Woodie Woodie Mine:

Targeted Conservation Significant Bat Survey 2020

Prepared for: Consolidated Minerals Limited

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Executive Summary

Introduction

Woodie Woodie Manganese Mine (Woodie Woodie) operates in the East Pilbara region of Western Australia. Consolidated Minerals Limited (CML) propose to mine 18 manganese prospects over the next five years. CML commissioned Western Wildlife to carry out a targeted survey for two species of conservation significant bat across the mine, the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*). This report details the findings of the survey conducted in June 2020, with additional records from October 2020.

Methods

The survey was undertaken in accordance with the Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (Environmental Protection Authority (EPA) 2020) and the Survey guidelines for Australia's threatened bats (DEWHA 2010).

A literature review was undertaken to provide a background summary of the ecology and status of the Ghost Bat and Pilbara Leaf-nosed Bat. Areas that may contain critical habitat (diurnal roost sites) were identified from existing fauna habitat mapping and field observations. The field survey was carried out between the 22nd and 28th June 2020. Walking transects were undertaken in areas of potentially suitable habitat to search for caves. Caves and foraging habitat were sampled with Anabat Swift detectors. For recordings with the Pilbara Leaf-nosed Bat, the time of first and last detection was determined and, for sites with about 50 passes of bats or more, the nightly activity pattern was graphed. Anabat recording at cave entrances were reviewed in situ for the presence of the Pilbara Leaf-nosed Bat and if the pattern of bat activity suggested a possible roost site (i.e., peaks of activity at dusk and dawn indicating leaving and returning to a roost), then the cave was further investigated.

Results and Discussion

The Ghost Bat is not known to occur at Woodie Woodie and was not recorded on this survey.

The Pilbara Leaf-nosed Bat is known to occur at Woodie Woodie and was recorded on this survey. No diurnal roost sites were detected and there were very few caves present. This species is likely to use caves and overhangs in the study area as nocturnal refuges, and foraging habitat considered to be a high priority for conservation is present, including gorges with pools, gullies and rocky outcrops.

Woodie Woodie is not likely to provide roosting habitat critical to the survival of the Ghost Bat or Pilbara Leaf-nosed Bat. This can be stated with a relatively high degree of confidence, as Woodie Woodie is dominated by rolling stony hills and the areas of rocky ridge and gorge are small and generally do not bear caves. However, Woodie Woodie still provides foraging habitat and nocturnal refuges for the Pilbara Leaf-nosed Bat and possibly the Ghost Bat. Although not considered critical habitat, foraging habitat and nocturnal refuges are likely to be important for maintaining local populations of these species.

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1. Introduction

Woodie Woodie Manganese Mine (Woodie Woodie) operates in the East Pilbara region of Western Australia. Consolidated Minerals Limited (CML) propose to mine 18 manganese prospects over the next five years. The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) was recorded at Woodie Woodie on previous surveys and is listed as Vulnerable under *The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Biodiversity Conservation Act 2016* (BC Act). The Ghost Bat is also listed as Vulnerable under both the EPBC Act and BC Act, and is not currently known to occur at Woodie Woodie. CML commissioned Western Wildlife to investigate the status of the two species of conservation significant bat at Woodie Woodie.

The objectives of the conservation significant bat survey were to:

- Identify potential bat roosting habitat in the study area.
- Survey for the presence of bats, particularly at potential roost sites, in potential habitat areas.

This report details the findings of the targeted survey conducted in February 2020 with addional data from October 2020.

1.1 Regional Location

The Woodie Woodie Manganese Mine is about 400 km southeast of Port Hedland, 170 km southeast of Marble Bar and 100 km east of Nullagine in the Eastern Pilbara region of Western Australia (Figure 1).

Woodie Woodie is within the Chichester subregion of the Pilbara Bioregion (DEWHA 2004), which is comprised of undulating plains of Achaean granite and basalt, with basalt ranges (Kendrick and McKenzie 2001). The climate is semi-desert tropical, receiving about 300mm of rain per year (Kendrick and McKenzie 2001). The dominant land-uses are grazing on native pastures, Aboriginal lands and reserves, Unallocated Crown Land and Crown Reserves, Conservation and Mining (Kendrick and McKenzie 2001).

A significant feature in the area surrounding the mine is the Oakover River and its various tributaries. The Oakover River contains permanent water at Running Waters, Yilgalong Pool and Carawine Pool (among others), and is thus important fauna habitat for wetland species. About 15km to the east of the survey area is the Little Sandy Desert, which supports a different faunal assemblage. Species that favour rocky habitats, including bats that roost in caves such as the Pilbara Leaf-nosed Bat and Ghost Bat, are likely to be close to the eastern edge of their range in the region.

1.2 Study Area

The study area for the conservation significant bat survey was the development envelope, totalling 12,708 ha. Although the overall study area was large, surveys concentrated only on potentially suitable habitat.

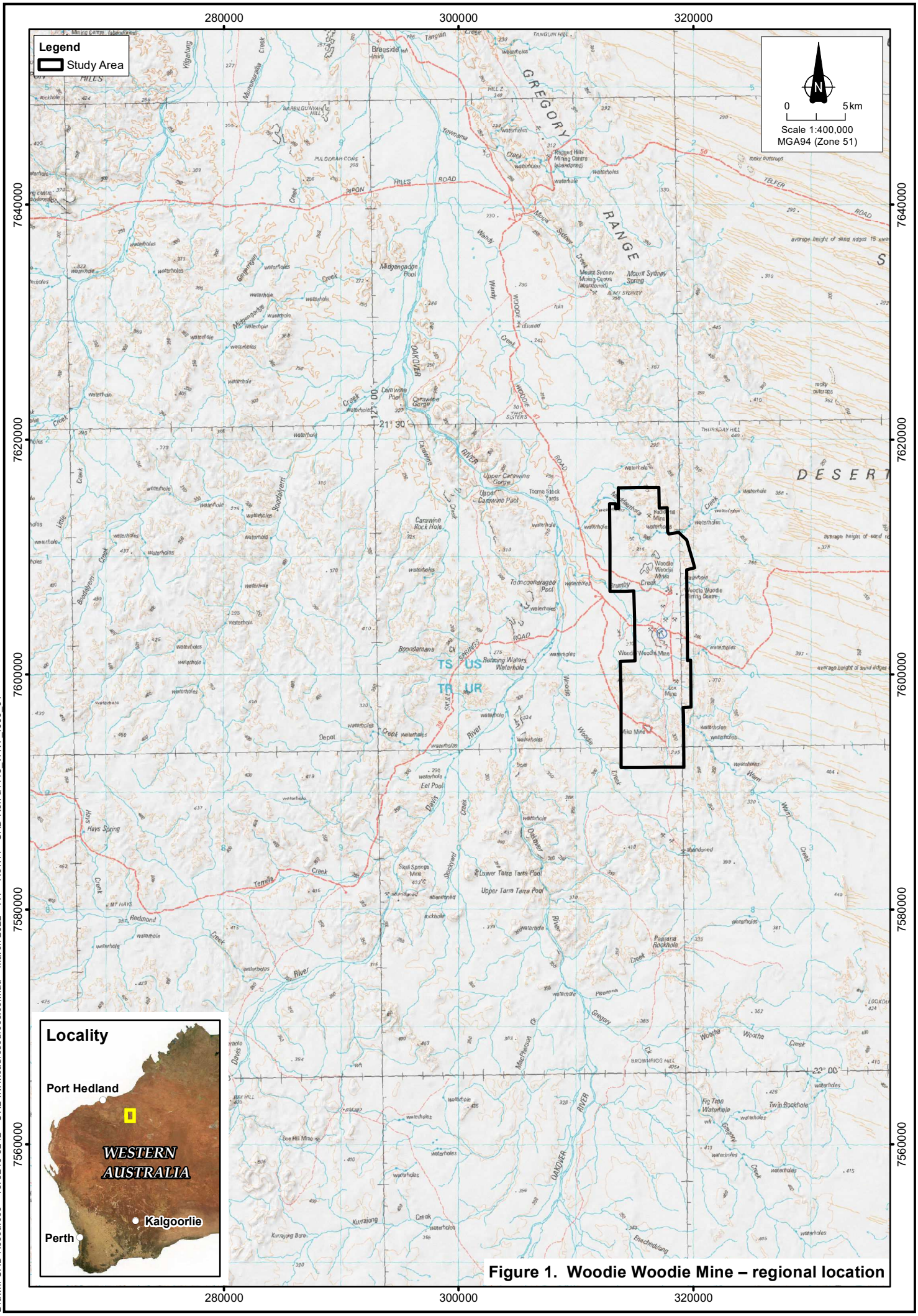

Figure 1. Woodie Woodie Mine – regional location

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1.3 Climate and Weather

The nearest weather station is Telfer Aero (Bureau of Meteorology Site 013030). The climate is characterised by hot wet summers and cool dry winters (Figure 3). The mean annual rainfall is 362.2mm, based on data collected 1974 – 2020 (BOM 2020). Prior to the survey the summer rainfall was below average in December and February, but well above average in January and May. The weather during the survey period was typically warm and dry (Table 1).

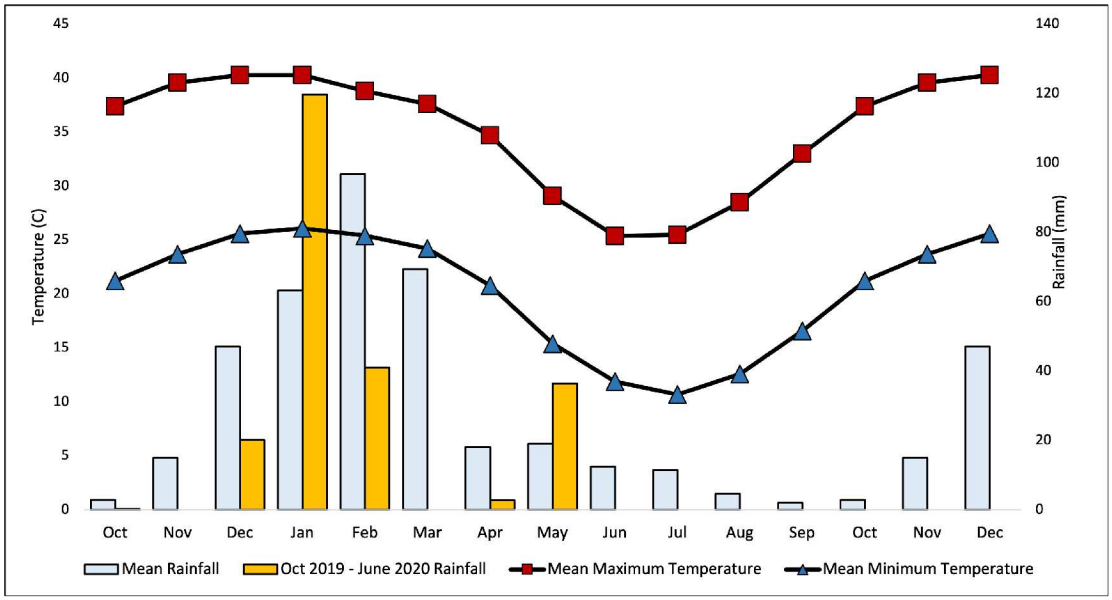


Figure 2. Climate statistics for Telfer Aero (data after BOM 2021).

Table 1. Weather for Telfer Aero, 13 – 28 June 2020.

Day	Temperature (°C)		Rainfall (mm)	Survey Period
	Minimum	Maximum		
13	21.8	26.3	0	
14	17.6	25.9	0	
15	15.5	26.7	0	
16	15.4	30.0	0	
17	15.5	30.0	0	
18	12.0	30.2	0	
19	14.7	28.7	0	
20	14.5	27.5	0	
21	12.3	25.3	0	
22	11.7	27.3	0	+
23	10.3	27.6	0	+
24	10.1	27.0	0	+
25	9.9	26.2	0	+
26	8.8	25.4	0	+
27	9.2	25.8	0	+
28	10.2	27.7	0	+

2. Methods

2.1 Guidance Documents and Licencing

The fauna surveys were conducted in accordance with:

- Technical guidance - terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020)
- Survey guidelines for Australia's threatened bats (DEWHA 2010)

All fauna works were carried out under an Authorisation to Take or Disturb Threatened Species TFA 2020-0083 issued by the Department of Biodiversity, Conservation and Attractions (DBCA).

2.2 Personnel

The personnel involved in the fauna survey are listed in Table 2.

Table 2. Personnel involved with the fauna survey.

Person	Qualification	Role	Experience
[redacted]	BSc. Hons.	Lead Zoologist • Plan, supervise and conduct fauna survey • Collate data • Prepare report	21 years
[redacted]	BSc. Hons.	Senior Zoologist • Undertake fieldwork	15 years
[redacted]	BSc.	Assisting Zoologist • Undertake fieldwork	10 years (as environmental officer)

2.3 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report follow the Western Australian Museum checklists, as updated in November 2020. In the text, common names are used where appropriate, and all scientific names are given in species lists. Where a species lacks a common name, they are referred to by their scientific name.

2.4 Literature Review

A review of the relevant literature was undertaken in order to provide background information on the distribution, habitat, biology, ecology and current threats to the Pilbara Leaf-nosed Bat and Ghost Bat. Sources consulted included general biology texts, action plans, recovery plans, referral guidelines, journal articles and unpublished environmental reports. In addition, DBCA's Threatened and Priority Fauna Database was searched for conservation significant bat records within 100km of a central point in the survey area (21° 39' 58" S, 121° 14' 09" E).

Several other surveys have been undertaken at Woodie Woodie, where bat calls were recorded as part of the survey of the broader faunal assemblage. This includes the following surveys:

- Western Wildlife (2007). *Woodie Woodie Project Area: Baseline Fauna Survey 2006/2007*. Unpublished Report to MBS Environmental.
- Western Wildlife (2009). *Prospect Areas at Woodie Woodie: Fauna Survey October 2008 and April 2009*. Unpublished Report to MBS Environmental.
- Western Wildlife (2014). *Woodie South and Max Projects, East Pilbara*. Unpublished report to Pilbara Manganese Pty Ltd.
- Western Wildlife (2021, *in press*). *Woodie Woodie Mine: Detailed Vertebrate Fauna Survey 2020 – 2021*. Unpublished report to Consolidated Minerals Limited.

Records of conservation significant bats from these surveys were collated as part of the literature review.

2.5 Field Studies

The fieldwork was undertaken between 22nd – 27th June 2020. Fieldwork focussed on identifying diurnal roosting habitat. Rocky habitat has previously been identified in the study area, and these rocky areas were walked to search for potential roost caves. The survey effort in searching for caves is shown in Figure 4. Note that the field team had all undertaken other surveys in rocky habitat at Woodie Woodie (Western Wildlife 2019, 2020), so were already familiar with many of these areas.

Any caves located were recorded with a GPS location, photograph, height and width, minimum visible depth and any sign of bats (e.g., odour, scats or middens). Caves were not entered due to health and safety considerations as well as the risk of disturbing roosting bats during the day. Anabat Swift bat detectors were place in the cave entrance to sample bat calls between dusk and dawn. As very few caves were identified, Anabats were also placed in other locations likely to be visited by foraging bats, such as rocky creeklines, gullies and waterholes (Table 3).

Anabat recording at cave entrances were reviewed in situ for the presence of the Pilbara Leaf-nosed Bat using Kaleidoscope Pro software. If the pattern of bat activity suggested a possible roost site (i.e., peaks of activity at dusk and dawn indicating leaving and returning to a roost), then the cave was further investigated. Covering the cave entrance with cloth prior to dusk would temporarily trap bats inside the cave. Monitoring with Anabats both inside and outside the cave would then determine whether the bats present had originated inside the cave (and thus the cave was a roost site) or outside the cave (and thus the cave was a nocturnal rest site). The cloth would be removed two hours after dark to allow bats free movement.

In addition, Anabat recordings collected in October 2020 (Western Wildlife 2021, *in press*), were also used to provide additional context. None of these recordings were at caves, but they sampled additional foraging habitat sites.

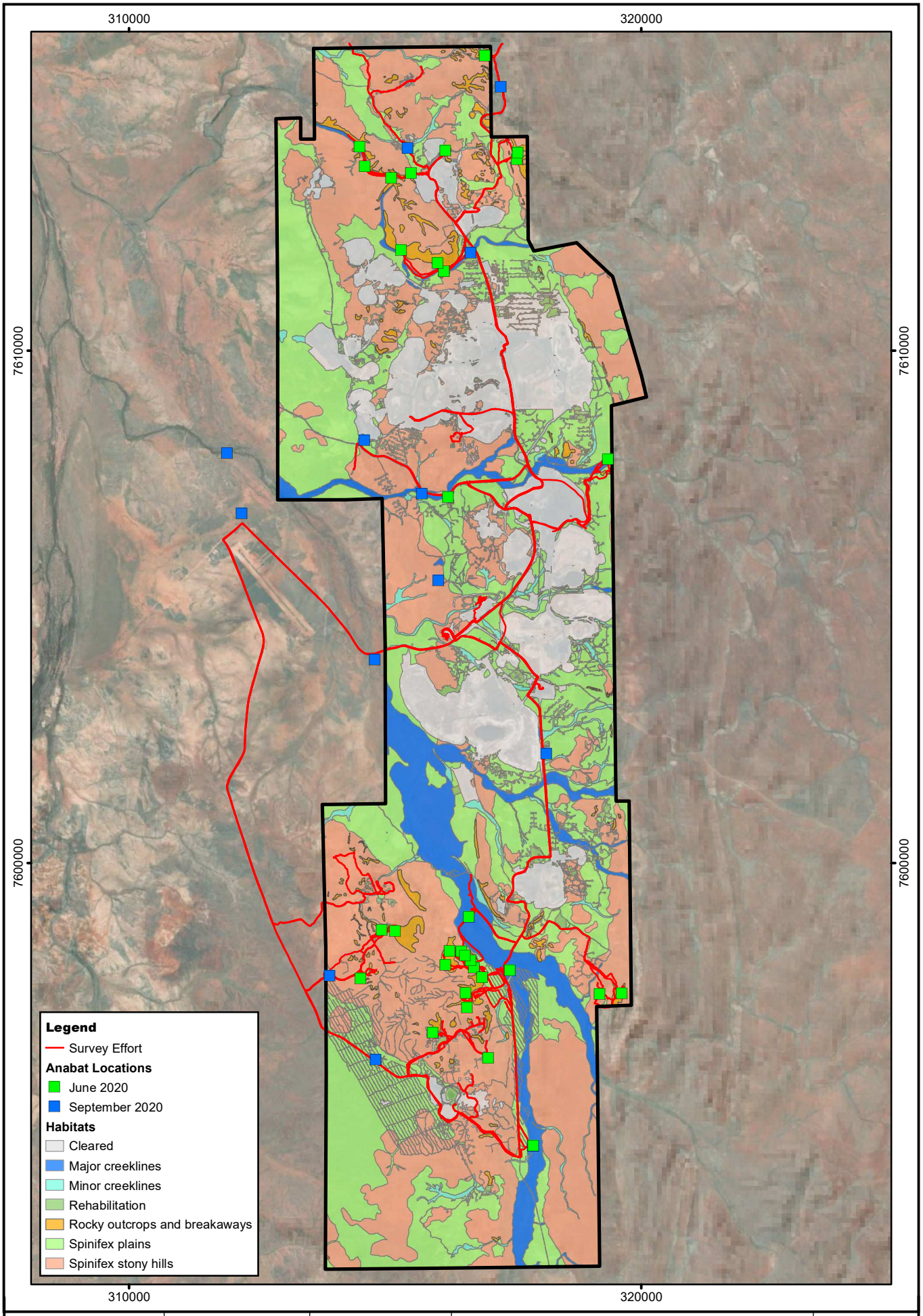
All Anabat recordings were analysed by Kyle Armstrong (Specialised Zoological) after the field survey, identifying all bat species present. For recordings with the Pilbara Leaf-nosed Bat, the time of first and last detection was determined and, for sites with about 50 passes of bats or more, the nightly activity pattern was graphed. The methods of analysis are detailed further in the report by Specialised Zoological (Appendix 1).

Table 3. Anabat Swift sampling locations.

Site name	Anabat Code and Deployment Date	Zone	Easting	Northing	Habitat
WB01	449958-22/6/20	51	316147	7611556	Rocky outcrop with many small cracks on Muddauthera Creek
WB02	449958-23/6/20	51	316736	7597958	Dry rocky gully between stony chert hills with small breakaways.
WB03	449958-24/6/20	51	316258	7598280	Top of dry gully (dolomite).
WB04	449958-25/6/20	51	314512	7597745	Low chert breakaways in stony hills.
WB05	449958-26/6/20	51	317438	7597898	Dry large eucalypt-lined creekline near stony hills.
WB06	449958-27/6/20	51	315117	7613374	Small waterpool at base of dolomite rock wall on Muddauthera Creek.
WB07	449972-22/6/20	51	315315	7611968	Dry waterhole at base of rock wall (dolomite) on Muddauthera Creek
WB08	449972-23/6/20	51	316555	7598200	Crevices in chert outcropping at the top of a dry gully on a stony hill
WB09	449972-24/6/20	51	316177	7598007	Dry gully (dolomite) with many shallow crevices.
WB10	449972-25/6/20	51	314927	7598687	Top of dry gully with low chert breakaways in stony hills.
WB11	449972-27/6/20	51	315508	7613469	**Cave in low dolomite gorge**, cave entrance 1.5m high, 3m wide and at least 8m deep (back not visible).
WB12	449995-23/6/20	51	316663	7598094	Possible small cave or crevice under chert boulders on the side of a stony hill.

Table 3. (cont.)

Site name	Anabat Code and Deployment Date	Zone	Easting	Northing	Habitat
WB13	449995-24/6/20	51	316225	7607143	Dry large eucalypt-lined creekline near low stony hills.
WB14	449995-25/6/20	51	319616	7597450	**Small cave in low ridgeline**. Cave entrance 0.5m high x 1m wide, at least 4m deep (back not visible).
WB15	449995-26/6/20	51	317889	7594482	Dry large eucalypt-lined creekline near stony hills.
WB16	449995-27/6/20	51	314497	7613982	Dry large eucalypt-lined creekline near low dolomite outcrops on Muddauthera Creek.
WB17	450007-22/6/20	51	316023	7611715	Dry rocky gully (dolomite) on Muddauthera Creek
WB18	450007-23/6/20	51	316631	7598946	Dry large eucalypt-lined creekline near stony hills.
WB19	450053-22/6/20	51	316945	7615756	Dry rocky gully with small overhangs on low ridgeline
WB20	450053-23/6/20	51	316489	7598278	**Cave in chert breakaway** on side of stony hill. Cave entrance 2.5m high, 7m wide, at least 20m deep (back not visible).
WB21	450053-24/6/20	51	315931	7596692	Overhang in chert breakaway in the top of dry gully.
WB22	450053-25/6/20	51	315196	7598673	Top of dry gully with low chert breakaways in stony hills.
WB23	450053-26/6/20	51	317016	7596192	Dry creekline in low dolomite gorge.
WB24	450053-27/6/20	51	316174	7613907	Dry gully (dolomite) with many shallow crevices.
WB25	450091-22/6/20	51	317571	7613737	Small overhang on low ridgeline
WB26	450091-23/6/20	51	316892	7597769	Dry gully (dolomite) where it exits onto stony plains
WB27	450091-24/6/20	51	319349	7607876	Dry large eucalypt-lined creekline near stony hills.
WB28	450091-25/6/20	51	319184	7597440	**Cave in low ridgeline**. Cave entrance 1m high, 2m wide, at least 8.5m deep (back not visible).
WB29	450091-26/6/20	51	316601	7597174	Large overhang in top of dry gully in chert breakaway in stony hills.
WB30	450091-27/6/20	51	314600	7613601	Rocky wall (dolomite) with many small cracks on Muddauthera Creek
WB31	449972-26/6/20	51	316576	7597465	Dry gully with rocky outcropping with overhangs and shallow crevices.
WB32	449995-22/6/20	51	317588	7613868	Dry gully on low ridgeline.



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MGA94 (Zone 50)

Author: J. Wilcox

Western Wildlife

Woodie Woodie Mine

Survey sites and effort

Figure: **3**

3. Survey Limitations

Various factors can limit the effectiveness of a fauna survey. Pursuant to EPA Technical Guidance (EPA 2020), these factors have been identified and their potential to impact on the effectiveness of the surveys has been assessed in Table 4 below.

Table 4. Fauna survey limitations.

Potential Limitation	Extent of limitation for the fauna survey	
Availability of data and information	Minor limitation	There are some regional records of conservation significant bats on DBCA Threatened and Priority Fauna Database, but no data on roosting locations near Woodie Woodie (i.e., sites where bats foraging at Woodie Woodie would roost). There are previous records of Pilbara Leaf-nosed Bat at Woodie Woodie.
Competency /experience of the team carrying out the survey	Not limiting	Supervising zoologist has 21 years' experience with fauna surveys in Western Australia, including surveys in the Pilbara Bioregion and at Woodie Woodie in particular. Assisting zoologist has more than 10 years' experience.
Scope of survey (e.g., faunal groups excluded from the survey)	Not limiting	Both species of conservation significant bat were targeted in the survey.
Timing, weather and season	Not limiting	The timing was suitable for the identification of potential roost sites as winter is the time at which this species is likely to be the most dispersed.
Disturbance that may have affected the results	Not limiting	None noted.
Proportion of fauna identified, recorded and/or collected.	Not limiting	The Pilbara Leaf-nosed Bat was recorded during the survey.
The adequacy of the survey intensity and proportion of survey achieved (e.g., extent to which the area was surveyed)	Not limiting	The rocky ridge and gorge habitat that potentially included roost sites was well investigated, both in this survey and previous surveys at Woodie Woodie 2006 – 2020. Caves may remain undetected if the entrances are small, but this would be common to all surveys of this nature and all care was taken to identify potential roosts.
Remoteness and/or access problems	Not limiting	The relevant habitats were accessible on foot.
Problems with data and analysis, including sampling biases	Not limiting	None noted.

4. Results

4.1 Background on the Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) is listed as Vulnerable under both *The* Environment *Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Biodiversity Conservation Act 2016* (BC Act). As a Threatened species under the EPBC Act, it is considered a Matter of National Environmental Significance (MNES).

4.1.1 Description and Biology

The Pilbara Leaf-nosed Bat is a moderate sized bat with short fur, relatively small ears and a fleshy nose leaf structure surrounding the nostrils. It has bright orange fur on the front of the body and the back appears darker because of brownish tips on the fur.

Morphologically smaller than the northern form of this species, the nocturnal Pilbara Leaf-nosed Bat has a head and body length ranging from 40.8 – 47.4 mm, with an average of 42.7 mm (van Dyck and Strahan 2008). The Pilbara Leaf-nosed Bat is opportunistic in its diet, with prey primarily consisting of moths, beetles and termites, but supplemented with other insects (Churchill 2008).

Mating occurs in July, with females giving birth to solitary young in late December or early January. Young grow rapidly until weaning in February, with females becoming sexually mature in their first year at about seven months, although males do not mature until their second year.

4.1.2 Population

On the basis of genetic work, the Pilbara leaf-nosed Bats are considered to be a single population (TSSC 2016b). This population is divided among a series of colonies. As known breeding colonies are relatively few, they are likely to be regionally important in maintaining the species.

4.1.3 Habitat

The local distribution of the Pilbara Leaf-nosed Bat is mostly strongly influenced by the suitability of roost caves (hot and with a high humidity level) rather than habitat type. The species is heavily reliant on warm (28 - 32°C), humid (85 - 100%) sites for roosting, which enables individuals to reduce water loss and energy expenditure (Baudinette et al. 2000).

Within the Pilbara, many deeper caves that provide a suitable microclimate arise in Brockman Iron Formation ranges (Armstrong 2001), and there is a general association of the species records with this geology type. Core roost sites are thought to be restricted to caves where at least semi-permanent water is nearby (Armstrong 2001, Churchill 2008), although significant roosts have also become established in man-made structures such as abandoned mines in the Pilbara region (Churchill 1991).

For the Pilbara Leaf-nosed Bat, 'habitat critical to the survival of the species' is defined by TSSC (2016b) as underground diurnal roosts with warm temperatures and high humidity, listed in order of priority for conservation, they are:

- **Permanent Diurnal Roost**:

  "occupied year-round and likely the focus for some part of the 9-month breeding cycle; considered as critical habitat that is essential for the daily survival of the Pilbara leaf-nosed bat."

- **Non-Permanent Breeding Roost**:

  "*evidence of usage during some part of the 9-month breeding cycle (July–March), but not occupied year-round; considered as critical habitat that is essential for both the daily and long-term survival of the Pilbara leaf-nosed bat*."

- **Transitory Diurnal Roost:**

  "occupied for part of the year only, outside the breeding season (April–June), and which could facilitate long distance dispersal in the region; considered as critical habitat that is essential for both the daily and long-term survival of the Pilbara leaf-nosed bat."

Habitat important for the persistence of the local population, although not considered to be critical habitat, is:

- **Nocturnal Refuge:**

  "occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Excludes overhangs. Not considered critical habitat but are important for persistence in a local area."

It is difficult to define critical foraging habitat (TSSC 2016b). Foraging habitat appears to be diverse and not a restricting factor, however, suitable foraging habitat located within vicinity of a diurnal roost in order of priority for conservation includes:

- gorges with pools (Priority 1)
- gullies (Priority 2)
- rocky outcrops (Priority 3)
- major watercourses (Priority 4)
- open grasslands and woodlands (Priority 5)

4.1.4 Threats

The TSSC (2016b) lists nine threats to the conservation status of the Pilbara Leaf-nosed Bat:

- heat and water loss: the species is known for its poor ability to maintain body temperature and water
- mine collapse: resulting in direct mortality
- flooding: resulting in destruction of roost sites and possibly direct mortality
- natural predators
- mine development: may result in the destruction of roost sites
- blasting in adjacent workings: resulting in abandoning of roost sites by bats
- human entry of roosts: resulting in animals abandoning the site
- road kills: direct mortality resulting from increased vehicle activity
- site rehabilitation.

4.1.5 Records

There are records of the Pilbara Leaf-nosed Bat in the surrounding area on DBCA's Threatened and Priority Fauna Database (Figure 4). The records range from 2009 to 2015 and are mainly from previous surveys at Woodie Woodie (Western Wildlife 2007, 2009, 2010, 2014), Ant Hill Mesa, Robe River and Ripon Hills.

4.2 Background on the Ghost Bat

The Ghost Bat (*Macroderma gigas*) is listed as Vulnerable under both *The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Biodiversity Conservation Act 2016* (BC Act). As a Threatened species under the EPBC Act, it is considered a Matter of National Environmental Significance (MNES).

4.2.1 Description and Biology

The Ghost Bat is Australia's only carnivorous bat and is known to feed on a variety of vertebrate species including, frogs, lizards, small birds, small mammals and other bats (Van Dyck and Strahan 2008). Ghost Bats mate between July and August, with females bearing a single young around November in Western Australia. Mothers form nursery colonies and genetic testing has shown that the entire species is centralised upon regional maternity sites (Van Dyck and Strahan 2008).

Unlike other microbats, the Ghost Bat does not use echolocation call continuously whilst in flight. Ghost Bats have large well-developed eyes and ears and quietly scan an area before swooping on their prey (Van Dyck and Strahan 2008).

4.2.2 Population

The Ghost Bats of the Pilbara region are disjunct and genetically distinct to those that occur in the Kimberley, Northern Territory and Queensland. The Pilbara population is divided between those in the Hamersley Ranges and those in the Chichester Ranges, though the genetic differentiation is low, suggesting bats move between these populations (Ottewell *et al*. 2017). If Ghost Bats are present at Woodie Woodie, they would fall within the Chichester Range subpopulation, which is estimated to be about 1,500 individuals (TSSC 2016a).

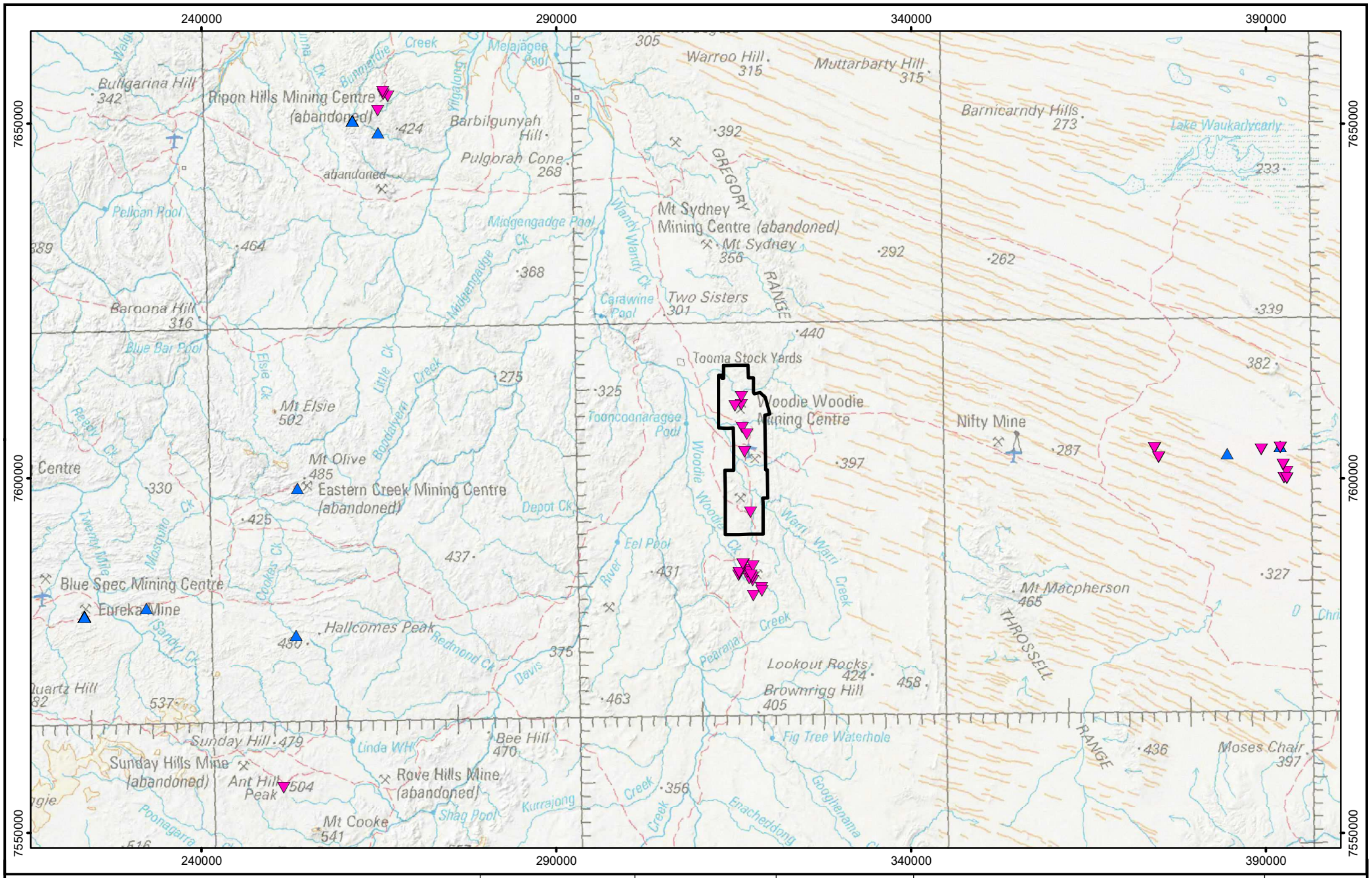
In the Chichester region, Ghost Bats are often found in large maternal roosts and these congregations are important for the survival of the species. However, smaller roosts are also likely to be important, allowing bats to occupy and forage through more of the landscape, resulting in dispersal and gene-flow between larger roosts. As the overall Chichester population is so small, all populations are likely to be important.

4.2.3 Habitat

Ghost Bats utilise several diurnal and nocturnal roost caves within an area for feeding, resting, breeding and maternity. In the Pilbara, a number of natural formations are used by the Ghost Bat intermittently as short-term transient roosts and for feeding activity for single or small numbers of individuals, whilst others are used by maternity colonies (Armstrong and Anstee, 2000).

The structure of a roost site is largely indicative of its use. Transient day roosts or feeding sites for Ghost Bats are often shallower with microclimates similar to ambient conditions (Armstrong and Anstee, 2000). Breeding activity for Ghost Bats is associated with roost sites that have a relative humidity of above 80% (Armstrong and Anstee, 2000). Restricted to gorges and escarpments in the Pilbara where access to surface water, particularly where permanent or semi-permanent rock pools are present, is reasonably accessible. Individuals and small groups may shelter in deep rock crevices and abandoned mine pits.

Although the foraging ecology of the Pilbara populations has not been studied, a recent Queensland study has found that male Ghost Bats forage up to 11.8km from the roost, while lactating females forage within 3km (Augusteyn *et al*. 2018). A study in the Northern Territory found that bats foraged on average 1.9km from their diurnal roost (Tidemann *et al*. 1985). Ghost Bats have large wings and are capable of flying considerable distances to forage, but there is uncertainty around the relative importance of close foraging habitats. If bats are forced to fly further to forage, this may impact on breeding success and cause population decline (Augusteyn *et al*. 2018). Therefore, any foraging habitat within 3km of a diurnal roost or potential maternity roost may be considered important foraging habitat.



Legend

Study Area **DBCA Records**

- Macroderma gigas - Ghost bat - VU
- Rhinonicteris aurantia (Pilbara) - Pilbara leaf-nosed bat - VU

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DBCA records of Ghost Bat and Pilbara Leaf-nosed Bat

Figure: **4**

4.2.4 Threats

Threats to the conservation status of the Ghost Bat include:

- direct heat and water loss: the species is known for its poor ability to maintain body temperature and water
- wide fluctuations in cave temperature and humidity due to extrinsic disturbances, especially maternity caves, leading to direct mortality and cave abandonment
- mine/cave collapse: resulting in direct mortality
- flooding: resulting in destruction of roost sites and possibly direct mortality
- mine development: may result in the destruction of roost sites
- blasting in adjacent workings: resulting in abandoning of roost sites by bats
- human entry of roosts: resulting in animals abandoning the site.

4.2.5 Records

There are records of the Ghost Bat in the surrounding area on DBCA's Threatened and Priority Fauna Database (Figure 4). The records range from undated historical specimens to 2018, mainly from All Nations Mine with a few records from Robe River and Ripon Hills.

4.3 Potential Bat Roosting Habitat at Woodie Woodie

No diurnal roost sites were recorded during the survey. Despite extensive searching in rocky habitats, only five caves were found (Figure 5, Table 5, Plates 1 - 3). Anabat detectors set at the cave mouths returned no records of Ghost Bat and no evidence of Ghost Bat presence (scats or middens) was found. Although the Pilbara Leaf-nosed Bat was recorded at each cave, the overall number of passes was low (Table 5, Appendix 1). The pattern of Pilbara Leaf-nosed Bat activity at the caves was not suggestive of diurnal roosts, as there was no indication of an exodus of bats at dusk and return of bat prior to dawn (Appendix 1). It is likely that any roost sites present are nocturnal refuges only, where bats rest or forage during the night.

Table 5. Conservation significant bat records in caves at Woodie Woodie.

Cave	Description	Anabat Site	Pilbara Leaf-nosed Bat	Ghost Bat
Cave01	**Cave in low dolomite gorge**, cave entrance 1.5m high, 3m wide and at least 8m deep (back not visible).	WB11	Yes (1 pass recorded)	No
Cave02	**Possible small cave or crevice** under chert boulders on the side of a stony hill.	WB12	Yes (69 passes recorded)	No
Cave03	**Small cave in low ridgeline**. Cave entrance 0.5m high x 1m wide, at least 4m deep (back not visible).	WB14	Yes (3 passes recorded)	No
Cave04	**Cave in chert breakaway** on side of stony hill. Cave entrance 2.5m high, 7m wide, at least 20m deep (back not visible).	WB20	Yes (47 passes recorded)	No
Cave05	**Cave in low ridgeline**. Cave entrance 1m high, 2m wide, at least 8.5m deep (back not visible).	WB28	Yes (81 passes recorded)	No

Plate 1. Cave02.

Plate 2. Cave04.

Plate 3. Cave05.

4.4 Potential Bat Foraging Habitat at Woodie Woodie

It is uncertain whether Woodie Woodie comprises foraging habitat for the Ghost Bat, as this species has not been confirmed as occurring in the study area. If present, this species may forage over any habitat.

The study area does provide foraging habitat for the Pilbara Leaf-nosed Bat, with this species recorded at several locations on this and previous surveys (Figures 4 and 5). All types of foraging habitat identified by the TSSC (2016b) are present, including low gorges with pools, gullies, rocky outcrops, major watercourses and open spinifex grassland (Plates 4 – 8). In many cases these habitat types overlap, for example, there are rocky outcrops associated with major watercourses and gullies.

Plate 4. Waterhole in low gorge on Muddauthera Creek.

Plate 5. Dry gullies.

Plate 6. Rocky outcrops.

Plate 7. Major watercourse.

Plate 8. Open spinifex grasslands.

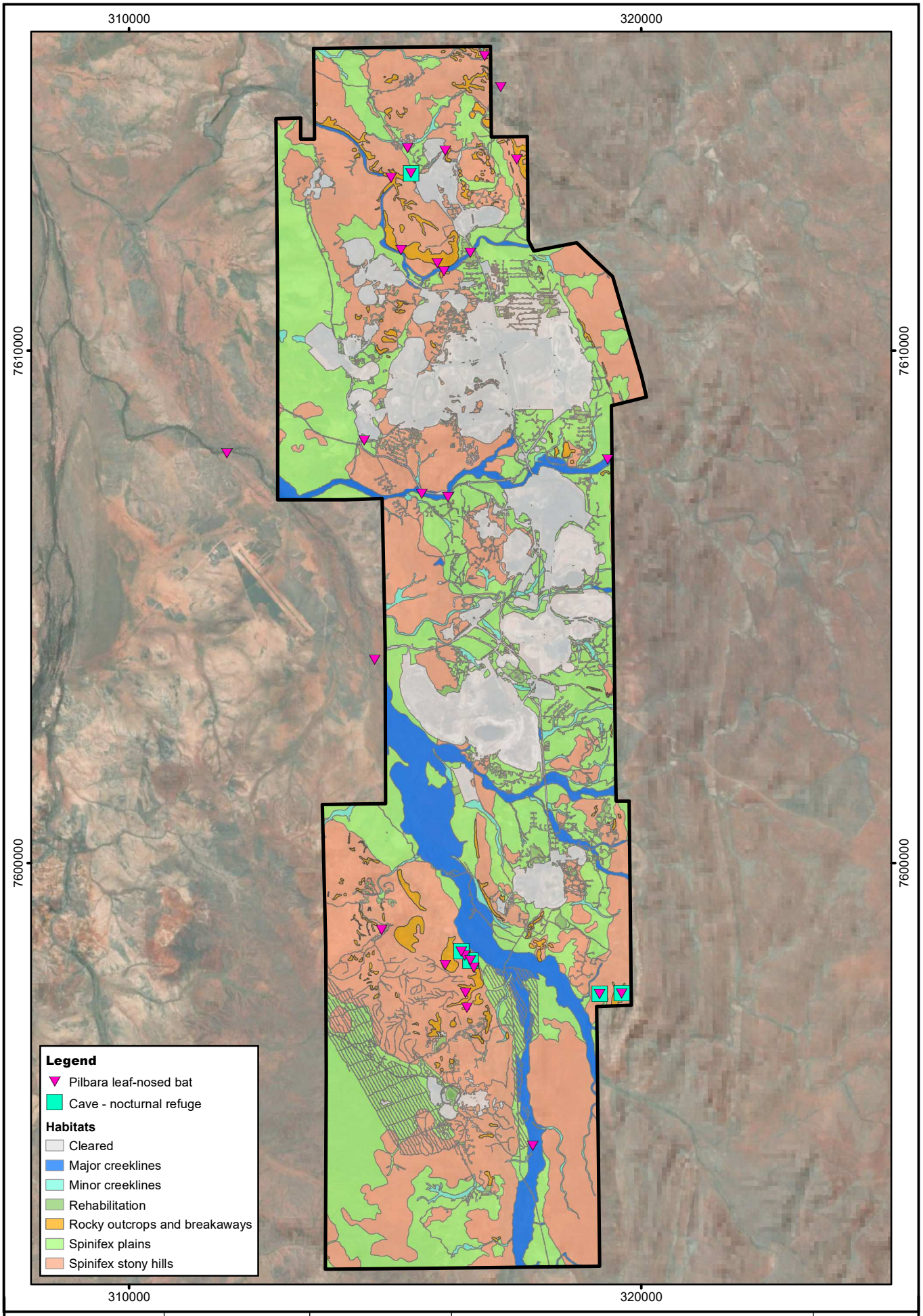
5. Discussion and Conclusions

The Ghost Bat is not known to occur at Woodie Woodie. Although the species may potentially occur, Woodie Woodie is not likely to supply the caves that this species relies on for breeding and diurnal roosting.

The Pilbara Leaf-nosed Bat is known to occur at Woodie Woodie, with records of bats from across the study area in both June and October 2020 (Figure 5). No diurnal roost sites were detected and there were very few caves present. This species is likely to use caves and overhangs in the study area as nocturnal refuges, but these are not considered habitat critical to the survival of the species. Foraging habitat considered to be a high priority for conservation is present, including gorges with pools, gullies and rocky outcrops. Foraging habitat in general is not considered critical habitat but is still important for supporting this species.

The roost location (or locations) of the Pilbara Leaf-nosed Bats recorded at Woodie Woodie is currently unknown. There are considerable tracts of rocky habitat in the region, much of which remains uninvestigated for this species.

Woodie Woodie is not likely to provide roosting habitat critical to the survival of the Ghost Bat or Pilbara Leaf-nosed Bat. This can be stated with a relatively high degree of confidence, as Woodie Woodie is dominated by rolling stony hills and the areas of rocky ridge and gorge are small and generally do not bear caves. However, Woodie Woodie still provides foraging habitat and nocturnal refuges for the Pilbara Leaf-nosed Bat and possibly the Ghost Bat. Although not considered critical habitat, foraging habitat and nocturnal refuges are likely to be important for maintaining local populations of these species.



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Scale: 1:100,000
MGA94 (Zone 50)

Western Wildlife

Woodie Woodie Mine
Pilbara Leaf-nosed Bat records and habitat

Figure: **5**

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Appendices

Appendix 1. Bat call Analysis.

Acoustic analysis and bat call identification from Woodie Woodie, Western Australia

Prepared for **Western Wildlife Pty Ltd**

Version **18 December 2020**

SZ project reference **SZ531**

Prepared by [redacted]

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This report should be included as an appendix in any larger submission to Government, and cited as:

Specialised Zoological (2020). Acoustic analysis and bat call identification from Woodie Woodie, Western Australia. Unpublished report by Specialised Zoological for Western Wildlife Pty Ltd, 18 December 2020, project reference SZ531.

Summary

Bat identifications from acoustic recordings are provided from Woodie Woodie, in the Pilbara region of Western Australia. The identification of bat species from full spectrum WAV-format recordings of their echolocation calls was based on measurements of characteristic frequency, observation of pulse shape, and the pattern of harmonics. Nine species of bat were identified unambiguously as being present (**Tables 1** and **2**). The Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* (Rhinonycteridae) was detected on 31 recording nights, but times of first detection relative to sunset and the end of civil twilight, as well as nightly activity patterns, did not suggest the presence of any type of diurnal roost site at any bat detector recording site. The Ghost Bat *Macroderma gigas* (Megadermatidae) was not detected. Representative echolocation calls for each identification are illustrated (**Figure 1**), as recommended by the Australasian Bat Society (ABS 2006). Further details are available should verification be required.

Methods

The data provided were recorded in full spectrum WAV format with Titley Scientific Anabat Swift bat detectors (sampling rate 500 kHz, set to turn on automatically at sunset and off at sunrise).

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong and Aplin 2014; Armstrong et al. 2016) was applied to the recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language script that performed three tasks:

1. undertook a Discriminant Function Analysis on training data from representative calls from the Pilbara;

2. from the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over confidence regions for the defined call types; and

3. facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in Adobe Audition CS6 version 5.0.2.

Species were identified based on information in McKenzie and Bullen (2009) and the author's own unpublished material; and nomenclature follows Jackson and Groves (2015).

In addition, a custom R script was used to compile a list of the WAV files containing calls of the Pilbara Leaf-nosed Bat. This information was summarised to enable interpretations to be made about the likelihood of a diurnal roost being present.

Roosts of the Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat was detected on more than half of the recording nights (31 out of 51 sites). As a first step to determining the likelihood of this species roosting in any of the caves that had bat detectors placed at the entrance, or at sites nearby, four parameters were calculated from the recordings:

1. The time of first detection relative to sunset time and the end of civil twilight;
2. The time of last detection relative to the beginning of civil twilight before sunrise;
3. The total number of passes (echolocation call sequences) per night; and
4. The activity pattern over the course of each night.

No calls were detected in the period of twilight between sunset and civil set, or between civil rise and sunrise. In addition, no calls were detected within the 30 minutes after civil set or before civil rise (**Table 3**). We would expect to detect the Pilbara Leaf-nosed bat within one of these periods if it were present during the day inside the cave being assessed, or in another cave nearby.

The total number of echolocation calls per night was relatively low (**Table 3**). Even the presence of a small number of individuals would probably result in more calls being detected than at these sites, since they often linger around cave entrances soon after dusk or just before dawn.

There were no large peaks of activity just after sunset or just prior to dawn (**Figure 2**), which would result from bats lingering at the cave entrance soon after emerging, or soon after returning from a night foraging elsewhere. These patterns are more suggestive of foraging activity in the open nearby, casual visitation of rocky outcrop, or a nocturnal refuge in the case of caves.

All observations compiled here do not suggest the presence of a diurnal roost in the areas surveyed. If all caves have been assessed in the project area, then it is likely that a diurnal roost (*sensu* TSSC 2016) is not present in the project area.

Limitations

The identifications presented in this report have been made within the following context:

1. The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party' (the client named on the front of this report).
2. The scope of this report extended to providing information on the identification of bat species in bulk ultrasonic recordings. Further comment on these species and the possible impacts of a planned project on bat species were not part of the scope.
3. In the case of the present report, the recording equipment was set up and supplied by Specialised Zoological. The equipment was operated by the third party during the survey.
4. Other than the general location of the study area, Specialised Zoological has not been provided with detailed information of the survey area, has not made a visit to observe the habitats available for bats, nor have we visited the specific project areas on a previous occasion.
5. Specialised Zoological has had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
6. While Specialised Zoological has made identifications to the best of our ability given the available materials, and reserves the right to re-examine the data and revise any identification following a query, it is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping effort or non-invasive methods such as video recordings. Specialised Zoological bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported on here.
7. There are a variety of factors that affect the 'detectability' of each bat species, given the frequency, power and shape characteristics of their calls. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
8. The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method. If an identification in the present report is ambiguous or in question, a trapping programme would help to resolve the presence of the possibilities in the project area.

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URL:
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Table 1. Species identified in the present survey from all sites combined.

EMBALLONURIDAE	
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*
Common Sheath-tailed Bat	*Taphozous georgianus*
RHINONYCTERIDAE	
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*
VESPERTILIONIDAE	
Gould's Wattled Bat	*Chalinolobus gouldii*
Little Broad-nosed Bat	*Scotorepens greyii*
Finlayson's Cave Bat	*Vespadelus finlaysoni*
MOLOSSIDAE	
White-striped Free-tailed Bat	*Austronomus australis*
Greater Northern Free-tailed Bat	*Chaerephon jobensis*
Northern Free-tailed Bat	*Ozimops lumsdenae*

Table 2. Species identifications, with the degree of confidence indicated by a code. Date and recording unit number correlates with site; see *Table 1* for full species names. Detections from June 2020

		A. australis	*C. gouldii*	*C. jobensis*	*O. lumsdenae*	*R. aurantia*	*S. flaviventris*	*S. greyii*	*T. georgianus*	*V. finlaysoni*
Swift 449958										
22/06/2020	-21.589917 S, 121.223960 E	X	X	X	—	X	—	X	X	X
23/06/2020	-21.712377 S, 121.228247 E	—	—	—	—	X	—	—	X	—
24/06/2020	-21.709485 S, 121.223668 E	—	X	—	—	—	—	—	X	—
25/06/2020	-21.714117 S, 121.206820 E	—	X	—	—	—	—	—	—	—
26/06/2020	-21.712922 S, 121.234925 E	—	X	—	—	—	—	—	X	—
27/06/2020	-21.573250 S, 121.214548 E	X	X	X	—	X	—	X	X	X
Swift 449972										
22/06/2020	-21.585215 S, 121.216525 E	X	X	X	—	X	—	X	X	X
23/06/2020	-21.709070 S, 121.225177 E	—	X	—	—	X	—	—	X	—
24/06/2020	-21.711978 S, 121.222745 E	—	X	—	—	X	—	—	—	—
25/06/2020	-21.705633 S, 121.210858 E	X	X	—	—	X	—	—	X	—
26/06/2020	-21.716765 S, 121.226688 E	X	X	—	—	X	—	—	X	—
28/06/2020	-21.647533 S, 121.229788 E	X	X	X	—	X	—	X	X	—
Swift 449995										
22/06/2020	-21.568900 S, 121.238162 E	—	X	—	—	—	—	X	X	X
23/06/2020	-21.710923 S, 121.227848 E	—	—	—	—	X	—	—	X	—
24/06/2020	-21.629422 S, 121.224505 E	X	X	X	—	X	—	—	X	X
25/06/2020	-21.717260 S, 121.256060 E	—	X	—	—	X	—	—	X	—
26/06/2020	-21.744067 S, 121.239078 E	X	X	—	—	—	—	—	—	—
27/06/2020	-21.567263 S, 121.208028 E	X	X	—	—	—	—	X	X	X

Definition of confidence level codes

— Not detected.

X Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material. Greater confidence in this ID would come only after capture and supported by morphological measurements or a DNA sequence.

NC Needs Confirmation. Either call quality was poor, or the species cannot be distinguished reliably from another that makes similar calls. Alternative identifications are indicated in the *Comments on identifications* section of this report. If this is a species of conservation significance, further survey work might be required to confirm the record.

Table 2. Species identifications—*continued.* Detections from June 2020

		A. australis	*C. gouldii*	*C. jobensis*	*O. lumsdenae*	*R. aurantia*	*S. flaviventris*	*S. greyii*	*T. georgianus*	*V. finlaysoni*
Swift 450007										
22/06/2020	-21.588090 S, 121.222947 E	X	X	X	—	X	—	X	X	X
23/06/2020	-21.703462 S, 121.227295 E	—	X	—	—	—	—	—	X	—
Swift 450053										
22/06/2020	-21.552402 S, 121.232157 E	X	X	—	—	X	—	X	X	—
23/06/2020	-21.709545 S, 121.225815 E	—	—	—	—	X	—	—	X	—
24/06/2020	-21.723768 S, 121.220413 E	—	—	—	—	—	—	X	X	—
25/06/2020	-21.705773 S, 121.213475 E	—	—	—	—	—	—	—	—	—
26/06/2020	-21.728385 S, 121.230805 E	X	X	—	—	—	—	X	X	X
27/06/2020	-21.568340 S, 121.224575 E	X	X	—	—	X	—	—	X	—
Swift 450091										
22/06/2020	-21.569680 S, 121.238845 E	—	X	—	—	X	—	—	X	X
23/06/2020	-21.714113 S, 121.229750 E	—	X	—	—	—	—	—	X	X
24/06/2020	-21.623112 S, 121.254638 E	—	X	—	—	X	—	X	—	X
25/06/2020	-21.623112 S, 121.254638 E	—	—	—	—	X	—	—	X	—
26/06/2020	-21.719237 S, 121.226990 E	—	X	—	—	X	—	X	X	X

Table 2. Species identifications—*continued*. Detections from September 2020.

		A. australis	*C. gouldii*	*C. jobensis*	*O. lumsdenae*	*R. aurantia*	*S. flaviventris*	*S. greyii*	*T. georgianus*	*V. finlaysoni*
Swift 449972										
19/09/2020	-21.657028 S, 121.210230 E	—	X	X	X	X	—	X	X	—
21/09/2020	-21.744282 S, 121.238707 E	—	X	—	—	X	—	X	—	X
22/09/2020	-21.774612 S, 121.235145 E	—	X	—	—	—	X	X	—	X
23/09/2020	-21.728458 S, 121.209585 E	—	X	—	—	—	X	—	X	—
24/09/2020	-21.567830 S, 121.217408 E	—	X	X	—	X	X	X	—	X
25/09/2020	-21.536953 S, 121.195588 E	—	—	—	—	X	X	X	—	—
26/09/2020	-21.619122 S, 121.208670 E	—	X	X	—	X	—	X	X	X
27/09/2020	-21.586263 S, 121.229208 E	—	X	—	X	X	—	X	—	X
28/09/2020	-21.801253 S, 121.237367 E	—	X	—	—	—	—	X	—	X
29/09/2020	-21.557207 S, 121.235313 E	—	X	—	—	X	—	X	—	X
Swift 49995										
19/09/2020	-21.631820 S, 121.184833 E	—	—	X	—	—	X	—	—	X
21/09/2020	-21.674828 S, 121.242367 E	—	X	X	—	—	X	—	X	—
22/09/2020	-21.785455 S, 121.241447 E	—	X	—	—	—	X	X	—	—
23/09/2020	-21.713548 S, 121.200982 E	—	X	—	—	—	X	X	X	X
24/09/2020	-21.544215 S, 121.204208 E	—	X	X	—	X	—	X	X	—
25/09/2020	-21.644083 S, 121.222430 E	—	—	X	—	—	—	X	—	—
26/09/2020	-21.628633 S, 121.219323 E	—	X	X	—	X	X	X	—	—
27/09/2020	-21.621228 S, 121.182813 E	—	X	X	—	X	—	X	—	X
28/09/2020	-21.621228 S, 121.182813 E	—	X	—	X	—	X	X	—	—
29/09/2020	-21.539130 S, 121.234632 E	—	X	—	—	—	X	X	—	—

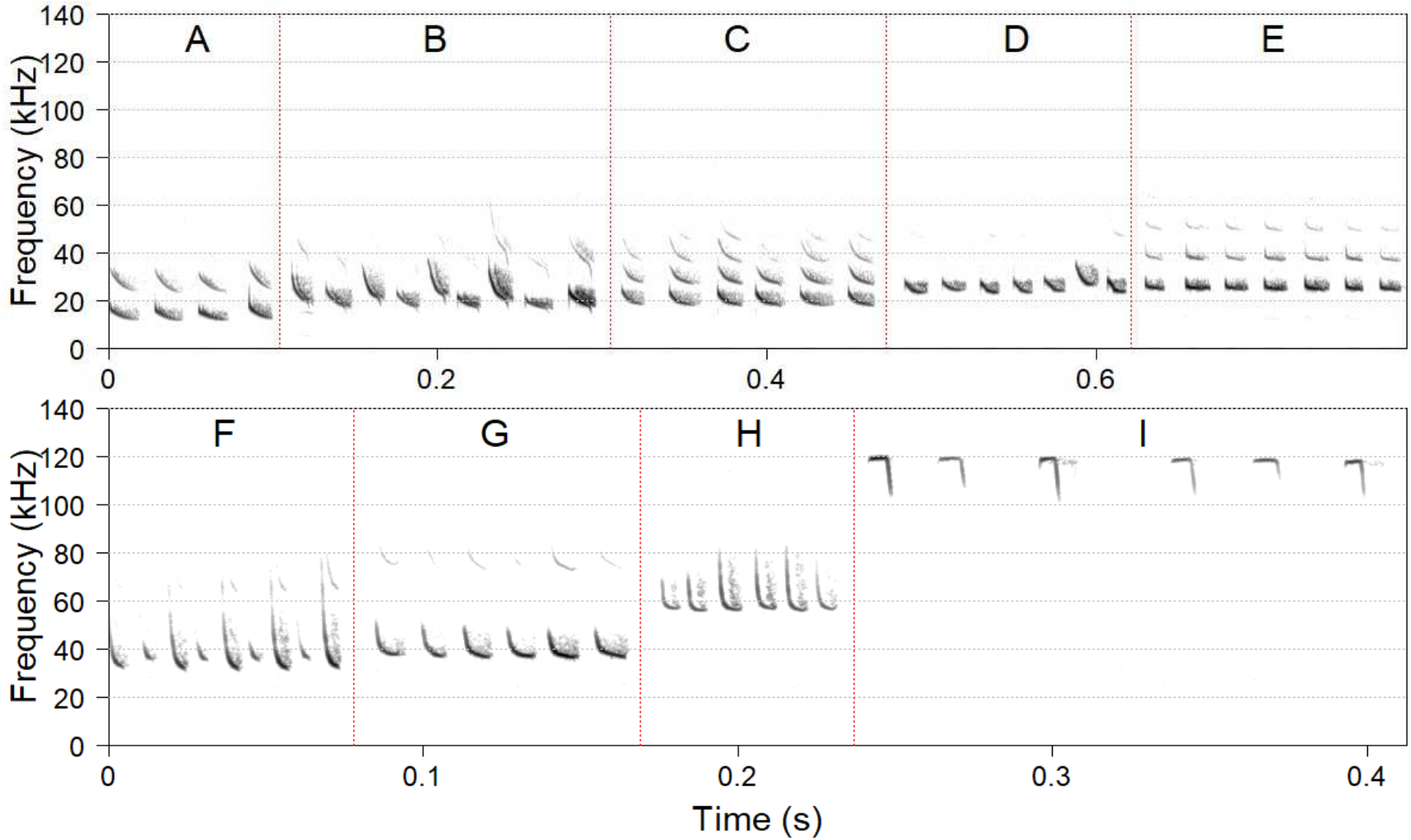

Figure 1. Representative echolocation call sequence portions of the species identified (**A**: *Austronomus australis*; **B**: *Chaerephon jobensis*; **C**: *Saccolaimus flaviventris*; **D**: *Ozimops lumsdenae*; **E**: *Taphozous georgianus*; **F**: *Chalinolobus gouldii*; **G**: *Scotorepens greyii*; **H**: *Vespadelus finlaysoni*; **I**: *Rhinonicteris aurantia*; time between pulses has been compressed).

Table 3. Summary of the times of first detection of the Pilbara Leaf-nosed Bat relative to sunset time and the end of civil twilight; plus time of last detection relative to the beginning of civil twilight before sunrise. Blue shading of dates indicates recording at the entrance of a cave or overhang.

		First detection HH:MM:SS	Last detection HH:MM:SS	Sunrise HH:MM	Sunset HH:MM	Civil rise HH:MM	Civil set HH:MM	Time since sunset HH:MM	Time since civilset HH:MM	Time before sunrise HH:MM	Time before civilrise HH:MM	No. passes per night
	June 2020											
Swift 449958												
22/06/2020	-21.589917 S, 121.223960 E	18:48:19	02:33:43	06:33	17:20	06:08	17:45	01:28	01:03	03:59	03:34	11
23/06/2020	-21.712377 S, 121.228247 E	23:17:00	23:17:00	06:33	17:21	06:09	17:45	05:56	05:32	07:16	06:52	1
27/06/2020	-21.573250 S, 121.214548 E	18:31:32	05:06:39	06:34	17:22	06:09	17:46	01:09	00:45	01:27	01:02	107
Swift 449972												
22/06/2020	-21.585215 S, 121.216525 E	18:39:53	04:41:11	06:33	17:20	06:08	17:45	01:19	00:54	01:51	01:26	47
23/06/2020	-21.709070 S, 121.225177 E	19:28:06	04:51:38	06:33	17:21	06:09	17:45	02:07	01:43	01:41	01:17	31
24/06/2020	-21.711978 S, 121.222745 E	23:20:28	03:27:36	06:33	17:21	06:09	17:45	05:59	05:35	03:05	02:41	4
25/06/2020	-21.705633 S, 121.210858 E	18:49:14	02:26:11	06:33	17:21	06:09	17:45	01:28	01:04	04:06	03:42	22
26/06/2020	-21.716765 S, 121.226688 E	00:27:29	01:54:45	06:33	17:21	06:09	17:46	07:06	06:41	04:38	04:14	2
28/06/2020	-21.647533 S, 121.229788 E	21:35:25	21:35:25	06:34	17:22	06:09	17:46	04:13	03:49	08:58	08:33	1
Swift 449995												
23/06/2020	-21.710923 S, 121.227848 E	19:25:31	04:33:00	06:33	17:21	06:09	17:45	02:04	01:40	02:00	01:36	69
24/06/2020	-21.629422 S, 121.224505 E	19:09:49	21:47:16	06:33	17:21	06:09	17:45	01:48	01:24	08:45	08:21	4
25/06/2020	-21.717260 S, 121.256060 E	22:04:49	01:26:20	06:33	17:21	06:09	17:45	04:43	04:19	05:06	04:42	3
Swift 450007												
22/06/2020	-21.588090 S, 121.222947 E	20:38:24	03:44:37	06:33	17:20	06:08	17:45	03:18	02:53	02:48	02:23	4
Swift 450053												
22/06/2020	-21.552402 S, 121.232157 E	20:42:13	03:34:13	06:33	17:20	06:08	17:45	03:22	02:57	02:58	02:33	2
23/06/2020	-21.709545 S, 121.225815 E	19:03:54	05:07:27	06:33	17:21	06:09	17:45	01:42	01:18	01:25	01:01	47
24/06/2020	-21.723768 S, 121.220413 E	01:56:01	01:56:01	06:33	17:21	06:09	17:45	08:35	08:11	04:36	04:12	1
27/06/2020	-21.568340 S, 121.224575 E	19:22:42	21:52:12	06:34	17:22	06:09	17:46	02:00	01:36	08:41	08:16	9

		First detection HH:MM:SS	Last detection HH:MM:SS	Sunrise HH:MM	Sunset HH:MM	Civil rise HH:MM	Civil set HH:MM	Time since sunset HH:MM	Time since civilset HH:MM	Time before sunrise HH:MM	Time before civilrise HH:MM	No. passes per night
Swift 450091												
22/06/2020	-21.569680 S, 121.238845 E	20:21:12	20:21:19	06:33	17:20	06:08	17:45	03:01	02:36	10:11	09:46	2
24/06/2020	-21.623112 S, 121.254638 E	20:26:09	04:37:32	06:33	17:21	06:09	17:45	03:05	02:41	01:55	01:31	8
25/06/2020	-21.623112 S, 121.254638 E	19:19:56	04:48:35	06:33	17:21	06:09	17:45	01:58	01:34	01:44	01:20	81
26/06/2020	-21.719237 S, 121.226990 E	23:51:03	23:51:03	06:33	17:21	06:09	17:46	06:30	06:05	06:41	06:17	1
	September 2020											
Swift 49995												
24/09/2020	-21.544215 S, 121.204208 E	03:44:18	03:44:18	05:42	17:51	05:20	18:13	09:53	09:31	01:57	01:35	1
26/09/2020	-21.628633 S, 121.219323 E	23:46:34	04:13:07	05:40	17:52	05:18	18:14	05:54	05:32	01:26	01:04	2
27/09/2020	-21.621228 S, 121.182813 E	18:48:13	04:04:35	05:39	17:52	05:17	18:14	00:56	00:34	01:34	01:12	16
Swift 449972												
19/09/2020	-21.657028 S, 121.210230 E	19:04:45	04:03:07	05:47	17:50	05:24	18:12	01:14	00:52	01:43	01:20	9
21/09/2020	-21.744282 S, 121.238707 E	20:57:37	20:57:37	05:45	17:50	05:23	18:13	03:07	02:44	08:47	08:25	1
24/09/2020	-21.567830 S, 121.217408 E	22:41:04	04:16:35	05:42	17:51	05:20	18:13	04:50	04:28	01:25	01:03	4
25/09/2020	-21.536953 S, 121.195588 E	04:16:35	04:16:35	05:41	17:51	05:19	18:14	10:25	10:02	01:24	01:02	1
26/09/2020	-21.619122 S, 121.208670 E	20:39:39	04:35:54	05:40	17:52	05:18	18:14	02:47	02:25	01:04	00:42	17
27/09/2020	-21.586263 S, 121.229208 E	19:07:03	03:57:06	05:39	17:52	05:17	18:14	01:15	00:53	01:41	01:19	7
29/09/2020	-21.557207 S, 121.235313 E	19:15:06	03:47:28	05:37	17:53	05:15	18:15	01:22	01:00	01:49	01:27	7

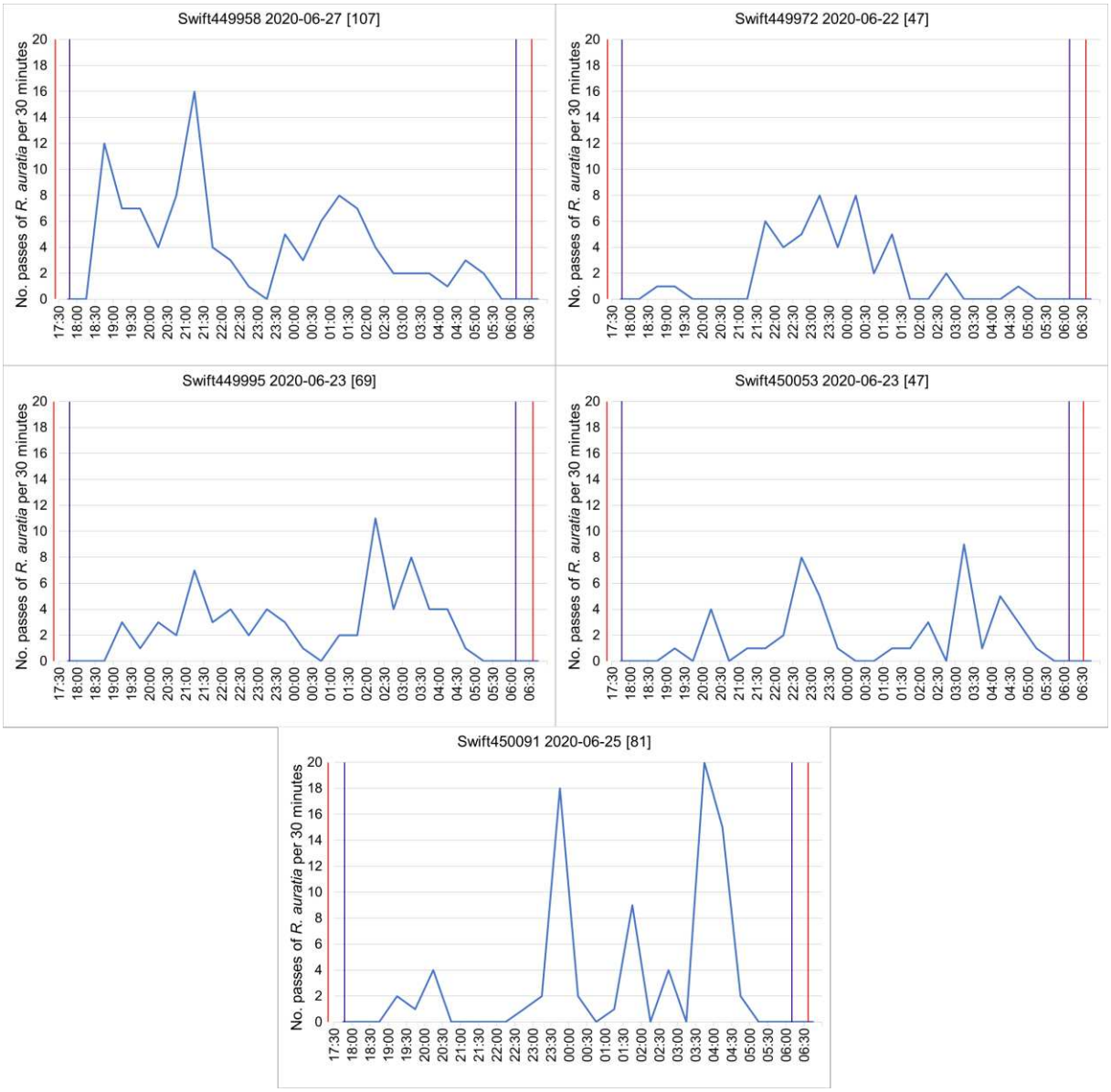

Figure 2. Nightly activity patterns at recording sites that had c. 50 passes or more of the Pilbara Leaf-nosed Bat in a single night. Red vertical lines are times of sunset and sunrise; Blue vertical lines are times of the end of civil twilight after sunset, and the beginning of civil twilight before sunrise; square brackets are total number of nightly passes of the Pilbara Leaf-nosed Bat.