oystercatcher	Low	3.7%	7.7%	0.0%
	Moderate	23.5%	50.9%	0.0%
	High	4.8%	9.6%	0.0%
Sooty Shearwater	Low	4.9%	16.3%	2.5%
	Moderate	12.0%	40.6%	7.1%
	High	3.1%	11.4%	1.9%
South-eastern Long-eared Bat	Low	0.5%	1.1%	6.5%
	Moderate	4.0%	13.1%	74.8%
	High	0.0%	0.0%	0.0%
South Polar Skua	Low	0.0%	12.3%	0.0%
	Moderate	0.0%	50.4%	0.0%
	High	0.0%	37.4%	0.0%
Southern Bent-wing Bat	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	0.0%	41.1%
	High	0.0%	0.0%	58.9%
Southern Giant-Petrel	Low	2.0%	1.1%	9.3%
	Moderate	7.8%	4.4%	37.1%
	High	5.9%	3.1%	29.3%
Southern Royal Albatross	Low	3.2%	6.5%	3.3%
	Moderate	12.3%	24.5%	12.1%
	High	9.3%	18.8%	10.0%
Speckled Warbler	Low	43.8%	56.2%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Spotted Bowerbird	Low	4.7%	21.4%	37.8%
	Moderate	2.5%	12.5%	21.1%
	High	0.0%	0.0%	0.0%
Spotted Harrier	Low	0.0%	0.0%	0.0%
	Moderate	4.2%	4.4%	0.0%
	High	43.9%	47.6%	0.0%
Spotted Quail-thrush	Low	67.5%	32.5%	0.0%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Square-tailed Kite	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	18.9%	8.7%
	High	0.0%	48.8%	23.6%
Striated Grasswren	Low	51.3%	28.5%	20.2%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Superb Parrot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	51.0%	33.1%
	High	0.0%	9.6%	6.3%
Swift Parrot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	40.5%	27.1%
	High	0.0%	19.8%	12.6%

Species	Likelihood	Consequences		
		Low	Moderate	High
Terek Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	15.7%	64.4%
	High	0.0%	4.0%	15.9%
Turquoise Parrot	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	100.0%	0.0%
	High	0.0%	0.0%	0.0%
Wandering Albatross	Low	3.3%	6.6%	6.4%
	Moderate	12.4%	23.6%	24.3%
	High	4.6%	9.4%	9.4%
Wandering Tattler	Low	0.0%	0.0%	0.0%
	Moderate	20.8%	58.9%	0.0%
	High	5.1%	15.2%	0.0%
Western Whipbird (eastern)	Low	0.0%	16.4%	83.6%
	Moderate	0.0%	0.0%	0.0%
	High	0.0%	0.0%	0.0%
Whimbrel	Low	0.0%	0.0%	0.0%
	Moderate	2.6%	69.3%	0.0%
	High	1.0%	27.1%	0.0%
Whiskered Tern	Low	0.0%	0.0%	0.0%
	Moderate	16.8%	55.6%	0.0%
	High	6.4%	21.3%	0.0%
White-bellied Sea-Eagle	Low	0.0%	0.0%	0.0%
	Moderate	3.6%	11.6%	18.5%
	High	7.2%	22.0%	37.1%
White-browed Treecreeper	Low	15.0%	34.1%	14.8%
	Moderate	8.9%	19.1%	8.1%
	High	0.0%	0.0%	0.0%
White-chinned Petrel	Low	0.0%	20.6%	4.4%
	Moderate	0.0%	41.6%	8.3%
	High	0.0%	21.0%	4.1%
White-faced Storm-Petrel	Low	0.0%	22.9%	1.6%
	Moderate	0.0%	47.1%	3.0%
	High	0.0%	23.8%	1.7%
White-fronted Tern	Low	2.6%	5.6%	0.0%
	Moderate	18.8%	38.2%	0.0%
	High	11.5%	23.4%	0.0%
White-throated Needletail	Low	0.0%	0.0%	0.0%
	Moderate	9.7%	6.6%	0.4%
	High	48.6%	32.4%	2.3%
White-winged Black Tern	Low	1.9%	2.2%	0.0%
	Moderate	26.6%	28.8%	0.0%
	High	19.1%	21.4%	0.0%
Wilson's Storm-Petrel	Low	6.4%	15.5%	3.0%
	Moderate	12.3%	30.8%	5.6%
	High	6.2%	16.7%	3.5%
Wood Sandpiper	Low	0.0%	0.0%	0.0%
	Moderate	0.0%	75.7%	0.0%
	High	0.0%	24.3%	0.0%
Yellow-bellied Sheathtail Bat	Low	0.0%	0.0%	0.0%
	Moderate	16.7%	2.2%	0.0%
	High	71.8%	9.3%	0.0%

Appendix 5. Summary of key literature providing criteria for defining key 'species of concern' for wind farms

Table A5.1: Key literature providing criteria for defining species of concern'

Report	Summary	Criteria
Desholm M. (2009). Avian sensitivity to mortality: Prioritising migratory bird species for assessment at proposed windfarms, *Journal of Environmental Management* 90 (8): 2672-2679.	Study developed a simple and logical framework for ranking bird species with regard to their relative sensitivity to bird wind turbine collisions and applied it to 38 avian migrant species at the Nysted offshore windfarm in Denmark.	• A measure of relative abundance • An assessment of demographic sensitivity (elasticity of population growth rate to changes in adult survival). • IUCN status for each species considered for prioritisation
Diffendorfer et al. (2015). *Preliminary methodology to assess the national and regional impact of U.S. wind energy development on birds and bats.* Scientific Investigations Report 2015-5066. U.S. Geological Survey, Reston, Virginia.	Study developed methodology applicable to birds and bats to assess the impacts of wind energy on wildlife at the national scale. A ranked list of species was developed based on relative risk and quantitative measures of the magnitude of effect on species population trend size.	• Relative risk based on species conservation status • Fatality Risk Index – relative risk from collision fatalities (direct risk) • Indirect Risk Index – relative risk from habitat modification (indirect risk)
Hull et al. (2013). Avian collisions at two wind farms in Tasmania, Australia: taxonomic and ecological characteristics of colliders versus non-colliders, *New Zealand Journal of Zoology* **40**(1), 47-62.	Study compared two 10-year data sets from Tasmania which found that presence on site was a poor indicator of collision risk. Specific families/ superfamilies and foraging strategies/ zones were associated with collision risk and indicated that particular morphological, ecological and behavioural factors were associated with a species vulnerability to colliding with wind turbines.	• Characteristics of species that collided were determined based on specific species family /superfamily and foraging strategies.
Bright et al. (2006). *Bird sensitivity map to provide locational guidance for onshore wind farms in Scotland*. Royal Society for the Protection of Birds	A bird sensitivity map was produced to aid location of onshore windfarms for Scotland based on distributional data for a suite of sensitive bird species. Species included in the map were part of one or more of the following groups: • listed on Annex 1 of the EU Birds Directive • species of conservation concern • known or suspected susceptibility to the effects of wind turbines on birds (notably collision mortality and disturbance displacement)	• Sensitivity to wind energy based from literature and being included on Annex 1 of the EU Birds Directive • Species with small, localised populations • Species with recent population declines • Species with lack of recent comprehensive data were not included

Report	Summary	Criteria
Environment Protection and Heritage Council. (2010). *National Wind Farm Development Guidelines - Draft.* Commonwealth of Australia and each Australian State and Territory. Pp 1 – 198	Appendix D: 'Birds and Bats' outlines a national best practice approach to the assessment of the impacts if wind farm projects on birds and bats. It includes criteria to consider when determining bird and bat species which are important for consideration within assessments.	• Taxa listed under any category of threatened conservation status by legislation of any jurisdiction in which the site is located. • Taxa that meet IUCN criteria for any category of threatened conservation status whether or not yet listed under provisions of legislation in any jurisdiction in which the site is located. • Taxa listed under provisions of relevant legislation that provide protection for particular categories of taxa whether threatened or not (for example species listed under provisions of the *EPBC Act* that provide specific protection for international migratory and marine fauna and encompass national obligations under international agreements). • Taxa naturally occurring at low densities because of their ecological function high in the trophic order. This will primarily relate to taxa like raptors that are top-order predators. • Taxa that have special cultural significance. • Any other taxa that relevant authorities require to be considered for a particular site such as species not included in the categories above but for which the site is especially significant.

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