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Southern Bent-wing Bat Adaptive Management Plan for Mt Fyans Wind Farm

Prepared for Woolnorth Renewables

November 2022

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1. Introduction

Mt Fyans Wind Farm Pty Ltd commissioned Biosis Pty Ltd to prepare this Southern Bent-wing Bat Adaptive Management Plan (SBWB-AMP) for Mt Fyans Wind Farm. Preparation of the Plan precedes submission of a development plan for the project and its objective is to guide relevant aspects in planning and decision-making for the proposed wind farm. It recognises the importance of the Southern Bent-wing Bat (SBWB) and the imperative to ensure the project has minimal effect on the population of the species.

This SBWB-AMP is a key document in the planning permit framework for the Mt Fyans Wind Farm. The SBWB-AMP sits under the Bat and Avifauna Management (BAM) Plan which is reasonably expected to be a condition of a planning permit for the wind farm.

The SBWB-AMP is set out in two primary parts. Sections 2 to 5 provide explanatory information and the rationale underpinning design and management of Mt Fyans Wind Farm that are intended to avoid and minimise effects on the SBWB. Sections 6 to 10 describe the SBWB Monitoring Program and set out a framework of adaptive measures from project siting and design through to the operational functioning of the planned wind farm, to which Mt Fyans Wind Farm Pty Ltd is committed to ensure the proposed wind farm has minimal effect on the SBWB.

Detailed information about investigations undertaken for Southern Bent-wing Bat for the project are provided in the report Mt Fyans Wind Farm EPBC Act Draft Assessment Documentation (Mt Fyans Wind Farm Pty Ltd 2020).

Mt Fyans Wind Farm Pty Ltd is committed to research funding for the conservation of the SBWB. Section 11 sets out the framework and arrangements for that funding.

1.1 Mt Fyans Wind Farm

A detailed description of the proposed Mt Fyans Wind Farm project is provided in Woolnorth Renewables (2022). The following is a summary.

1.1.2 Project background

Mt Fyans Wind Farm Pty Ltd is proposing to develop the Mt Fyans Wind Farm approximately 140 kilometres west of Geelong and 5 kilometres north of the town of Mortlake in southwest Victoria. The Project will comprise of a maximum of 81 wind turbines, with a maximum blade tip height of up to 200 metres, and a combined capacity of approximately 400 megawatts. The project also includes infrastructure associated with exporting electricity to the National Electricity Market via the nearby Mortlake Terminal Substation. Electrical infrastructure will include onsite and offsite substations and overhead and underground cabling.

The project was proposed in 2008 and a planning permit for up to 85 turbines with a maximum tip height of 200 metres was submitted in late 2018.

To ensure that all potential impacts of the proposed Mt Fyans Wind Farm project were assessed, 18 specialist studies were undertaken covering a wide range of disciplines, as outlined in Woolnorth Renewables (2022). The studies inform the planning application by identifying the potential impacts and, where appropriate, recommend mitigation measures.

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1.1.3 Mt Fyans Wind Farm project context

The project covers approximately 12,549 hectares and is bordered to the south by the Hamilton Highway, to the north by Woorndoo–Dundonnell Road, to the east by Six Mile Lane and Darlington–Nerrin Road and to the west by the Hamilton Highway and Salt Creek.

The majority of the project is within the Farming Zone (Moyne Shire), with some areas of roadside within Road Zone. No overlays relevant to flora and fauna are located within the study area.

The project is within the Victorian Volcanic Plain Bioregion, and the surface geology is the result of quaternary basalt flows, with small areas of more recent alluvial sediments (derived from basalt) around lakes and waterways. The most recent basalt flows, which are confined to the northern section of the study area, have formed complex stony rises, interspersed with low-lying areas and wetlands. Older basalt flows in the southern section of the study area have weathered to an undulating or flat landscape.

Most of the project area has been cleared of native vegetation and is currently managed for grazing and cropping. However, areas of remnant native vegetation persist within the stony rises, and in low-lying areas associated with depressions and drainage lines. Several roadsides within the wider area are known to support high-value native grasslands. Very few remnant native trees are present within the turbine development area. Consistent with the highly disturbed nature of the environment, the intensive grazing and cleared land for cropping there are occasional shelter belts of non-native trees.

The project area includes upper reaches of Blind Creek, a number of unnamed tributaries of Stony Creek and Mount Emu Creek and a number of wetlands and farm dams.

The project also includes the proposed transmission line corridor, which extends from the southwest edge of the wind farm, through an area supporting open River Red Gum woodland and a commercial Blue Gum plantation before terminating at the Mortlake Power Station.

The Project site is within the:

- Victorian Volcanic Plain Bioregion
- Hopkins River Basin
- Management area of the Glenelg Hopkins Catchment Management Authority
- Moyne Shire Local Government Area.

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1.2 The Adaptive Management Process and this Plan

As outlined above, the SBWB-AMP is likely to be a key document in the planning permit framework for the Mt Fyans Wind Farm. It logically forms part of the overall Bat and Avifauna Management (BAM) Plan which is reasonably expected to be a condition of a planning permit for the wind farm (but is yet to be developed).

Adaptive Management is a widely used process in environmental management. It is a relevant process to the Mt Fyans Wind Farm project because of the nature of the difficulties in describing methods for managing SBWB impacts and particularly before they are empirically identified and described. To summarise further, adaptive management is a four staged process (Figure 1.1):

Plan - identifying an environmental impact and determining objectives and management strategies.

Do – implement initial management strategies and introduce monitoring to obtain relevant information or data on the impact

Evaluate and Learn - evaluation of these data for evidence of effects or the need for modifications to monitoring, the preparation of trials or tests of potential mitigation strategies

Adjust – if identified in the previous process step (evaluate and learn) implement necessary adjustments to management strategies, monitoring, operational approaches

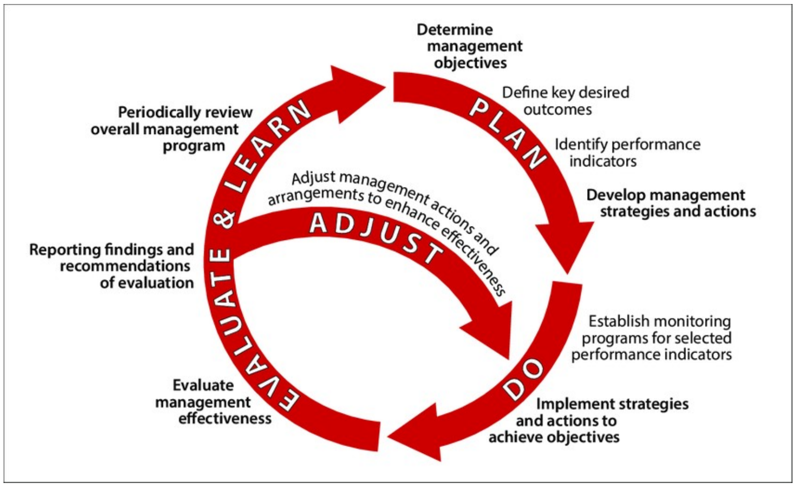

Figure 1.1 The adaptive management process (based on Walters, 1986)

The process is intended to be reiterative and continue for as long as reasonably practicable, with the logical end point being when the impact has been resolved or is sufficiently understood (and does not require further management intervention).

An adaptive management approach for the SBWB is broadly described and committed to in the EPBC Assessment Documentation. This document provides more detail on the overall application of the process to the issue of SBWB impacts from the Mt Fyans Project and expands on the details of the commitments made. Figure 1.2 provides a summary of how the adaptive management plan process will be applied to the issue of SBWB impacts, if they are observed, from the operation of the Mt Fyans Wind Farm.

This document provides additional detail to support the elements of Figure 1.2.

The approach should be considered in the context of current knowledge and management strategies and it is acknowledged that intrinsic to the adaptive management process is review and adjustment, and on this basis, there may be merit in adjusting the current approach.

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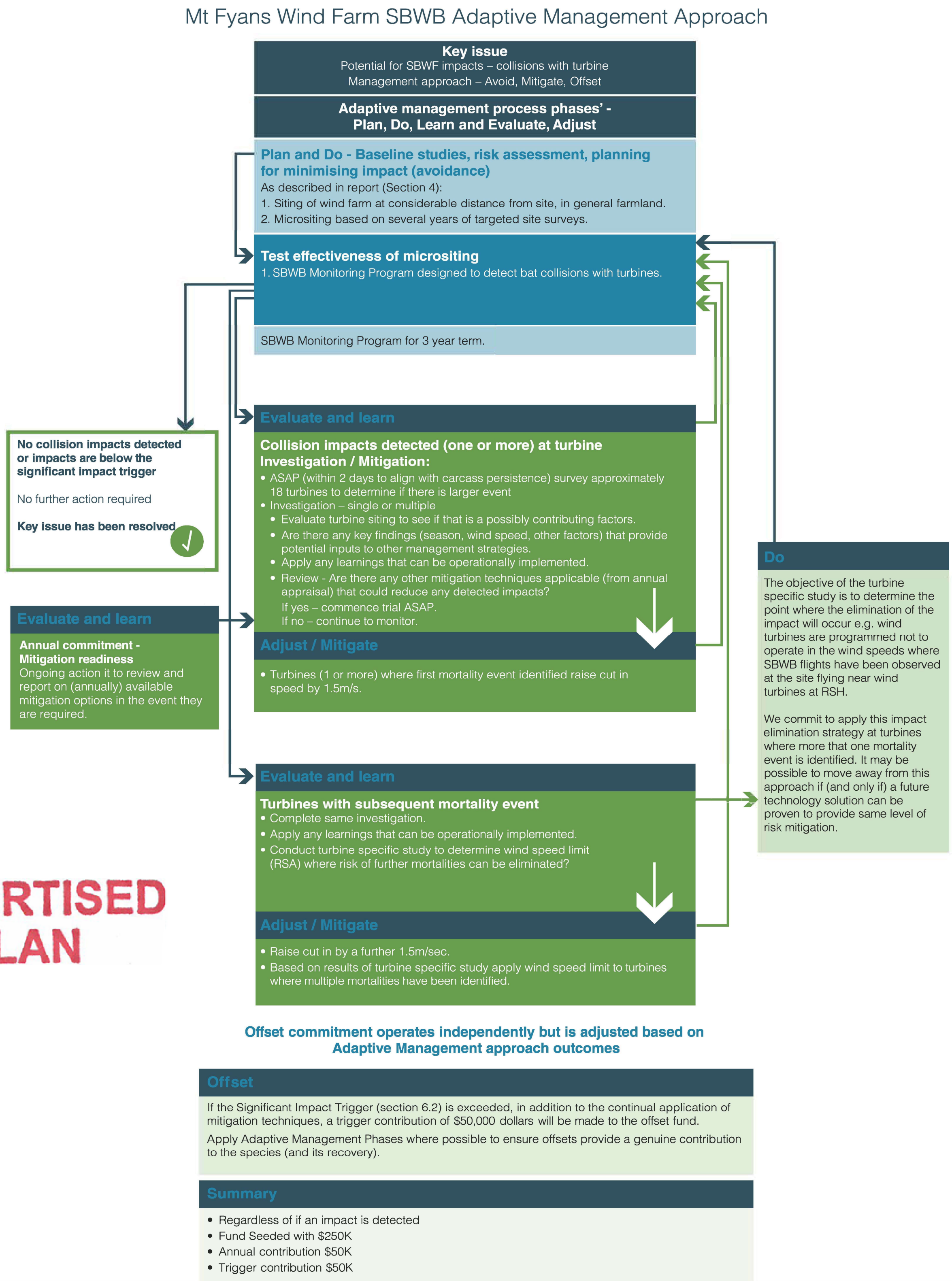

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Figure 1.2 SBWB Adaptive Management process for Mt Fyans Wind Farm

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2. Background to wind energy impacts on Southern Bent-wing Bat

2.1 Southern Bent-wing Bat

The SBWB is listed as critically endangered under both the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Flora and Fauna Guarantee Act 1988*.

The National Recovery Plan (DELWP 2020) provides the following information about taxonomy and distribution of the Southern Bent-wing Bat *Miniopterus orianae bassanii*. The SBWB is recognised as a subspecies of the Common Bent-wing Bat *Miniopterus orianae.* This species was formerly called *M. schreibersii*, however genetic studies reveal that the Australian bats are distinct from the overseas *M. schreibersii*.

Within Australia there are three subspecies of the Common Bent-wing Bat *M. orianae*. The Northern Bent-wing Bat *M. o. orianae* is distributed across the north of Western Australia and Northern Territory; the Eastern Bent-wing Bat *M. o. oceanensis* along the east coast of Australia from Cape York to southern Victoria; and the SBWB *M. o. bassanii* in south-west Victoria and south-east South Australia. The distribution of the SBWB and the Eastern Bent-wing Bat overlap in a portion of western Victoria with both subspecies recorded from four caves in the Otways/Camperdown/Lorne area.

The three subspecies of the Common Bent-wing Bat are morphologically similar but differ genetically and form separate maternity colonies so that they are believed to be reproductively isolated from each other. It is currently not possible to reliably distinguish the SBWB from the Eastern Bent-wing Bat using traditional field-based techniques.

The Conservation Advice for the Southern Bent-wing Bat (subspecies *bassanii*) (TSSC 2021) indicates that its overall population may consist of three subpopulations based on the three known maternity caves at Naracoorte (SA), Portland (Vic.) and Warrnambool (Vic). The appendix to the Conservation Advice provides 2019-2020 count data for adults at the three maternity caves. These indicate that the Portland cave contained a mean total of 1445 individuals; the Warrnambool cave contained a mean total of 15,550 individuals and the Naracoorte cave contained a mean total of 27,265 individuals. The entire adult population for 2019-2020 was estimated to comprise of a mean of 44,260 animals.

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2.2 Detection of bats

Bats are primarily active during the hours of darkness and human observers are generally unable to detect them or accurately document their numbers or most of their activities. Various technological approaches are therefore necessary to detect their presence and activities. These include either detection of bat calls or some method, such as radar scanning, thermal imaging or night-vision equipment that allows bats to be 'seen'.

Some of these technologies, in particular ultrasonic bat call recorders, have been developed into automated systems that can be deployed to collect data for subsequent analysis to determine whether particular taxa occur at a site. Ultrasonic call detectors are applicable for species that emit calls within specified sound frequencies and as a result of the characteristic calls of most echo-locating species, permit the identification of many species. While the calls of the Bent-wing Bat can be distinguished from other species, the calls of the three subspecies cannot be distinguished from each other. Hence in a portion of western Victoria where genetic indicators have shown that the ranges of Eastern and SBWB s overlap, it is not possible to discriminate between them on the basis of recorded calls. As a consequence, in response to the more threatened status of the SBWB , the project has adopted the approach of considering that all Bent-wing Bats documented from the site are SBWB, but it is plausible that a portion of them are Eastern Bent-wing Bats.

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Ultrasonic detectors record calls, but they cannot provide information about how many individuals of any species are present. They provide a sample of calls as they are generally limited by the capacity of microphones which are directional and can detect calls only within about 20 – 30 metres.

It should be acknowledged that there is considerable overlap in call parameters between the Bent-wing bats and other species (particularly three species of forest bats *Vespadelus* spp.), and these cannot always be distinguished from Bent-wing bats. This is as much of a constraint on call identification as the difficulty in distinguishing between the two Bent-wing bat subspecies in southern Victoria.

Radar is capable of detecting flying objects of different size classes but does not have capacity to distinguish different species. Thermal imaging and night-vision gear are both significantly limited by distance, obstacles like trees, and the need for human observers to be present. They also do not generally allow an observer to distinguish between species that are similar in size and behaviour.

2.3 Wind energy and Southern Bent-wing Bat

The National Recovery Plan (DELWP 2020) includes the potential impacts of wind energy facilities as one of nine potential threats to the subspecies. In this regard it says:

> *The impact of the recent proliferation of wind farms within the range of Southern Bent-wing Bat is currently unclear, however, it is possible that any wind farm built close to a significant roosting site could have a major impact on that population. International studies suggest there may be cumulative impacts of wind farms on migratory species in particular, with the impacts greater at particular times of the year and under certain weather conditions (Johnson et al. 2004; Kunz et al. 2007). The risk increases the closer the wind farm is to an important site, particularly a maternity site or migration path. Risks include cave destruction during construction, mortalities due to collisions, and altered access to foraging areas (Kerr and Bonifacio 2009).*

Mt Fyans Wind Farm project will have no foreseeable impact on any known caves or other SBWB roost sites. Possible roosting locations on and near the site have also been investigated for the presence of the SBWB but no new locations were identified. Wetlands, trees and other environmental features that represent potential foraging areas will remain unaltered. The potential for the project to have any measurable impact on the subspecies is confined to fatalities resulting from interactions with the moving blades of the turbine.

The term 'collision' is used here in reference to incidents in which a bat physically strikes, or is struck by, the moving blades of a turbine and to the potential for barotrauma. Barotrauma in bats was described by Baerwald *et al.* (2008) as the fatal effect on an animal's respiratory tract due to its encountering a rapid change in air pressure close to a moving turbine blade. The effect has since been questioned as it has been shown to be difficult to diagnose and may have been confused with traumatic injury associated with direct collisions (Rollins *et al.* 2012).

Two recent reviews provide information about the incidence of wind turbine collisions by SBWB at operating wind farms in Victoria. The aims and methods of the two studies differed in some elements but the data available was largely common to both.

The Arthur Rylah Institute of DELWP published an investigation of bird and bat mortality at operational wind farms (Moloney et al. 2019). Data was collated from post-construction mortality surveys covering the period from 2003 to 2018 for 15 Victorian wind farms. Nine of the wind farms were within the known geographic range of the SBWB. Symbolix (2020a) reviewed all detected bird and bat collisions from 10 wind farms for the period between 2014 and 2019, with a total of 5432 turbine searches and over 14,746 hectares searched for carcasses. The report intentionally does not name the wind farms studied but notes that five of the wind farms included were in south-western Victoria and it would seem likely that those were within the

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distributional range of the SBWB. It is not known what proportion of the searches or total searched area the five sites encompass but given the large size of some of wind farms in that region, it is likely that they contributed a substantial majority of both the number of searches and total searched area covered by the review.

Both reviews document a total of eight detected mortalities of SBWB at 'less than three' wind farms. Given the overlap between the studies and information provided to Biosis by wind energy operators in south-western Victoria, it is understood the same eight records are common to both reviews and that they represent the total of detected wind turbine fatalities for the species until 2019. Those collisions occurred at two wind farms. Biosis is not aware of reports of any collisions by the subspecies since 2019.

It is not possible to know whether, or how many, SBWBs might have collided with turbines and not have been detected. Both Moloney et al. (2019) and Symbolix (2020a) provide estimates of total mortalities calculated from the combined values for numbers of carcasses found; carcass persistence rate; searcher efficiency rate; and the percentage of turbines that are searched. Due to the small number of SBWBs found and variables in the other factors, the resulting estimates are associated with extremely large confidence intervals and no estimate of total collisions for SBWBs can be made for any wind farm where none have been found as collision victims. Moloney et al. (2019) make the point that site-specific factors mean it is not possible to extrapolate from the mortality estimates of one wind farm to predict mortality for any other wind farm.

Moloney et al. (2019) also note that mortality rates are likely to vary markedly between wind farms depending on their proximity to key habitat features such as important cave roosts for SBWBs and other variables. The empirical evidence (as set out in the review studies) to-date bears this out as SBWBs have been found as collision victims at only two of nine (Moloney et al. 2019) and (the same) two of five (Symbolix 2020a) wind farms (within the subspecies range). Importantly, all of sites included in the review study have undertaken substantial regimes for monitoring of collision (5 to 15 years). Further, we understand that the known fatalities comprise one carcass found at a large wind farm and seven found at one small facility. The latter wind farm is at a coastal site and is understood to be within 10 kilometres of caves routinely used by SBWBs.

As indicated by site studies, the Mt Fyans Wind Farm site is subject to levels of SBWB activity that are likely to be similar to those that occur in the broader regional landscape at a distance of 35km from any known non-breeding roost sites.

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3. Aims and objective

The National Recovery Plan for the SBWB (DELWP 2020) states:

> *Any activities that have the potential to significantly impact the Southern Bent-wing Bat should serve as a trigger under the EPBC Act. Recent examples of activities that have the potential to become a trigger include agricultural practices that risk the collapse of the Warrnambool maternity cave, and wind farm developments. The first step in wind farm development planning should be to avoid and then minimise the impact of wind farms on any key areas used by the Southern Bent-wing Bat. These areas would be defined using a risk-based approach. If wind farms are, however, built close to an important site, or potentially within a migration route, then development of mitigating actions and extensive post-construction monitoring is required. As the full extent of the impact of wind farms is not yet known, including cumulative effects from multiple developments, all wind farms within the range of the Southern Bent-wing Bat should undergo rigorous pre-construction assessments and post-construction monitoring, so that any impacts can be detected. Any known roosting caves located within close proximity of wind farms (e.g. within 10 km) should be regularly monitored for changes in population numbers. New techniques for improving preconstruction assessments should be explored and developed, e.g. radar (Gration 2011). All mortality data should be shared between relevant parties so that it can be used to improve scientific understanding of threats to the subspecies. To facilitate this, information from wind farm monitoring should be collated into a central registry.*

In line with the points made by the Recovery Plan, this document has the following aims:

- To provide a rationale and outline an evidence-based method for determining what may constitute a significant impact (and trigger level) on the SBWB population.
- To define management action(s) to be implemented if mortalities of SBWB are identified and if they reach or exceed the significant impact trigger level.
- To provide an overview of measures to avoid and minimise effects on the species that have been incorporated into the design of Mt Fyans Wind Farm.
- To set out the principles, rationale and methods of a comprehensive bat mortality survey program, including details of the survey program and its performance/ capabilities, site-based carcass persistence and searcher efficiency rates.
- To set out mitigation measures that Mt Fyans Wind Farm Pty Ltd commits to undertake if SBWB mortalities are detected.
- To set out procedures for required analyses and periodic reporting of aspects of the plan to regulatory authorities and the wider community.

The primary objective of this Southern Bent-wing Bat Adaptive Management Plan is:

To ensure operations of Mt Fyans Wind Farm do not result in net significant or lasting impacts on the viability or conservation status of the Victorian SBWB population.

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4. Design of Mt Fyans Wind Farm aimed at impact avoidance

Avoidance of potential impacts through landscape-scale spatial planning and site design is considered the most effective primary means of achieving good ecological outcomes. Minimising impacts at the site design level by avoiding areas with a higher level of risk is a secondary measure. The avoidance considerations taken during the development of the Mt Fyans Wind Farm project are set out below and further details and discussion are provided in Biosis (2021b).

4.1 Landscape-scale avoidance

The National Recovery Plan for the SBWB (DELWP 2020) recognises that:

- It is possible that a wind farm built close to a significant roosting site could have a major impact on that population.
- The risk increases the closer the wind farm is to an important site, particularly a maternity site or a migration path.

In southwest Victoria, the majority of non-maternity roosting caves are along the coast in limestone formations. There are also major roost sites in some lava tube caves. The Mt Fyans Wind Farm site is approximately 35 kilometres north of the closest documented non-maternity roost sites at Panmure and Grassmere and 50 kilometres north of the Starlight Cave maternity site.

As indicated by site studies, the Mt Fyans Wind Farm site is subject to levels of SBWB activity that are likely to be similar to those that occur in the broader regional landscape. In terms of broadscale avoidance (regional spatial level), the location of the Mt Fyans Wind Farm project has avoided many of the risks associated with proximity to major roost and maternity sites and their likely associated flight paths. In relation to the location of known maternity and non-maternity major roost sites, this results in a low likelihood of the wind farm site imposing a significant risk. Importantly the site is unlikely to be within or near:

- migration paths associated with annual movements to and from the known maternity roost; and/or
- travel paths associated with movements between known non-maternity roost sites.

4.2 Site-specific avoidance

4.2.2 Avoidance of habitat loss

The development of the Mt Fyans Wind Farm will not entail loss or modification of any important (known or likely) habitats. Therefore, there will be no direct impacts on habitat for SBWB as a result of construction or operation of the proposed wind farm.

4.2.3 Avoidance of potential for collisions

As described in Woolnorth Renewables (2022) and Biosis (2021b), a suite of studies have been conducted to provide an informed view regarding areas of the Mt Fyans Wind Farm site utilised by SBWB. Analysis of the data concluded that the level of SBWB call activity across the proposed turbine areas (open areas of grazing and cropping farmland) is very low. Design of the proposed wind farm layout includes the avoidance and provision of distance buffers around specific habitats, including large permanent and seasonal waterbodies, as described below.

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- The northern section of the site, in the newer volcanic landscape of the Mt Fyans lava-flow, contains a high density of permanent and seasonally inundated wetlands. Based on available knowledge of the species, this area has the greatest potential for foraging by SBWBs. This area has been avoided.
- Buffers of between 800 metres and 1.2 kilometres have been applied to the three areas where the highest incidence of SBWB calls were detected. These are the scoria woodland (Mondilibi Hill), Walmsley Dam and the aquatic herb land (Down Ampney Laneway Paddock).

The design of Mt Fyans Wind Farm has also been determined by the allocation of turbine-free buffers from wetlands used for breeding and flocking by Brolgas *Antigone rubicundus*. In accordance with Department of Sustainability and Environment (2011) and as specified in Biosis (2021a), three Brolga breeding wetlands exist within or overlapping the boundaries of properties of the wind farm. In addition, the design has avoided any turbines within specified distance of three Brolga flocking wetlands to the north-east of the site. The buffers from these wetlands will also serve to protect SBWBs.

- The wind farm has been designed to have no turbines within 1134 metres of three Brolga breeding wetlands within or overlapping the boundaries of properties of the wind farm.
- The wind farm has been designed to have no turbines within 5 kilometres of Lake Barnie Bolac, Long Dam and Lake Sheepwash that are all Brolga flocking wetlands to the north-east of Mt Fyans Wind Farm.

Many wetlands in the region have been modified and some have been permanently drained. In order to determine which further waterbodies may represent reliable foraging and drinking resources for SBWBs a study was undertaken by CPU Australia (2021). It scrutinized publicly available water observations from space (WOfS) datasets available from Geoscience Australia for the entire past 32-year period to assess the likelihood of water bodies occurring within the project site. The analysis of the WOfS dataset using frequency of surface water provides a reliable indication of the position of semi-permanent and ephemeral waterbodies within the Mt Fyans project site. It was deemed appropriate to consider that all bodies of water should be buffered if they have a frequency of surface water greater than 30% of records over the 32-year period irrespective of the seasonal time frame for the period of detection.

Avoidance has been applied to these wetland areas as described below.

- All wetlands that meet the criteria for having retained surface water for greater than 30% of records over the past 32-years (irrespective of seasonality), have been buffered by exclusion of turbines (inclusive of the rotor swept area) from within 200 metres of the maximum recognisable inundation zone. To achieve this buffer, the turbine locations are shown at distance of 300m from the extent of the inundation zone.

4.3 Impact avoidance conclusions

As the location of the proposed Mt Fyans Wind Farm is a significant distance away from all known major roost sites in southern Victoria and does not appear to be a focal site for SBWB, a range of avoidance considerations, including large buffers, have been applied to the proposal and site-based habitat will not be impacted. It is concluded that the Mt Fyans Wind Farm proposal is not likely to pose a significant risk to the SBWB population.

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5. Overview of potential measures to reduce microbat collisions with wind turbines

This section offers a brief review and evaluation of mechanisms that may assist in reduction of turbine collision risk for SBWB s at Mt Fyans Wind Farm.

A number of methods have the potential to reduce the incidence of microchiropteran bats colliding with turbines by acting pre-emptively to reduce collision risk to bats (by curtailing or pausing turbine operation).

These methods fall into three broad categories and include:

- Setting the minimum wind-speed at which turbines begin to operate (turbine 'cut-in' wind-speed) at a level above the range of wind-speeds during which the species of concern spends most time in flight. This approach is termed 'low wind-speed turbine curtailment'.
- Using methods that may actively dissuade bats from approaching turbines.
- Technology designed to detect bats in proximity to a turbine and shut it down until the bat has moved way.

The great majority of these methods have never been applied to wind turbines in Australia and other than one study of low wind-speed turbine curtailment for a number of microbat species, there is no empirical information that is directly applicable to SBWB. A detailed review of various techniques under these three categories is provided in Appendix 1.

The review is specifically intended to assess the applicability of potential methods for the SBWB at Mt Fyans Wind Farm.

5.1 Summary of potential mechanisms to reduce collision risk

As detailed in Appendix 1, the potential applicability of various mechanisms can be summarized as follows:

- Use of low wind-speed turbine curtailment of selected turbines when SBWBs are most active may be applicable to reduce collision risk for the subspecies.
- Some methods intended to deter bats from approaching wind turbines have been tried overseas. Due to the entirely experimental nature of these possible deterrent techniques, they will not be included in the SBWB-AMP at Mt Fyans Wind Farm.
- Current information suggests that systems for turbine shut-down and re-start triggered by radar are not applicable to the specific and individual requirements for reduction of collision risk for SBWBs at Mt Fyans Wind Farm.
- Current limitations on systems for turbine shut-down and re-start triggered by ultrasonic bat calls due to inability to obtain consistent, accurate identification of SBWB; call-detection distance relative to size of turbines; and time taken for turbine shut-down, indicate that such systems do not have capacity to achieve meaningful reduction of collision risk for the species.
- Systems using thermal imaging and acoustic sensors do not offer the capacity for targeted, species-specific automated shut-down and re-start of turbines and are not applicable to reduction of turbine collision risk for SBWB.

On the basis of the review, low wind-speed turbine curtailment could be adopted (if required) and further assessment of this is provided below.

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5.2 Low wind-speed curtailment for microbats

A number of investigations overseas have demonstrated that flight activity of small species of bats is concentrated on periods when wind-speeds are relatively low (e.g. Arnett et al. 2010; Arnett 2017; Martin et al. 2017). Analysis of SBWB call activity data and comparison with on-site wind data concluded that at the Mt Fyans Wind Farm site, 96% of SBWB activity occurs under 7.0m/s and is not significantly influenced by wind speed up until 7.0 m/s. This was observed at both foraging and open farmland (habitat) sites. Once wind speed increases and exceeds 7.0 m/s there is a rapid decline in activity with no activity recorded above 9.5 m/s. This is shown in Fig 4.1 being the result of SBWB recorded call activity correlated with wind speed over 770 nights of data (multi-year/season).

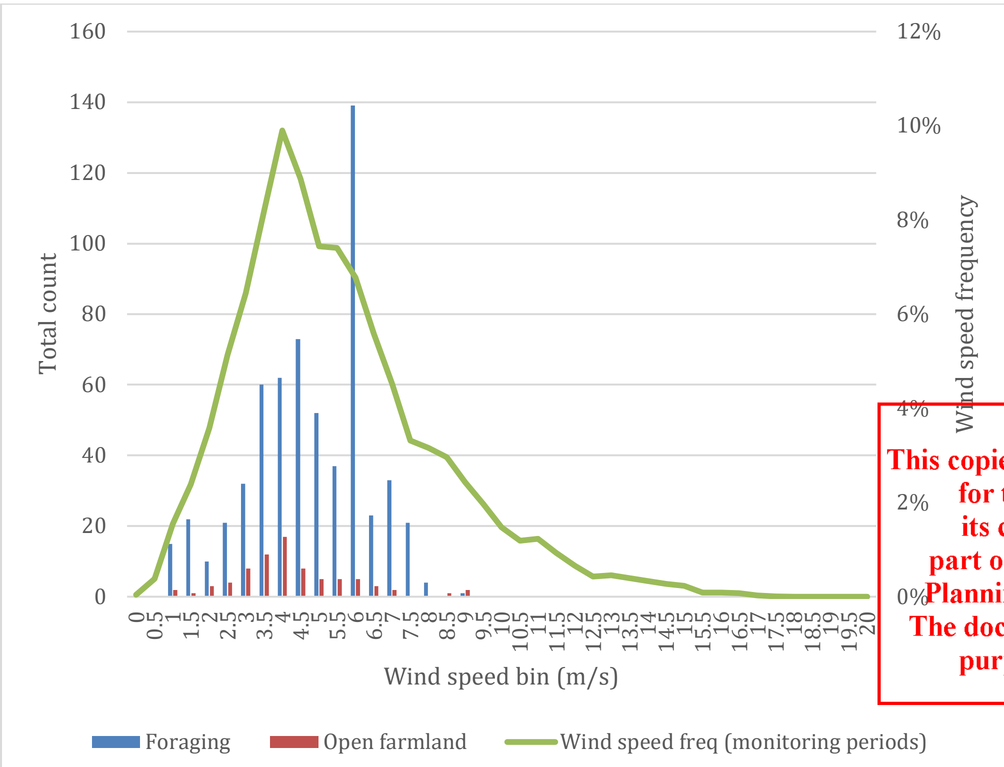

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Figure 5.1 Comparison of SBWB recorded call activity 2017–2018 survey periods vs wind speed

Modern wind turbines commence rotation of the blades only once the wind speed reaches an average of above 3.5 metres per second (m/s). The rotation (RPM) is relatively constant but as wind speed increases, the RPM also increases (marginally) until a wind speed of approximately 11 m/s. Above 11 m/s, the RPM is then constant until blade rotation ceases at approximately 25 m/s.

In recent years various studies have investigated whether a reduction in bat fatalities due to turbine collision can be achieved by the relatively simple measure of programming the turbines to alter their night-time operation so that their rotors/blades do not turn during periods of specified low wind-speed when many species of bats are most active (Arnett et al. 2009; Arnett 2017, Forcey et al. 2016). This is termed 'low wind-speed turbine curtailment'.

The majority of published studies of low wind-speed curtailment have been undertaken in North America and the species primarily involved have been migratory, tree roosting bat species with relatively high incidences of collisions. Low wind-speed curtailment has been demonstrated to be an effective operational measure to reduce fatalities of these bats by up to 50% when turbine cut-in speed was increased from manufacturers' rated cut-in speed by at least 1.5 m/s (operational commencement at wind speeds of 4-5m/s).

5.2.2 Low wind-speed curtailment for Southern Bent-wing Bat

A single investigation of low wind-speed turbine curtailment involving SBWB has taken place in Australia. The following information has been made available courtesy of Pacific Hydro who sponsored the study.

The investigation is described in Bennett (2021). In summary, the study was designed to explore the potential effects of low wind-speed curtailment of turbines on the incidence of collisions by microbats, including SBWBs. The study took the form of a 'before : after' experiment involving all 11 turbines at Pacific Hydro's Cape Nelson North Wind Farm. Among other species, a small number of SBWB mortalities had occurred at the wind farm. The 'before' component related to a period from January to April of 2018 prior to curtailment, while 'after' related to the same months of curtailment in 2019. During the 'before' period turbines were permitted to operate normally (from 3.0m/s). During the 'after' portion of the trial, curtailment was applied between dusk and dawn, triggered by wind conditions. Turbines were not permitted to turn until the average wind speed reached 4.5 m/s (an increase of 1.5m/s to the normal operational rated cut-in wind speed).

In addition to curtailment and carcass searches throughout the experiment, bat call activity was documented for the duration to permit comparison of the rates of bat activity at the site.

The study documented 30 mortalities of eight species of microbats during the 'before' period. This included two SBWBs. During the 'after' curtailment period a total of 16 mortalities of four species of microbats were recorded and they included a single SBWB. The report also noted that general bat activity levels as indicated by call rates, were comparable or even a bit higher in the "after" curtailment period.

An important qualification is that the Cape Nelson North Wind Farm is remarkably different than the proposed Mt Fyans Farm site, particularly with respect to its location to known breeding sites. The level of bat activity and collision risk is therefore likely to be different. On a 'calls per night' basis, studies done at Mt Fyans Wind Farm site revealed an average of 0.51 calls per night compared with 4.5 calls per night at Cape Nelson North Wind Farm.

It is important to recognise that the positive result achieved through low wind speed turbine curtailment at Cape Nelson North Wind Farm was at a site where the SBWB activity levels are significantly (9 times) higher that at Mt Fyans and potentially the associated collision risk is likely to be also higher. Whilst low wind speed curtailment is also expected to be effective at Mt Fyans the degree of effectiveness is yet to be determined.

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6. Determining Significant Impact on Southern Bent-wing Bat

Moloney et al. (2019) point out that it is useful to distinguish the terms 'effect' and 'impact'. They quote Masden et al. (2010):

> *"An impact is the ultimate change due to an effect, with the effect being the proximate response of an individual to an action."*

This distinction is of particular relevance in the present context, where a turbine or a wind farm may have an effect on individual bats, but the focus of impact assessment is on changes that may reduce the species population.

As noted in the Conservation Advice for Southern Bent-wing Bat TSSC (2021), the subspecies is known to breed at three geographically separate maternity caves and while some mixing may occur, these may represent three discrete subpopulations. While any impact due to Mount Fyans Wind Farm may ultimately influence the SBWB population, DELWP have specified that the project impact assessment should be confined to the SBWB subpopulation using the Warrnambool maternity cave and DELWP have further advised the population-estimate to use is 17,000 (mean based off the 16,000-18,000 range). This approach offers capacity to evaluate effects at the local level.

There is no available mechanism to predict whether collision mortalities of SBWB may occur at Mount Fyans Wind Farm, nor, if they do, how many mortalities might occur. Mathematical collision risk modelling is not applicable to bats because it is not possible to detect or quantify numbers of bat flights that are pre-requisite to use of that approach.

Regulatory policies for both Victorian and Australian Government planning processes clearly indicate that the level of impact that may be considered to be significant is based on the measure of change that might be experienced by the population of a threatened taxon. This 'population' approach is ecologically meaningful as it responds appropriately to the size of the population of concern. Regulatory policies offer some guidance for what may constitute a 'significant impact' or a 'significant effect' on a threatened species.

While it has been determined that the Mt Fyans Wind Farm is not subject to an Environmental Effects Statement under the Victorian *Environmental Effects Act 1978*, the *Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978* (DSE 2006) set out the following criterion related to threatened species for what may constitute a 'significant effect on the environment':

- Potential long-term loss of a significant proportion (1 to 5 percent depending on the conservation status of the species) of known remaining habitat or population of a threatened species within Victoria.

Policy statements issued by the Commonwealth for the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) do not quantify significant impacts numerically or as a proportion of population size for most taxa, including threatened bat species.

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6.1 Population Viability Analysis

Mathematical population models are designed to explore influences on the demographic functioning of an animal population. Population Viability Analysis (PVA) is a demographic model that has had wide application. It was developed as a means to evaluate negative or positive influences on threatened wildlife populations (Gilpin & Soulé 1986), including deleterious human impacts and positive conservation measures. A demographic modelling approach offers a transparent and robust method for testing the potential effects of turbine collisions on the SBWB population. Estimates of the effects on extinction risk (or quasi-extinction risk) for the population can be ascertained by the use of population viability analysis (PVA).

As with all numerical modelling, PVA requires values for various input parameters. For PVA, these include demographic information for the size of the population, adult sex ratio, mean generation length, age- and sex-specific mortality rates, density dependence and measures of stochasticity for relevant values.

The SBWB Recovery Team recently undertook PVA for the subspecies to evaluate some impacts other than wind energy (TSSC 2021). The Appendix to the Conservation Advice (TSSC 2021) sets out the majority of parameter values used for that analysis. This approach has been made possible on the basis of newly available demographic information for the Southern Bent-wing Bat from investigations by van Harten (2020).

Mt Fyans Wind Farm Pty Ltd proposes to use PVA is to test the potential effects of SBWB mortalities due to operations of Mt Fyans Wind Farm on population extinction risk over the intended 30-year life of the wind farm. In light of the fact that wildlife populations have natural capacity for variation and because potential rates of mortality due to the wind farm are not known, the purpose of PVA will be to test various rates of additional mortality due to the wind farm in order to discern a rate that would have a deleterious impact on viability of the population within the relevant timeframe. This rate will be identified to represent a 'Significant Impact Trigger' on the population. In order to ensure that PVA to be run for the Mt Fyans project conforms with the analysis undertaken by the SBWB Recovery Team, Mt Fyans Wind Farm Pty Ltd proposes to use the same PVA program (Vortex 10.3.6.0) and with inputs, settings and background parameter values tailored for the purpose described above. The PVA will be completed prior to commissioning and the results reported to the Responsible Authority (s). It is proposed that various annual mortalities of between 1 and 50 SBWB will be run in PVA for this purpose.

6.2 Southern Bent-wing Bat PVA derived trigger thresholds for Mt Fyans Wind Farm

Results of the planned PVA will be used to determine the Significant Impact Trigger. It is the responsibility of the Mt Fyans Wind Farm operator to remain below the Significant Impact Trigger level to ensure that viability of the population does not decline as a consequence of mortalities occurring at Mt Fyans Wind Farm. In order to ensure that SBWB mortalities at the Mt Fyans Wind Farm do not result in impacts that would significantly impact viability of the population, the adaptive management approach (outlined in Figure 1.1) will be followed.

As outlined in Section 7 of this Plan, the SBWB Monitoring Program is designed to detect SBWB mortalities. In the event that the monitoring program detects any SBWB mortalities (due to collision with turbines) and reaches the Significant Impact Trigger, the approaches set out in Sections 9 and 10 of this Plan will be applied.

The impact of the wind farm on the Victoria population of the SBWB will be continuously calculated based on detected SBWB mortalities and the resulting estimate statistically determined by the search regime. One or more SBWB mortalities will result in a range (confidence / credible interval) of estimated mortalities along with a mean annual estimate. The Annualised Impact Assessment is the measure of estimated annual mortalities using the mean of estimated annual mortalities derived from the search regime and this will be compared with the Significant Impact Trigger as described above.

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7. SBWB Monitoring Program

7.1 Turbine bat mortality searches

A SBWB Monitoring Program will be implemented during the operational phase of the project to determine the incidence of SBWB mortalities due to collision with turbines, evidenced by the presence of bat carcasses (within the defined search areas). The carcass searches, although designed and targeted at identifying SBWB collisions with turbines, will also detect other species of avifauna. The program is designed to allow estimates of fatality rates for the SBWB (and other species) to be calculated for the wind farm and/or for individual turbines.

It is well recognized that any bat (bird) mortality monitoring program will not detect all carcasses. Factors such as carcass persistence and searcher efficiency influence the probabilities of detection and the estimated range of mortalities based on what is detected. It is necessary to have a clear understanding of the factors that influence the probability of detection and design a mortality search regime accordingly. As well as carcass persistence and searcher efficiency, the search regime chosen has to be sustainable and feasible. Whilst it may be desirable to provide 24/7 monitoring of turbines to detect any mortalities, this is neither sustainable nor feasible. Practical matters such as limited resources to conduct searches, access to land, and allowance for downtime such as due to extremes of weather, all need to be factored into the design of the search regime.

The mortality monitoring program has been developed based on expert advice and consultation with Symbolix, considering the project parameters, other relevant factors and the programs objective. Their report is attached as Appendix 2. Symbolix (Appendix 2) evaluated a range of possible options with a view to determining a search regime that is feasible to implement in practice and that improves the precision of total mortality estimates. Two search regimes were analyzed:

1. One-third of turbines are searched each month. In September - May, there is a standard survey (95m radius) followed by a pulse survey (70m radius) two days later. In June/July/August, only standard surveys are performed. This search regime results in 609 searches events each year.
2. 100% of turbines are searched each month. In September - May, half of the turbines have a standard survey (95m radius) followed by a pulse survey (70m radius) two days later, whereas the other half of the turbines have a standard survey only. In June/July/August, only standard surveys are performed. This search regime results in 1,407 searches events each year.

Note – surveys are more intensive in the months September to May inclusive, being the period when bat activity is likely to be highest and when condition of wetlands/ water bodies adjacent to the MFWF site may be conducive to an increased level of bat utilisation

The second option is a significantly greater and intensive search method/effort than the first option. It should be recognized that the majority of search regimes currently operating at other wind energy facilities in Victoria are aligned with the first regime.

A well-known and respected consulting firm, that specialises in conducting avifauna surveys utilising specially trained search dog, has provided advice on implementing each of the survey regimes described above. Option 1 requires search teams being on-site for one week every month, or one quarter of each year. Option 2 requires multiple search teams being on-site for two weeks every month or one half of each year. Option 2 represents the most extreme search regime that can be practically implemented and sustained.

Mt Fyans Wind Farm Pty Ltd explored, with both the canine survey consultants and Symbolix the potential for even more intensive search regimes. Both companies advised that there are practical and statistical

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limitations with any program. From a practical perspective there are resource limitations and option 2 (Table 7.1) represents the practical limit for a program (that can be implemented consistently and compliantly). From a statistical perspective, even if all turbines were surveyed daily, the detection probability does not reach over 80%.

Mt Fyans Wind Farm Pty Ltd proposes implementing search regime 'Option 2' which is a substantial commitment and from a practical perspective is at the upper limit of being able to be delivered in a compliant manner and sustained across multiple years (as is proposed).

The intensity of search regime Option 2 is designed to minimise the influences of variables (e.g. carcass persistence rate; searcher efficiency etc.). The resulting confidence intervals associated with total mortality estimates are substantially improved over that of Option 1. Symbolix (Appendix 2) provides the following calculated results for both survey designs.

Table 7.1 The overall probability of detection and the median and 95% confidence interval for the mortality estimate (given one carcass found in one year of surveys) for both search regimes.

Search Regime	Probability of Detection of one SBWB mortality	Median	95% Confidence Interval on finding one SBWB mortality
Option 1	0.09	18	Range of 2 to 65
Option 2	0.20	8	Range of 1 to 24

The following section provides further detailed description and justification regarding the chosen search regime.

7.1.2 Search zone

To ensure that the survey regime is capable of detecting all SBWB mortalities due to collision with turbines, carcass searches will cover the entire estimated 'fall zone'. It is acknowledged that a small number of carcasses may be moved by scavengers to an area outside the 'fall zone' and this is a consideration difficult to overcome and is noted as a factor influencing the survey design's performance.

Hull and Muir (2010) have calculated the fall zone distribution for bats using physics-based ballistics equations. A key input to this methodology is the size envelope of the wind turbines that are being applied for under the Mt Fyans Wind Farm planning application (120m hub height, 80m blade length, maximum tip height 200m).

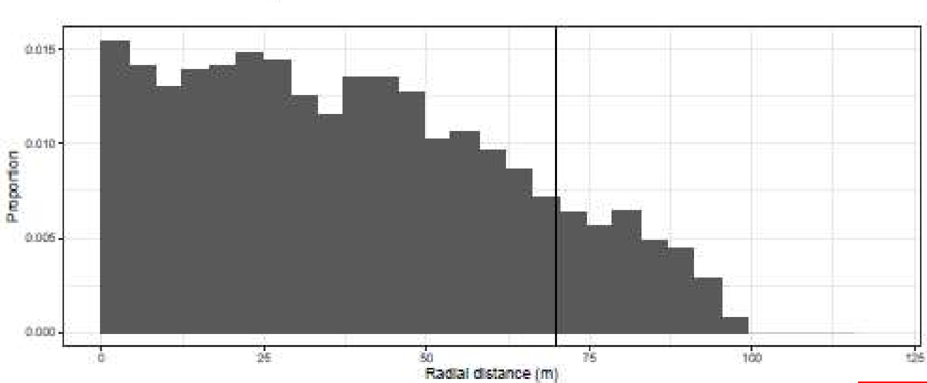

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Figure 7.1 Fall zone distribution for bats (vertical line represents 70m) based on likely wind turbine size.

The results are summarized as:

- Minimum search radius of 70m achieves a modelled estimated performance of 87%.
- There is a noticeable, disproportionate gain by searching beyond a 70m radius to 100m radius. It is calculated to be an increase in carcass detection of 13% despite an increase of 205% in the area being searched. i.e. search area is doubled.
- A search radius of 95m achieves a modelled estimated performance of 100%.

For reference and additional justification, Huso and Dalthorp (2014) compared five estimators for the relationship of carcass density to distance from the base of towers of current generation wind turbines. Their estimators were based on empirical data from three search regimes at two wind farms in the U.S.A. For all five estimators tested they found that density of carcasses approaches zero at about 70 metres from the turbine base. That is, the proportion of carcasses diminish with increased distance from a turbine tower while the radial area to be searched very substantially increases with increased distance from the tower. There is thus a sharp decline in return for search effort as the radial distance increases (Huso and Dalthorp, 2014).

For most bat/bird survey programs the size of zones to be searched provides a balance between capacity to detect the majority of carcasses and diminished return for effort in searching a zone that is too large and, in the extremities, where carcasses become increasingly rare. Huso and Dalthorp (2014) and Hull and Muir (2010) provide a sound basis for understanding that density of carcasses will not be evenly distributed below a turbine and that, as a general rule, density will decrease with increased distance from the turbine tower.

On the basis of the analyses of Huso and Dalthorp (2014) and Symbolix (2021) a search zone of 70m is expected to encompass (>87%) of carcasses for the dimensions of turbines at Mt Fyans Wind Farm. The survey regime selected for the Mt Fyans Wind Farm will cover the entire modelled fall zone.

Despite the studies and analysis stated above being based on a search radius of 95m, for practical reasons the maximum extent for primary surveys will be set at 100m radius from the wind turbine tower. Secondary and pulse surveys shall be conducted to maximum extent of 70m radius from the wind turbine tower.

7.1.3 Search method

Trained dogs have been shown to be significantly more efficient than humans at detecting carcasses of bats (Mathews et al. 2013; Bennett 2015; Moloney et al 2019) and all carcass searches at Mt Fyans Wind Farm will be implemented by the use of trained dog and handler teams. Ground cover in search zones will vary but this may not present a significant limitation of searches using dogs. All turbines will have a hardstand area and a road on which visibility is expected to be high. Visibility in areas of crops and pastures is expected to vary seasonally and when ground cover is high and dense it is likely to make detection of carcasses difficult. The percentage of searchable area is likely to be reduced when crops reach a certain height and the search area may then be limited. The use of dogs will assist in managing the effects of ground cover which is expected to change from season to season and year to year.

Each search will extend to a radius from the tower as described in Table 7.2. A small GPS unit will be attached to the dog's collar to record all tracks taken by the dog during searches. Using dogs obviates the need for formal transects to be established in the search zone, which are required when using human observers.

In all cases, where a search area is limited or restricted during any session, that detail will be recorded for input into statistical analyses. Limitations to search areas are common to many wind farms and Huso and Dalthorp (2014) and Huso et al. (2017) provide sound approaches to accounting for search restrictions.

7.1.4 Turbines to be searched, search duration and frequency

The regime of carcass searching will commence after all turbines are commissioned and become operational at the wind farm, represented by the Commercial Operation Date. Once the program commences, Table 7.2 summarises the months of the year when primary and secondary surveys are undertaken and the months of the year when just primary surveys are conducted.

Surveys will be conducted for a minimum of 36 months and will not cease until the reporting obligations outlined in section 10.3 have been fulfilled and the Responsible Authority (s) has approved surveys to cease (or be modified). 36 months is selected as the initial survey program period on the basis it will be provided sufficient data for analyses as well as adequately sample year to year and seasonal variations.

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Table 7.2 MFWF Survey Regime Timing and Distribution

Timing	Primary survey – 100m	Secondary/pulse survey – 70m*
September to May inclusive	100% of wind turbines each month	50% of wind turbines each month#
June to August inclusive	100% of wind turbines each month	No secondary or pulse survey

All turbines randomly distributed into two groups. Groups will alternate from month to month to ensure the application of a pulse survey regime is applied as evenly as possible across the initial 3 years program period.

* The selection of 70m for the Secondary survey is justified by the modelled performance indicating 87% of bats will be detected by searching this radius.

Two important factors have informed the frequency and timing of the surveys. They are when site conditions influence bat activity and carcass persistence rates.

Site conditions

Bat mortality surveys are conducted more intensively in the months of September to May (inclusive). This period is intended to cover the times of the year when bat activity is likely to be highest and when condition of wetlands/ water bodies adjacent to the MFWF site may be conducive to an increased level of bat utilisation. Conversely, June to August (inclusive) is surveyed less frequently as it is thought likely to be a period of low bat utilisation.

Scavenging rates/ Carcass persistence (see also sections 7.2 and 7.3)

Experience suggests that carcasses of bats will be scavenged quickly at the site. Symbolix (2020) found that evidence of microbat carcasses in Victoria was lost after an average of 2.69 days. Carcass persistence trials will be undertaken during the course of the mortality monitoring program, particularly to inform analyses required to extrapolate from numbers of carcasses detected to estimate the total number of collisions. In order for the search regime to accommodate the likelihood of rapid scavenging, a secondary/pulse survey will be undertaken during periods of the year in which SBWBs are thought to be most active (September to May). This secondary survey will be scheduled to be undertaken between 2 and 3 days of the primary survey. This approach provides good capacity to determine frequency of collisions, because there is a high probability that a carcass found on the second of the two searches must have collided in the preceding two days.

7.1.5 Carcass & data collection & management

During all searches, all species of bats detected as full or partial carcasses, will be recorded on a digital or hardcopy form designed for the purpose. All information, including metadata, for each turbine search will be recorded irrespective of whether a carcass is found during the search. All data will be entered into a single (backed-up) database to be maintained by MFWF. Raw data will be available to Responsible Authorities on request.

On finding a carcass, it will be photographed in situ and its location will be logged using a portable GPS device. Carcasses of all taxa, whether listed species or not, will be collected, labelled with relevant data details and frozen to allow any necessary investigations of cause of death and/or for use in future searcher efficiency or persistence trials. A freezer for this purpose will be available on-site. As required all specimens will be made available to Museum of Victoria.

Carcasses found of common species may be used later for scavenger trials. To avoid human scent being imparted to a carcass (and potentially influencing scavenger trial results), and for health and safety reasons, gloves will be worn when handling carcasses.

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Summary of formal SBWB mortalities monitoring program

In summary, carcass searches will be undertaken as follows:

- A monthly survey of all wind turbines will be conducted.
- These monthly primary surveys will search an area 100m radius from the turbine base.
- The survey regime considers and responds to site conditions and bat activity. During the months of September to May (inclusive) surveys will be repeated (conducted twice) within a two-three day interval of the primary survey. These secondary surveys will be conducted out to a 70m radius from the turbine base.
- Surveys will take into account carcass persistence (see section 7.2).
- Surveys will be conducted by trained dogs and handlers (searcher efficiency trials will be conducted as outlined in Section 7.3) to increase detection capacity.
- Data will be recorded to document survey effort as well as details of carcasses found. Carcass will be retained and where required made available to third parties (Museum of Victoria).

7.2 Carcass persistence trials

Trials to determine persistence time of carcasses are required to derive correction factors necessary to estimate total fatalities from the results of the carcass searches. These trials are often termed 'scavenger trials'. Carcasses are likely to be removed by scavengers and will also naturally deteriorate over time. Symbolix (2020a) found no significant difference for microbats, between study sites, in mean time of carcass persistence or searcher efficiency for wind Farms in Victoria. They concluded that the rates they determined for those values can be validly applied for similar sites and species. Nonetheless, for the purposes of assessing effects on SBWBs, it is prudent to undertake site-specific carcass persistence trials for two years at Mt Fyans Wind Farm.

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For the trials to closely simulate the circumstance of actual collision mortalities, carcasses for use in the trials will be as fresh as possible and representative of species that occur at the Mt Fyans Wind Farm site. They may be sourced from collision carcasses previously collected at the site and frozen, or from other appropriate sources. It is not expected that SBWB carcasses will be available for this purpose, but other species of microbats will ideally be included in the trials. The source of carcasses is not currently known, and availability will be determined closer to the time of the trial.

The details of the carcass persistence trials are:

- Two carcass persistence trials will be undertaken to coincide with periods of high ground cover, hot, dry and low ground cover, cold, wet.
- In each trial, Symbolix (Appendix 2) advises that 20 carcasses including specimens of various sizes of birds (n.10) and bats (n.10) are required.
- Carcasses will be placed at predetermined, randomly selected turbines. The exact location of the carcass will also randomly selected (direction and distance from the tower - <100m).
- It is necessary for the trial to sample the range of environments/habitats across the wind farm site.
- Remote cameras will be used to record persistence of carcasses placed for the purpose of the trials.
  - Cameras will be set to take a photograph every hour (day and night) for each carcass and they will also be set to be triggered by movement and/or infra-red detection.
  - This method has been demonstrated in Victoria to be highly efficient and substantially reduces potential influence on scavengers that may occur when human observers visit frequently to check carcasses.
  - Cameras are deployed and left to operate for the duration of the trial and this entails substantially less effort than having people check carcasses daily.
  - Cameras triggered by movement have the additional advantage of recording the precise time of carcass removal and the species of scavenger that removes a carcass. As a result of the precise documentation of the time of carcass removal, where the camera detects the removal successfully, there is no need to estimate the period of carcass persistence which is required when carcasses are checked only at intervals of several days.
  - Right-censored analysis will be required to account for any carcasses that persist beyond the trial period to ensure they do not bias results of the trials (Klein & Moschberger 2003).
- Carcasses used for trials will be individually marked to ensure they are not confused with collision carcasses. Individual marking allows trial carcasses to be identified if they are simply moved by scavengers.
- Each trial will be run for up to one month, but cameras will be checked after two weeks to check on their operation and at that point the trial may be terminated if the carcass has been removed or a second carcass may be placed to increase the sample size of the trial.

The results of these trials will permit average carcass persistence times to be determined for each class size and SBWB microbats. The resulting persistence rates will be used in analyses to estimate total numbers of collisions. The statistical method used to derive scavenger rates will follow commonly accepted international best practice at the time.

A trial methodology will be documented prior to the trial commencing to cover off technical and practical aspects of the trial.

7.3 Searcher efficiency trials

As outlined above, dogs and handlers will undertake the carcass searches. This is because the search efficiency of dogs is typically around 84% and is much greater than human observers being typically around

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52% (as described in Appendix 2). Although dogs have a high rate of efficiency, they do not routinely find all carcasses. Therefore, it is necessary in to ascertain the efficiency of searches in order to determine and apply appropriate correction factors for carcasses missed to inform estimation of total collision mortality for species of concern.

The efficiency of each dog or person undertaking searches will be tested through a dedicated trial. Two trials will be undertaken in each year of the monitoring regime, one in each of spring and autumn. Symbolix (Appendix 2) have advised that 20 samples/carcasses are required for each trial and this will permit the detection efficiency of searches to be determined. Other relevant aspects of the trial:

- Carcasses for the trials will be sourced from bird and bat carcasses found at the site or from other appropriate sources.
- Species used will be representative of the bird and bat fauna of Mt Fyans Wind Farm.
- Carcasses of microbats will be included in the trial.
- Carcasses used for the purpose will be marked to ensure they are not confused with previously undetected collision carcasses.
- New search personnel or dogs employed to undertake searches must also evaluated by a searcher efficiency trail as detailed here.

A trial methodology will be documented prior to the trail commencing to cover off technical and practical aspects of the trial.

Explanatory note on Blind Trials

Blind trials are often used for searcher efficiency trials in order to provide the most representative approach to testing searcher efficiency. There are however a range of practical reasons as to why blind trials are difficult to implement and Symbolix (Appendix 2) advise against blind trials for two very rational reasons:

- In a searcher efficiency trial, there is a higher density of carcasses than by chance due to turbine fatalities – so it will be obvious to the searchers.
- Carcasses cannot always be procured in sufficient numbers to match the species profile of the site

7.4 Incidental finds of bat carcasses

It is possible that during the life of the wind farm, bat carcasses will be discovered incidentally by site personnel. Therefore, all site personnel will be trained on procedures for the event in which they encounter dead or injured bats. Upon incidental discovery, carcasses must be photographed *in situ* and then removed. Notes must be made for consideration to the estimate of annual mortalities during official search regime to guard against the possibility of incidental finds introducing bias into the results. Any member of the site personnel who finds a carcass of a bat must complete the relevant carcass data sheet. Copies of carcass data sheets will be available on site for use by all site staff.

The individual circumstances of any incidental finds that are outside of the defined fall-zones of turbines will be assessed in determining whether they represent turbine fatalities or not. If they are, they will not be included in calculations of total mortality estimates because they cannot be placed within the timing regime of routine searches. However, they will be included in annual reporting as incidental finds.

7.5 Determination of collision mortality rates

Estimates of the number of SBWB turbine mortalities, along with confidence intervals, will be calculated based on mortalities detected during the regime of carcass searches. The estimate will account for the search

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frequency and search area as well as searcher efficiency rates and carcass persistence rates. Analyses will also account for any other variations in turbine searches such as restrictions of areas searched or instances when individual turbines are not able to be searched. Annual collision estimates will be calculated according to best practice, using current published methodologies. Current best practice (2021) for these analyses are provided by Huso (2009, 2010), Huso and Dalthorp (2014) and Huso et al. (2017). In Australia, Symbolix has developed methods and software to undertake this analysis.

The estimate of annual SBWB turbine mortalities is deemed the Annualised Impact Assessment and will be continuously recalculated on a rolling 12-month basis using the mean of estimated annual mortalities derived from the search regime. The Final Impact Assessment will be determined at the conclusion of the survey program and will consider the estimate of annual SBWB turbine mortalities for the duration of the survey program.

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8. Injured bats

Injured birds and bats may be encountered during carcass searches or incidentally throughout the operational life of the wind farm. The present plan is focused on bats. Handling injured bats requires specialist skill as there is the risk of injury to both animals and people and there is potential for disease transmission in some cases. Injured bats will only be handled by person(s) authorised under the Wildlife Act (1975). Mt Fyans Wind Farm Pty Ltd will apply for authorisation of its permanent site-staff. The details of any injured bats found will be recorded and maintained with all other data (see 6.1.6). To reduce the risk associated with Australian Bat Lyssavirus, any injured bats must be handled only by people who have up-to-date inoculation for rabies (an appropriate level of antibodies for the rabies virus, based on vaccination, offers the best available protection against Australian Bat Lyssavirus. See also Australian Department of Health https://immunisationhandbook.health.gov.au/recommendations/people-with-ongoing-occupational-exposure-to-lyssaviruses-are-recommended-to-receive).

Prior to implementation of this plan, arrangements must be made with a conveniently located veterinary surgery to ensure that arrangements are in place for acceptance and treatment of any injured birds or bats. As options for treatment of injured wildlife may change over the life of the wind farm, an arrangement must be kept current and current telephone numbers for the surgery and for Wildlife Victoria Emergency Response Service must be readily available to all site personnel (e.g. on their mobile phones). Where an injured bat can be readily captured it should be placed into a tied calico bag or a box and kept in a quiet and dark location while it is transported to a veterinarian for treatment. In the event that an injured bat cannot be readily captured, site personnel should telephone Wildlife Victoria Emergency Response Service (current telephone number is 03 8400 7300) for assistance.

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9. Trigger Levels and Adaptive Management Actions

9.1 Adaptive Management Process

The adaptive management process will be implemented prior to the wind farm commencing operations to ensure all activities may be started once all wind turbines are operational. Figure 1.2 SBWB Adaptive Management process for Mt Fyans Wind Farm describes the individual steps taken as part of the adaptive management approach and how they are related.

9.1.2 Trigger Level 1

Trigger Level 1 will be reached on discovery of the first SBWB mortality at any of the installed wind turbines on a per turbine basis. Trigger Level 1 is defined as a temporally distinct event i.e. multiple SBWB mortalities on one night are counted as a single event for the purposes of incident investigation and mitigation measures. The resulting actions on a Trigger Level 1 are:

Additional Survey Activity

To gain a greater understanding of the collision activity, and possible SBWB activity on the site, additional surveys shall be conducted.

While the search team is on the site, they will promptly conduct Primary searches at 18 of nearest wind turbines (any turbines defined in the nearest 18 list already surveyed – on the day – will not be surveyed again). The purpose of this survey is to identify if there are any adjacent turbines where mortalities could have occurred. The mortality surveys will be completed in a manner consistent with the 'secondary/pulse survey' approach. Outcomes of the surveys will help to inform the investigation process as described next.

Adaptive Mitigations - Low Wind Speed Curtailment Stage 1

As outlined in Section 5.2, there is evidence currently available that low wind speed turbine curtailment is likely to be a suitable mitigation of wind turbine associated mortalities. On reaching a Trigger Level 1, low wind speed curtailment shall be immediately imposed at that wind turbine such that the cut-in parameters of that turbine will be increased by 1.5m/s between sunset and sunrise for the September to May (inclusive) period(this being the period when bat activity is likely to be highest and when condition of wetlands/ water bodies adjacent to the MFWF site may be conducive to an increased level of bat utilisation). This cut-in wind speed will remain as an operational setting unless evidence determines it is not warranted.

Incident Investigation

An investigation will commence and be concluded at the earliest opportunity. The investigation will seek to assess any relevant attributes associated with the particular SBWB mortality. For example, it will address (but not be limited to):

- Date/time/season of mortality
- Likely wind speed at the time of the mortality
- Other weather variables
- Landscape factors (dry, wet)
- Proximity to habitat type and foraging resource availability
- Proximity to possible SBWB movement corridor
- Proximity and history of other mortalities on the project site
- Proximity and history of wind turbine curtailments
- Update and compare the Annualised Impact Assessment with the Significant Trigger Level

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The investigation will assess all available evidence, as outlined above, and based on the conclusions of the investigation, will make recommendations regarding future actions consistent with the stated aim of the Mt Fyans SBWB Adaptive Management Program. For example:

- Retention, removal, increase or decrease of the curtailment applied to that wind turbine and other wind turbines to determine the efficacy of curtailment measures.
- Other measures to monitor or modify operation of the wind farm and elements of the program including proactive measures such as deterrents and research.

The report will be provided to the Responsible Authority.

9.2 Trigger Level 2

Trigger Level 2 will be reached on discovery of the second and each subsequent SBWB mortality at each of the installed wind turbines, whereby that wind turbine has previously experienced a Trigger Level 1 as a temporally distinct event i.e. multiple SBWB mortalities on one night are counted as a single event for the purposes of incident investigation and mitigation measures. The resulting actions on a Trigger Level 2 are:

Additional Survey Activity

To gain a greater understanding of the collision activity, and possible SBWB activity on the site, additional surveys shall be conducted as described for Trigger Level 1.

Adaptive Mitigations - Low Wind Speed Curtailment Stage 2

As outlined in Section 5.2, there is evidence currently available that low wind speed turbine curtailment is likely to be a suitable mitigation of wind turbine associated mortalities. On reaching a Trigger Level 2, low wind speed curtailment shall be immediately increased at that wind turbine such that, the cut-in parameters of this turbine will be increased by a further 1.5m/s between sunset and sunrise for the September to May (inclusive) period. (This being the period when bat activity is likely to be highest and when condition of wetlands/ water bodies adjacent to the MFWF site may be conducive to an increased level of bat utilisation). This cut-in wind speed will remain as an operational setting unless evidence determines it is not warranted.

If an additional mortality event is identified at a wind turbine where the cut-in wind speed has already been raised by a total of 3m/s, the degree of low wind speed curtailment will be deemed to be maximised and other mitigation techniques are required to be employed.

Incident Investigation

An investigation will commence and be concluded at the earliest opportunity. The investigation will seek to assess any relevant factors associated with SBWB collisions. For example, it will address (but not be limited to):

- Date/time/season of mortality
- Likely wind speed at the time of the mortality
- Other weather variables
- Landscape factors (dry, wet)
- Proximity to habitat type and foraging resource availability
- Proximity to possible SBWB movement corridor
- Proximity and history of other mortalities on the project site
- Proximity and history of wind turbine curtailments
- Update and compare the Annualised Impact Assessment with the Significant Trigger Level

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The investigation will assess all available evidence, as outlined above, and based on the conclusions of the investigation, will make recommendations regarding future actions consistent with the stated aim of the Mt Fyans SBWB Adaptive Management Program. For example:

- Retention, removal, increase or decrease of the curtailment applied to that wind turbine and other wind turbines to determine the efficacy of curtailment measures.
- Other measures to monitor or modify operation of the wind farm and elements of the program including proactive measures such as deterrents and research. For wind turbines that have reached the second Trigger Level 2 (i.e the third SBWB mortality and the maximum amount of low wind speed curtailment has been initiated) additional mitigation techniques must be employed.

The report will be provided to the Responsible Authority.

Turbine Specific Study

As committed to in Figure 1.2 SBWB Adaptive Management process for Mt Fyans Wind Farm, a Turbine Specific Study (TSS) will be undertaken if one turbine has experienced a Trigger Level 2 event. The objective of the Turbine Specific Study will be to:

> ***Determine the point where the elimination of the impact will occur e.g. wind turbines are programmed not to operate in the wind speeds where SBWB flights have been observed at the site flying near wind turbines at rotor swept height.***

The Mt Fyans Wind Farm Operator will implement the measures identified by the TSS and suitable mitigation techniques. The results of the assessment, recommendations and mitigations implemented will be made available to the Responsible Authority.

This strategy is proposed as an approach to eliminate or substantially reduce the likelihood of future mortalities. Monitoring to determine effectiveness of mitigations implemented will be undertaken as soon as practicable, and the recommendations implemented as quickly as reasonably practicable. It may be possible to move away from this approach if (and only if) a future technology solution can be proven to provide a high degree of mitigation.

9.3 Significant Impact Trigger

The Annualised Impact Assessment will be continuously monitored, and the trend closely examined. When the Annualised Impact Assessment is seen to approach, reach or exceeds the Significant Impact Trigger the Mt Fyans Wind Farm operator will implement actions in a manner consistent with the adaptive management process described by Figure 1.2 SBWB Adaptive Management process for Mt Fyans Wind Farm. Refer to the specific actions that are required to respond to Trigger Levels 1 and 2 and the TSS.

It should be noted that actions are taken on each and every mortality identified, in a scaled manner. Specifically, the TSS is proposed (at turbines where more than one mortality event has been identified) to identify the wind speed conditions when SBWBs are no longer observed to be flying at rotor swept height (RSA). This approach is intended to manage and mitigate SBWB collisions and reduce the likelihood of reaching the defined Significant Impact Trigger threshold.

If the Significant Impact Trigger is exceeded, in addition to the continual application of mitigation techniques, a trigger contribution of $50,000 dollars will be made to the offset research fund.

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10. Reporting

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10.1 Report on Discovery SBWB Mortalities

Refer to Chapter 9 regarding Trigger Levels 1,2 and Turbine Specific Studies.

10.2 Annual Reporting

A report will be prepared and submitted to the Responsible Authority within three months of conclusion of the first, second and third twelve-month periods of monitoring. The report will consider the following:

- details of survey, mitigations, analyses and methods employed
- results and analyses
- Update and compare the Annualised Impact Assessment with the Significant Trigger Level
- Observations and trends of bat observations, mortalities and curtailments to establish patterns and cause-effect. This component of the annual report will consider any annual trends or variances in the seasonality of any detected mortalities and any applied low wind speed curtailment and make recommendations to extend or restrict either or both of surveys and low wind speed curtailments.
- Results and progress of all programs, research, analyses and activities.
- Modification, continuation, cessation and prioritisation of all programs, research and activities
- Appraisal of the mortality data and any conclusion or recommendations discussed with the Responsible Authority and other subject matter experts.
- Recommendations aimed at refinement or improvements for the subsequent years.

The reports will be reviewed collaboratively by Mt Fyans Wind Farm Pty Ltd and the Responsible Authority (DELWP, DAWE). The emphasis of the review will be on refinements to maximize efficiencies and any changes necessary to meet the objectives of the program. Every effort will be made to avoid any increase of resource requirements to implement the plan unless the review indicates that there has been demonstrable and unexpected impacts on a threatened species that necessitates greater intensity of effort. If the review indicates any other requirement for adjustments to the search protocol any changes will be determined in consultation with Responsible Authority.

10.3 Annual Mitigation Readiness Review

On the basis it is possible that effective mitigation solution(s) may become available in the future, MFWF commits to an annual literature review of techniques being trialed and/or applied to mitigate bat mortalities at wind farms elsewhere. The findings of this review will be presented as a report 'Annual Mitigation Readiness Review'. This report will be provided to the Responsible Authority on an annual basis (either as a stand-alone report or, within the Annual Report).

At a minimum the report will include information on any of the current techniques and/ or any newly developed ones:

- Review of Low wind speed curtailment

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- Review of techniques to discourage bat activity around operating wind turbines (e.g. ultrasonic acoustic devices)
- Review of approaches to detect and deter or detect and curtail.
- Any new or novel techniques developed or under trial.

10.4 Completion of SBWB Monitoring Program Report

The Completion of SBWB Monitoring Program Report (Completion Report) produced after 36 months of the SBWB Monitoring Program will cover all material listed above in paragraphs 10.1, 10.2 and 10.3. This report shall consider the long-term future direction of the adaptive management program. Specifically, the report shall consider activities for the remaining operational life of the wind farm and if necessary coordination with activities under the management of the offset research fund to maintain the Annualised Impact Assessment under the level of the Significant Impact Trigger.

The Completion Report shall consider and update the same categories as the annual reports and provide an overall update for all activities conducted for the term of the survey program:

- details of survey, mitigations, analyses and methods employed
- results and analyses
- Determine the Final Impact Assessment to take into account all estimated mortalities of the duration of the survey program
- Update and compare the Final Impact Assessment with the Significant Trigger Level
- Observations and trends of bat observations, mortalities and curtailments to establish patterns and cause-effect
- Results and progress of all programs, research, analyses and activities.
- Modification, continuation, cessation and prioritisation of all programs, research and activities
- Appraisal of the mortality data and any conclusion or recommendations discussed with the Responsible Authority and other subject matter experts.

The Completion Report shall also consider:

- Recommendations aimed at refinement or improvements for the subsequent years including determining any operational/configuration changes that will be implemented as part of wholistic treatment in response to 3 years of observations/mortalities. This will include consideration of adaptive measures, pro-active deterrents, indirect offsets (research fund).
- The Completion Report is to consider the following and provide clear and binding recommendations regarding:
    A. If the Final Impact Assessment is lower than the Significant Impact Trigger, then any adaptive measures implemented on the site shall remain in place.
    B. If the Final Impact Assessment is higher than the Significant Impact Trigger, then adaptive measures and pro-active deterrents are to be increased. Further requirements are specified below.
- In this case of “A” where the Mt Fyans Wind Farm Operator wishes to decrease the adaptive measures implemented on the site then the Operator may elect to extend the duration of the entire SBWB Monitoring Program and adaptive management program by another term of three years.
- In the case of “B”, the Mt Fyans Wind Farm Operator shall extend the duration of the entire SBWB Monitoring Program and adaptive management program by another term of three years and continue to monitor the Annualised Impact Assessment and increase the adaptive management methods implemented until the Annualised Impact Assessment falls below the level of the Significant Impact Trigger. These may include (but not be limited to):
    - Extend the duration or modify the search regime,

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- Extend the levels and application of low wind speed curtailment in response to detected mortalities,
- Consider wider application of results of TSSs conducted,
- Employ pro-active deterrents and conduct trials to determine their effectiveness
- Conduct other activities in conjunction with the Research Fund after gaining the prior approval of the Fund Administration.

- As an example, only; At the end of the three-year SBWB Monitoring Program: The Final Impact Assessment is higher than the Significant Impact Trigger. All mortalities were experienced at 3 turbines all close to farm dams or wetlands (but not at other turbines) then an adaptive measure would be to initiate low wind speed curtailment at all turbines within a set distance from farm dams and wetlands in conjunction with installing bat deterrent technology that is funded and monitored as part of the research fund. The SBWB Monitoring Program is extended for another 3 year term and the survey period is extended in duration and applied to only those turbines within a set distance from farm dams and wetlands to determine the effectiveness of the newly initiated adaptive measures and pro-active deterrents.

10.5 Offset Fund Report

See details outlined in Section 11.6

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11. Southern Bent-wing Bat offset research and projects fund

The implementation of offsets for the Mt Fyans Wind Farm project are a part of managing the overall and potential impacts to the SBWB from the operation of the wind farm. There is no way to determine the level of impact through collision risk modelling. The level of impact is estimated (likely) to be low and through the mortality monitoring surveys (Section 7) the impact will be monitored. As outlined in Section 7, there are no mortality monitoring programs that are perfect. Therefore, there will therefore be some uncertainty in the in the precise level of impact. Based on this uncertainty, a SBWB Offset Research and Projects Fund (Fund) is proposed regardless of whether Mt Fyans Wind Farm has any detectable effect on the subspecies.

As indicated in this Plan, through the adaptive management process, mitigation actions will be undertaken to manage and reduce the level of impact. These mitigations may be imperfect. The Fund will therefore operate in a complimentary and compensatory manner to the mitigation program and is intended to address the various uncertainties. It should also be noted, that on reaching or exceeding the significant impact trigger, additional funding will be contributed to the fund in addition to mitigation measures.

The overall approach of implementing mitigation actions and offsets in parallel is intended to ensure the Plan's objective are achieved - ***To ensure operations of Mt Fyans Wind Farm do not result in net significant or lasting impacts on the viability or conservation status of the Victorian SBWB population.***

Advice from DAWE (Department of Agriculture, Water and Environment) is that the establishment of the Fund is considered an indirect offset. The Fund proposed, is the mechanism to deliver offsets for the project, (not the offset). It is possible that projects delivered out of the fund will be a mix of direct and indirect offsets. As outlined in Section 11.4, priority will be given over projects that can deliver direct outcomes to the subspecies.

It is acknowledged that the EPBC Act, Environmental Offsets Policy (2012) provides a 90% direct offset benchmark and that deviations from the 90% benchmark will only be considered if the scientific uncertainty of any potential options for direct offsets is high (and that it isn't possible to determine a direct offset that is likely to be of benefit to the protected matter). It is likely that many of the projects delivered through the Fund will be indirect offsets and this is because there are simply no direct offsets at this time that can be implemented. This may change in the future. We note that there are many similar species (e.g. wedge-tailed eagle, orange-bellied parrot where direct offsets are not possible and that indirect offsets are the only mechanism to support the species of concern.

If the Fund is unable to support any direct offsets, based on the National Recovery Plan (DEWLP 2020) and the Conservation Advice (TSSC 2021), it is clear that research into this subspecies forms a critical part of the recovery action. Research aligned to the priority actions of the species (as is proposed to be delivered via the offset fund) is aimed at providing an offset equivalent to a direct offset.

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11.1 Overview

A SBWB Offset Research Fund will be established using contributions from the operator of Mt Fyans Wind Farm. The purpose of these contributions is to provide a structured mechanism to offset potential mortalities of SBWB resulting from collisions with turbines at the wind farm (irrespective of whether collisions by the species are confirmed to occur). The Fund will be administered by an independent body (Fund Administrator - yet to be determined or selected) that has capacity to provide administrative and governance support. The Fund and administration will operate independently from Mt Fyans Wind Farm. The Fund will be overseen by a Panel as outlined in Section 11.4 below. The Panel will be tasked with reviewing and selecting applications for support from the Fund, with projects that provide conservation to the species prioritised. The Fund will be set up prior to commissioning of the Mt Fyans Wind Farm and will operate for 10 years after the wind farm Commercial Operation Date. The Fund will receive funding as set out in the Table 1. The Fund design is similar to the successfully established (state and Commonwealth Regulator approved) Wedge-tailed Eagle Research Fund for the Cattle Hill Wind Farm project in Tasmania (Joule Logic 2018).

11.2 Allocation of Funding to the Fund by the operator of Mt Fyans Wind Farm

The level of funding has no basis that is linked to the loss of one or more SBWBs. There are no known methods of calculating a value. The seeding value, annual and exceedance contribution are based on the fact that for effective research projects to be delivered, a reasonable level of funding is required. It is envisaged that the level of funding offered will allow at least 3 research projects varying in scale and complexity spanning the range of under-graduate, post-graduate, and independent research bodies. The level of funding should provide for commensurate and compensatory outcomes.

Table 8. Allocation of Funding to the Fund

Timing of Payment	Funding amount
6 months following Commercial Operation Date	$250,000
Annually for 10 years following Commercial Operation Date	$50,000*
As required, if Annualised Impact Assessment exceed Significant Impact Trigger#	$50,000* for each calendar year an exceedance occurs.
*CPI adjusted using the Melbourne index number last published before the commencement of Annual payments. # Exceedance of the values set out in Section 5.2 & 9.3 of this Plan	

At the completion of the 10-year funding period, the Fund will cease to operate (unless required to continue – as an outcome/action of 10.4). Any funds remaining in the Fund will be allocated, in full, to a suitable project. No funds will remain in the Fund.

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11.3 Objective of the Fund

The objective of the Fund is to support high quality ecological or other relevant scientific research on the SBWB, or management activities, the results of which will assist with the management and protection of the species. Priority will be given to projects that provide a direct benefit to the subspecies. Support will also be priorities to projects/research that is scientifically rigorous, conducted by suitably qualified, knowledgeable and experienced scientists, and which is consistent with the objectives of the *National Recovery Plan for the SBWB* (DELWP 2020), or any subsequent SBWB Recovery Plan.

11.4 Operation of the fund

The Fund will be established with an independent organisation that has the capacity to provide the necessary administrative and governance support to allow the Fund to operate successfully. This organisation will be selected closer to the time the Fund is expected to commence operation and will be done is collaboration with the Panel. It will operate as a not-for-profit Fund. Any interest accrued by the Fund will be reinvested into the Fund to support research. The operator of Mt Fyans Wind Farm will cover the administrative costs associated with the Fund, including:

- Any establishment fees
- Any annual management fees
- Any annual fund support fees (including meeting costs)
- Reasonable costs associated with advertising a funding round

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At a minimum the Panel will comprise:

- A representative from the Fund Administrator
- One relevant Representative of DEWLP
- One relevant Representative of DAWE
- One other suitable Representative (South Australian Government advisor, or Community)

The Panel will be chaired by a person experienced in commissioning biological research.

Panel members can be reimbursed for any reasonable travel costs for attendance at meetings. Where appropriate, the panel will meet via video or telephone conference to minimise travel and accommodation costs. Panel members will be appointed for three years. Payments to Panel members will be administered by the Fund Administrator.

The Panel will meet (in person, by phone or video link) approximately twice yearly to:

- Review funding applications and select those to be supported.
- Monitor the progress of the research of grant recipients.
- Determine whether to accept research reports (i.e. whether they are fulfilling the requirements of their support).

Members of the Panel and their direct family members are not eligible to receive funds from the Fund. Given the uniqueness of the species and those conducting research it is foreseeable that a member of the Panel will be involved in an application to the Fund. Panel members must disclose real and perceived conflicts of interest of which they are aware and abstain from commenting and voting on those applications they are party to.

In the event of a conflict of interest or a dispute between panel members about applications to support, a final decision will be made by the Administrator of the fund.

The roles and responsibilities are outlined in the Guidance section (Section 10.7)

11.4.2 Reporting and Payment

Successful applicants will be required to submit a progress report to the Panel on a six-monthly basis and a final report at the end of the project. Failure to comply with these requirements could result in termination of support. Payments to the successful applicants will be in three stages:

- Partial payment at the commencement of the project
- Partial payment part way through
- Final payment upon acceptance of the final report

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11.5 Research Priorities

Suitably qualified researchers will be eligible to apply for funds to support relevant projects or research on the SBWB consistent with specific objectives of the Recovery Plan (2020). Critical research that can demonstrate a sound experimental design and statistical rigour will be viewed most favourably, as will projects that provide a direct benefit.

Note that support will <u>not be provided</u> for studies on SBWB required for commercial or private developments (e.g. avifauna surveys or trials required by conditions of a permit).

Guidance on the application process is provided in the Guidance section (Section 11.7).

Depending on the amount of money in the Fund and applications received, approximately

75% (as a guide) will be allocated to research grants each year, but this will depend on the applications received (multi-year studies may be supported). The remainder will accrue interest. The Fund will commence supporting research as early as possible after its inception, preferably in the first year of establishment.

Applicants will be expected to submit their research and data for publication in an open- access, peer-reviewed scientific, unless otherwise agreed by the Panel. Failure to submit for publication may result in the Panel not supporting further funding applications.

11.6 Reporting

The Fund Administrator will provide an annual report (by 31 March of each calendar year – for the previous calendar year) including a summary of projects being funded to the Panel and the operator of the Mt Fyans Wind Farm. This will also include project progress and the financial details of the Fund.

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11.7 Southern Bent-wing Bat Offset Research Fund – Guidance

11.7.2 Roles and Responsibilities

Fund Administrator

- Responsible for receipt, management and audit of the Fund.
- Assist with the identification and selection of panel members. The Panel members selected will be agreed by the SBWB Recovery Team and a representative of DEWLP.
- Host, recruit and administer/support the panel to prioritise, assess and distribute research funds – approximately two meetings per year.
- Prepare the grants application process, templates etc.
- Coordinate meetings, meeting minutes and the project selection process. Including:
- Justification for the selection of successful applicants.
- The amount of funding the recipients will be allocated and amount and
- Project payment schedules.
- Comments on the progress reviews of grant recipients.
- Any other relevant matters.
- Administer reimbursement of panel members reasonable travel costs for attendance to Fund meetings.
- Advertise, administer and coordinate research applications, and in conjunction with the Panel develop and maintain the assessment process.
- Contract and administer the research funds on behalf of the Panel, including coordination of progress and final reports.
- Provide advice and reports to the operator of Mt Fyans Wind Farm and any other contributors to the Fund on an annual basis.

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Southern Bent-wing Bat Research Fund Panel

- To meet approximately twice yearly.
- To establish criteria for the selection and quantum of research funds to be allocated annually.
- To ensure that the Fund Administrator advertises annually for grant applicants.
- To review grant applications received in relation to the previously established selection criteria and select the successful applicants.
- To review the progress and final reports of grant recipients and determine whether to accept these.
- To notify the Fund Administrator of any grant recipients in breach of their funding responsibilities.

11.7.3 Draft Application process

An Application Form will be prepared by the Fund Administrator. Applicant will be required to submit an application and supporting documentation. The application should document the following:

- Objective/s of the research
- Relevance to the priorities of the Fund and/or objectives of the Recovery Plan

- How the project will provide a conservation benefit to the species. Note that projects that can provide a direct benefit will be supported as a priority.
- Methods
- Duration of the research
- Whether the research is part of a larger project (if so, include details of the larger project)
- Quantum of funds being sought and project budget overview
- Whether relevant permits have been obtained, or if not, when they are likely to be obtained
- Details of the researchers involved, including their qualifications and research background

Unsuccessful applicants can request feedback on why their application was not supported, but negotiation with the Panel about the selection process or its decisions will not be entered into.

The Panel reserves the right to not offer any grants if no suitable applications are received.

11.7.4 Successful applicants

Those receiving support from the Fund will be required to provide:

- Evidence of receipt of all necessary permits before project commencement e.g. Animal Ethics, Scientific, etc.
- A final report outlining the details of the research, including objectives, methods, results and discussion, within 60 days of project completion, for review by the Fund Administrator and the Panel.
- An interim report if the research continues for greater than six months, within 30 days of the first six months of the project. This report will outline progress on the research and will be reviewed by the Fund administrator and the Panel.
- Notification to the Fund administrator and the Panel as soon as reasonably practical if the research is substantially delayed or must be discontinued

Funding will be provided in the following stages:

- An initial part payment to commence the research (proportion to be determined by the Panel).
- Final payment upon evidence of successful completion of the project and approval by the Panel of necessary reports and articles.

If the project extends for more than six months, partial payments will be scheduled and approved by the Panel.

11.7.5 Termination of funding

If a project is determined by the Panel to be non-compliant with grant requirements, funding may be terminated. Grant recipients should raise with the Panel any potential issues with satisfying requirements at the earliest opportunity.

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12. Review of this Plan

Mt Fyans Wind Farm may in their absolute discretion, undertake a review or part review of this document any time. However, the approved Plan (or parts of) may only be amended with the approval of the Responsible Authority and until such time an amended plan is approved, the previous approved plan shall be followed.

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Appendix 1 Potential methods to reduce collision risk for microbats

This appendix offers a brief review of potential methods to reduce turbine collision risk for microbats. It is divided into three concepts:

- Pre-emptive methods that may reduce the existence of a collision risk
- Methods aimed at deterring bats from the proximity of turbines
- Automated systems designed to detect bats in proximity to a turbine and curtail it.

For completeness, we also provide information about automated systems to detect collisions.

Pre-emptive methods

A number of methods have the potential to reduce the incidence of microbats colliding with turbines by acting pre-emptively to reduce their exposure to the turning rotors of operational wind turbines. The following is a brief review of those methods and a consideration of their potential application at Mt Fyans.

It should be noted that to-date there is no evidence that SBWB s may be attracted to wind turbines.

Any measures to reduce collision risk by the shut-down of turbines has the potential to result in some loss of electricity generation which may have implications to contractual obligations under which the facility operates. Ideally, any system that entailed turbine shut-down should provide a rapid response capable of preventing collisions while efficiently minimising the loss of electricity generation.

Low wind-speed turbine curtailment

A number of investigations overseas have demonstrated that flight activity of small species of bats is concentrated on periods when wind-speeds are relatively low (e.g. Arnett et al. 2009; Arnett 2017; Martin et al. 2017).

A wind turbine will not operate under zero wind conditions, but as the wind-speed increases, the rotating speed of the turbine will also increase until it reaches a point where it is effective to generate electricity, this point is known as the 'cut-in' wind-speed. The manufacturer's rated cut-in speed for turbines planned to be used at Mt Fyans is approximately 3.0 metres per second (m/s).

In recent years various studies have investigated whether a reduction in bat fatalities due to turbine collision can be achieved by programming the turbines to alter their night-time operation so that their rotors do not turn during periods of specified low wind-speed when many species of bats are most active (Arnett et al. 2009; Arnett 2017). This is termed 'low wind-speed turbine curtailment'.

The majority of published studies of low wind-speed curtailment have been undertaken in North America and the species primarily involved have been migratory, tree roosting bat species with relatively high incidences of collisions. Low wind-speed curtailment has been demonstrated to be an effective operational measure to reduce fatalities of these bats by up to 50% when turbine cut-in speed was increased from manufacturers'

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rated cut-in speed by at least 1.5 m/s. Importantly, a recent study in Victoria has also demonstrated that a significant reduction in microbat collisions was achieved by a targeted regime of low wind-speed turbine curtailment (raised operational commencement to 4.5m/s).

While there is no empirical data about flight activity of Southern Bent-wing Bats, there is potential that low wind-speed turbine curtailment might reduce the incidence of turbine collisions by these bats.

Low wind-speed turbine curtailment would be relevant only during the active period of SBWBs, i.e. during the night and in the portion of the year when they have capacity to occur at Mt Fyans Wind Farm

There is potential that low wind-speed curtailment of turbines might reduce the risk of turbine collisions for SBWBs at Mt Fyans Wind Farm.

Deterrence from proximity of turbines

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Ultrasonic noise

Arnett et al. (2013) undertook experiments at an operational wind farm to evaluate the effectiveness broadcasting ultrasound noise with the intent of deterring bats that rely on their own emission of ultrasound for navigation and foraging.

Some commercially available systems to deter bats from the proximity of wind turbines use ultrasonic noise to 'jam' the frequencies of echo-locating bat calls. Overall, the effectiveness of the use of ultrasound has not been well demonstrated and the largely experimental nature of this approach does not yet indicate that it is likely to provide a suitable method for use at Mt Fyans Wind Farm.

The use of ultrasonic noise is not a proven reliable deterrent of microbats and may not be suitable to reduce the risk of turbine collisions for SBWB at Mt Fyans Wind Farm.

Ultraviolet lighting

Gorresen et al. (2015) carried out a trial in which they illuminated trees with dim flickering ultraviolet light in areas frequented by Hawaiian Hoary Bats *Lasiurus cinereus semotus*, an endangered subspecies affected by wind turbines, to ascertain whether this would reduce their flights in proximity to the illuminated trees. They used a repeated-measures design to quantify bat activity near trees with acoustic detectors and thermal video cameras in the presence and absence of ultraviolet illumination, while concurrently monitoring insect numbers. Results indicated that dim UV did reduce bat activity despite an increase in insect numbers. However, the experimental treatment did not completely inhibit bat activity. This method is not known to have been tried on operational wind turbines and for the present this method can be considered to be purely experimental. There is no known information about the possible response of SBWBs to ultraviolet light.

The effects of ultraviolet lighting on SBWB sis not known, and it is not a proven reliable deterrent of microbats and may not be suitable to reduce the risk of turbine collisions for SBWB at Mt Fyans Wind Farm

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Automated systems to reduce collision risk

This section provides a review of various types of automated systems that have been developed to monitor the presence of bats in proximity to wind turbines and, where a collision risk is considered likely, to shut-down and subsequently re-start turbine(s). The majority of such systems are designed to do this by using some type of monitoring that is linked to the automated SCADA (supervisory control and data acquisition) mechanism for control of turbines in response to wind conditions. Commercially available systems employ radar, infrared imaging and/or visible light cameras. Some now use integration of these into a single system. The advantages of these types of systems is that they are triggered by the detected presence of a target species and can thus be expected to be the most efficient means to reduce collision risk.

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Integrated radar systems

A number of commercially available automated systems use radar, linked to the turbine SCADA system to detect target species and to respond by shutting down turbines when an animal is within a prescribed radius of a turbine or turbines. Radar uses radio waves to scan a given radius to detect objects within the airspace.

Major advantages of radar as a detection method include:

- The capacity for a single unit to simultaneously scan and plot the positions and movements of multiple targets over horizontal distances spanning several kilometres
- simultaneous use of horizontal and vertical surveillance radars allows scanning in three dimensions
- the capacity to detect objects throughout the 24-hour cycle.

Where the surrounding terrestrial landscape has a complex topography or multiple obstacles such as trees or buildings, this 'clutter' renders radar ineffective for detecting targets that are close to the ground or amongst those obstacles. Capacity of radar can also be substantially limited or reduced by rain or other weather conditions.

The major drawback of radar is that it does not have intrinsic capacity to distinguish particular species. Information about the use of radar at wind farms elsewhere suggest that its primary applications are where the species of concern are large birds or flocks of birds that are approaching a wind farm from outside its boundaries. It has been of value in detecting the approach of migrating flocks of birds or of individuals of large species like eagles, vultures or cranes. This type of application is of particular relevance where such events may occur seasonally or infrequently and a turbine shut-down can be used to reduce collision risk while the animals pass through the wind farm.

The SBWB is one of more than a dozen species of small bats that may occur at the Mt Fyans site a number of which can be expected to be present throughout much of the year. Radar does not have capacity to distinguish between them. Hence, radar as a primary mechanism to detect microbats will not be effective for turbine shut-down in response to the presence of SBWBs.

Radar does not have capacity to distinguish SBWBs from other microbat species that occur at Mt Fyans Wind Farm. Hence any system that relies on radar as a primary mechanism to detect the species and to effect turbine-shut downs will not be effective.

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Integrated imaging systems

A number of commercially available automated systems use visible light cameras for daytime detection of flying animals and/or thermal imaging (infra-red) detectors for nocturnal detection. In a similar manner to the use of radar, these systems are linked to the turbine SCADA system to respond to an animal detected within a given radius of turbines by shutting down turbine(s).

Visible light cameras are dependent on appropriate light conditions and an uncluttered view. Activity of SBWB is nocturnal and thus systems using visible light photography would not be applicable to reduction of collisions and they are not considered further here.

Thermographic cameras detect radiation in the long-infrared range of the electromagnetic spectrum. Effectively this allows an image to be made from the variable temperatures of items in the absence of visible light. Detection of birds and mammals that maintain a constant body temperature can usually be achieved but is most effective when the temperature of the animal is substantially different from the ambient temperatures of the surrounding landscape. Thermal imaging requires a view that is not interrupted by items with thermal properties that might obscure the image of a fauna target. Thermal imaging cameras have now been used widely to detect and 'see' nocturnal wildlife and hand-held thermal imaging was used effectively to detect microbats at and near the Mt Fyans Wind Farm.

A major advantage of thermal imaging as a detection method is that, for some animals, images allow the animals to be identified directly to species. However, given the number of other microbat species at Mt Fyans Wind Farm, it is not likely that SBWBs could be reliably distinguished from a number of similar species. Also, the distance over which thermal cameras can reliably monitor is much shorter (within tens of metres under ideal conditions) than that of radar.

It is worth noting that the majority of international literature related to the use of thermal imaging at wind farms relates purely to detection of volant fauna at wind farms, and while thermal imaging has been widely used and reporting for that purpose, there appear to be a very few integrated turbine-control systems triggered by thermal imaging that have been fully tested beyond the experimental concept stage.

One or two imaging systems that entail the use of thermal cameras to detect a target and then follow its movements are in development and may be available overseas. The alternative is the use of fixed thermal cameras that have a defined field of view and may require cameras to be mounted on each turbine. It is uncertain whether such systems can reliably and consistently monitor the entire rotor-swept areas of turbines, or the distance at which they might detect a SBWBs before it was at risk of a collision.

To-date, we are not aware of any commercial-scale wind energy project in Australia that has installed an integrated thermal imaging system to reduce collision risk for fauna. Our enquiries suggest this is likely to be due to uncertainty about their reliability in the current, early conceptual stage of such systems and to the high initial capital cost costs of such systems that would be followed by routine operations of the system that may include the services of specialist technicians.

It is possible that integrated systems using thermal imaging that could function to reduce turbine collisions by SBWBs may become available in the future but at present there is little available information about the reliability of such systems, and no experience with them for Australian

microbats. As such there is no certainty about their capacity to reduce collision risk for the species at Mt Fyans Wind Farm.

Integrated systems triggered by bat calls

Some systems have been tried overseas that use detection of ultrasonic bat calls as a mechanism to trigger turbine shut-down. Current limitations on systems for turbine shut-down and re-start triggered by ultrasonic bat calls relate to inability to obtain consistent, accurate identification of particular species; call-detection distance relative to size of turbines; and time taken for turbine shut-down. At present, it is not likely that such systems are sufficiently developed to achieve meaningful reduction of collision risk for SBWBs.

At present, it is not likely that systems triggered by detection of ultrasonic bat calls are sufficiently developed to achieve meaningful reduction of collision risk for SBWBs at Mt Fyans Wind Farm.

Collision monitoring systems

More than one commercially available system functions to detect and record turbine collisions by flying animals and we note this category of method simply for completeness. These use a combination of acoustic sensors installed within rotor blades and on the turbine tower to detect a collision and trigger active infrared video cameras to record the event.

These systems are designed to record collisions but do not control turbine shut-down and re-start and thus they do not have capacity to reduce collisions for any species.

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Appendix 2 Symbolix report

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Mt Fyans Wind Farm BBAMP review

Prepared for Woolnorth Renewables, 17 September 2021, Ver. 1.1

1 About this document

WWH is preparing a BBAMP as part of the approvals process for Mt Fyans Wind Farm. This document provides statistical review of key components of the study. In undertaking the review we consider the competing survey needs:

- Obtaining an unbiased estimate of total turbine strike.
- Optimising the probability of carcass detections, through survey frequency and timing.
- Maintaining operational safety and human/canine resources (e.g. avoiding excessive field survey load or poor field conditions).

We have reviewed the survey and adaptive management plan (Biosis 2021). The overall survey design conforms to current best practice, with carcass searches augmented by scavenger and searcher efficiency trials to generate a statistical estimate of annual mortality. The document recognises the need to balance a mortality estimate with adaptive management triggers based on carcass counts which are not subject to any statistical uncertainty.

In this memo we consider each component of the proposed surveys and provide advice about the specifics of each. To guide this advice we will estimate the impact of our choices on both the statistical uncertainty of the mortality estimate and the detection probability for rare events.

2 Design considerations

2.1 Site specifics

- There is one main species of concern: the critically endangered Southern Bent-wing Bat (SBWB).
- The site is reasonably homogenenous, requiring no stratification into areas of different scavenger rate or searcher efficiency.

What determines a statistically valid monitoring program

A good statistical sampling design must balance four broad considerations (Kish 1995):

- **Goal orientation:** The design must reflect the goal; e.g. to determine the mortality rate

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across the whole site we should sample randomly from the whole site (rather than bias to certain areas).

- **Measurability:** The design must support statistical inference/estimation, including the ability to determine measures of statistical variability (e.g. standard errors). In this project, we want to ensure the design will support the application of a Horvitz-Thompson style estimator (analytical or algorithmic) for mortality estimation.
- **Practicality:** The design must be practical. For example, assuring 95%+ detection probability is not practical within the bounds of OH&S requirements using dogs or humans (e.g. see Moloney and Smales (2019) for modelling of detection probabilities). However, collecting robust data to enable a Horvitz-Thompson style estimate of mortality (see next section) is practical and feasible.
- **Economy:** This is economy in the broad sense of not oversampling beyond the point required by our objectives. For instance, we will obtain a more precise estimate of the time to scavenger loss with 200 carcass trials than 20, but there is a point of diminishing returns where the extra information gathered is not justified by the effort (when such effort could potentially be used on actual conservation outcomes).

2.2 Mortality program objectives

The primary objective of this wind farm post-construction mortality program is to generate a statistical estimate of the number of bird and bat fatalities due to turbine collision over a period of time (typically annually). We will need to estimate total mortalities for groups of species and individual estimates for species of concern.

At Mt Fyans Wind Farm, a secondary consideration is to inform the application of triggers for adaptive management. Carcass counts are the physical trigger, and the trigger values should be based on the likely (i.e. estimated) true species mortality. Given the skewed nature of the mortality distribution we recommend the median over the mean for these measures.

The primary objective requires a statistical design so that the carcass counts can be expanded to estimate total mortality. This does not require full coverage of the site - only a randomised statistical sample. However, we attempt to ensure there is "reasonable" coverage to assist with adaptive management.

This letter will assess the design based on **current understanding of best practice for estimating mortality from carcass search programs.** For clarity, we outline that approach first.

Standard approach to estimation

To assess measurability, we need to establish the metric the data will feed. Mortalities ($\hat{M}_{ij}$) at turbine i during search j are estimated by (M. M. P. Huso, Dalthorp, and Korner-Nievergelt (2015) and references therein)

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$$\hat{M}_{ij} \cong \frac{C_{ij}}{\hat{g}_{ij}} \quad (1)$$

where

- C_{ij} is the number of carcasses found
- $\hat{g}_{ij}$ is the estimate of the detection probability for that search and turbine

For a given turbine, $\hat{g}_{ij}$ is a function of

$$\hat{g}_{ij} \cong a_i p_{ij} s_{ij} \quad (2)$$

- a_i is the fraction of total carcasses within the searched area
- p_{ij} is the probability that an existing carcass will be detected by the searcher
- s_{ij} is the fraction of the carcasses that arrived at turbine i but have not been lost to scavenge or decay before search j. It is a function of the rate of decay and the search interval, relative to the expected time to scavenge (M. M. Huso 2011)

Through field surveys we can estimate $\hat{a}$, $\hat{s}$ and $\hat{p}$. C is given by the field observation data.

These components estimate $\hat{M}$ (and confidence bounds) for the site and time period.

Now that we have outlined the framework, we consider each component of the proposed design against that framework.

3 Field design

3.1 Scavenger trials

Scavenger trials involve leaving carcasses out in field and monitoring their time until removal.

3.1.1 Aim

The purpose of scavenger (or carcass persistence) trials is the quantify the rate of removal of carcasses from the study area.

3.1.2 Metric studied

The metric studied is the *survival function* $S(t)$, which determines the probability that a carcass will "survive" in-field past time t. When this is estimated, the mean and confidence interval on time to scavenge can be found.

3.1.3 Field methodology

- Studies will be conducted twice a year.

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- "In each trial, a predetermined number of carcasses including specimens of various sizes of birds and bats will be distributed under a predetermined number of a randomly selected turbines within the range of environments across the wind farm."
- Remote cameras will monitor the carcasses for a period of one month.

3.1.4 Advice: Minimum sample size

If we assume a lognormal loss function for carcasses, the relative standard error on the median loss time is:

$$\mathrm{RSE}(n|\hat{\mu}, \hat{\sigma}^2) = \frac{\sqrt{[\exp(\hat{\sigma}^2/n) - 1] \cdot \exp(2\hat{\mu} + \hat{\sigma}^2/n)}}{\exp(\hat{\mu})}$$

Figure 1 shows the sample size n versus the relative standard error, under the assumption of a lognormal scavenger loss function. The parameters μ and σ^2 are taken from a model of time to loss for bat carcasses (Stark and Muir 2020).

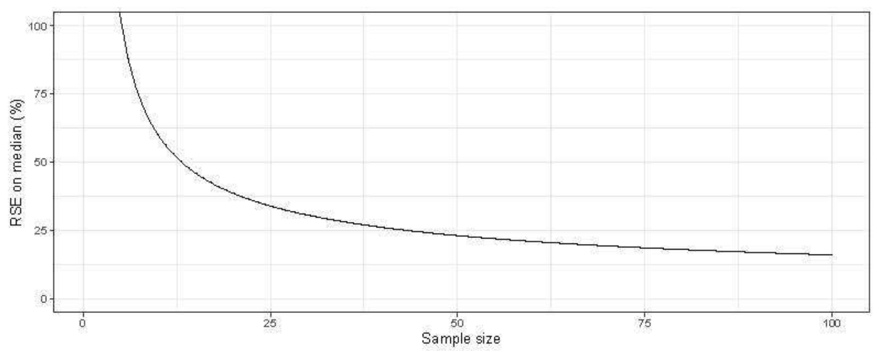

Figure 1: Sample size versus relative standard error.

The precision is not greatly improved by increasing the number of trials. 20 trials balances the precision requirements with the operational difficulty of sourcing carcasses.

3.1.5 Advice: Survey timing

In Victoria we can roughly categorise seasons into "hot-dry" (Nov-Mar) and "cold-wet" (Apr-Sep). Meta-analysis (Stark and Muir 2020) suggests that there is no significant difference in scavenger rates between the two seasons in Victoria. This suggests it is valid to estimate annual mortality, combining seasonal data. The result represents scavenger behaviour for the whole year, on Victorian sites.

3.1.6 Advice: Stratification

Although this plan focuses on SBWB, it would be advantageous to also estimate avian mortality, at least for the first year or two. This means we want want to be able to split carcasses into "bat" and "bird" groups, as generally bats have shorter time to scavenge than birds (Stark and Muir 2020). If you want the potential to distinguish bird size classes (for example, "small," "medium," "large"), it is important to include sufficient numbers of each size class in the trials.

However, it may be sufficient to have a single bat and single bird class given that SBWB is the focus. You would need to have 20 trials (10 per season) for each size class, as each stratum is estimated independantly.

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3.2 Searcher efficiency trials

Searcher efficiency trials involve the surveyors going out into field as in the main mortality program and looking for prior (manually) placed carcasses.

3.2.1 Aim

The aim of searcher efficiency trials is the quantify the probability that the searcher will find a carcass, given it is within their search area.

3.2.2 Metric studied

We are interested in the parameter p, which is the probability of that a searchers finds a carcass given it is within their search area.

3.2.3 Field methodology

- Studies will be conducted twice a year
- Dog searchers will be used (as per the carcass searches).

If using canine searchers: Stark and Muir (2020) found that while human and canine searchers had approximately the same searcher efficiency for birds, they were quite different for bats (52% for humans versus 84% for dogs). This supports using canine searchers for mortality surveys.

The search area and field protocol in the searcher efficiency trials must be identical to those used in the main mortality survey program.

3.2.4 Advice: Use of blind trials

Blind trials are not recommended. Reasons for this include:

- in a searcher efficiency trial, there is a higher density of carcasses than by chance due to turbine fatalities
- carcasses can't always be procured in sufficient numbers to match the species profile of the site

3.2.5 Advice: Minimum sample size

Figure 2 shows the trade-off between sample size and the size of the confidence interval. We can see that if the searchers are operating at high efficiency (e.g. dogs, or humans searching for birds) then approximately 20 trials will be appropriate (there is not much gain in confidence after that). If the searchers are operating at around 50% efficiency, it's closer to 30 trials that are needed.

Figure 2 shows the confidence intervals on two searcher types. The left plot shows the confidence interval when probability of success $p = 0.52$, which is a consistent with human

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observers looking for bats (Stark and Muir 2020). The right plot shows the confidence interval when $p = 0.86$, which is consistent with canine observers, or human observers looking for birds. In both, we can see diminishing returns in the size of the 95% confidence intervals with increasing sample size.

Right plot: for observers with high searcher efficiency (or conversely, low searcher efficiency), about $n = 20$ trials is a good balance between confidence interval size and sample size. If the searcher efficiency is closer to 50% (left plot), then approximately $n = 30$ are needed.

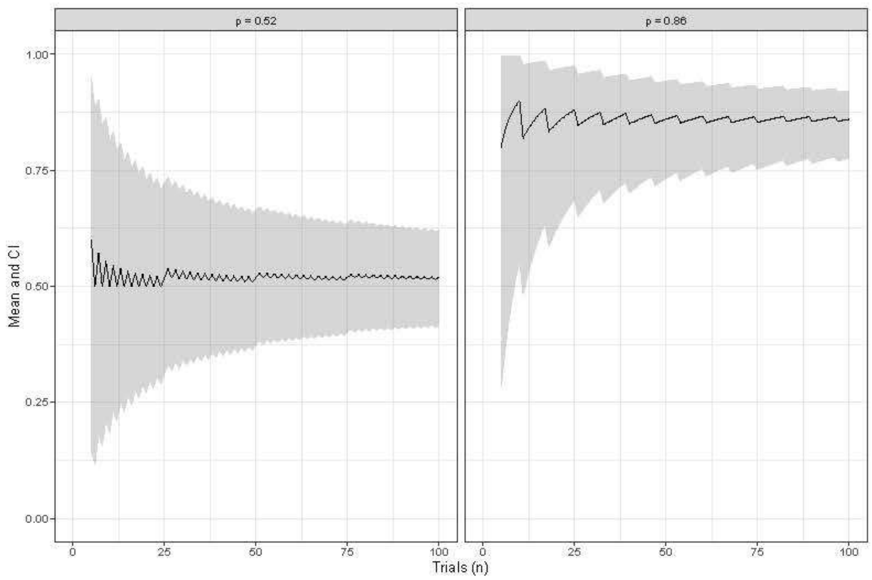

Figure 2: Confidence intervals of probability of finding a carcass.

As canine searchers will be used and thus searcher efficiency is likely to be high, we expect 20 trials to be sufficient.

3.2.6 Advice: Other stratification

We recommend stratifying into size classes as per scavenger trials.

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3.3 Proportion of area searched

3.3.1 Aim

Quantify an expansion factor to account for carcasses that fall outside the searched area of a turbine.

3.3.2 Metric estimated

The landing position of a struck carcass forms a radial distribution from the base of the turbine, and is dependant on the mass, size, and shape of the animal, as well as the size and height of the turbine (Hull and Muir 2010).

We need to estimate the proportion of this distribution covered by the proposed survey protocol.

3.3.3 Analysis method

Hull and Muir (2010) uses a Monte-Carlo simulation to generate the distribution of landing positions (the 'fall zone'), using a physics-based ballistics equation.

We have used that same software to generate the fall zone distribution for bats for Mt Fyans Wind Farm. We assume the hub height is 120m and the blade length 80m.

The results are shown in Figure 3.

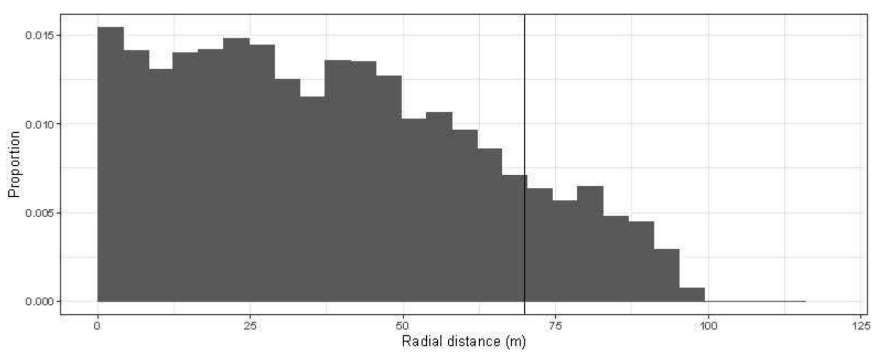

Figure 3: Fall zone distributions for bats. The vertical line represents the 70m search radius.

3.3.4 Advice: Suitable search radius

The proposed minimum search radius of 70m covers approximately 87% of the bat fall zone. A 95m circular search zone covers approximately 100% of the bat fall zone.

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3.4 Carcass searches and mortality estimation

3.4.1 Aim

The carcass searches sample the actual turbine collision mortalities and provide the final input to estimate the total mortality.

Mortality estimation aims to quantify the total collision mortality of a species or species cohort. It provides a comparison metric between sites, and adds to cumulative modelling.

While it can be used for compliance with long term trigger values, this only applies if a trigger or 'permitted take' is specified.

3.4.2 Metric studied

The metric under consideration is the total mortality of a species (cohort) of interest due to wind turbine operation.

3.4.3 Possible survey designs

These are two competing survey designs:

- Scenario 1: One-third of turbines are searched each month. In September - May, there is a standard (95m) followed by a pulse (70m radius) survey two days later. In June - August, only standard surveys are performed.
- Scenario 2: 100% of turbines are searched each month. In September - May, half have a standard (95m) followed by a pulse (70m radius) survey two days later, whereas the other half just have a standard survey. In June - August, only standard surveys are performed.

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3.4.4 Statistical review of survey designs

There is no 'golden rule' governing the optimal frequency of searches. For example, we are not trying to determine the difference between classes, so a power analysis is not applicable.

We can use simulation methods to estimate the proportion of carcasses that will be found given this survey design. The same method can help us understand the likelihood of a true absence by simulating the frequency of the search protocol missing all mortalities.

We will consider two related points:

1. **What is the overall probability of detection of the survey?**
2. **Given we detect evidence of mortality, what is the likely range of mortalities that occur?**

We simulate the survey protocols as outlined in Section 3.4.3.

We use the nominal values for general bat searcher efficiency (using dog searchers) and scavenger loss rates from Stark and Muir (2020), and assume the same searcher and scavenger efficiency for all scenarios.

It's worth remembering that the mortality estimate itself does **not** require coverage of all turbines and dates - only that the sample is chosen in a way that does not fail the assumptions of the Horvitz-Thompson estimator. However, increasing the proportion of turbines surveyed increases the overall probability of finding at least one carcass.

In this section, we concentrate on how the two possible survey designs perform in detecting bats. For each survey design we refer to, the results are based off $n = 5 \times 10^4$ simulations.

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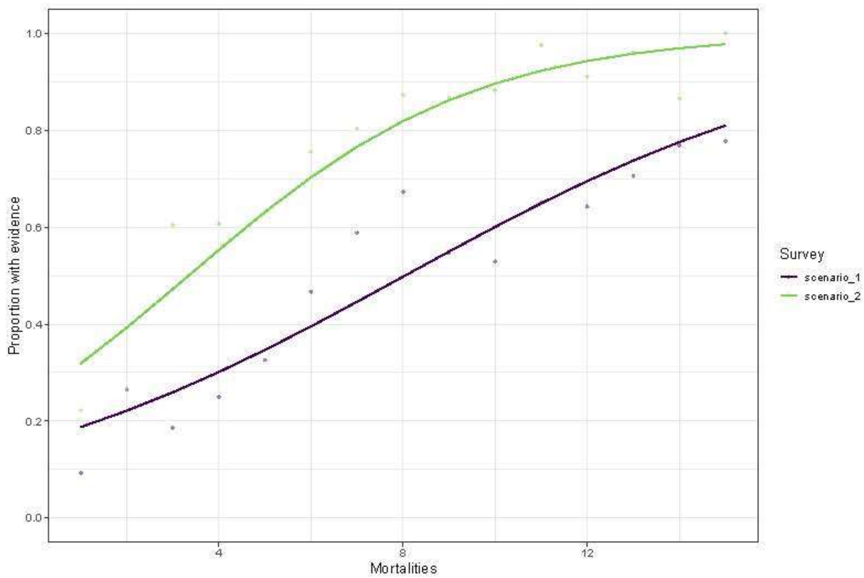

Figure 4: Percentage chance of finding some evidence of mortality for different actual mortalities. The fitted line is a GAM smoother curve to aid the eye.

Figure 4 shows the chance of finding **at least one carcass** for a range of actual mortalities. Under scenario 1 there is a >50% chance of seeing evidence once approximately eight individuals are struck, whereas for scenario 2 there is a similar chance of seeing evidence once approximately three individuals are struck.

The overall probability of detection is roughly 9% for scenario 1 and 20% for scenario 2. We note that a survey design with a relatively low probability of detection will still give an unbiased estimate of overall mortality. However, under such a design it will be more difficult to inform adaptive management actions for the SBWB if no or few carcasses are found.

Table 1 shows for both scenarios the overall probability of detection and the median and 95% confidence interval for the mortality estimate (given that one SBWB carcass is found during one year of surveys). We see that if one carcass is found, the predicted number of mortalities is around 18 (95% confidence interval [2, 65]) for scenario 1 and around 8 (95% confidence interval [1, 24]) for scenario 2. The precision of the estimate is higher under scenario 2, as the likely range of mortalities is lower than for scenario 1.

Table 1: The overall probability of detection and the median and 95% confidence interval for the mortality estimate (given one carcass found in one year of surveys) for both survey designs.

Design	Prob. detection	Median	95% confidence interval
scenario_1	0.09	18	[2, 65]
scenario_2	0.20	8	[1, 24]

In presenting these scenarios we hope to inform the survey design discussion with realistic simulations of the survey results after one year. Both survey designs considered here are appropriate for estimating detection, but there is a tradeoff between resources (and OH&S) and statistical precision.

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