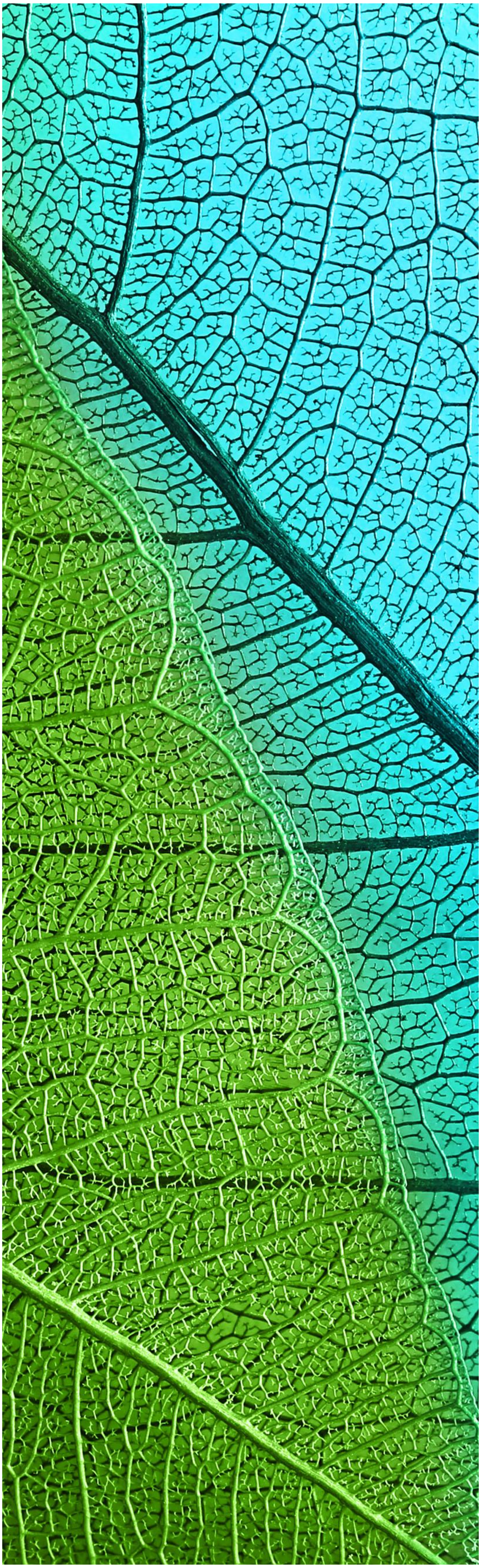
RE Future

Swansons Lane Wind Farm

Application for Planning Permit

Appendix E – Southern Bent Wing Bat Assessment

May 2025



Swansons Lane Wind Farm

Southern Bent-wing Bat and Yellow-bellied Sheath-tail Bat Assessment – 2024

Prepared for RE Future Pty Ltd

June 2024
Report No. 22316.1 (2.1)

Nature Advisory
(Formerly Brett Lane & Associates Pty Ltd)
5/61-63 Camberwell Road
Hawthorn East, VIC 3123
PO Box 337, Camberwell VIC 3124
(03) 9815 2111
www.natureadvisory.com.au

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1. Executive summary

The proposed Swansons Lane Wind Farm (SLWF), located in south-west Victoria, would comprise up to five turbines with a minimum rotor swept height (RSH) of 64 m above ground level (AGL) and a maximum RSH of 252 m AGL.

The SLWF study area encompasses operational dairy farms and is predominantly characterised by large open expanses of mixed grazing exotic grasslands.

The specific focus of this investigation was on generating baseline data documenting presence/absence and temporal activity of the Southern Bent-wing Bat (SBWB, *Miniopterus orianae bassanii*; Critically Endangered, EPBC Act, Vulnerable FFG Act) and Yellow-bellied Sheath-tailed Bat (YBSB, *Saccolaimus flaviventris*; Vulnerable, FFG Act) across the study area.

Roost cave assessment

A desktop roost cave assessment was conducted by Environmental Geosurveys (Neville Rosengren) and Wakelin Associates (Dr Susan White). On-ground surveys were then conducted by EcoAerial Environmental Services (Rob Gration) in 2022 to assess key sites identified during the desktop review, specifically to verify existence of caves and current condition and suitability for use by SBWB. No new roost caves were identified during either the desktop or on-ground investigations.

Bat detector surveys

Bat detector surveys were initially conducted in the study area by EHP during 2021–2022, then continued by Nature Advisory during 2022–2023. The timing and duration of the targeted, intensive seasonal surveys was based on advice provided by DEECA. The surveys were intended to coincide with the periods when the greatest level of SBWB activity occurs across south-west Victoria as individuals are moving across the landscape between maternity and non-maternity roost caves (Department of Environment, Land, Water and Planning, 2020). Four 6-week long seasonal surveys were conducted in:

- Spring 2021 – 6 bat detector sites, 301 bat detector nights.
- Summer-Autumn 2022 – 6 bat detector sites, 253 bat detector nights.
- Summer 2022-2023 – 12 bat detector sites, 447 bat detector nights.
- Autumn 2023 – 22 bat detector sites, 668 bat detector nights.

An increased survey effort was undertaken during the Autumn 2023 survey that incorporated an additional 10 bat detector sites to increase spatial replication of sampling effort across the study area (i.e. 22 sites in total).

Across all four survey periods, the total survey effort comprised 1,672 bat detector nights.

Effort was made to place the bat detector sampling sites at locations representative of the range of habitats present across the study area. The following list summarises the total area (ha) and proportion of the entire study area that the five habitat categories present comprised:

- Open grazing paddocks with very few or no scattered trees (647.19 ha, 97.06%).
- Planted eucalypt windbreaks (9.90 ha, 1.49%).
- Roadside vegetation (5.33 ha, 0.89%).
- Remnant eucalypt woodland (1.80 ha, 0.27%).

- Farm dams located within open grazing paddocks (1.31 ha, 0.20%).
- Planted pine windbreaks (1.23 ha, 0.19%)

Several bat detector sites were also placed close to two Blue Gum forestry plantations located outside of the study area along the north and east boundaries of the site.

Echolocation calls recording during the surveys were identified using a combination of a machine learning automated ID process and manual validation.

Year 1 bat detector survey results can be summarised as follows:

Spring-Summer 2021

- One SBWB-definite call was positively identified at site 5. This represents an overall relative activity of 0.003 calls per detector night for SBWB-definite calls.
- No SBWB-complex calls were identified.
- No calls were assigned to YBSB.

Summer-Autumn 2022

- Three SBWB-definite calls were positively identified, all at site 3. This represents relative activity of 0.012 calls per detector night for SBWB-definite calls.
- No SBWB-complex calls were identified.
- No calls were assigned to YBSB.

Year 2 bat detector survey results can be summarised as follows:

Summer 2022-2023

- The random forest automated classifier identified calls from 10 microbat species.
- From the total 14,840 files identified by the automated classifier as containing bat calls, 35% were assigned to the edge-space high-frequency foraging guild (described in Section 5.3.1), which includes SBWB, Little Forest Bat, Southern Forest Bat and Chocolate Wattled Bat
- 19 SBWB-definite calls were identified from seven of the 12 bat detector sites; this equates to relative activity of 0.042 calls per detector night.
- 156 SBWB-complex calls were identified from all 12 sites at 0.347 calls per detector night.
- SBWB-definite and SBWB-complex calls combined accounted for 3.3% of the 5,364 calls assigned to the edge-space high-frequency foraging guild. Relative activity for this guild was 11.9 calls per detector night.
- The majority of both SBWB-definite (26.3%) and SBWB-complex (22.4%) calls occurred in the second hour after sunset.
- No calls were assigned to YBSB, including from 57 full-spectrum files that were manually checked.

Autumn 2023

- From the total 132,666 files identified by the automated classifier as containing bat calls, 24% were assigned to the edge-space high-frequency foraging guild.

- 84 SBWB-definite calls were identified from 13 of the 21 bat detector sites at 0.126 calls per detector night.
- 93 SBWB-complex calls were identified from 16 of the 21 bat detector sites at 0.139 calls per detector night.
- SBWB-definite and SBWB-complex calls combined accounted for 0.6% of the 32,080 calls assigned to the edge-space high-frequency foraging guild. Relative activity for this guild was 48.0 calls per detector night.
- The majority of SBWB-definite and SBWB-complex activity occurred during the third and fourth hours after sunset.
- Manual checking of 75 spectrograms of full-spectrum files assigned as SBWB-complex did not provide any additional evidence to assign them to SBWB-definite, or to confirm they were produced by another species.
- No calls were assigned to YBSB, including from 123 full-spectrum files that were manually checked.

Southern Bent-Wing Bat – overall activity patterns and impact assessment

From an intensive survey effort conducted at SLWF over two consecutive years comprising 1,672 bat detector nights, SBWBs were recorded in the study area at very low levels of activity. The overall relative activity (calls per detector night) of SBWB- definite and SBWB-complex calls during the four intensive surveys combined were 0.065 and 0.149, respectively.

During the year 2 surveys (total survey effort of 1,115 bat detector nights), the automated classifier identified 147,506 files containing bat calls. From this, 37,444 calls (25.3%) were assigned to the edge-space high-frequency foraging guild. This shows that the bat detectors were effective at detecting and recording calls produced by high-frequency (45-50kHz) calling species, which in the SLWF area include SBWB, Little Forest Bat (*Vespadelus vulturnus*), Southern Forest Bat (*Vespadelus regulus*), Chocolate Wattled Bat (*Chalinolobus morio*). Manual checking confirmed that SBWB-definite and SBWB-complex calls combined accounted for 0.9% of the 37,444 calls assigned by the automated classifier to the edge-space high-frequency foraging guild.

Checking full-spectrum spectrograms of 75 calls that had been manually assigned as SBWB-complex did not provide any additional information to assist in (i) confirming if these calls were in fact SBWB-definite, or (ii) were produced by other species.

Across the year 1 and 2 surveys, the highest levels of SBWB-definite activity were recorded at sites close to linear eucalypt features (planted windbreaks and roadside vegetation), Blue Gum forestry plantations (located outside of the study area) and the one remaining small, isolated patch of remnant eucalypt woodland. There was no SBWB-definite activity recorded at 13 of the 22 sites.

SBWB-complex activity was greatest close to the Blue Gum forestry plantations and linear eucalypt features. There was no SBWB-complex activity recorded at 11 of the 22 sites.

Habitat association models showed that SBWB activity declined significantly with increasing distance from eucalypt windbreaks and Blue Gum plantations, but not from any other habitat feature. The model results indicate that there was no statistically significant difference in SBWB activity between distances of 150 m and 200 m from eucalypt windbreaks.

An assessment of Matters of National Environmental Significance found that ***it was unlikely that the proposed SLWF would have a significant impact on the global SBWB population***. This was based on:

- Relatively low levels of SBWB activity recorded across the study area.
- Less than 3% of the total study area containing potentially suitable foraging habitats (trees and water bodies).
- Minimum RSH of the proposed turbines (64 m AGL) likely being above normal SBWB flight heights.
- Relatively low level of SBWB mortality recorded to date at operational wind farms in south-west Victoria.
- Minimum RSH of the proposed turbines at SLWF being almost twice that of turbines where the majority of SBWB mortalities reported to date have occurred.
- Systematic monitoring protocols and targeted mitigation measures designed to reduce the risk of impacts to SBWB that will be incorporated into the SLWF Bird and Bat Adaptive Management Plan, e.g. consideration of moderation of low wind-speed cut-in from 3.0 m/second to 4.5 m/second for all five turbines during periods of increased SBWB activity (Spring and Autumn).

Potential mitigation strategies to reduce risks to SBWB are discussed (see Section 9.4), along with the opportunity to create an offset fund to contribute to targeted conservation activities (see Section 9.5).

Yellow-bellied Sheath-tail Bat - overall activity patterns and impact assessment

No YBSB calls were identified during any of the four intensive seasonal bat detector surveys conducted over two consecutive years. This included 180 full-spectrum files that were manually checked to compare with zero crossing (ZC) versions of the same recordings.

Given that no YBSB calls were recorded, despite considerable survey effort, and that no mortalities have been reported at wind farms in Victoria to date, it is considered unlikely that the proposed SLWF will lead to regular mortality of this species. Therefore, a very low impact on the YBSB is predicted.

Suggested mitigations measures designed to reduce risks to SBWB are also likely to reduce risks to YBSB (see Section 9.4).

2. Introduction

2.1. Background and scope

RE Future Pty Ltd engaged Nature Advisory Pty Ltd to conduct pre-construction bat utilisation surveys for the proposed Swansons Lane Wind Farm (SLWF), located in south-west Victoria, adjacent to the Princes Highway approximately 2 km north-east of Garvoc and 7 km south-west of Terang.

The specific area investigated, referred to herein as the 'study area', comprised all areas within the proposed SLWF boundary as provided to Nature Advisory by RE Future. The specific focus of this investigation was on generating baseline data documenting presence/absence and temporal activity of the Southern Bent-wing Bat (SBWB, *Miniopterus orianae bassanii*; Critically Endangered, EPBC Act, Vulnerable FFG Act) and Yellow-bellied Sheath-tail Bat (YBSB, *Saccolaimus flaviventris*; Vulnerable, FFG Act) across the study area.

Targeted investigations designed to assess the potential for the proposed SLWF to impact upon SBWB and YBSB have been undertaken to fulfil the requirements outlined in The Victorian *Policy and planning guidelines – Development of wind energy facilities in Victoria* (Department of Environment, Land, Water and Planning, 2021) for wind farm proponents to assess the impacts of their projects on threatened species and communities listed on the state *Flora and Fauna Guarantee Act 1988* (FFG Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Potential risks posed by the proposed SLWF to all other bat species present in the study area will be addressed in separate Flora and Fauna Assessment report prepared by Ecology and Heritage Partners (EHP).

Initial intensive, seasonal bat detector surveys were conducted by EHP during spring 2021 and summer-autumn 2022. A second year of intensive surveys was then conducted by Nature Advisory in summer (December 2022 – February 2023) and autumn (March–April) 2023. Results from all bat detector surveys conducted over the 24-month period spanning 2021–2023 are presented in this report.

Identification of the echolocation call data recorded during the first year of surveys by EHP was conducted by Rob Gration (EcoAerial Environmental Services). Echolocation call data recorded by Nature Advisory during the second year of surveys was identified by Amanda Lo Cascio (University of Melbourne) and Rob Gration.

2.2. Report outline

This report is divided into the following sections.

Section 3 provides background on the proposed wind farm development.

Section 4 provides information on regulatory requirements.

Section 5 provides background on the Southern Bent-wing Bat.

Section 6 describes the bat detector survey methods used.

Section 7 presents and discusses the results.

Section 8 provides an impact assessment.

Section 9 outlines potential mitigation and offset measures.

Section 10 assesses Matters of National Environmental Significance.

This report was prepared by a team from Nature Advisory comprising Liz Browne (Zoologist), Michael Sebastian (Zoologist), Bradley Jones (Zoologist), Khalid Al-Dabbagh (Senior Zoologist), Dr Sergio Nolazco Plasier (Zoologist), Dr Steve Griffiths (Senior Ecologist) and Bernard O'Callaghan (Senior Ecologist and Project Manager).

3. Project description

3.1. Proposed development

The planning application for the proposed wind farm is being prepared on the basis of a dimensional envelope for the purposes of providing the permit applicant with a degree of optionality when it comes to the ultimate selection of a wind turbine model. Two configurations of two wind turbine models are being considered, namely the Vestas V162 HH150 and HH166, and the Vestas V172 HH150 and HH166. The dimensional envelope that takes in these four configurations, and which the planning application is therefore premised upon, is a hub height of 150–166 m, a rotor diameter of 162–172 m, a blade length of 81–86 m, a minimum blade ground clearance of 64 m above-ground-level (AGL), and a maximum blade tip height of 252 m AGL. This proposed minimum rotor swept height (RSH) is significantly higher than most wind turbines currently installed at operational wind farms in south-west Victoria.

Table 1: Specifications for the proposed wind turbines

Number of turbines	Up to 5
Maximum hub height (m)	150–166
Maximum rotor radius (m)	81–86
Minimum rotor swept height (m)	64
Maximum rotor swept height (m)	252

3.2. Study area context

The SLWF study area is located across multiple private properties currently used for agricultural purposes, with dairy farming being the predominant land-use.

The study area is generally flat and/or gently undulating, with a slight fall towards the south-west. There are no ridges, crests or waterways within or immediately adjacent to the development footprint. The study area contains several minor anthropogenic drainage lines that intersect the development footprint. Many of these were dry at the time of the field assessments.

Surrounding land use is consistent with the study area, being predominately agricultural, with scattered dams, agricultural buildings and rural dwellings present. Several immature native Blue Gum (*Eucalyptus globulus*) timber plantations are located on adjacent parcels to the north of the study area.

According to the Victorian Department of Energy, Environment and Climate Action (DEECA) NatureKit Map (https://www.environment.vic.gov.au/biodiversity/naturekit), the study area is located within the Victorian Volcanic Plain bioregion, Glenelg Hopkins Catchment Management Authority (CMA) and Corangamite Shire and Moyne Shire Councils municipality.

4. Regulatory context

This section presents the relevant Commonwealth and State legislation, policy and guidelines relating to the protection of biodiversity during the planning, construction and operation of wind farm facilities.

4.1. Commonwealth Environment Protection and Biodiversity Conservation Act

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) protects a range of Matters of National Environmental Significance (MNES) and matters protected by international treaties. These matters include a list of threatened species, ecological communities and migratory species. Any impact on such matters that is considered significant requires the approval of the Commonwealth Minister for the Environment.

One bat species listed under the EPBC Act is present in the SLWF study area:

- Southern Bent-wing Bat - Critically Endangered

A number of specific EPBC Act guidelines and associated species-specific documents have been consulted and directions from these applied during surveys and in formulating the investigations of fauna impacts described in this report. These include:

- Matters of National Environmental Significance - Significant Impact Guidelines 1.1 (Department of the Environment, 2013).
- Department of Environment, Land, Water and Planning, 2020. National Recovery Plan for the Southern Bent-wing Bat *Miniopterus orianae bassanii*. Victorian Government, Melbourne (Department of Environment, Land, Water and Planning, 2020).
- Threatened Species Scientific Committee, 2021. *Miniopterus orianae bassanii* (Southern Bent-wing Bat) Conservation Advice (Threatened Species Scientific Committee, 2021).
- Department of the Environment, Water, Heritage and the Arts, 2010. Survey Guidelines for Australia's Threatened Bats: Guidelines for Detecting Bats Listed as Threatened Under the Environment Protection and Biodiversity Conservation Act 1999 (Department of the Environment, Water, Heritage and the Arts, 2010).

4.2. Flora and Fauna Guarantee Act 1988

The Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) lists threatened and protected species and ecological communities (DELWP 2017b, DELWP 2017c). The Environment Effects Statement (EES) process in Victoria requires that impacts on FFG Act listed species be assessed, even on private land.

Two bat species listed under the FFG Act are present in the SLWF study area:

- Southern Bent-wing Bat – Critically Endangered.
- Yellow-bellied Sheath-tail Bat – Vulnerable.

4.3. Other Guidelines

In addition to the foregoing policy and legislative instruments, a number of wind farm specific guidelines have been consulted and key directions from these applied in formulating the investigations of potential impacts to fauna described in this report. These include:

- Best Practice Guidelines for Implementation of Wind Energy Projects in Australia (Clean Energy Council, 2018).
- Policy and Planning Guidelines - Development of Wind Energy Facilities in Victoria (Department of Environment, Land, Water and Planning, 2021).

5. Southern Bent-wing Bat

5.1. Taxonomy and distribution

In 2000, the SBWB was recognised as a subspecies distinct from the Northern (*Miniopterus orianae orianae*) and Eastern (*Miniopterus orianae oceanensis*) Bent-wing Bats (Cardinal and Christidis, 2000). There is one other Australian Miniopterid, the Little Bent-wing Bat (*Miniopterus australis*), but the distribution of this species spans south-eastern NSW to north-east Queensland and does not overlap with SBWB (Australasian Bat Society, 2024). With a mean weight of 15.7 g, head and body length of 52–58 mm, and forearm length of 45–49 mm, the SBWB is slightly larger than the other two *Miniopterus orianae* subspecies, however the three subspecies are morphologically very similar (Churchill, 2008).

The SBWB is an obligate cave-roosting species with a restricted distribution (19,452 km^2) in south-eastern Australia that spans an area from Robe, Naracoorte and Port MacDonnell in south-east South Australia, extending eastwards to Lorne and Pomborneit in south-west Victoria (Churchill, 2008; Threatened Species Scientific Committee, 2021). There is a small area of overlap in the distribution of the SBWB and Eastern Bent-wing Bat (EBWB) in western Victoria, where individuals of each subspecies may roost together in some non-maternity caves (Australasian Bat Society, 2024; Threatened Species Scientific Committee, 2021) (Figure 1). In this region, SBWB and EBWB cannot be reliably distinguished using traditional field-based techniques, such as by comparing morphometric measurements (Department of Environment, Land, Water and Planning, 2020).

5.1. Conservation status

The SBWB has undergone serious population decline since the 1960s (Department of Environment, Land, Water and Planning, 2020). Consequently, in 2007 the SBWB was listed as Critically Endangered under the EPBC Act. In Victoria, the species is listed as Critically Endangered under the FFG Act. A draft national recovery plan for the SBWB was issued in 2015 (Lumsden and Jemison, 2015), and a revised plan was formally adopted under the EPBC Act in 2020 (Department of Environment, Land, Water and Planning, 2020).

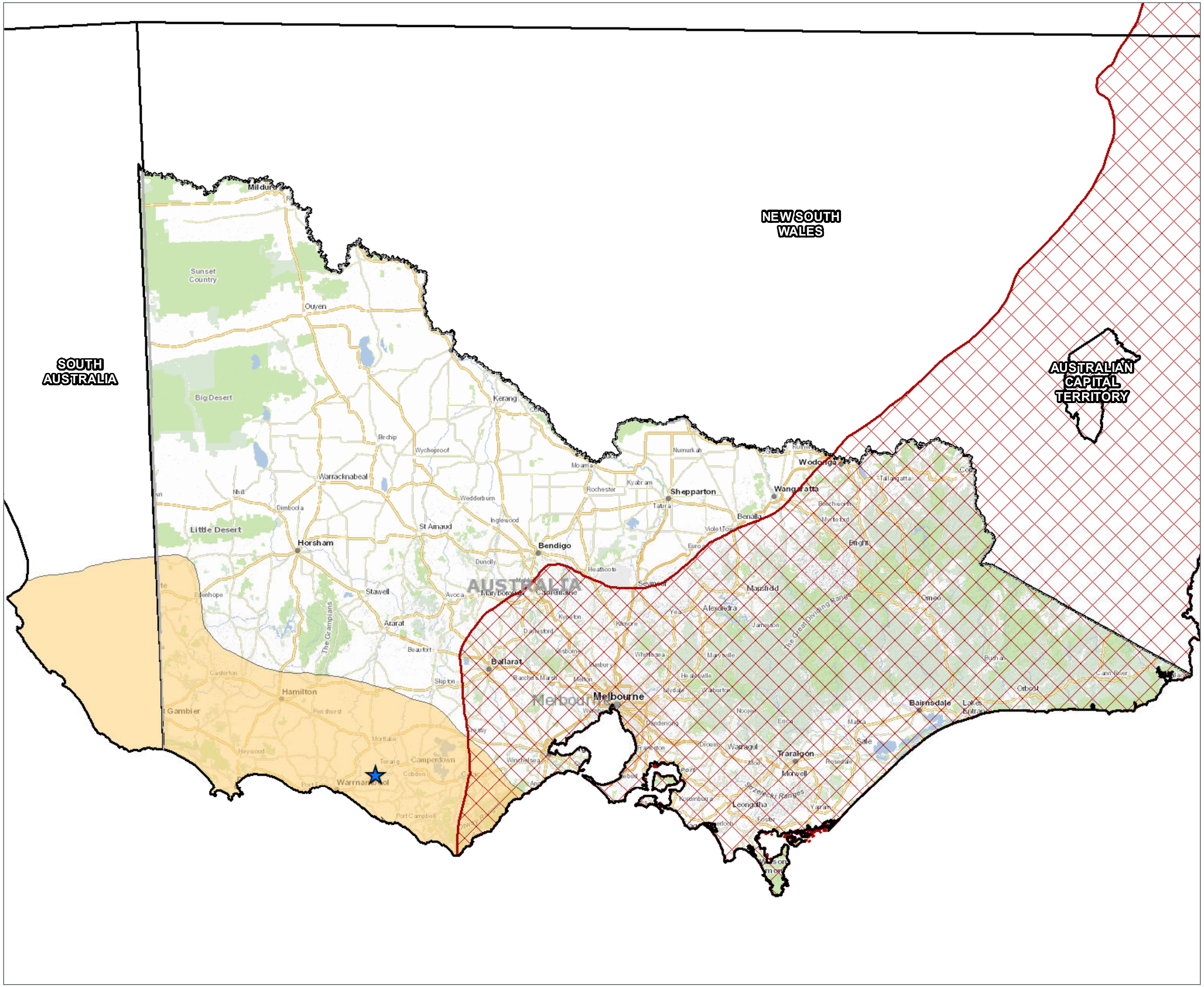
Recent population modelling predicted an 84% to 97% reduction in population size from 2020-2056 (van Harten et al., 2022b). Continued population decline is suspected to be driven primarily by historical and ongoing loss of foraging habitat via the conversion of wetlands and native vegetation for agricultural purposes. Drought and the introduction of White-nose Syndrome to Australia both pose significant threats to SBWB (Holz et al., 2019; Southern Bent-wing Bat National Recovery Team, 2022).

Figure 1: Southern Bent-wing Bat and Eastern Bent-wing Bat geographic distributions

Note - Distribution ranges were sourced from the Australasian Bat Society's BatMap open-source geodatabase (https://www.ausbats.org.au/batmap.html).

Figure 1: Southern and Eastern Bent-wing Bat distribution

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 8/08/2023



- Swansons Lane WF
- Victoria
- Eastern Bent-wing Bat
- Southern Bent-wing Bat

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Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

5.2. Foraging

The SBWB is a nocturnal, aerial hawking insectivorous species with a fast, direct flight pattern and they typically forage in open spaces (Dwyer, 1965). Where there are trees present, SBWBs typically forage above the canopy, but can fly closer to the ground in more open areas (Churchill, 2008; Threatened Species Scientific Committee, 2021). Limited radio-tracking studies have shown that SBWBs hunt in a range of habitat types, including wetlands, forested areas, native remnant vegetation, and over cleared agricultural and grazing land (Grant, 2004; Threatened Species Scientific Committee, 2021).

In 1977, a dietary study examining stomach contents of 11 bent-winged bat (*Miniopterus schreibersii*) individuals collected from eastern and northern Australia found moths (Lepidoptera) were the main prey item (Vestjens and Hall, 1977). In a more recent study using arthropod DNA metabarcoding from guano collected in roost caves, Kuhne et al. (2022) also found that moths comprised the main component of the SBWB diet. Of the 67 moth species identified, many are associated with agricultural landscapes, such as Pasture Webworm (*Hednota pedionoma*) and Armyworm (*Persectania dyscrita*) (Kuhne et al., 2022). These findings suggest SBWB may provide important ecosystem services by contributing to the control of populations of moth species considered to be agricultural pests (Kuhne et al., 2022).

Being an insectivorous bat, SBWBs have a high surface area to volume ratio and large, naked flight membranes, which in combination result in high rates of evaporative water loss (Webb et al., 1995). Consequently, they require access to surface water and drink on-the-wing from open waterbodies such as creeks and rivers, wetlands and farm dams (Threatened Species Scientific Committee, 2021). SBWBs are also known to access drinking water by licking droplets from drips in roost caves (Bourne and Hamilton-Smith, 2007; Codd et al., 1999).

5.3. Roost caves

SBWBs gather in late spring and early summer at maternity caves to give birth and raise their young, and then disperse in autumn to use non-breeding caves throughout the cooler parts of the year (Churchill, 2008). There are two major SBWB maternity caves with long histories of use: 'Bat Cave', located in the limestone cave system at Naracoorte in South Australia, and 'Starlight Cave', a sea cliff cave located near Warrnambool in Victoria (Threatened Species Scientific Committee, 2021). During the breeding season, the majority of the SBWB population is thought to roost in the two main maternity caves: around 28,000–35,200 bats in Bat Cave (Naracoorte, SA), and 17,233–18,000 bats in Starlight Cave, (Warrnambool, western Victoria) (Threatened Species Scientific Committee, 2021). A third, smaller maternity cave was discovered in 2015 near Portland, Victoria (Lumsden and Jemison, 2015). In 2020, The Department of Environment, Land, Water and Planning (DELWP) estimated there was a population of 1,000-1,500 individuals (including juveniles) using the Portland maternity cave (Threatened Species Scientific Committee, 2021).

Monitoring the abundance of SBWBs at the three maternity caves is ongoing, with data being used to develop long-term population models (Southern Bent-wing Bat National Recovery Team, 2022).

The SBWB maternity caves have specific structural characteristics that allow heat and humidity to build up, creating conditions suitable for rearing and development of dependent young (Dwyer, 1963). The caves used in winter are cooler, allowing the bats to lower their body temperature to facilitate the use of torpor, i.e. reduced metabolic rate (Baudinette et al., 1994; Hall, 1982). In Victoria, there are 18 caves used as roosting sites, spread throughout the south-west of the state, and in South Australia 52 caves are known to be used for roosting (Department of Environment, Land, Water and Planning, 2020).

Recent studies have collected data on patterns of movement between and use of caves that challenge previously held concepts of roost fidelity and temporal patterns of roost use. The Conservation Advice: *Miniopterus orianae bassanii* (Threatened Species Scientific Committee, 2021) summarises this as follows:

"*While caves that are consistently used by large numbers of Southern Bent-wing Bats may be considered critical sites, the availability of a large number of sites, even those used infrequently, may be equally important for the subspecies' survival.*

Recent research has provided new insights on movement patterns, seasonal migration, and torpor/hibernation (Bush et al., 2022; van Harten et al., 2022b, 2022a). The traditional view, based on the work of (Dwyer, 1963), had assumed there were two seasonal migrations, with all bats leaving overwintering caves in spring and taking several weeks to return to the maternity caves via stopovers at transition caves. In autumn, bats were thought to disperse from the maternity sites to overwintering caves, where they would enter extensive periods of torpor. Individuals were assumed to remain at these overwintering caves for the duration of winter. However, the new research, which tracks PIT-tagged SBWBs in South Australia, has revealed far more complex movement patterns (van Harten et al., 2022a). Tracking data has shown that so-called 'overwintering caves' can be used at any time of year, leading to discontinuation of the term 'overwintering cave' in favour of 'non-maternity cave' (Bush et al., 2022).

The use of non-maternity caves is now understood to be highly dynamic. For example, bats leaving the Naracoorte maternity cave in early autumn may visit many non-maternity caves over the course of a few weeks before returning to the maternity cave (van Harten et al., 2022a). Large distances can be flown in short periods of time. There are numerous examples of individuals flying between the Naracoorte maternity cave and a non-maternity cave 70 km away (this cave also has a PIT-tag reader) over the period of just a few hours, and sometimes returning to the maternity cave on the same night – a total distance of 140 km in 24 hours (van Harten et al., 2022a). Periods of torpor also appear to be shorter than previously thought, with some activity during winter, including movement between caves (van Harten et al., 2022a)."

The SLWF study area is located approximately 27 km north-east of Starlight Cave (the primary maternity cave in Victoria), 10 km north-east of the non-maternity cave at Panmure Cave, 28.3 km east of the non-maternity cave at Grassmere, 23 km north-west of the non-maternity cave at Timboon, 40 km west of non-maternity caves at Pomborneit and Porndon Arch, 65 km north-west of the of the non-maternity cave at Cape Valley, and 69 km east of the of the non-maternity caves at Yambuk and Deen Maar (Figure 2).

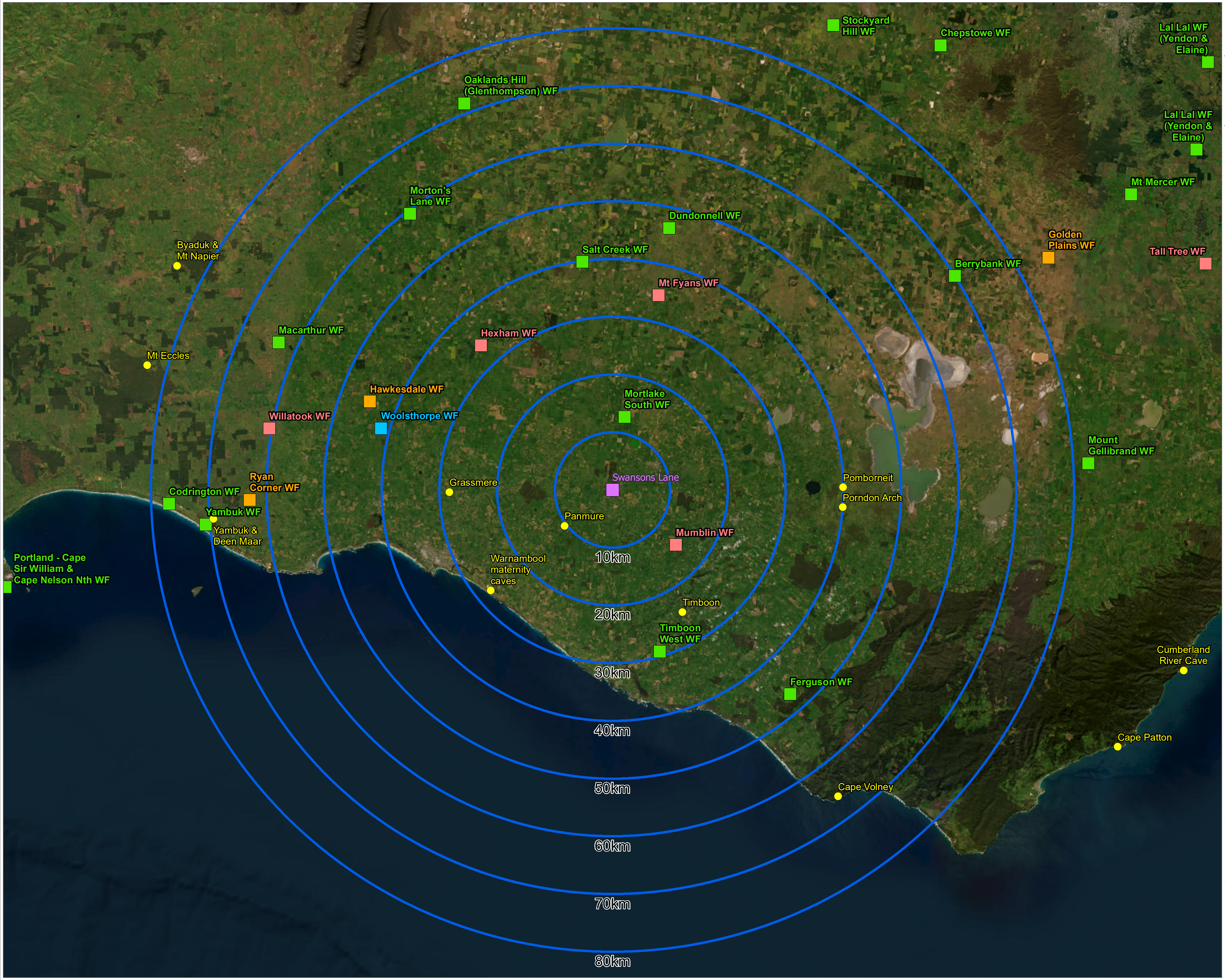

Figure 2: Location of SBWB roost caves and wind farms

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 15/03/2024

Search area
Windfarm site
SBWB roost caves

Surrounding wind farm status

Operating
Under construction
Approved (Not operational)
Permit application under development or consideration

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PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

5.3.1. *Insectivorous bat foraging guilds*

Differences in echolocation call characteristics and wing morphology drive variation in foraging strategies and contribute to resource partitioning among insectivorous bats (Aldridge and Rautenbach, 1987). These traits are often used to group different bat species according to foraging guilds (Schnitzler and Kalko, 2001). Broadly these foraging guilds are discussed in more detail below, but broadly can be categorised into the following guilds:

- Clutter Adapted.
- Open Space.
- Edge-space Low-frequency.
- Edge-space Medium-frequency.
- Edge-space High-frequency.

Species with high wing loading (larger wing area relative to mass) and high aspect ratio (long narrow wings) are adapted to fly at high speed in open space above the canopy and tend to produce lower-frequency calls that help locate larger prey items at greater distances (Schnitzler and Kalko, 2001). In south-eastern Australia, this 'open-space adapted' guild include members of the Emballonuridae (e.g., YBSB) and Mollosidae (e.g., White-striped Free-tailed Bat *Austronomus australis*) (Adams et al., 2009; Rhodes, 2002a). In the Northern Hemisphere, open-space adapted bats with low-frequency echolocation calls have been shown to spend a significant proportion of time flying at heights within the rotor swept area (RSA) of wind turbines (Roemer et al., 2019b).

Species with low wing loading and low aspect ratio (broad, rounded wings), such as the Lesser Long-eared Bat (*Nyctophilus geoffroyi*), are adapted for slow, manoeuvrable flight in cluttered environments below the canopy (Adams et al., 2009; Rhodes, 2002a). This 'clutter-adapted' guild tend to produce higher-frequency calls that allow them to navigate through relatively dense vegetation and locate smaller prey items that are relatively close to the bat (Schnitzler and Kalko, 2001).

Other species with wing morphology somewhere between these two extremes are adapted to forage in the space between and just above the canopy, i.e. edge-space adapted (Schnitzler and Kalko, 2001). In Australia, taxa within the 'edge-space' guild are often grouped into three sub-categories based on their call frequency: (1) low-frequency (e.g., Gould's Wattled Bat *Chalinolobus gouldii*), (2) medium-frequency (Eastern Falsistrelle *Falsistrellus tasmaniensis*) or (3) high-frequency calling (Haddock et al., 2019). Four species from the edge-space high-frequency guild occur in the SLWF study area: SBWB, Little Forest Bat (*Vespadelus vulturnus*), Southern Forest Bat (*Vespadelus regulus*) and Chocolate Wattled Bat (*Chalinolobus morio*).

In Table 2, all insectivorous bat species known to be present within 50 km of the SLWF study area are grouped according to foraging guilds, based on their wing morphology and echolocation call frequency. Wing loading and aspect ratio have not been reported for SBWB, so values recorded from the EBWB were used in Table 2 (Rhodes, 2002b); these two closely related sub-species are indistinguishable based on morphology (Threatened Species Scientific Committee, 2021). Wing morphology metrics were left blank in Table 2 for two species which these values have not been reported: Eastern Falsistrelle, Ride's Free-tailed Bat *Ozimops ridei*

Table 2: Bat species present within 50 km of the study area grouped by foraging guild

Foraging guild	Species	Common name	Call description and characteristic frequency (Fc)	Wing loading	Aspect ratio	Mean body weight (g)
Clutter Adapted	*Nyctophilus geoffroy*	Lesser Long-eared Bat	Near vertical, starts 70–80 kHz dropping to 35–45 kHz Fc	5.9 ± 1.0	5.6 ± 0.6	8.2
	Nyctophilus gouldi	Gould's Long-eared Bat	Near vertical, starts 70–80 kHz dropping to 35–45 kHz Fc	6.2 ± 1.3	5.5 ± 0.3	12.3
Open Space	*Austronomus australis*	White-striped Free-tailed Bat	Flat or curved, 11–15 kHz CF	15.5 ± 1.7	7.9 ± 0.8	37.6
	Ozimops planiceps	Southern Free-tailed Bat	Flat, 26–28 kHz Fc	12.5 ± 0.2	7.2 ± 7.1	9.0
	Ozimops ridei	Ride's Free-tailed Bat	Flat, 30–34 kHz Fc			9.0
	Saccolaimus flaviventris	Yellow-bellied Sheath-tail Bat	Curved, 18–22 kHz	15.9 ± 2.5	8.3 ± 0.4	44.0
Edge-space Low-frequency	*Chalinolobus gouldii*	Gould's Wattled Bat	Curved, alternating, 29–33 kHz	8.2 ± 2.3	6.5 ± 0.4	13.8
	Scotorepens balstoni	Inland Broad-nosed Bat	Curved, 28–34 kHz Fc	6.3	7.0	9.3
Edge-space Medium-frequency	*Falsistrellus tasmaniensis*	Eastern Falsistrelle	Curved and steep, 34–40 kHz			21.0
	Vespadelus darlingtoni	Large Forest Bat	Curved, 40–44 kHz	6.4	5.9	7.2
Edge-space High-frequency	*Chalinolobus morio*	Chocolate Wattled Bat	Curved, down-sweeping tail, 47–53 kHz	6.3 ± 1.08	6.1 ± 0.3	8.9
	Miniopterus orianae bassanii	Southern Bent-wing Bat	Curved, down-sweeping tail, 45–52 kHz	9.7 ± 1.6	6.7 ± 0.3	15.7
	Vespadelus regulus	Southern Forest Bat	Curved, up-sweeping tail, 42–46 kHz	6.2 ± 0.2	5.2 ± 0.3	5.2
	Vespadelus vulturnus	Little Forest Bat	Curved, up-sweeping tail, 46–48 kHz	6.4 ± 0.5	5.2 ± 0.5	3.9

Note – foraging guilds, echolocation characteristics and wing morphology metrics derived from: Adams et al., 2009; Churchill, 2008; Fullard et al., 1991; Lo Cascio et al., 2022; Rhodes, 2002a.

5.4. Flight heights

SBWB are considered to have a fast, direct flight pattern for foraging in open spaces (Dwyer, 1965). Observational records indicate that, in treed areas, SBWB typically forage just above the canopy or within gaps below the canopy (Department of Environment, Land, Water and Planning, 2020). However, no published data exist documenting specific heights that individuals fly when foraging above different habitat features or communing across the landscape between roosting caves. This has been identified as a knowledge gap and research priority within the Conservation Advice (Threatened Species Scientific Committee, 2021).

To address this, members of the SBWB Recovery Team (SBWBRT) have undertaken GPS tracking studies in Victoria in summer-autumn 2021 (following a pilot study in 2020) to directly investigate flight heights of SBWBs (Southern Bent-wing Bat National Recovery Team, 2021). The SBWBRT Annual Report for 2022 states that (Southern Bent-wing Bat National Recovery Team, 2022):

"*Amanda Bush's GPS tracking study will assist in assessing the susceptibility of SBWB to wind farm mortality by estimating the height Southern Bent-wing Bats fly at. Data collected in 2020 and 2021 are being analysed, and a drone is being used to calibrate the vertical accuracy of the GPS units*."

More generally, there is limited or no published information on flight heights for most Australian bats; this is primarily due to technical limitations in recording bat activity across a vertical gradient (Adams et al., 2009). Only a handful of peer-reviewed studies worldwide have attempted to quantify different bat species' use of vertical space (i.e. vertical niche partitioning) (Voigt et al., 2020). To address this limitation, the EUROBATS *Guidelines for Consideration of Bats in Wind Farm Projects* recommends that, for pre-commissioning bat surveys designed to generate data for impact assessments at proposed wind farms, bat detectors should be used to survey bat activity above the canopy, preferably within the RSA of proposed turbines (Rodrigues et al., 2015). The EUROBATS Guidelines suggest that at-height survey methods using detectors attached to kites or balloons have been shown to generate data that is limited in use, and instead recommend using stationary structures (Rodrigues et al., 2015). Therefore, attaching detectors to meteorological towers (met masts) is the most commonly employed method for investigating bat flights heights during pre-commissioning bat surveys at European wind farms (Roemer et al., 2017).

Following the EUROBATS Guidelines recommendation for monitoring at-height, several peer-reviewed studies, published in authoritative scientific journals, have used echolocation calls recorded by paired detectors placed at ground-level and at-height on met mats to quantify the activity of European insectivorous bats across a vertical gradient. The findings have been used to relate relative activity at height to echolocation call structure and wing morphology, and also to model predicted risk of collisions with wind turbines. Interestingly, this research showed that for Schreiber's Bent-winged bat *Miniopterus schreibersii*, 0.01% of all activity was recorded at-height (40-85 m) (Roemer et al., 2019b, 2019a, 2017). This co-generic European bent-winged bat species has a similar body size, wing morphology and high-frequency (Fc = ~53kHz) echolocation calls to SBWB, For more information, see:

- Roemer, C., Bas, Y., Disca, T., Coulon, A., 2019. Influence of landscape and time of year on bat-wind turbines collision risks. *Landscape Ecology* 34, 2869–2881.
- Roemer, C., Coulon, A., Disca, T., Bas, Y., 2019. Bat sonar and wing morphology predict species vertical niche. *The Journal of the Acoustical Society of America* 145, 3242–3251.

- Roemer, C., Disca, T., Coulon, A., Bas, Y., 2017. Bat flight height monitored from wind masts predicts mortality risk at wind farms. *Biological Conservation* 215, 116–122.

Further, a recent study conducted in Kenya, East Africa, also used bat detectors attached to met masts to quantify bat flight heights and relate the findings to the risk wind farms could pose to species that the authors characterised as either low, medium or high flying (Rainho et al., 2023).

The guidelines for monitoring bats at proposed wind farm developments published by the Victorian Government in 2007 recommends proponents undertake bat detector surveys with paired detectors placed at ground-level and at-height on a met mast or other portable tower structure (Lumsden, 2007). During Technical Reference Group consultations, DEECA has routinely suggested this is a methodology that wind farm proponents should incorporate into pre-commissioning bat detector surveys. Consequently, over the last decade or so, met mast bat detector surveys have been conducted during pre-commissioning surveys at multiple proposed wind farms in south-west Victoria in an attempt to quantify use of vertical space by SBWB; for example, Dundonell Wind Farm, Mortlake South Wind Farm, Bulgana Wind Farm, and Mt Fyans Wind Farm (see Section 8.3.1). For several wind farm development projects in Victoria that Nature Advisory is aware of, met masts were installed by proponents specifically for the purpose of conducting at-height bat detector surveys.

It is noted that there are a number of potential limitations with recording echolocation calls at height, such as increased noise from higher wind speeds. Plus, the high-frequency calls produced by SBWBs can be difficult to detect in these conditions due to increased atmospheric attenuation. However, as mentioned above, studies published in authoritative, international peer-reviewed journals have shown that detectors attached at-height to met masts are capable of recording high-frequency (45-53 kHz) calling bat species (Rainho et al., 2023; Roemer et al., 2019b, 2017).

The results from met mast bat detector surveys conducted at multiple sites in south-west Victoria are discussed in Section 8.3.1.

5.5. Threats and impacts to SBWB in Victoria

The Conservation Advice lists the following threats to the global SBWB population in order of severity and risk (Threatened Species Scientific Committee, 2021):

- Damage or destruction of roost sites.
- Clearing and modification of foraging habitat.
- Disease.
- Climate change.
- Human visitation and disturbance to caves.
- Feral predators – Feral Cat (*Felis catus*), European Red Fox (*Vulpes vulpes*) and Black Rat (*Rattus rattus*).
- Fencing, particularly barbed-wire fencing.
- Wind farms.
- Severe bushfire.
- Accumulation of pesticides or other toxins.

5.5.1. Wind farms

The SBWB Recovery Plan notes that risks posed by the development and operation of wind farms include cave destruction during construction, mortalities due to collisions, and altered access to foraging areas (Department of Environment, Land, Water and Planning, 2020). The risk is likely to increase the closer the wind farm is to an important site, particularly a maternity cave or if the site is located along a migration path between caves (Threatened Species Scientific Committee, 2021). The locations of operational wind farms in the region surrounding the proposed MWF site are shown in Figure 2.

A total of eight SBWB mortalities caused by turbine collisions were reported during post-construction carcass search surveys at operational wind farms conducted up to 2018 (Moloney et al., 2019; Stark and Muir, 2020). Nature Advisory understands that these eight SBWB carcasses were found at two wind farms located in south-west Victoria, and that both sites have turbines with a minimum RSH of approximately 25–30 metres AGL.

Since 2018, three SBWB mortalities attributed to collisions with turbines were recorded at one operational wind farm in Victoria (Bennett et al., 2022).

According to advice provided by DEECA, a further three documented mortalities which occurred since 2018 were reported in “DEECA's submission presented to the Mt Fyans Wind Farm Panel on 3 April 2023 (section 6.24.1)”. After the information provided on 01 September 2023, Nature Advisory contacted DEECA again on 05 September 2023 to request a copy of this document; the response provided by DEECA was that this document is not available to the public and an official request would need to be lodged with the by Department of Transport and Planning to seek access to it under the Freedom of Information Act 1982 (FOI 1982).

Nature Advisory is aware of one SBWB carcass that has been found since 2018 under a turbine at a Victorian wind farm (Rob Gration, pers. comm.). This information was provided anecdotally and has not yet been made publicly available through annual reporting for that wind farm project’s Bat and Avifauna Management Plan (BAMP). Therefore, the wind farm will not be named in this report. It is unclear if this is one of the three SBWB mortalities mentioned in DEECA's submission presented to the Mt Fyans Wind Farm Panel?

Information on the remaining 8 mortalities that were reported to DEECA between March to May 2023 have not yet been made publicly available (Table 3). However, Nature Advisory understands that these eight SBWB mortalities were recorded at Salt Creek Wind Farm (minimum RSH of 24 m AGL) and Dundonnell Wind Farm (minimum RSH of 39 m AGL) (Planning Victoria, pers. comm.).

In June 2023, Nature Advisory requested all available results of carcass searches documenting SBWB collisions at operational wind farms from DEECA (with specific wind farms anonymised to maintain commercial confidentially). On 13 February 2024, DEECA provided Nature Advisory with further clarification on the cumulative total number of SBWB mortalities at operational wind farms in south-west Victoria, which at that time was 21 (Table 3).

Since the advice provided by DEECA in February 2024, Nature Advisory is aware of a further five SBWB carcass that were found in Autumn 2024 at two operational wind farms in south-west Victoria (one carcass at one wind farm and four at another). This brings the total number of SBWB moralities at the time of the preparation of this report to 26 (Table 3). Information on these five mortalities have not yet been made publicly available, so the two wind farms will not be named in this report.

Table 3: Total SBWB mortalities reported to DEECA up to September 2023

Source	Time period	Number of SBWB mortalities
Moloney et al. (2019) and Stark and Muir (2020)	Up to 2018	8
Bennett et al. (2022) - Cape Nelson North Wind Farm	2018 and 2019	3
"DEECA's submission presented to the Mt Fyans Wind Farm Panel on 3 April 2023 (section 6.24.1)"	Not disclosed	3
"DEECA has been notified of 8 SBWB mortalities being found during post-construction monitoring between March to May 2023." Note – one of the 8 carcasses referred to here was previously included in the 3 carcasses documented in DEECA's submission presented to the Mt Fyans Wind Farm Panel on 3 April 2023. Consequently, only 7 SBWB mortalities are listed here.	March to May 2023	7
Five carcasses detected during scent dog searches at two operational wind farms in south-west Victoria. The wind farm operators have provided information on these carcasses to DEECA, but the details have not yet been made public.	Autumn 2024	5
	Total	**26**

Studies in the Northern Hemisphere have shown that impacts to bats caused by wind farms can be cumulative, particularly for migratory species (Arnett and Baerwald, 2013; Kunz et al., 2007). As part of the biodiversity investigations and risk assessments for proposed wind farm developments in Victoria, proponents are required to consider how cumulative impacts of a number of discrete wind energy developments within a broad area may affect bird and bat populations (Department of Environment, Land, Water and Planning, 2021). Ongoing post-construction monitoring is being conducted at operational wind farms in south-west Victoria, and the results are assessed by DEECA and The Department of Agriculture, Fisheries and Forestry (Southern Bent-wing Bat National Recovery Team, 2022). However, Moloney et al. (2019) highlight the following limitations of carcass searches conducted at operation wind farms in Victoria:

"Current practices used to detect dead birds and bats at wind farms have the capacity to detect only a small, but uncertain, percentage of the mortalities that may be occurring. Where few collision mortalities actually occur for a particular species, current methods have a low probability of detecting any carcasses at all. The capacity to detect carcasses is influenced by the frequency of searches, the proportion of turbines searched, and how searches are undertaken."

For the reasons mentioned above, and because not all SBWB carcass detections attributed to turbine collision are made publicly available, it is currently not possible to quantify the cumulative impacts to SBWB caused by operational wind farms. However, the 26 SBWB carcasses that have been reported to DEECA to date is likely an underestimate of the total number of mortalities.

6. Methods

6.1. Roost cave assessment

RE Future commissioned Environmental Geosurveys (Neville Rosengren) and Wakelin Associates (Dr Susan White) to conduct a desktop assessment of SBWB roost caves within 80 km of the proposed SLWF site.

Data on cave locations and reports of SBWB occupying specific caves in the study area was sourced from publications and other documents of the Victorian Speleological Association (VSA) and personal data (S. White). The comprehensive literature search covered the two catalogues of caves and karst—Matthews (1985) and Davey and White (1986)—all years of the VSA Journal *Nargun*, newsletters, guidebooks, conference proceedings, and personal field notes.

The records searched by Dr White that provided cave and SBWB data for the study area largely date between 1970 and 1996. Since then, in many areas—notably around Warrnambool—there has been significant change in land use, land tenure, ownership and management. As a result, some caves in this inventory may have been substantially altered or destroyed, by filling, excavation, and overbuilding. The resultant report suggested field checking of 16 potential caves in several areas (e.g., Timboon caves). To address this, on-ground surveys were conducted by Rob Gration in 2022 to check key sites identified during the desktop review, specifically to verify existence and current condition and suitability for bat use. A total of 15 of the potential cave sites were manually inspected after DEECA provided advice that one of the 16 caves (O'Keefe's Cave) should not be checked, because SBWB are known to use this cave and temporal occupancy patterns are being monitored on an ongoing basis by the SBWB Recovery Team.

Upon request from Dr Susan White that information about potential SBWB cave roosts should not be made publicly available due to confidentiality, the full list of potential caves is not presented here. Separate to this report, RE Future will provide DEECA with copies of both the desktop assessment and on-ground cave survey reports.

6.2. Bat detector surveys

Bat detector surveys were initially conducted in the study area by EHP during 2021–2022, then continued by Nature Advisory during 2022–2023. The timing and duration of the targeted, intensive seasonal surveys were accordance with *the Survey Guidelines for Australia's Threatened Bats* (Department of the Environment, Water, Heritage and the Arts, 2010) and the *Guidelines for Bat Surveys in Relation to Wind Farm Developments* (Lumsden, 2007). The surveys were intended to coincide with the periods when the greatest level of SBWB activity occurs across south-west Victoria as individuals are moving across the landscape between maternity and non-maternity roost caves (Department of Environment, Land, Water and Planning, 2020).

The data presented in this report are from all four intensive seasonal surveys (described below):

- Spring 2021.
- Summer-Autumn 2022.
- Summer 2022-2023.
- Autumn 2023.

An increased survey effort was undertaken during the Autumn 2023 survey that incorporated an additional 10 bat detector sites to increase spatial replication of sampling effort across the study area (i.e. 22 sites in total).

Echolocation calls produced by free-flying microbats were recorded using automated bat detectors secured to trees or fence posts approximately 1.5–2 metres AGL. Detectors were programmed to commence recording approximately 30-minutes before sunset and to cease approximately 30-minutes after sunrise, during which time they were triggered automatically by ultrasonic noise.

6.2.1. Year 1 – EHP

Two intensive seasonal surveys were conducted by EHP during late 2021 and early 2022 as follows.

Spring 2021 - Six Song Meter SM4BAT-ZC (Wildlife Acoustics, USA) detectors were deployed on 30 September 2021 at six sites (one detector per site) across the study area (Figure 3). Batteries and memory cards were replaced on 19–20 October and retrieved on 30 November 2021. In total, this survey comprised 61 nights; there was variation in the number of bat detector nights across sites caused by equipment malfunction or interference by livestock (Table 4).

Summer-autumn 2022 - Four SM4BAT-ZC and two Anabat SD1 (Titley Scientific, Australia) detectors were deployed across six sites on 04 February 2022 and retrieved on 19–20 March 2022. In total, this survey comprised 47 nights, with some variation in total detector nights across sites (Table 4).

Zero-crossing echolocation data recorded by each bat detector, along with the date and time of each individual call sequence (i.e. a series of echolocation pulses recorded in a single file), was saved onto a 64GB SD memory card.

6.2.2. Year 1 – survey sites

The study area encompasses operational dairy farms and is predominantly characterised by large open expanses of mixed grazing exotic grasslands (e.g. dairy cattle paddocks). Effort was made to place the sampling sites at locations representative of the range of habitats present across the site, these included:

- Open grazing paddocks with very few or no scattered trees.
- Open grazing paddocks with windbreaks comprising native or introduced tree species.
- Farm dams located within open grazing paddocks.
- Blue Gum forestry plantations located along the north and east boundaries of the study area.
- Remnant eucalypt woodland.

The characteristics of the bat detector survey sites are described in Table 5, and their locations shown in Figure 3.

Table 4: Bat detector specifications and recording dates during the EHP year 1 surveys

Surveys	Detector site ID	Bat detector model	Date deployed	Battery/memory card changed	Date retrieved	Total bat detector nights per site
Spring-summer 2021	1	SM4BAT-ZC	30/09/2021	19/11/2021	30/11/2021	29
	2	SM4BAT-ZC	30/09/2021	19/11/2021	30/11/2021	61
	3	SM4BAT-ZC	30/09/2021	19/11/2021	30/11/2021	38
	4	SM4BAT-ZC	30/09/2021	19/11/2021	30/11/2021	61
	5	SM4BAT-ZC	30/09/2021	19/11/2021	30/11/2021	61
	6	SM4BAT-ZC	30/09/2021	19/11/2021	30/11/2021	51
					Total bat detector nights	301
Autumn 2022	1	SM4BAT-ZC	4/02/2022	4 /02/2021	19/03/2022	55
	2	SM4BAT-ZC	4/02/2022	4 /02/2021	19/03/2022	25
	3	SM4BAT-ZC	4/02/2022	4 /02/2021	19/03/2022	47
	4	Anabat-SD1	4/02/2022	4 /02/2021	19/03/2022	50
	5	SM4BAT-ZC	4/02/2022	4 /02/2021	19/03/2022	23
	6	Anabat-SD1	4/02/2022	4 /02/2021	19/03/2022	53
					Total bat detector nights	253

Table 5: Descriptions provided by EHP of bat detector sites from the year 1 surveys

Site	Habitat/landscape description
1	Roadside vegetation along Swansons Lane, surrounded by cleared agricultural paddocks in all directions.
2	Roadside vegetation along Swansons Lane, surrounded by cleared agricultural paddocks in all directions.
3	End of windbreak, surrounded by cleared agricultural paddocks in all directions.
4	Along drainage line in agricultural paddock, surrounded by cleared agricultural paddocks in all directions.
5	Roadside vegetation along Swansons Lane, surrounded by cleared agricultural paddocks in all directions.
6	Border of study area; adjacent to farm dam, surrounded by cleared agricultural paddocks in all directions.

6.2.3. Year 2 – Nature Advisory

Two intensive seasonal surveys were conducted by Nature Advisory during late 2022 and early 2023 as follows.

Summer 2022-2023 – Eleven SM4BAT-FS detectors and one SM4BAT-ZC detector were deployed across 12 sites from 22 December 2022 to 02 February 2023 (Table 6, Figure 3). Six of these sites were placed close to the locations of the six bat detector sites surveyed during the EHP surveys in 2021 and 2022. Several detectors could not be placed at exactly the same locations sampled during previous surveys because of access limitations in summer 2022-2023; for example, in paddocks where bulls were present. In total, this survey comprised 43 nights, with some variation in total detector nights across sites (Table 6).

This survey was scheduled to occur during spring and early summer 2022; however, due to an unforeseen lack of availability of bat detector equipment caused by supply chain issues experienced by Wildlife Acoustics and their Australian distributor (Faunatech), the start date was unavoidably delayed by approximately 6-weeks.

Autumn 2023 - Eleven SM4BAT-FS detectors and one SM4BAT-ZC detector were deployed at the same 12 sites used during the summer 2022-2023 surveys, plus an additional 10 Song Meter Mini-bat detectors (Wildlife Acoustics, USA) were place at 10 extra sites (Figure 3). The autumn survey ran from 21 February to 03 April 2023. In total, this survey comprised 42 nights, with some variation in total detector nights across sites (Table 6).

Full-spectrum echolocation data recorded by each SM4BAT-FS bat detector and zero-crossing data recorded by the SM4BAT-ZC and each Mini-bat, along with the date and time of each individual call sequence (i.e. a series of echolocation pulses recorded in a single file), was saved onto a 64GB SD memory card. Specifications of the detector settings used during the year 2 surveys are provided in Table 8.

6.2.1. Year 2 – survey sites

The 10 additional detector sites sampled during the Autumn 2023 survey were selected to increase spatial replication across the study, and to ensure different habitat types were represented in the sampling regime. Selection of additional sites focused on areas out in open paddocks, plus habitats that could comprise suitable foraging areas for SBWB, for examples, close to farm dams, windbreaks, Blue Gum forestry plantations and remnant eucalypt woodland. Note – there is only one small patch of remnant eucalypt woodland (approximately 2 Ha) remaining within the study area.

The characteristics of the recording sites sampled during the year 2 surveys are described in Table 7, and their locations are shown in Figure 3. Examples of bat detectors installed on-site during the year 2 surveys are shown in Figure 4.

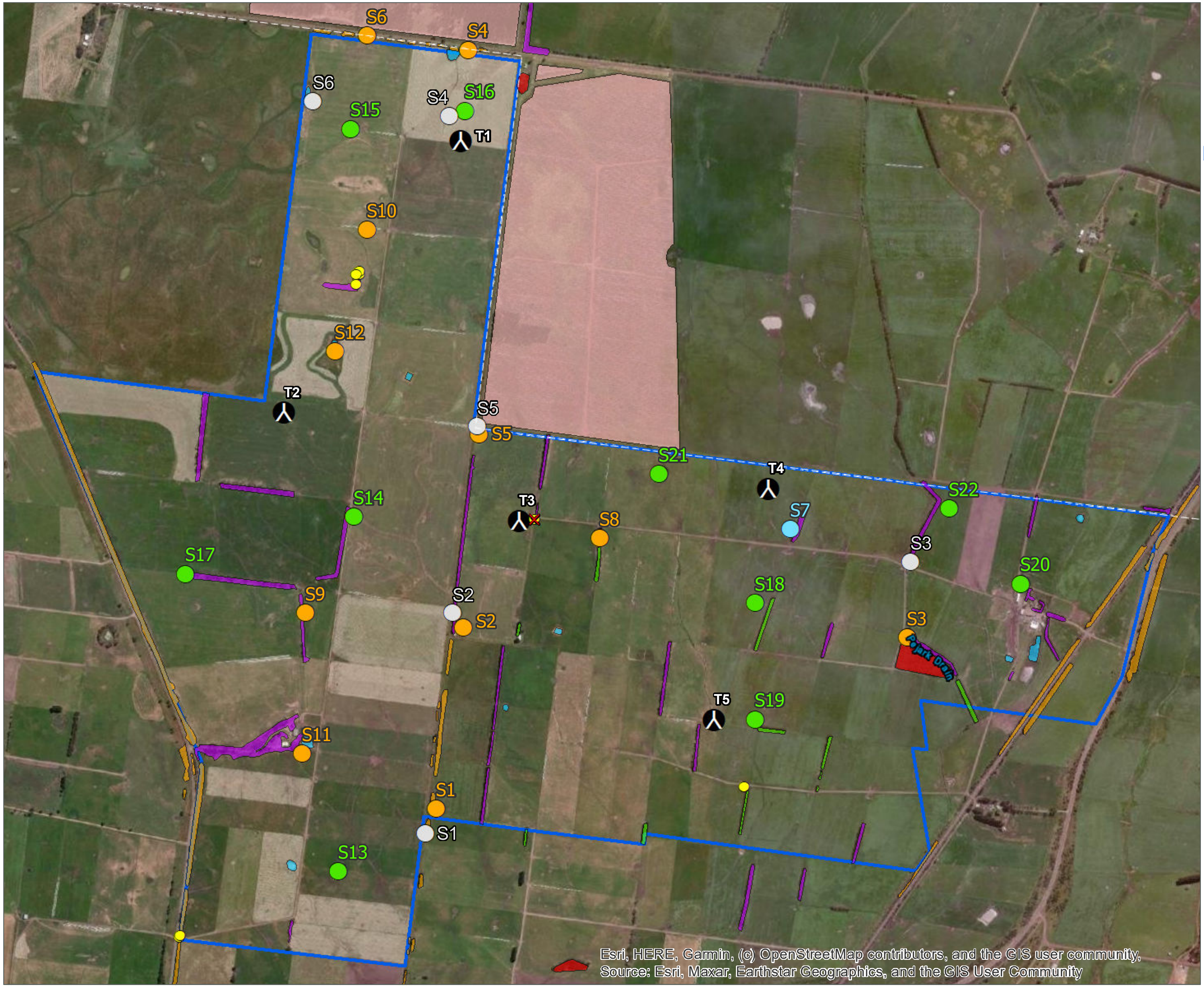

Figure 3: Bat detector locations and habitat features

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 12/03/2024

Study area

Wind turbine

Bat detectors

- EHP: SM4BAT-ZC/Anabat
- NA: SM4BAT-FS
- NA: SM4BAT-ZC
- NA: MiniBAT-ZC

Habitat

- Eucalypt windbreak
- Farm dam
- Forestry plantation
- Pine windbreak
- Remnant native woodland
- Roadside vegetation
- Scattered tree (EHP)
- Scattered tree to be removed

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Metres
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Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

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Figure 4: Examples of bat detectors installed on-site

Table 6: Bat detector specifications and recording dates during the year 2 surveys

		Summer 2022-2023			Autumn 2023		
Site	Song Meter model	Date installed	Date retrieved	Total bat detector nights per site	Date installed	Date retrieved	Total bat detector nights per site
1	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	3/04/2023	42
2	SM4BAT-FS	23/01/2023	2/02/2023	8	21/02/2023	3/04/2023	42
3	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	2/04/2023	41
4	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	2/04/2023	41
5	SM4BAT-FS	25/01/2023	2/02/2023	9	21/02/2023	4/03/2023	12
6	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	2/04/2023	41
7	SM4BAT-ZC	22/12/2022	2/02/2023	43	21/02/2023	3/04/2023	0
8	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	1/04/2023	40
9	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	2/04/2023	41
10	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	1/04/2023	40
11	SM4BAT-FS	22/12/2022	2/02/2023	43	21/02/2023	2/04/2023	41
12	SM4BAT-FS	22/12/2022	2/02/2023	43	28/02/2023	3/04/2023	35
13	Mini-bat	-	-	-	9/03/2023	3/04/2023	26
14	Mini-bat	-	-	-	9/03/2023	3/04/2023	26
15	Mini-bat	-	-	-	9/03/2023	3/04/2023	26
16	Mini-bat	-	-	-	9/03/2023	3/04/2023	26
17	Mini-bat	-	-	-	9/03/2023	3/04/2023	26
18	Mini-bat	-	-	-	9/03/2023	2/04/2023	25
19	Mini-bat	-	-	-	9/03/2023	2/04/2023	25
20	Mini-bat	-	-	-	10/03/2023	2/04/2023	24
21	Mini-bat	-	-	-	10/03/2023	2/04/2023	24
22	Mini-bat	-	-	-	10/03/2023	2/04/2023	24
Total bat detector nights				447			668

Table 7: Descriptions of bat detector sites from the year 2 surveys

Site	Habitat/landscape description
1	Open grazing paddock, along a farm track, on a dead pine tree among a pine windbreak.
2	Open grazing paddock, attached to cattle grid structure, 30m from eucalypt roadside vegetation.
3	On the edge of the only small patch of native eucalypt woodland (~2 ha) in the study area, surrounded by grazing paddocks and close to Pejark Drain.
4	Eucalypt roadside vegetation along an unsealed farm road (Coyles Road), attached to a small tree next to grazing paddock and a large farm dam. The dam was holding water in December 2022, but had dried out by March 2023. 40m south of a large Blue Gum (*Eucalyptus globulus*) forestry plantation to the north of Coyles Road.
5	Eucalypt roadside vegetation, attached to a large pine tree surrounded by large grazing paddocks and 50m south of a Blue Gum plantation.
6	Eucalypt roadside vegetation, along an unsealed farm road (Coyles Road), next to grazing paddock to the south and 30m from a large Blue Gum plantation to the north.
7	Eucalypt windbreak surrounded by large grazing paddock.
8	Eucalypt windbreak surrounded by large grazing paddock.
9	Eucalypt windbreak surrounded by large grazing paddock.
10	In the middle of a large grazing paddock.
11	Next to a large, permeant farm dam, close to the farm dwellings.
12	Next to a farm dam surrounded by large grazing paddocks; vegetation around the dam was cleared later during the survey period.
13	Along fence line in open paddock, no trees nearby.
14	Along fence line in open paddock, no trees nearby.
15	Along fence line in open paddock, no trees nearby.
16	Along fence line in open paddock, no trees nearby.
17	Along fence line in open paddock, 20m west of a eucalypt windbreak.
18	Along fence line in open paddock, 50m west of a pine windbreak.
19	Along fence line in open paddock, 30m west of a pine windbreak.
20	Along fence line in open paddock, near farm buildings and 35m west of several large pine trees.
21	Along fence line in open paddock, 100m south of a Blue Gum plantation.
22	Open grazing paddock, 40m east of a eucalypt windbreak along Pejark Drain.

Table 8: Bat detector settings during the year 2 surveys

Detector model	Song Meter SM4BAT-FS and SM4BAT-ZC	Song Meter Mini-bat
Power supply	4x internal D batteries, changed every 4-weeks	4x internal AA batteries, changed every 4-weeks
SD memory cards	1x 64GB SanDisk Extreme Pro SDXC memory card	1x 64GB SanDisk Extreme Pro SDXC memory card
Microphone	SMM-U2 attached directly to the detector; microphone sensitivity checked monthly	Built-in ultrasonic microphone; sensitivity checked monthly
Recording timeframe	30 minutes before sunset to 30 minutes after sunrise	30 minutes before sunset to 30 minutes after sunrise
Recording mode	Full-spectrum or Zero-crossing	Zero-crossing

6.3. Echolocation call identification

6.3.1. Year 1 - EHP

Echolocation calls recorded during two seasonal surveys conducted in year 1 by EHP were sent to Rob Gration for identification. All files were initially passed through a Decision Tree analysis using Anabat Insight software (Titley Scientific, Queensland) to group echolocation call sequences based on a combination of pulse characteristics, such as characteristic frequency (Fc), time between calls (TBC) and pulse curvature (Reinhold et al. 2001; Pennay et al. 2004). These pulse characteristics were then used to assign identifications to calls. Only call sequences that contained at least three definite and discrete echolocation pulses were classified as bat calls.

Call identification for the echolocation data recorded during the year 1 surveys focused only on the two threatened bat species present in the study area: YBSB (Vulnerable, FFG Act) and SBWB (Critically Endangered, EPBC Act and FFG Act). No attempt was made to confirm the presence of any other species, or to count the number of calls for species other than the two threatened species. In this report, only results relating to SBWB are presented. All results relating to other bat species recorded in the study area during the year 1 surveys will be presented in reporting that is being prepared by EHP.

During identification of the call data recorded during the 'Spring 2021' survey, the Decision Tree analysis assigned calls to a species complex containing calls with characteristics that could have been produced by either Chocolate Wattled Bat, Little Forest Bat or SBWB. All calls assigned by the Decision Tree analysis to this species complex were manually inspected to confirm identification.

6.3.2. Year 2 – Nature Advisory

Echolocation calls recorded by bat detectors were downloaded to a laptop and Kaleidoscope Lite 5.4 software (Wildlife Acoustics) was used to convert the WAV files into zero crossing (ZC) files, with the outputs saved in nightly subdirectories. Noise files were selected using the default filter in Kaleidoscope Lite and moved into a 'Noise' subfolder – these files were not considered further in the analysis.

Echolocation calls recorded during the Summer survey conducted in year 2 were sent to Amanda Lo Cascio (University of Melbourne) for identification. The following datasets were analysed:

- Summer 2022-2023 - 66,984 zero-crossing (ZC) files were analysed from recordings across 12 sites from a total survey effort comprising 450 bat detector nights (Appendix 1).
- Autumn 2023 - 192,868 zero-crossing (ZC) files were analysed from recordings across 22 sites from a total survey effort comprising 668 bat detector nights (Appendix 2).

In total, 19 predictor variables from each of these datasets were extracted, per call, from the dominant harmonic following Parsons et al. (2000), using the built-in algorithm in Anabat Insight v1.9.7 (Table 9).

The calls were identified using a combination of a machine learning automated ID process and manual validation (following Lo Cascio et al., 2022). This approach uses manually identified calls produced by free flying bats, along with reference 'hand-release' voucher calls recorded from captured bats that were identified to species-level prior to being released, to build a predictive model using a 'random forest automated classifier' (following Lo Cascio et al., 2022). For species known to exhibit regional variation, additional calls were sourced from within the region (see Lo Cascio et al., 2022).

For a call sequence (i.e. a series of echolocation pulses within a single zero-crossing file) to be assigned a positive identification to species-level, it must have had a minimum of three echolocation pulses and pass the species-specific kappa maximising threshold (Lo Cascio et al., 2022). For each zero-crossing file containing bat echolocation pulses, the automated classifier assigned the species with the most weight, which was taken as the species with highest number of pulses within the call sequence and the highest probability.

6.3.3. Species inventory – Summer 2022-2023 survey only

For the Sumer 2022-2023 survey data, files containing bat calls were then manually inspected for presence or absence per site, that is until at least one species per site was manually verified. For this summary of presence/absence, calls that could not be identified definitively to species-level were allocated to the following species complexes, which comprise two or more species with similar call characteristics (see Section 6.4.2):

- Large-footed Myotis (*Myotis macropus*)/Long-eared Bat (*Nyctophilus* spp.).
- Large Forest Bat (*Vespadelus darlingtoni*)/Southern Forest Bat (*Vespadelus regulus*)/Little Forest Bat.
- SBWB/Forest Bat spp./Chocolate Wattled Bat

For the Autumn 2023 survey data, all calls assigned by the automated classifier to species in the 45-50 kHz range, plus calls assigned to YBSB, were manually inspected to confirm identification.

Table 9: Description of echolocation call predictor variables

Metric	Definition
Fc kHz	Characteristic Frequency (Fc); the frequency (kHz) at the right-hand end of the portion of the call with the lowest absolute slope (the body)
Sc OPS	Characteristic Slope: the slope of the body of the call measured in Octaves Per Second (OPS).
Dur ms	Pulse Duration: the duration of the pulse, measured in milliseconds
Fmax kHz	The maximum frequency (kHz) of the pulse.
Fmin kHz	The minimum frequency (kHz) of the pulse.
Fmean kHz	The mean frequency, which is a weighted mean F_{Mean} = (N – 1) D/2d where N is number of points counted in the display D is the division ratio and d is the duration of the call.
TBC ms	Time between calls; the time from the start of one pulse until the start of the next pulse.
Fk kHz	Frequency of the knee; frequency (kHz) of the junction (point of greatest change in slope) between the initial and pre-characteristic sections
Tk ms	The time from the start of the call to the knee measured in milliseconds (ms).
Quality	The average smoothness for the whole call. Smoothness is the absolute value of the difference between the frequency of any point and the average of the frequencies of the points either side of it divided by the frequency of that point. These values are summed over the whole call
S1 OPS	The slope of the first five points in a pulse
Tc ms	The time from the start of the call to the characteristic section
PMC	The proportion of maximum frequency to characteristic frequency. - PMC = 100 x (Fmax - Fc)/Fc
Curvature	A measure to characterize the shape of bat calls where frequency~= timeP (where P is an integer value). If P is a positive number, the call is upward curving
Fstart kHz	The frequency at the start of the pulse. In the case of ZC the frequency of the first ZC dot of the pulse.
Fend kHz	The frequency at the end of the pulse. In the case of ZC the frequency of the last ZC dot of the pulse.
Smin OPS	The minimum amount of slope occurring over 2 to 5 ZC dots within the pulse relating to the flattest part of the pulse.
Smax OPS	The maximum amount of slope occurring over 2 to 5 ZC dots within the pulse relating to the steepest part of the pulse.
Send OPS	The slope of the last 5 ZC dots in each pulse.

6.3.4. Identification of SBWB calls

The number of hand-release voucher calls and manually identified free-flying calls (total number of pulses shown) for SBWB, Little Forest Bat, Southern Forest Bat and Chocolate Wattled Bat that were used to build the automated classifier are presented in Table 10 (adapted from Lo Cascio et al., 2022).

A conservative approach was applied to the process of identification of calls belonging to the SBWB, whereby automatic identification was initially accepted if a call sequence had at least three pulses that passed a species-specific threshold, which was set to maximise sensitivity. All zero-crossing files recorded during the Summer 2022-2023 and Autumn 2023 surveys that contained possible SBWB calls were then moved into a sub-folder for manual verification.

Little Forest Bat, Southern Forest Bat and Chocolate Wattled Bat overlap considerably with SBWB in the study area (see Section 6.4.2). Comparison of model confidence with manually identified calls indicated high overlap between the SBWB-definite and SBWB/Forest Bat spp./Chocolate Wattled Bat complex calls (hereafter SBWB-complex) (Appendix 1 and 2) and, as such, counts per site for both SBWB categories are presented.

Visual inspection of spectrograms (frequency versus time graphs) of calls assigned by the automated classifier as SBWB-definite or SBWB-complex was conducted by Rob Gration using Anabat Insight. Reporting on the presence/absence and relative activity of SBWB in the study area during the year 2 surveys was based on the output from this manual identification. Characteristics used to identify SBWB calls are presented in Table 11.

A more detailed description of the call identification process undertaken for analysis of the year 2 survey data is provided in Appendix 1 and 2.

Table 10: Number of pulses per species indicating geographic location and call type

Species	Location	Hand-release	Free-flying
Miniopteridae (Bent-wing bats)			
Southern Bent-wing Bat *Miniopterus orianae bassanii*	Naracoorte, SA	431	
	Western plains, Vic	391	
	Naracoorte, SA		1,459
	Manual identification		2,444
	Total	822	3,903
Vespertilionidae (Evening bats)			
Chocolate Wattled Bat *Chalinolobus morio*	Hand release trapping	461	
	Manual identification		87
	Western plains, Vic	7,032	
	Manual identification		279
	Total	7,439	366
Little Forest Bat *Vespadelus vulturnus*	Hand release trapping	4,433	
	Manual identification		1,998
	Western plains, Vic	9,247	
	Manual identification		50,982
	Total	13,680	52,980
Southern Forest Bat *Vespadelus regulus*	Hand release trapping	433	
	Manual identification		528
	Western plains, Vic	2,481	
	Manual identification		9979
	Total	2,914	10,507
Emballonuridae (Sheath-tailed bats)			
Yellow-bellied Sheath-tailed Bat *Saccolaimus flaviventris*	Western plains, Vic	157	
	Manual identification		45
	Total	157	45

Note – adapted from Lo Cascio et al. (2022).

Table 11: Identification criteria for assigning a call sequence to Southern Bent-wing Bat or Yellow-bellied Sheath-tailed Bat

Definite	Recording contains at least 3 pulses identified by the automated classifier as the species.	Call is manually verified by visual inspection of the spectrogram.
Possible	Majority of pulses are in the characteristic frequency range for the species **AND**	
	Pulses within the sequence contain diagnostic features that assist separation from other species calling within the characteristic frequency range.	*Southern Bent-wing Bat:* • Angular knee/heel. • Hooks are not cup shaped (Little Forest Bat, Southern Forest Bat). • Down sweep is more angular than drooping or down sweeping (Chocolate Wattled Bat). *Yellow-bellied Sheath-tailed Bat*: • In full-spectrum recordings, harmonics can be used to differentiate between *Saccolaimus* species and other bats using the same frequency range. • In ZC recordings, YBSB calls can be separated from clutter calls of White-striped Free-tailed Bats by shape, with YBSB being vertical or steeper curvilinear without abrupt changes between pulses, while White-striped Free-tailed Bat calls at the same frequency are more vertical and in general 'messy'.
	If pulses are not 'strictly' within the characteristic frequency for the species, there are other diagnostic features.	***Justification:*** It is unlikely that we know the full range of calls produced by the species. There is significant overlap with this species and other species.
Unlikely	Pulses are within the characteristic frequency range.	**BUT** There is insufficient detail or call structure to assign positive identification **OR** calls have been identified as another species.

6.3.5. Full-spectrum files

The rationale for examining a subset of full-spectrum files and comparing them with the equivalent zero-crossing files is presented in Section 6.4.5 below.

Yellow-bellied Sheath-tailed Bat - During analysis of the data recorded during the Summer 2022-2023 survey, spectrograms of full-spectrum (.WAV) versions of 57 of the call sequences assigned to YBSB by the automated classifier were inspected by Amanda Lo Cascio using Anabat Insight version 2.0.7-0-g3e26022 (Table 12).

During analysis of the data recorded during the Autumn 2023 survey, spectrograms of full-spectrum (.WAV) versions of 126 of the call sequences assigned to YBSB by the automated classifier were inspected by Amanda Lo Cascio (Table 12).

This additional step, incorporating a second manual verification, was done because full-spectrum data can be helpful in identifying YBSB calls that are masked by background noise, and separating them from calls made by other low-frequency calling species (Armstrong et al., 2020).

Southern Bent-wing Bat - During analysis of the data recorded during the Autumn 2023 survey, spectrograms of full-spectrum (.WAV) versions of 75 call sequences that were manually identified to the SBWB-complex were inspected by Rob Gration using Anabat Insight version 2.0.7-0-g3e26022. The subset of 75 full-spectrum SBWB-complex files that were manually checked were recorded at sites where SM4BAT-FS detectors recorded echolocation data in full-spectrum mode (Table 12). The other 22 files assigned as SBWB-complex calls were from sites where detectors recorded in zero-crossing mode and therefore could not be double-checked in full-spectrum mode (Table 6).

This additional step, incorporating a second manual verification, was done to address the suggestion raised by DEECA during recent consultations for other proposed wind farms in south-west Victoria that full-spectrum call data provides additional information to zero-crossing data (e.g. amplitude, peak energy) which can aid in differentiating SBWB calls from other species with similar call characteristics (e.g. Little Forest Bat, Southern Forest Bat, Chocolate Wattled Bat).

Table 12: Full-spectrum calls checked to confirm identification

	Yellow-bellied Sheath-tail Bat		Southern Bent-wing Bat-complex
Site	Summer 2022-2023	Autumn 2023	Autumn 2023
1	2	2	7
2	0	26	8
3	2	0	11
4	32	78	8
5	0	0	10
6	8	0	15
8	5	3	6
9	0	9	5
10	0	0	3
11	3	0	1
12	2	1	1

6.3.6. *Timing of activity relative to sunset*

SBWBs leave cave roosts after sunset and fly to areas that provide drinking and foraging resources (Grant, 2004). Therefore, the timing of when calls are recorded relative to sunset can provide a rough indication of how far away from the study area SBWB might be roosting.

For each call from the Summer 2022-2023 and Autumn 2023 surveys that was manually assigned as either SBWB-definite or SBWB-complex, the time after sunset of when each call was recorded was calculated (as minutes after sunset). Timing of SBWB-definite and SBWB-complex calls recorded during each survey period were then summarised graphically to visualise patterns of activity throughout the night.

6.3.7. *Habitat association models*

Variation in SBWB activity in relation to proximity to different habitat features across the SLWF study area was examined. For this analysis, manually confirmed SBWB-definite and SBWB-complex calls recorded during the Summer 2022-2023 and Autumn 2023 surveys were pooled. This resulted in sample sizes of 102 SBWB-definite calls and 247 SBWB-complex calls.

Across the study area, there are seven habitat feature categories present that could potentially provide foraging and drinking resources for SBWB. These seven habitat features were mapped (Figure 3) and then distances from the 22 bat detector sites to each habitat feature was measured (Appendix 3).

The proportion of the total study area that each habitat feature comprised was also calculated. Blue Gum forestry plantations were not included in these calculations, as they are located outside of the project boundary (Figure 3). Scattered paddock trees were also excluded because the canopy dimensions of the four trees identified within the study area by EHP were not available. The following list summarises the total area (ha) and proportion of the entire study area that the remaining five habitat categories comprised; these metrics were also calculated for open grazing paddocks:

- Open grazing paddocks (647.19 ha, 97.06%).
- Eucalypt windbreaks (9.90 ha, 1.49%).
- Roadside vegetation (5.33 ha, 0.80%).
- Eucalypt woodland patches (1.80 ha, 0.27%).
- Pine windbreaks (1.23 ha, 0.19%).
- Farm dams (1.31 ha, 0.20%).

To investigate the relationship between bat activity (the dependent variable) and the distance in metres to habitat features (independent variables), generalised linear models were built using R statistical software (R Development Core Team, 2011). Three separate models were built for: (1) SBWB-definite calls, (2) SBWB-complex calls, and (3) both groups combined. Essentially, these models use on-site empirical information to predict how the degree of SBWB activity varied in relation with distance to particular habitat features. Consequently, the outcomes of these models can offer evidence-based guidance to facilitate micro-siting of wind turbines, with the goal of minimising the potential for SBWB fatalities.

Several aspects of the models were taken into consideration to ensure the reliability of the results. Ensuring that the statistical assumption of independence of observations is not violated is a crucial first step to determine whether to trust the results of a model. Observations may not be independent if data from the bat detectors depends on their spatial proximity between each other (i.e. spatial autocorrelation). Another situation that can lead to biased estimates and unreliable predictions is to have highly correlated independent variables (i.e. multicollinearity). No significant evidence of spatial autocorrelation (Moran's I p-values > 0.05) nor multicollinearity issues (variance inflation factors VIF < 4) were detected. Some observations were inherently not independent, as some of the same detectors (11) were placed in the exact same locations during different survey periods. To address the issue of these potential confounding effects, the initial models incorporated "survey" as a covariate and "location" of the detectors as a random effect. These variables were later removed from the final models since their inclusion did not significantly improve the models' fit. In addition, to control for false positives resulting from testing multiple hypothesis in the same model concerning the six habitat features, false discovery rate (FDR) corrections were systematically applied to all significant *p*-values.

To ensure the optimal selection of models for the type of data analysed, a range of regression models that handle count data were used, including Poisson, negative binomial, and zero-inflated negative binomial. The selection of the most suitable model was based on the model fit penalised for the number of estimated parameters, following the corrected Akaike Information Criteria (AICc). The negative binomial regression model, which accounts for over-dispersed data, was consistently selected as the best model. To account for variations in sampling effort, due to differences in the total number of recording nights at each detector (Table 6), the models included the number of nights as an offset variable. Consequently, SBWB activity was always expressed as a standardised rate (calls per detector-night).

6.4. Limitations of bat detector surveys

6.4.1. General considerations

Remotely deployed electronic recording devices, such as bat detectors, occasionally experience technical difficulties, such as errors in writing data onto memory cards, failure of internal electronic components, loose internal connectors, and batteries discharging to a level where the unit shuts down (Hayes, 2000). As a result, the number of nights and total hours of recording can vary between the different detectors deployed during a survey (Griffiths et al., 2020).

Bat detectors are only capable of detecting echolocation calls that arrive at the microphone above a critical sound pressure level (SPL) and at a sufficiently high signal-to-noise ratio (SNR) (Russo et al., 2018). This means that, for an echolocation call to be recorded by a bat detector, it must be louder than background or ambient noise (Agranat, 2014). Sources of background noise that can interfere with a bat detector's ability to detect and record bat echolocation calls include sound generated by civil infrastructure (e.g. windmills, high voltage power inverters), traffic, wind, rain, dripping/running water and insects (Fraser et al., 2020). As the level of background noise can change from night-to-night, or within a single survey night, the timing and duration of bat detector surveys should be designed to ensure that an adequate number of nights are sampled when background acoustic conditions are conducive to recording bat calls (Department of the Environment, Water, Heritage and the Arts, 2010).

Bat activity levels within and between nights may vary in response to weather variables such as air temperature, relative humidity, barometric pressure, wind speed, direction and gusts and rain (Erickson and West, 2002; Milne et al., 2005). Typically, bats are found to be less active during the following circumstances:

- When minimum nighttime temperature drops below a critical threshold (actual value depends on survey location);

- At higher wind speeds, e.g. over 10 metres per second; and
- During moderate to heavy rainfall.

To account for variation that can occur in bat activity from night-to-night, the bat detector surveys conducted for this investigation encompassed a much greater temporal replication (total bat detector nights across all four survey periods = 1,672) than is typically undertaken for biodiversity surveys designed to asses potential impacts of development projects to listed bat species in Australia (see Department of the Environment, Water, Heritage and the Arts, 2010).

6.4.2. Overlap in species-specific call characteristics

Insectivorous bats generate ultrasonic sounds using their vocal chords and 'listen' to the corresponding echoes which provide the bat with a three-dimensional acoustic image of their immediate surroundings (Fenton, 2013). As opposed to bird song, where calls are used to communicate messages and information to conspecifics, bats use echolocation calls to orientate, detect obstacles, and acquire information on the presence and location of food and other key spatial resources (Moss and Surlykke, 2001). To optimise the sensory information provided by echolocation calls, bats change call structure when flying through different habitat structures (e.g. open versus cluttered areas) or performing different tasks, such as commuting or foraging (Schnitzler and Kalko, 2001). Consequently, calls produced by one bat species may at times closely resemble those of other species (Barclay, 1999). The considerable variability in calls produced by free-flying echolocating bats often makes it difficult, or sometimes impossible, to assign species-level identifications to passively recorded calls (Barclay, 1999; Russo et al., 2018).

In Australia, several insectivorous bats cannot be distinguished to species-level from the characteristics of their echolocation pulses (Milne, 2002; Pennay et al., 2004). Therefore, calls that cannot be positively identified are assigned to a species complex, which typically comprises 2-3 species. In the study area, these include:

- Large-footed Myotis/Long-eared Bat spp. (*Nyctophilus geoffroyi and Nyctophilus gouldi*).
- Large Forest Bat (*Vespadelus darlingtoni*)/Southern Forest Bat/Little Forest Bat.
- SBWB/Southern Forest Bat/Little Forest Bat/Chocolate wattled bat.

6.4.3. Relative activity versus abundance

Passively collected echolocation call data cannot be used to quantify numbers of bats present in a given area (Hayes, 2000). As an example, if 10 calls of a particular species are recorded, it is not known if this represents 10 individuals of that species flying past the detector, or one individual flying past 10 times. Therefore, it is not possible to determine population numbers (abundance), but rather only a measure of relative activity (e.g. calls per night per site). Activity indices generated from passively collected echolocation data are the industry standard method used worldwide in ecological research and environmental management to investigate factors driving landscape-scale patterns and processes in bat communities (Fraser et al., 2020). Trapping is required in situations where additional information is required, such as estimating local abundance, morphometric measurements, sex, age or reproductive status of individual bats.

6.4.4. Zone of detection

Echolocation calls produced by bats attenuate (reduce in amplitude) as they travel through air, with higher frequency calls attenuating faster than lower frequency calls (Schnitzler and Kalko, 2001). The rate at which a call reduces in amplitude is influenced by geometric and atmospheric attenuation. Geometric attenuation causes a halving of call amplitude with each doubling of the distance to the bat emitting the call (Russo et al., 2018). Atmospheric attenuation is influenced by several factors, including air temperature, humidity and call frequency, and causes a linear decline in SPL with increasing distance between a calling bat and the ultrasonic microphone (Goerlitz, 2018).

Because lower-frequency calls travel further through air than higher-frequency calls, low-frequency calling bat species are more likely to be recorded by a bat detector when they are further away from the microphone than high-frequency calling species (Adams et al., 2012). In Australia, low frequency calling species, such as White-striped Free-tailed Bat (*Austronomus australis*, characteristic frequency 10-15 kHz), are likely to be detected at greater distances from a bat detector than higher-frequency calling species, such as Chocolate Wattled Bat (46-53 kHz). Detection ranges of free-flying bats have been calculated for some species in the Northern Hemisphere. Of particular relevance to this investigation is the detection distance of 30 m reported for Schreiber's Bent-winged Bat (Barataud et al., 2015). As mentioned above, this co-generic species has similar wing morphology, flight patterns and high-frequency calls to SBWB.

In comparison, specific detection ranges for free-flying Australian echolocating bats are largely unknown, as this is difficult to measure in the field and is likely to vary significantly from survey-to-survey depending environmental conditions, the surrounding habitat, the type of detector used, and what the bat is doing (Adams et al., 2012).

While there is likely to be variation in detection distances for different species, and in different habitat types or environmental conditions, the bat detectors used during this investigation are typically able to record most echolocating bat species that are present within a volume of airspace (the detection zone) approximately 20-30 metres from the microphone (Sherwood Snyder, Wildlife Acoustics, pers. comm.).

The co-generic EBWB, which has similar flight patterns, foraging strategy and high-frequency calls as SBWB, are typically recorded by a ground-level bat detector as they fly above the canopy at a distance of 25-30 m from the microphone (Michael Pennay, pers. comm.).

6.4.5. Zero-crossing versus full-spectrum call data

Broadband bat detectors (that can record signals across the ultrasonic frequency range) are required in surveys where multiple species with different call characteristics are present. Depending on the make and model of detector, broadband detectors record two different types of data, described below.

Zero-crossing (ZC) – this recording method was developed by Chris Corben to extract the basic time-frequency content of an ultrasonic signal. Put simply, a detector using zero-crossing mode takes measurements of an incoming audio signal's most prominent (loudest) ultrasonic frequency at a given time. Zero-crossing recordings do not contain amplitude information, nor can they represent multiple frequencies that are present within a signal at any point in time. This means that components of bat echolocation calls such as harmonics, overlapping calls, and faint signals in the presence of background noise are not captured in zero-crossing mode (Adams et al., 2012). However, the resulting recordings take up very little data space, which was an important consideration when the zero-crossing method was invented, because at that time floppy disks were the industry standard data storage technology.

Despite the limitations mentioned above, zero-crossing call data is still used in bat echolocation research and environmental monitoring programs globally (Fraser et al., 2020), particularly in situations where data storage capacity is an important consideration. Notably, published bat call identification guides for Australian echolocating bats use zero-crossing data (e.g., Milne, 2002;

Pennay et al., 2004), and there are currently no publicly available guides based on full-spectrum call data. Similarly, most automated call identification software systems use metrics calculated from zero-crossing data to distinguish calls produced by different species; for example, see Adams et al. (2010) and Lo Cascio et al. (2022).

Full-spectrum – in this mode, a detector will record acoustic data as audio (.WAV) files that capture the entire frequency range present within a signal (not just the loudest frequency at any particular point in time), plus amplitude, harmonic frequencies, and also background noise. This extra detail can help to distinguish bat calls from background noise and in some cases help to differentiate calls produced by different species. For example, calls produced by several Emballonurid (Sheath-tail bat) species present in northern Australia cannot be consistently and reliably separated from zero-crossing files (Milne, 2002). Recent research using full-spectrum data has shown that the amount of energy (amplitude) that sheath-tailed bats put into different harmonics can be used to differentiate some species in some situations (Armstrong et al., 2020).

One important consideration when recording full-spectrum data is the much larger file sizes compared to zero-crossing data files. Recording in full-spectrum mode can result in memory cards filing up very quickly during field deployments and requires a large amount of hard disk storage capacity to house data from completed surveys. This is particularly relevant for the intensive (6-8 week-long) seasonal bat detector surveys that are currently required for proposed wind farms within the SBWB range of south-west Victoria. Current limitations in storage capacity and computing power makes dealing with full-spectrum call datasets of this size problematic.

As mentioned above, even if full-spectrum data were recorded, the methods used to identify bat calls to species or complex-level rely on metrics extracted from a zero-crossing version of the full-spectrum file. So, the first step in analysis is to convert all the full-spectrum data into zero-crossing files, then use the metrics from ZC files to conduct various types of semi-automated ID processes, followed by manually inspecting spectrograms of subsets of the calls based on target species of interest (e.g., Lo Cascio et al., 2022).

7. Results

7.1. Roost cave assessment

No new roost caves were discovered through the desktop assessment documenting historical and current records of caves used by SBWB. Additionally, no new SBWB roost caves were discovered through the on-ground survey to investigate 15 potential caves identified during the desktop assessment.

As mentioned previously, RE Future will provide DEECA with copies of the desktop assessment and on-ground cave search reports.

7.2. Bat detector surveys

7.2.1. Year 1 - EHP

Nature Advisory was only provided with results from the year 1 bat survey data from surveys conducted by EHP relating to listed species. Results of the bat detector surveys describing records of non-listed bats recorded across the study area will be presented in the Flora and Fauna Assessment Reports being prepared by EHP. Results of the analysis of echolocation calls recorded during the two intensive seasonal survey periods revealed the following results.

Spring-Summer 2021: From a survey effort comprising 301 bat detector nights, 85 calls were assigned to a SBWB species complex that, after manual inspection, were all identified as either Little Forest Bat or Chocolate Wattled Bat calls. One SBWB call was positively identified at site 5; this site was located along roadside vegetation close to a large Blue Gum forestry plantation (Figure 3). This represents relative activity of 0.003 calls per detector night for SBWB-definite calls during the Spring-Summer 2021 survey.

No calls were assigned to YBSB during the Spring-Summer 2021 survey.

Summer-Autumn 2022: From a survey effort comprising 253 bat detector nights, three SBWB calls were positively identified, all from site 3, which was located next to the only small patch of remnant eucalypt woodland within the study area (Figure 3). In addition, there were 2,472 calls were assigned to a SBWB species complex, which after manual inspection were all identified as Chocolate Wattled Bat calls. This represents relative activity of 0.012 calls per detector night for SBWB-definite calls during the Summer-Autumn 2022 survey.

No calls were assigned to YBSB during the Summer-Autumn 2022 survey.

Across both intensive seasonal surveys combined, overall relative activity was 0.007 calls per detector night for SBWB-definite calls. No calls were assigned to YBSB.

7.2.2. Year 2 – Nature Advisory

Species inventory

Summer 2022-2023: The random forest automated classifier identified ten species from echolocation call data recorded within the study area, including two listed species: YBSB and SBWB (Table 13). Activity of YBSB and SBWB are described below in Sections 7.2.1 and 7.2.4, respectively.

Unresolved calls attributed to the 'Large-footed Myotis/Long-eared Bat' species complex were most likely to have been produced by two Long-eared Bat species that are known to occur in the study area: Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Gould's Long-eared Bat (*Nyctophilus gouldi*).

Southern Forest Bat was also tentatively identified from calls assigned to the Large Forest Bat/Little Forest Bat/Southern Forest Bat complex (Table 13, Appendix 1).

The automated classifier identified a total of 14,840 call sequences containing bat calls, with the highest level of activity at Site 5, followed by Site 4 (Table 14). Temporal patterns of overall bat activity recorded at each site during the Summer 2022-2023 survey are presented in Figure 5.

Table 13: Bat species recorded during the summer 2022-2023 survey

		Bat detector site											
Common name	Species	1	2	3	4	5	6	7	8	9	10	11	12
White-striped Free-tailed Bat	*Austronomus australis*	X	X	X	X	X	X	X	X	X	X	X	X
Gould's Wattled Bat	*Chalinolobus gouldii*	X	X	X	X	X	X	X	X	X	X	X	X
Chocolate Wattled Bat	*Chalinolobus morio*	X	X	X	X	X	X	X	X		X	X	X
Eastern Falsistrelle	*Falsistrellus tasmaniensis*	X	X	X	X	X	X	X	X	X	X	X	X
Southern Bent-wing Bat	*Miniopterus orianae bassanii*	X				X			X		X	X	X
Ride's Free-tailed Bat	*Ozimops ridei*	X	X	X	X	X	X	X	X	X	X	X	X
Inland Broad-nosed Bat	*Scotorepens balstoni*	X	X	X	X	X	X	X	X	X	X	X	X
Large Forest Bat	*Vespadelus darlingtoni*	X	X	X	X	X	X	#	X	X	X	X	X
Little Forest Bat	*Vespadelus vulturnus*	X		X	X	X	X	X	X	X	X	X	X
Species complex													
Southern Bent-wing Bat/Forest Bat spp.		#	#	#	#	#	#	#	#	#	#	#	#
Large-footed Myotis (*Myotis Macropus*)/Long-eared Bat (*Nyctophilus*) spp.		#	#	#	#	#	#	#	#	#	#	#	#
Large Forest Bat/Little Forest Bat/Southern Forest Bat		#	#	#	#	#	#	#	X	#	#	#	#

X = Definite, # = Probable

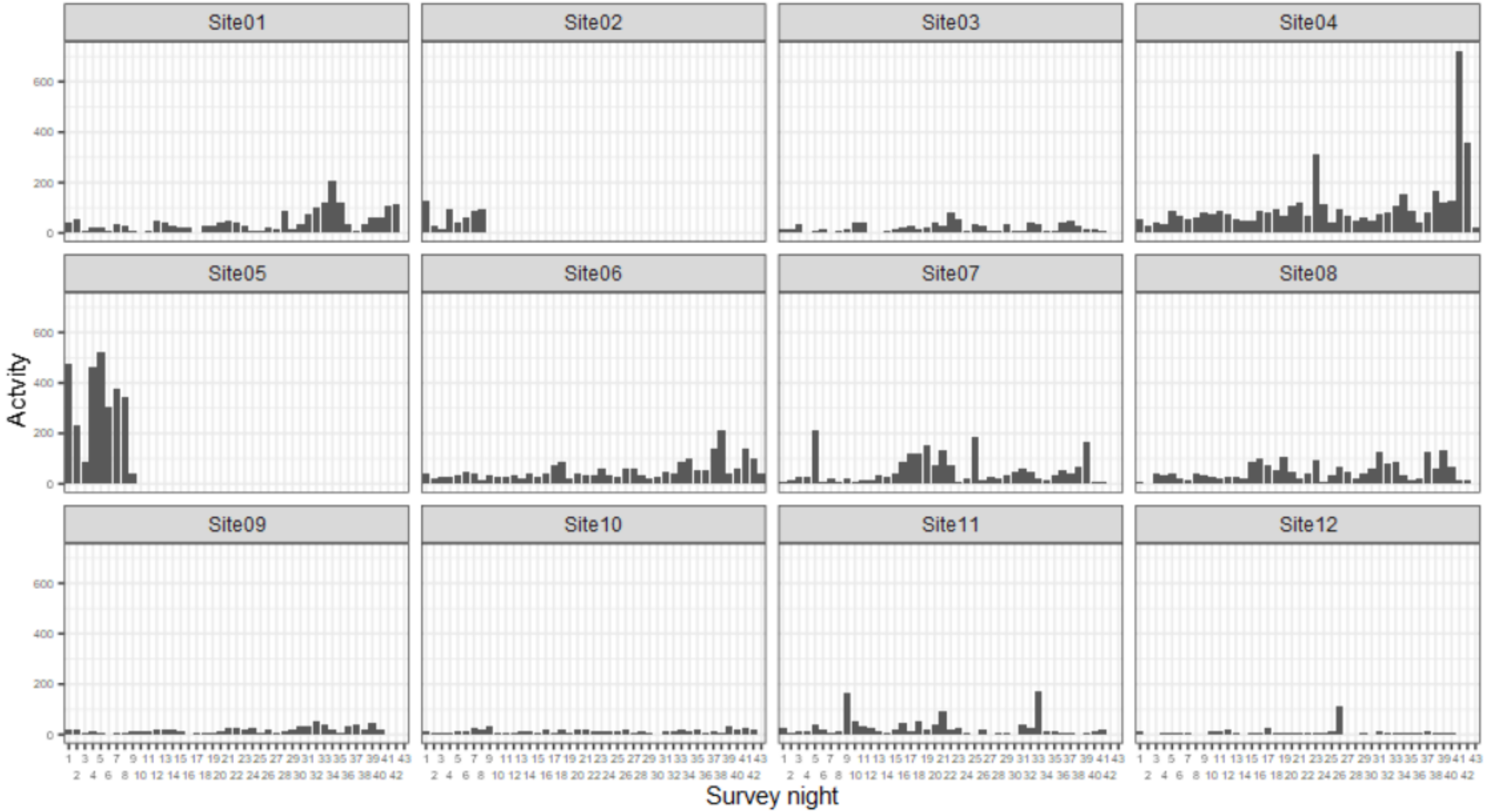


Figure 5: Count of total bat calls per site per night (activity) during the Summer 2022-2023 survey

Table 14: Total bat calls and relative activity (calls per night per site)

	Sumer 2022-2023 survey			Autumn 2023 survey		
Site	Total bat detector nights per site	Bat calls	Relative activity (calls per night per site)	Total bat detector nights per site	Bat calls	Relative activity (calls per night per site)
1	43	1420	33.0	42	13985	333.0
2	8	417	37.9	42	14258	339.5
3	43	811	18.9	41	6960	169.8
4	43	3288	76.5	41	23654	576.9
5	9	1989	221.0	12	11350	945.8
6	43	1624	37.8	41	12142	296.1
7	43	1575	36.6	0	-	-
8	43	1520	35.3	40	8865	221.6
9	43	541	12.6	41	5211	127.1
10	43	412	9.6	40	4695	117.4
11	43	930	21.6	41	2645	64.5
12	43	313	7.3	35	2247	64.2
13	-	-	-	26	671	25.8
14	-	-	-	26	919	35.3
15	-	-	-	26	2519	96.9
16	-	-	-	26	3171	122.0
17	-	-	-	26	7422	285.5
18	-	-	-	25	615	24.6
19	-	-	-	25	1729	69.2
20	-	-	-	24	917	38.2
21	-	-	-	24	3500	145.8
22	-	-	-	24	5191	216.3
Total	447	14,840		668	132,666	

Autumn 2023: The focus of the analysis for the Autumn 2023 survey was identifying SBWB and YBSB calls. Consequently, manually checking the automated identifications to confirm species presence/absence per site was not conducted.

To briefly summarise overall bat activity, the automated classifier identified 132,666 call sequences containing bat calls. There was a large increase in call activity recorded across the study area compared to the Summer 2022-2023 survey. The highest level of activity was again recorded at Site 5, followed by Sites 4, 1 and 2 (Table 14). Temporal patterns of overall bat activity recorded at each site during the Autumn 2023 survey are presented in Figure 6.

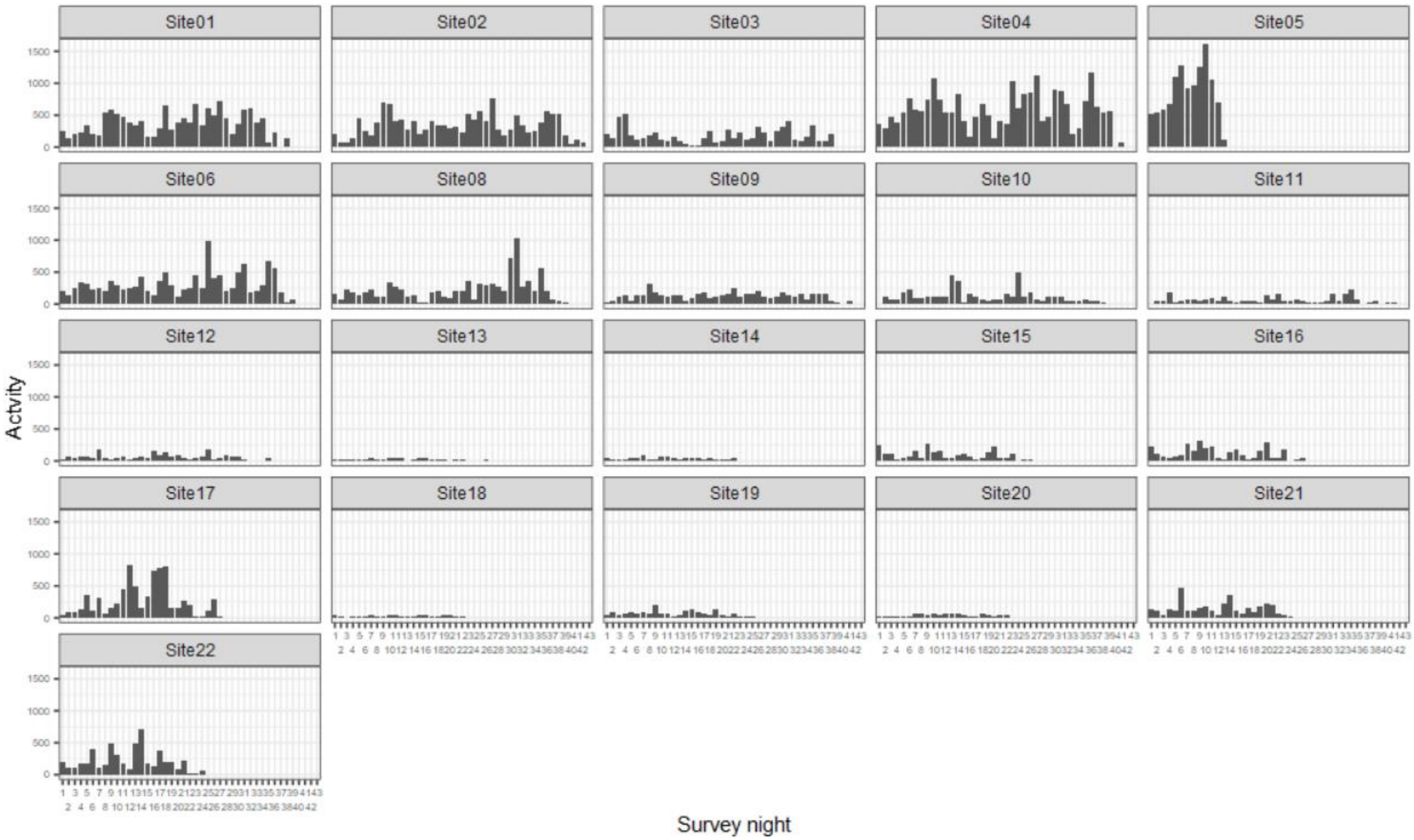


Figure 6: Count of total bat calls per site per night (activity) during Summer 2022-2023

7.2.3. Overall bat activity - foraging guilds

Summer 2022-2023: From the total 14,840 files identified by the automated classifier as containing bat calls, the greatest level of activity was assigned to the edge-space high-frequency foraging guild (35% of all bat calls), which includes SBWB, Little Forest Bat, Southern Forest Bat and Chocolate Wattled Bat (Figure 7a). The open-space guild was the next most commonly recorded (30% of all calls), followed by edge-space low-frequency (15%) (Figure 7a).

Calls assigned to the edge-space high-frequency guild were recorded at all 12 bat detector sites. The highest level of activity occurred at Site 5 (22.3%), followed by Site 1 (12.9%), Site 4 (12.5%) and Site 8 (11.2%) (Figure 8a).

Autumn 2023: From the total 132,666 files identified by the automated classifier as containing bat calls, the majority (38% of all calls) were assigned to the open-space foraging guild, followed by the edge-space high-frequency (24% of all calls) and edge-space low-frequency guilds (15%) (Figure 7b).

Calls assigned to the edge-space high-frequency guild were recorded at all 12 bat detector sites. The highest level of activity occurred at Site 1 (20.3%), followed by Site 6 (12.2%), Site 4 (9.6%) and Site 5 (8.9%) (Figure 8b).

Patterns of SBWB activity during the Summer 2022-2023 and Autumn 2023 surveys determined through manually checking spectrograms is presented in Section 7.2.4.

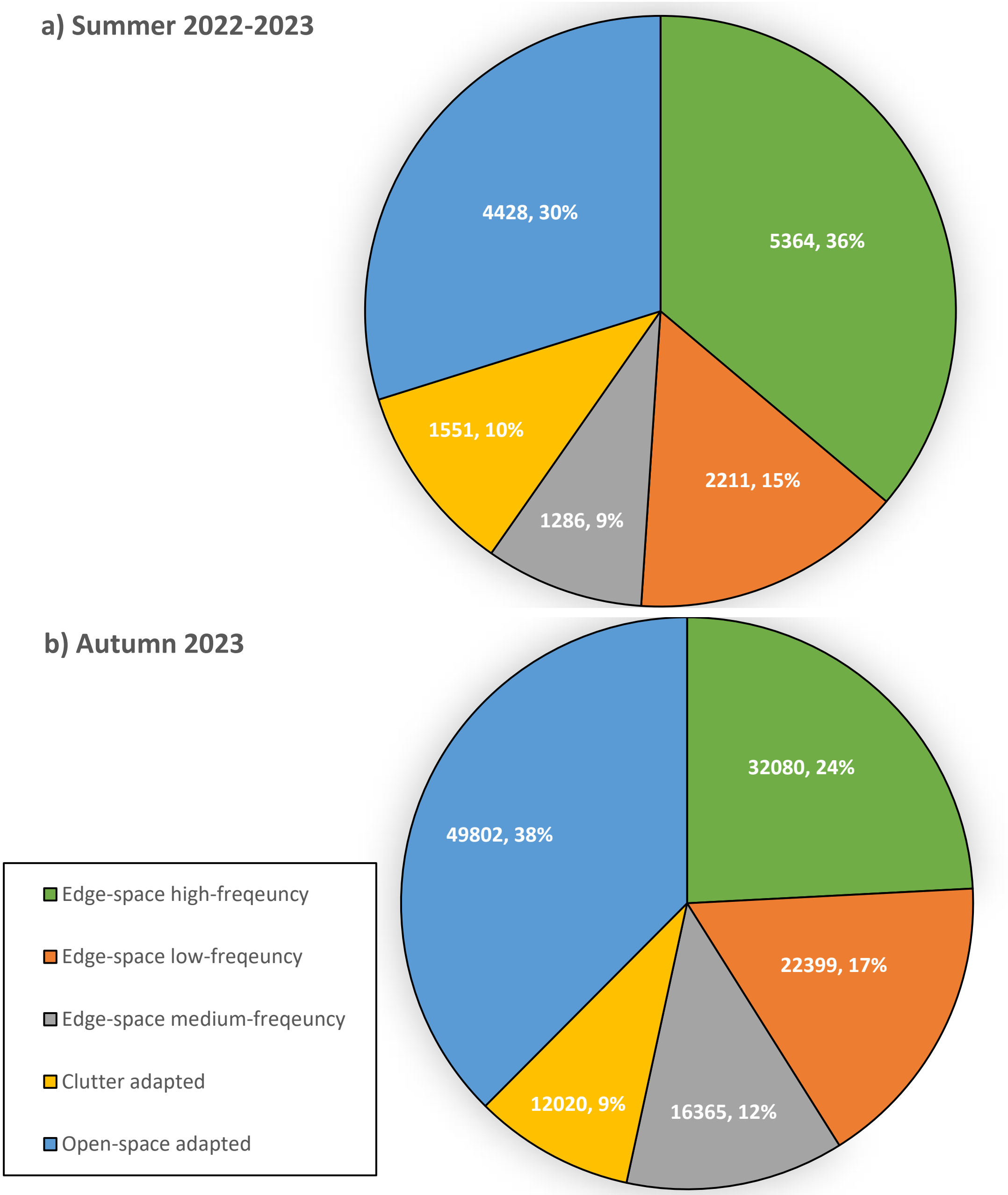


Figure 7: Total number and percentage of all bat calls assigned by the automated classifier to species within five foraging guilds

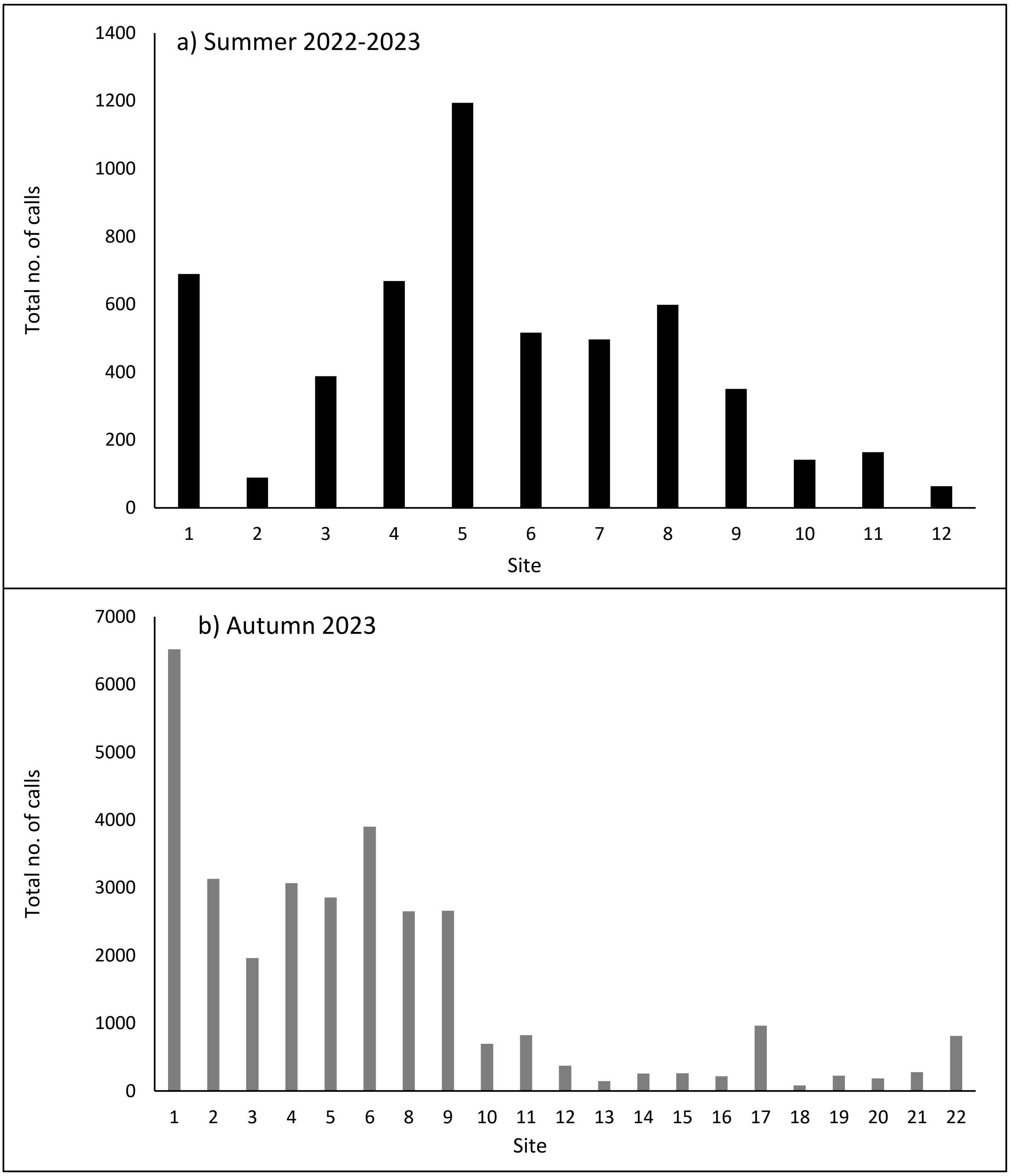


Figure 8: Edge-space high-frequency guild calls (45-50 kHz) recorded per site

Note - this foraging guild includes Sothern Bent-wing Bat, Little Forest Bat, Southern Forest Bat and Chocolate Wattled Bat.

7.2.4. Southern Bent-wing Bat

Summer 2022-2023: From a survey effort comprising 447 bat detector nights, the automated classifier identified 2,748 calls as containing at least 3 SBWB pulses and therefore required further investigation to confirm species identifications. From this dataset, 19 SBWB calls were manually identified by visual inspection of spectrograms of the call sequences. At least one SBWB call was manually identified at seven of the 12 bat detector sites. The greatest number of manually identified SBWB calls were recorded at Site 10 (six calls), followed by four calls at both Sites 5 and 11. Across the seven sites where manually identified SBWB calls were recorded, combined relative activity was 0.043 (Table 15).

In addition, a further 156 calls were manually assigned to the SBWB-complex. Pulses within these call sequences were in the appropriate frequency range for both SBWB and Little Forest Bat, and it is possible that these calls contained some SBWB pulses. It is therefore possible that estimates of SBWB activity based on definite manual identifications alone represent an underestimation of actual activity in the study area (see Appendix 1). The largest number of calls assigned to the SBWB-complex were recorded at Site 5 (43 calls), followed by 24 calls at Site 10, 21 calls at Site 4 and 13 calls at Site 11 (Table 15).

Table 15: Summary of manually identified Southern Bent-wing Bat calls from the summer 2022-2023 survey

		SBWB-definite		SBWB-complex		
Site	Bat detector nights	No. of calls	Calls per bat detector night	No. of calls	Calls per bat detector night	Combined calls per night
1	43	1	0.02	8	0.19	0.21
2	8	0	0	3	0.38	0.38
3	43	0	0	4	0.09	0.09
4	43	0	0	21	0.49	0.49
5	9	4	0.44	43	4.78	5.22
6	43	0	0	14	0.33	0.33
7	43	0	0	4	0.09	0.09
8	43	1	0.02	6	0.14	0.16
9	43	1	0.02	9	0.21	0.23
10	43	6	0.14	24	0.56	0.70
11	43	4	0.09	13	0.30	0.40
12	43	2	0.05	7	0.16	0.21
Total	447	19		156		

Autumn 2023: From a survey effort comprising 668 bat detector nights, the automated classifier identified 2,748 calls as containing at least 3 SBWB pulses and therefore required further investigation to confirm species identifications. From this dataset, 85 SBWB calls were manually identified by visual inspection of spectrograms of the call sequences. At least one SBWB call was manually identified at 13 of the 22 bat detector sites. The greatest number of manually identified SBWB calls were recorded at Sites 5 and 6 (14 calls), followed by Sites 3 and 8 (10 calls each).

Across the 13 sites where manually identified SBWB calls were recorded, combined relative activity was 0.18 (Table 16).

A further 93 calls were manually assigned to the SBWB-complex. Pulses within these call sequences were in the appropriate frequency range for both SBWB and Little Forest Bat, and it is possible that these calls contained some SBWB pulses. The largest number of calls assigned to the SBWB-complex were recorded at Site 6 (15 calls), followed by Site 3 (11 calls), and 5 (10 calls). (Table 16).

7.2.5. *Full-spectrum files*

Manual checking of 75 spectrograms of full-spectrum files did not provide any additional evidence to assign them to SBWB-definite or to confirm they were produced by another species. There were no feeding buzzes in any of the 75 calls, nor was there any evidence of Doppler shift, a feature that has been recommended as sometimes being helpful in differentiating between forest bat and SBWB calls: forest bat calls often display a Doppler pattern as the bat circles past the detector multiple times, while *Miniopterus* typically fly past the detector once (Michael Pennay, pers. comm.). Figure 9 shows an example of both full-spectrum and ZC spectrograms of a call assigned as SBWB-complex. This call shows a combination of pulse shapes ranging from upturned and downturned and various pulse durations.

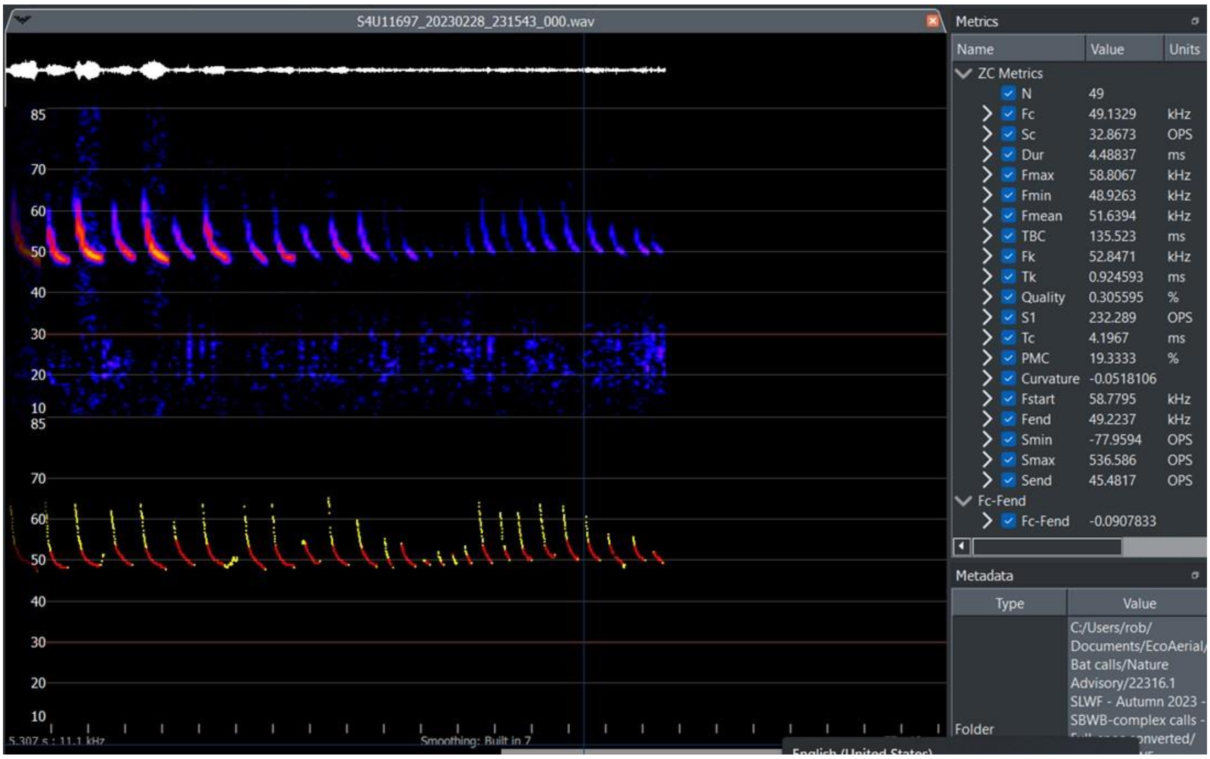


Figure 9: Full-spectrum (top spectrogram) and zero-crossing (bottom spectrogram) versions of the same SBWB-complex call

In relation to the utility of full-spectrum data for identifying Australian *Miniopterus* calls, during the call identification process for this investigation, Amanda Lo Cascio, Rob Gration and Steve Griffiths were involved in ongoing discussions with bat call experts in the Australasian Bat Society's 'Bat Call Identification' group. The consensus among these experts on current best-practice methods for identifying echolocation calls for Australian *Miniopterus* can be summarised as follows:

- Frequency characteristics of feeding buzzes from good-quality full-spectrum calls can be used to separate *Miniopterus* from vespertilionids. However, there are typically relatively few, if any, *Miniopterus* feeding buzz calls in any given recording dataset. Therefore, this feature is unlikely to be a useful way of separating *Miniopterus* calls from vespertilionids from passively collected call datasets.
- Other features of full-spectrum call data that can aid in identification have been reported for *Miniopterus* species in the Solomon Islands (energy distribution at different points of the pulse) (Pennay and Lavery, 2017). However, their applicability needs to be demonstrated further in Australia, specifically the degree to which such features are diagnostic to the point of consistently facilitating accurate species-level identifications.
- Even when full-spectrum data are recorded, the methods currently used by most Australian experts to identify bat calls to species or complex-level relies on metrics extracted from ZC versions of the full-spectrum files.
- There is currently insufficient evidence that visually inspecting spectrograms of full-spectrum calls compared to ZC files can consistently provide any additional information that increases the chance of correctly identifying or separating SBWB calls from other taxa with similar call features (e.g., Little Forest Bat, Southern Forest Bat, Chocolate Wattled Bat).

7.2.6. Timing of activity relative to sunset

The temporal distribution of SBWB-definite and SBWB-complex calls recorded throughout the night (relative to sunset) for the Summer 2022-2023 survey are presented in Figure 10, and for the Autum 2023 survey in Figure 11.

During the Summer 2022-2023 survey, no SBWB-definite and six SBWB-complex calls were recorded in the first hour after sunset. The majority of both definite (26.3%) and complex (22.4%) calls occurred in the second hour after sunset. Lower levels of activity were recorded from 4-6 hours after sunset, followed by another peak during hours 7 and 8. No SBWB calls were recorded later than 8 hours after sunset (Figure 10).

During the Autumn 2023 survey, no SBWB calls were recorded in the first hour after sunset, and only 4 SBWB-definite calls were in the second hour. The majority of activity occurred during the third and fourth hours after sunset. Lower levels of activity were then recorded throughout the night. There was not a second peak in activity close to dawn in Autumn 2023 (Figure 11), as was observed during Summer 2022-2023 (Figure 10).

There is no information published on flight speeds of SBWB. The co-generic EBWB is one of the fastest flying insectivorous bats in Australia, and can fly at speeds between 40 and 50 km/hr (Bullen et al., 2016). Mills and Pennay (2017) found that EBWB may travel 20-25 km from a roost cave in 30-40 minutes to reach foraging sites. Presuming that SBWB flight speeds are similar to EBWB, the timing of nightly activity recorded in this investigation suggest most of the SBWB recorded in the study area were probably roosting 20-30 km away.

Table 16: Summary of manually identified Southern Bent-wing Bat calls from the autumn 2023 survey

		SBWB-definite		SBWB-complex		
Site	Bat detector nights	No. of calls	Calls per bat detector night	No. of calls	Calls per bat detector night	Combined calls per night
1	42	6	0.14	7	0.17	0.31
2	42	8	0	8	0.19	0.38
3	41	10	0	11	0.27	0.51
4	41	3	0	8	0.20	0.27
5	12	14	1.17	10	0.83	2.00
6	41	14	0	15	0.37	0.71
7	0	-	-	-	-	-
8	40	10	0.25	6	0.15	0.40
9	41	6	0.15	5	0.12	0.27
10	40	1	0.03	4	0.10	0.13
11	41	3	0.07	2	0.05	0.12
12	35	2	0.06	1	0.03	0.09
13	26	0	0	1	0.04	0.04
14	26	0	0	1	0.04	0.04
15	26	0	0	0	0	0
16	26	0	0	0	0	0
17	26	4	0.15	8	0.31	0.46
18	25	0	0	0	0	0
19	25	0	0	0	0	0
20	24	0	0	3	0.13	0.13
21	24	0	0	3	0.13	0.13
22	24	4	0.17	0	0	0
Total	668	85		93		

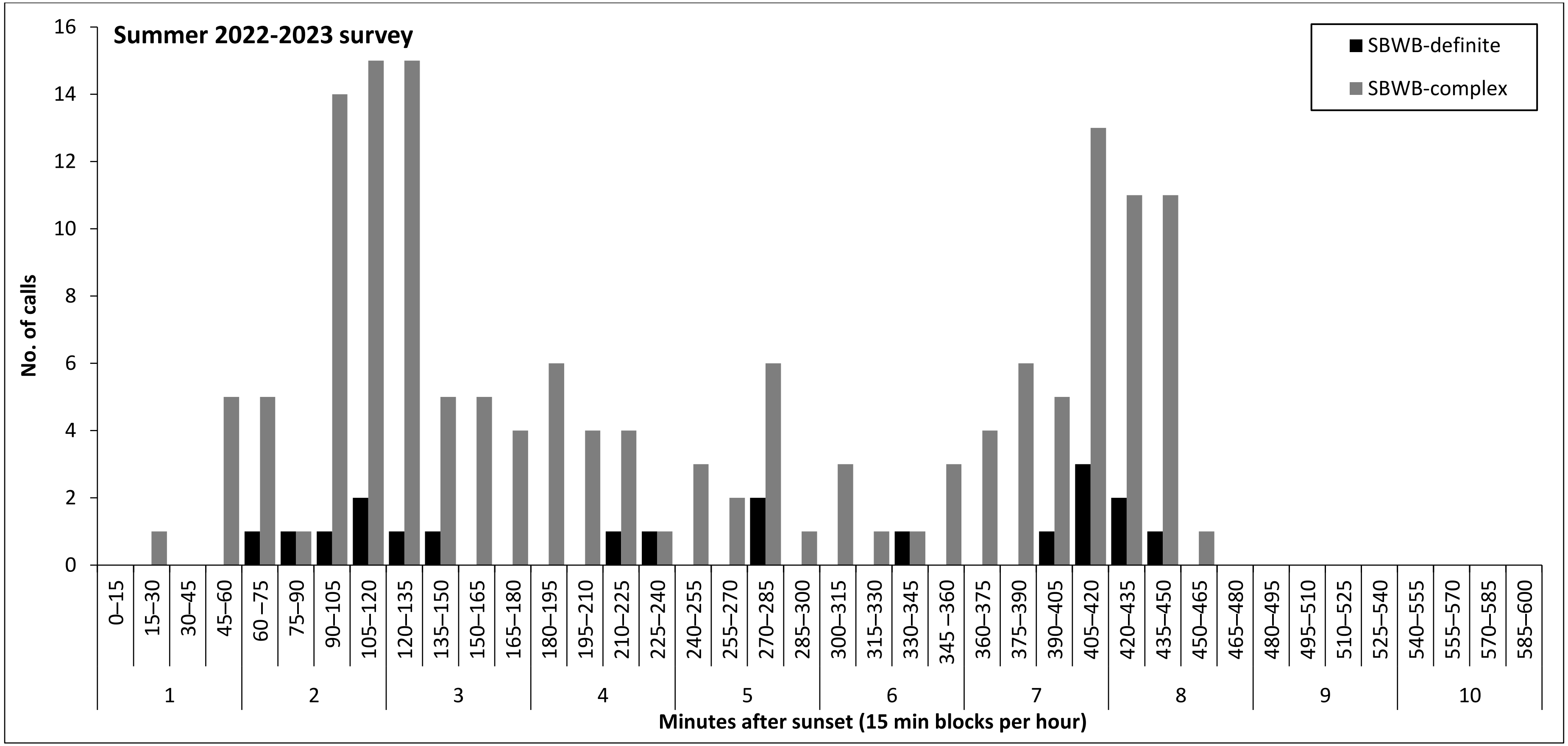


Figure 10: Temporal distribution of SBWB calls throughout the night – Summer 2022-2023

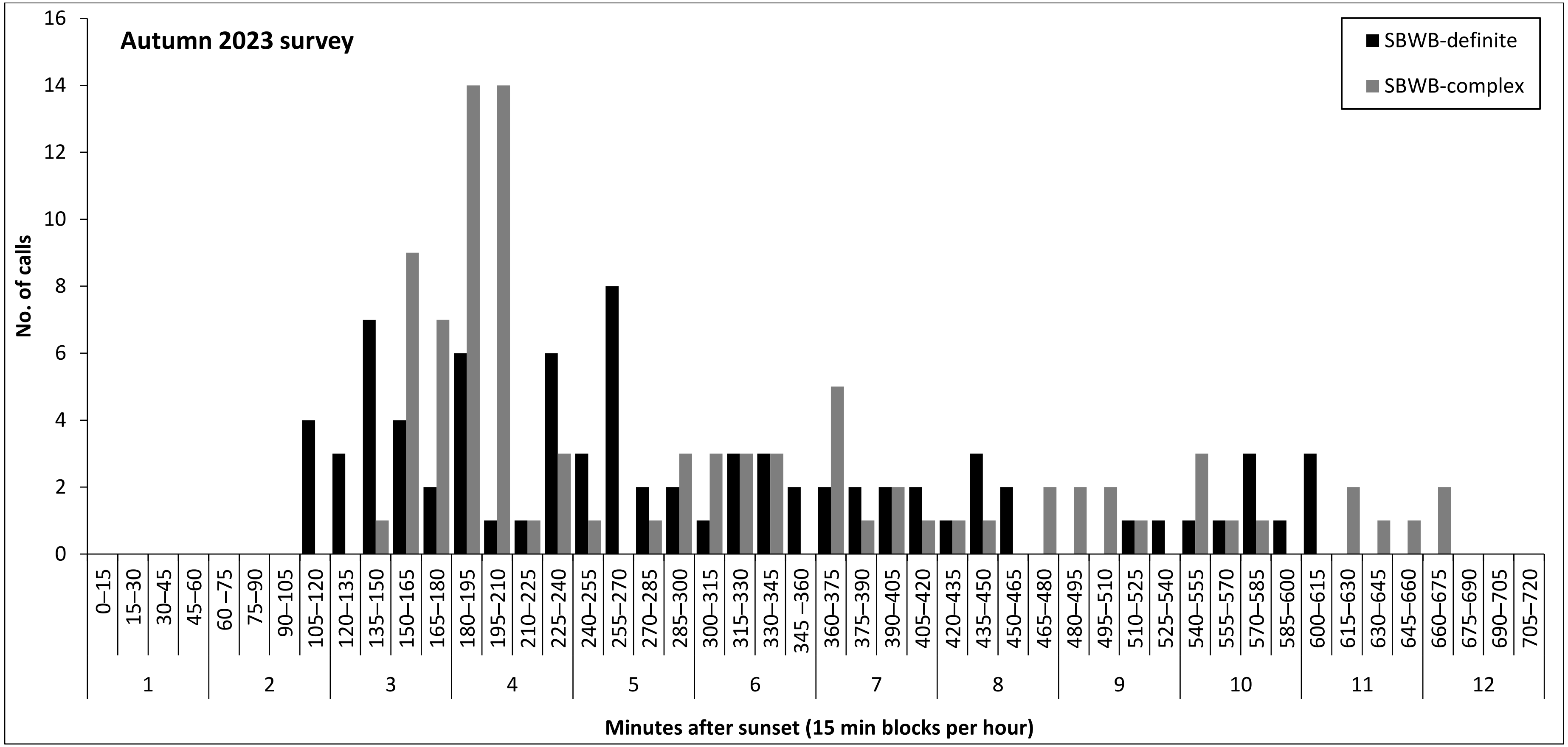


Figure 11: Temporal distribution of SBWB calls throughout the night – Autumn 2023

7.2.7. Habitat associations

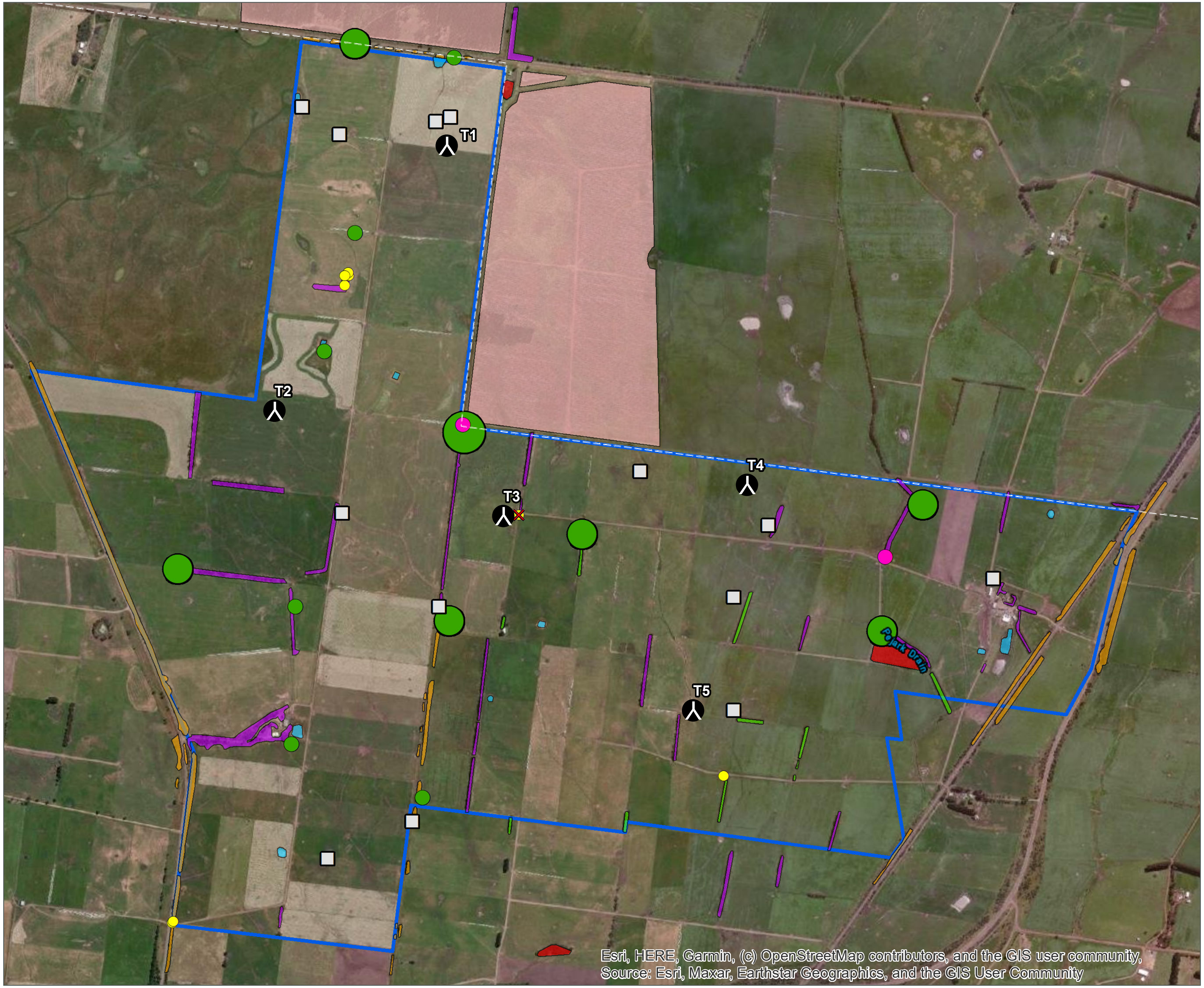
General patterns - The relative activity of SBWB-definite and SBWB-complex calls recorded at bat detector sites relative to the nearest habitat feature is displayed in Figure 12 and Figure 13, respectively.

The highest levels of SBWB-definite activity were recorded at sites close to linear eucalypt features (windbreaks and roadside vegetation), Blue Gum forestry plantations and the one remaining remnant eucalypt patch. Activity was also recorded at several sites close to farm dams. Across all four survey periods, no SBWB-definite activity was recorded at 13 sites, including several sites that were close to habitat features (Figure 12).

SBWB-complex activity was greatest close to Blue Gum forestry plantations and linear eucalypt features. Lower levels of SBWB-complex activity were recorded close to farm dams and the remnant eucalypt patch. Across all four survey periods, no SBWB-complex activity was recorded at 11 sites, including several sites that were close to habitat features (Figure 13).

Figure 12: SBWB-definite calls and habitat features

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 15/03/2024



Study area
Wind turbine
Site with no calls

Survey period

EHP: 2021-2022
NA: 2022-2023

Relative activity – calls per night

(Proportional size 0.01 - 0.86)

Habitat

Eucalypt windbreak
Farm dam
Forestry plantation
Pine windbreak
Remnant native woodland
Roadside vegetation
Scattered tree (EHP)
Scattered tree to be removed

N

Metres
0 200

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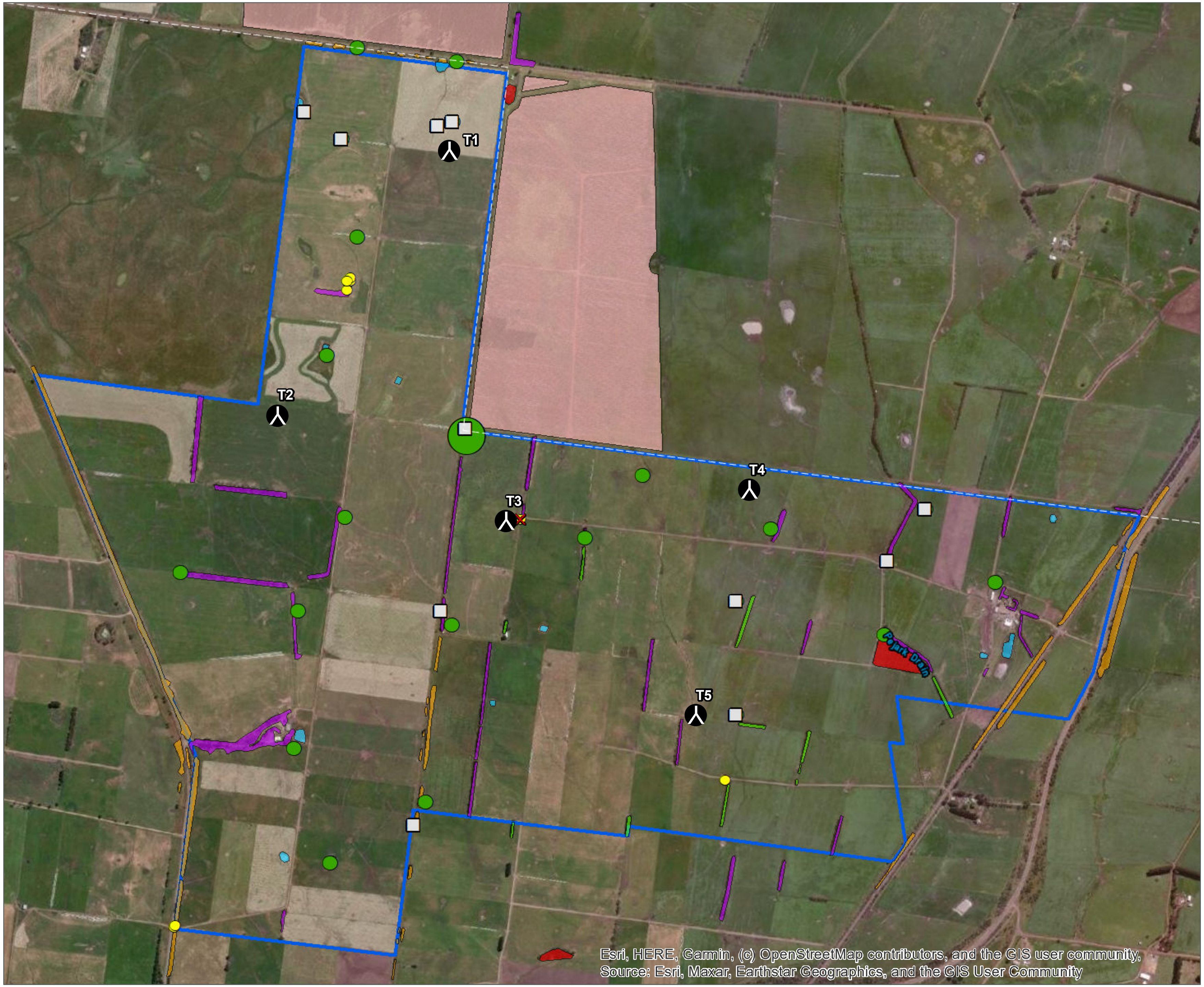

Figure 13: SBWB-complex calls and habitat features

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 8/03/2024

Study area
Wind turbine
Site with no calls

Survey period

NA: 2022-2023

Relative activity – calls per night

(Proportional size 0.05 - 2.55)

Habitat

Eucalypt windbreak
Farm dam
Forestry plantation
Pine windbreak
Remnant native woodland
Roadside vegetation
Scattered tree (EHP)
Scattered tree to be removed

N

Metres
0 200

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Habitat association models – Activity of SBWB-definite, SBWB-complex, and the combined group all exhibited a marked decline with distance from eucalypt windbreaks, the most common and widespread habitat feature within the study area (Figure 3). Activity also decreased significantly with increasing distance from eucalypt forestry plantations, except for SBWB-definite. Activity did not significantly decrease with distance from any other habitat features (Figure 14).

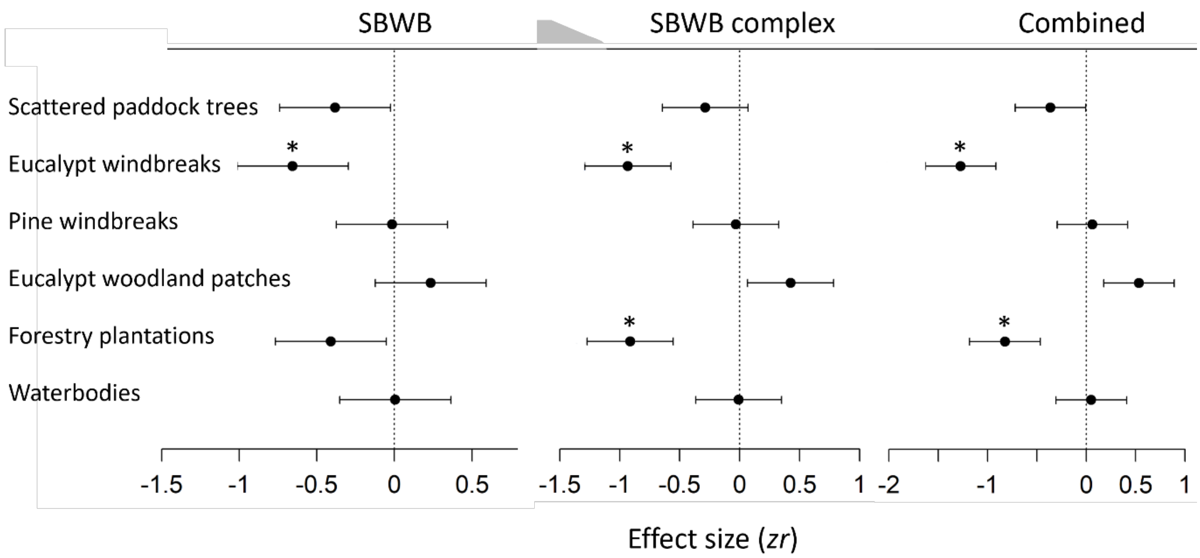


Figure 14: Effect sizes (zr) along with 95% confidence intervals for the association between SBWB activity (calls per detector night) and distance from habitat features.

*Significant effects indicating a decrease of bat activity with distance from habitat features after false discovery rate (FDR) corrections. SBWB categories: SBWB-definite, SBWB-complex, Combined = SBWB-definite + SBWB-complex.

The next subsections provide detailed explanations of the results specific to each habitat feature and are accompanied by conditional plots showing the prediction curves along with 95% CI bands for significant associations.

Eucalypt windbreaks

Activity of SBWB-definite, SBWB-complex, and the combined group all showed a decrease with increasing distance from eucalypt windbreaks (Figure 15). This result is consistent across models and provides detailed predictive information of SBWB activity across a range of distances from eucalypt windbreaks throughout the study area (Figure 3). For SBWB-definite, the model predicted a decline in activity from eucalypt windbreaks to 50% at 50 m, 24% at 100 m, 12% at 150 m, and 6% at 200 m. These findings exhibit a similar trend, albeit with a less abrupt decline in activity, for the SBWB-complex (50 m = 64%, 100 m = 41%, 150 m = 26%, 200 m = 17%), and for the combined group (50 m = 62%, 100 m = 38%, 150 m = 24%, 200 m = 15%). Moreover, the results indicate that there are no statistically significant differences in bat activity between distances of 150 m and 200 m from eucalypt windbreaks.

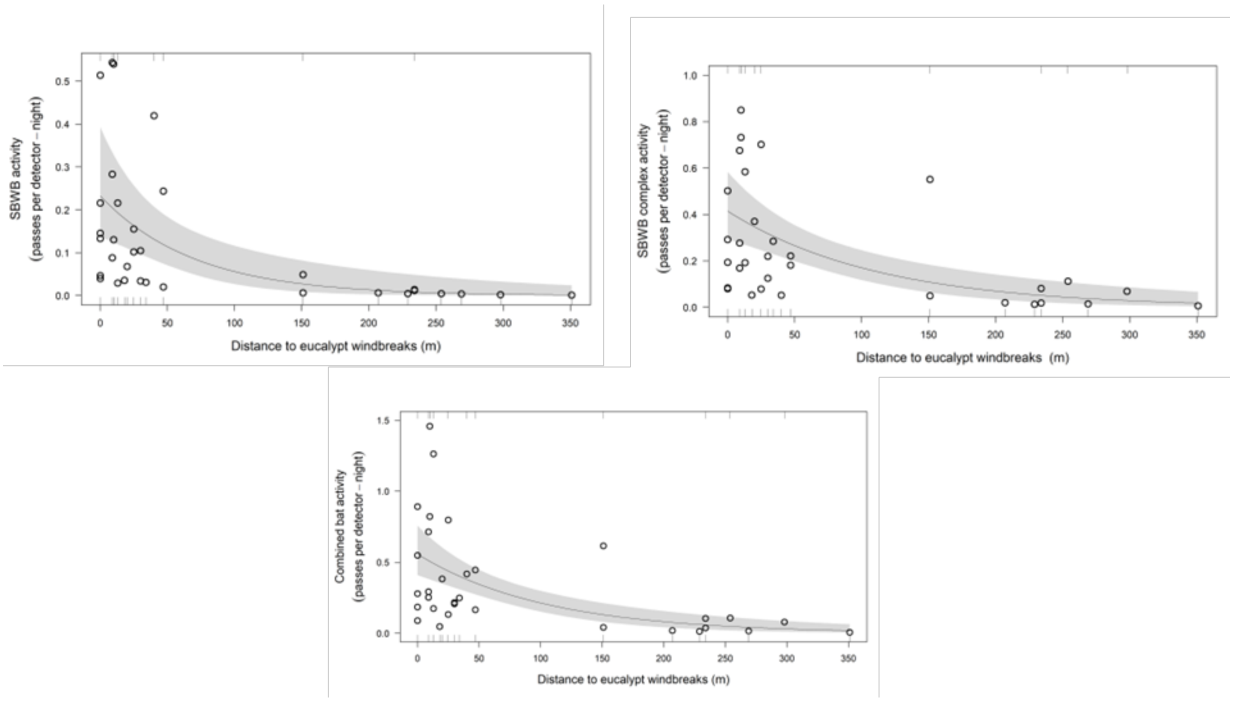


Figure 15: SBWB activity decreased with distance from eucalypt windbreaks.

Pine windbreaks and scattered paddock trees

SBWB activity did not exhibit a decreasing trend with increasing distance from pine windbreaks (Figure 16) or scattered paddock trees (Figure 17). Both these habitat types were sparsely distributed in the study area; pine windbreaks comprised 0.19% of the total study area, and there were only eight scattered trees mapped by EHP.

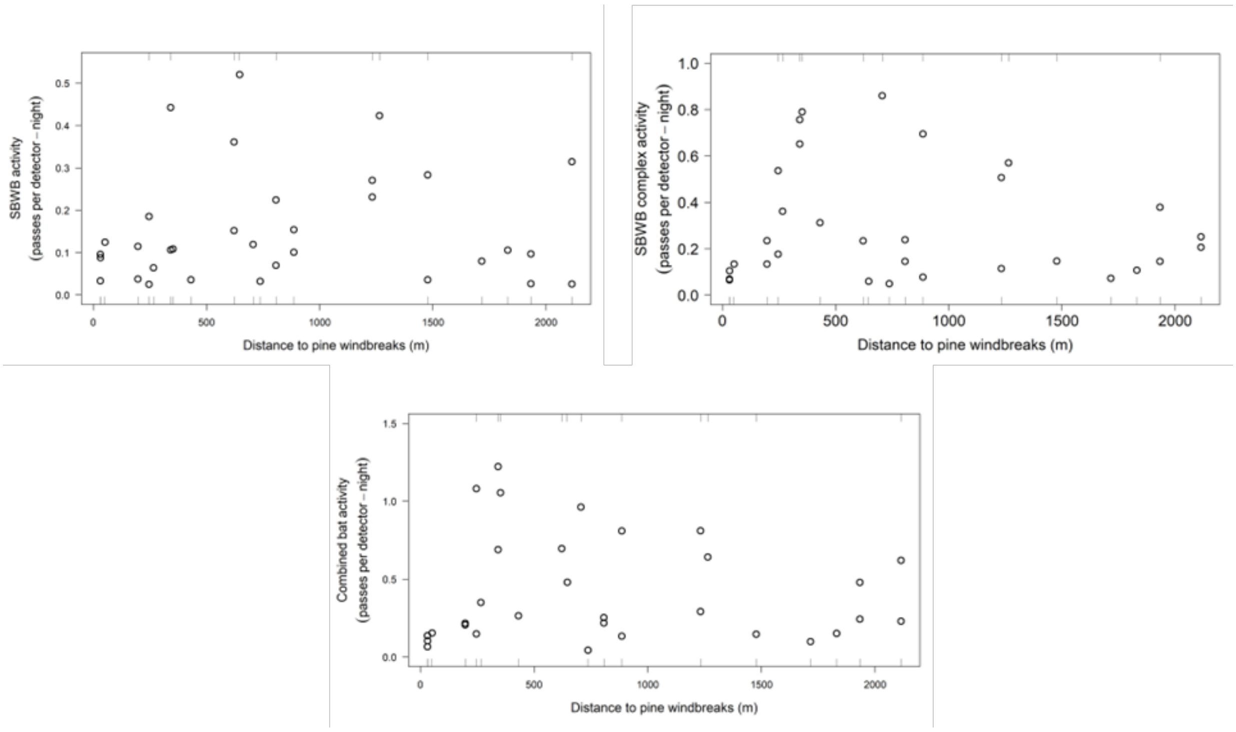


Figure 16: SBWB activity did not change with distance from pine windbreaks.

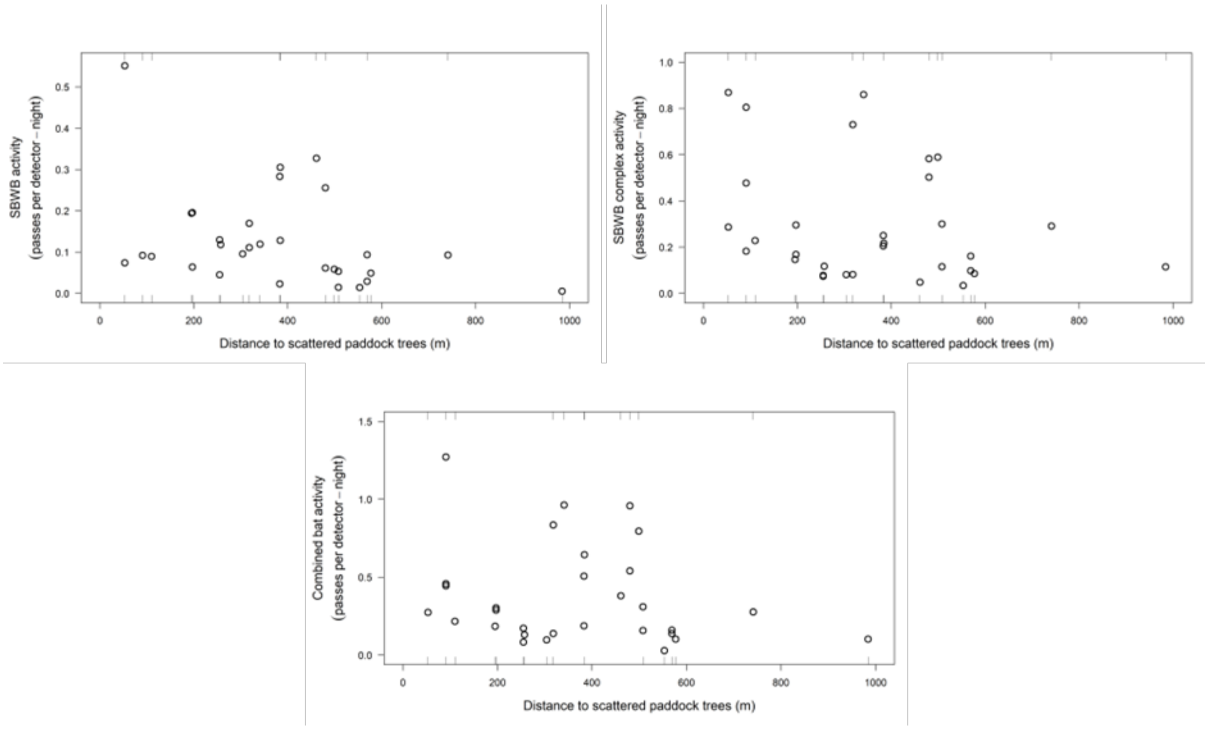


Figure 17: SBWB activity did not change with distance from scattered paddock trees

Forestry eucalypt plantations, eucalypt woodland patches, and farm dams

Activity of SBWB-complex and the combined group decreased with distance to forestry plantations, but there was no relationship for SBWB-definite (Figure 18). This decreasing trend of activity was not evident for eucalypt woodland patches (Figure 19) or waterbodies (Figure 20). These habitat features are expected to attract bats by providing foraging and drinking resources.

There are certain limitations of the study design to be taken into consideration when interpreting these results and using the findings to inform decision-making. The data used for the current analysis were not collected from a study specifically designed to address the question on how bat activity varies in relation to distance from habitat features. Hence, some habitat features can be underrepresented, resulting in irregular distance gradients from detector sites to habitat features, resulting in large gaps in bat activity data. This is particularly evident in the case of distance data related to eucalypt woodland patches, forestry plantations, and waterbodies. These three habitat features, unlike eucalypt windbreaks and pine windbreaks, are clustered or very sparse and patchily distributed within the study area (Figure 3). As a result, the analysis is likely to "overlook" bat activity patterns that might only be detectable with enough information at close distances. For instance, bat activity data in relation to distances from eucalypt windbreaks show that decreases in activity might not be detectable or be insignificant beyond 150 m (Figure 15). Given these considerations, the results regarding eucalypt woodland patches, forestry plantations, and waterbodies lack precision and should be viewed as preliminary information on how bat activity changes with distance from these habitat features.

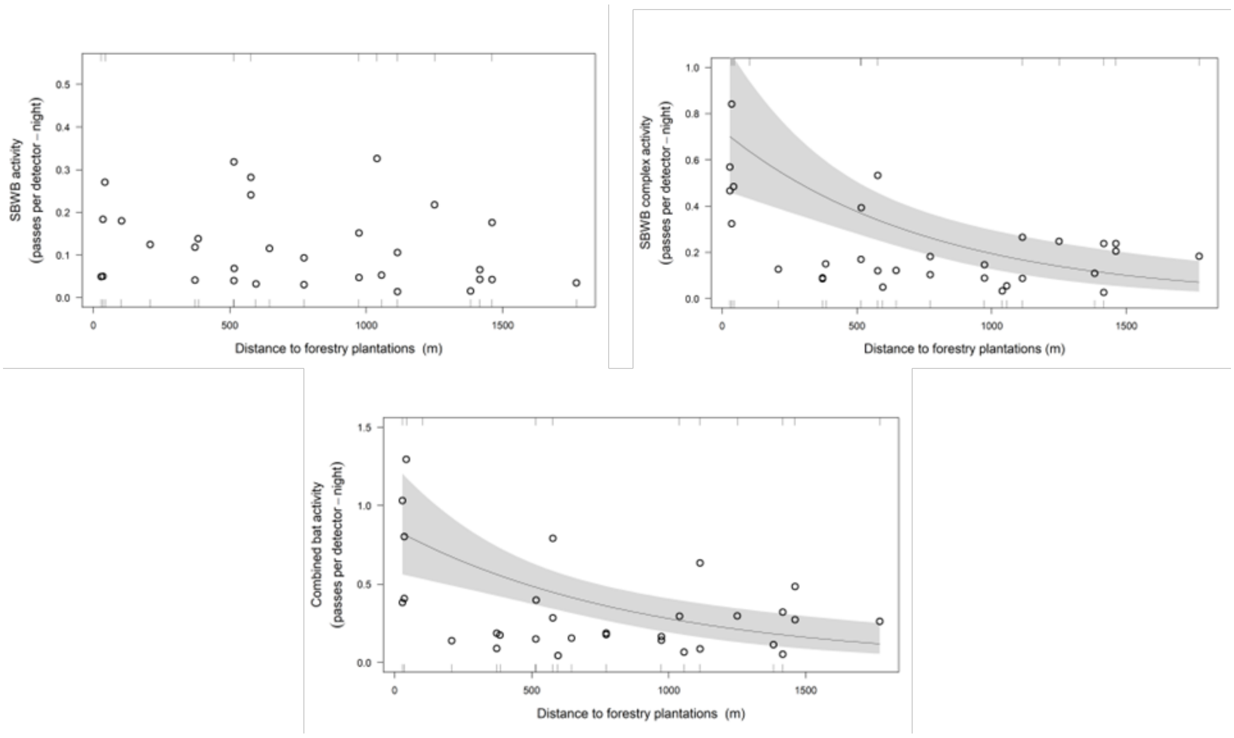


Figure 18: SBWB-definite activity remained consistent with distance from forestry plantations, whereas SBWB-complex did decrease in activity.

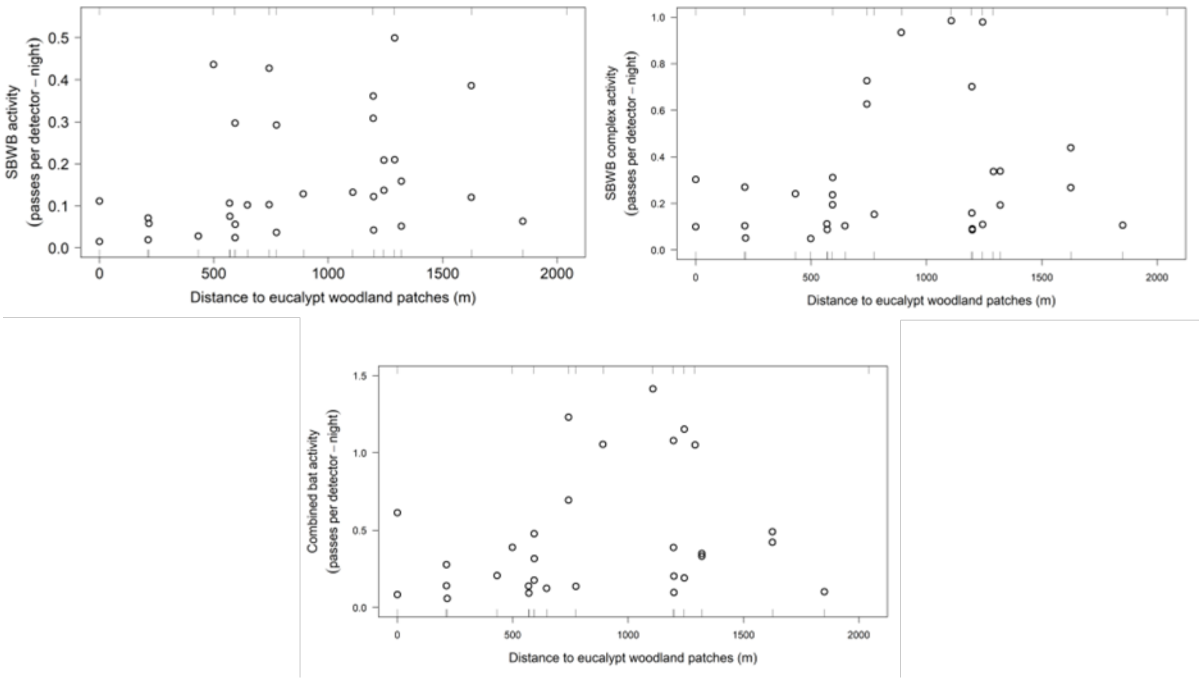


Figure 19: SBWB activity did not decrease with distance from eucalypt woodland patches.

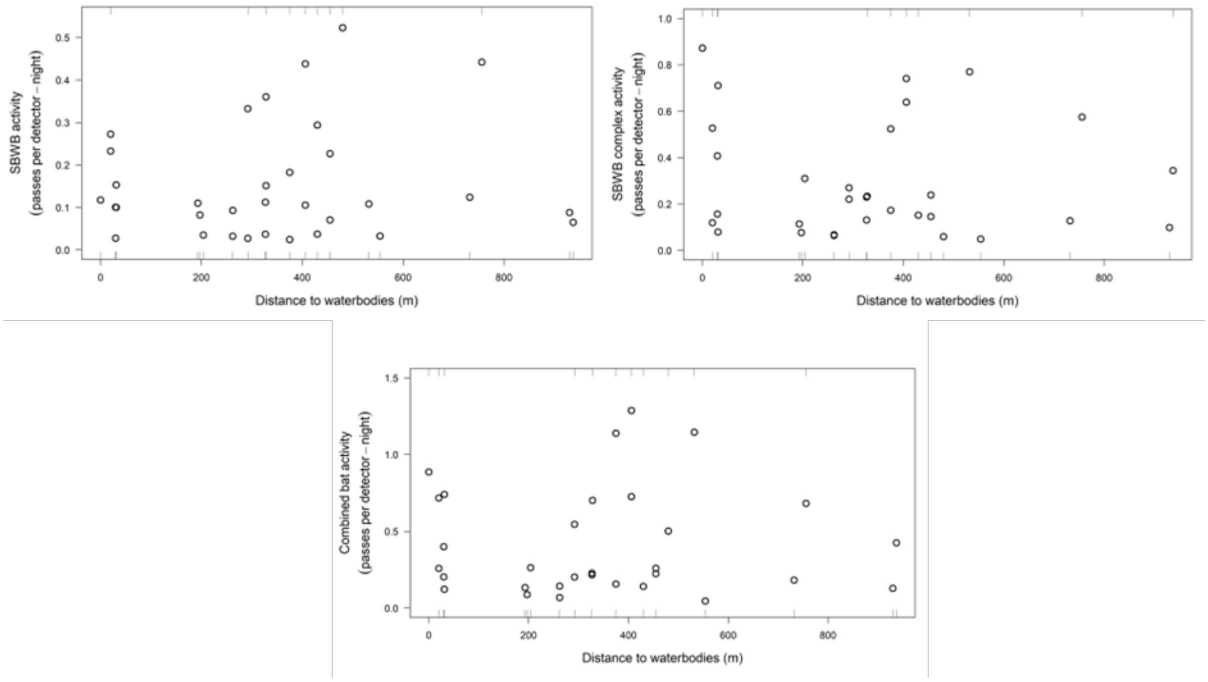


Figure 20: SBWB activity did not decrease with distance from farm dams.

7.2.1. Yellow-bellied Sheath-tailed Bat

Summer 2022-2023: The automated classifier assigned 847 call sequences to YBSB. Visual inspection of the call spectrograms revealed that many of these files contained noise and/or calls produced by other species (Figure 21a). Due to the greater resolution of full-spectrum data compared to ZC data, any ambiguous examples from the 847 files were also manually inspected in the original full spectrum (WAV) format (e.g., Figure 22). This resulted in manually checking spectrograms of 57 full-spectrum calls across 7 sites; two calls from one site (site 7) were not available in full-spectrum because a ZC detector was installed at this site (Table 12).

Manual checking of the 847 files confirmed that none contained YBSB calls, this included the 57 full-spectrum files that were manually checked (e.g., Figure 22). YBSB was not identified in the Summer 2022-2023 dataset.

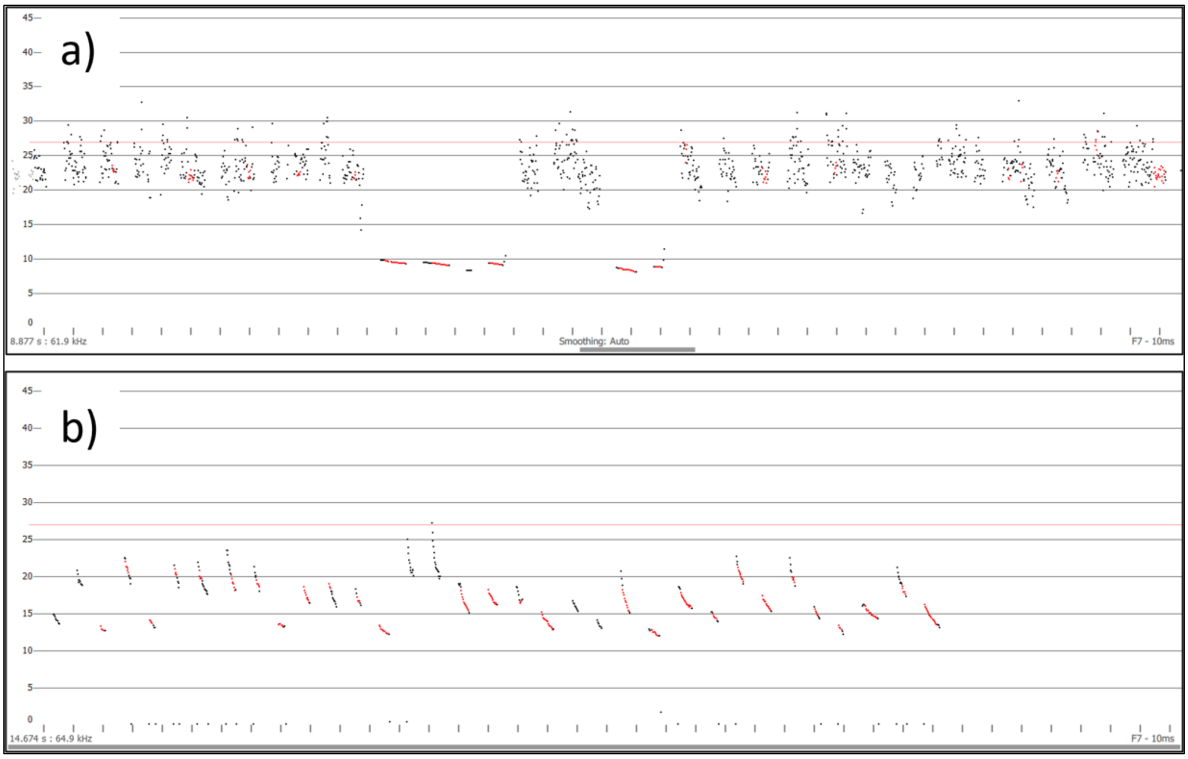


Figure 21: Spectrograms of zero-crossing recordings assigned by the automated classifier to Yellow-bellied Sheath-tailed Bat

Note – a) is a call recorded during Summer 2022-2023 that contains White-striped Free-tailed Bat calls (individual pulses) at 10 kHz and noise at 20 kHz. b) is a call recorded during Autumn 2023 that contains White-striped Free-tailed Bat calls (individual pulses at 12-15 kHz) along with higher-frequency clutter calls of the same individual at 20 kHz.

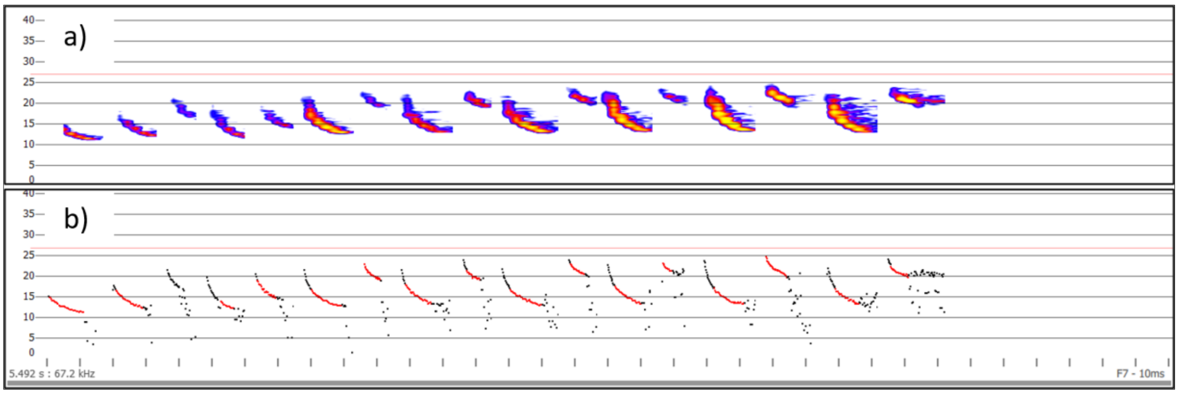


Figure 22: (a) Full-spectrum and (b) zero-crossing spectrograms of the recording assigned by the automated classifier to Yellow-bellied Sheath-tailed Bat

Note – These alternating calls most likely belong to White-striped Free-tailed Bat and may have been produced by two individuals and hence appear as alternating pulses.

Autumn 2023: A total of 2,299 files were marked by the automated classifier as containing at least 3 YBSB pulses. Many of these files contained noise and calls from other species (e.g., Figure 21b). Any ambiguous examples from the 847 files were also examined in the original full spectrum (WAV) format. This resulted in the checking of 123 full-spectrum calls across 6 sites. Full-spectrum files were not available for 3 sites (Site 15, Site 17 and Site 22; 23 call sequences in total).

Manual checking of the 2,299 files confirmed that none contained YBSB calls, this includes the 123 full-spectrum files that were manually checked. YBSB was not identified in the Autumn 2023 survey dataset.

8. Impact assessment

8.1. Project objectives

The specific focus of this investigation was on generating baseline data documenting presence/absence and temporal activity of the two listed bat species that are either present, or can potentially occur in the study area:

- Southern Bent-wing Bat (Critically Endangered, EPBC Act, Vulnerable FFG Act)
- Yellow-bellied Sheath-tailed Bat (Vulnerable, FFG Act)

Targeted investigations designed to assess the potential for the proposed SLWF to impact negatively upon SBWB and YBSB were undertaken. The investigation comprised a roost cave assessment and four seasonal bat detector surveys conducted over two consecutive years.

8.2. SBWB activity patterns across the study area

Below is a brief summary of results from the four bat detector survey periods:

- From an intensive survey effort conducted at SLWF over two consecutive years comprising 1,672 bat detector nights, SBWBs were recorded in the study area at low levels of activity. The overall relative activity (calls per detector night) of SBWB-definite and SBWB-complex calls during the four intensive surveys combined were 0.065 and 0.149, respectively.
- During the year 2 surveys (total survey effort of 1,115 bat detector nights), the automated classifier identified 147,506 files containing bat calls. From this, 37,444 calls (25.3%) were assigned to the edge-space high-frequency foraging guild. This shows that the bat detectors were effective at detecting and recoding calls produced by high-frequency (45-50kHz) calling species (SBWB, Little Forest Bat, Southern Forest Bat, Chocolate Wattled Bat). Manual checking confirmed that SBWB-definite and SBWB-complex calls combined accounted for 0.9% of the 37,444 calls assigned by the automated classifier to the edge-space high-frequency foraging guild.
- Checking full-spectrum spectrograms of calls that had been manually assigned as SBWB-complex did not provide any additional information to assist in (i) confirming if these calls were in fact SBWB-definite, or (ii) were produced by other species.
- The highest levels of SBWB-definite and SBWB-complex activity were recorded at sites close to linear eucalypt features (planted windbreaks and roadside vegetation), Blue Gum forestry plantations (located outside of the study area) and the one remaining small, isolated patch of remnant eucalypt woodland.
- Habitat association models showed that SBWB activity declined significantly with increasing distance from eucalypt windbreaks and Blue Gum plantations, but not from any other habitat feature. Further, there was no difference between SBWB activity at sites that were 150 m or 200 m away from eucalypt windbreaks.
- The majority of SBWB-definite and SBWB-complex activity occurred during the second to fourth hours after sunset. This suggests that the SBWB that were recorded in the study area were probably roosting 20-30 km away.

8.2.1. General comparison with SBWB activity at other wind farm sites

Several factors could potentially influence SBWB call activity recorded during pre-commissioning surveys conducted for different wind farms, including use of different detectors which could have different sensitivities, timing and location of surveys relative to potentially important habitat features, the experience-level of the expert conducting the call identification and the process employed (e.g., manual compared to automated). While direct comparisons are problematic, activity levels recorded during surveys at other wind farms in south-west Victoria are summarised in Figure 23 to facilitate a general comparison with SLWF.

From an intensive survey effort conducted at SLWF comprising 1,672 bat detector nights over two consecutive years, SBWBs were recorded in the study area at very low levels of activity. The overall relative activity (calls per detector night) of SBWB-definite and SBWB-complex calls during the four intensive surveys combined were 0.065 and 0.149, respectively. This activity level is similar to that recorded at other proposed and operational wind farms in the region (Figure 23). For example, 0.031 calls per detector night at Willatook Wind Farm (from a survey effort of 4,924 bat detector nights), 0.025 calls per detector night at Dundonnell Wind Farm (838 bat detector nights), 0.013 calls per detector night at Woolsthrope WF (224 bat detector nights), and 0.011 calls per detector night at Mortons Lane WF (512 bat detector nights). In comparison, the SBWB activity level recorded at SLWF was significantly lower than several other wind farms in the region, such as Ryan Corner (1.78 calls per detector night over 46 bat detector nights), MacArthur Wind Farm (2.15 calls per detector night over 800 bat detector nights), and Hawkesdale Wind Farm (4.25 calls per detector night over 105 bat detector nights) (Nature Advisory, 2022).

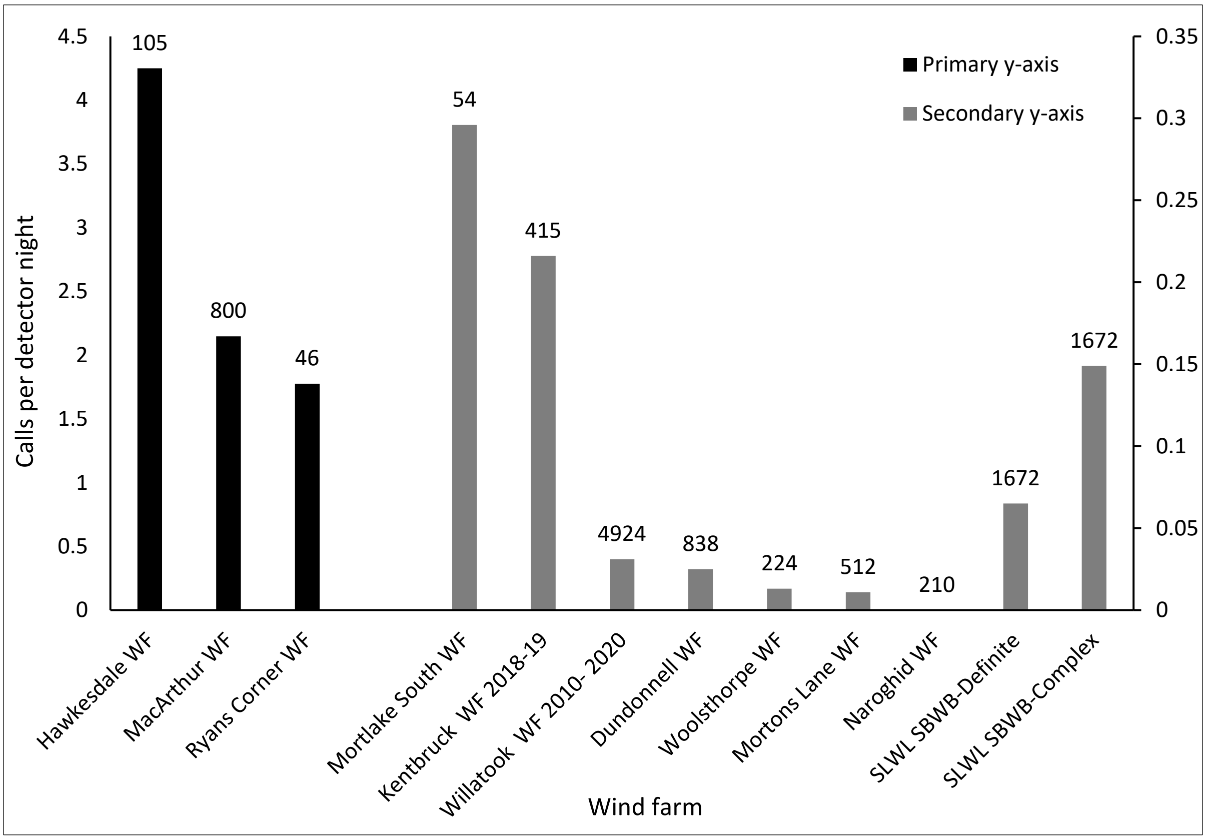


Figure 23: SBWB relative activity during other wind farm surveys

Note – Numbers above bars represent the survey effort (bat detector nights). Relative activity for the first three wind farms (black bars) is shown on different scale (0–4.5 calls per night) to the other eight wind farms (orange bars; 0–0.35 calls per night).

8.3. Flight height

As mentioned in Section 5.4, there is currently no published data documenting flight heights for SBWB (Threatened Species Scientific Committee, 2021). The only publicly available data is from met mast bat detector surveys. This methodology has been recommended by DEECA to multiple wind farm proponents in Victoria, and also in the EUROBATS Guidelines (Rodrigues et al., 2015). At-height bat detector surveys using met masts have been shown to be effective at recording bat activity at-height, including edge-space high-frequency species with similar morphological and behavioural characteristics as SBWB (Roemer et al., 2019b, 2017). Further, a study at two operational wind farms in the US showed that bat activity recorded on bat detectors attached to turbine towers at 20 m AGL (just below the RSA) was 10 times greater than activity recorded at the top of the nacelle. These differences in acoustic activity were highly correlated with the number of carcasses found during corresponding mortality monitoring (Peterson, 2023). These findings demonstrate that measuring acoustic bat activity at heights equivalent to the RSA (e.g., on met masts) can provide a quantitative basis for estimating potential fatality rates (Behr et al., 2023; Peterson et al., 2021).

At-height bat detector surveys have not been conducted in the SLWF study area because the Proponent did not install met masts at the site. However, this methodology has been recommended by DEECA as an important component of pre-commissioning surveys (Lumsden, 2007), and as a result, surveys have been conducted at multiple proposed wind farms in south-west Victoria. Results from publicly available examples of such studies conducted in Victoria and NSW are presented below.

8.3.1. Met mast surveys

Surveys within geographic range of Eastern Bent-wing Bat

At Crowlands Wind Farm (CWF), located in central northern Victoria, met mast surveys were conducted in Autumn of 2005 (Brett Lane & Associates, 2006). This site was located outside the range of the SBWB but was potentially within the range of the EBWB. Bat detectors were placed 45 m AGL on two met masts and paired with ground-level detectors at the base of the masts. An additional 6 detectors were deployed at ground-level elsewhere across the site. The survey ran for 8 nights at met mast sites and 7-9 nights at other sites. In total, 2,343 calls were recorded. Of these, 1,187 were assigned to a species or complex. White-striped Free-tailed Bat and Gould's Wattled Bat/*Ozimops* spp. complex formed the majority of calls recorded, both at height and at ground level. No EBWB were recorded during the survey either at ground level or at 45 m (Brett Lane & Associates, 2006).

At Bald Hills Wind Farm (BHWF), located in south east Victoria, met mast surveys were conducted in Autumn 2003 at one site (one recorder at 45 m above ground and one at ground level), with the survey yielding 5 nights of useful data (CEE Consultants, 2003). This survey was within the range EBWB but not SBWB. In total, 107 calls were detected, with the large majority from the White-striped Free-tailed Bat, including all calls at height. No EBWB calls were recorded during the survey at BHWF (CEE Consultants, 2003).

At Crookwell 2 Wind Farm (C2WF), in NSW, met mast surveys were conducted in Autumn, and late Spring – early Summer of 2017 (Brett Lane & Associates, 2018a). This survey was outside the range of the SBWB but within the range of the EBWB. One bat detector was mounted on a met mast at 50 m AGL and another at ground level at the same site. A further 8 detectors were deployed at ground level elsewhere across the site. The survey ran for 25 nights in Autumn and 8 nights in late Spring/early Summer. The EBWB/Forest Bat complex was recorded at height and at ground level. The YBSB was also recorded at ground level. The relative activity of the different microbat species was not reported.

At Alberton Wind Farm (AWF), in central west Victoria, met mast surveys were conducted in summer-autumn of 2015 (Brett Lane & Associates, 2016). This survey was outside the range of the SBWB, but potentially within the range of the EBWB. One recorder was mounted on a met mast at 50 m AGL, paired with a detector at ground level. A further four detectors were located at ground level at other sites. The survey ran for 13 nights for most detectors – two of the ground-level detectors (but not the one at height) only recorded data for 10 nights. In total, 1205 bat calls were identified. No bat calls were detected at height. Calls at ground level were largely identified as Gould's Wattled Bat/*Ozimops* spp. complex (46.5%), Large Forest Bat (21.8%), and Little Forest Bat (11%). No EBWB calls were detected either at height or at ground-level during the met mast survey at AWF (Brett Lane & Associates, 2016).

Mills and Pennay (2017) surveyed bat activity at-height about 5 km from the EBWB cave roost at Wee Jasper, NSW, using a bat detector attached to a tethered helium balloon. The at-height detector was paired with another detector placed at ground-level. One site was sampled near the entrance to Wee Jasper for six nights, and six sites were sampled at Parsons Creek, about 20 km from Wee Jasper, over 19 nights. Close to the entrance to Wee Jasper, EBWB calls were recorded at ~100 m elevation on 3 of 6 nights (0.26 passes per hour). In comparison, SBWB calls were recorded on 6 of 6 nights at ground-level and were 9.3 times more likely to be recorded closer to ground level (2.46 passes per hour) than at-height. At Parsons Creek, the concentration of EBWB activity was much lower than Wee Jasper, no EBWB calls were recorded at 100 m elevation over 19 nights of sampling, while activity was recorded on the ground-level detector on 6 of 19 nights (0.23 passes per hour) (Mills and Pennay, 2017).

Surveys within geographic range of Southern Bent-wing Bat

At Dundonnell Wind Farm (DWF), in south-west Victoria, met mast surveys were conducted in Autumn of 2011 (Brett Lane & Associates, 2011). This survey was within the range of the SBWB. One recorder was mounted on a met mast at 50 m AGL for 14 nights, with two other detectors mounted at 25 m AGL (one with receiver pointing up and one with receiver pointing down) at the same site for 7 of those nights. In addition, four detectors were located at ground level for the remainder of the survey. The survey ran for 28 nights. In total, 3578 bat calls were identified. At 50 m AGL, all calls were from White-striped Free-tailed Bat. At 25 m AGL, calls were split evenly (microphone facing up) or 4:1 (microphone facing down) between White-striped Free-tailed Bat and the *Ozimops* spp. complex. At ground level, calls were identified as Southern Free-tailed Bat (25.2%), Southern Forest Bat (18.8%), *Nyctophilus* spp. (18.3%), and Large Forest Bat (13.7%). The remainder of the ground-level calls were split between various species and complexes, including Bent-wing Bat spp. (0.4%) and the Bent-wing/Forest Bat spp. complex (1.5%) (Brett Lane & Associates, 2011).

At Mortlake South Wind Farm (MSWF), in south-west Victoria, met mast surveys were conducted in Spring of 2017 (Brett Lane & Associates, 2018b). This survey was within the range of SBWB and possibly EBWB. Bat detectors were mounted on two met masts at 50 m AGL, each paired with a detector installed at ground level. A further 5 detectors were placed at ground level elsewhere across the site. The survey ran for 24 nights. In total, 704 bat calls were identified. The majority of calls recorded at height were identified as White-striped Free-tailed Bat. The majority of calls at ground level were assigned to Forest Bat spp. YBSB was also recorded at ground level (0.4%). No SBWB or EBWB were recorded during the survey at MSWF (Brett Lane & Associates, 2018b).

At MacArthur Wind Farm (MWF), in south-west Victoria, met mast surveys were conducted in Autumn and Spring in 2014 (Wood, 2017). This survey was conducted within the range of the SBWB. One detector was mounted on a met mast at 45 m AGL, paired with another detector at ground level directly beneath. A further 8 detectors were mounted at ground level at a range of other sites. The survey effort comprised 388 bat detector nights in Autumn and 390 in Spring. A total of 19,086 bat calls were identified. The majority of calls at height were identified as White-striped Free-tailed Bat. In contrast, at ground level, just under half of all calls were from Chocolate Wattled Bat (37.6%) and Gould's Wattled Bat (10.3%). The remaining calls from ground-level were split fairly evenly among a large number of species and complexes, including SBWB (9.0%). Confirmed SBWB calls were not detected with at height, but calls assigned to a SBWB/Forest Bat spp. complex accounted for 1.3% of calls at height (Wood, 2017).

At Willatook Wind Farm (WWF), in south-west Victoria, met mast surveys were conducted from Summer-Autumn and Winter in 2019, as well as in Spring in 2010 and 2018, plus in Autumn in 2011 (Nature Advisory unpub. data). This survey was conducted within the range of the SBWB. Two detectors were mounted, one at 50 m AGL and another at an unknown height, at different sites, with two more recorders correspondingly located at ground level directly beneath. All other recorders (20 in 2019, 16 in 2011, 19 in 2010, and 33 in 2018) were located at ground level at different sites. The length of the survey varied depending on the location of the recorders (see Table 1), ranging from 20-156 nights in 2019, 7-59 nights in 2011, 7-26 nights in 2010, and 5-50 nights in 2018. In summary, YBSB, SBWB, and SBWB-Forest Bat spp. complex calls were recorded from several ground-level detectors. SBWB calls were not detected at-height. A total of 150 SBWB calls were identified from 4924 bat detector nights surveyed across all years.

At Mt Fyans Wind Farm (MFWF), in south-west Victoria, a met mast survey was conducted for seven nights in Summer-Autumn 2016. One detector was attached to the mast at 50 m, paired with another detector at ground-level. No SBWB were recorded at 50 m AGL or ground-level. However, due to an excessive amount of wind interference, the 50 m detector recorded few discernible bat calls. A very low call rate of overall bat activity was recorded from detectors at ground level from the same site (average of 0.03-0.04 calls per night) (Biosis, 2022a).

Surveys outside Bent-wing Bat geographic range

At Bulgana Wind Farm (BWF), in central west Victoria, met mast surveys were conducted in Spring of 2013 and Summer of 2014 (Brett Lane & Associates, 2015). This survey was outside the known range of both the SBWB and EBWB. One bat detector was mounted on a met mast 50 m AGL, paired with another at ground level. A further 8 detectors were located at ground-level at other sites. The survey ran for 29 nights in Spring, and 14 nights in Summer. In total, 3472 bat calls were identified. The majority of calls detected at height were identified as White-striped Free-tailed Bat. Calls recorded at ground level were assigned to Large Forest Bat (38.4%), Southern Free-tailed Bat (29.2%) and Eastern Free-tailed Bat (14.4%). While 0.8% of calls identified at ground-level belonged to the Bent-wing Bat/Forest Bat spp. complex. No confirmed SBWB or EBWB were detected at heigh or at ground-level during the met mast surveys at BWF (Brett Lane & Associates, 2015).

8.4. Potential impacts

As mentioned in Section 5.5, wind farms are one of nine potential threats listed in The National Recovery Plan, which describes potential impacts of the wind industry on the global population of SBWB as follows (Department of Environment, Land, Water and Planning, 2020, pp 12-13):

The impact of the recent proliferation of wind farms within the range of Southern Bent-wing Bats is currently unclear, however, it is possible that any wind farm built close to a Southern Bent-wing Bat 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).

8.4.1. Direct

Bat mortalities are known to occur at wind farms worldwide (Arnett et al., 2016). The overall level of impact is concerning, with over 500,000 bats estimated to be killed annually across Canada and the United States and over 300,000 killed annually at wind energy facilities in Germany alone (Frick et al., 2020; Hayes, 2013; Voigt et al., 2022).

The primary cause of bat mortality is collision with operational turbine blades. Barotrauma has also been suggested as a direct impact pathway (Baerwald et al., 2008), but remains somewhat controversial due to difficulties in diagnosing the specific cause of death for bat carcasses discovered at wind farms (Rollins et al., 2012). To avoid confusion, it seems reasonable to assume that, for bat carcasses found beneath operating wind turbines, mortality was most likely the result of direct interaction with rotating turbine blades.

The investigation described in this report shows that SBWB was recorded at multiple sites across the study area at relatively low levels of activity compared to other species in the edge-space high-frequency foraging guild. Consequently, there is a possibility that SBWB could occasionally collide with operational turbines at SLWF. Potential mitigation measures to minimise direct impacts to SBW caused by collisions with turbines are discussed in Section 8.5.

From information provided by DEECA, via the SBWB Recovery Team, a total of 21 SBWB mortalities had been documented up to September 2023. While specific information about the majority of these mortalities has not been made publicly available, the following can be ascertained from records that are in the public domain:

- Moloney et al. (2019) reviewed bird and bat mortality data recorded during post-construction mortality surveys at 15 Victorian wind farms for the period 2003 to 2018. This dataset included nine wind farms within the geographic range of SBWB.
- Stark and Muir (2020) reviewed all detected bird and bat collisions from 10 wind farms for the period between 2014 and 2019. Nature Advisory understands five of these wind farms were within the geographic range of SBWB.
- Both reviews reported 8 SBWB mortalities from "less than three wind farms"; Nature Advisory presumes this means mortalities were recorded at two wind farms. Nature Advisory understands two of these mortalities occurred at McCarthur Wind Farm (see below), while the locations where the other six mortalities were detected have not been made public:

  - McCarthur Wind Farm (Wood, 2017) – 2 SBWB mortalities. This is a 140-turbine wind farm. The turbines have an 85 m hub height, 46.5 m blade length and minimum RSH of 23 m AGL.
- Since the mortalities that occurred up to 2018, one peer-reviewed study has documented SBWB mortalities at one Victorian wind farm:
  - Bennett et al. (2022) reported the results of carcass searches conducted from January to April in 2018 and 2019 at Cape Nelson North Wind Farm, a 23-turbine facility in south-west Victoria, 5 km south-west of Portland and approximately 10 km from Bats Ridge roost cave. A total of 3 SBWB carcasses were recorded during the study: two in 2018 and one in 2019. Turbines at this wind farm are located a few hundred metres from the coastline among vegetation in the Narrawong Coastal Reserve, adjacent to Yellow Rock Coastal Park. The turbines have an 80 m hub height, 56 m blade length and minimum RSH of 34 m AGL.
- Further to the publicly available records described above, Nature Advisory is anecdotally aware of one additional SBWB carcass found in Autumn 2020 at a wind farm in south-west Victoria (Rob Gration, pers. comm.). This mortality has not yet been made publicly available, so the wind farm will not be named here. Turbines at this wind farm have a minimum RSH of 24 m AGL.
- Eight mortalities were reported to DEECA between March to May 2023. Specific details have not yet been made publicly available. However, Nature Advisory understands that these eight SBWB mortalities were recorded at Salt Creek Wind Farm (minimum RSH of 24 m AGL) and Dundonnell Wind Farm (minimum RSH of 39 m AGL) (Planning Victoria, pers. comm.).

Nature Advisory is aware that, since information was provided by DEECA in September 2023, an additional 5 SBWB carcasses were discovered in Autumn 2024 at two wind farms in south-west Victoria. Information on these mortalities have not been made publicly available, so the wind farms will not be named here. Four of these SBWB mortalities occurred at a wind farm that has turbines with a minimum RSH of 24 m, while the other single mortality occurred at a wind farm with a minimum turbine RSH of 31 m AGL.

In summary, as of June 2024, Nature Advisory is aware of a total of 26 SBWB carcasses that have been detected at operational wind farms in Victoria.

Further to the mortality records describes above, post-commissioning mortality surveys have been conducted at several Victorian wind farms within the geographic range of SBWB, with the results made publicly available on each project's website. The findings from surveys that have been made publicly available are described below and summarised in Table 17.

The first year of mortality monitoring at Dundonnell Wind Farm (DWF) commenced in November 2020 and involved searches of 27 of 80 turbines. Each turbine was searched twice each month by scent detection dogs (Skylos Ecology), with an initial 120 m search followed by a 60 m pulse search two to three days later. A total of 61 bat carcasses were detected, consisting of four species. White-striped Free-tailed Bat was the most commonly recorded species (34 carcasses). No SBWB were detected at DWF (Biosis, 2022b) (Table 17). However, as mentioned in section 5.5.1, SBWB mortalities have since been reported at DWF.

Mortality monitoring at Mortons Lane Wind Farm (MLWF) was conducted monthly at all 13 turbines for the following periods: April – December 2015; May 2016 – April 2018; and April - June 2019.

Carcass searches were undertaken monthly by scent detection dogs (Elmoby Ecology) with a search radius of 120 m. A total of 47 bat carcasses were found, including five species. White-striped Free-tailed Bat was the most commonly recorded species (22 carcasses), followed by Gould's Wattled Bat (12 carcasses). No SBWB carcasses were recorded at MLWF (Biosis, 2019) (Table 17).

Oaklands Hill Wind Farm (OHWF) mortality monitoring was conducted from 2019 to 2021 at 16 of 32 turbines. Turbines were searched monthly by two humans (Australian Ecological Research Services) walking 12 m spaced transects over a 115 m radius search area from May to August. From September to April, 4 m transects of the inner zone (0-65 m from the base of the turbine tower) were undertaken weekly, and a search of the outer zone (65–115 m) was completed monthly with 12 m transects. A total of 10 bat carcasses were detected, consisting of two species. Gould's Wattled Bat was the most commonly detected species (seven carcasses), followed by White-striped Free-tailed Bat (three carcasses) (Wood, 2021) (Table 17).

Mortality monitoring at Salt Creek Wind Farm (SCWF) was conducted from 2018 to 2020 at all 15 turbines. Turbines were initially search monthly by two humans (Nature Advisory), using transects to cover the inner and outer zone of a 132-m radius search area. From April 2019, scent detection dogs were used (Nature Advisory and Elmoby Ecology). A total of 97 bat carcasses were detected at SCWF, consisting of seven species. White-striped Free-tailed Bat was the most commonly recorded species (46 carcasses), followed by Grey-headed Flying Fox (17 carcasses), and Gould's Wattled Bat (14 carcasses). No SBWB carcasses were recorded at SCWF (Biosis, 2020; Nature Advisory, 2020) (Table 17). However, as mentioned in section 5.5.1, SBWB mortalities have since been reported at SCWF.

8.4.2. Indirect

As outlined in The National Recovery Plan (Department of Environment, Land, Water and Planning, 2020), indirect impacts to SBWB caused by wind farm development and/or operation could include:

- Disturbance to maternity and non-maternity caves
- Removal or degradation of foraging habitats

The proposed SLWF is unlikely to have any indirect impacts to SBWB. No known roost caves are present within the study area (Section 6.1); therefore, no caves will be disturbed during construction or operational phases of the wind farm.

The study area has been extensively cleared and is currently used for agriculture, with 97.1% (647.19 ha) of the site comprised of open grazing paddocks with exotic pasture species used for cattle grazing. There is only one small, isolated patch of remnant eucalypt woodland (1.80 ha, 0.27%) present in the east of the study aera. Temporal activity patterns throughout the night observed during this two-year investigation suggest that SBWB are not roosting anywhere within the study area, including in the small patch of woodland. This patch of woodland will not be disturbed during construction or operational phases of the SLWF project. The closet proposed turbine (turbine 5) would be located approximated 700 m away from this woodland patch (Figure 3). Planted eucalypts present within linear strips along roadsides (5.33 ha) and windbreaks (1.80 ha) comprise a combined 1.1% of the site.

A small amount native vegetation would be removed during the construction phase of the project, including the removal of one mature *eucalyptus* tree from within the study area close to the proposed location of turbine 3. This vegetation removal is unlikely to have any impact on the SBWB global population.

8.4.3. Cumulative

Studies in the Northern Hemisphere have shown that impacts to bats caused by wind farms can be cumulative, particularly for migratory species (Arnett and Baerwald, 2013; Kunz et al., 2007). To address this, Moloney et al. (2019) and Stark and Muir (2020) estimated total mortalities using combined values for carcass counts, persistence rate, searcher efficiency, and turbine search percentage. However, due to the small number of SBWB carcasses detected, plus variable factors across sites where carcass searches were conducted, the resulting mortality estimates have very wide confidence intervals. Moloney et al. (2019) emphasise it is not possible to use carcass detections form one wind farm to accurately predict mortality rate at another wind farm without recorded collisions. Currently, there is currently no total collision estimate to quantify industry wide impacts to the global SBWB population.

Table 17: Bat mortality monitoring at selected operational wind farms within the geographic range of SBWB in Victoria

Wind Farm	Year	Total No. Turbines	No. Turbines Searched	No. Searches	Min RSH	Max RSH	Total Bat Mortality	No. Bat Species	SBWB	WSFT	GWB	Unidentified Bats	Data Source
Dundonnell	2020 - 2021	80	27	672	39	189	61	4	0	34	5	17	(Biosis, 2022b)
Mortons Lane	2015 - 2019	13	13	468			47	5	0	22	12	5	(Biosis, 2019)
Oaklands Hill	2019 - 2021	32	16	1296	36	124	10	2	0	3	7	0	(Wood, 2021)
Salt Creek	2018 - 2020	15	15	403	20	150	97	7	0	46	14	1	(Biosis, 2020; Nature Advisory, 2020)

Note: RSH = Rotor Swept Height, SBWB = Southern Bent-wing Bat, WSFT = White-striped Free-tailed Bat, GWB = Gould's Wattled Bat.

8.5. Yellow-bellied Sheath-tailed Bat

The YBSB is a wide-ranging species present through tropical and sub-tropical Australia. The species occurs in a wide range of habitats from wet and dry sclerophyll forests to open woodlands. It usually roosts in large tree hollows but sometimes uses buildings (Churchill, 2008; Menkhorst, 1995; NSW Office of Environment and Heritage, 2021).

There is no information on the number of YBSBs that are present in Victoria, but the species is considered to be a rare visitor to southern Australia, predominantly in late summer and autumn (NSW Office of Environment and Heritage, 2021). Many of the YBSBs recorded in Victoria have been found in exposed situations in an exhausted condition (e.g., hanging from the outside wall of buildings in broad daylight, or on fence posts in open paddocks), which might suggest that they have been unintentionally driven south by adverse wind conditions.

The YBSB is a large (mean body weight = 44 g), open-space adapted species that flies high and fast above the canopy, but has been observed flying lower over open spaces and at the forest edge (Churchill, 2008). The species has been recorded colliding with wind turbines further north in its range in NSW, where it is more abundant, indicating that it is vulnerable to turbine collision (Nature Advisory, unpublished data). Nature Advisory is not aware of any SBWB carcasses being recorded during mortality monitoring at operational wind farms in Victoria.

No YBSB calls were recorded during the four intensive seasonal bat detector surveys conducted in the study area over two consecutive years. The number of individuals that occur in Victoria are not known but the lack of calls recorded at SLWF, compared with other, more common bat species, indicates that the population in this part of Victorian is probably small and unlikely to represent a highly significant part of the overall global population.

Given that no YBSB calls were recorded, despite considerable survey effort, and that no mortalities have been reported at wind farms in Victoria to date, it is considered unlikely that the proposed SLWF will lead to regular mortality of this species. Therefore, a very low impact on the YBSB is predicted. Suggested mitigations measures designed to reduce risks to SBWB will also reduce risks to YBSB, see Section 9.

9. Mitigations and offsets

9.1. Turbine specifications

In the most recent annual update, The SBWBRT acknowledge that there could be a relationship between the physical characteristics of newer model turbines and collision risk to SBWB (Southern Bent-wing Bat National Recovery Team, 2022):

"Wind turbine characteristics continue to evolve. Newer proposed turbines are typically higher, with longer blades, and set higher off the ground. These features may alter mortality risk to SBWB however this has yet to be quantified."

Nature Advisory understands that the minimum RSH for the proposed turbine model at SLWF is 64 m AGL. This is significantly higher than most wind turbines currently installed in south-west Victoria and is higher than the minimum RSH of turbines where the majority of impacts on SBWB have been recorded. Nature Advisory understands that the minimum RSH of turbines at four of the wind farms where SBWB carcasses have been detected are 23 m, 24 m, 35 m and 39 m AGL (see Section 8.4.1). Given that information on all SBWB mortalities detected to date at operational wind farms have not been made publicly available, it is unknown if the minimum RSH range described above incorporates all turbines where mortalities have occurred.

Based on met mast surveys conducted at proposed and operational wind farms in Victoria, a minimum RSH of 64 m AGL will mean that turbines are above heights that SBWB typically fly at when foraging and commuting across the landscape.

Nature Advisory is currently undertaking analysis of existing monitoring data to investigate how turbine model specifications influence mortality rates for Australian bat species. Mortality data are being sourced from post-commissioning monitoring conducted at more than a dozen operational wind farms in Victoria, ACT and NSW. Permissions are currently being sought from wind farm operators regarding access to data and the results being made publicly available (with information about specific wind farms and turbine locations remaining anonymised). Preliminary results to date have revealed a trend whereby total bat mortality significantly decreases as minimum RSH increases above 40 m AGL. Further, as turbine blades are raised higher above the ground, the number of microbat species impacted decreases, with open-space adapted taxa accounting for most mortalities (Nature Advisory, unpub. data). These findings are similar to those reported from the Northern Hemisphere, where risk of colliding with turbines has been shown to correlate with wing morphology and echolocation frequency (characteristics that are used to group bats into foraging guilds) and the proportion of time that bats from different foraging guilds spend flying high above the canopy at RSA heights (Arnett et al., 2016; Roemer et al., 2019b, 2017).

9.2. Turbine-habitat buffers

It is well-established that, for most insectivorous bats, activity increases closer to important habitat features, such as treed areas and water bodies, and decreases further away from these habitats into more open areas with less tree cover. Consequently, placing turbines close to these important bat habitats is likely to increase the chance of bat-turbine interactions (Arnett et al., 2016).

There are currently no Australian State or Federal guidelines that prescribe appropriate buffer distances between turbine blade edges and habitat features that are important for insectivorous bats (e.g., treed areas and water bodies) to reduce collision risks to an acceptable level. Two different turbine-habitat buffer distances have been proposed in the Northern Hemisphere:

- United Kingdom - minimum 50 m from nearest habitat feature (trees, hedges) to blade-tips (Natural England, 2014)
- Europe – minimum 200 m from nearest habitat feature (woodland, tree lines, hedgerow networks, wetlands, waterbodies and watercourses) to blade-tips (Rodrigues et al., 2015).

Justification presented for the 50 m buffer distance is based on evidence that the activity of bats found in the UK tends to decline rapidly with increasing distance from linear landscape features and woodlands (Natural England, 2014). In comparison, the EUROBATS guidelines were designed for a region with much greater species diversity, including several migratory bats that fly very long distances across the landscape, including over open areas with minimal tree cover (Rodrigues et al., 2015).

Recently, DEECA has recommended that proposed Victorian wind farm developments within the geographic range of SBWB should adopt the EUROBATS 200 m turbine-habitat buffer for all turbines. Nature Advisory understands this recommendation is based on applying the precautionary principle, as opposed to empirical evidence that this specific turbine-habitat buffer distance is appropriate for wind farms located in southern Australia, or that its implementation has been proven to result in reduced impacts to bats. Nature Advisory is not aware of any published evidence that the EUROBATS 200 m turbine-habitat buffer has been effective at reducing impacts to bats at European wind farms (see Berthinussen et al., 2021).

Nature Advisory is not aware of DEECA recommending any proposed wind farms in Victoria adopt the 50-m turbine-habitat buffer distance prescribed by Natural England (2014).

The following section examines the evidence supporting the recommendation of the EUROBATS 200 m distance from turbine blade tips to important bat habitats and whether this recommended buffer distance is suitable to be applied to bats in Europe and beyond.

In 2008, UNEP/EUROBATS (The Agreement on the Conservation of Populations of European Bats) published its guidelines designed to minimize negative impacts on bats from wind farm projects (Rodrigues et al., 2008). The Guidelines recommend wind turbines be located no closer than 200 m from woodlands to avoid a high risk of bat fatalities. In 2014, the Guidelines were superseded by a revised version (Rodrigues et al., 2015) in which the 200 m buffer recommendation was maintained, being further supported by published studies, and this recommendation was explicitly expanded to other habitat features used by bats (woodlands, tree lines, hedgerow networks, wetlands, waterbodies, and watercourses). The updated guidelines (hereafter the Guidelines) are the most comprehensive transnational effort to protect bats, providing guidance to companies, consultants, scientists, and regulators in the wind farm industry.

The Guidelines cite a review (Dürr, 2007) and correlational study (Kelm et al., 2014) of wind turbines in Germany to support the inclusion of the 200 m buffer recommendation. The Dürr (2007) review reached the conclusion that a 150 m buffer plus rotor radius (approximately 190-200 m) could be sufficient to substantially reduce bat fatalities to an “accidental level”. This recommendation was supported by findings showing that microbat fatalities were most frequent around wind turbines closer to wooded edges. Bengsch (2006) (cited by Dürr, 2007) indicating that 90% of all bat fatalities occurred at turbines located less than 200 m from wooded edges. Similarly, Dürr & Bach (2004) found that *Pipistrellus* spp. bats were mainly found at turbines located close to wooded areas (mean distance = 50 m), but *Nyctalus noctula* bats were mainly found at wind turbines at a mean distance of 200 m from those areas. The Kelm et al. (2014) study investigated the correlation between echolocation recordings (as a proxy for bat activity) and distance to hedgerows (intervals between 0-200 m) in an agricultural landscape. They found that bat activity was greater at hedges (68%), decreasing further away from hedges to only 8% at 100 m and 7% at 200 m. Based solely on these limited cited sources, for most species of bats, the proposed buffer distance in the Guidelines appears conservative.

Since the Guidelines were published, several studies have shown that risk of bats colliding with wind turbines can increase closer to habitat features. For example, a study conducted in France and Belgium by Roemer et al. (2019a) found that bat densities were generally higher closer to woodland, estimating that at 200 m, bat density decreases by 77% compared to distances a few meters from trees. This pattern of bat densities is consistent with fatality data from wind farms. For example, two studies found higher mortality rates for European bats in forested areas compared to open landscapes (Rydell et al., 2010; Santos et al., 2013). The pattern of high estimated mortality rates at wind farms located in forested habitats has also been reported in other continents. Arnett et al. (2008) showed that wind farms situated in forested habitats in North America exhibited a higher estimated mortality rates when compared to those located in open landscapes. Despite the available evidence indicating a greater risk to bat assemblages near habitat features, the Guideline's recommended 200 m buffer has not been effectively implemented in many European countries (e.g., UK, Germany, and France (Barré et al., 2022)).

The 200 m buffer guideline for wind turbines aims to protect entire bat assemblages, albeit the effectiveness of its implementation may vary substantially between species (Schöll and Nopp-Mayr, 2021). For instance, some species can have higher activity patterns closer to hedgerows than others (Kelm et al., 2014; Leroux et al., 2022). Bat activity patterns can also vary by species depending on the type of wooded edge. In Germany, some species (e.g., *Pipistrellus nathusii*, *Pipistrellus pipistrellus*) may be more attracted to forest edges than to agricultural hedgerows (Heim et al., 2018). Thus, differences in habitat selection by bats may partly explain why some species seem to be more common further from some types of wooded edges. Some bat species can even show seasonal variation in activity patterns, for example, *Nyctalus noctula* and *P. nathusii* (unlike other *Pipistrellus* and *Myotis* spp.) show increased activity away from hedgerows in summer. Moreover, *N. noctula* activity during summer was constant across a 0-200 m distance gradient from hedgerows (Kelm et al., 2014). Species-specific activity patterns can also influence the number of fatalities for a given species; for example, Dürr & Bach (2004) found more *Pipistrellus* spp. carcasses around turbines closer to wooded edges while the opposite was found for *N. noctula*. In contrast to the identification of such fatality patterns, our understanding of the causes of species-specific variation in relation to distance from habitat features remains poor.

The application of a wind turbine buffer to habitat features may not have the desired effect on protecting some species of bats from collisions. For example, a study by Roemer et al. (2019a) conducted in northwestern Europe showed that activity by *Nyctalus* bats (typically a high-flying species when in open landscapes) was not correlated with distance between wind turbines and woodland (approximately 0-1100 m gradient). In another study conducted at a wind farm in Texas, Bennett & Hale (2018) found no relationship between distance to habitat features (including wooded edges as resources for foraging and roosting) and fatalities for migratory bats. In this study, up to 33% of those fatalities occurred at turbines with no known habitat features within 200 m of the turbines. Indeed, some migratory bats like *Tadarida brasiliensis* are considered vulnerable to wind turbine collision, irrespective of wind turbine distance from wooded edges. This species is known to use open agricultural areas for foraging where it serves as a pest controller (Cleveland et al., 2006). Across North America, around 80% of the fatalities linked to wind farms are specifically attributed to tree-roosting, migratory bats (Arnett and Baerwald, 2013). These patterns suggest that some species, in particular migratory ones (Thaxter et al., 2017), can be more susceptible to collisions with wind turbines independent of distance to wooded vegetation or other habitat features. However, this is not consistent across the world (reviewed in Barclay et al. 2017). An emerging hypothesis focusses on a more proximate cause, namely that the bat species most likely to be killed by turbines are those that fly and feed in less cluttered more open spaces, irrespective of location, habitat, migration, or roost preferences (Arnett et al., 2016).

There is consensus that when wind turbines are situated near certain habitat features, this can result in greater numbers of fatalities for numerous bat species (Arnett et al., 2016). What is less understood is how habitat loss and modification effects bat activity in relation to distance from operational wind turbines. It has been hypothesised that turbines may attract some bat species in several ways. First, bats may be attracted to wind turbines because of turbine noise or movement. Second, bats may mistake wind turbines for large, scattered trees and fly upwards to investigate. Third, turbines may attract insects, which could in turn attract insectivorous bats (Barclay et al., 2017). However, some studies suggest that turbines near habitat features could have the opposite effect on some bat species, by repelling them. A study conducted in agricultural landscapes in northwest France found that for most species, bat activity at hedgerows decreased with distance from wind turbines (0-1000 m) (Barré et al., 2018). A stronger effect of turbine distance on bat activity was found in slow-flying, clutter-adapted gleaning bats, which reduced their activity within 1000 m of turbines by around 54% (Barré et al., 2018). In another study conducted in the same region, the authors concluded that wind turbines close to hedgerows were avoided by bats, but those turbines located farther away in open areas could attract some species (Leroux et al., 2022). The authors showed that activity patterns for most bat species decreased at hedgerows when turbines were located nearby (within 10-43 m), but no effects were detected when turbines were located at 100 m or further (0-283 m gradient) (Leroux et al., 2022). It seems these effects have not been considered, at least not explicitly, by the the Guidelines.

Several studies from outside of Europe and the UK do not seem to have been considered during the development of the Guidelines. Johnson et al. (2004) did not find a significant relationship between the number of bat fatalities and distance to the nearest wetland or a range of habitat types within 100 m of turbines at wind farms in Minnesota. Grodsky (2010) found that bat fatalities were lower near the Horicon Marsh in Wisconsin. And in Australia, Hull and Cawthen (2012) found no relationships between bat fatalities and distance from turbines to vegetation. These three studies show that correlating high-risk locations with particular habitat types or topographic patterns has proven difficult and inconsistent (Arnett et al., 2016).

Based on the available literature, it is advisable to regard the 200 m buffer recommendation in the Guidelines as merely approximate, with this prescribed distance between turbine blade tips and bat habitats not yet supported by a convincing body of evidence in Europe, and with little or no evidence from other continents. Notably, there is virtually no literature on this subject in Australia. It is therefore critical that research is conducted in Australia to guide the development and implementation of evidence-based turbine-habitat buffers that effectively mitigate the negative impacts of wind farms on bats.

9.2.1. SLWF turbine-habitat buffers

Buffer distances for SLWF are somewhat uncertain given that a final decision on the specific turbine model has not been made. Presuming that the turbines will have a hub height of 150 m and blade length of 86 m (minimum RSH of 64 m AGL), using the method to calculate the distance from the edge of the RSA to the edge of the nearest habitat feature (presuming that was a 30-m tall tree) described by Natural England (2014), the following buffer distances would be required to comply with the two Northern Hemisphere recommendations:

- 64 m from the base of the turbine to the nearest habitat edge for the Natural England (2014) 50-m buffer from RSA edge to habitat edge.
- 260 m from the base of the turbine to the nearest habitat edge for the EUROBATS (2015) 200-m buffer from RSA edge to habitat edge.

The formula used to calculate these turbine-habitat buffer distances is (Natural England, 2014, page 2):

$$b = \sqrt{(c + bl)^2 - (hh - fh)^2}$$

Where:

b = distance from the base of the turbine tower to the edge of the habitat feature.

c = prescribed buffer distance from the blade tip to the edge of the habitat feature.

bl = blade length

hh = hub height.

fh = feature height (in m) (see Figure 24).

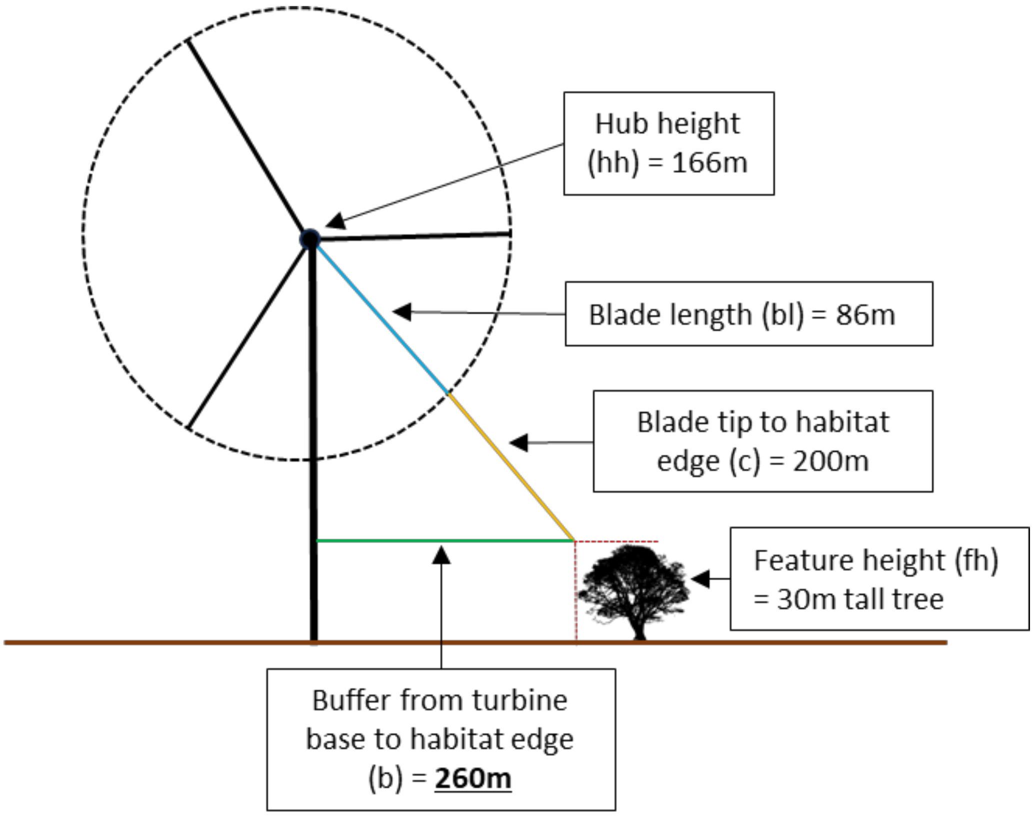


Figure 24: Schematic showing 260 m turbine-habitat buffer

Note – this diagram is not to scale.

The 260 m buffer required to achieve 200 m separation from blade tips to habitat edges includes a contingency because the majority of trees present across the SLWF study area are significantly less than 30 m tall, i.e. the distance from blade tips to the habitat features that are less than 30 m would be greater than 260 m.

Design response

Nature Advisory understands that the wind turbine layout of the proposed SLWF has been through three revisions. The first revision consisted of seven wind turbines, two of which were in close proximity to the two Blue Gum plantations located adjacent to the subject site, one of which was located within 260 m of a farm dam, and all of which were located within 260 m of planted windbreaks. The second revision consisted of six wind turbines, two of which were within 260 m of the two Blue Gum plantations located adjacent to the site, one of which was located within 260 m of a farm dam, and four of which were located within 260 m of planted windbreaks. The third, and current, revision of the wind turbine layout consists of five wind turbines, one of which is located within 260 m of a Blue Gum plantation and three of which are located within 260 m of planted windbreaks (Figure 25).

With each revision, all reasonable attempts have been made to place wind turbines further than 260 m from potential SBWB habitat, with a hierarchy of habitat types adopted according to which waterbodies were the highest priority, Blue Gum plantations the next most important habitat type, and planted windbreaks the lowest priority. It is for this reason that, of the final turbine locations selected, one encroaches within 260 m of a Blue Gum plantation, while three encroach within 260 m of planted windbreaks.

The proportion of habitat features present within the SLWF study are shown in Table 18. Open paddocks comprise 97.1% of the total study area. Wooded areas comprise only 2.7% and farm dams the remaining 0.2% of the total area. Despite the small amount of treed habitat present across the extensively cleared study area, it was simply not possible to locate all five wind turbines further than 260 m from habitat edges (particularly planted windbreaks) while also complying with other, similarly important, regulatory requirements pertaining to potential amenity impacts, in particular shadow flicker and noise emissions, plus maintaining turbine separation distances required for optimal power generation.

The difficulty in applying the EUROBATS 200 m buffer for turbines at the proposed SLWF, where treed habitats that require buffering comprise only 2.7% of the total area within the development site, highlights the logistical difficulty in implanting this recommendation in real-world scenarios. This is likely to be a factor contributing to the EUROBATS recommended turbine-habitat buffers only being adopted at 56%, 61% and 78% of large wind facilities in France, the UK and Germany, respectively (Barré et al., 2022). This low level of implementation has occurred despite 37 countries ratifying the agreement, which has been in place since 1994, with the 200 m buffer becoming an official recommendation in 2008 (Barré et al., 2022).

Modelling conducted using bat call data collected during in this investigation shows that there was no difference in SBWB activity (definite and complex calls combined) between sites located 150 m to 200 m from planted eucalypt windbreaks (Figure 15). This suggests that a buffer of 150 m from blade tips to the edge of eucalypt windbreaks would be appropriate to reduce risks to SBWB. However, even if this smaller buffer distance of 150 m was applied, turbines 3, 4 and 5 would still have small amounts of planted windbreaks within the buffer zones.

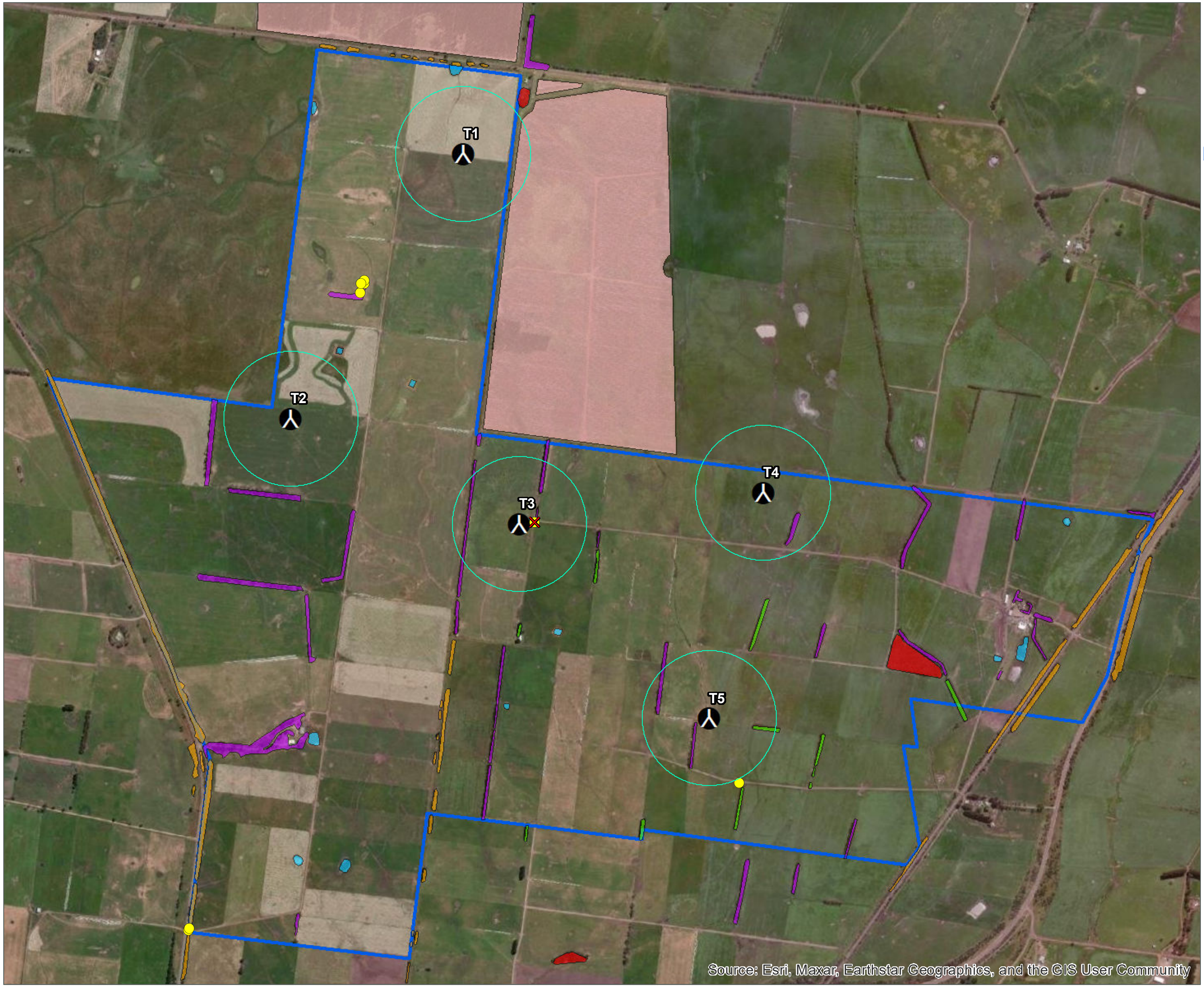
As it is not possible to comply with the ERUOBATS guidelines and place all turbines 260 m away from planted eucalypt and pine trees, the Proponent is investigating the option to remove any sections of planted windbreaks that are within the 260-m radius buffer zones for turbines 3, 4 and 5. To compensate, the Proponent is proposing to replace any trees removed by planting eucalypt windbreaks at a ratio of 2:1 (windbreaks removed : windbreaks replanted) at locations in the study area that are not within turbine-habitat buffer zones. Any plans to remove and replant windbreaks would be conducted via consultation and collaboration between the Proponent and relevant land owners.

Table 18: Amount of habitat features present (area in ha, and % of total buffer area)

		Amount of habitat within each 260-m radius turbine buffer zone				
Habitat	Entire study area	1	2	3	4	5
Open paddock	647.19 (97.1%)	19.30 (90.9%)	21.24 (100%)	20.65 (97.3%)	21.03 (99.0%)	20.71 (97.5%)
Eucalypt windbreak	9.90 (1.5%)	0	0	0.55 (2.6%)	0.21 (1.0%)	0.40 (1.9%)
Roadside vegetation	5.33 (0.8%)	0.80 (3.8%)	0	0	0	0
Pine windbreak	1.23 (0.2%)	0	0	0	0	0.12 (0.6%)
Blue Gum Forestry plantation	0	1.14 (5.4%)	0	0	0	0
Remnant eucalypt woodland	1.80 (0.3%)	0	0	0	0	0
Farm dam	1.31 (0.2%)	0	0	0.04 (0.2%)	0	0

Figure 25: Turbine buffers

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 8/03/2024



Study area
Wind turbine
Turbine buffer (260m radius)

Habitat

Eucalypt windbreak
Farm dam
Forestry plantation
Pine windbreak
Remnant native woodland
Roadside vegetation
Scattered tree (EHP)
Scattered tree to be removed

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Figure 25a: Turbine buffers - T1

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Client: ReFuture Pty Ltd
Date: 8/03/2024

Study area
Wind turbine
Turbine buffer (260m radius)

Habitat

Forestry plantation
Remnant native woodland

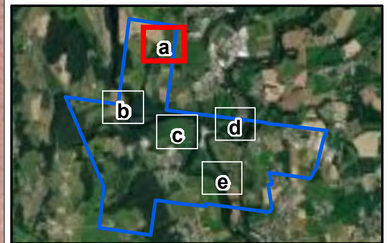

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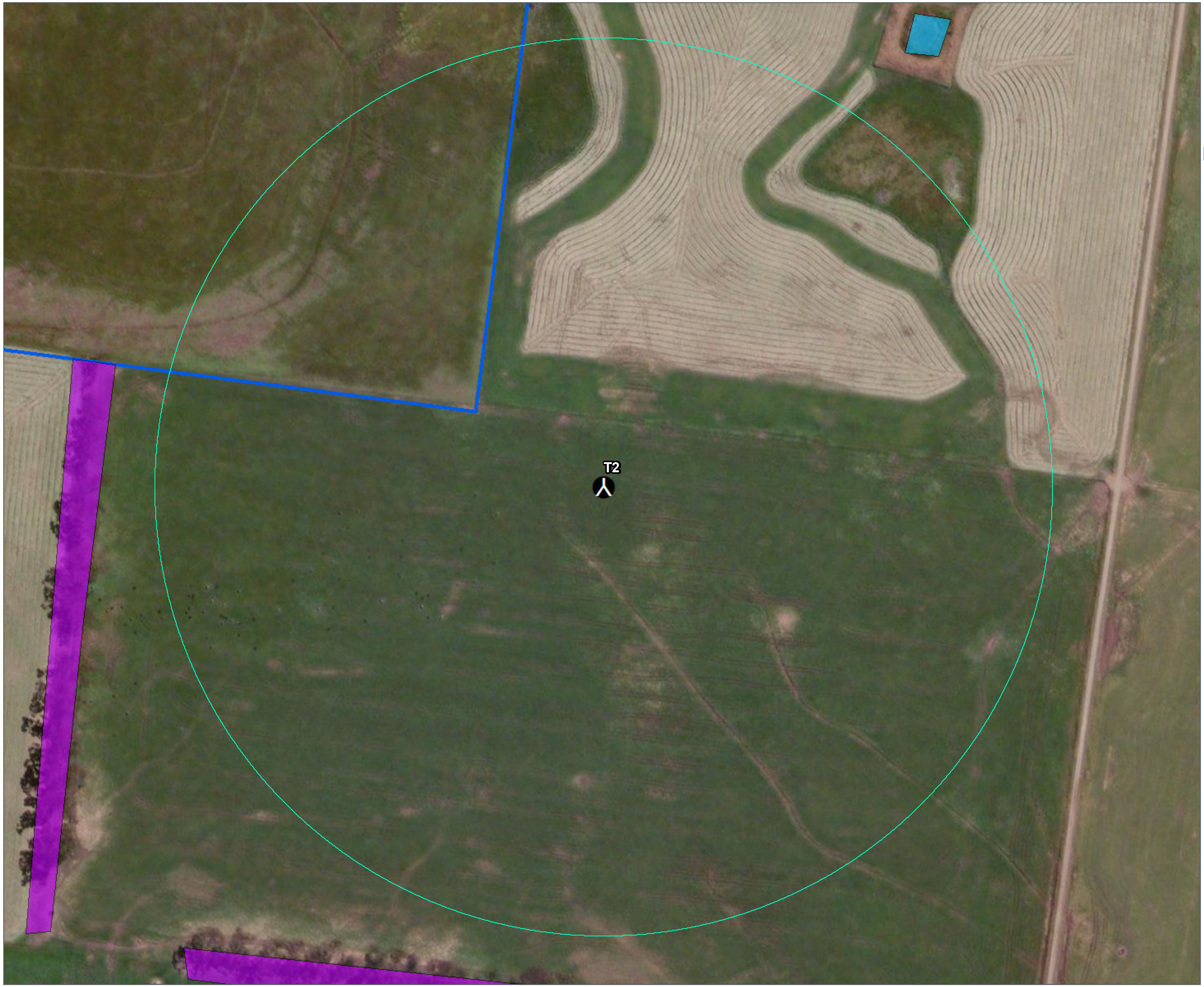
Figure 25b: Turbine buffers - T2

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 8/03/2024



Study area
Wind turbine
Turbine buffer (260m radius)

Habitat

Eucalypt windbreak
Farm dam

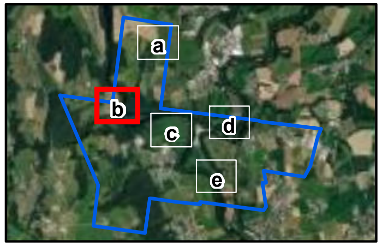


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Figure 25c: Turbine buffers - T3

Project: Swansons Lane Wind Farm
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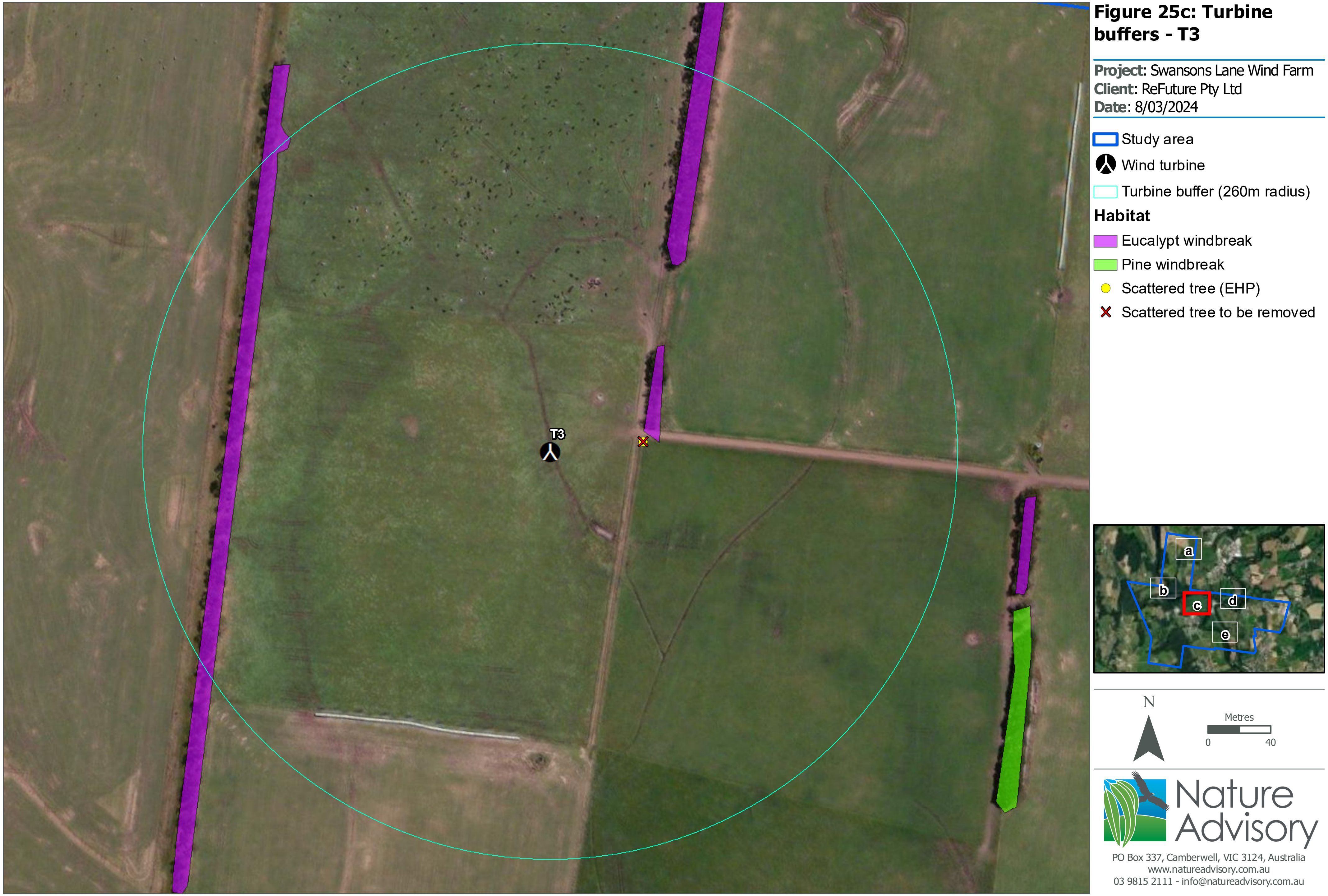
Date: 8/03/2024



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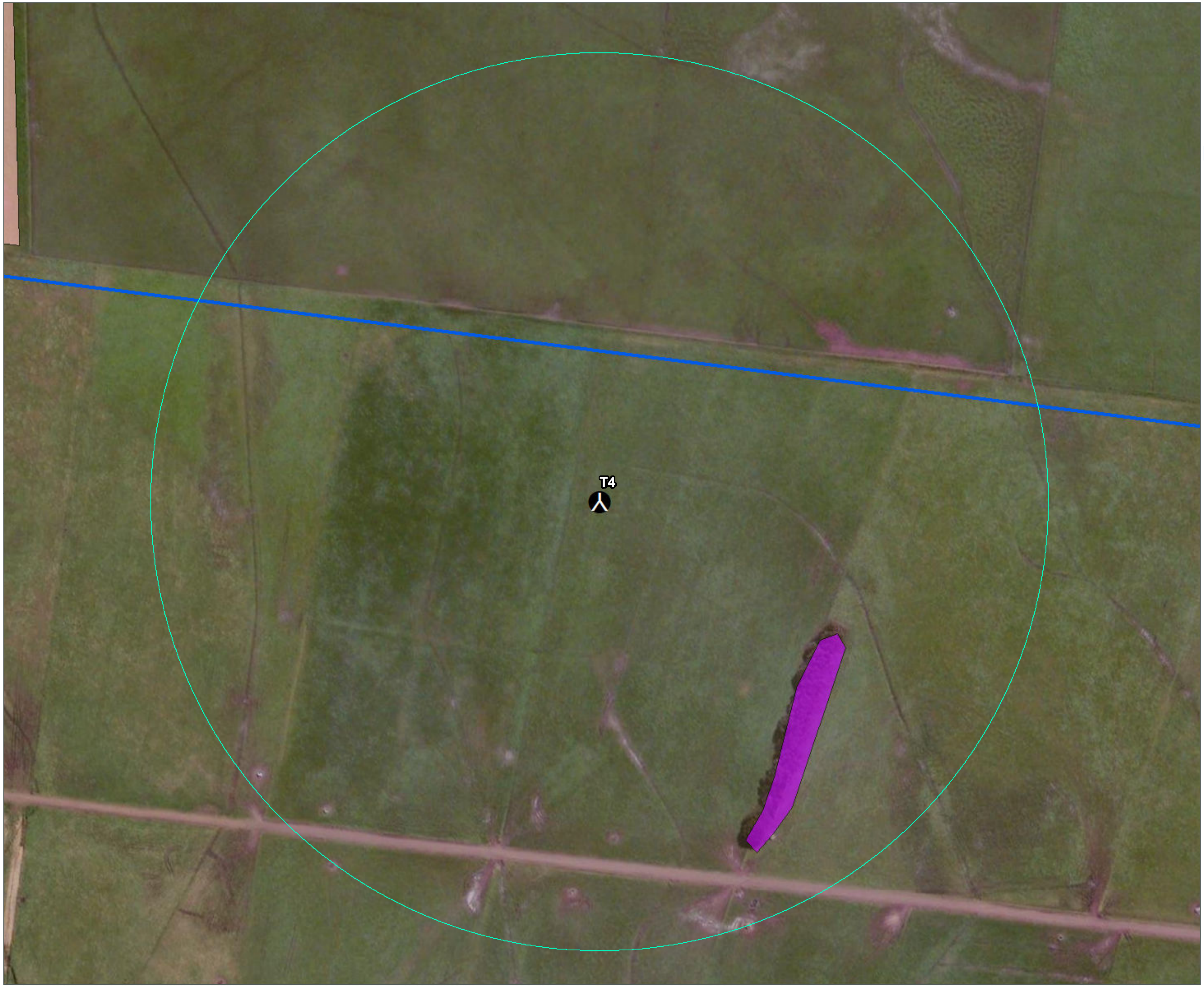

Figure 25d: Turbine buffers - T4

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 8/03/2024

Study area
Wind turbine
Turbine buffer (260m

Habitat

Eucalypt windbreak
Forestry plantation

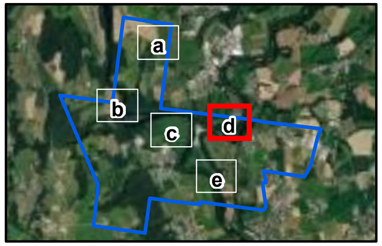

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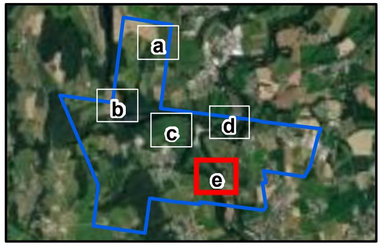
Figure 25e: Turbine buffers - T5

Project: Swansons Lane Wind Farm
Client: ReFuture Pty Ltd
Date: 8/03/2024

Study area
Wind turbine
Turbine buffer (260m radius)

Habitat

Eucalypt windbreak
Pine windbreak
Scattered tree (EHP)



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9.3. Active deterrent options

9.3.1. Technologies in development or testing

Potential methods for deterring bats from airspace within turbine RSAs include light, radar and sound (Werber et al., 2023). Most technologies in the active deterrent space appear to be in early testing phases, with limited evidence of efficacy when implemented at-scale at operational wind facilities. Consequently, while there are some promising developments, the majority of these technologies are not yet commercially available as off-the-shelf products ready for use at operational wind farms. These include:

- Electromagnetic radiation produced by marine radar as a deterrent (Gilmour et al., 2020).
- Using drones to disturb wildlife (Kuhlmann et al., 2022; Werber et al., 2023).
- Creating ultrasonic noise by ejecting compressed air from nozzles as a supersonic jet (Romano et al., 2019).
- Attaching passive ultrasonic whistle directly onto turbine blades (Zeng and Sharma, 2023).
- Attaching miniaturised speakers directly onto turbine blades (Cooper et al., 2020).
- Visual deterrents, such as dim ultraviolet light (Gorresen et al., 2015).
- Automated monitoring systems incorporating thermal video, radar and/or echolocation to trigger short-term curtailment when target species are detected approaching a turbine (McClure et al., 2021; Rabie et al., 2022).

The mitigation technologies that have been tested to date, but are not yet commercially available as off-the-shelf products, are briefly summarised in Appendix 4.

Two mitigation methods that have been tested at operational wind farms and have shown some level of effectiveness are discussed below in Sections 9.3.2 and 9.3.3.

9.3.2. Low wind-speed turbine curtailment

Low wind-speed curtailment is an approach to mitigate bat mortality at wind farms that involves modifying nighttime turbine operations during periods of elevated risk to bats (Arnett et al., 2011). This is achieved by adjusting turbine blade orientation to align with the wind (known as feathering) and increasing the cut-in speed of the turbines. Feathering involves rotating the blades parallel to the wind to reduce the amount of wind they catch and therefore slow or stop rotation. Increasing the cut-in speed above the manufacturer's specified speed, which is the wind speed at which electricity generation begins, stops blades rotating until a designated, higher wind-speed occurs. Increasing turbine cut-in speed can reduce bat fatalities because bats tend to be less active at higher wind speeds (Arnett et al., 2011; Baerwald et al., 2009).

The effectiveness of nighttime low wind-speed curtailment in significantly reducing mortality among insectivorous bats is recognised on a global scale (Arnett et al., 2016; Lloyd et al., 2023; Whitby et al., 2021). Results from a meta-analysis of bat fatalities at wind energy facilities in the United States showed that, for every 1.0 m/second increase in nighttime cut-in speed, total bat fatalities were reduced by approximately 33% (Whitby et al., 2021).

Only one study has investigated the effectiveness of nighttime low wind-speed curtailment in reducing bat impacts at an operational wind farm in Australia. The study by Bennett et al. (2022) was undertaken in response to SBWB mortalities resulting from collisions with turbines at Cape Nelson North Wind Farm, near Portland, Victoria. Bennett et al. (2022) experimented with implementing seasonal and nightly turbine curtailment during periods of low wind speeds. Turbines were set to start operating at wind speeds of 4.5 m/second, which was a 1.5 m/second increase from the manufacturer's default cut-in speed of 3.0 m/ second. This adjustment resulted in a 54% decrease in overall bat mortality. The potential loss in total annual energy generation as a result of applying the increased cut-in speed was estimated to be 0.16%, accompanied by a revenue loss of 0.09% (Bennett et al., 2022). It is noted that these wind turbines have a minimum RSH of 34 metres AGL and are located on the coast approximately 10 km from the maternity cave near Portland.

9.3.3. Acoustic deterrents

Anthropogenic noise is known to reduce bat activity, for example as a result of traffic noise generated by major road networks (Bhardwaj et al., 2021). Ultrasonic acoustic deterrent systems have been proposed as a method to reduce activity of echolocating bats to mediate bat-human conflicts (Zeale et al., 2016), including close to wind turbines. These systems generate ultrasonic sound within the frequency range used by bats that is designed to mask returning echoes from the bat's echolocation signal, forcing them to leave the airspace (Arnett et al., 2013). Several methods for producing the required sound have been tested, including ultrasonic speakers (Szewczak and Arnett, 2007), pumping compressed air through nozzles (Kinzie and Miller, 2018; Romano et al., 2019), and attaching passive whistles directly to turbine blades (Sievert et al., 2021).

From investigations Nature Advisory has made into these technologies, custom-made electronic systems that transmit a signal through ultrasonic speakers are the only acoustic deterrent systems currently available as off-the-shelf products that have been field-tested at operational wind farms. For example, NRG Systems Bat Deterrent System, which emits a signal that spans the frequency range 30-50 kHz at a SPL of 120 dB at 1-m, has been tested at three operational wind farms in the USA.

Results from initial trials described by Schirmacher et al. (2020) combining curtailment and acoustic deterrents were mixed, with a range of technological issues experienced that limited the system's capacity. The findings from this study represent an initial beta-test of the NRG acoustic deterrent system in a real-world scenario. Technical problems experienced informed changes made to the system prior to deployment in subsequent field studies, described below.

Weaver et al. (2020) tested acoustic deterrents on 16 turbines at a wind farm in Texas, USA. On each turbine, they attached five or six speakers to the nacelle (4 on the top and 2 on the bottom). From 31 July to 30 October 2017 and 2018, 8 turbines were randomly assigned to the control (i.e. deterrents off) and 8 to the treatment (i.e. deterrents on) groups, so that each turbine was both a control and treatment turbine during the study. Carcass searches were conducted daily at all 16 turbines. The results showed deterrents significantly reduced bat fatalities for Hoary Bats (*Lasiurus cinereus*) and Mexcian Free-tailed Bats (*Tadarida brasiliensis*) by 78% and 54%, respectively. But no significant reduction in fatalities was recorded for other species in the genus *Lasiurius*. Thus, deterrents represent a potential impact reduction strategy for some but not all bat species (Weaver et al., 2020).

Good et al. (2022) tested the effectiveness of combining curtailment (increasing low wind-speed cut-in to 5 m/second) with acoustic deterrents at two wind farms in Illinois, USA. From 1 August to 15 October 2018, acoustic deterrents were attached to the nacelle of 15 turbines, each system comprised 8 sound projection units that were oriented to face toward the RSA. Carcass searches were conducted daily at 10 control turbines, and weekly at 5 control and all 15 treatment turbines at one wind farm. All control and treatment turbines were searched weekly at the second wind farm. Overall bat fatality rates were 66.9% lower at curtailed turbines with acoustic deterrents compared to turbines that operated at manufacturer cut-in speed. Curtailment and the deterrent reduced bat mortality to varying degrees between species, ranging from 58.1% for Eastern Red Bats (*Lasiurus borealis*) to 94.4% for Big Brown Bats (*Eptesicus fuscus*). Hoary Bat and Silver-haired Bat (*Lasionycteris noctivagans*) mortality was reduced by 71.4% and 71.6%, respectively (Good et al., 2022).

An important consideration for proponents considering testing these systems in Australia is that, because ultrasonic signals produced by acoustic deterrents are subject to the same sound attenuation as bat echolocation calls, it is not possible for nacelle or tower-mounted deterrents to generate ultrasound at all frequencies at the required volume to fill the entire RSA (Arnett et al., 2013; Good et al., 2022). Because of atmospheric and geometric attenuation, the effective range of the signal produced by a deterrent system will be shorter for higher frequencies compared to lower frequencies. This means bats with lower-frequency calls are likely to detect the deterrent signal from a greater distance than higher-frequency calling species (Weaver et al., 2020). Whereas, high-frequency calling species flying at RSA height may not perceive the deterrent signal until they are already too close to evade blades that are rotating at lethal speeds. However, for high-frequency bats flying closer to the ground that encounter a turbine tower and fly upwards to investigate (Cryan et al., 2014; Cryan, 2008; Rydell et al., 2010), the signal produced by acoustic deterrents mounted on the tower could be effectively detected by the bats before they reach the edge of the RSA, allowing them time to leave the area and avoid the potential impact zone.

The findings presented by Weaver et al. (2020) and Good et al. (2022) provide promising evidence that ultrasonic acoustics deterrents can reduce bat collisions, but the effectiveness appears to be species-specific. While this technology has the potential to play a role in impact reduction for at least some bats species, its efficacy for reducing impacts to Australian bats needs to be systemically tested. Therefore, if the Proponent was interested in investigating the potential of incorporating ultrasonic acoustic deterrents as a mitigation measure at SLWF, it would be necessary to conduct a systematic investigation to empirically test their effectiveness. Given comments provided previously by DEECA on the efficacy of ultrasonic acoustic deterrents, Nature Advisory expects that evidence in the form a peer-reviewed study would be required before the regulator would consider ultrasonic acoustic deterrents as an effective mitigation measure that could reduce the risk of bat collisions at Victorian wind farms.

9.4. Recommended mitigation strategy

A Bat and Avifauna Management Plan (BAMP) will be developed for SLWF to *provide an overall strategy for managing and mitigating any significant bird and bat strikes arising from operations of the wind energy facility*. The BAMP will be developed in consultation with DEECA prior to commencement of construction to facilitate a consultation period where suggested changes can be considered.

Specifically in relation to this investigation, the objective of the BAMP will be to ensure that operation of the SLWF will not negatively influence the survival of populations of bat species of conservation concern, namely:

- *Southern Bent-wing Bat;*
- *Yellow-bellied Sheath-tailed Bat.*

These objectives will be achieved by establishing monitoring and management protocols, consistent with the methods described by the Australian Wind Energy Association (Brett Lane & Associates, 2005) and endorsed in the Clean Energy Council's Best Practice Guidelines (2018).

The BAMP will be adaptive so that management measures can be amended based on monitoring results to ensure more effective management and mitigation are implemented in response to the site-specific findings generated by the monitoring.

9.4.1. Recommended mitigation measures

Turbine specifications – The final turbine model to be installed at SLWF has not yet been selected. Nature advisory understands that, of the options being considered, the lowest RSH would be 64 m AGL. The specific physical characteristics of the turbines installed at SLWF will be governed by engineering considerations relating to optimising energy production. As such, turbine selection is therefore not a mitigation measure chosen specifically to reduce risks to bats. However, available evidence on bat flight heights, derived from wing morphology and echolocation frequency, plus activity levels recorded during at-height bat detector surveys, along with mortality records from carcass searches conducted at operational wind farms, suggests that increasing the minimum RSH to 64 m AGL will significantly reduce collision risk for SBWB.

In comparison, YBSB a high-flying, open-space adapted species that is likely to fly within the RSA of the proposed turbines at SLWF; consequently, raising minimum RSH to the maximum level possible may reduce overall risks but is unlikely to be effective in eliminating YBSB collisions. Evidence presented in this investigation suggests YBSB are not common in the study area, with no call activity recorded over two consecutive years. Consequently, YBSB collisions are considered unlikely to occur at SLWF.

Acoustic deterrents – Peer-reviewed studies in the Northern Hemisphere provide promising preliminary evidence that acoustic deterrents could contribute to reducing bat collisions at wind farms, particularly when paired with targeted operational curtailment (Good et al., 2022; Weaver et al., 2020). It is recommended to conduct a trial during the two-year post-commissioning period to test the effectiveness of ultrasonic acoustic deterrents in reducing bat collisions.

Nature Advisory is currently investigating commercially available acoustic deterrent systems designed to be installed on current-model wind turbines. From conversations with acoustic deterrent manufacturers, Nature Advisory understands it should be possible to design a custom-made system that generates an ultrasonic deterrent envelope (20-50 kHz) that spans the bottom half of the RSA of the turbines proposed for SLWF, i.e. from edge of the blade tips (minimum of 64 m AGL) to the nacelle (~150 m AGL). While this would not deter bats from the entire RSA, it should cover the volume of airspace where most SBWB activity is likely to occur (see Sections 5.4 and 8.3). This deterrent system configuration could also reduce impacts to other bat species flying within this volume of airspace, or to lower-flying species that fly upward to investigate a turbine when they encounter a tower (Cryan et al., 2014; Cryan, 2008; Rydell et al., 2010).

The specific acoustic deterrents to be used, and the experimental design employed to test efficacy of the system, would be determined during development of the BAMP.

Increasing low-wind-speed cut-in – It is recommended to consider the increase nighttime low wind-speed cut-in for all turbines to a minimum of 4.5 m/second during periods when SBWB are most actively moving across the landscape; this represents consideration of a 1.5 m/second increase from the manufacturer's minimum cut-in speed of 3.0 m/second. Advice would need to be sought from DEECA and the SBWB Recovery Team, but Nature Advisory understands these periods would likely include:

- Spring (September to November)
- Autumn (March to May)

It would also be important to consideration of the feathering (i.e., with blades oriented parallel to the wind) of rotor blades when nighttime wind speed is below 4.5 m/second to minimise blade rotation speed until the minimum cut-in speed is detected (e.g., to maintain maximum rotation speed to one rotation per minute (Barré et al., 2023).

Mortality monitoring would be a critical component of the BAMP to empirically assess the effectiveness of increasing low-wind speed cut-in at SLWF. The specific details of the mortality monitoring regime would be described in the BAMP, but the following components are likely to need to be considered:

- Mortality surveys conducted monthly with conservation scent dogs at all five turbines.
- Intensive scent dog surveys (e.g., two surveys per week over 2-4 weeks) at all five turbines during periods of peak SBWB activity.

The frequency, timing and duration of intensive targeted scent dog surveys would need to be determine in consultation with DEECA, with advice sought from the SBWB Recovery Team as to exactly when peak activity periods of SBWB are likely to occur in the study area.

It will also be necessary to conduct bat detector surveys during the two-year post-commissioning period to generate further data on temporal activity patterns of SBWB and YBSB in the study area. Paired bat detectors should be placed at ground-level and on turbine nacelles. Given the small size of the proposed SLWF, it should be possible to conduct bat detector surveys at all five operational turbines. As for the scent dog surveys, consultation with DEECA and the SBWB Recovery Team would be required to determine the frequency, timing and duration of the bat detector surveys.

A critical component of the post-commissioning bat detector surveys would be to use weather data recorded at ground-level and nacelle to test how variation in a range of environmental factors, such as wind speed, air temperature and rainfall, influence bat activity. A two-year survey period combining site-specific information on weather conditions, bat echolocation call activity and bat mortalities could generate sufficient data to inform the development of a "smart curtailment algorithm" for SLWF. Research in the Northern Hemisphere has shown smart curtailment algorithms that make predictions about the level of risk to bats at wind energy facilities under various environmental conditions, and then use this information to guide curtailment decisions, have great potential in reducing bat fatalities while also reducing energy loss when compared to employing blanket turbine curtailment (Barré et al., 2023; Behr et al., 2017; Hayes et al., 2023, 2019).

Another critical component of the BAMP would be defining trigger events (e.g., SBWB or YBSB mortalities) and prescribing mitigation actions (e.g., stepped increases in nighttime cut-in speed) and monitoring protocols to be implemented if impacts are detected. As above, triggers, mitigation measures and intensive monitoring designed to assess the effectiveness of these management actions under an adaptive management framework would be described in detail in the BAMP, following consultation with DEECA.

9.5. Offset fund

The Recovery Plan discusses the need for offsets to be incorporated into long-term planning for conserving the global SBWB population. The potential for financial contributions from the wind industry toward an offset fund are described as follows (Department of Environment, Land, Water and Planning, 2020):

"Offset requirements from wind farm developments may have positive benefits to local communities or landholders if funding was provided to implement on-ground management actions, such as cleaning rubbish out of caves."

Further, Section 6.2 of the Recovery Plan states that (Department of Environment, Land, Water and Planning, 2020):

"Develop a site-specific register of projects related to on-ground habitat management on both public and private land, and research/monitoring requirements for the Southern Bent-wing Bat. Prioritise the projects to direct funding to the most urgent tasks. The register could also be used to respond to requests for potential offsets resulting from wind farm developments."

The Conservation Advice also outlines several priority conservations and management actions that could potentially be funded by contributions from wind farm proponents under an offset agreement (Threatened Species Scientific Committee, 2021):

- *Implement management actions to increase the condition and extent of foraging habitat, especially within foraging range of key roosting sites.*
- *Establish conservation covenants or management agreements on private land containing important roost or foraging sites.*
- *Investigate and trial options for restoring caves previously used by the Southern Bent-wing Bat but rendered unsuitable due to guano mining or other anthropogenic activities.*

Nature Advisory suggests that a formal meeting be set up with the Proponent, DEECA, The Department of Transport and Planning, and relevant members of The SBWB Recovery Team, to begin discussions on potentially suitable conservation management actions and the logistics and legal considerations involved in establishing a SBWB offset fund for SLWF.

10. Matters of National Environmental Significance

This section of the report assesses the potential impacts of the proposed wind farm on the one EPBC Act listed bat species recorded as present during surveys at the SLWF site.

- Southern Bent-wing Bat – Critically Endangered

The impacts of the proposed SLWF on the SBWB are considered in Table 19 against the EPBC Act Significant Impact Guidelines for Critically Endangered species (Department of the Environment, 2013).

Table 19: Matters of National Environmental Significance (MNES) – Southern Bent-wing Bat

Significant impact criterion	Assessment	Significant impact likelihood
Lead to a long-term decrease in the size of a population	The population of SBWB using the Warrnambool maternity cave during the 2020/21 breeding season was estimated to be approximately 17,233-18,299 individuals, and the population using the Portland maternity cave in 2020 was 1,000-1,500 individuals. In the 2020/21 breeding season, there were between 28,800 and 35,200 individuals estimated to be roosting at Bat Cave in Naracoorte, SA (Southern Bent-wing Bat National Recovery Team, 2022). While bat detector surveys cannot give an accurate representation of numbers of individuals in an area, the relatively low number of SBWB-definite and SBWB-complex calls recorded compared to other high-frequency calling species indicates that it is unlikely that a significant number of SBWB individuals regularly move through or utilise the study area. Native vegetation within the SLWF study area has been extensively cleared for agricultural purposes, with open grazing paddocks comprising 97.1% of the site. There is only one small patch of native woodland (1.80 ha, 0.27%). There are several small farm dams within open grazing paddocks, but no natural wetlands with emergent vegetation. At most bat detector survey sites located in open grazing paddocks where turbines will be located, very few SBWB-definite or SBWB-complex calls were recorded. The minimum RSH of the turbines at SLWF will be 64 m AGL. This would be one of the highest minimum RSHs of turbines at a wind farm in south-western Victoria. Further, it is approximately twice the minimum RSH of turbines at operational wind farms in Victoria where the majority of SBWB mortalities have been reported. As SBWB are not known to regularly fly at or above 64 m AGL when foraging or commuting across the landscape in areas away from roost caves, it is highly unlikely that interactions between the turbines and SBWB will occur. Systematic monitoring and mitigation measures will be deployed, and their effectiveness assessed, during the post-operational phase at SLWF through implementation of the BAMP. Proposed mitigation measures include: (i) increasing nighttime cut-in speed during periods of increased SBWB activity (Spring and Autumn), (ii) intensive systematic scent dog surveys with triggers to increase nighttime cut-in speed if SBWB carcasses are detected, (iii) testing the efficacy of ultrasonic acoustic deterrents in reducing bat mortalities. The Proponent is also proposing to establish a SBWB offset fund for SLWF	Unlikely

Significant impact criterion	Assessment	Significant impact likelihood
	to fund on-ground actions that could benefit long-term recovery of the species. A low number of SBWB calls were detected over two years, likely related to the very small amount of potentially suitable habitat (treed areas and water bodies) that is present across the proposed wind farm site. The minimum RSH of 64 m AGL for the proposed turbines to be installed at SLWF reduces the likelihood of SBWB flying within the RSA. Proposed mitigation measures that will be implemented through the SLWF BAMP, further reduce the likelihood of collisions, e.g. increasing nighttime cut-in speed to 4.5 m/second during Spring and Autum. Consequently, the chance of collisions with turbines by SBWB at SLWF is considered very low. No impact on the global SBWB population of a scale that would lead to a long-term decrease in numbers is expected from the project.	
Reduce the area of occupancy of the species	The proposed wind farm site supports mostly highly modified habitat comprising open grazing paddocks used for agriculture. Bat detector surveys show SBWB are present in the study area at very low levels of activity compared to other bat species with high-frequency calls. The proposed turbine locations and associated infrastructure will be primarily located within grazing paddocks with no trees and therefore will not affect areas that could provide important foraging or roosting resources to SBWB. No key habitat for SBWB will be removed during construction and therefore the project will not reduce the overall area of occupancy of the species within its geographic range across south-west Victoria.	Unlikely
Fragment an existing population into two or more populations	When flying across the site, SBWBs are likely to fly below the minimum RSH of the turbines (64 m AGL), therefore the proposed SLWF is unlikely to present any barrier to SBWB movements between caves and from caves to foraging sites and will not fragment the population.	Unlikely
Adversely affect habitat critical to the survival of a species	Habitat critical to the survival of the species includes the three known breeding caves, located in South Australia, Warrnambool and Portland. The closest of these (Starlight Cave) is approximately 27 km away from the SLWF site. Non-breeding caves are also critical habitat for the SBWB, the closest of these are Panmure, (approximately 10 km from the SLWF site), Timboon (~23 km away) Grassmere (~28 km away). There are no other known non-maternity caves closer to the site, no new caves were discovered during cave assessments conducted during this investigation. No known maternity or non-maternity caves would be directly impacted by the construction or operation of the SLWF. Foraging habitat (e.g., woodland, wetlands with emergent vegetation) in proximity to the above-mentioned caves is also critical habitat to SBWB. None of this critical habitat occurs on the proposed SLWF site.	Unlikely
Disrupt the breeding cycle of a population	The proposed SLWF site is located approximately 27 km from the nearest maternity cave (Starlight Cave, near Warrnambool), and about 116 km from the Portland maternity cave. The construction and operation of the proposed SLWF would not have any direct impact on maternity caves, or on the bats roosting in the caves during the	Unlikely

Significant impact criterion	Assessment	Significant impact likelihood
	breeding season. The project is not predicted to disrupt the breeding cycle of the SBWB population.	
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposed SLWF site does not support any SBWB roosting habitat, there is a very small area of treed habitats mostly in linear planted features, and there are no permanently inundated or ephemeral wetlands with emergent vegetation that could be used for foraging. For this reason, the construction and operation of the proposed SLWF would not decrease the availability or quality of suitable habitat for SBWB in the region and the overall population would therefore not decline as a result.	Unlikely
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	The Project will be constructed and operated in accordance with a detailed environmental management plan that will include monitoring and adaptive control of weed and pest animal infestations and agricultural and plant diseases. It will therefore not result in an outbreak of any invasive species or diseases on the site.	Unlikely
Introduce disease that may cause the species to decline	See previous comment.	Unlikely
Interfere with the recovery of the species	The site does not constitute important habitat that could contribute to the recovery of this species – there are no known roost caves, only a very small amount of native woodland and no wetlands with emergent vegetation. The study area will continue to be used for farming, including grazing and will not be available for revegetation that might increase the area of suitable foraging habitat within the SBWB geographic range in south-west Victoria.	Unlikely
Overall assessment of likelihood of significant impact		***Unlikely***

On this basis, the SLWF is **unlikely** to have a significant impact on the global SBWB population.

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12. Appendices

Appendix 1: Echolocation call identification report – Summer 2022-2023

Identification of echolocation call sequences recorded at Swansons Lane, Southwest Victoria.

Methods

Data

Data was received by mail on March 23rd, 2023. In total 66,984 ZC files were received collected at 12 sites over 516 survey nights. The number of survey nights per site and identifications per site are presented in Table 1. Issues with the locator on the detectors at the time of recording mean that site locations are not provided. Information provided with the dataset indicate that surveys were conducted on Swansons lane between Terang and Hexham southwest Victoria.

Bat call analysis and species identification

Acoustic recordings made with Wildlife acoustics SM4BAT - FS detectors. The WAV files were first converted to zero crossing using Kaleidoscope 5.4.9 (without advanced signal processing). The zero crossing calls were then identified using a combination of machine learning followed my manual validation and (following Lo Cascio et al. 2022). This approach uses manually identified free flying bat calls along with reference calls of free flying bats to build a predictive model using a 'random forest classifier' (following Lo Cascio et al. 2022). For species known to exhibit regional variation, calls were sourced from within the region.

For a call sequence to be positively categorized, a call sequence must have a minimum of three calls and pass the specifies specific kappa maximising threshold. For each recording we assigned the species with the most weight, which was taken as the species with highest number of calls and the highest probability. In line with the scope of works, recordings were then manually identified producing a presence absence per site. That is manual identification was only completed until at least one recording was identified to each species per site. Overall activity per site, per night is given without manual verification, as a measure of overall bat activity.

Identifications of calls belonging to the Southern Bent-wing Bat (Miniopterus *orianae bassanii*) was completed using a more conservative approach which accepted automatic identification if a recording had at least three calls that passed a species specific threshold, which was set to maximise sensitivity. For large acoustic data sets errors associated with detecting false positives (low specificity) are less labour-intensive because manual identification only requires verification of automatically detected events. All recording containing possible *Miniopterus orianae bassanii* calls were then moved into a folder for manual identification.

Visual inspection of calls attributed to *Miniopterus orianae bassanii* was completed, by Rob Gration Of Eco Aerial Environmental Services. In line with the scope of works reporting of the activity of *Miniopterus orianae bassanii* in the study area has been competed based on this manual identification.

Table 1. Species identification per detector location. Automated identification followed by manual identification to confirm presence only. To assign a single species to a recording, the maximum occurring species with the highest probability associated with identification was assigned. Please note *Saccolaimus flaviventris* was not identified by taking the species with the most weight per recording. It was however identified as occurring in recordings with other species. Manual identification was beyond the scope of the project, for this species and so it has not been included in the table.

	Site 1 – S4U09561	Site 2 – S4U16724	Site 3 – S4U11697	Site 4 - S4U11689	Site 5 - S4U11710	Site 6 - S4U16728
Dates	22/12/2022 – 02/02/2023	23/01/23 – 02/02/2023	22/12/2022 – 02/02/2023	22/12/2022 – 02/02/2023	25/01/2023 – 02/03/2023	22/12/2022 – 02/02/2023
Number of ZC files received from client passing Kaleidoscope © noise filter	5,467	1,141	36,145	7,696	2,516	4,904
Survey nights	43	8	43	43	9	43
Species						
Austronomus australis	X	X	X	X	X	X
Ozimops ridei	X	X	X	X	X	X
Chalinolobus gouldii	X	X	X	X	X	X
Falsistrellus tasmaniensis	X	X	X	X	X	X
Scotorepens balstoni	X	X	X	X	X	X
Myotis macropus/Nyctophilus spp.	#	#	#	#	#	#
Vespadelus darlingtoni	X	X	X	X	X	X
Vespadelus regulus/V. vulturnus	#	#	#	#	#	#
Miniopterus orianae bassanii /Vespadelus spp.	#	#	#	#	#	#
Miniopterus bassanii	X				X	
Chalinolobus morio	X	X	X	X	X	X
Vespadelus vulturnus	X		X	X	X	X

Cont.

	Site 7 - S4Z00406	Site 8 - S4U16729	Site 9 - S4U16731	Site 10 - S4U16709	Site 11 - S4U06328	Site 12 – S4U16733
Dates	22/12/2022 – 02/02/2023	22/12/2022 – 02/02/2023	22/12/2022 – 02/02/2023	22/12/2022 – 02/02/2023	22/12/2022 – 02/02/2023	22/12/2022 – 02/02/2023
Number of ZC files received from client passing Kaleidoscope © noise filter	2,221	3,337	1,214	640	1,113	590
Survey nights	43	43	43	43	43	43
Species						
Austronomus australis	X	X	X	X	X	X
Ozimops ridei	X	X	X	X	X	X
Chalinolobus gouldii	X	X	X	X	X	X
Falsistrellus tasmaniensis	X	X	X	X	X	X
Scotorepens balstoni	X	X	X	X	X	X
Myotis macropus/Nyctophilus spp.	#	#	#	#	#	#
Vespadelus darlingtoni	#	X	X	X	X	X
Vespadelus regulus/V. vulturnus	#	X	#	#	#	#
Miniopterus orianae bassanii /Vespadelus spp.	#	#	#	#	#	#
Miniopterus bassanii		X		X	X	X
Chalinolobus morio	X	X		X	X	X
Vespadelus vulturnus	X	X	X	X	X	X

X - Definite

- Probable

Please note many recordings ~ half were identified by the random forest model as containing multiple species. As not in scope of works these were not validated.

Microbat activity per site per night

In line with the scope of works a count of microbat calls per site and per night was generated from automated identification only and is shown in Figure 1. Model confidence for classification of each acoustic recording is provided in Figure 2.

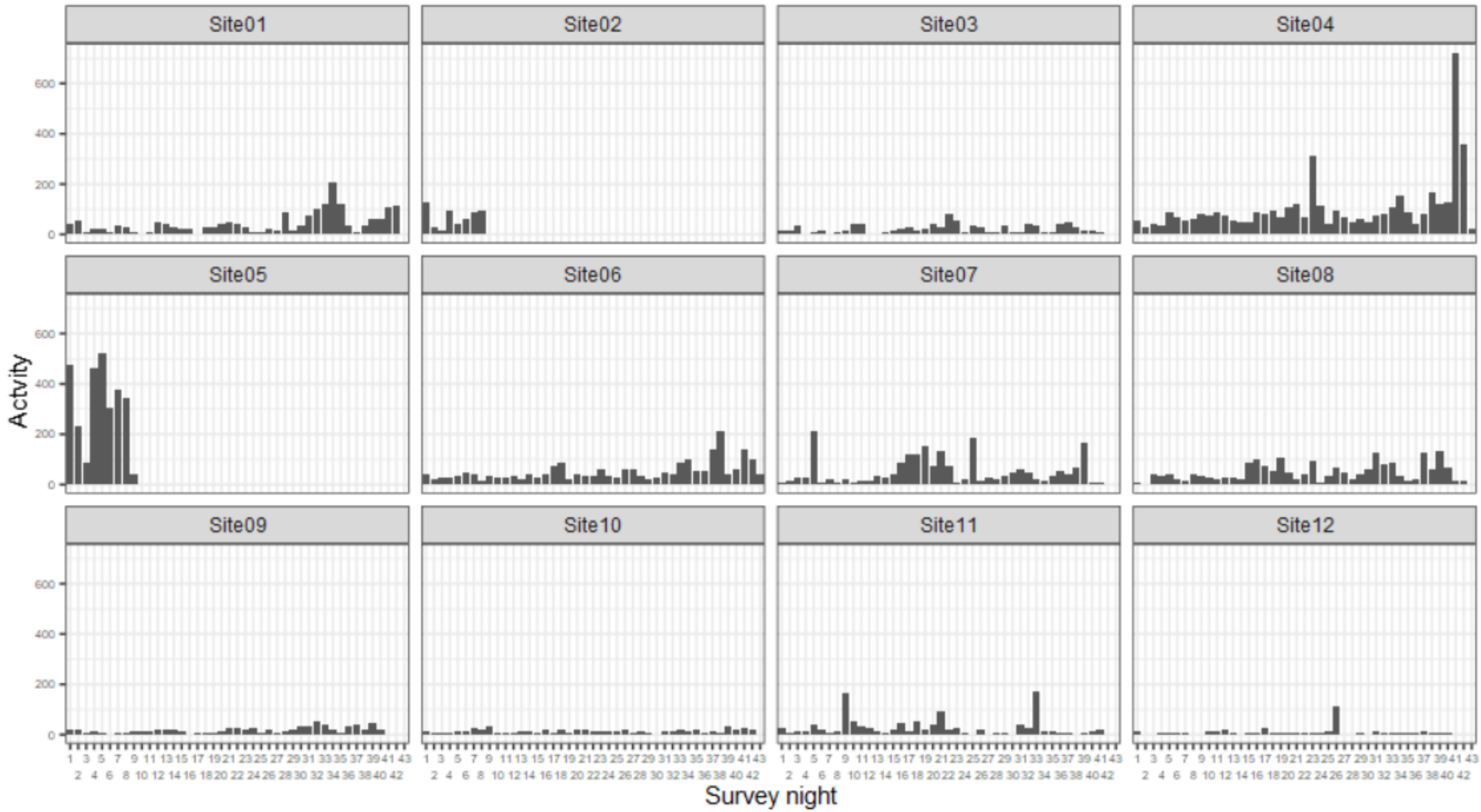


Figure 1. Count of species per site generated from automated identification only. For ease of plotting survey night is sequential night of survey which is provided in Table 1.

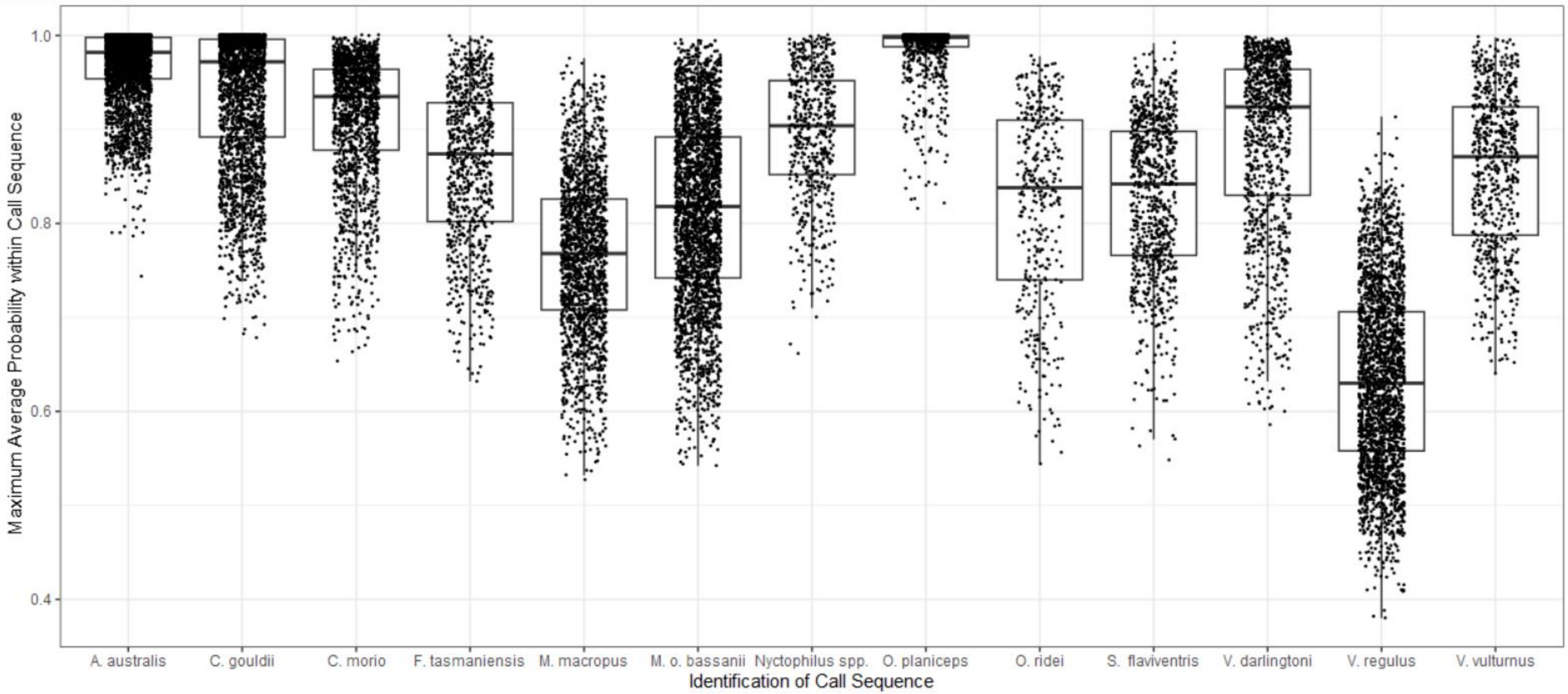


Figure 2. Confidence for identification of each call sequence. Note probability values used are specific for each species using a kappa maximising threshold (following Lo Cascio et al., 2022).

Results

Reliability of species identification

Myotis macropus/Nyctophilus spp.

Calls of *Myotis macropus*, and species of long-eared bat *Nyctophilus* spp. cannot always be separated. These species are typically reported as a species complex.

Vespadelus regulus/V. vulturnus

These species overlap in this region and are difficult to separate.

Vespadelus species or *M. o. bassanii*

Both *V. vulturnus* and *V. regulus* overlap considerably with *M.o. bassanii* in this region. Comparison of model confidence with manually identified calls indicate high overlap between the definite and species complex calls (Figure 3) and as such counts per site for this species include both categories. *C. morio* also overlaps substantially in this region, however manual identifications did not include a *C. morio/M.o. bassanii* group for this dataset.

The random forest model identified 2,748 calls to *M.o. bassanii*. Calls were in the appropriate frequency range for this spaces, and it is possible that these calls all contain *M.o. bassanii*. Not all sequences from *M. o. bassanii* will contain enough information to allow confident identification, that separates *M. o. bassanii* from Vespadelus spp. Therefore, it is appropriate to assign complex groups, which contain all three species. The high overlap of this species calls with other species effect its identification from acoustic datasets (Lo Cascio et al. 2022). Thereby, estimations of activity based on definite identifications only, are likely to be underestimated. Further, flight and foraging strategies of these species suggest that the number of calls used to make up activity are not directly comparable. For example, *M.o. bassanii* flies fast with low manoeuvrability, foraging primarily above-canopy and in open-spaces; whereas the two forest bats it overlaps with acoustically (*V. vulturnus, V. regulus*) are clutter adapted, with slow, highly agile flight, and forage mainly below-canopy and close to vegetation. This means that it is common to record multiple, long-duration forest bat call sequences as individuals circle and make repeated passes above the detector (i.e., one individual is recorded many times within a short period). In contrast, *M.o. bassanii* is more likely to pass quickly over the detector, resulting in relatively shorter call sequences being recorded less often than forest bat calls (Pennay & Lavery 2017, Van Harten et al., 2022). These different foraging behaviours also mean that detectors placed in open areas are more likely to record *M.o. bassanii* than *Vespadelus* species (Holz et al., 2020).

An outcome of this analysis is the ability to objectively compare activity of threatened species over time. While manual identification is an important step there will be differences in the number of call sequences identified to a given species for a given dataset based on the method used, and the person undertaking the analysis. That is activity levels of *M. o. bassanii* will be influenced by any difference in interpretation between analysts, the analysis methods used, aspects of survey timing and detector placement, and seasonality. If activity levels are being used within a project to make biological interpretations, then there is an imperative to standardise the sampling and analysis to minimise the effect of confounding factors.

Table 2. Count of definite and probable identifications of *M.o. bassanii* per site, based on manual identification. Counts include complex groups containing species known to overall significantly with *M.o. bassanii* in this region.

Site	*Miniopterus orianae bassanii*	Manual Identification
1	1	Definite
	8	Complex
2	3	Complex
3	4	Complex
4	21	Complex
5	4	Definite
	43	Complex
6	14	Complex
7	4	Complex
8	1	Definite
	6	Complex
9	1	Definite
	9	Complex
10	6	Definite
	24	Complex
11	4	Definite
	13	Complex
12	2	Definite
	7	Complex

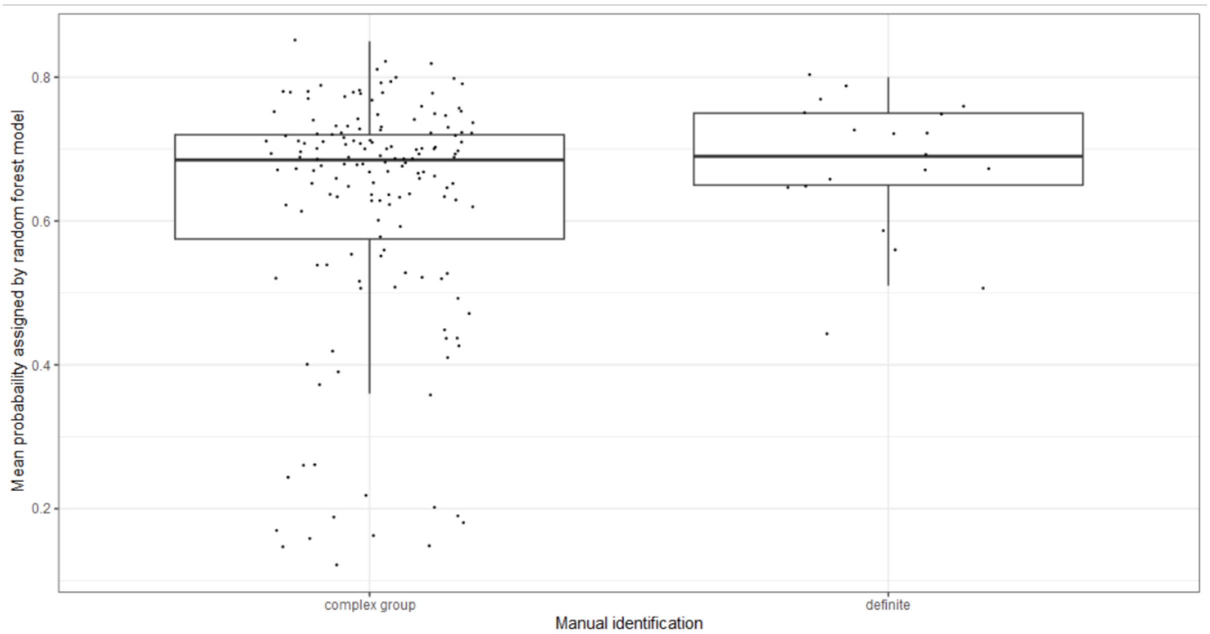
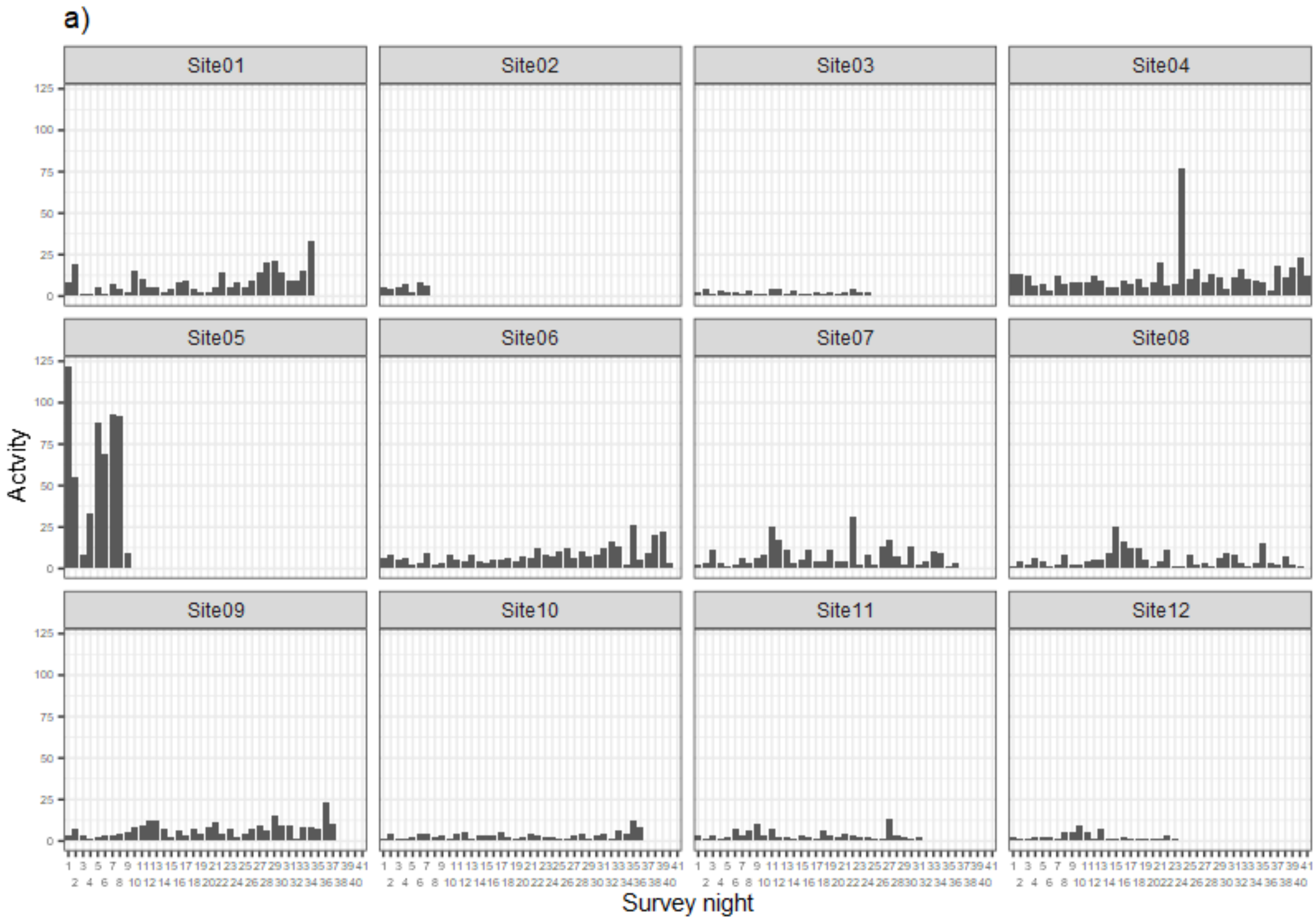
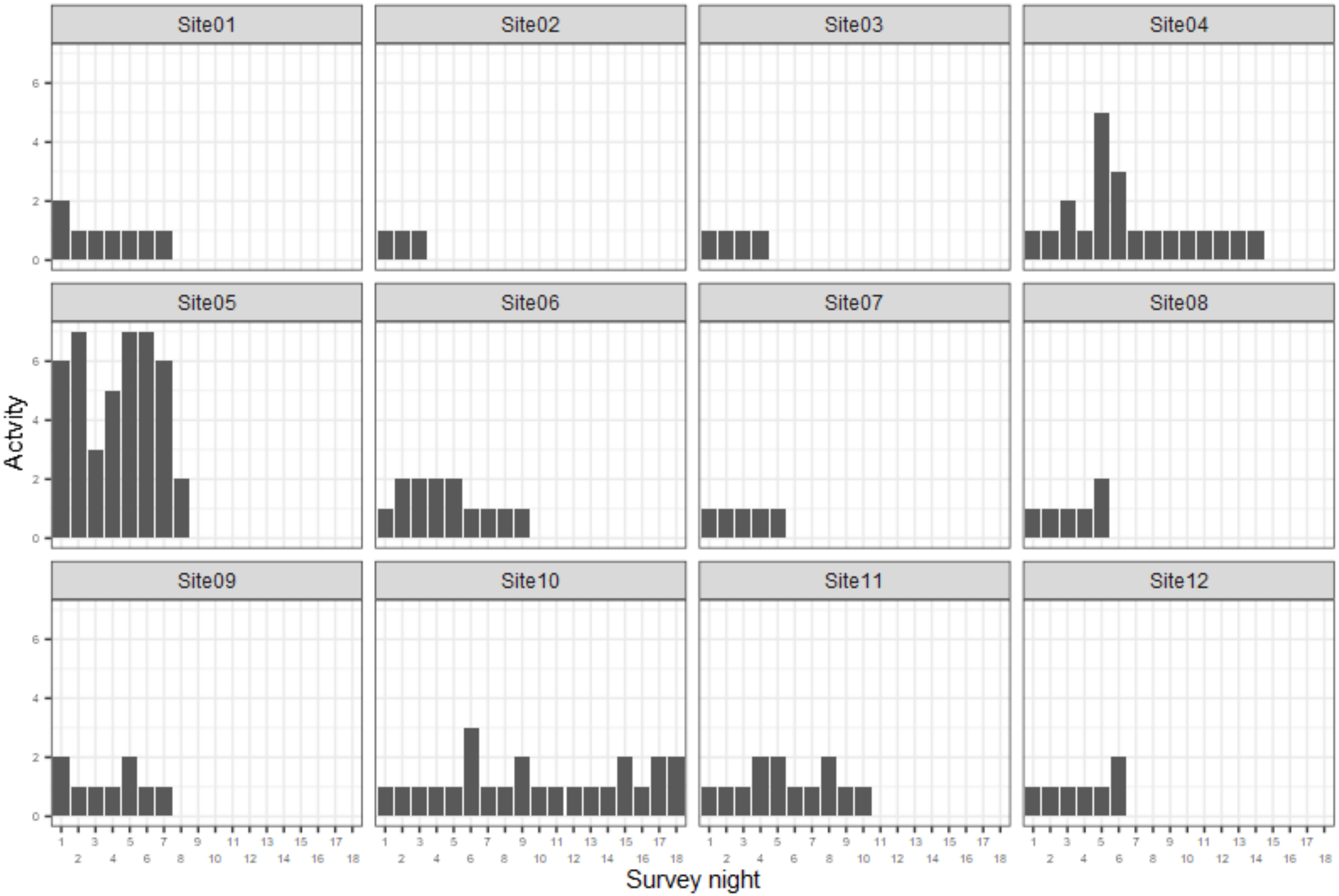


Figure 3. Comparison of model confidence with Manually verified *M.o. bassanii* calls assigned to definite and complex groups.

Activity of *Miniopterus orianae bassanii*



b)



Site01
Site02
Site03
Site04
Site05
Site06
Site07
Site08
Site09
Site10
Site11
Site12
Actvity
Survey night

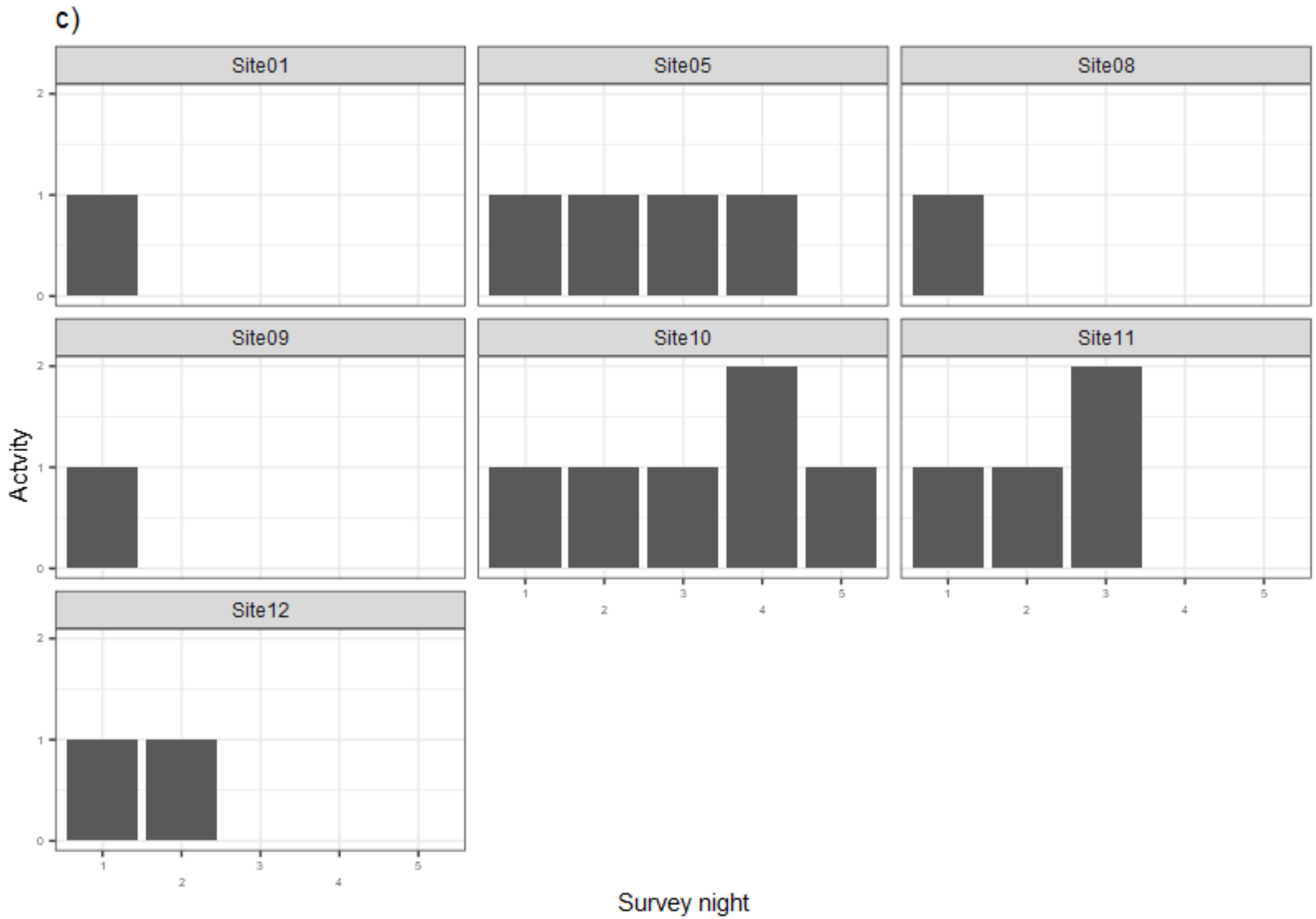
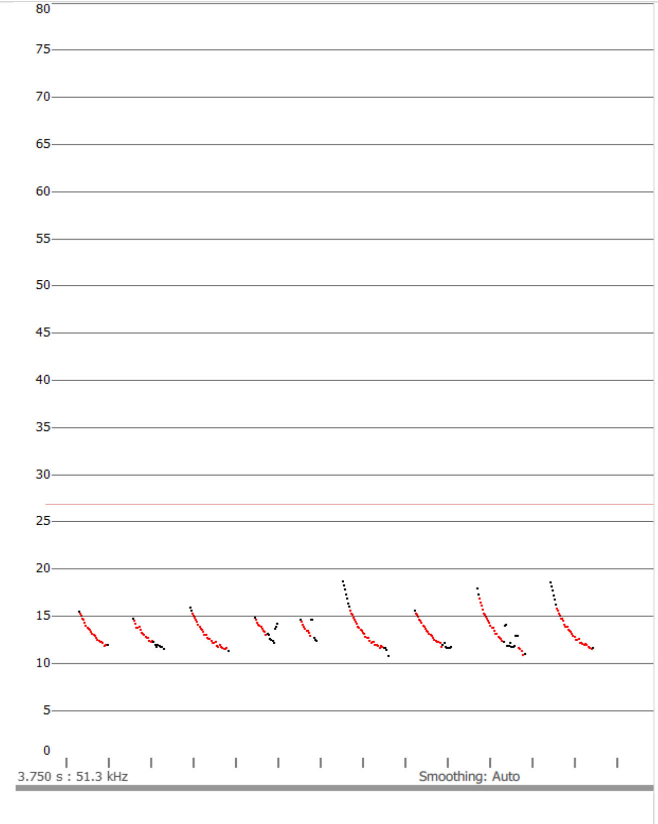
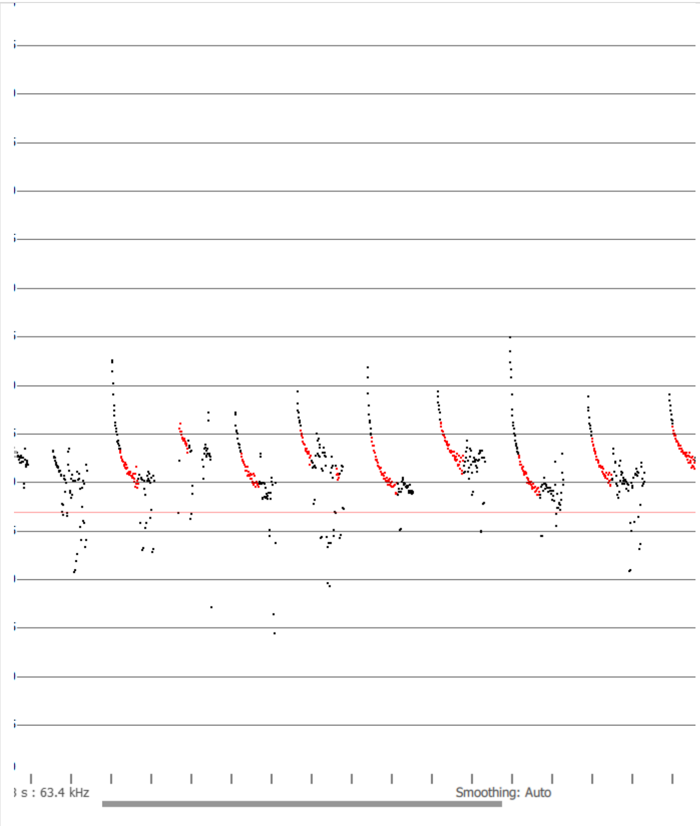

c)
Site01
Site05
Site08
Site09
Site10
Site11
Site12
Activity
Survey night
0
1
2
1
2
3
4
5

Figure 4. Site activity of *Miniopterus orianae bassanii* based on a) automatically identified calls plot; b) manually identified Species Complex calls plot; and c) manually identified definite calls plot. For ease of plotting, survey night is sequential night of survey which is provided in Table 1. Please note that y – axes for plots are not on the same scale.

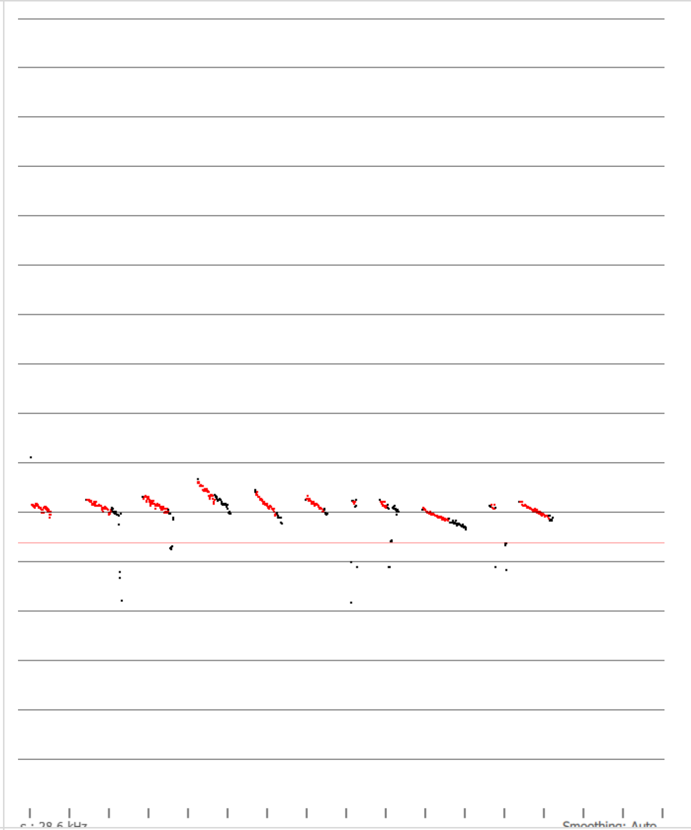
Representative call sequences



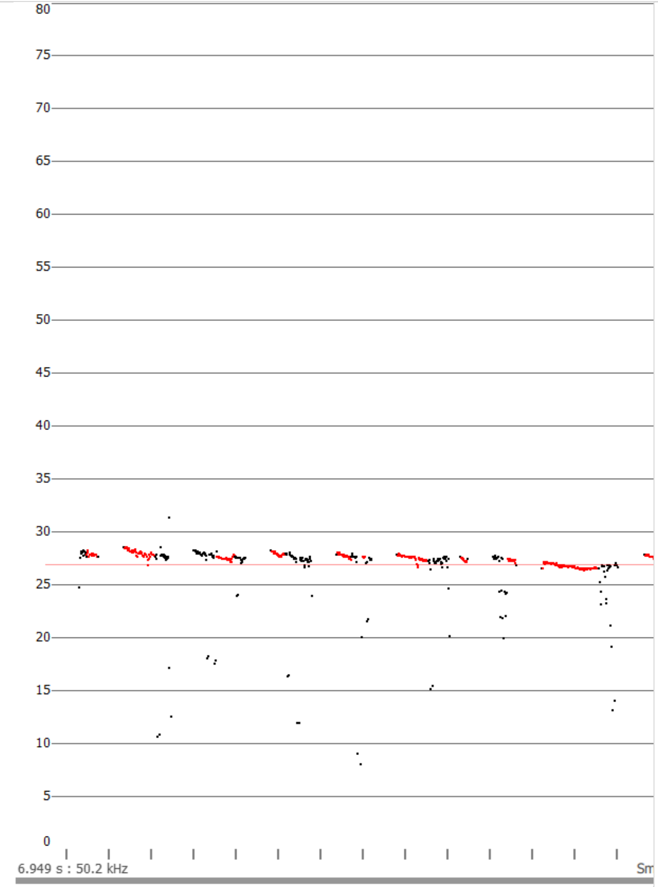
Austronomus australis



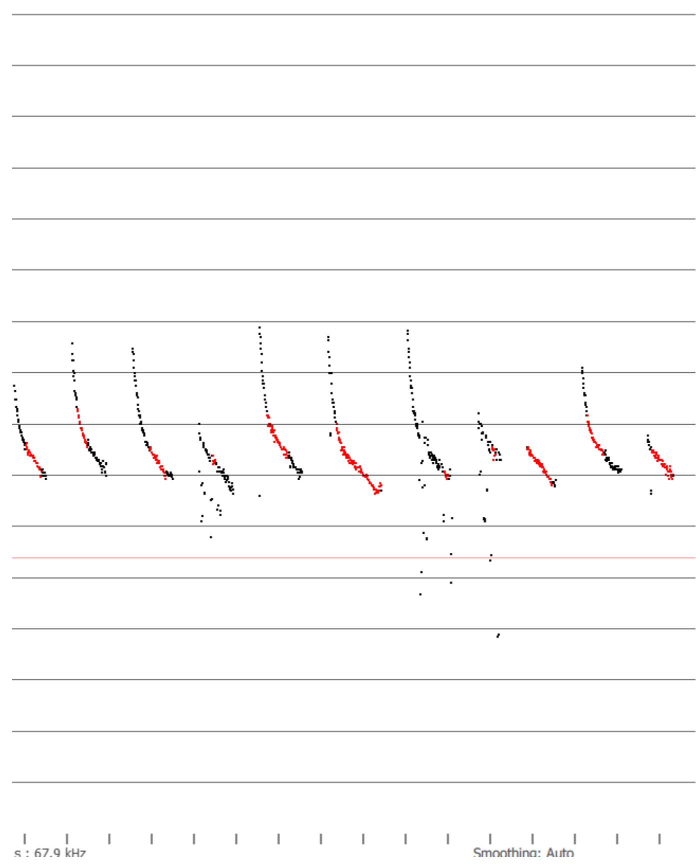
Chalinolobus gouldii



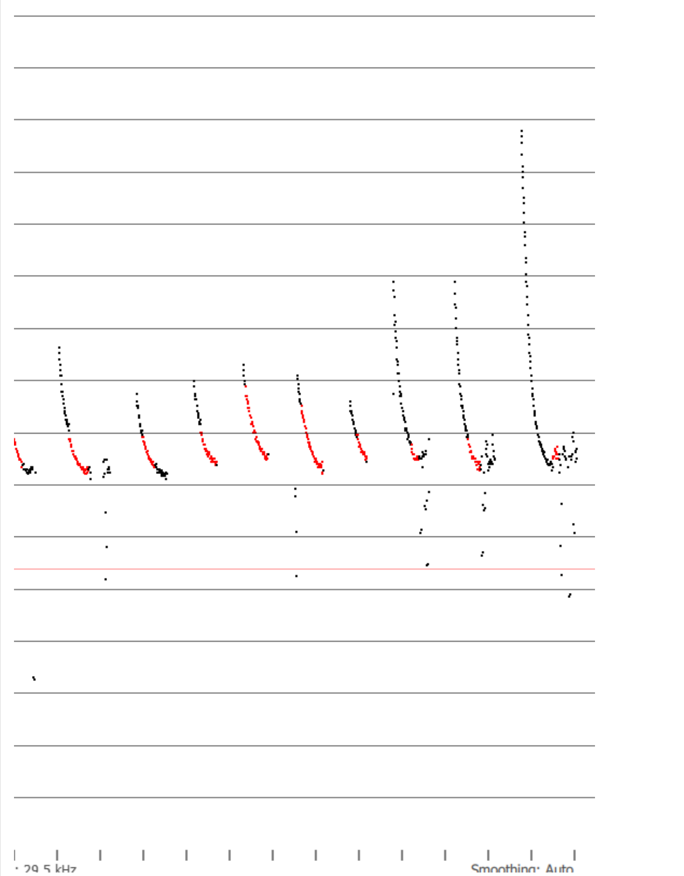
Ozimops ridei



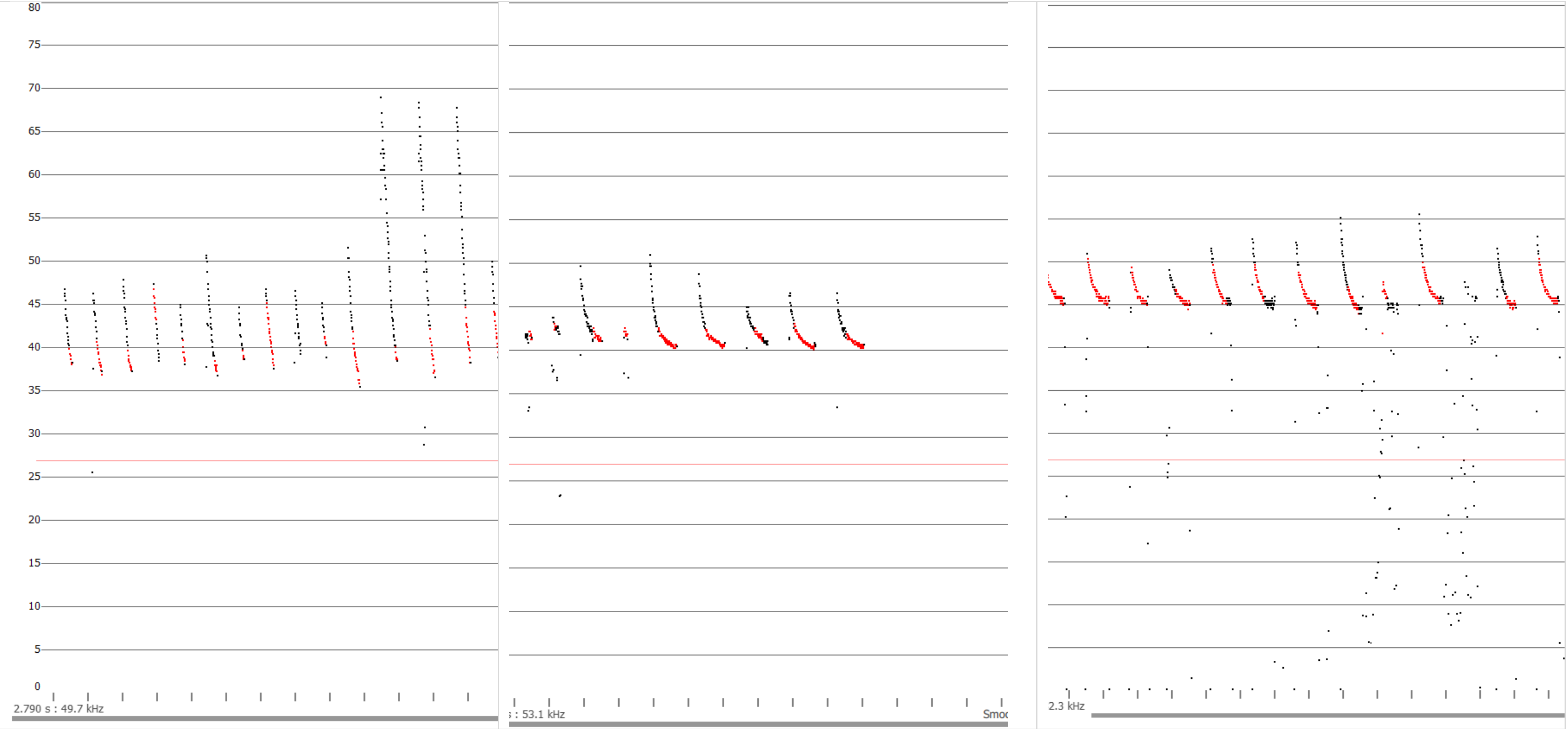
Ozimops ridei (lower frequency) *O. planiceps* is not expected in the study area



Scotrepens basltoni



Falsistrellus tasmaniensis



Myotis macropus/Nyctophilsu spp.	*Vespadelus darlingtoni*	*Vespadelus regulus/V. vulturnus*

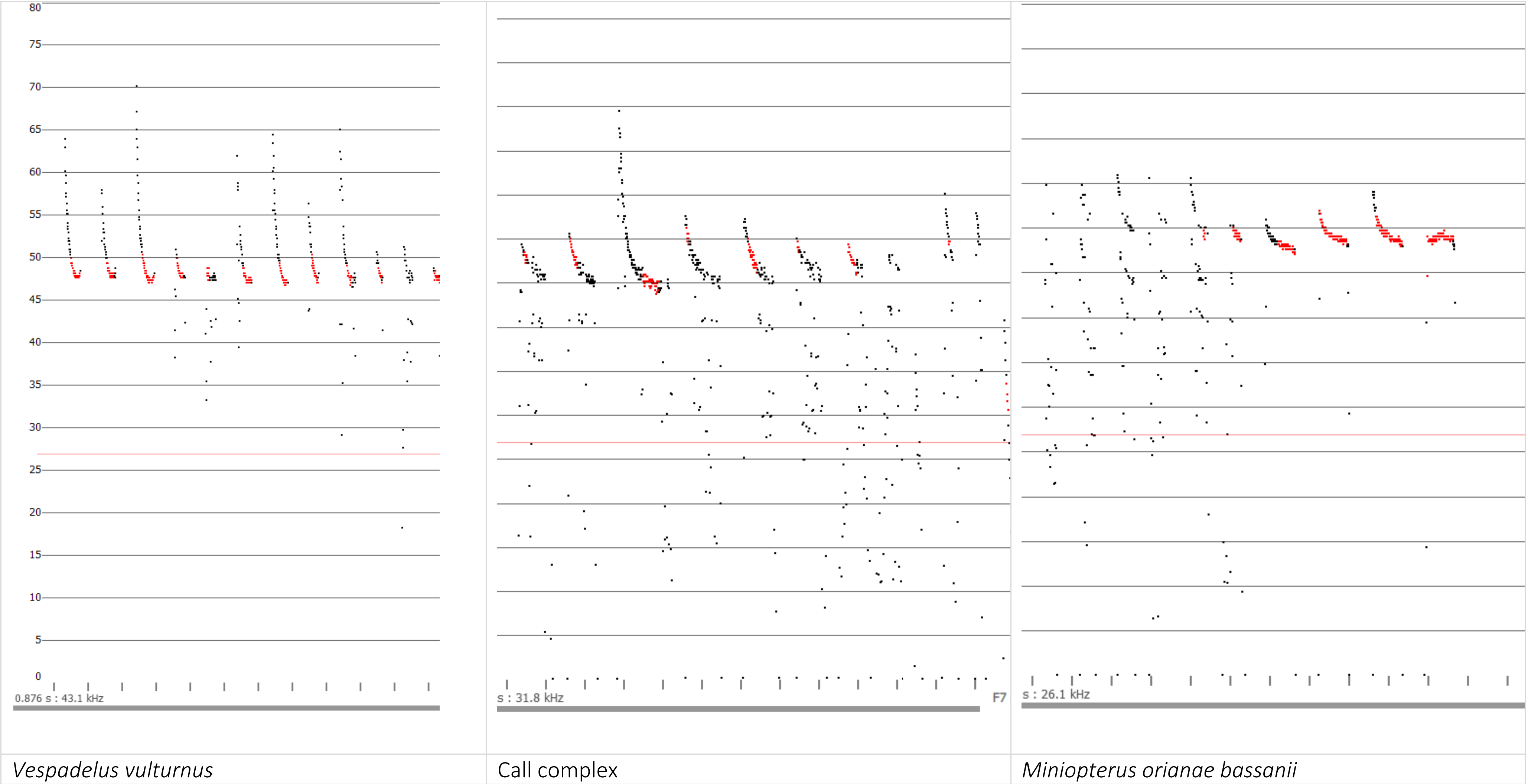


Figure 5. Representative call examples for species identified in the dataset.

Appendix

Table S1 - Count of definite and probable identifications of *M.o. bassanii* per site. Counts include complex groups containing species known to overall significantly with *M.o. bassanii* in this region. Calls have been manually verified and model probability means calculated per recording are provided. Model probability scale is from 0 – 1.

Site	*Austronomus australis*	*Chalinolobus gouldii*	*Chalinolobus morio*	*Falsistrellus tasmaniensis*	*Miniopterus orianae bassanii*	*Myotis macropus*	*Nyctophilus spp.*	*Ozimops planiceps*	*Ozimops ridei*	*Saccolaimus flaviventris*	*Scotorepens balstoni*	*Vespadelus darlingtoni*	*Vespadelus regulus*	*Vespadelus vulturnus*	manual identification	file name	Site totals
1	0.00	0.00	0.10	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	definite	Site01_S4U09561_20221224_215724_000.zc	
1	0.00	0.00	0.01	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14	0.13	complex group	Site01_S4U09561_20221222_225244_000.zc	
1	0.00	0.00	0.01	0.00	0.70	0.01	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.10	complex group	Site01_S4U09561_20221222_234637_000.zc	
1	0.00	0.00	0.01	0.00	0.67	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.29	complex group	Site01_S4U09561_20221226_000013_000.zc	
1	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.22	0.01	complex group	Site01_S4U09561_20221226_232250_000.zc	
1	0.00	0.00	0.01	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	complex group	Site01_S4U09561_20221230_041406_000.zc	
1	0.00	0.00	0.02	0.01	0.16	0.04	0.02	0.00	0.00	0.00	0.00	0.26	0.46	0.06	complex group	Site01_S4U09561_20230104_225125_000.zc	
1	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.13	0.08	complex group	Site01_S4U09561_20230108_233859_000.zc	
1	0.00	0.00	0.02	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	complex group	Site01_S4U09561_20230201_221002_000.zc	9
2	0.00	0.00	0.08	0.00	0.63	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.28	complex group	Site02_S4U16724_20230128_214815_000.zc	
2	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.04	complex group	Site02_S4U16724_20230131_034145_000.zc	
2	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.17	complex group	Site02_S4U16724_20230201_221352_000.zc	3
3	0.00	0.00	0.01	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.11	complex group	Site03_S4U11697_20221225_023942_000.zc	
3	0.00	0.00	0.01	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.16	complex group	Site03_S4U11697_20221228_223021_000.zc	
3	0.00	0.00	0.02	0.00	0.68	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.26	complex group	Site03_S4U11697_20221231_232804_000.zc	
3	0.00	0.00	0.01	0.00	0.78	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.11	complex group	Site03_S4U11697_20230104_230402_000.zc	4
4	0.00	0.00	0.01	0.02	0.72	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.10	0.15	complex group	Site04_S4U11689_20221224_002138_000.zc	
4	0.00	0.00	0.01	0.00	0.72	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.06	0.20	complex group	Site04_S4U11689_20221228_002542_000.zc	
4	0.00	0.00	0.01	0.00	0.69	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.07	0.23	complex group	Site04_S4U11689_20221228_230342_000.zc	
4	0.00	0.00	0.01	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.19	complex group	Site04_S4U11689_20221229_000634_000.zc	
4	0.00	0.00	0.01	0.00	0.65	0.01	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.16	complex group	Site04_S4U11689_20221230_034401_000.zc	
4	0.00	0.00	0.01	0.01	0.68	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.24	complex group	Site04_S4U11689_20221231_224220_000.zc	
4	0.00	0.00	0.01	0.00	0.80	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.04	0.15	complex group	Site04_S4U11689_20221231_232349_000.zc	
4	0.00	0.00	0.02	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	complex group	Site04_S4U11689_20221231_233425_000.zc	
4	0.00	0.00	0.02	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.20	0.29	complex group	Site04_S4U11689_20230101_035057_000.zc	
4	0.00	0.00	0.01	0.00	0.60	0.00	0.01	0.00	0.00	0.00	0.00	0.12	0.18	0.17	complex group	Site04_S4U11689_20230101_040750_000.zc	
4	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.19	complex group	Site04_S4U11689_20230102_222533_000.zc	
4	0.00	0.00	0.01	0.00	0.45	0.02	0.02	0.00	0.00	0.00	0.00	0.14	0.32	0.08	complex group	Site04_S4U11689_20230103_034658_000.zc	
4	0.00	0.00	0.01	0.00	0.62	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.18	0.14	complex group	Site04_S4U11689_20230103_034813_000.zc	
4	0.00	0.00	0.00	0.00	0.69	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.13	0.14	complex group	Site04_S4U11689_20230106_035838_000.zc	
4	0.00	0.00	0.01	0.00	0.72	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.23	complex group	Site04_S4U11689_20230106_230709_000.zc	
4	0.00	0.00	0.00	0.01	0.63	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.18	0.13	complex group	Site04_S4U11689_20230110_234309_000.zc	
4	0.00	0.00	0.03	0.00	0.72	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	complex group	Site04_S4U11689_20230111_220217_000.zc	

4	0.00	0.00	0.01	0.01	0.61	0.01	0.01	0.00	0.00	0.00	0.00	0.07	0.16	0.18	complex group	Site04_S4U11689_20230116_010423_000.zc	
4	0.00	0.00	0.01	0.01	0.63	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.14	0.17	complex group	Site04_S4U11689_20230117_034022_000.zc	
4	0.00	0.00	0.01	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.22	complex group	Site04_S4U11689_20230123_041546_000.zc	
4	0.00	0.00	0.01	0.01	0.52	0.01	0.01	0.00	0.00	0.00	0.00	0.12	0.26	0.12	complex group	Site04_S4U11689_20230201_222316_000.zc	21
5	0.00	0.00	0.03	0.00	0.56	0.01	0.01	0.00	0.00	0.00	0.00	0.13	0.20	0.09	definite	Site05_S4U11710_20230126_034801_000.zc	
5	0.00	0.00	0.03	0.00	0.59	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.34	definite	Site05_S4U11710_20230130_035851_000.zc	
5	0.00	0.00	0.01	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11	0.07	definite	Site05_S4U11710_20230201_033633_000.zc	
5	0.00	0.00	0.03	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	definite	Site05_S4U11710_20230201_221030_000.zc	
5	0.00	0.00	0.08	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	complex group	Site05_S4U11710_20230125_231030_000.zc	
5	0.00	0.00	0.01	0.00	0.49	0.01	0.01	0.00	0.00	0.00	0.00	0.12	0.33	0.05	complex group	Site05_S4U11710_20230126_024318_000.zc	
5	0.00	0.00	0.02	0.00	0.72	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.15	0.10	complex group	Site05_S4U11710_20230126_030314_000.zc	
5	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.17	complex group	Site05_S4U11710_20230126_034958_000.zc	
5	0.00	0.00	0.01	0.00	0.67	0.00	0.01	0.00	0.00	0.00	0.00	0.07	0.16	0.10	complex group	Site05_S4U11710_20230126_041222_000.zc	
5	0.00	0.00	0.03	0.00	0.69	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.15	0.11	complex group	Site05_S4U11710_20230126_041319_000.zc	
5	0.00	0.00	0.03	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.14	0.10	complex group	Site05_S4U11710_20230126_223232_000.zc	
5	0.00	0.00	0.02	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.25	0.06	complex group	Site05_S4U11710_20230126_223734_000.zc	
5	0.00	0.00	0.03	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.17	0.05	complex group	Site05_S4U11710_20230126_223810_000.zc	
5	0.00	0.00	0.00	0.00	0.72	0.01	0.01	0.00	0.00	0.00	0.00	0.07	0.19	0.01	complex group	Site05_S4U11710_20230127_005809_000.zc	
5	0.00	0.00	0.01	0.02	0.20	0.02	0.02	0.00	0.00	0.00	0.00	0.30	0.47	0.01	complex group	Site05_S4U11710_20230127_032943_000.zc	
5	0.00	0.00	0.00	0.00	0.26	0.00	0.02	0.00	0.00	0.00	0.00	0.26	0.47	0.01	complex group	Site05_S4U11710_20230127_040426_000.zc	
5	0.00	0.00	0.01	0.00	0.19	0.00	0.01	0.00	0.00	0.00	0.00	0.33	0.47	0.01	complex group	Site05_S4U11710_20230127_040732_000.zc	
5	0.00	0.00	0.01	0.00	0.40	0.01	0.00	0.00	0.00	0.00	0.00	0.20	0.36	0.03	complex group	Site05_S4U11710_20230128_222732_000.zc	
5	0.00	0.00	0.03	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.11	complex group	Site05_S4U11710_20230128_223209_000.zc	
5	0.00	0.00	0.05	0.01	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.26	0.11	complex group	Site05_S4U11710_20230128_230047_000.zc	
5	0.00	0.00	0.00	0.00	0.18	0.01	0.01	0.00	0.00	0.00	0.00	0.28	0.53	0.00	complex group	Site05_S4U11710_20230129_224029_000.zc	
5	0.00	0.00	0.09	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	complex group	Site05_S4U11710_20230129_233000_000.zc	
5	0.00	0.00	0.01	0.01	0.52	0.02	0.01	0.00	0.00	0.00	0.00	0.09	0.28	0.09	complex group	Site05_S4U11710_20230130_012826_000.zc	
5	0.00	0.00	0.01	0.00	0.52	0.01	0.01	0.00	0.00	0.00	0.00	0.14	0.29	0.04	complex group	Site05_S4U11710_20230130_022749_000.zc	
5	0.00	0.00	0.00	0.00	0.72	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.08	0.18	complex group	Site05_S4U11710_20230130_040033_000.zc	
5	0.00	0.00	0.03	0.02	0.71	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.12	0.12	complex group	Site05_S4U11710_20230130_224632_000.zc	
5	0.00	0.00	0.01	0.00	0.72	0.01	0.01	0.00	0.00	0.00	0.00	0.05	0.20	0.03	complex group	Site05_S4U11710_20230130_224921_000.zc	
5	0.00	0.00	0.01	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.17	0.11	complex group	Site05_S4U11710_20230130_224953_000.zc	
5	0.00	0.00	0.03	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.34	0.32	complex group	Site05_S4U11710_20230131_014652_000.zc	
5	0.00	0.00	0.01	0.00	0.52	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.29	0.03	complex group	Site05_S4U11710_20230131_033934_000.zc	
5	0.00	0.00	0.00	0.01	0.39	0.01	0.01	0.00	0.00	0.00	0.00	0.19	0.37	0.05	complex group	Site05_S4U11710_20230131_034343_000.zc	
5	0.00	0.00	0.01	0.00	0.67	0.01	0.00	0.00	0.00	0.00	0.00	0.07	0.19	0.07	complex group	Site05_S4U11710_20230131_040556_000.zc	
5	0.00	0.00	0.02	0.00	0.51	0.01	0.01	0.00	0.00	0.00	0.00	0.16	0.24	0.11	complex group	Site05_S4U11710_20230131_223940_000.zc	

5	0.00	0.00	0.00	0.02	0.17	0.02	0.01	0.00	0.00	0.00	0.00	0.29	0.52	0.00	complex group	Site05_S4U11710_20230201_005304_000.zc	
5	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.45	0.00	complex group	Site05_S4U11710_20230201_031549_000.zc	
5	0.00	0.00	0.00	0.00	0.15	0.00	0.01	0.00	0.00	0.00	0.00	0.36	0.48	0.00	complex group	Site05_S4U11710_20230201_032659_000.zc	
5	0.00	0.00	0.01	0.00	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.20	0.33	0.07	complex group	Site05_S4U11710_20230201_033821_000.zc	
5	0.00	0.00	0.00	0.00	0.16	0.01	0.01	0.00	0.00	0.00	0.00	0.28	0.55	0.01	complex group	Site05_S4U11710_20230201_034007_000.zc	
5	0.00	0.00	0.04	0.00	0.44	0.01	0.01	0.00	0.00	0.00	0.00	0.14	0.33	0.09	complex group	Site05_S4U11710_20230201_035639_000.zc	
5	0.00	0.00	0.02	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.17	0.07	complex group	Site05_S4U11710_20230201_222540_000.zc	
5	0.00	0.00	0.02	0.00	0.69	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.08	0.17	complex group	Site05_S4U11710_20230201_223616_000.zc	
5	0.00	0.00	0.02	0.00	0.67	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.20	complex group	Site05_S4U11710_20230201_224405_000.zc	
5	0.00	0.00	0.02	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.15	complex group	Site05_S4U11710_20230202_012156_000.zc	
5	0.00	0.00	0.02	0.00	0.65	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.13	0.17	complex group	Site05_S4U11710_20230202_034944_000.zc	
5	0.00	0.00	0.01	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.18	0.09	complex group	Site05_S4U11710_20230202_042304_000.zc	
5	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.19	0.05	complex group	Site05_S4U11710_20230203_012509_000.zc	
5	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.05	complex group	Site05_S4U11710_20230203_015412_000.zc	47
6	0.00	0.00	0.01	0.00	0.65	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.13	0.18	complex group	Site06_S4U16728_20221224_031809_000.zc	
6	0.00	0.00	0.01	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.16	0.18	complex group	Site06_S4U16728_20221229_225114_000.zc	
6	0.00	0.00	0.01	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.18	0.09	complex group	Site06_S4U16728_20221230_034400_000.zc	
6	0.00	0.00	0.07	0.00	0.62	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.29	complex group	Site06_S4U16728_20230101_220738_000.zc	
6	0.00	0.00	0.03	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	complex group	Site06_S4U16728_20230101_231140_000.zc	
6	0.00	0.00	0.02	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.31	complex group	Site06_S4U16728_20230102_223324_000.zc	
6	0.00	0.00	0.00	0.02	0.36	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.38	0.07	complex group	Site06_S4U16728_20230103_034216_000.zc	
6	0.00	0.00	0.00	0.01	0.19	0.02	0.01	0.00	0.00	0.00	0.00	0.27	0.51	0.01	complex group	Site06_S4U16728_20230110_222652_000.zc	
6	0.00	0.00	0.01	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.15	complex group	Site06_S4U16728_20230110_230736_000.zc	
6	0.00	0.00	0.01	0.00	0.66	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.10	0.21	complex group	Site06_S4U16728_20230112_015410_000.zc	
6	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.24	complex group	Site06_S4U16728_20230115_225322_000.zc	
6	0.00	0.00	0.01	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.20	complex group	Site06_S4U16728_20230121_031254_000.zc	
6	0.00	0.00	0.00	0.00	0.22	0.02	0.03	0.00	0.00	0.00	0.00	0.20	0.48	0.06	complex group	Site06_S4U16728_20230127_040350_000.zc	13
7	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.16	complex group	Site07_S4Z00406__20221226_003609_009.zc	
7	0.00	0.00	0.03	0.00	0.62	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.34	complex group	Site07_S4Z00406__20221226_220749_000.zc	
7	0.00	0.00	0.01	0.00	0.63	0.02	0.01	0.00	0.00	0.00	0.00	0.05	0.17	0.15	complex group	Site07_S4Z00406__20221230_030646_000.zc	
7	0.00	0.00	0.01	0.01	0.54	0.01	0.02	0.00	0.00	0.00	0.00	0.09	0.22	0.13	complex group	Site07_S4Z00406__20221230_230049_000.zc	
7	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.15	complex group	Site07_S4Z00406__20230103_223023_000.zc	5
8	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.32	definite	Site08_S4U16729_20221225_230057_000.zc	
8	0.00	0.00	0.02	0.00	0.63	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.16	0.16	complex group	Site08_S4U16729_20221226_031427_000.zc	
8	0.00	0.00	0.01	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.23	complex group	Site08_S4U16729_20221230_230625_000.zc	
8	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.10	0.17	complex group	Site08_S4U16729_20230101_002022_000.zc	
8	0.00	0.00	0.00	0.00	0.78	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.11	0.08	complex group	Site08_S4U16729_20230101_224943_000.zc	

8	0.00	0.00	0.00	0.01	0.24	0.03	0.01	0.00	0.00	0.00	0.00	0.18	0.51	0.03	complex group	Site08_S4U16729_20230107_002812_000.zc	
8	0.00	0.00	0.01	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.22	0.04	complex group	Site08_S4U16729_20230107_002931_000.zc	7
9	0.00	0.00	0.01	0.00	0.75	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.21	definite	Site09_S4U16731_20230122_012451_000.zc	
9	0.00	0.00	0.01	0.00	0.64	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.16	0.15	complex group	Site09_S4U16731_20221223_211848_000.zc	
9	0.00	0.00	0.01	0.00	0.37	0.01	0.01	0.00	0.00	0.00	0.00	0.14	0.34	0.14	complex group	Site09_S4U16731_20221224_011205_000.zc	
9	0.00	0.00	0.00	0.00	0.64	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.19	0.10	complex group	Site09_S4U16731_20221224_215255_000.zc	
9	0.00	0.00	0.01	0.00	0.75	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.21	complex group	Site09_S4U16731_20221230_020928_000.zc	
9	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.15	0.16	complex group	Site09_S4U16731_20230105_214333_000.zc	
9	0.00	0.00	0.01	0.00	0.73	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.08	0.16	complex group	Site09_S4U16731_20230123_224023_000.zc	
9	0.00	0.00	0.01	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.21	0.07	complex group	Site09_S4U16731_20230124_012014_000.zc	
9	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.16	0.08	complex group	Site09_S4U16731_20230126_220016_000.zc	
9	0.00	0.00	0.28	0.00	0.54	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.10	0.13	complex group	Site09_S4U16731_20230201_212936_000.zc	10
10	0.00	0.00	0.02	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.19	0.06	definite	Site10_S4U16709_20230101_003656_000.zc	
10	0.00	0.00	0.01	0.00	0.67	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.18	0.09	definite	Site10_S4U16709_20230101_224240_000.zc	
10	0.00	0.00	0.01	0.00	0.72	0.01	0.01	0.00	0.00	0.00	0.00	0.05	0.16	0.09	definite	Site10_S4U16709_20230103_225329_000.zc	
10	0.00	0.00	0.04	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.11	definite	Site10_S4U16709_20230104_223905_000.zc	
10	0.00	0.00	0.02	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.09	0.13	definite	Site10_S4U16709_20230105_023444_000.zc	
10	0.00	0.00	0.01	0.00	0.75	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.11	0.11	definite	Site10_S4U16709_20230116_013602_000.zc	
10	0.00	0.00	0.01	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.11	complex group	Site10_S4U16709_20221224_000700_000.zc	
10	0.00	0.00	0.01	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.25	0.11	complex group	Site10_S4U16709_20221228_225459_000.zc	
10	0.00	0.00	0.04	0.00	0.76	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.09	0.09	complex group	Site10_S4U16709_20221229_235600_000.zc	
10	0.00	0.00	0.01	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.01	complex group	Site10_S4U16709_20221231_225410_000.zc	
10	0.00	0.00	0.01	0.00	0.63	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.18	0.12	complex group	Site10_S4U16709_20230102_031229_000.zc	
10	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.05	complex group	Site10_S4U16709_20230103_222703_000.zc	
10	0.00	0.00	0.00	0.00	0.12	0.00	0.01	0.00	0.00	0.00	0.00	0.35	0.52	0.00	complex group	Site10_S4U16709_20230103_223349_000.zc	
10	0.00	0.00	0.00	0.00	0.44	0.01	0.01	0.00	0.00	0.00	0.00	0.20	0.35	0.01	complex group	Site10_S4U16709_20230104_000917_000.zc	
10	0.00	0.00	0.01	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.12	0.04	complex group	Site10_S4U16709_20230105_035906_000.zc	
10	0.00	0.00	0.03	0.00	0.70	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.10	0.15	complex group	Site10_S4U16709_20230106_014737_000.zc	
10	0.00	0.00	0.02	0.00	0.78	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.08	0.11	complex group	Site10_S4U16709_20230110_234512_000.zc	
10	0.00	0.00	0.01	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.16	0.08	complex group	Site10_S4U16709_20230111_005353_000.zc	
10	0.00	0.00	0.01	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.15	0.08	complex group	Site10_S4U16709_20230116_233755_000.zc	
10	0.00	0.00	0.01	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14	0.12	complex group	Site10_S4U16709_20230121_025505_000.zc	
10	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.14	0.08	complex group	Site10_S4U16709_20230122_224227_000.zc	
10	0.00	0.00	0.01	0.00	0.78	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.06	0.15	complex group	Site10_S4U16709_20230124_041223_000.zc	
10	0.00	0.00	0.02	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.15	0.08	complex group	Site10_S4U16709_20230126_034913_000.zc	
10	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.15	0.09	complex group	Site10_S4U16709_20230127_030455_000.zc	
10	0.00	0.00	0.01	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.12	0.11	complex group	Site10_S4U16709_20230127_035356_000.zc	

10	0.00	0.00	0.01	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.14	0.06	complex group	Site10_S4U16709_20230130_035819_000.zc	
10	0.00	0.00	0.01	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.09	complex group	Site10_S4U16709_20230131_034627_000.zc	
10	0.00	0.00	0.01	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.24	0.07	complex group	Site10_S4U16709_20230131_040111_000.zc	
10	0.00	0.00	0.02	0.00	0.74	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.10	0.13	complex group	Site10_S4U16709_20230201_033417_000.zc	
10	0.00	0.00	0.01	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.32	0.13	complex group	Site10_S4U16709_20230201_034403_000.zc	30
11	0.00	0.00	0.05	0.00	0.44	0.01	0.01	0.00	0.00	0.00	0.00	0.15	0.35	0.04	definite	Site11_S4U06328_20221224_231417_000.zc	
11	0.00	0.00	0.01	0.00	0.51	0.00	0.01	0.00	0.00	0.00	0.00	0.16	0.28	0.06	definite	Site11_S4U06328_20221230_033205_000.zc	
11	0.00	0.00	0.01	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.12	definite	Site11_S4U06328_20230124_033925_000.zc	
11	0.00	0.00	0.01	0.00	0.66	0.01	0.01	0.00	0.00	0.00	0.00	0.05	0.22	0.05	definite	Site11_S4U06328_20230124_041154_000.zc	
11	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12	0.09	complex group	Site11_S4U06328_20221223_030305_000.zc	
11	0.00	0.00	0.05	0.00	0.58	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.10	0.25	complex group	Site11_S4U06328_20221228_011026_000.zc	
11	0.00	0.00	0.02	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.19	complex group	Site11_S4U06328_20221229_000403_000.zc	
11	0.00	0.00	0.03	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.07	complex group	Site11_S4U06328_20221231_012402_000.zc	
11	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.21	0.09	complex group	Site11_S4U06328_20221231_032515_000.zc	
11	0.00	0.00	0.04	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	complex group	Site11_S4U06328_20221231_215303_000.zc	
11	0.00	0.00	0.03	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.19	complex group	Site11_S4U06328_20221231_231944_000.zc	
11	0.00	0.00	0.05	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	complex group	Site11_S4U06328_20230101_215450_000.zc	
11	0.00	0.00	0.01	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.17	0.19	complex group	Site11_S4U06328_20230103_032802_000.zc	
11	0.00	0.00	0.01	0.00	0.74	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.12	0.10	complex group	Site11_S4U06328_20230105_223311_000.zc	
11	0.00	0.00	0.04	0.00	0.68	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.27	complex group	Site11_S4U06328_20230105_235758_000.zc	
11	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.10	0.15	complex group	Site11_S4U06328_20230106_225815_000.zc	
11	0.00	0.00	0.01	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.16	0.12	complex group	Site11_S4U06328_20230113_234517_000.zc	17
12	0.00	0.00	0.01	0.00	0.69	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.12	0.15	definite	Site12_S4U16733_20221230_034327_000.zc	
12	0.00	0.00	0.01	0.01	0.72	0.04	0.01	0.00	0.00	0.00	0.00	0.09	0.11	0.12	definite	Site12_S4U16733_20230125_004345_000.zc	
12	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.12	complex group	Site12_S4U16733_20221223_030232_000.zc	
12	0.00	0.00	0.02	0.00	0.77	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.06	0.13	complex group	Site12_S4U16733_20221231_001649_000.zc	
12	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.18	0.03	complex group	Site12_S4U16733_20230101_224352_000.zc	
12	0.00	0.00	0.00	0.00	0.78	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.12	0.07	complex group	Site12_S4U16733_20230103_223516_000.zc	
12	0.00	0.00	0.02	0.00	0.55	0.00	0.01	0.00	0.00	0.00	0.00	0.13	0.23	0.11	complex group	Site12_S4U16733_20230104_222744_000.zc	
12	0.00	0.00	0.01	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.26	0.07	complex group	Site12_S4U16733_20230109_012801_000.zc	
12	0.00	0.00	0.02	0.00	0.69	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.17	0.08	complex group	Site12_S4U16733_20230109_024530_000.zc	9

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Disclaimer

Addendum to Identification of echolocation call sequences recorded at Swansons Lane Survey 1.

Saccolaimus flaviventris

A total of 847 recordings were marked by the random forest classifier as containing at least 3 pulses of *Saccolaimus flaviventris*. Many of the recordings contained noise and other species (Figure 1). Due to the greater resolution of Full Spectrum (FS) data compared to Zero Crossing (ZC) data any ambiguous examples from the 847 recordings were also examined in the original full spectrum format. This resulted in the checking of 57 Full spectrum calls across 7 sites, two files from one site (site 7 was not available in FS).

Manual checking of 847 recordings identified by the classifier as containing *Saccolaimus flaviventris* confirmed that no recordings contained the species, this includes the checking of 57 FS recordings. This species was **not identified** in this dataset.

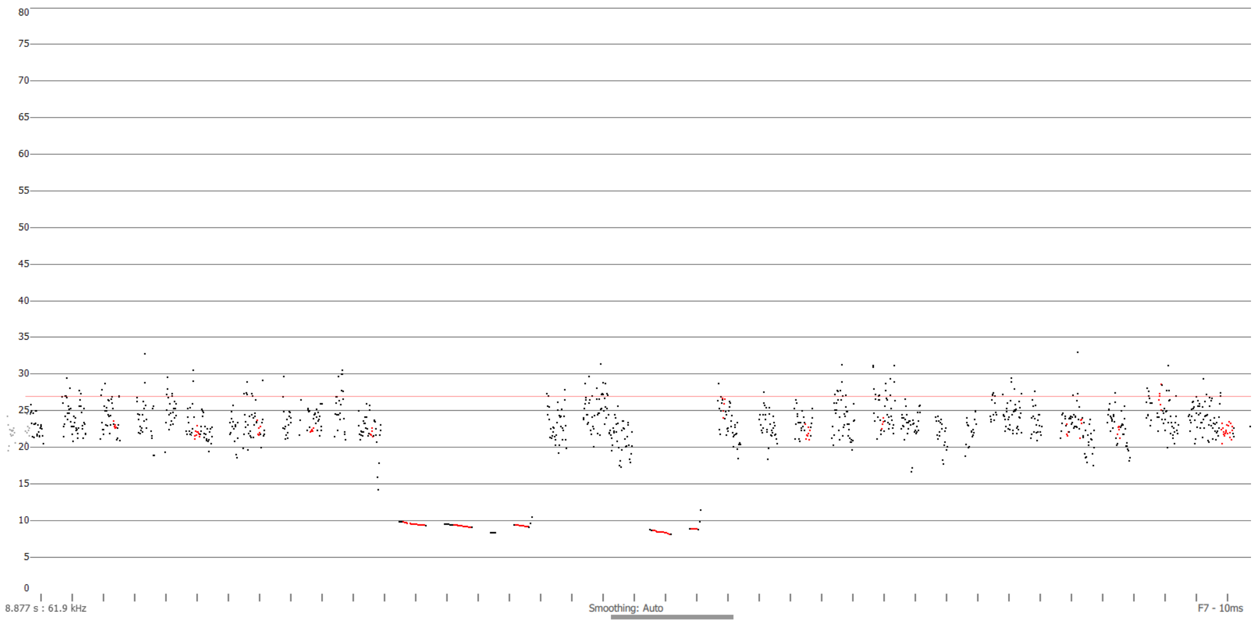


Figure 1. An example of a recording identified as containing *Saccolaimus flaviventris*. This recording contains *Austronomus australis* calls (individual pulses) and noise at 20 kHz.

Examples of FS calls that were checked that didn't contain calls from *Saccolaimus flaviventris*, are presented below in Figure 2 and Figure 3.

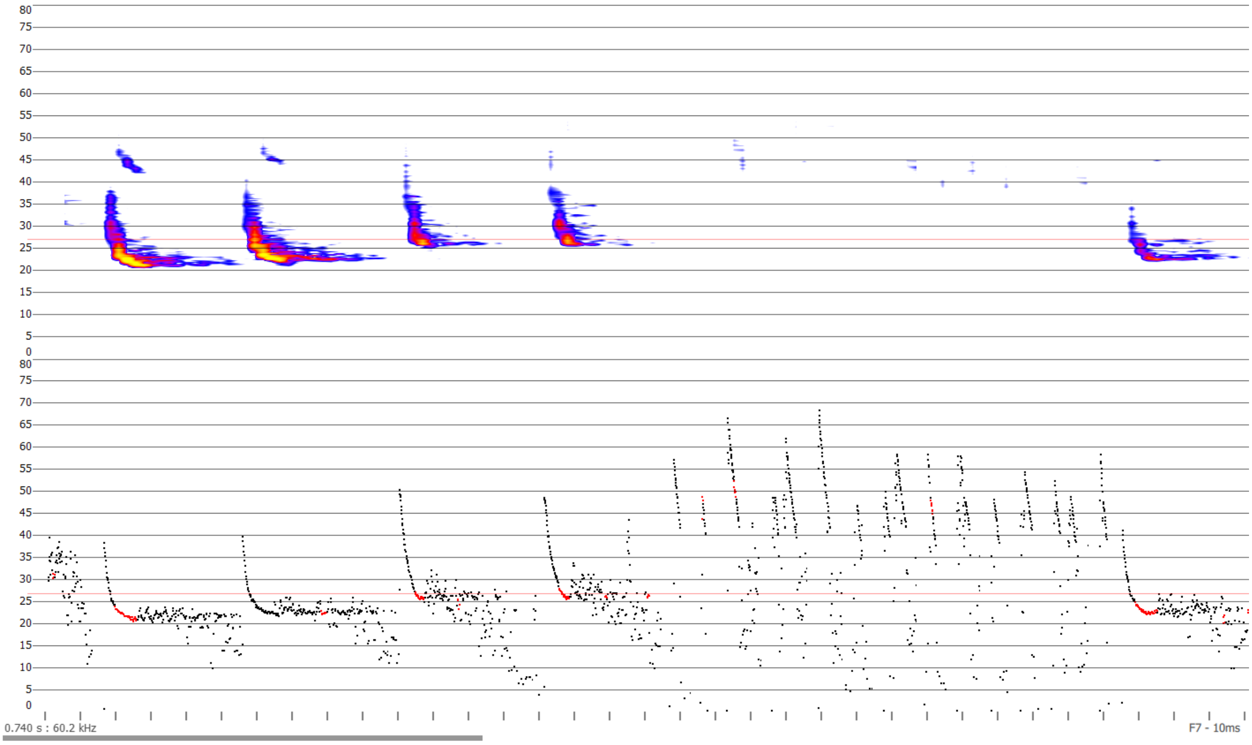


Figure 2. Calls at 20 kHz are likely to be social calls of probable *Myotis macropus* mid-way through the sequence.

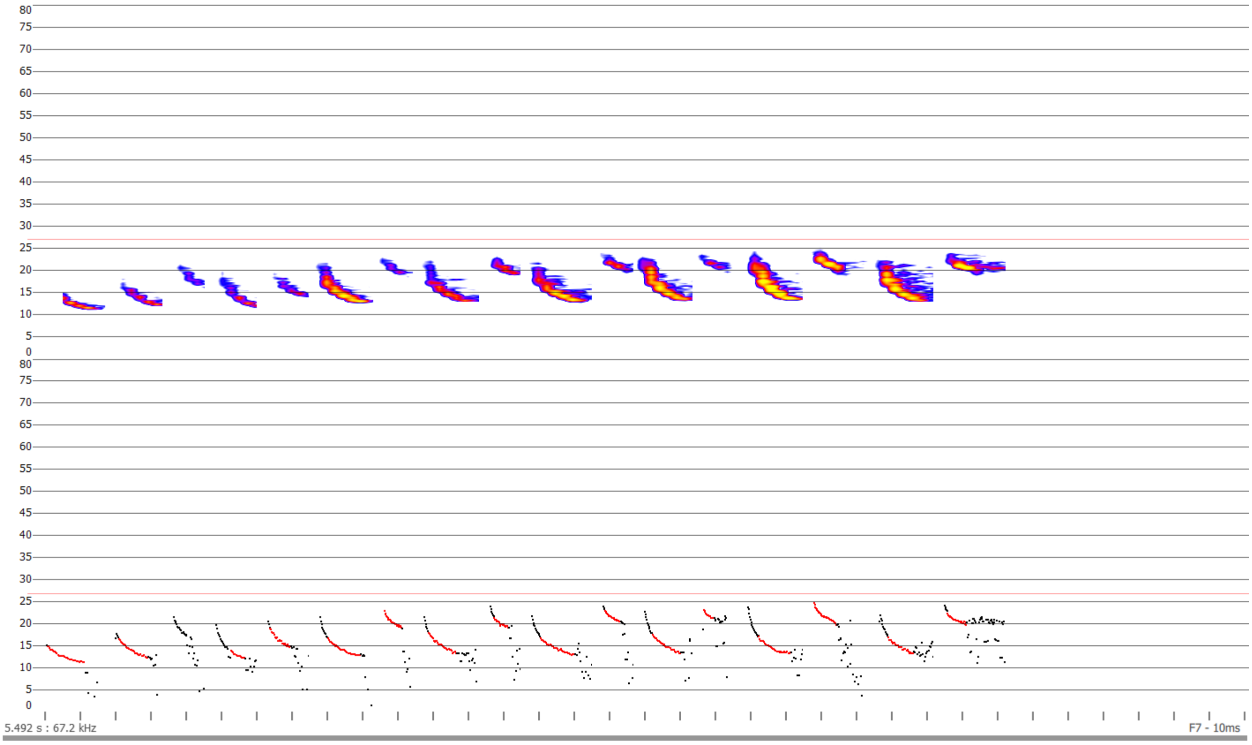


Figure 3. Alternating calls most likely belonging to *Austronomus australis*. These calls may belong to two individuals and hence appear as alternations.

Appendix 2: Echolocation call identification report – Autumn 2023

Identification of echolocation call sequences recorded at Swansons Lane Survey 2.

Methods

Data

Data was received by mail in April 2023. In total 192,868 ZC files were received, collected at 21 sites over 668 survey nights. Files received from client are those that passed passing Kaleidoscope © noise filter, without advanced signal processing. Survey effort per site is presented in Table 1.

Bat call analysis and species identification

In total, 19 predictor variables from each of these datasets were extracted, per call, from the dominant harmonic following Parsons et al. (2000), using the built-in algorithm in Anabat Insight v1.9.7 (Titley Scientific, 2019) (Table 2).

The zero crossing calls were then identified using a combination of machine learning followed my manual validation (following Lo Cascio et al. 2022). This approach uses manually identified free flying bat calls along with reference calls of free flying bats to build a predictive model using a 'random forest classifier' (following Lo Cascio et al. 2022). For species known to exhibit regional variation, reference calls were sourced from within the region.

For a call sequence to be positively categorized, the sequence must contain a minimum of three calls and pass the specifies specific kappa maximising threshold. The kappa maximising threshold is generated from observed and expected accuracy, in this case presence and absence values. These are evaluated against the corresponding confidence scores generated by the random forest classifier, and a kappa statistic is calculated. The threshold at which kappa is highest "kappa maximizing" is taken as a species-specific threshold and areas below this threshold, per species, are considered unlikely to be species based on the model parameters.

For each recording we assigned the species with the most weight. In line with the scope of works, species not considered to be of conservation significance were not manually identified. Therefore, overall activity per site, per night is given without manual verification, as a measure of overall bat activity.

Species of conservation significance

The scope of the analysis required particular attention be given to the identification and counting of echolocation sequences of species of conservation significance. Therefore, calls identified as belonging to the Southern Bent-wing Bat (*Miniopterus orianae bassanii*) and Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) were moved into a folder for manual identification. This included all recordings that had a least three calls identified to the species, even if the species assigned with the most weight differed. Criteria for assigning definite, possible, and unlikely identifications are presented in Table 3.

Call identification was based on call keys and descriptions for bat species in New South Wales (Pennay et al. 2004), and with further reference to information on bat species in southern Queensland (Reinhold et al. 2001), plus the authors' own resource of echolocation recordings collected in southern Victoria (A. Lo Cascio unpublished data).

Nomenclature follows Jackson and Groves (2015). Identifications were supported by distribution information in a curated source of distribution records maintained by the Australasian Bat Society, Inc. (https://www.ausbats.org.au/batmap.html).

Visual inspection of calls attributed to *Miniopterus orianae bassanii* was completed, by Rob Gration Of Eco Aerial Environmental Services. In line with the scope of works reporting of the activity of *Miniopterus orianae bassanii* in the study area has been competed based on this manual identification.

Table 1. Survey effort per site

	Site 1 – S4U09561	Site 2 – S4U16724	Site 3 –S4U11697	Site 4 - S4U11689	Site 5 - S4U11710	Site 6 - S4U16728	Site 8 - S4U16729
Dates	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23
Number of ZC files received from client	16,233	17,650	13,120	39,432	12,447	28,156	14,667
Survey nights	42	42	41	41	12	41	40

	Site 9 - S4U16731	Site 10 - 4U16709	Site 11 - S4U6328	Site 12 - 4U16733	MO1- SMU10192	MO2 - SMU10422	MO3 - SMU10422
Dates	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23	21/02/23 – 3/04/23	9/03/23 – 3/04/23	9/03/23 – 3/04/23	9/03/23 – 3/04/23
Number of ZC files received from client	6,982	5,307	3,282	2,552	877	1,165	2,985
Survey nights	41	40	41	35	26	26	26

	MO4 - SMU10418	MO5 - SMU10420	MO6- SMU10573	MO7- SMU10356	MO8 - SMU10195	MO9 - SMU10275	MO10 - MU10193
Dates							
Number of ZC files received from client	3,669	8,794	795	2,197	1,508	4,088	6,961
Survey nights	26	26	25	25	24	24	24

Table 2 – Call identification criteria for assigning *Miniopterus orianae bassanii* and *Saccolaimus flaviventris* to a recording.

Definite	Recording contains at least 3 calls identified by the classifier as the species	Call is manually verified
Possible	Majority of calls are in the characteristic frequency range for the species **AND**	
	Calls within the sequence contain diagnostic features that assist separation from other species calling within the characteristic frequency range.	***Miniopterus orianae bassanii:*** - Angular knee/heel - Hooks are not cup shaped (*Vespadelus vulturnus, V. regulus*) - Down sweep is more angular than drooping or down sweeping (*Chalinolobus morio*). ***Saccolaimus flaviventris***: - Harmonics can be used to differentiate between *Saccolaimus* species and other bats using the same frequency range. More commonly seen in full spectrum call data.
	If calls are not 'strictly' within the characteristic frequency for the species, there are other diagnostic features.	***Justification****:* It is unlikely that we know the full range of calls produced by the species. There is significant overlap with this species and other species.
Unlikely	Calls are within the characteristic frequency range	**BUT** There is insufficient detail or call structure to assign positive identification **OR** calls have been identified as another species

Table 3. Description of predictor variables.

Metric	Definition
Fc kHz	Characteristic Frequency; the frequency (kHz) at the right-hand end of the portion of the call with the lowest absolute slope (the body)
Sc OPS	Characteristic Slope: the slope of the body of the call measured in Octaves Per Second (OPS).
Dur ms	Pulse Duration: the duration of the pulse, measured in milliseconds
Fmax kHz	The maximum frequency (kHz) of the pulse.
Fmin kHz	The minimum frequency (kHz) of the pulse.
Fmean kHz	The mean frequency, which is a weighted mean FMean = (N – 1) D/2d where N is number of points counted in the display D is the division ratio and d is the duration of the call.
TBC ms	Time between calls; the time from the start of one pulse until the start of the next pulse.
Fk kHz	Frequency of the knee; frequency (kHz) of the junction (point of greatest change in slope) between the initial and pre-characteristic sections
Tk ms	The time from the start of the call to the knee measured in milliseconds (ms).
Quality	The average smoothness for the whole call. Smoothness is the absolute value of the difference between the frequency of any point and the average of the frequencies of the points either side of it divided by the frequency of that point. These values are summed over the whole call
S1 OPS	The slope of the first five points in a pulse
Tc ms	The time from the start of the call to the characteristic section
PMC	The proportion of maximum frequency to characteristic frequency. - PMC = 100 x (FMax - Fc)/Fc
Curvature	A measure to characterize the shape of bat calls where frequency~= timeP (where P is an integer value). If P is a positive number, the call is upward curving
Fstart kHz	The frequency at the start of the pulse. In the case of ZC the frequency of the first ZC dot of the pulse.
Fend kHz	The frequency at the end of the pulse. In the case of ZC the frequency of the last ZC dot of the pulse.
Smin OPS	The minimum amount of slope occurring over 2 to 5 ZC dots within the pulse relating to the flattest part of the pulse.
Smax OPS	The maximum amount of slope occurring over 2 to 5 ZC dots within the pulse relating to the steepest part of the pulse.
Send OPS	The slope of the last 5 ZC dots in each pulse.

Results

Data filtering

From the 192,868 ZC recordings, 4,166,241 individual pulses were extracted using the generate report function in Anabat Insight using a ZC level threshold of 10. Zero crossing pulses with less than all 19 metrics were excluding from the analysis, this removed 127,754 individual calls.

As part of the automated identification process 2,446,914 individual calls passed the species specific threshold, and 132,666 recordings containing 2,264,375 calls were accepted as containing at least 3 pluses of a species. In addition, many of the recordings were marked as containing multiple species, while this is likely to be overstated due to the high overlap of species in this region, many files contained non acoustically overlapping species. The random forest classifier identified the 132,666 recordings to 13 species by assigning the species with the highest mean probability, per call.

Microbat activity per site per night

In line with the scope of works a count of microbat calls per site and per night was generated from automated identification only and is shown in Figure 1 and Table 4. Model confidence for classification of each acoustic recording is provided in Figure 2. The figure depicts the distribution (box and whiskers) of confidence scores (each individual dot) associated with automatically identifying each species. For example, an easier to identify species such as *A. australis*, has a distribution closer to 1 (100% confidence), compared to a harder to identify species such as *V. regulus* who displays a greater spread of confidence values (darker areas lower than higher values). Values closer to one indicated that there is greater confidence that each call was produced by the species that the model assigned identification. Please note that confidence scores are associated with individual calls, each recording can contain 100s of calls from multiple species.

Table 4. Counts of species per site identified by the Classifier **WITHOUT** manual identification.

Site	Species	Count	Totals	Site	Species	Count	Totals
Site01	*A. australis*	563		cont. Site 12			
	C. gouldii	1,960			*Nyctophilus spp.*	85	
	C. morio	3,607			*O. planiceps*	147	
	F. tasmaniensis	2,754			*O. ridei*	74	
	M. o. bassanii	2,053			*S. flaviventris*	3	
	M. macropus	1,405			*V. darlingtoni*	226	
	Nyctophilus spp.	171			*V. regulus*	64	
	O. planiceps	211			*V. vulturnus*	65	2,247
	O. ridei	94		Site13	*A. australis*	126	
	S. flaviventris	66			*C. gouldii*	57	
	V. darlingtoni	239			*C. morio*	2	
	V. regulus	247			*F. tasmaniensis*	77	
	V. vulturnus	615	13,985		*M. o. bassanii*	92	
Site02	*A. australis*	2,604			*M. macropus*	87	
	C. gouldii	3,780			*Nyctophilus spp.*	38	
	C. morio	939			*O. planiceps*	56	
	F. tasmaniensis	2,193			*O. ridei*	9	
	M. o. bassanii	1,541			*S. flaviventris*	1	
	M. macropus	1,284			*V. darlingtoni*	74	
	Nyctophilus spp.	95			*V. regulus*	40	
	O. planiceps	637			*V. vulturnus*	12	671
	O. ridei	120		Site14	*A. australis*	158	
	S. flaviventris	47			*C. gouldii*	90	
	V. darlingtoni	365			*C. morio*	9	
	V. regulus	205			*F. tasmaniensis*	65	
	V. vulturnus	448	14,258		*M. o. bassanii*	107	
Site03	*A. australis*	2,428			*M. macropus*	90	
	C. gouldii	997			*Nyctophilus spp.*	67	
	C. morio	225			*O. planiceps*	87	
	F. tasmaniensis	891			*O. ridei*	14	
	M. o. bassanii	898			*S. flaviventris*	3	
	M. macropus	200			*V. darlingtoni*	87	
	Nyctophilus spp.	182			*V. regulus*	99	
	O. planiceps	78			*V. vulturnus*	43	919
	O. ridei	23		Site15	*A. australis*	1,391	
	S. flaviventris	26			*C. gouldii*	108	
	V. darlingtoni	174			*C. morio*	13	
	V. regulus	174			*F. tasmaniensis*	156	
	V. vulturnus	664	6,960		*M. o. bassanii*	122	
Site04	*A. australis*	10,734			*M. macropus*	180	
	C. gouldii	5,495			*Nyctophilus spp.*	106	
	C. morio	393			*O. planiceps*	171	
	F. tasmaniensis	691			*O. ridei*	42	
	M. o. bassanii	1,665			*V. darlingtoni*	104	
	M. macropus	887			*V. regulus*	106	
	Nyctophilus spp.	252			*V. vulturnus*	20	2,519

	O. planiceps	2,086	
	O. ridei	77	
	S. flaviventris	174	
	V. darlingtoni	191	
	V. regulus	366	
	V. vulturnus	643	23,654
Site05	*A. australis*	4,486	
	C. gouldii	1,289	
	C. morio	1,103	
	F. tasmaniensis	1,488	
	M. o. bassanii	1,072	
	M. macropus	309	
	Nyctophilus spp.	196	
	O. planiceps	551	
	O. ridei	7	
	S. flaviventris	27	
	V. darlingtoni	140	
	V. regulus	385	
	V. vulturnus	297	11,350
Site06	*A. australis*	1,943	
	C. gouldii	3,290	
	C. morio	256	
	F. tasmaniensis	279	
	M. o. bassanii	3,027	
	M. macropus	765	
	Nyctophilus spp.	82	
	O. planiceps	1,472	
	O. ridei	142	
	S. flaviventris	148	
	V. darlingtoni	118	
	V. regulus	192	
	V. vulturnus	428	12,142
Site08	*A. australis*	2,643	
	C. gouldii	1,809	
	C. morio	430	
	F. tasmaniensis	552	
	M. o. bassanii	1,389	
	M. macropus	493	
	Nyctophilus spp.	317	
	O. planiceps	166	
	O. ridei	61	
	S. flaviventris	43	
	V. darlingtoni	129	
	V. regulus	459	
	V. vulturnus	374	
	A. australis	113	8,978
Site09	*C. gouldii*	686	
	C. morio	339	
	F. tasmaniensis	410	
Site16	*A. australis*	1,907	
	C. gouldii	135	
	C. morio	9	
	F. tasmaniensis	135	
	M. o. bassanii	78	
	M. macropus	383	
	Nyctophilus spp.	106	
	O. planiceps	185	
	O. ridei	31	
	S. flaviventris	1	
	V. darlingtoni	72	
	V. regulus	103	
	V. vulturnus	26	3,171
Site17	*A. australis*	283	
	C. gouldii	586	
	C. morio	139	
	F. tasmaniensis	725	
	M. o. bassanii	481	
	M. macropus	1,615	
	Nyctophilus spp.	57	
	O. planiceps	2,181	
	O. ridei	24	
	S. flaviventris	5	
	V. darlingtoni	981	
	V. regulus	263	
	V. vulturnus	82	7,422
Site18	*A. australis*	236	
	C. gouldii	34	
	C. morio	1	
	F. tasmaniensis	35	
	M. o. bassanii	40	
	M. macropus	96	
	Nyctophilus spp.	30	
	O. planiceps	48	
	O. ridei	22	
	S. flaviventris	1	
	V. darlingtoni	30	
	V. regulus	38	
	V. vulturnus	4	615
Site19	*A. australis*	621	
	C. gouldii	94	
	C. morio	33	
	F. tasmaniensis	68	
	M. o. bassanii	99	
	M. macropus	298	
	Nyctophilus spp.	118	
	O. planiceps	148	
	O. ridei	24	
	S. flaviventris	4	

	M. o. bassanii	1,590			*V. darlingtoni*	130	
	M. macropus	490			*V. regulus*	81	
	Nyctophilus spp.	150			*V. vulturnus*	11	1,729
	O. planiceps	85		Site20	*A. australis*	186	
	O. ridei	30			*C. gouldii*	93	
	S. flaviventris	8			*F. tasmaniensis*	1	
	V. darlingtoni	579			*M. o. bassanii*	50	
	V. regulus	395			*M. macropus*	136	
	V. vulturnus	336	5,098		*Nyctophilus spp.*	7	
Site10	*A. australis*	2,585			*O. planiceps*	161	
	C. gouldii	316			*O. ridei*	8	
	C. morio	52			*S. flaviventris*	73	
	F. tasmaniensis	476			*V. darlingtoni*	65	
	M. o. bassanii	460			*V. regulus*	113	
	M. macropus	167			*V. vulturnus*	24	917
	Nyctophilus spp.	159		Site21	*A. australis*	822	
	O. planiceps	135			*C. gouldii*	387	
	O. ridei	73			*C. morio*	39	
	S. flaviventris	2			*F. tasmaniensis*	69	
	V. darlingtoni	84			*M. o. bassanii*	116	
	V. regulus	65			*M. macropus*	216	
	V. vulturnus	121	4,695		*Nyctophilus spp.*	64	
Site11	*A. australis*	533			*O. planiceps*	1,598	
	C. gouldii	349			*O. ridei*	16	
	C. morio	37			*S. flaviventris*	2	
	F. tasmaniensis	176			*V. darlingtoni*	48	
	M. o. bassanii	429			*V. regulus*	107	
	M. macropus	72			*V. vulturnus*	16	3,500
	Nyctophilus spp.	12		Site22	*A. australis*	1,260	
	O. planiceps	72			*C. gouldii*	505	
	O. ridei	36			*C. morio*	13	
	S. flaviventris	3			*F. tasmaniensis*	136	
	V. darlingtoni	568			*M. o. bassanii*	421	
	V. regulus	260			*M. macropus*	381	
	V. vulturnus	98	2,645		*Nyctophilus spp.*	57	
Site12	*A. australis*	564			*O. planiceps*	1,745	
	C. gouldii	339			*O. ridei*	21	
	C. morio	11			*S. flaviventris*	11	
	F. tasmaniensis	321			*V. darlingtoni*	263	
	M. o. bassanii	233			*V. regulus*	362	
	M. macropus	115			*V. vulturnus*	16	5,191

There are likely to be errors in identification based on automated identification, particularly for species known to display high overlap of call parameters with other species in the dataset. This is also likely for species calling in a frequency range common for insect sounds or other noise commonly recorded in acoustic datasets. As noted, automated identification presented in this table is based on assigning the species with the most weight per recording, this approach favours easier to identify species (Lo Cascio et al., 2022).

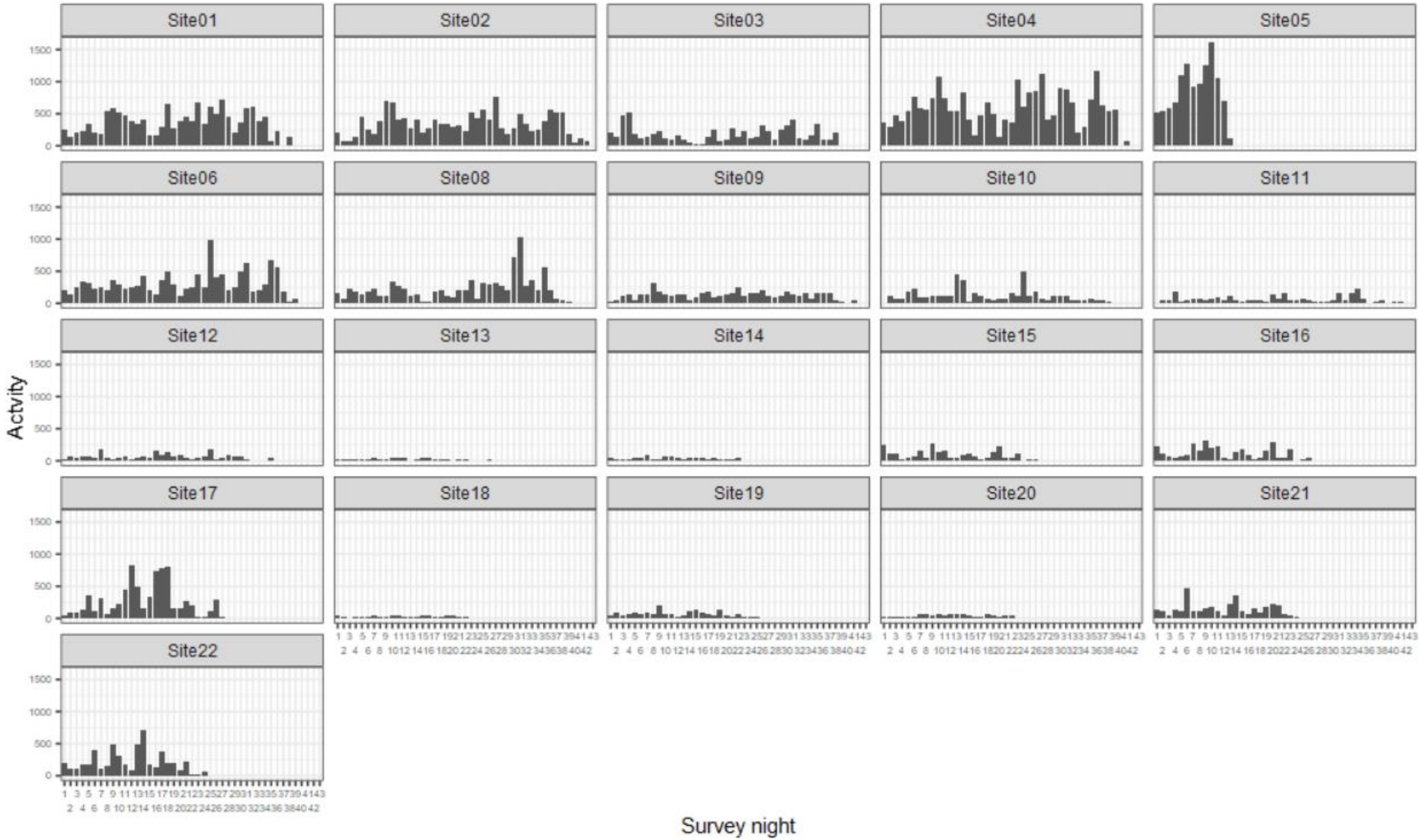


Figure 1. Count of total bat recordings per site generated from automated identification only. For ease of plotting survey night is sequential night of survey which is provided in Table 1.

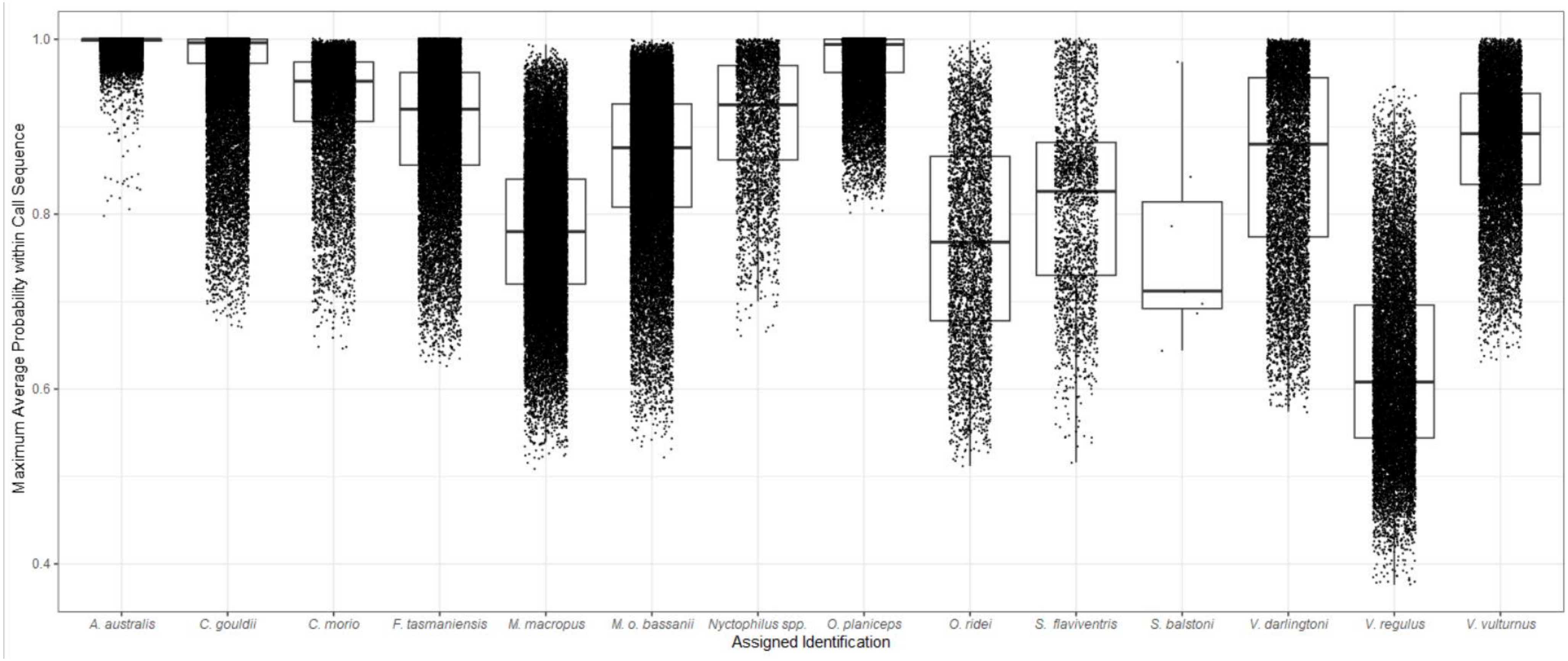


Figure 2. Distribution of confidence scores from Random Forest Classifier for identification of each individual call (pulse). The density of points and box plots indicate the range of values generated by the Classifier for identification of each species. Note probability values used are specific for each species after using a kappa maximising threshold (following Lo Cascio et al., 2022).

Reliability of species identification for species of conservation significance

Miniopterus orianae bassanii

Automated identification attributed 24,285 recordings having at least 3 calls belonging to *M. o. bassanii*, i.e., taking the average across the recording might identify another species – this was done for cases were multiple species occur within a recording. Of these 15,963 recordings were assigned to *M.o. bassanii* predominantly. All 24,285 recordings were manually checked. **This species was identified in this dataset**.

For pulses with a characteristic frequency in the range of 45 – 50 kHz, there are several features that can be used to attribute a call sequence to this species, or other species with similar calls such as *Vespadelus regulus*, *V. vulturnus* and *Chalinolobus morio*. The search phase echolocation calls of *M. o. bassanii* sometimes have 'drooped' (decreasing frequency) terminations to pulses, but pulses also terminate abruptly without increasing or decreasing terminating frequency sweeps, so that they flatten rather than down sweep. An angular knee/heel is also typical in cruise phase.

Frequency characteristics of the feeding buzz can also be used to separate *Miniopterus* from vespertilionids, but there are typically relatively few feeding buzz examples in a given recording dataset. Other useful features for use in identification have been reported for *Miniopterus* species in the Solomon Islands (energy distribution at different points of the pulse; Pennay & Lavery, 2017), but their applicability needs to be demonstrated further in Australia, as well as the degree to which such features are diagnostic.

Not all sequences from *M. o. bassanii* will contain enough information to allow confident identification, allowing separation from Vespadelus species or *Chalinolobus morio*. It is therefore appropriate to assign complex groups. Comparison of model confidence with manually identified calls indicate high overlap between the definite and species complex calls (Figure 3) and as such counts per site for this species include both categories.

The random forest model assigned 15,963 recordings as belonging to *M.o. bassanii* predominantly. Calls were in the appropriate frequency range for this species, and it is possible that these sequences all contain *M.o. bassanii*. Manual identification further assigned 85 sequences as definite and 93 sequences as possible (Table 5).

The high overlap of this species calls with other species effect its identification from acoustic datasets (Lo Cascio et al. 2022). Thereby, estimations of activity based on definite identifications only, are likely to be underestimated. Unlike species-specific bird songs whose function is to convey unambiguous messages to conspecifics, the echolocation calls of bats have been selected for navigating and hunting (Barclay, 1999; Russo et al., 2018). Accordingly, species occupying similar foraging niches are known to produce similar calls due to adaptive convergence or phylogenetic relatedness (Russo et al., 2018). Echolocation call plasticity, whereby an individual changes call structure to fulfill different tasks (Obrist, 1995), further increases the likelihood that an individual's calls may resemble those of another species.

Further, flight and foraging strategies of these species suggest that the number of calls used to make up activity are not directly comparable. For example, *M.o. bassanii* flies fast with low manoeuvrability, foraging primarily above-canopy and in open-spaces; whereas the two forest bats it overlaps with acoustically (*V. vulturnus, V. regulus*) are 'clutter' adapted, with slow, highly agile flight, and forage mainly below-canopy and close to vegetation (Fullard et al., 1991; Norberg & Rayner, 1987; O'Neill & Taylor, 2006). This means that it is common to record multiple, long-duration forest bat call sequences as individuals circle and make repeated passes above the detector (i.e., one individual is recorded many times within a short period). In contrast, *M.o. bassanii* is more likely to pass quickly over the detector, resulting in relatively shorter call sequences being recorded less often than forest bat calls (Pennay & Lavery 2017; Van Harten et al., 2022).These different foraging behaviours also mean that detectors placed in open areas are more likely to record *M.o. bassanii than Vespadelus species* (Holz et al., 2020).

An outcome of this analysis is the ability to objectively compare activity of threatened species over time. While manual identification is an important step there will be differences in the number of call sequences identified to a given species for a given dataset based on the method used, and the person undertaking the analysis. That is activity levels of *M. o. bassanii* will be influenced by any difference in interpretation between analysts, the analysis methods used, aspects of survey timing and detector placement, and seasonality. If activity levels are being used within a project to make biological interpretations, then there is an imperative to standardise the sampling and analysis to minimise the effect of confounding factors.

Table 5. Count of definite and possible identifications of *M.o. bassanii* per site, based on manual identification. Counts include complex groups containing species known to overall significantly with *M.o. bassanii* in this region.

Site	*Miniopterus orianae bassanii*	Manual Identification
Site01	6 7	Definite Possible
Site02	8 8	Definite Possible
Site03	10 11	Definite Possible
Site04	3 8	Definite Possible
Site05	14 10	Definite Possible
Site06	14 15	Definite Possible
Site08	10 6	Definite Possible
Site09	6 5	Definite Possible
Site10	1 4	Definite Possible
Site11	3 2	Definite Possible
Site12	2 1	Definite Possible
Site13	1	Possible
Site14	1	Possible
Site17	4 8	Definite Possible
Site20	3	Possible
Site21	3	Possible
Site22	4	Definite

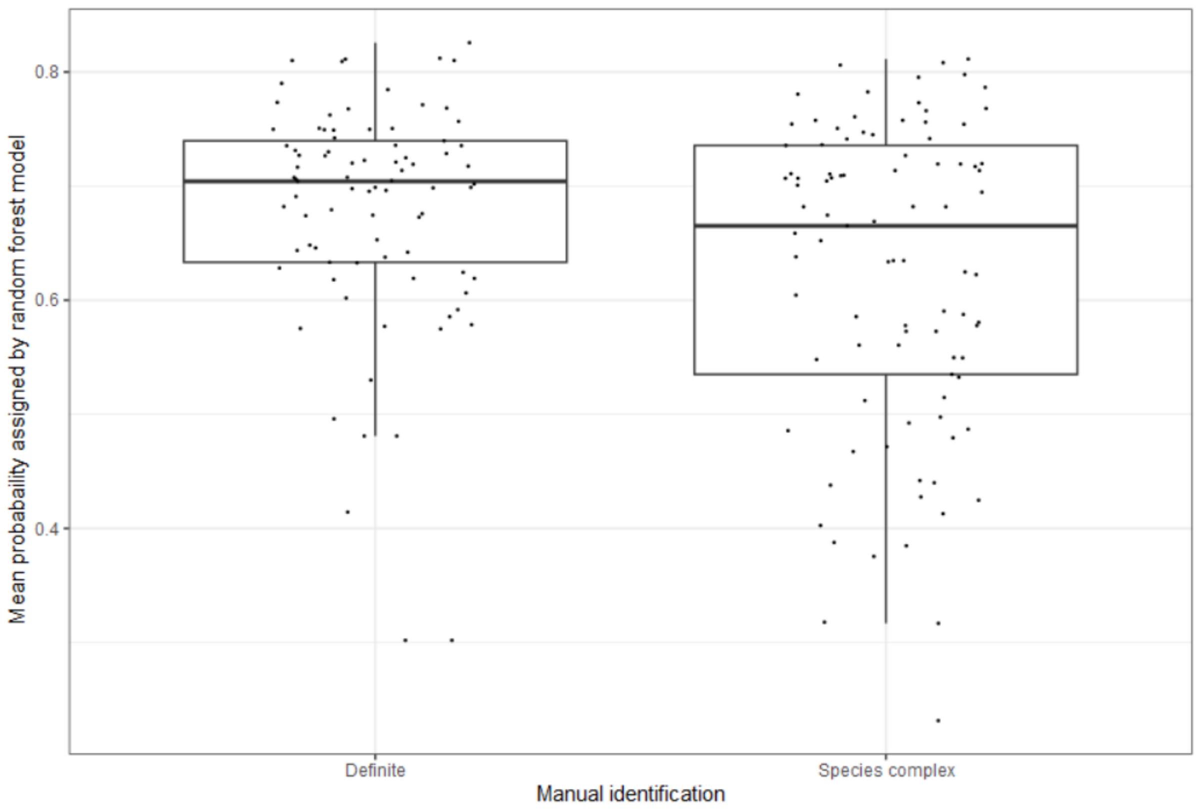
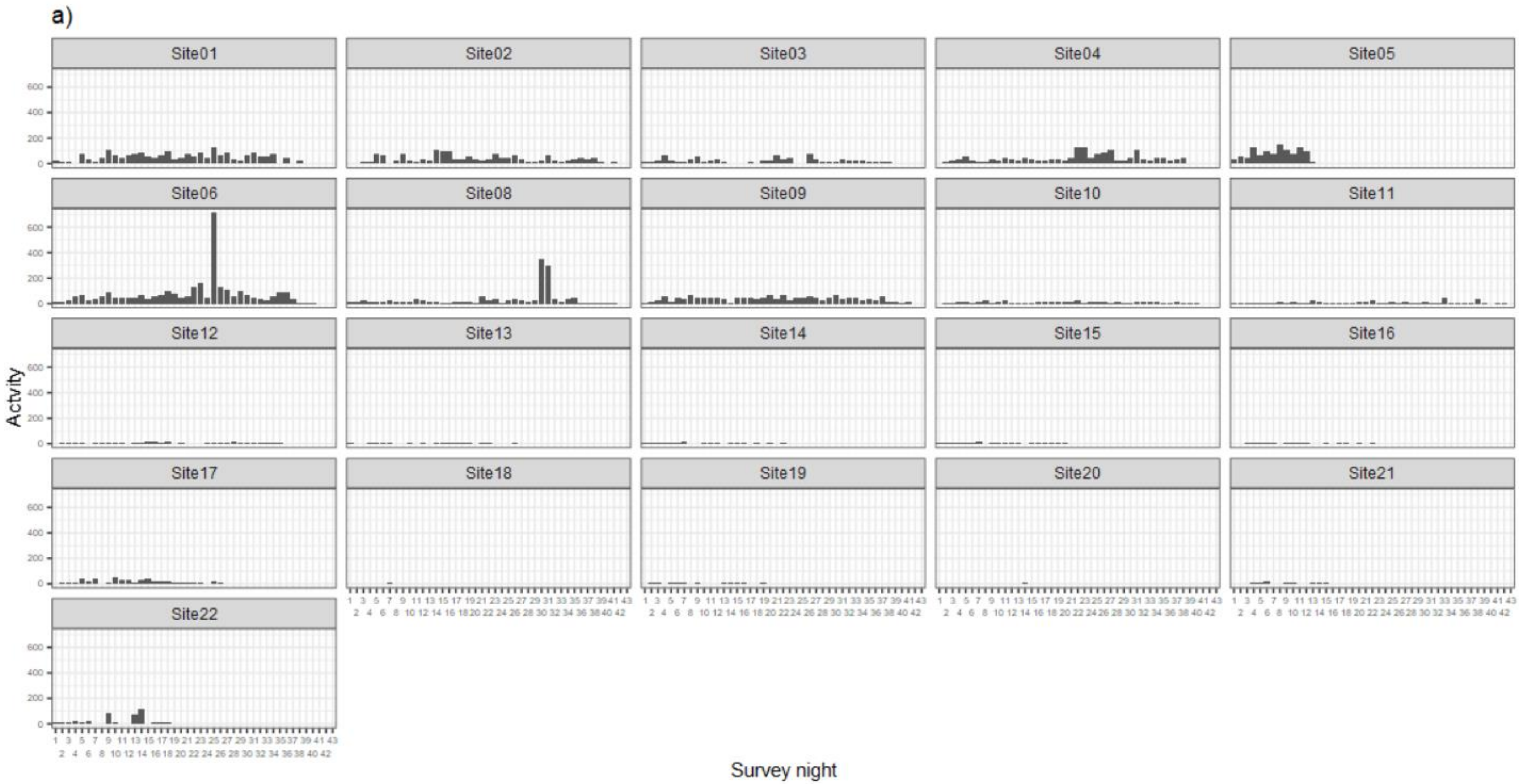
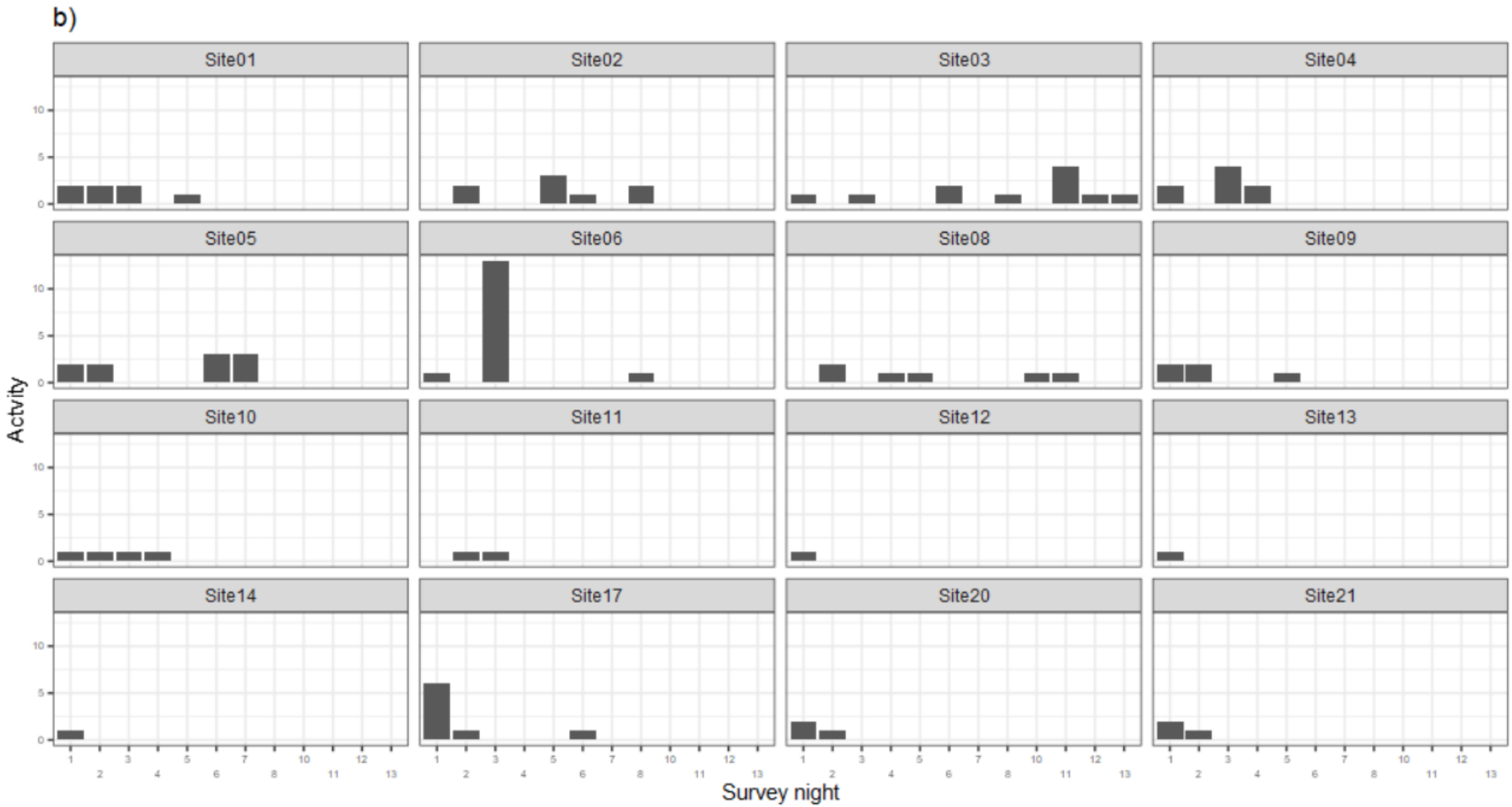


Figure 3. Com parison of model confidence with manually identified *M.o. bassanii* calls assigned to definite and complex groups.

Activity of *Miniopterus orianae bassanii*




b)
Site01
Site02
Site03
Site04
Site05
Site06
Site08
Site09
Site10
Site11
Site12
Site13
Site14
Site17
Site20
Site21
Activity
Survey night

c)

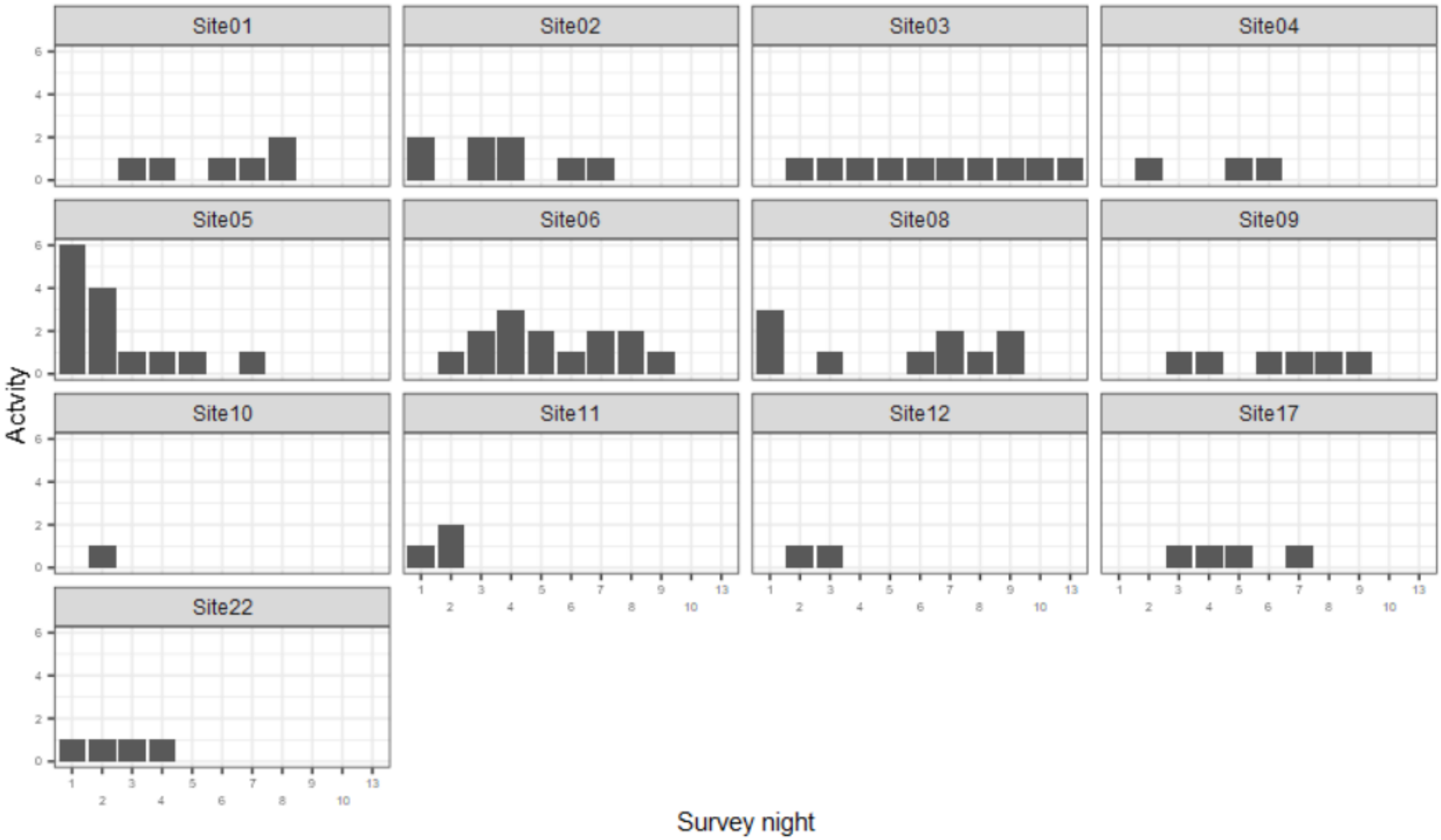

Site01
Site02
Site03
Site04
Site05
Site06
Site08
Site09
Site10
Site11
Site12
Site17
Site22
Activity
Survey night

Figure 4. a) Site activity of *Miniopterus orianae bassanii* based on automatically identified calls plot; b) manually identified Species Complex calls plot; c) and manually identified definite calls plot. For ease of plotting survey night is sequential night of survey which is provided in Table 1. Please note that y – axes are not on the same scale.

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Appendix

Table S1 - Count of definite and possible identifications of *M.o. bassanii* per site. Counts include complex groups containing species known to overlap significantly with *M.o. bassanii* in this region. Calls have been manually verified and model probability means calculated per recording are provided. Model probability scale is from 0 – 1.

Site	*Austronomus australis*	*Chalinolobus gouldii*	*Chalinolobus morio*	*Falsistrellus tasmaniensis*	*Miniopterus orianae bassanii*	*Myotis macropus*	*Nyctophilus spp.*	*Ozimops planiceps*	*Ozimops ridei*	*Saccolaimus flaviventris*	*Scotorepens balstoni*	*Vespadelus darlingtoni*	*Vespadelus regulus*	*Vespadelus vulturnus*	Manual identification	File name
Site01	0.00	0.00	0.03	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	Definite	Site01_S4U09561_20230221_211215_000.zc
Site01	0.00	0.00	0.02	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.23	Definite	Site01_S4U09561_20230221_233646_000.zc
Site01	0.00	0.00	0.02	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.23	Definite	Site01_S4U09561_20230225_233407_000.zc
Site01	0.00	0.00	0.01	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.18	Definite	Site01_S4U09561_20230227_222356_000.zc
Site01	0.00	0.00	0.10	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	Definite	Site01_S4U09561_20230304_210122_000.zc
Site01	0.00	0.00	0.02	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.18	Definite	Site01_S4U09561_20230312_000640_000.zc
Site01	0.00	0.00	0.03	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.17	Species complex	Site01_S4U09561_20230222_004327_000.zc
Site01	0.00	0.00	0.03	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.17	Species complex	Site01_S4U09561_20230222_004327_000.zc
Site01	0.00	0.00	0.02	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.18	Species complex	Site01_S4U09561_20230228_214234_000.zc
Site01	0.00	0.00	0.05	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	Species complex	Site01_S4U09561_20230312_052456_000.zc
Site01	0.00	0.00	0.02	0.00	0.67	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.14	0.13	Species complex	Site01_S4U09561_20230312_213945_000.zc
Site01	0.00	0.00	0.01	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.19	0.30	Species complex	Site01_S4U09561_20230314_214424_000.zc
Site01	0.00	0.00	0.27	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.15	Species complex	Site01_S4U09561_20230314_215848_000.zc
Site02	0.00	0.00	0.06	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	Definite	Site02_S4U16724_20230227_212642_000.zc
Site02	0.00	0.00	0.06	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	Definite	Site02_S4U16724_20230227_212642_000.zc
Site02	0.00	0.00	0.02	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.19	Definite	Site02_S4U16724_20230228_215623_000.zc
Site02	0.00	0.00	0.02	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	Definite	Site02_S4U16724_20230301_222308_000.zc
Site02	0.00	0.00	0.03	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	Definite	Site02_S4U16724_20230308_021924_000.zc
Site02	0.00	0.00	0.03	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.28	Definite	Site02_S4U16724_20230308_232147_000.zc
Site02	0.00	0.00	0.03	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.16	Definite	Site02_S4U16724_20230310_223745_000.zc
Site02	0.00	0.00	0.03	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.21	Definite	Site02_S4U16724_20230310_231853_000.zc
Site02	0.00	0.00	0.51	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	Species complex	Site02_S4U16724_20230225_031639_000.zc
Site02	0.00	0.44	0.01	0.00	0.28	0.01	0.00	0.15	0.02	0.00	0.01	0.00	0.01	0.06	Species complex	Site02_S4U16724_20230225_230332_000.zc
Site02	0.00	0.00	0.01	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.23	Species complex	Site02_S4U16724_20230301_022252_000.zc
Site02	0.00	0.00	0.01	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.13	Species complex	Site02_S4U16724_20230307_011027_000.zc
Site02	0.00	0.00	0.01	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	Species complex	Site02_S4U16724_20230307_011051_000.zc
Site02	0.00	0.00	0.01	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.18	Species complex	Site02_S4U16724_20230307_011214_000.zc
Site02	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.05	Species complex	Site02_S4U16724_20230312_213632_000.zc
Site02	0.00	0.00	0.03	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	Species complex	Site02_S4U16724_20230312_214352_000.zc
Site03	0.00	0.00	0.02	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.16	Definite	Site03_S4U11697_20230221_231745_000.zc
Site03	0.00	0.00	0.02	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.15	Definite	Site03_S4U11697_20230224_013633_000.zc
Site03	0.00	0.00	0.03	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.24	Definite	Site03_S4U11697_20230225_014302_000.zc

Site03	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	Definite	Site03_S4U11697_20230228_035942_000.zc
Site03	0.00	0.00	0.31	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	Definite	Site03_S4U11697_20230305_041937_000.zc
Site03	0.00	0.00	0.02	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.14	Definite	Site03_S4U11697_20230314_224004_000.zc
Site03	0.00	0.00	0.10	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	Definite	Site03_S4U11697_20230322_224225_000.zc
Site03	0.00	0.00	0.09	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	Definite	Site03_S4U11697_20230325_041121_000.zc
Site03	0.00	0.00	0.22	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	Definite	Site03_S4U11697_20230327_042930_000.zc
Site03	0.00	0.00	0.18	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	Definite	Site03_S4U11697_20230330_204728_000.zc
Site03	0.00	0.00	0.43	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	Species complex	Site03_S4U11697_20230221_215831_000.zc
Site03	0.00	0.00	0.02	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.13	Species complex	Site03_S4U11697_20230222_001146_000.zc
Site03	0.00	0.00	0.16	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	Species complex	Site03_S4U11697_20230223_015959_000.zc
Site03	0.00	0.00	0.17	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	Species complex	Site03_S4U11697_20230223_020006_000.zc
Site03	0.00	0.00	0.13	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	Species complex	Site03_S4U11697_20230223_042240_000.zc
Site03	0.00	0.00	0.08	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	Species complex	Site03_S4U11697_20230223_042246_000.zc
Site03	0.00	0.00	0.34	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	Species complex	Site03_S4U11697_20230228_231543_000.zc
Site03	0.00	0.00	0.03	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.59	Species complex	Site03_S4U11697_20230311_233227_000.zc
Site03	0.00	0.00	0.10	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	Species complex	Site03_S4U11697_20230314_214238_000.zc
Site03	0.00	0.00	0.02	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.14	0.24	Species complex	Site03_S4U11697_20230314_220901_000.zc
Site03	0.00	0.00	0.41	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	Species complex	Site03_S4U11697_20230327_021903_000.zc
Site04	0.00	0.00	0.01	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.34	Definite	Site04_S4U11689_20230302_000704_000.zc
Site04	0.00	0.00	0.01	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.20	Definite	Site04_S4U11689_20230310_215736_000.zc
Site04	0.00	0.00	0.13	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.26	Definite	Site04_S4U11689_20230323_002704_000.zc
Site04	0.00	0.00	0.01	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.19	Species complex	Site04_S4U11689_20230309_222358_000.zc
Site04	0.00	0.00	0.01	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.19	Species complex	Site04_S4U11689_20230309_222358_000.zc
Site04	0.00	0.00	0.01	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.47	Species complex	Site04_S4U11689_20230312_213747_000.zc
Site04	0.00	0.00	0.01	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.22	Species complex	Site04_S4U11689_20230312_213838_000.zc
Site04	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.17	Species complex	Site04_S4U11689_20230314_214716_000.zc
Site04	0.00	0.00	0.02	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.20	Species complex	Site04_S4U11689_20230314_215902_000.zc
Site04	0.00	0.00	0.01	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.17	Species complex	Site04_S4U11689_20230314_221307_000.zc
Site04	0.00	0.00	0.02	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	Species complex	Site04_S4U11689_20230314_221403_000.zc
Site05	0.00	0.00	0.04	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.32	Definite	Site05_S4U11710_20230222_000038_000.zc
Site05	0.00	0.00	0.04	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.26	Definite	Site05_S4U11710_20230224_015948_000.zc
Site05	0.00	0.00	0.05	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.35	Definite	Site05_S4U11710_20230225_004906_000.zc
Site05	0.00	0.00	0.06	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	Definite	Site05_S4U11710_20230227_035058_000.zc
Site05	0.00	0.00	0.50	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	Definite	Site05_S4U11710_20230228_214418_000.zc
Site05	0.00	0.00	0.03	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.15	Definite	Site05_S4U11710_20230228_221814_000.zc
Site05	0.00	0.00	0.05	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.17	Definite	Site05_S4U11710_20230228_230636_000.zc

Site05	0.00	0.00	0.04	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.21	Definite	Site05_S4U11710_20230228_235322_000.zc
Site05	0.00	0.09	0.13	0.41	0.11	0.15	0.03	0.00	0.01	0.00	0.01	0.01	0.00	0.04	Definite	Site05_S4U11710_20230301_000301_000.zc
Site05	0.00	0.00	0.58	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	Definite	Site05_S4U11710_20230301_003143_000.zc
Site05	0.00	0.00	0.58	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	Definite	Site05_S4U11710_20230301_003519_000.zc
Site05	0.00	0.00	0.60	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	Definite	Site05_S4U11710_20230301_004212_000.zc
Site05	0.00	0.00	0.21	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.30	0.04	Definite	Site05_S4U11710_20230301_051303_000.zc
Site05	0.00	0.00	0.21	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.30	0.04	Definite	Site05_S4U11710_20230301_051303_000.zc
Site05	0.00	0.00	0.11	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.33	Species complex	Site05_S4U11710_20230222_003340_000.zc
Site05	0.00	0.00	0.03	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.15	Species complex	Site05_S4U11710_20230222_003812_000.zc
Site05	0.00	0.00	0.04	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.41	Species complex	Site05_S4U11710_20230222_013236_000.zc
Site05	0.00	0.00	0.04	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.17	0.12	Species complex	Site05_S4U11710_20230223_001908_000.zc
Site05	0.00	0.00	0.12	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	Species complex	Site05_S4U11710_20230223_032220_000.zc
Site05	0.00	0.00	0.02	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.15	Species complex	Site05_S4U11710_20230223_033115_000.zc
Site05	0.00	0.00	0.02	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.19	Species complex	Site05_S4U11710_20230228_001716_000.zc
Site05	0.00	0.00	0.44	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	Species complex	Site05_S4U11710_20230228_012919_000.zc
Site05	0.00	0.00	0.75	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	Species complex	Site05_S4U11710_20230301_044031_000.zc
Site05	0.32	0.25	0.01	0.00	0.21	0.02	0.00	0.09	0.01	0.00	0.01	0.00	0.01	0.06	Species complex	Site05_S4U11710_20230301_225327_000.zc
Site06	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.22	Definite	Site06_S4U16728_20230225_222407_000.zc
Site06	0.00	0.00	0.02	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.20	Definite	Site06_S4U16728_20230228_212823_000.zc
Site06	0.00	0.00	0.03	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.23	Definite	Site06_S4U16728_20230228_212932_000.zc
Site06	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.18	Definite	Site06_S4U16728_20230301_011254_000.zc
Site06	0.00	0.00	0.01	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.20	Definite	Site06_S4U16728_20230301_045448_000.zc
Site06	0.00	0.00	0.03	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.28	Definite	Site06_S4U16728_20230308_022034_000.zc
Site06	0.00	0.00	0.02	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.18	Definite	Site06_S4U16728_20230310_211602_000.zc
Site06	0.00	0.00	0.02	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.24	Definite	Site06_S4U16728_20230310_213227_000.zc
Site06	0.00	0.00	0.02	0.00	0.62	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.08	0.27	Definite	Site06_S4U16728_20230311_211243_000.zc
Site06	0.00	0.00	0.02	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.19	Definite	Site06_S4U16728_20230311_212425_000.zc
Site06	0.00	0.00	0.02	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	Definite	Site06_S4U16728_20230311_213834_000.zc
Site06	0.00	0.00	0.02	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	Definite	Site06_S4U16728_20230314_221343_000.zc
Site06	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.25	Definite	Site06_S4U16728_20230314_225353_000.zc
Site06	0.00	0.00	0.02	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	Definite	Site06_S4U16728_20230317_013026_000.zc
Site06	0.00	0.00	0.03	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.24	Species complex	Site06_S4U16728_20230228_215746_000.zc
Site06	0.00	0.00	0.01	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.50	Species complex	Site06_S4U16728_20230313_052004_000.zc
Site06	0.00	0.00	0.02	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.34	Species complex	Site06_S4U16728_20230314_215300_000.zc
Site06	0.00	0.00	0.02	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	Species complex	Site06_S4U16728_20230314_215518_000.zc
Site06	0.00	0.00	0.01	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.19	Species complex	Site06_S4U16728_20230314_215748_000.zc
Site06	0.00	0.00	0.03	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.37	Species complex	Site06_S4U16728_20230314_220201_000.zc

Site06	0.00	0.00	0.20	0.00	0.55	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.20	Species complex	Site06_S4U16728_20230314_220254_000.zc
Site06	0.00	0.00	0.01	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	Species complex	Site06_S4U16728_20230314_220457_000.zc
Site06	0.00	0.00	0.04	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.25	Species complex	Site06_S4U16728_20230314_220546_000.zc
Site06	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.17	0.33	Species complex	Site06_S4U16728_20230314_220625_000.zc
Site06	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.18	Species complex	Site06_S4U16728_20230314_220725_000.zc
Site06	0.00	0.00	0.01	0.00	0.53	0.01	0.03	0.00	0.00	0.00	0.00	0.08	0.14	0.19	Species complex	Site06_S4U16728_20230314_220824_000.zc
Site06	0.00	0.00	0.01	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.14	Species complex	Site06_S4U16728_20230314_220933_000.zc
Site06	0.00	0.00	0.02	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.33	Species complex	Site06_S4U16728_20230314_221130_000.zc
Site06	0.00	0.01	0.01	0.17	0.23	0.18	0.03	0.00	0.00	0.00	0.00	0.08	0.08	0.22	Species complex	Site06_S4U16728_20230314_221324_000.zc
Site08	0.00	0.00	0.04	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.21	Definite	Site08_S4U16729_20230226_012409_000.zc
Site08	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.24	Definite	Site08_S4U16729_20230226_233924_000.zc
Site08	0.00	0.00	0.03	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.24	Definite	Site08_S4U16729_20230227_233433_000.zc
Site08	0.00	0.00	0.01	0.00	0.71	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.08	0.17	Definite	Site08_S4U16729_20230301_215701_000.zc
Site08	0.00	0.00	0.02	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.17	Definite	Site08_S4U16729_20230301_225642_000.zc
Site08	0.00	0.00	0.04	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.20	Definite	Site08_S4U16729_20230308_020706_000.zc
Site08	0.00	0.00	0.01	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.19	Definite	Site08_S4U16729_20230317_022026_000.zc
Site08	0.00	0.48	0.01	0.00	0.34	0.02	0.00	0.01	0.02	0.00	0.01	0.00	0.01	0.10	Definite	Site08_S4U16729_20230322_222700_000.zc
Site08	0.00	0.48	0.01	0.00	0.34	0.02	0.00	0.01	0.02	0.00	0.01	0.00	0.01	0.10	Definite	Site08_S4U16729_20230322_222700_000.zc
Site08	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.15	Definite	Site08_S4U16729_20230322_230739_000.zc
Site08	0.00	0.00	0.01	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	Species complex	Site08_S4U16729_20230222_005105_000.zc
Site08	0.00	0.00	0.32	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	Species complex	Site08_S4U16729_20230223_033817_000.zc
Site08	0.00	0.00	0.02	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.19	0.24	Species complex	Site08_S4U16729_20230312_213633_000.zc
Site08	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.18	Species complex	Site08_S4U16729_20230314_220946_000.zc
Site08	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.17	0.07	Species complex	Site08_S4U16729_20230323_001137_000.zc
Site08	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.16	Species complex	Site08_S4U16729_20230323_232846_000.zc
Site09	0.00	0.00	0.02	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.18	Definite	Site09_S4U16731_20230228_205742_000.zc
Site09	0.00	0.00	0.02	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.21	Definite	Site09_S4U16731_20230301_023930_000.zc
Site09	0.00	0.00	0.01	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.16	Definite	Site09_S4U16731_20230303_024253_000.zc
Site09	0.00	0.00	0.03	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.22	Definite	Site09_S4U16731_20230306_020010_000.zc
Site09	0.00	0.00	0.02	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.24	Definite	Site09_S4U16731_20230317_002258_000.zc
Site09	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.12	Definite	Site09_S4U16731_20230327_044123_000.zc
Site09	0.00	0.00	0.09	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	Species complex	Site09_S4U16731_20230310_031844_000.zc
Site09	0.00	0.00	0.01	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.34	Species complex	Site09_S4U16731_20230314_220249_000.zc
Site09	0.00	0.00	0.01	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.34	Species complex	Site09_S4U16731_20230314_220249_000.zc
Site09	0.00	0.00	0.02	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.23	Species complex	Site09_S4U16731_20230331_053925_000.zc

Site09	0.00	0.00	0.02	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.23	Species complex	Site09_S4U16731_20230331_053925_000.zc
Site10	0.00	0.00	0.01	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.24	0.07	Species complex	Site10_S4U16709_20230301_214543_000.zc
Site10	0.00	0.00	0.01	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.10	0.08	Species complex	Site10_S4U16709_20230312_213800_000.zc
Site10	0.00	0.00	0.04	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.22	Species complex	Site10_S4U16709_20230323_212125_000.zc
Site11	0.00	0.00	0.03	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.18	Definite	Site11_S4U06328_20230301_231206_000.zc
Site11	0.00	0.00	0.05	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	Definite	Site11_S4U06328_20230306_220655_000.zc
Site11	0.00	0.00	0.01	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	Species complex	Site11_S4U06328_20230228_230635_000.zc
Site12	0.00	0.00	0.05	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.25	Definite	Site12_S4U16733_20230310_211336_000.zc
Site12	0.00	0.00	0.04	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	Definite	Site12_S4U16733_20230316_004347_000.zc
Site12	0.00	0.00	0.02	0.00	0.68	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.15	0.12	Species complex	Site12_S4U16733_20230307_011026_000.zc
Site13	0.00	0.00	0.02	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.28	0.10	Species complex	Site13_SMU10192_20230314_215515_000.zc
Site14	0.00	0.00	0.04	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.25	Species complex	Site14_SMU10422_20230312_214354_000.zc
Site17	0.00	0.00	0.04	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.22	Definite	Site17_SMU10420_20230318_041516_000.zc
Site17	0.00	0.00	0.14	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	Definite	Site17_SMU10420_20230321_042247_000.zc
Site17	0.00	0.00	0.05	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.17	Definite	Site17_SMU10420_20230323_000402_000.zc
Site17	0.00	0.00	0.14	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.18	Definite	Site17_SMU10420_20230324_202610_000.zc
Site17	0.00	0.17	0.02	0.27	0.05	0.38	0.03	0.00	0.02	0.00	0.02	0.01	0.00	0.02	Species complex	Site17_SMU10420_20230320_205801_000.zc
Site17	0.00	0.00	0.01	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.20	Species complex	Site17_SMU10420_20230329_221905_000.zc
Site17	0.00	0.00	0.01	0.00	0.71	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.04	0.21	Species complex	Site17_SMU10420_20230403_014108_000.zc
Site17	0.00	0.00	0.07	0.00	0.75	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.13	Species complex	Site17_SMU10420_20230403_035531_000.zc
Site17	0.00	0.00	0.04	0.02	0.18	0.02	0.01	0.00	0.00	0.00	0.00	0.57	0.09	0.08	Species complex	Site17_SMU10420_20230403_214806_000.zc
Site17	0.00	0.00	0.04	0.02	0.18	0.02	0.01	0.00	0.00	0.00	0.00	0.57	0.09	0.08	Species complex	Site17_SMU10420_20230403_214806_000.zc
Site17	0.00	0.00	0.30	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	Species complex	Site17_SMU10420_20230403_231906_000.zc
Site17	0.00	0.00	0.40	0.00	0.40	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.16	Species complex	Site17_SMU10420_20230403_235449_000.zc
Site20	0.00	0.00	0.02	0.00	0.40	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.54	Species complex	Site20_SMU10195_20230328_011656_000.zc
Site20	0.00	0.00	0.01	0.01	0.26	0.04	0.02	0.00	0.00	0.00	0.00	0.20	0.38	0.08	Species complex	Site20_SMU10195_20230328_052154_000.zc
Site20	0.00	0.00	0.01	0.01	0.30	0.02	0.01	0.00	0.00	0.00	0.00	0.09	0.24	0.32	Species complex	Site20_SMU10195_20230401_025715_000.zc
Site21	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.14	Species complex	Site21_SMU10275_20230314_220439_000.zc
Site21	0.00	0.00	0.01	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.14	Species complex	Site21_SMU10275_20230314_220439_000.zc
Site21	0.00	0.00	0.11	0.01	0.58	0.07	0.03	0.00	0.00	0.00	0.00	0.02	0.02	0.16	Species complex	Site21_SMU10275_20230403_045751_000.zc
Site22	0.00	0.00	0.05	0.00	0.65	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.06	0.21	Definite	Site22_SMU10193_20230311_231438_000.zc
Site22	0.00	0.00	0.05	0.00	0.63	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.05	0.22	Definite	Site22_SMU10193_20230312_213439_000.zc
Site22	0.00	0.00	0.01	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.25	Definite	Site22_SMU10193_20230318_205207_000.zc
Site22	0.00	0.00	0.05	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	Definite	Site22_SMU10193_20230323_012652_000.zc

Disclaimer

Addendum to Identification of echolocation call sequences recorded at Swansons Lane Survey 2.

Saccolaimus flaviventris

A total of 2,299 recordings were marked by the random forest classifier as containing at least 3 pulses of *Saccolaimus flaviventris*. Many of the recordings contained noise and other species (Figure 1). Due to the greater resolution of Full Spectrum (FS) data compared to Zero Crossing (ZC) data any ambiguous examples from the 2,299 recordings were also examined in the original full spectrum format. This resulted in the checking of 123 FS calls across 6 sites. FS recordings were not available for 3 sites (Site 15, Site 17 and Site 22, containing 23 recordings).

Manual checking of 2,299 recordings identified by the classifier as containing *Saccolaimus flaviventris* confirmed that no recordings contained the species, this includes the checking of 123 FS recordings. This species was **not identified** in this dataset.

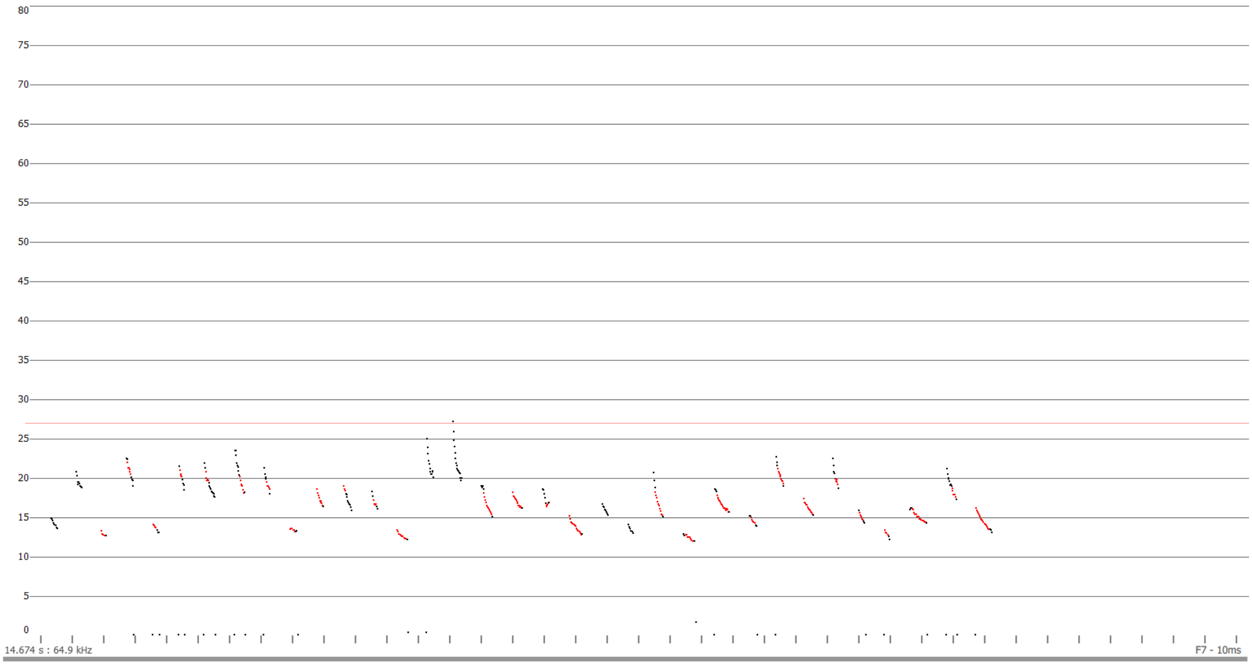

Figure 1. An example of a recording identified as containing *Saccolaimus flaviventris*. This recording contains *Austronomus australis* calls (individual pulses) with higher cluster calls of the same individual at 20 kHz.

Examples of FS calls that were checked that didn't contain calls from *Saccolaimus flaviventris*, are presented below in Figure 2 and Figure 3.

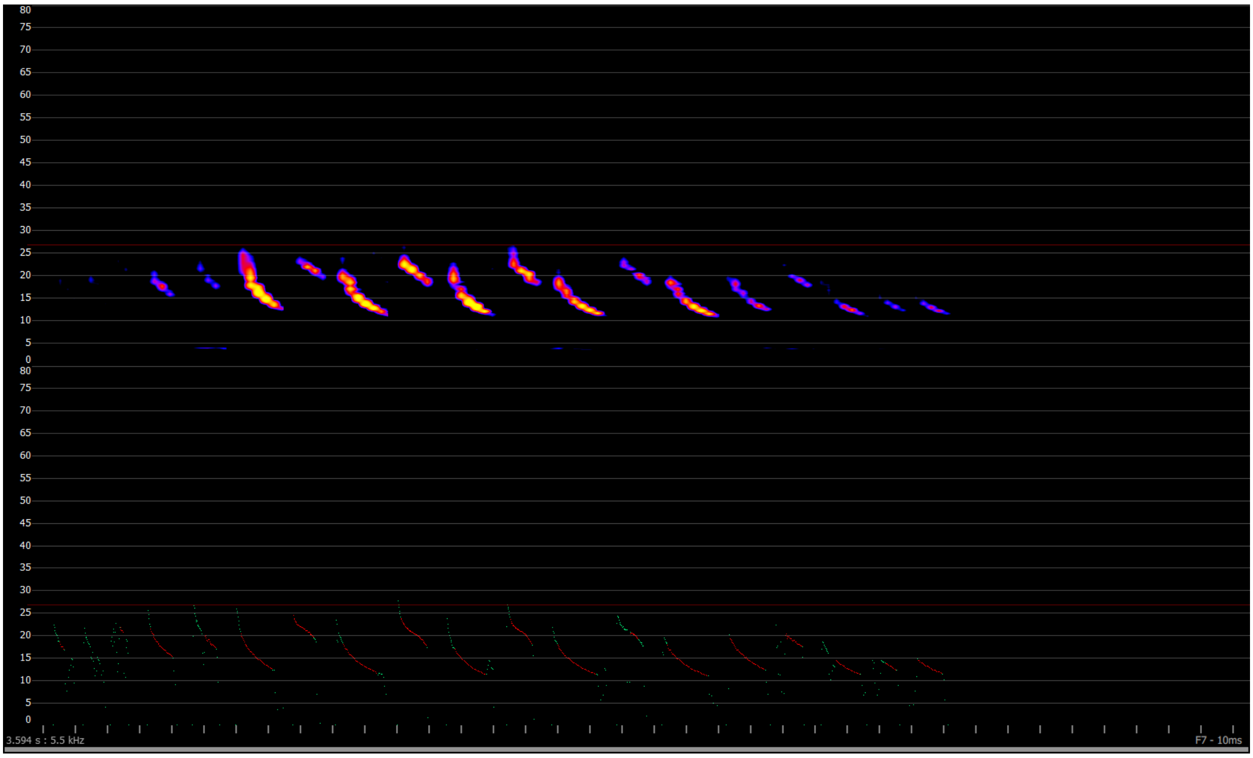

Figure 2. Calls at 20 kHz are likely to be calls of a second *Austronomus australis*, using acoustic separation.

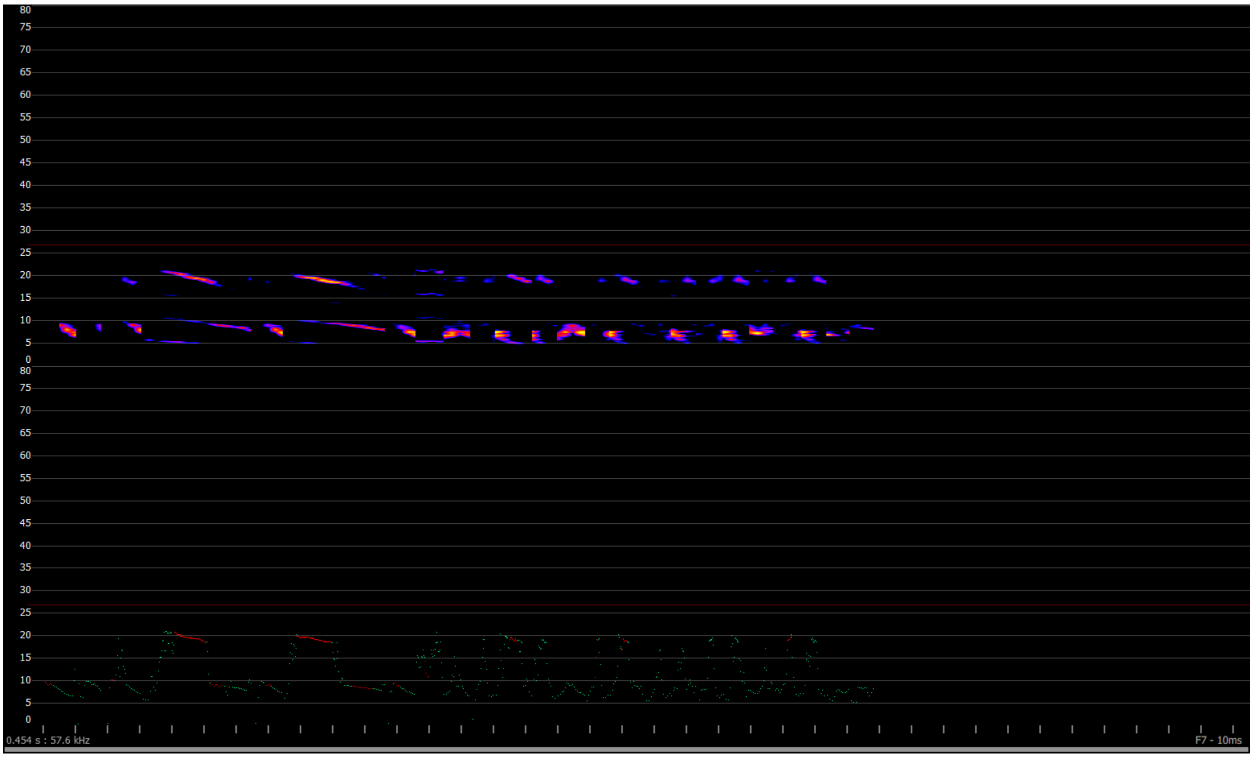

Figure 3. These are likely to be noise which has been picked up by the detector as belonging to a bat.

Appendix 3: Distance from bat detector sites to habitat features

	Distance to habitats (m)						
Site#	Scattered paddock tree	Roadside vegetation	Eucalpyt windbreak	Pine windbreak	Eucalypt woodland patch	Forestry plantation (eucalypt)	Farm dam
1	480	10	170	342	742	1461	406
2	197	62	30	197	1,320	772	327
3	53	53a4	13	246	0	1,114	375
4	508	0	204	1,933	213	35	30
5	384	784	0	622	1,291	42	328
6	383	47	590	2,114	593	28	292
7	984	1,263	20	266	594	516	937
8	255	672	0	31	1,199	372	262
9	569	552	9	807	1,626	973	455
10	110	715	151	1,477	774	515	430
11	318	368	25	886	1,244	1,416	31
12	91	1,105	234	1,232	1,197	577	20
13	341	306	254	706	891	1,770	0
14	553	586	18	737	1,851	596	554
15	195	351	529	1,831	647	384	193
16	304	229	311	1,716	216	208	197
17	741	228	9	1,264	2,043	1,250	756
18	577	1,144	269	52	569	645	732
19	257	924	207	32	570	1,056	930
20	91	288	34	431	432	1,382	204
21	499	996	298	352	1,108	103	532
22	461	679	40	646	499	1,039	480

Appendix 4: Summary of mitigation methods

Mitigation method	Citation	Title	Study type	Method investigated	Brief summary
Acoustic deterrent	Weaver et al. (2020) Global Ecology and Conservation, 24, e01099	Ultrasonic acoustic deterrents significantly reduce bat fatalities at wind turbines	Trial at operational wind farm	Ultrasound	Deterrents mounted on the nacelles significantly reduced bat fatalities at a wind farm in US (Texas) for *Lasiurus cinereus* and *Tadarida brasiliensis* by 78% and 54%, respectively. We observed no significant reduction in fatalities for other species in the genus *Lasiurius*.
Acoustic deterrent	Sievert et al. (2021) Report by University of Massachusetts. Report for US Department of Energy. Report No. DE-EE0007032.	A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines	Trial outside wind farms	Ultrasound	Passively activated (blown by the wind) ultrasonic deterrent that is intended to be implemented on turbine blades. The developed deterrent produce ultrasound in the 25-35 kHz, 35-45 kHz, and 45-55 kHz ranges. Researchers played recordings of these sounds to bats in a laboratory setting, and showed that flight paths of Mexican free-tailed bats *Tadarida brasiliensis* were affected, but tricolored bats *Perimyotis subflavus* were not.
Acoustic deterrent	Good, R. E., Iskali, G., Lombardi, J., McDonald, T., Dubridge, K., Azeka, M., & Tredennick, A. (2022) The Journal of Wildlife Management, 86(6), e22244.	Curtailment and acoustic deterrents reduce bat mortality at wind farms	Trial at operational wind farm	Smart curtailment	Tested with curtailment combined with acoustic deterrent. Curtailment alone reduced bat mortality by 42.5%. Curtailment plus deterrent reduced mortality by 66.9% (species dependent, ranging from 58.1% in some species to 94.4% in others.
Acoustic deterrent	Arnett, E. B., Hein, C. D., Schirmacher, M. R., Huso, M. M., & Szewczak, J. M. (2013). PloS One, 8(6), e65794.	Evaluating the Effectiveness of an Ultrasonic Acoustic Deterrent for Reducing Bat Fatalities at Wind Turbines	Trial at operational wind farm	Ultrasound emission	Used waterproof box (~45x45 cm, 0.9 kg) that housed 16 transducers that emitted continuous broadband ultrasound from 20–100 kHz (manufactured by Deaton Engineering, Georgetown, Texas). 21–51% fewer bats were killed per treatment turbine than per control turbine.
Acoustic deterrent	Cooper, D., Green, T., Miller, M., & Rickards, E. (2020). Frontier Wind LLC, Rocklin, CA (United States).	Bat Impact Minimization Technology: An Improved Bat Deterrent for the Full Swept Rotor Area of Any Wind Turbine (No. DE-EE0007034; CEC-500-2020-008)	Trial at operational wind farm	Ultrasound emission	The Strike Free system developed for this project extended the ultrasonic coverage to the entire area swept by the turbine blades, not just the centre of the turbine. Did this by attaching transmitters onto the blades of the turbines. Saw approx. 73.5% less fatalities at turbines with treatment in contrast to control turbines.
Acoustic deterrent	Gilmour, L. R., Holderied, M. W., Pickering, S. P., & Jones, G. (2021). Journal of Experimental Biology, 224(20), jeb242715.	Acoustic deterrents influence foraging activity, flight and echolocation behaviour of free-flying bats	Trial not on wind farm	Ultrasound emission, thermal video	Used stereo thermal videogrammetry and acoustic methods. Filmed bats using two synchronised thermal imaging cameras (Optris PI640 thermal imaging camera). Deaton ultrasonic speakers, emitted ultrasound at a frequency range of 20–100 kHz. Overall bat activity was reduced by 30%.
Acoustic deterrent	Kinzie, K., Hale, A., Bennett, V., Romano, B., Skalski, J., Coppinger, K., & Miller, M. F. (2018). General Electric Co., Schenectady, NY (United States).	Ultrasonic Bat Deterrent Technology (No. DOE-GE-07035)	Trial at operational wind farm	Ultrasound emission, thermal video	Tried different setup but found no statistically significant benefit compared to previously existing systems. Up to 60% bat activity reduction.
Acoustic deterrent	NRG Systems (2021)	Exploring How Attenuation Affects NRG Systems' Bat Deterrent System	Trial at operational wind farm	Ultrasound emission	Investigates attenuation of ultrasound, study showed a 6db loss of sound volume for every doubling of radius. Also showed ultrasound devices performed better with lower humidity and temperature.
Acoustic deterrent	Romano, W. B., Skalski, J. R., Townsend, R. L., Kinzie, K. W., Coppinger, K. D., & Miller, M. F. (2019). Wildlife Society Bulletin, 43(4), 608-618.	Evaluation of an Acoustic Deterrent to Reduce Bat Mortalities at an Illinois Wind Farm	Trial at operational wind farm	Ultrasound emission	29.2% - 32.5% reduction in bat mortality, air jet ultrasonic emitters mounted on turbine nacelles. The deterrent system jets (nozzles) produced a broad-band sound designed to overlap the entire range of frequencies (~30–100 kHz) generated by and audible to most bat species

Mitigation method	Citation	Title	Study type	Method investigated	Brief summary
Acoustic deterrent	Zeng, Z., & Sharma, A. (2023). arXiv preprint arXiv:2302.08037.	Novel ultrasonic bat deterrents based on aerodynamic whistles	Lab	Ultrasound emission	Explores single to six whistle acoustic design outputting 20 Hz - 50 kHz frequency range.
Radar and acoustic deterrent	Gilmour et al. (2020) Plos One, 15(2), e0228668.	Comparing acoustic and radar deterrence methods as mitigation measures to reduce human-bat impacts and conservation conflicts	Trial outside wind farms	Radar and ultrasound	Ultrasonic speakers were effective as bat deterrents at foraging sites, but radar was not. In riparian sites (border of England and Wales), ultrasonic deterrents decreased overall bat activity (filmed on infrared cameras) by ~80% when deployed alone and in combination with radar. Species responded differently to the ultrasound treatments.
Visual and acoustic deterrent	Werber et al. (2023) Remote Sensing in Ecology and Conservation, 9(3), 404-419.	Drone-mounted audio-visual deterrence of bats: implications for reducing aerial wildlife mortality by wind turbines	Trial outside wind farms	Drone	A drone with auditory and visual signals decreases bat activity. Activity decreases significantly (~40%) below and significantly above (~50%) the drone flight altitude at Northern Israel. LIDAR was used to assess the drone impact below its flight altitude and RADAR to assess impact above its flight altitude.
Visual and acoustic deterrent	Kuhlmann, K., Fontaine, A., Brisson-Curadeau, É., Bird, D. M., & Elliott, K. H. (2022). Methods in Ecology and Evolution, 13(4), 842-851.	Miniaturization eliminates detectable impacts of drones on bat activity	Trial at operational wind farm	Drone	Found that smaller UAV models had negligible impact on bat activity, suggest that when employing drones as a deterrent, the size of the drone should be taken into consideration.
Visual deterrent	Cryan et al. (2022) Animals, 12(1), 9.	Influencing activity of bats by dimly lighting wind turbine surfaces with ultraviolet light	Trial at operational wind farm	Ultraviolet light	No significant change in nighttime bat, insect, or bird activity at wind turbines when lit with UV light compared with that of unlit nights (US, Colorado).
Visual deterrent	Gorresen, P. M., Cryan, P. M., Dalton, D. C., Wolf, S., Johnson, J. A., Todd, C. M., & Bonaccorso, F. J. (2015). Endangered Species Research, 28(3), 249-257.	Dim ultraviolet light as a means of deterring activity by the Hawaiian hoary bat *Lasiurus cinereus semotus*	Trial not on wind farm	Ultraviolet light	44% reduction in bat detections in treatments with dim, flickering UV light compared to control, despite increased insect biomass with UV treatment. Duty cycle of flickering was 0.1-5sec, peak wavelength 365nm, spectral spread 10nm, power density of 1 microwatt cm^-2 over circular area of 20m. Hawaii.
Curtailment	Bennett et al. (2022) Austral Ecology, 47(6), 1329-1339.	Curtailment as a successful method for reducing bat mortality at a southern Australian wind farm	Trial at operational wind farm	Low wind-speed curtailment	Increasing turbine cut-in speed from 3.0 to 4.5 ms-1 from dawn to dusk at a southern Australian wind farm significantly reduced bat fatalities by 54%.
Curtailment	Anderson et al. (2022) Facets, 7, 1281-1297.	Effects of turbine height and cut-in speed on bat and swallow fatalities at wind energy facilities	Correlational at operational wind farms	Low wind-speed curtailment	Raising cut-in speeds result in fewer bat fatalities in Canada (Ontario). Turbines under nocturnal mitigation killed 33% fewer bats than turbines without cut-in adjustments in late summer.
Curtailment	Hayes, M. A., Hooton, L. A., Gilland, K. L., Grandgent, C., Smith, R. L., Lindsay, S. R., & Goodrich-Mahoney, J. (2019). Ecological Applications, 29(4), e01881.	A smart curtailment approach for reducing bat fatalities and curtailment time at wind energy facilities	Trial at operational wind farm	Bat-detection/low wind speed curtailment	A new system of tools for analysing bat activity and wind speed data to make near real-time curtailment decisions when bats are detected at control turbines (N=10) vs. treatment turbines (N=10) at a US wind farm (Wisconsin). Overall reductions in bat fatalities (~74% to 91% per species). ~3.2% loss in power output, 48% reduction in downtime compared to other USA windfarms using standard curtailment.
Curtailment	Adams et al. (2021) Plos One, 16(11), e0256382.	A review of the effectiveness of operational curtailment for reducing bat fatalities at terrestrial wind farms in North America	Trials at operational wind farms	Low wind-speed curtailment	Meta-analysis of experimental studies (n = 36 control-treatment studies from 17 wind farms in US) 63% decrease in fatalities. A non-linear model shows that fatality rates decreased when the difference in curtailment cut-in speeds was 2m/s or larger.
Curtailment	Martin et al. (2017) Journal of Mammalogy, 98(2), 378-385.	Reducing bat fatalities at wind facilities while improving the economic efficiency of operational mitigation	Trial at operational wind farm	Low wind-speed and high T curtailment	Raising cut-in speed of turbines (from 4 to 6 m/s) reduced bat fatalities by 62% (CI 34–78%) at a US wind farm (Vermont). Cut-in speed at 6.0 m/s was always done at T > 9.5°C, unlike cut-in at 4 m/s (wind speed only).

Mitigation method	Citation	Title	Study type	Method investigated	Brief summary
Curtailment	Baerwald et al. (2009) Journal of Wildlife Management, 73(7), 1077-1081.	A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities	Trial at operational wind farm	Low wind-speed curtailment and turbine modifications	Increasing turbine cut-in speed from 4.0 to 5.5 m/s resulted in a significant 60% reduction in bat fatalities. Comparing turbines with cut-in speed at 4.0 m/s against turbines with modified angles to reduce rotor speed (blades near motionless in low-wind speeds), resulted in a significant reduction in bat fatalities by 57.5%. Study conducted at a wind farm in Canada (Alberta).
Curtailment	Rnjak et al. (2023) Mammalia, 87(3), 259-270.	Reducing bat mortality at wind farms using site-specific mitigation measures: a case study in the Mediterranean region, Croatia	Trial at operational wind farm	Low wind-speed curtailment	Wind turbine curtailment was implemented in the high collision risk period at a wind farm in Croatia. Estimated total number of bat fatalities decreased by 78% when implementing curtailment from sunset to sunrise at variable turbine cut-in speeds (5.0 - 6.5 m/s).
Curtailment	Whitby, M. D., Schirmacher, M. R., & Frick, W. F. (2021). Bat Conservation International, Austin, Texas.	The State of the Science on Operational Minimization to Reduce Bat Fatality at Wind Energy Facilities. A report submitted to the National Renewable Energy Laboratory.	Trial across multiple wind farms.	Low wind-speed curtailment	33-79% fatality reduction estimate based on 5m/s increase in cut in speed (extrapolated). 0.06-3.2% annual energy production loss.
Curtailment	Rabie, P. A., Welch-Acosta, B., Nasman, K., Schumacher, S., Schueller, S., & Gruver, J. (2022). Plos One, 17(4), e0266500.	Efficacy and cost of acoustic-informed and wind speed-only turbine curtailment to reduce bat fatalities at a wind energy facility in Wisconsin	Trial at operational wind farm	Low wind-speed curtailment	Used Turbine Integrated Mortality Reduction (TMIR) system reduced bat fatalities by 75-84%, compared to wind-speed only curtailment (WOC) (47%). Using software and acoustic detection of bats in real time.
Curtailment	Arnett, E. B., Schirmacher, M., Huso, M. M., & Hayes, J. P. (2009). Bat Conservation International. Austin, Texas, USA.	Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities. An annual report submitted to the Bats and Wind Energy Cooperative	Trial at operational wind farm	Low wind-speed curtailment	Tested curtailment at low wind speeds. Found now difference between cut-in speeds of 5m/s vs 6.5m/s. Fully operation turbines had ~5.2 times as many fatalities as curtailed ones. Pennsylvania, USA.
Curtailment	Arnett, E. B., Huso, M. M., Schirmacher, M. R., & Hayes, J. P. (2011). Frontiers in Ecology and the Environment, 9(4), 209-214.	Altering turbine speed reduces bat mortality at wind-energy facilities	Trial at operational wind farm	Low wind-speed curtailment	Bat mortality 5.4 and 3.6 times that of 2008 & 2009 compared to turbines employing low wind speed curtailment in this study, with less than a 1% loss of power generation annually. Pennsylvania, USA.
Curtailment	Maclaurin, G., Hein, C., Williams, T., Roberts, O., Lantz, E., Buster, G., & Lopez, A. (2022). Wind Energy, 25(9), 1514-1529.	National-scale impacts on wind energy production under curtailment scenarios to reduce bat fatalities	Trial at operational wind farm	Low wind-speed curtailment	Focusses more on implications for annual energy production rather than mitigating bat fatalities. Compares smart curtailment against blanket curtailment, under low, medium and high levels of curtailment. USA.
Curtailment	Măntoiu, D. Ş., Kravchenko, K., Lehnert, L. S., Vlaschenko, A., Moldovan, O. T., Mirea, I. C., & Voigt, C. C. (2020). European Journal of Wildlife Research, 66(3), 1-13.	Wildlife and infrastructure: impact of wind turbines on bats in the Black Sea coast region	Trial at operational wind farm	Low wind-speed curtailment	Found that WT in Romania in migration corridor killed approx. 30 bats/WT/year, curtailment reduced fatality rates by 78%. Used hydrogen stable isotope rations to est. Origin of some bats, came from as far away as Ukraine, Belarus & Russia. Test involved raising cut-in speeds from 4m/s to 6.5m/s, applied during high risk migration periods.
Curtailment	Smallwood, K. S., & Bell, D. A. (2020). The Journal of Wildlife Management, 84(4), 685-696.	Effects of Wind Turbine Curtailment on Bird and Bat Fatalities	Trial at operational wind farm	Shut down curtailment	Found that curtailment helped reduce bat fatalities significantly, but had substantially less effect on reducing bird fatalities. Found that bats were twice as likely to pass through an operating turbine's rotors than inoperable ones, suggesting again that some species may be attracted to operating rotors. Findings also suggest that designing turbines without accessible interior spaces could reduce fatalities of cavity-nesting and cavity-roosting birds.

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Curtailment	Squires, K. A., Thurber, B. G., Zimmerling, J. R., & Francis, C. M. (2021). Animals, 11(12), 3503.	Timing and Weather Offer Alternative Mitigation Strategies for Lowering Bat Mortality at Wind Energy Facilities in Ontario	Data from operational wind farms		Rain and low temperatures saw reduced bat activity and fatalities. Wind conditions, moon illumination, and rain to primarily influence migration flights, while temperature, humidity, air pressure, and rain to influence foraging. Mortality and activity were lower when it rained, highest with above-average temperatures, and declined with wind speed.
Curtailment (Smart)	Matzner, S., Warfel, T., & Hull, R. (2020). Ecological Informatics, 57, 101069.	ThermalTracker-3D: A thermal stereo vision system for quantifying bird and bat activity at offshore wind energy sites	Trial with drone	Smart curtailment	Thermal tracking to predict flight paths of flying animals. Software was able to estimate drone within +-20m of actual position against GPS for 90% of data points.
Curtailment (Smart)	Barré, K., Froidevaux, J. S., Sotillo, A., Roemer, C., & Kerbiriou, C. (2023). Science of the Total Environment, 866, 161404.	Drivers of bat activity at wind turbines advocate for mitigating bat exposure using multicriteria algorithm-based curtailment	Trial at operational wind farm	Smart curtailment	Investigated algorithm-controlled curtailment compared to traditional blanket curtailment. Reduces fatal collisions by 7-31% compared to blanket curtailment.
Curtailment (Smart)	Hayes, M. A., Lindsay, S. R., Solick, D. I., & Newman, C. M. (2023). Wildlife Society Bulletin, 47(1), e1399.	Simulating the influences of bat curtailment on power production at wind energy facilities	Trial at operational wind farm	Low wind-speed curtailment	Focusses more on implications for annual energy production, comparing blanket curtailment to smart curtailment, rather than any impacts on mortality. Energy losses ranged between 0.2 and 1.7% for blanket curtailment, vs 0.0 to 0.9% for smart curtailment. Canada.
Thermal video detection	Georgiev, M., & Zehtindjiev, P. (2022) Wind Europe.	Real-Time Bird Detection and Collision Risk Control in Wind Farms	Trial at operational wind farm	Thermal imaging	Used thermal imaging to detect birds. Testing detection rates of birds, 83.1 to 91.8% correct detection rates. Detection ranges: 60cm wingspan at 350m, 100cm at 600m, 150cm at 1050m.Detection rates of bats looks <10%.