Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Annual Ecological Monitoring Report

February 2024 - February 2025

Transport for NSW | May 2025

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Contents

Introduction

This report provides an update on the ecological monitoring outcomes associated with the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway upgrade and covers the period from February 2024 to February 2025. The report has been prepared in accordance with the Warrell Creek to Nambucca Heads Ecological Monitoring Program (Roads and Maritime 2018), for submission to the Department of Planning and Environment and Environment Protection Authority (EPA).

This represents the ninth annual report for the WC2NH project, with Table 1 below highlighting the ecological monitoring reports for the period February 2024 to February 2025.

Table 1 Ecological monitoring reports for the reporting period Feb 24 – Feb 25 included in this annual report.

Species / mitigation monitored	Timing	Reporting
Fauna Underpass	Spring / summer, winter	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.
Giant Barred Frog	Spring, summer and autumn	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.
Yellow-bellied Glider	August to October population monitoring August to January song meter deployment	**Year 6 Annual Report 2024.** **The monitoring and reporting have been undertaken and provided following the recommendation from the Year 4 2022 Annual report to *"move the programmed year 7 yellow-bellied glider population survey to year six (i.e. spring 2023) to reduce the time between samples and better track population change."***
Threatened Flora	Spring	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.
Landscape Monitoring	Quarterly	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.
Road kill	12 weeks following commencement of operation of each stage. Thereafter seasonally	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.

Species / mitigation monitored	Timing	Reporting
Widened Vegetation Median	Summer/autumn and winter/spring commencing in Year 2 of operation	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.
Green-thighed frog	Annually based on rainfall events. **Year 10 2023/24 scheduled dependent if suitable rainfall event occurs. The required trigger rainfall events did not occur during the required seasonal period for monitoring.**	**No monitoring was undertaken in Year 10. This is the final year for Operational Monitoring and Reporting. As the monitoring did not occur, advice has been previously provided which recommends that no further monitoring is required.** **Advice from NSW DCCEEW BCS was that only 3 of the 5 monitoring events as outline in the Ecological Monitoring Program had been undertaken during the Operational monitoring period and that the remaining 2 monitoring events are still required to be undertaken.** **The remaining monitoring events will be undertaken as per the Ecological Monitoring Program and the necessary rainfall trigger events.**
Koala	Spring	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.
Nest Boxes	Winter and Summer	Not required for this reporting period. All monitoring and reporting has been completed as required by the Ecological Monitoring Program.

Statutory and planning framework

Approval for the Warrell Creek to Urunga Pacific Highway Pacific Highway upgrade was granted by the then Department of Planning & Infrastructure on 19 July 2011 subject to the Minister's Conditions of Approval (CoA) being met. Roads and Maritime has constructed and opened the project in stages. The three main stages of the project are:

- Stage 1 - The Nambucca Heads to Urunga (NH2U) project involved construction of approximately 21.6km of new highway between Nambucca Heads, to the south of Nambucca Heads Interchange, at (Ch19500) and the existing Waterfall Way Interchange at Raleigh, north of Urunga. Stage 1 of the project opened to traffic in July 2016.
- Stage 2 - The Warrell Creek to Nambucca Heads (WC2NH) project involves construction of approximately 19.5km of new highway between the existing Allgomera deviation south of Warrell Creek and extends to the southern extent of the NH2U stage 1. This stage of the project opened to traffic in two parts initially on 19 December 2017 and finally in its entirety on 29 June 2018.

The Warrell Creek to Nambucca Heads Pacific Highway upgrade approval included the requirement to develop an ecological monitoring program:

Prior to the commencement of any construction work that will result in the disturbance of any native vegetation, the Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the mitigation measures implemented as part of the project. The program shall be developed in consultation with EPA and prepared by a suitably qualified ecologist and shall include but not necessarily be limited to:

(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in condition B1 to B6, B7(b), B7(d), B21(c) and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate appropriate and justified monitoring periods and performance targets against which effectiveness will be measured. The monitoring shall include operational road kill surveys to assess the effectiveness of fauna crossing and exclusion fencing implemented as part of the project;
(b) mechanism for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1);
(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods (i.e. 5 years) after opening of the project to traffic, unless otherwise agreed to by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with EPA, depending on the outcomes of the monitoring;
(d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project;
(e) details of contingency measures that will be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and
(f) provision for annual reporting of monitoring results to the Director General and EPA, or as otherwise agreed by those agencies.

The Program shall be submitted for the Director General's approval prior to the commencement of any construction work that will result in the disturbance of any native vegetation. Unless otherwise agreed, the Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that will result in the disturbance of any native vegetation.

The Warrell Creek to Nambucca Heads ecological monitoring program was approved by the Department of Planning & Environment on 14 March 2018 with a minor change updated by the Department of Planning & Environment independent environmental representative on 1 June 2018

Appendix A Yellow-bellied Glider Population Monitoring

Pacific Highway Upgrade Warrell Creek to Nambucca Heads

Yellow-bellied glider (*Petaurus australis*) population monitoring. Year six operation phase.

Transport for New South Wales | September 2024 | Final report.

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Pacific Highway Upgrade – Warrell Creek to Nambucca Heads

Yellow-bellied glider (*Petaurus australis*) population monitoring – year six operation phase

Sandpiper Ecological Surveys

Final Report

12 September 2024

Document Distribution

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Project Team:

Dr D. Rohweder (Project Management, review, fieldwork)

Mr L. Andrews (Report, fieldwork)

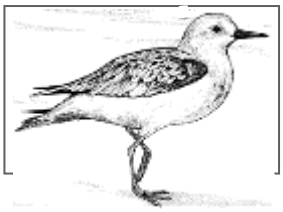
Mrs N. Makings (Fieldwork)

Ms A. English (Fieldwork)

Mr. F. Makin (Fieldwork)

Report prepared for:

Transport for New South Wales



ABN: 82 084 096 828

837 Rogerson Road, McKees Hill
david@sandpipereco.com.au

13 Alkina Street, Sapphire Beach
luke@sandpipereco.com.au

Cover Photo: N/A

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1 Introduction

1.1 Background

Transport for NSW (TfNSW), in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH) in 2015. The upgrade was subsequently completed and the final stage of the project open to traffic in June 2018.

Approvals for the WC2NH upgrade required monitoring of several species and mitigation measures during the operational phase. Species and mitigation measures targeted include koala *Phascolarctos cinereus*, yellow-bellied glider *Petaurus australis*, giant barred frog *Mixophyes iteratus*, constructed ponds for green-thighed frog *Litoria brevipalmata*, fauna underpasses, vegetated median, roadkill, exclusion fence, and threatened flora. Sandpiper Ecological Surveys (Sandpiper Ecological) was contracted by TfNSW to deliver the WC2NH operational ecological and water quality monitoring program in accordance with the WC2NH Operational Ecological and Water Quality Monitoring Brief (the Brief) as informed by the WC2NH Ecological Monitoring Program (EMP) (RMS 2018).

The EMP sets out a yellow-bellied glider monitoring program that extends to year one of the operational phase and refers to details provided in the WC2NH Ecological Monitoring Program for the Yellow-bellied Glider (herein referred to as YBG EMP) (Goldingay 2014a). The program was largely based on pre-construction phase (baseline) surveys completed in 2014 (Goldingay 2015) and aims to assess both individual level and population level responses to the highway upgrade.

An individual-level response will be measured by comparing forest use adjacent to the highway upgrade before and after construction. This will be assessed using spotlighting and song meters to detect and record yellow-bellied glider calls near the highway upgrade (RMS 2018). A population-level response will be assessed by comparing the proportion of survey sites occupied by yellow-bellied gliders in Nambucca State Forest (SF) with those in reference locations, both before and after construction (RMS 2018). This will involve using spotlight transects in Nambucca SF and at reference sites in Yarriabini National Park (NP) and Ngambaa Nature Reserve (NR).

1.2 Species ecology

The yellow-bellied glider is Australia's largest Petaurid glider, weighing between 450 - 700 g (Russell 1995). It feeds on a range of food including plant and insect exudates (sap, manna gum, honeydew, nectar and pollen) as well as insects and spiders (Goldingay and Jackson 2004). Population abundance is strongly related to the degree of forest maturity and the diversity of floristic resources (Kavanagh 1987). Yellow-bellied gliders den within tree hollows in small family groups of 2 - 6 individuals, including an adult male and one to two females and their offspring (Goldingay and Kavanagh 1991). Breeding females give birth to one offspring in most years but may not breed when environmental conditions are poor (Craig 1985; Goldingay 1992).

Yellow-bellied gliders are highly mobile and family groups feature home ranges in the order of 25 - 100 ha (Goldingay and Jackson 2004, Goldingay and Quin 2004). The species are also highly vocal and may be heard well over 200 m away. Individuals call up to 15 times/hour for several hours after dark (Goldingay 1994). Calls are given at frequencies of 700-6400 Hz (main energy band 1000 - 3000 Hz) and range in duration from less than one second for a gliding moan, and up to four seconds for a full call (Goldingay 1992). The loudness and frequency of yellow-bellied glider calling make them

relatively detectable during population surveys. This is enhanced by use of call playback, which is known to elicit higher calling rates (Goldingay 1994).

1.3 Scope of works

In addition to baseline surveys the YBGEMP also required completion of construction phase population surveys, which were conducted in 2016/17 (Sandpiper Ecological 2018), and operation phase monitoring in years 1, 2, 4, 7 and 10 of the operational phase. Year one operation phase was completed in 2018/19 (Sandpiper Ecological 2019a), year two in 2019/20 (Sandpiper Ecological 2020), and year four in 2021/22 (Sandpiper Ecological 2023). In response to fire and logging in Nambucca State Forest an additional survey was undertaken in year three of the operational phase (Sandpiper Ecological 2021). Due to concern about the population of YBG in Nambucca State Forest after year 4 the programmed year seven yellow-bellied glider population survey was brought forward one year to year six (i.e. spring 2023). This was done to reduce the time between samples and provide a better opportunity to track population change within Nambucca SF.

The scope of works for the current reporting period included:

1. Spotlight surveys of all 92 transects across Nambucca SF (40 sites), Yarriabini NP (20 sites) and Ngambaa (32 sites) on three occasions during late winter/spring 2023 (year six).
2. Installation of six song meters within each of the three Nambucca SF blocks (18 units in total), including six units near the alignment and six units away from the alignment in the north-west and south blocks, for a period of six months.
3. Analysis of song meter recordings for presence and frequency of yellow-bellied glider calls using Kaleidoscope Pro software.

The following report details and discusses year six operation phase yellow-bellied glider population monitoring activities. The report also considers the following performance indicators:

1. No reduction in proportion of sites occupied by yellow-bellied gliders in Nambucca SF post-construction.
2. No reduction in forest use adjacent to the highway in Nambucca SF post-construction.

2 Study Area

Surveys were conducted within Nambucca SF, which is located on the mid-north coast of NSW (Figure 1). Transects (200m long) were established during the pre-construction surveys in 2014 and were located on management tracks and spaced a minimum of 500m apart to increase the likelihood of independence. Forty transects were positioned in Nambucca SF (Figure 2), 20 in Yarriabini NP (Figure 3) and 32 in Ngambaa NR (Figure 4). The three study areas featured similar dry open forest habitat with moist gullies.

Nambucca SF featured three blocks: north-east, north-west, and south with the latter two blocks separated by the highway corridor (Figure 2). The north-east block has been heavily logged whereas the north-west and south blocks of Nambucca SF, Yarriabini NP, and Ngambaa NR have experienced less intensive, selective logging. Part of the south block in Nambucca SF was logged immediately prior to the 2020 survey.

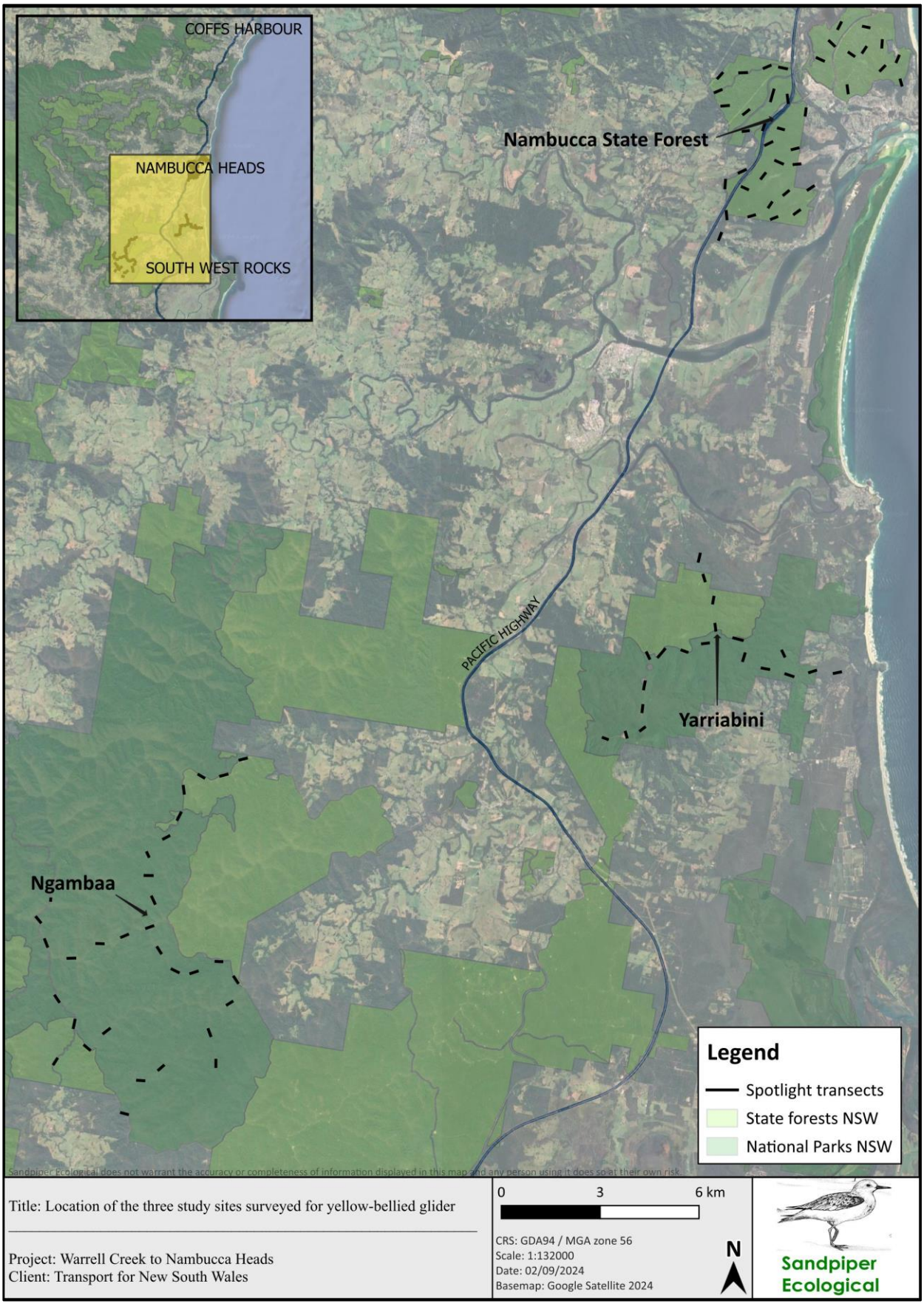

Figure 1: Location of Nambucca SF in relation to nearby conservation reserves.

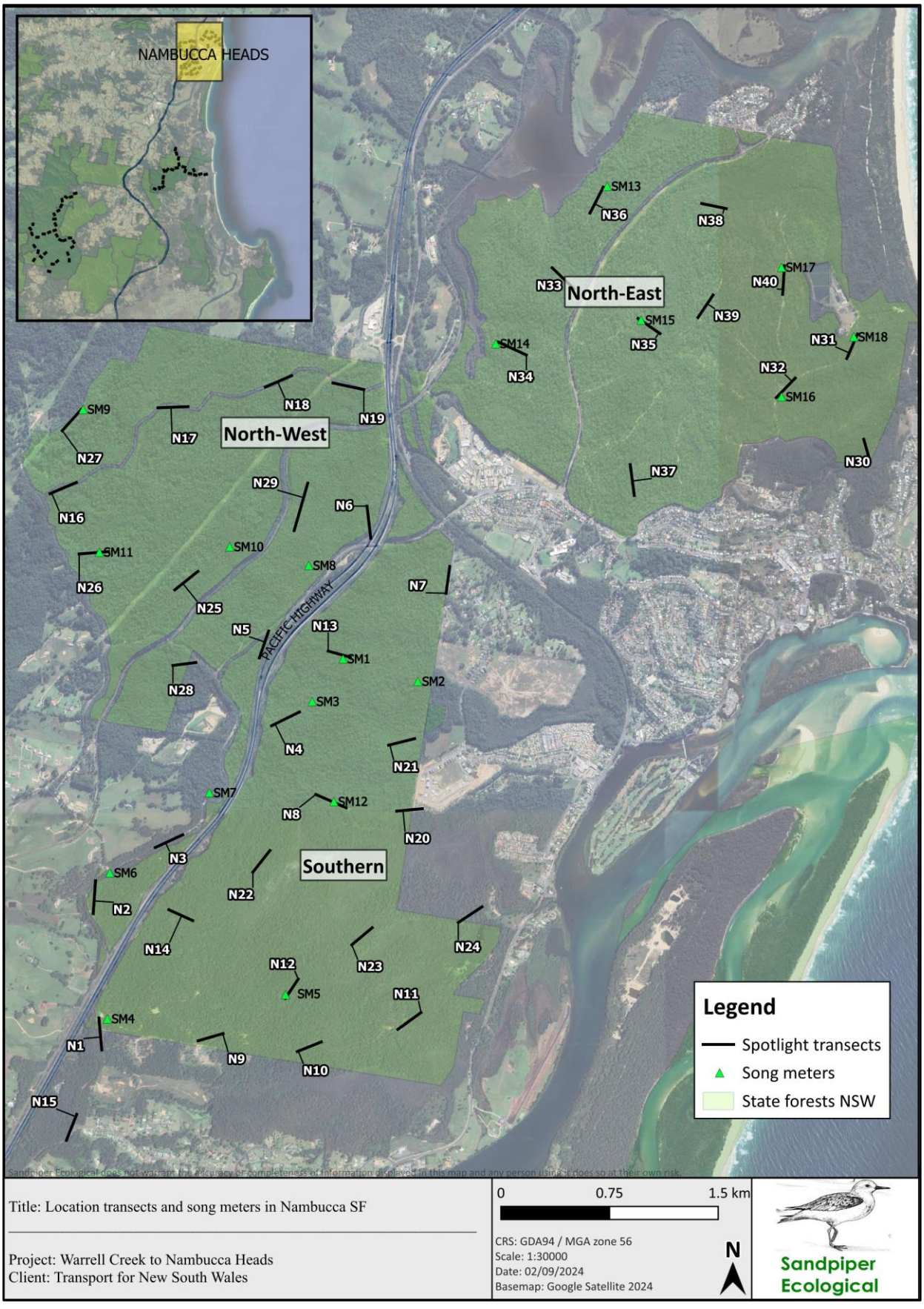

Figure 2: Location of 40 spotlight transects and 18 song meters within Nambucca SF.

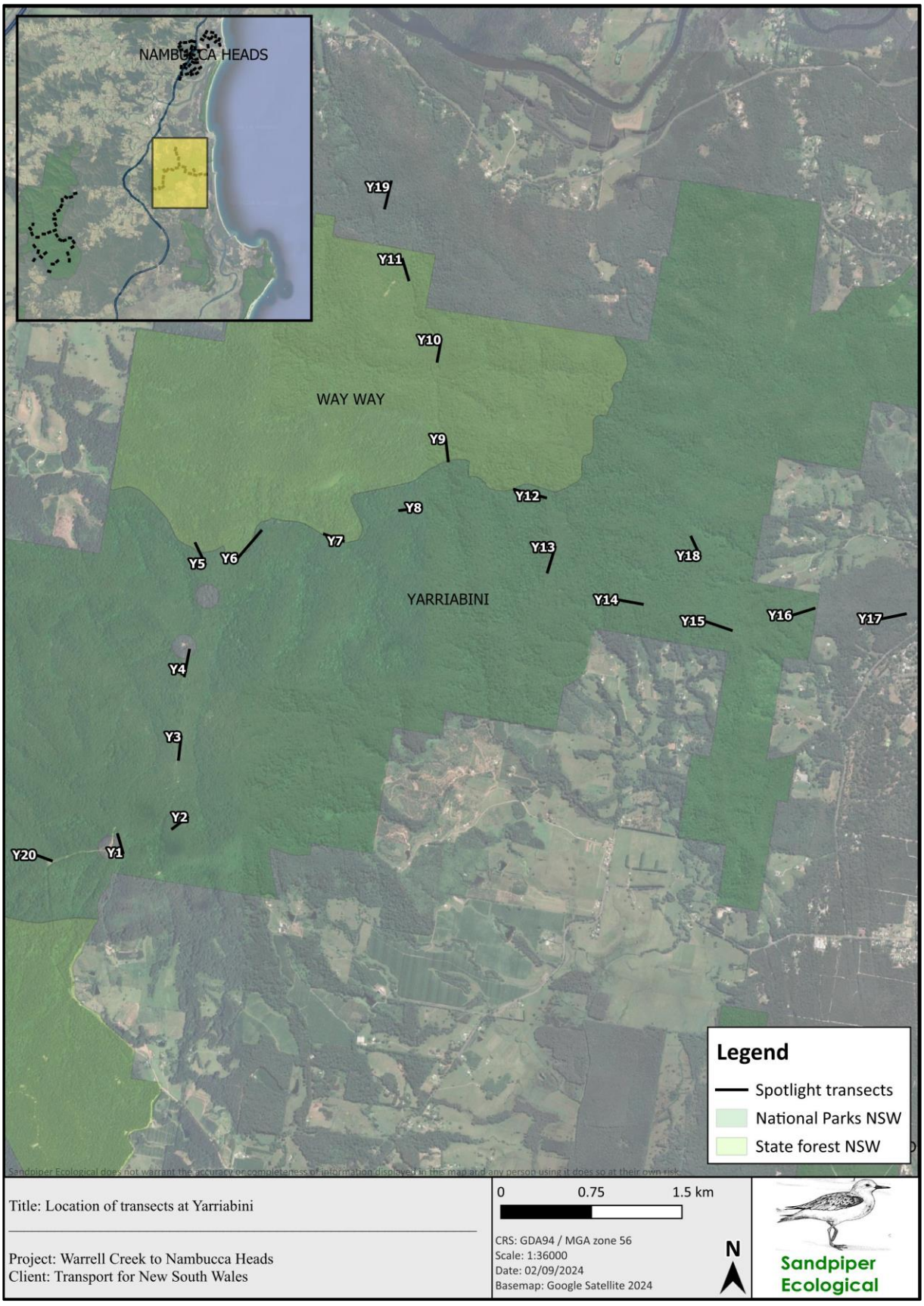

Figure 3: Location of 20 spotlight transects in Yarriabini NP.

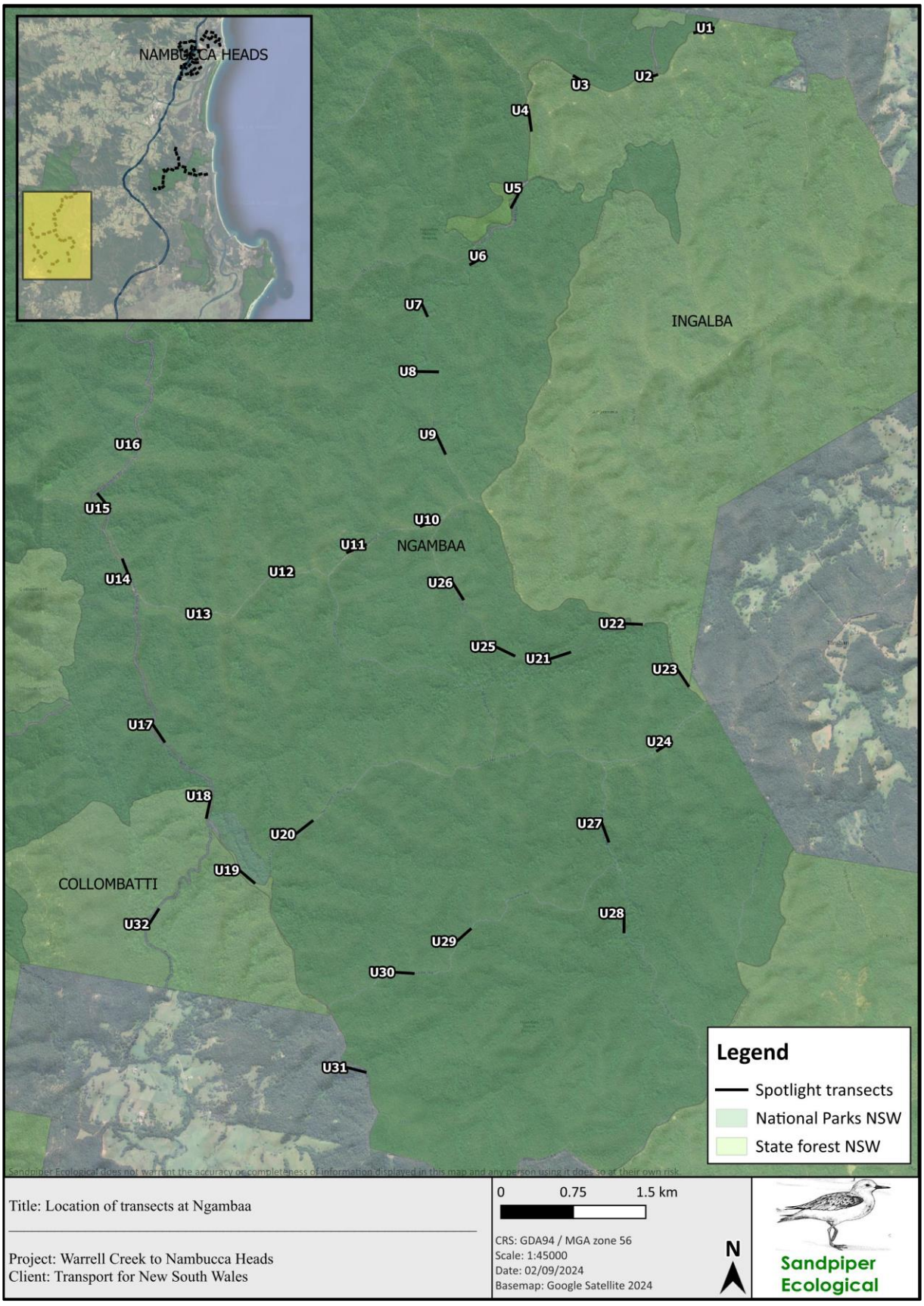

Figure 4: Location of 32 transects in Ngambaa NR.

3 Methods

3.1 Spotlight/Call Playback Surveys

Three spotlight/call playback survey sessions targeting yellow-bellied gliders were conducted during late winter/spring 2023. Surveys followed the method described by Goldingay (2015) and included the same sites in Nambucca SF as all previous surveys. Surveys occurred on 21-23 August (survey 1), 11-13 October (survey 2) and 13-16 November 2023 (survey 3). Teams of three or four ecologists completed surveys operating concurrently on proximal transects. Surveys commenced when dark, approximately 40 minutes after sunset (i.e., after civil twilight), and most surveys were completed within four hours of last light.

Transects were spotlighted on one occasion during each session. Each transect was spotlighted for a minimum of 20 person minutes by 1-2 personnel using a 500-800 lumen spotlight and binoculars, as required. At the 10-minute mark, four recorded calls of the yellow-bellied glider and four recorded calls of the powerful owl (*Ninox strenua*) were broadcast from a 10watt megaphone. The powerful owl is a known predator of YBG and its call is known to elicit a vocal response from gliders (Irish and Kavanagh 2011; Goldingay et al. 2016). Call broadcast volume was calibrated to be audible to the human ear to approximately 200m and therefore easily audible to yellow-bellied glider within this range.

Information recorded for each yellow-bellied glider detection included: time, distance along transect, approximate distance and compass bearing from operator and mode of detection (i.e., heard call, saw individual, heard movement, saw eye-shine). The time and direction of yellow-bellied glider detections were compared at completion of surveys to ensure double counting did not occur for neighboring transects.

Surveys were mostly conducted around the dark phase of the moon between last quarter and first quarter. Weather conditions were mostly clear making it suitable for spotlight surveys (Tables A1-A3, Appendix A). Full details of weather conditions and survey effort are provided in Appendix A.

3.2 Song Meter Surveys

3.2.1 Song meter recording

Sixteen song meters (SM4, manufactured by Wildlife Acoustics, USA) were installed across Nambucca SF on 24 August 2023, with two additional song meters (SM15 and SM17) installed in the northeast forest block on 20 November 2023. The spatial configuration of the array followed the 2018/19 surveys (see Figure 2). In the northeast block, six units were evenly distributed across the block. In the northwest block, three units were placed less than 300 meters from the highway (i.e., near), and three units were placed more than 700 meters from the highway (i.e., away). Similarly, in the south block, three units were installed less than 300 meters from the highway, and three units were installed more than 700 meters from the highway. Song meters were strapped to trees with a python lock at approximately 6m above ground level using a ladder. Each unit was powered by four 1.5v D-size batteries and received either two 32 gigabyte or one 64 gigabyte memory card. Units were programmed to record three hours of audio nightly beginning approximately one hour after sunset. Song meters were inspected on 20 November 2023 to replace batteries and SD cards. All units were collected on 22 February 2024

3.2.2 Song meter analysis

Analysis of 2016/17 and 2018/19 audio recordings was performed using Song Scope (Version 4.0; Wildlife Acoustics) sound recognition software. This software has been largely superseded by Kaleidoscope Pro (version 5.1.9g, Wildlife Acoustics), a more advanced sound recognition software package. Kaleidoscope Pro

enables users to undertake cluster analysis of sound recordings and to develop an advanced classifier to detect a vocalization of interest – in this case, the yellow-bellied glider.

An advanced classifier (i.e., YbG-AC) was built using annotated calls of the yellow-bellied glider derived from sound recordings from Nambucca SF in 2016/17 and 2018/19. The building process involved 'training' the advanced classifier to detect or match vocalisations of the yellow-bellied glider from sound recordings. Numerous sensitivity analysis tests were performed to determine optimal signal parameters. In this way, the building process is highly iterative and proceeds through numerous 'tuning' phases whereby batches of sound files are progressively analysed and incorrectly labelled vocalisations (i.e. false positives) are removed and the classifier algorithm updated or refined. The outcome of this process was final candidate model YbG-AC (Settings: Range = 250-10000 Hz; Length = 1.0 – 7.5 sec; Max inter-syllable gap = 0.35 sec; FFT window = 5.33 ms; Max distance from cluster center = 1.4; Max states = 12; Max distance to cluster center for building clusters = 0.5; Max clusters = 500).

To determine the relative performance capabilities of the final candidate advanced classifier (YbG-AC), we analysed seven sound recording files previously analysed by the Song Scope Recogniser (i.e., YbG-Rec) and known to contain calls of yellow-bellied gliders. The YbG-AC detected equal or greater the number of calls than the YbG-Rec on four of the seven sound files (i.e., 57%). This suggested that the YbG-AC was moderately more effective than the YbG-Rec in detecting yellow-bellied glider vocalisations and thereby appropriate for analysing 2023/24 sound recordings. The YbG-AC was used to analyse recordings from each of the 18 song meters during year six monitoring using the Batch processing option. All audio recordings positively identified by the YbG-AC were subsequently checked and true-positive call detections logged. The number of true-positive call detections and number of nights when calls were detected were then tabulated for each song meter site.

4 Results

4.1 Year six surveys

4.1.1 Spotlight

During year six spotlight surveys yellow-bellied gliders were not detected on any of the 40 transects sampled within the Nambucca SF (Table 1). Comparatively, at the Yarriabini NP reference site, yellow-bellied gliders were detected on six occasions across the 20 transects sampled, representing 30% occupancy (Table 1). Detections occurred on one transect during survey 1 (Y7), one transect during survey 2 (Y8), and four transects during survey 3 (Y4, Y12, Y13, Y14) (Figure 5). At Ngambaa NR, yellow-bellied gliders were detected on ten occasions at six of the 32 transects sampled, representing 18.8% occupancy of all transects (Table 1). Detections occurred on four transects during survey 1 (U32, U18, U28, U21), four transects during survey 2 (U32, U28, U27, U22), and two transects during survey 3 (U28, U22) (Figure 6). All detections were initially made by call. Full details of yellow-bellied glider spotlight surveys are provided in Appendix A.

Table 1: Yellow-bellied glider detections at Nambucca SF and two reference sites (Yarriabini and Ngambaa) in 2023 during spotlight surveys. Data was pooled for the three surveys.

Site	Nambucca	Yarriabini	Ngambaa
Number of transects	40	20	32
Number of unique transects with YBG	0	6	6
% of transects with YBG detected	0.0%	30.0%	18.8%

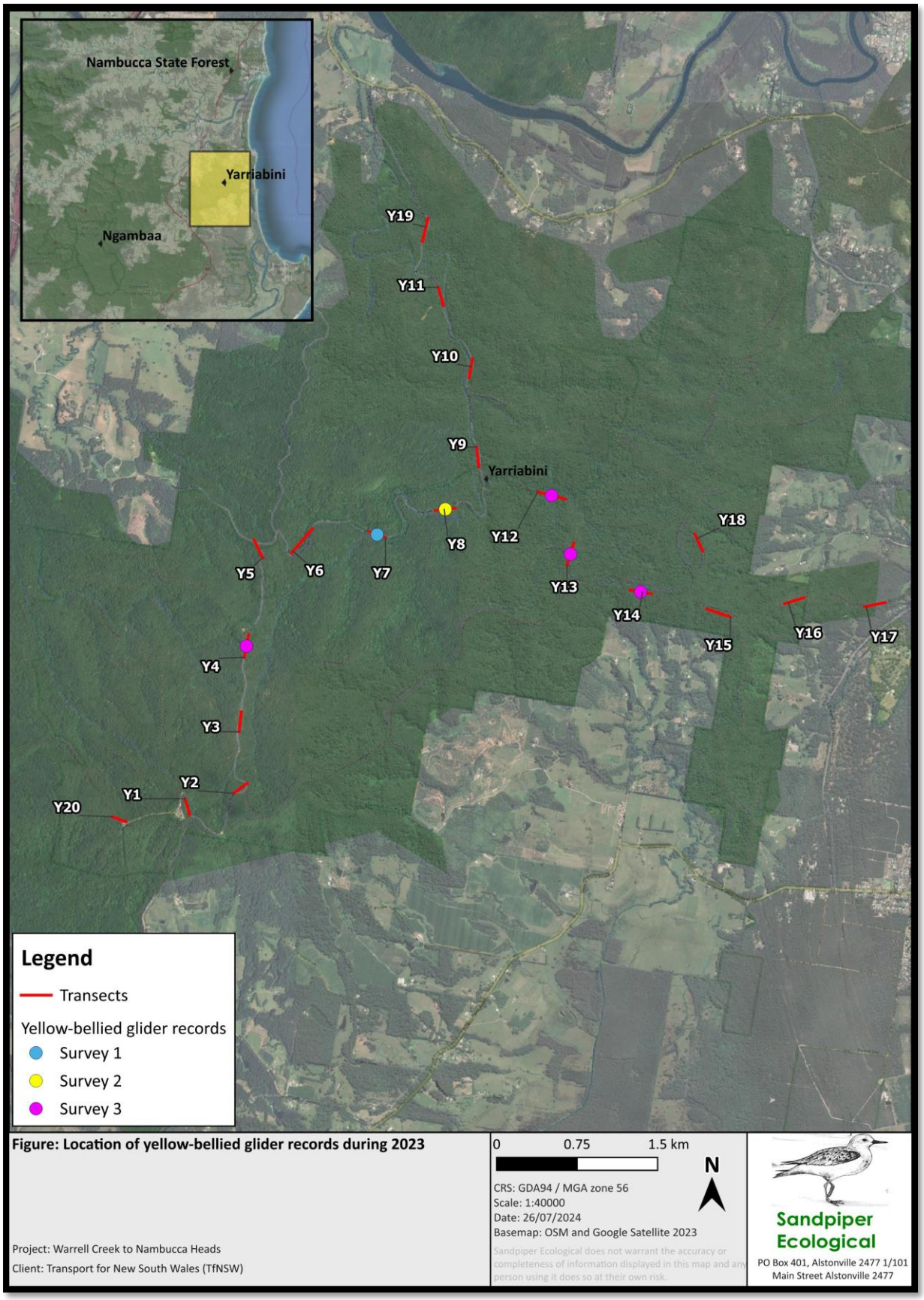

Figure 5: Location of yellow-bellied glider records at Yarriabini NP during year six operational monitoring.

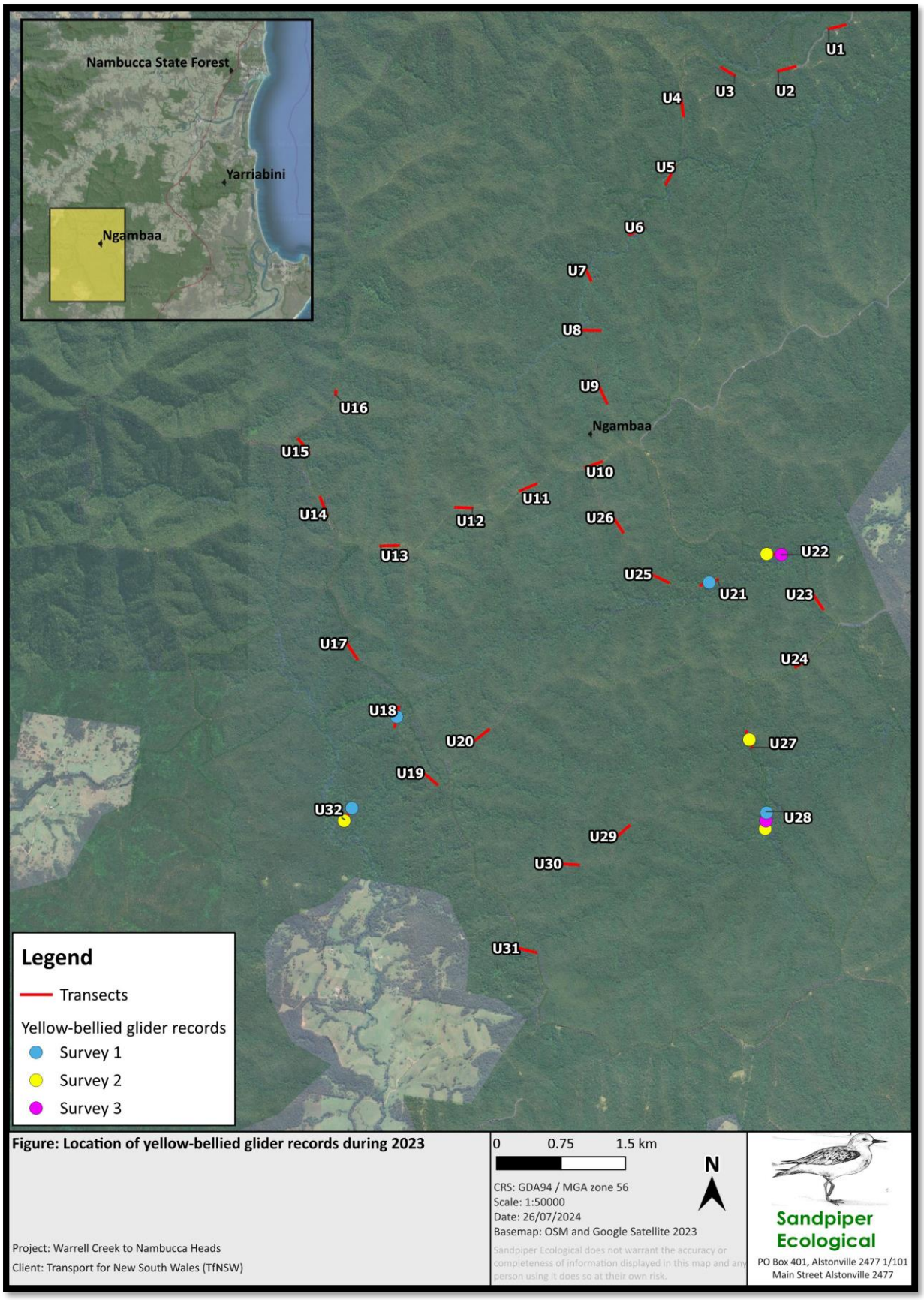

Figure 6: Location of yellow-bellied glider records at Ngambaa NR during year six operational monitoring.

4.1.2 Song meter

Eighteen song meters operated for a total of 3,006 nights (mean 167 ± 34.55 nights). Fifteen of the eighteen units were active for the entire 26-week deployment period (182 days each). Two units (SM14 and SM17), installed late in the NE forest block, where yellow-bellied gliders have not yet been recorded, were active for a total of 94 days. Late installation occurred as two units were damaged during previous surveys and had to be replaced. One song meter (SM11) encountered formatting issues during the first download period and was active for 88 days. No calls were detected by any of the song meters. For full details refer to song meter deployment data in Appendix B, Table B1.

4.2 Temporal trends

4.2.1 Spotlight

Yellow-bellied glider occupancy has varied over time between impact and reference sites, showing distinct trends. At Nambucca SF (impact site), occupancy declined from 12.5% during pre-construction (2014) to 10% during construction (2016), and further to 2.5% in year one (2018) of the operational phase, representing an 80% decrease from pre-construction levels (Figure 7). This decline continued, with nil occupancy recorded in years two (2019) and three (2020). One individual was recorded in year four (2021), resulting in 2.5% occupancy. The most recent year six surveys (2023) did not detect occupancy on any transects, demonstrating a 100% decline from pre-construction levels. Notably, yellow-bellied gliders have not been recorded in the north-east forest block to date.

Reference sites also showed a decline in occupancy from pre-construction (2014) to year one of operation (2018) and occupancy remained below pre-construction levels throughout the operational phase (Figure 7). A recovery in occupancy was evident in 2021 and 2023. In Yarriabini NP occupancy declined from 35.0% during pre-construction (2014) to 10.0% in year one of operation (2018), a 71.4% decrease (Figure 7). However, it recovered to 30.0% by year six (2023), a 200.0% increase year one (2018), and an overall 14.3% decline from pre-construction. Ngambaa NR showed a similar pattern, with occupancy decreasing from 28.1% during pre-construction to 15.6% in year one (2018), a 44.5% decline, and further to 6.3% in year two (2019), a 77.6% decline from pre-construction occupancy rates. However, it recovered to 18.8% by year six (2023), a 198.4% increase from year two (2019), representing a 33.1% decline from pre-construction.

These trends highlight a severe and prolonged decline at Nambucca SF compared to the recovery in occupancy recorded at Yarriabini NP and Ngambaa NR from years four (2021/22) to six (2023/24) of operational monitoring.

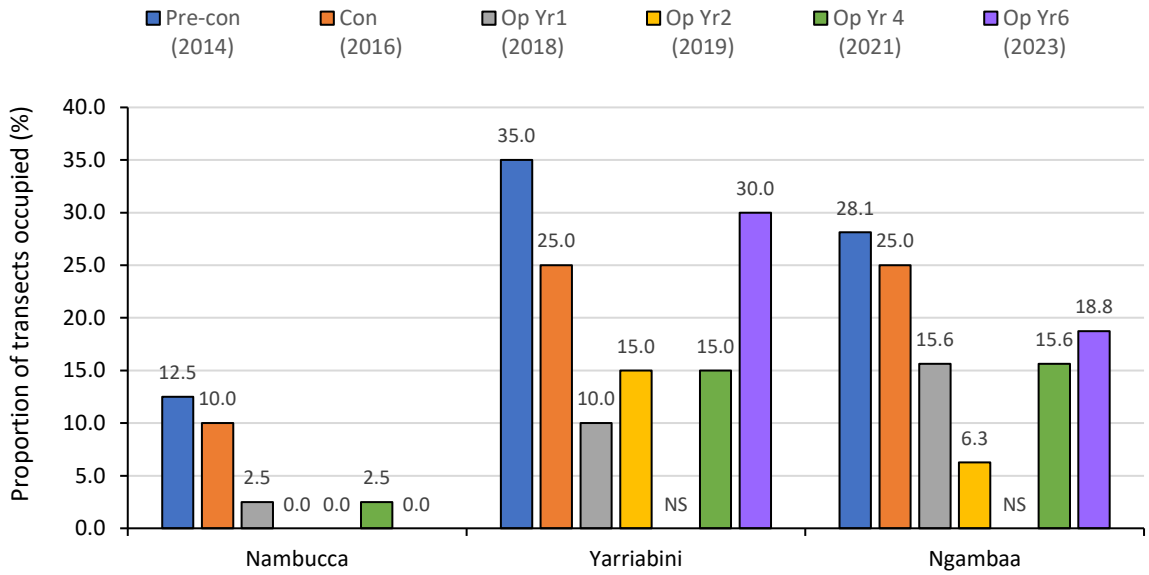

Figure 7: Yellow-bellied glider occupancy rates (%) at Nambucca SF (impact site), Yarriabini NP, and Ngambaa NR (reference sites) during pre-construction (Pre-con), construction (Con) and operation year one (Op1), year two (Op2), year three (Op3), year four (Op4) and year six (Op6). NS= not sampled – refers to year 3 survey of Nambucca SF only.

4.2.2 Song meter

The trend in yellow-bellied glider call detections (% of nights with calls) recorded by song meters reflects the pattern observed in spotlight surveys, with a general decline in recorded calls over time within Nambucca SF. Notably, no yellow-bellied glider calls were detected during year six of operational monitoring.

At SM7, yellow-bellied gliders were consistently recorded calling during all survey periods until year six (2023), when no calls were recorded (Figure 8). In contrast, sites SM1, SM2 (away from the highway), and SM3 (south, near the highway), which all initially recorded yellow-bellied glider calls during pre-construction surveys, showed a general decline in the number of call detections during the construction phase and year one of operation. By year three of operational monitoring (2020), and continuing through to year six (2023), no calls were detected at these sites (Figure 8).

Excluding the additional song meter sites deployed during construction and year one of operation (SM10, SM11, and SM12), there is a clear trend of decreasing site occupancy over time (Figure 8). Initially, four sites (SM1, SM2, SM3, and SM7) recorded yellow-bellied glider presence during the pre-construction, construction, and year one of operation. This number decreased to two sites (SM4 and SM7) in year two of operation, with SM4 recording its first and only detection during this period. By year three and year four, only SM7 continued to record calls. By year six, no yellow-bellied glider calls were detected at any site.

Records at SM10 and SM11 (located in the northwest forest block away from the highway) during construction and year one are likely from the same family group given their proximity (<700 m) to each other. No calls were detected at these sites from years 2 to 6. Similarly, SM12 (located in the southern forest block away from the highway) recorded calls during operational year one but recorded no further detections from years 3 to 6.

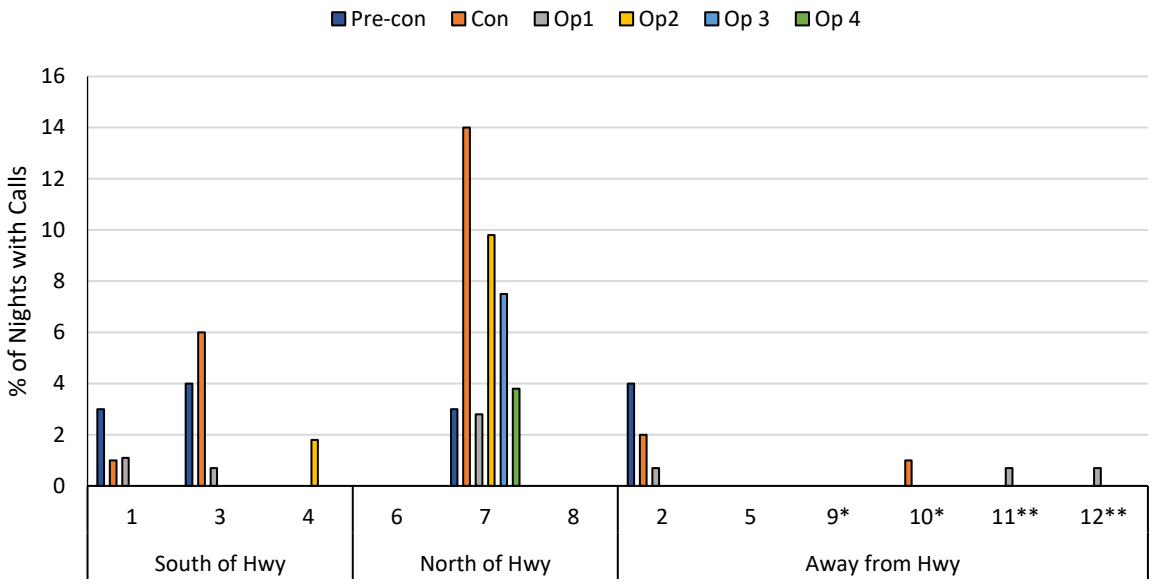

Figure 8: Percentage of nights in which yellow-bellied gliders were detected by song meters in the north-west and southern blocks (numbered 1-12) near the highway alignment (i.e., <300m) and away from the alignment (i.e., >700m) during pre-construction (Pre-con), construction (Con) and operation year one (Op1), year two (Op2), year three (Op3) and year four (Op4). No records were recorded during Op6 (2023). * = song meters 9 & 10 deployed during construction and operation phases only; ** = song meters 11 & 12 deployed during operation phases only.

4.2.3 Detection spotlight vs song meters

The percentage of nights with detections declined from pre-construction and construction levels into the operational phase for both song meters and spotlight surveys, reaching nil for both methods during year six surveys (Figure 9). Excluding the song meter and spotlighting effort in the northeast block, where yellow-bellied gliders have not been recorded to date, song meters consistently detected yellow-bellied glider calls on 0.3% to 2.3% of survey nights (Figure 9). Comparatively, higher detection rates were recorded during spotlighting than song meters during the pre-construction (5.7% vs 2% of nights), construction (4.6% vs 2.3% of nights) and year four of operational monitoring (1.1% vs 0.3% of nights) (Figure 9).

Despite yielding higher detection rates, spotlighting was less consistent than song meters, which effectively captured the location of most glider groups (Figure 10). Any robust comparison of song meters and spotlighting needs to consider home range and the distribution of habitat. Evidence suggests that the two methods complemented each other although a more systematic deployment of song meters could address any deficiencies identified by spotlighting. Song meters effectively captured all known family groups over time except one individual at N24.

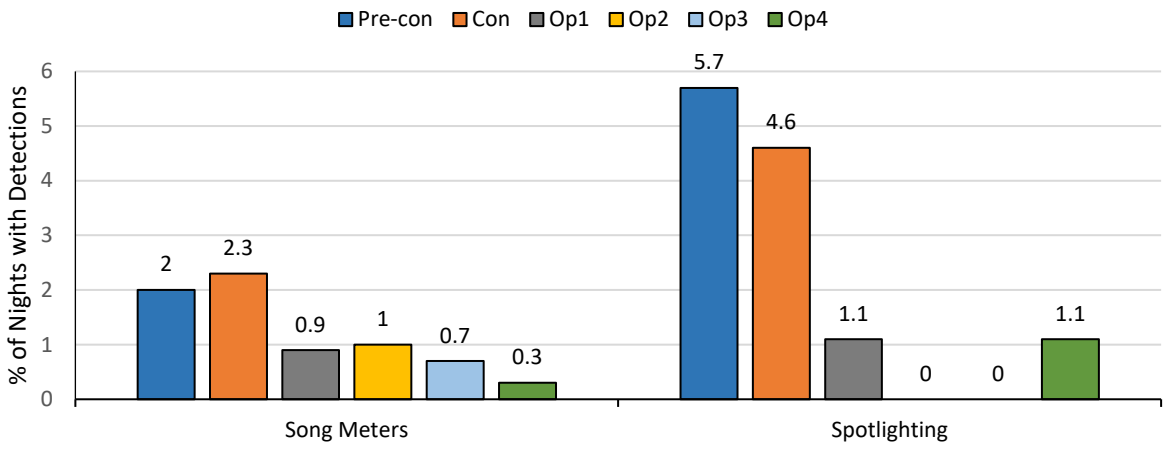

Figure 9: Percentage of survey nights in which yellow-bellied gliders were detected by song meters and spotlighting during pre-construction, construction, operation within Nambucca SF. Data from north-east block not included. Song meter data are for eight units during pre-construction (SM1-8), 10 units during construction (SM1-10) and 12 units during operation phases (SM1-12). Spotlighting detections are from three surveys of 29 sites across the north-west and south blocks in each monitoring period. No data is presented for Op6 as no records were found.

4.3 Temporal distribution of yellow-bellied gliders in Nambucca SF

Both the spotlighting and song meter data from current and previous surveys indicate a marked decline in yellow-bellied glider social groups in Nambucca SF (Figure 10). During the pre-construction surveys, two social groups were identified in the northwest forest block, one around SM7 and the other near transect N25. In the southern forest block, records were clustered between N20 and N7 along a north-south axis (approximately 1.5 km apart) and between N21 and N4 along an east-west axis (approximately 1 km apart). This cluster included detection at three song meter sites and four spotlight transects, suggesting the presence of at least two social groups in this area. Overall, there were four social groups in Nambucca SF during the pre-construction surveys.

During the construction phase, the distribution of records remained similar to pre-construction, with the same social groups identified in both forest blocks. In operation year one, these social groups were still present, and a new song meter record was recorded at SM11, likely representing the same social group recorded at N25 during the pre-construction surveys and at SM10 during construction (Figure 10). Fewer calls were detected on song meters in the southern forest block, and for the first time, no records were observed at N7.

The number of family groups and distribution of records remained consistent into year one of the operational phase. However, by year two of operation, the distribution of yellow-bellied gliders had contracted to one social group around SM7. In year two, no calls were detected near SM11, SM10, and N25 in the northwest forest block, or in the cluster between N20 and N7 in the southern forest block. One call was recorded at SM4, approximately 2.5 km south of the previous N20-N7 cluster (Figure 10).

In operation year three, only the social group near SM7 was detected, and by year four, this group continued to be recorded at SM7, with one individual detected on the spotlight transect N24. N24 is approximately 1 km south of the N20-N7 group recorded in pre-construction and 2.6 km east of the SM4 record in operation year two. By year six, no YBG were recorded using either survey technique, suggesting that none of the social groups identified during the pre-construction surveys remain present in Nambucca SF.

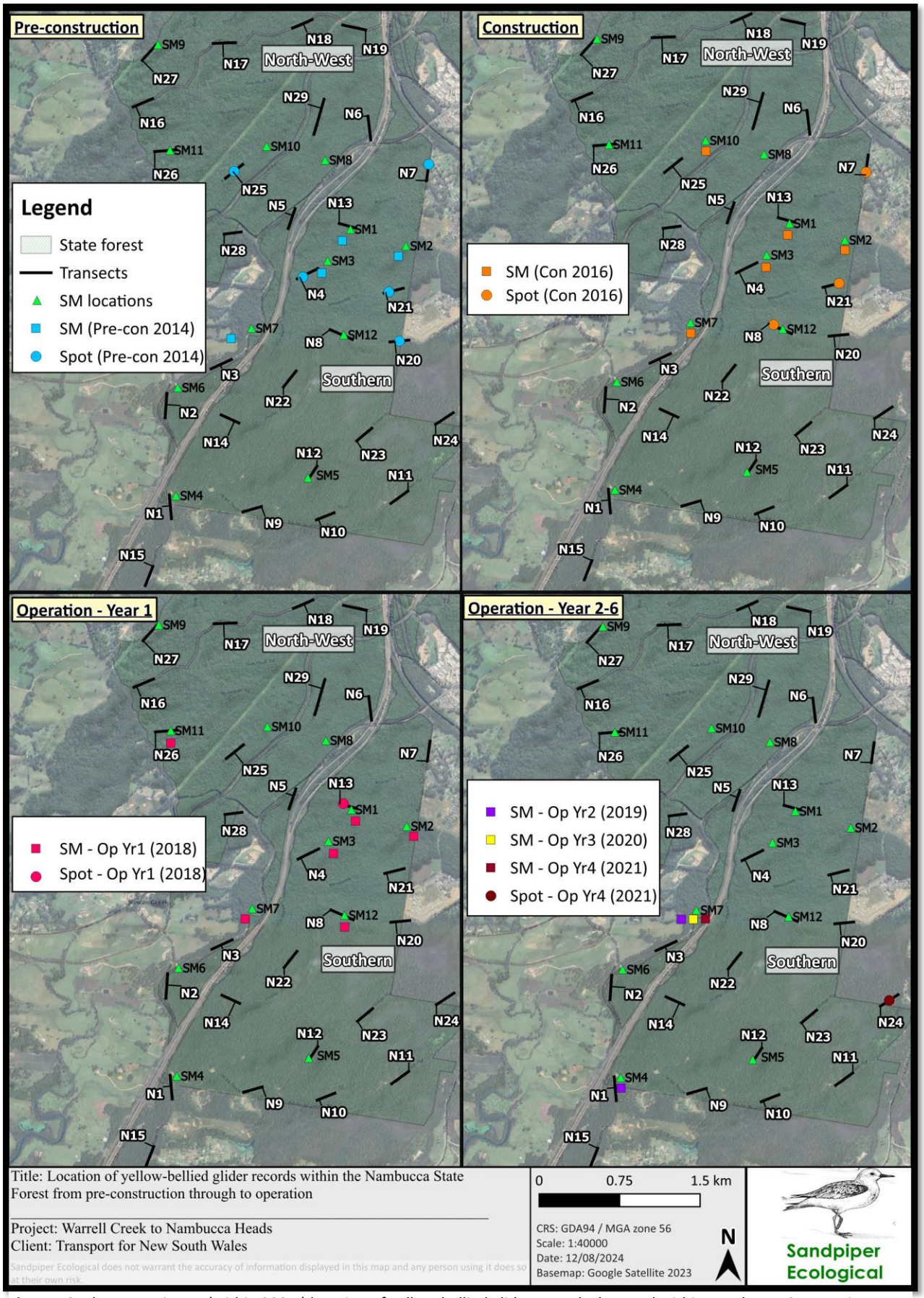

Figure 10: The approximate (within 200m) location of yellow-bellied glider records detected within Nambucca SF over time during song meter and spotlight surveys. The north-east forest block is not included as no YBG have been recorded there.

5 Discussion

The results of the year six operational phase of the yellow-bellied glider (ybg) population monitoring are discussed below with reference to the performance indicators outlined in the YBGEMP (Goldingay 2014a). The WC2NH yellow-bellied glider monitoring program was designed to detect individual and population level responses to the upgrade (Goldingay 2014a). An individual response may occur if local habitat availability is reduced, and the highway poses a barrier to movement. Such a response may help to explain a subsequent population response, or it may be confined to a small number of animals living near the new highway (Goldingay 2014a). A population level response is indicated by changes in abundance of yellow-bellied gliders in Nambucca SF.

5.1 No reduction in forest use adjacent to the highway in Nambucca SF post-construction (individual level response)

The YBGMP outlines that individual responses to the highway upgrade will be assessed by comparing forest use at "near" song meter sites before and after construction (Goldingay 2014a). This comparison aims to determine whether gliders near the highway are impacted by construction activities. However, the rapid population decline at Nambucca SF has largely obscured any nuanced individual level responses. In the first year of operation, a decrease in the number of calls was recorded at “near sites”, yet a similar pattern was observed at "away" sites. No calls were detected at “away” sites by the second year of operation, while calls were still recorded at one “near” site (SM7). This suggests that any discernible changes at the individual level have been masked by factors contributing to the overall population decline.

5.2 No reduction in proportion of sites occupied by yellow-bellied gliders in Nambucca SF post-construction (population level response)

The YBGEMP directs that an assessment of a population level response should be measured by comparison of the proportion of survey sites (transects) occupied by yellow-bellied gliders in Nambucca SF with that at reference sites within Yarriabini NP and Ngambaa NR before and after construction. More specifically, the performance indicator for a population level response is no reduction in proportion of sites occupied by yellow-bellied gliders in Nambucca SF post-construction.

The proportion of occupied sites (song meter and spotlight transects) in Nambucca SF has declined substantially compared to pre-construction levels. The year six operational survey showed a 100% reduction in occupancy post-construction, a result that is consistent with the pattern of decline recorded since year one of operation. These findings suggest that none of the four social groups identified during the pre-construction survey remain in Nambucca SF, and confirm an obvious population level response.

Concerningly, year six results at Nambucca SF continued to diverge from the population trends observed at the reference sites (Yarriabini NP and Ngambaa NR). Despite initial declines at Yarriabini NP (71.4% decrease) and Ngambaa NR (77.6% decrease) in year one and two of operation, both reference sites showed signs of recovery by year six, contrasting with the complete absence of yellow-bellied gliders at Nambucca SF. This disparity demonstrates a more severe and prolonged decline at Nambucca SF compared to the recovery trends observed at Yarriabini NP and Ngambaa NR.

As is often the case with ecological monitoring, assigning cause and effect is difficult. This is exacerbated when the sample population is small and patchily distributed as is the present case and there are multiple threatening processes. The timing of the decline in Nambucca SF overlaps with a major drought (2018/19), logging (2020), highway construction and operation, minor wildfire (2019) and clearing of land (i.e., at site 20).

Understanding the interplay of these factors, particularly the role of climate, is crucial in examining the compounded impacts on the Nambucca SF population.

5.2.1 Climatic factors driving population trends

Yellow-bellied gliders are sensitive to climatic changes due to their specialized diet, low and variable breeding potential (with a maximum of one young per year under favorable conditions), and relatively short lifespan (around six years) (Goldingay & Kavanagh 1991, 1993; Goldingay et al. 2001). Extreme drought or prolonged periods of below-average rainfall can negatively impact populations, as drier conditions reduce the availability of plant and insect exudates that they rely on, leading to food scarcity and contributing to a subsequent decline in abundance (Goldingay et al. 2023, 1992).

Population monitoring at Nambucca SF and the two reference sites supports the supposition of a relationship with rainfall, as occupancy rates closely followed annual rainfall patterns. To best represent the climatic conditions of the area, rainfall data was obtained from Kalang (Station No. 59146, BOM 2024), the nearest long-term Bureau of Meteorology station with a complete dataset, located less than 35 km from all sites (Figure 11). The area received either above-average rainfall (in 2008, 2009, and 2013) or rainfall close to the average (in 2011, 2012, and 2013), with only one drought period (2010) in the six years preceding the pre-construction surveys (Figure 11). The pre-construction report (Goldingay 2015) suggested that yellow-bellied glider populations in the region were likely at or above their long-term average due to these favorable conditions. It was also predicted that any decline in rainfall after the pre-construction surveys would likely be associated with lower occupancy (Goldingay 2015).

The scenario appeared to unfold in the study area as the monitoring program transitioned into the operational phase. Below-average rainfall was recorded from 2014 through 2019, culminating in a severe drought in 2019 (Figure 11). During this period (from pre-construction to operation year two in 2019), yellow-bellied glider occupancy declined substantially at all sites, with a 71.4% decrease at Yarriabini NP, a 77.6% decrease at Ngambaa NR, and an 80% decrease at Nambucca SF. These substantial declines in occupancy, particularly during the severe statewide drought in 2019, were not limited to the study area with similar trends observed across other lowland areas of the NSW north coast. Notably, 80-100% declines were recorded between Woolgoolga and Ballina (W2B) (Sandpiper Ecological 2023a), between Port Macquarie and Kempsey (Niche 2023), and at Devils Pulpit (Geolink 2023). Local abundance of yellow-bellied gliders also decreased by 43% following the drought at a site considered to have high local abundance in the Richmond Range NP (Goldingay et al., 2023). Interestingly, the Richmond Range experienced a delayed effect of the drought compared to the lowland coastal areas adjacent to the Pacific Highway, where the impact was almost immediate (Geolink 2023, Niche 2023 Sandpiper Ecological 2023a).

In contrast to declines at lowland sites, the Ngambaa and Yarriabini reference sites showed a substantial increase in occupancy during the most recent monitoring years (2021 and 2023). By year six of monitoring (2023), Ngambaa exhibited a 198.4% increase in occupancy from the low in 2019, while Yarriabinni recorded a 200.0% increase from its lowest point in 2018. These findings support the idea that drought, and more specifically rainfall, played a significant role in driving both the population declines and subsequent recovery at these sites. Rainfall alone does not explain why populations at reference sites have recovered whilst those in Nambucca SF have not. Factors that may have restricted recovery in Nambucca SF include, population size, forest age and management history, forest fragmentation and elevation.

The post-drought recovery at Ngambaa and Yarriabini and the delayed response in the Richmond Range suggests that the effect of drought may be buffered in higher elevation forests that have steeper slopes and deep gullies, and are able to capture more moisture during drought. DAWE (2022) highlight the effect of

climate change and higher nighttime temperatures on greater gliders and suggest that YBG may be similarly affected. Higher elevation forests may experience less severe temperature variations than lowland forests.

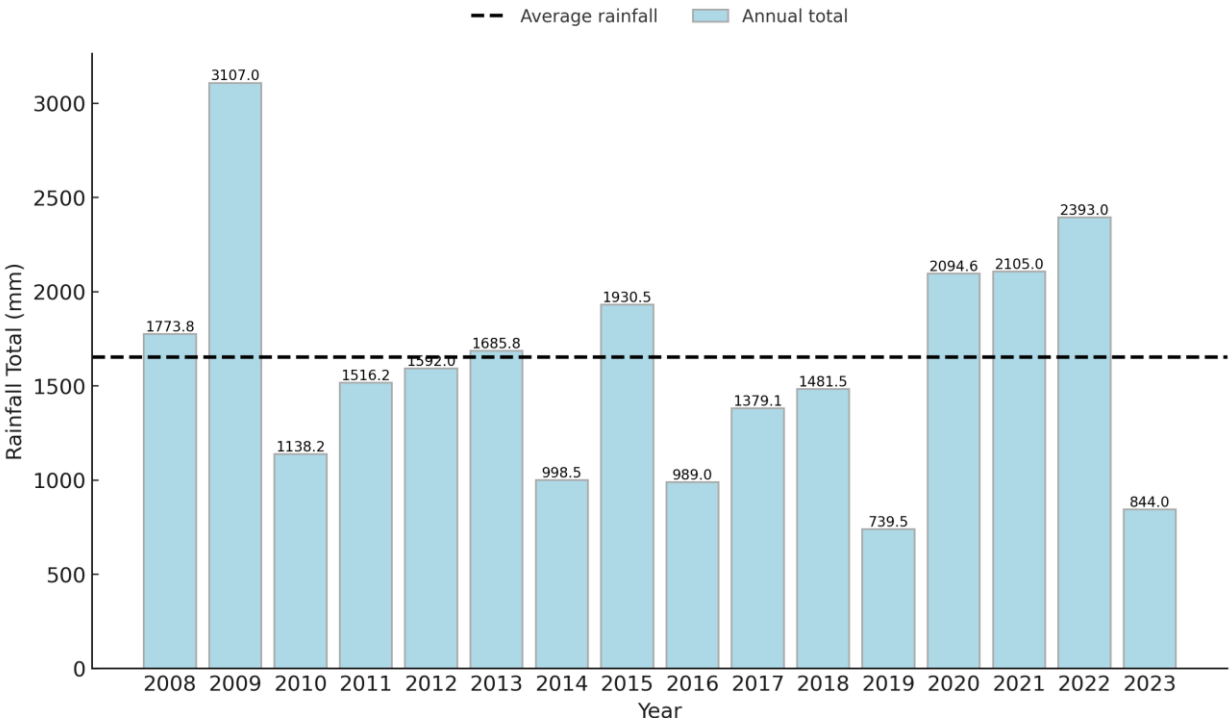

Figure 11: Total annual rainfall and average annual rainfall recorded at Kalang (Kooroowi Station No. 59146) from 2008 through the 2023

5.2.2 Other factors contributing to populations trends

Habitat suitability and population viability in the Nambucca SF

The pronounced decline of the yellow-bellied glider population in Nambucca SF following the 2019 drought is likely due to a combination of small population size and limited habitat suitability. Goldingay (2015) noted that the habitat within Nambucca SF had only modest suitability, primarily due to the dominance of blackbutt (*Eucalyptus pilularis*) and the absence of old-growth forest for denning, a consequence of the area's logging history. Pre-construction surveys estimated a small population of 4–6 social groups, though this may have been an overestimate, likely due to the yellow-bellied glider's high mobility. This mobility allows them to cover 600 meters in 20 minutes while foraging and to travel over 2 kilometers in a single night, making it challenging to obtain an accurate population estimate (Goldingay, 1989; Goldingay and Kavanagh, 1991).

The high prevalence of blackbutt, combined with low habitat suitability, high mobility of individuals, and the sparse and clustered nature of records between sites N7 and N20 in the southern forest block (1.5 km apart), suggests that the actual number of social groups may be lower than initially estimated. Given that yellow-bellied glider home ranges can extend up to 100 hectares (Goldingay and Quin, 2004) and the detectability range of their calls is likely within 200 meters (Goldingay et al., 2023), the distance between records at N7 and N20 could effectively reduce to 1.1 km, which is within their specified nightly foraging range of up to 2 km (Goldingay and Kavanagh, 1991). This suggests that 1–2 social groups might be responsible for all records within the N20 to N7 area, rather than the initially estimated 2–3 groups. It is likely that the two family groups

in the northwest forest block (near N25 and SM7) were indeed separate from the southern block groups, given the distance between them (>2 km), bringing the total to a likely 3–4 social groups recorded in Nambucca SF pre-construction.

Yellow-bellied glider social groups in habitats of average productivity typically consist of an adult pair and one sub-adult offspring (Goldingay and Kavanagh 1990). This suggests that the adult population in Nambucca may have been only 9-12 individuals prior to construction, which is well below the threshold for a viable sub-population. Goldingay and Possingham (1995) suggest that a minimum habitat area of 180–350 km², with at least 150 glider groups, is required to achieve a 0.95 probability of persistence over 100 years. In comparison, the contiguous forest in Nambucca SF is approximately 17.5 km², Yarriabini is approximately 50 km², and Ngambaa including the adjoining state forest is 395 km². In summary, the limited habitat area, habitat suitability and small adult population size in Nambucca SF likely render the yellow-bellied glider population insufficient to sustain a viable sub-population over the long term, making it highly vulnerable to any impact or changes in climatic conditions.

Impacts

Recent fire and logging in Nambucca SF may have further contributed to the population's decline and hampered recovery. While evidence shows that logging and fire negatively impact gliders in tall eucalypt forests in eastern Australia (Lunney 1987; McLean et al. 2018; Goldingay 2021; Lindenmayer et al. 2021; Bilney et al. 2022), some studies have identified positive or neutral impacts (Kambouris et al. 2013; Heise-Pavlov et al. 2017). Wildfire and logging in September 2019 and early 2020 impacted approximately 40 hectares and 65 hectares respectively in the south forest block. The cool burn in September 2019 affected four transects and burnt to the mid-canopy level. While neither the scale of logging or wildfire is regarded as sufficient to have a population-level impact, they likely compounded the effects of the drought.

The apparent decline in population numbers across all three locations during the drought suggests that the highway upgrade is not the primary cause, though it may have affected population fitness through habitat removal and the ability to recover after drought through fragmentation of habitat, isolation of family groups and disruption of communication within social groups. If the highway upgrade were the primary cause, we would expect to see evidence of this decline exclusively at the Nambucca SF site. These potential factors should not be overlooked, especially given the 100% decline of several yellow-bellied glider populations near the Pacific Highway in lowland coastal areas during the same period, compared to populations in areas not impacted by the highway, such as Richmond Range NP, Yarriabini NP, and Ngambaa NP, which did not experience the same level of decline (Geolink 2023; Niche 2023; Sandpiper Ecological 2023a; Goldingay et al., 2023).

5.3 Assessment and management of potential impacts on yellow-bellied glider

Year six findings from the yellow-bellied glider population monitoring program reveal a concerning 100% decline in occupancy within Nambucca State Forest (SF), indicating a substantial and prolonged population decline not observed at the reference sites (Yarriabini NP and Ngambaa NR). While climatic factors, particularly drought, initially drove the pronounced decline in Nambucca SF, the small population size and limited habitat suitability, combined with additional impacts such as clearing for the highway, fragmentation of habitat, fire, and logging, have likely exacerbated the drought's effect.

Following the year four population monitoring report and vegetated median report Sandpiper Ecological (2023b and 2024) recommended:

1. findings of the year 6 operational phase population survey be used to determine if additional mitigation measures are required; and

2. should a population survey be undertaken in year 6 then a song-meter survey of Nambucca SF should be undertaken in year 8 (2025) of the operational phase.

With respect to recommendation 1, no additional mitigation measures are warranted based on the findings of year six surveys which suggest that yellow-bellied gliders may no longer occur within Nambucca SF. To further confirm the status of yellow-bellied gliders in Nambucca SF recommendation number 2 should be implemented. An expanded song meter survey in year 8 is considered the most effective means of confirming the species status. Song meters have consistently captured all known family groups, and a systematic deployment would improve the likelihood of detecting remaining individuals and family groups. The methodology proposed by Whisson et al. (2021) should be integrated with the existing song meter method to achieve a robust survey of the northwest and southern forest blocks. Findings from the year 8 study will help determine if a year 10 population survey is necessary, particularly if the population in the Nambucca SF is no longer present.

6 Recommendations

Recommendations stemming from the year six operational phase survey are presented in Table 2.

Table 2: Recommendations based on findings of the year six operational phase yellow-bellied glider monitoring program.

Number	Recommendation	Transport for NSW Response
1	Conduct a targeted song meter survey during year 8 (2025/26) in the north-west and southern forest blocks of Nambucca SF. The survey should include the systematic deployment of song meters and consider the methods proposed by Whisson *et al.* 2021.	Agree.
2	The year 8 survey should not include Yarriabinni NP or Ngambaa NR as the priority is to confirm the continued presence of gliders in Nambucca SF.	Agree.

7 References

Bilney, R. J., Kambouris, P. J., Peterie, J., Dunne, C., Makeham, K., Kavanagh, R. P., Gonsalves, L. & Law, B. (2022). Long-term monitoring of an endangered population of yellow-bellied gliders *Petaurus australis* on the Bago Plateau, New South Wales, and its response to wildfires and timber harvesting in a changing climate. *Australian Zoologist:* **42,** 592-607.

Bureau of Meteorology (2024). *Climate data for station 059146*. Retrieved August 15, 2024, from http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=059146

Craig, S. (1985). Social organisation, reproduction and feeding behaviour of a population of yellow-bellied gliders, *Petaurus australis* (Marsupalia: Petauridae). *Australian Wildlife Research* 12, 1-18.

Department of Agriculture Water and the Environment (2022). *Conservation advice for Petaurus australis australis {yellow-bellied glider (south-eastern)}*. Australian Government, Canberra.

Ellingsen, K. E., Yoccoz, N. G., Tveraa, T., Hewitt, J. E. & Thrush, S. F. (2017). Long-term environmental

Geolink (2023). Pacific Highway Upgrade – Devils Pulpit: Yellow-bellied Glider (Petaurus australis) Monitoring: Third and Final Annual Report. Report prepared for Transport for New South Wales.

Goldingay, R. (1992). Sociology of the yellow-bellied glider in a coastal forest. *Australian Journal of Zoology* 40**,** 267-278.

Goldingay, R. L & Kavanagh, R. P. (1991). The yellow-bellied glider: a review of its ecology, and management considerations. Pages 365-375 *in* Conservation of Australia's Forest Fauna, ed D. Lunney, Royal Zoological Society of New South Wales, Mosman.

Goldingay, R. L & Kavanagh, R. P. (1993). Home-range estimates and habitat of the yellow-bellied glider (Petaurus australis) at Waratah Creek, New South Wales. *Wildlife Research:* **20,** 387-403.

Goldingay, R. (1994). Loud calls of the yellow-bellied glider Petaurus australis: territorial behavior by an arboreal marsupial? *Australian Journal of Zoology* 42**,** 279-93.

Goldingay, R. L., Quin, D. G., & Churchill, S. (2001). Spatial variability in the social organisation of the yellow-bellied glider (Petaurus australis) near Ravenshoe, north Queensland. *Australian Journal of Zoology:* **49,** 397-409.

Goldingay, R. (2014a). WC2NH Pacific Highway Upgrade: A 10-year Ecological Monitoring Program for the Yellow-bellied Glider. Prepared for NSW Roads and Maritime Services.

Goldingay, R. (2015). *WC2NH Pacific Highway Upgrade: Baseline Monitoring of the Yellow-bellied Glider Population in Nambucca SF.* Report prepared for NSW Roads and Maritime Services.

Goldingay, R. and Jackson, S. (2004). A review of the ecology of the Australian Petauridae. In '*The biology of Australian possums and gliders*'. (Eds RL Goldingay and SM Jackson) pp. 376-400. (Surrey Beatty & Sons: Chipping Norton)

Goldingay, R. L., & Quin, D. G. (2004). Components of the habitat of the yellow-bellied glider in north Queensland. In R. L. Goldingay & S. M. Jackson (Eds.), *The Biology of Australian Possums and Gliders* (pp. 369-375). Surrey Beatty & Sons.

Goldingay, R. L. (2021). General or local habitat preferences? Unravelling geographically consistent patterns of habitat preference in gliding mammals. *Forest Ecology and Management:* **491,** 119204.

Goldingay, R. L., Parkyn, J. L., & McHugh, D. (2023). Drought-induced population decline in an exudivorous mammal and its relevance to forest management. *Forest Ecology and Management*, 548, 121424. https://doi.org/10.1016/j.foreco.2023.121424

Goldingay, R., and Kavanagh, R. (1991). The yellow-bellied glider: a review of its ecology, and management considerations. In '*Conservation of Australia's forest fauna'*. (Ed D Lunney) pp. 365-375. (Royal Zoological Society of NSW: Mosman).

Heise-Pavlov, S. R., Chizinski, T. & Walker, N. E. (2017). Selection of sap feed trees by yellow-bellied gliders (Petaurus australis) in north-eastern Queensland, Australia – implications for site specific habitat management. *Australian Mammalogy:* **40,** 10-15.

Irish, P., & Kavanagh, R. (2011). Distribution, habitat preference and conservation status of the Yellow-bellied Glider (Petaurus australis) in The Hills Shire, northwestern Sydney. *Australian Zoologist*, **35**, 941-952.

Kambouris, P. J., Kavanagh, R. P. & Rowley, K. A. (2013). Distribution, habitat preferences and management of yellow-bellied glider, *Petaurus australis,* on the Bago Plateau, New South Wales: a reassessment of the population and its status. *Wildlife Research:* **40,** 599-614.

Kavanagh, R. (1987). Forest phenology and its effect on foraging behaviour and selection of habitat by the yellow-bellied glider, Petaurus australis Shaw. *Australian Wildlife Research* 14, 371-384.

Lunney, D. (1987). Effects of logging, fire and drought on possums and gliders in the coastal forests near Bega, NSW. *Australian Wildlife Research:* **14,** 263-274.

Lindenmayer, D. B., Blanchard, W., Blair, D., McBurney, L., Taylor, C., Scheele, B. C., Westgate, M. J., Robinson, N., Forster, C. (2021). The response of arboreal marsupials to long-term changes in forest disturbance. *Animal Conservation:* **24,** 246-258.

Mclean, C. M., Kavanagh, R. P., Penman, T. D. & Bradstock, R. A. (2018). The threatened status of the hollow dependent arboreal marsupial, the greater glider (Petauroids volans) can be explained by impacts from wildfire and selective logging. *Forest Ecology and Management*: **415-416,** 19-25.

Niche Environment and Heritage (2023). Pacific Highway Upgrade – Oxley Highway to Kempsey: Yellow-bellied Glider (Petaurus australis) Monitoring: Year Eight Operational Phase. Report prepared for Transport for New South Wales.

Roads and Maritime Services NSW (2018a). *Warrell Creek to Nambucca Heads Ecological Monitoring Program (June 2018)*. Roads and Maritime Services, Sydney.

Russell, R. (1995). Yellow-bellied Glider. In '*The Mammals of Australia*'. (Ed. R Strahan) pp. 226-228. (Reed Books: Chatsworth, Sydney).

Sandpiper Ecological (2018). *Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway Upgrade - Yellow-bellied glider Population Monitoring – Construction Phase Surveys.* Report prepared for NSW Roads and Maritime Services.

Sandpiper Ecological (2019). *Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway Upgrade - Yellow-bellied glider Population Monitoring – Year one Operation Phase Surveys.* Report prepared for NSW Roads and Maritime Services.

Sandpiper Ecological (2020a). *Pacific Highway Upgrade – Warrell Creek to Nambucca Heads: yellow-bellied glider (Petaurus australis) population monitoring: year two operational phase*. Report prepared for Transport for New South Wales.

Sandpiper Ecological (2020b). *Warrell Creek to Nambucca Heads: vegetated median monitoring report – year two operational phase (2019-20)*. Report prepared for Transport for New South Wales.

Sandpiper Ecological (2021a). *Pacific Highway Upgrade – Warrell Creek to Nambucca Heads: yellow-bellied glider (Petaurus australis) population monitoring: year three operational phase post fire and logging*. Report prepared for Transport for New South Wales.

Sandpiper Ecological (2021b). *Woolgoolga to Ballina Pacific Highway Upgrade: threatened gliders monitoring program annual report 2020 (year four)*. Report prepared for Pacific Complete.

Sandpiper Ecological (2021c). *Warrell Creek to Nambucca Heads: vegetated median monitoring report – year three operational phase (2020-21)*. Report prepared for Transport for New South Wales.

Sandpiper Ecological (2022). *Pacific Highway Upgrade Woolgoolga to Ballina: threatened gliders monitoring program, year 5 (2021).* Report prepared for Transport for New South Wales.

Sandpiper Ecological (2024). *Warrell Creek to Nambucca Heads: vegetated median monitoring report – year five operational phase (2022-23)*. Report prepared for Transport for New South Wales.

Sandpiper Ecological (2023a). *Pacific Highway Upgrade Woolgoolga to Ballina sections 3-11: threatened gliders monitoring program, year six (2022)*. Report prepared for Transport for New South Wales.

Sandpiper Ecological (2023b). *Pacific Highway Upgrade – Warrell Creek to Nambucca Heads: yellow-bellied glider (Petaurus australis) population monitoring: year four operational phase*. Report prepared for Transport for New South Wales.

Taylor, B. D. & Rohweder, D. A. (2013). Radio-tracking three sugar gliders using forested highway median strips at Bongil Bongil NP, north-east New South Wales. *Ecological Management & Restoration:* **14,** 228-230.

Taylor, B. D. & Rohweder, D. A. (2020). Yellow-bellied gliders use glide poles to cross the Pacific Highway at Halfway Creek, north-east New South Wales. *Australian Mammalogy* **42**(3), 385-387.

Whisson, D. A., McKinnon, F., Lefoe, M., & Rendall, A. R. (2021). Passive acoustic monitoring for detecting the yellow-bellied glider, a highly vocal arboreal marsupial. *PLoS One:* **16, doi: 10.1371/journal.pone.0252092**

Wildlife Acoustics (2011). *Song Scope Software Version 4.0 User Guide.* Maynard, USA.

Wildlife Acoustics (2021). *Kaleidoscope Pro 5 User Guide.* Maynard, USA

Appendix A – Yellow-bellied glider spotlight surveys field data

Table A1: Yellow-bellied glider detections during three spotlight/call playback surveys conducted in late winter/spring 2023. se = saw eyeshine; hc = heard call; hm = heard movement; sm = saw movement; PB = playback; GHFF – grey-headed flying-fox; CRP – common ringtail possum; OnJ – owlet nightjar; WtNJ = white-throated nightjar; SuG – sugar glider; TF – tawny frogmouth; CBTP – common brushtail possum; SeBtP = short-eared brushtail possum; BbO – southern boobook; PO = powerful owl; FtG – feathertail glider; Nmn – new moon; FQ – first quarter; LQ – last quarter

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	1	1	21/08/2023	13	2337	2347	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Acacia
N	1	2	10/10/2023	7	2137	2147	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	1	3	16/11/2023	8	2153	2203	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	2	1	21/08/2023	11	23:13	23:23	Nil	Nil	Nil	Nil	Nil	btp spp sm, wallaby hm, microbats sm, frogmouth	nil	nil
N	2	2	10/10/2023	10	2305	2315	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	2	3	14/11/2023	9	2257	2307	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tallow
N	3	1	21/08/2023	12	2311	2321	Nil	Nil	Nil	Nil	Nil	FtG hm, TfM se	Nil	Acacia
N	3	2	10/10/2023	11	2219	2229	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	3	3	14/11/2023	10	2312	2322	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	4	1	22/08/2023	2	2246	2256	Nil	Nil	Nil	Nil	Nil	OnJ	Nil	Nil
N	4	2	10/10/2023	2	1941	2001	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	4	3	14/11/2023	7	2219	2239	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	5	1	21/08/2023	9	22:15	22:25	Nil	Nil	Nil	Nil	Nil	wallaby spp. HM, microbats sm, tylerii HC	Nil	Nil
N	5	2	10/10/2023	5	2147	2217	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	5	3	14/11/2023	11	2330	2340	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	6	1	21/08/2023	7	21:20	21:30	Nil	Nil	Nil	Nil	Nil	Owlet nightjar HC	Nil	Nil
N	6	2	10/10/2023	5	2116	2136	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	6	3	14/11/2023	13	1222	1232	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	7	1	21/08/2023	13	23:55	00:05	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	7	2	10/10/2023	1	1915	1935	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	7	3	14/11/2023	9	2309	2339	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	8	1	22/08/2023	2	2222	2232	Nil	Nil	Nil	Nil	Nil	SuG hc, OnJ hc	Nil	Nil
N	8	2	10/10/2023	3	2014	2034	Nil	Nil	Nil	Nil	Nil	Koala	496861, 6607786	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	8	3	14/11/2023	7	2231	2251	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	9	1	21/08/2023	7	00:00	00:10	Nil	Nil	Nil	Nil	Nil	wallaby hm	Nil	
N	9	2	10/10/2023	6	2124	2134	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	9	3	16/11/2023	7	2139	2149	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	10	1	21/08/2023	14	2355	2405	Nil	Nil	Nil	Nil	Nil	GHFF hc,FtG hm	Nil	Acacia
N	10	2	10/10/2023	4	2048	2058	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	10	3	16/11/2023	5	2124	2134	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	11	1	21/08/2023	14	00:10	00:20	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	11	2	10/10/2023	3	2030	2040	Nil	Nil	Nil	Nil	Nil	OnJ hc, LnB hc	Nil	Nil
N	11	3	16/11/2023	4	2111	2121	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	12	1	23/08/2023	1	1900	1910	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	12	2	10/10/2023	5	2106	2116	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	12	3	16/11/2023	6	2051	2101	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	13	1	22/08/2023	1	2207	2217	Nil	Nil	Nil	Nil	Nil	OnJ	Nil	Nil
N	13	2	10/10/2023	1	1915	1935	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	13	3	14/11/2023	8	2244	2304	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	14	1	23/08/2023	4	2044	2054	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	14	2	10/10/2023	8	2202	2212	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	14	3	16/11/2023	3	2028	2038	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	15	1	21/08/2023	12	23:38	23:48	Nil	Nil	Nil	Nil	Nil	falix hc microbat sm wallaby spp. hm	nil	nil
N	15	2	10/10/2023	9	2235	2245	Nil	Nil	Nil	Nil	Nil	SuG se, SeBtP se	Nil	Nil
N	15	3	14/11/2023	10	0001	0021	Nil	Nil	Nil	Nil	Nil	Sug SE	Nil	Nil
N	16	1	21/08/2023	9	2153	2203	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
N	16	2	10/10/2023	6	2219	2239	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	16	3	14/11/2023	5	2140	2150	Nil	Nil	Nil	Nil	Nil	SuG se, FtG sg	Nil	Nil
N	17	1	21/08/2023	8	2126	2136	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	17	2	10/10/2023	7	2219	2239	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	17	3	14/11/2023	4	2120	2130	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
N	18	1	21/08/2023	7	2104	2114	Nil	Nil	Nil	Nil	Nil	Prob sooty owl hc	Nil	Nil
N	18	2	10/10/2023	8	2248	2308	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	18	3	14/11/2023	3	2105	2115	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	19	1	21/08/2023	6	2045	2055	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	19	2	10/10/2023	6	2219	2239	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	19	3	14/11/2023	2	2044	2054	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
N	20	1	22/08/2023	3	2245	2255	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
N	20	2	10/10/2023	4	2045	2105	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	20	3	14/11/2023	6	2207	2227	Nil	Nil	Nil	Nil	Nil	SuG SE	Nil	Nil
N	21	1	22/08/2023	3	2302	2312	Nil	Nil	Nil	Nil	Nil	OnJ	Nil	Nil
N	21	2	10/10/2023	2	1941	2001	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	21	3	14/11/2023	8	2259	2319	Nil	Nil	Nil	Nil	Nil	Koala SE 497565, 6608846	Nil	Nil
N	22	1	22/08/2023	1	2159	2209	Nil	Nil	Nil	Nil	Nil	OnJ hc, GhFf hc	Nil	Nil
N	22	2	10/10/2023	3	2014	2034	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	22	3	14/11/2023	9	2334	2354	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	23	1	23/08/2023	3	2011	2021	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	23	2	10/10/2023	2	2000	2010	Nil	Nil	Nil	Nil	Nil	SuG SE 100Son trans, OnJ hc	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	23	3	16/11/2023	1	1950	2000	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	24	1	23/08/2023	2	1949	1959	Nil	Nil	Nil	Nil	Nil	PO HC	Nil	Nil
N	24	2	10/10/2023	1	1932	1942	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
N	24	3	16/11/2023	2	2006	2016	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	25	1	21/08/2023	11	2245	2255	Nil	Nil	Nil	Nil	Nil	Koala,se 496057.6610077	Nil	Acacia
N	25	2	10/10/2023	12	2340	2350	Nil	Nil	Nil	Nil	Nil	OnJ hc, GhFf hc	Nil	Nil
N	25	3	14/11/2023	7	2221	2231	Nil	Nil	Nil	Nil	Nil	SEBtP x 2 se	Nil	Nil
N	26	1	21/08/2023	10	2214	2224	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	26	2	10/10/2023	8	2319	2349	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tallowwood
N	26	3	14/11/2023	6	2200	2210	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	27	1	21/08/2023	5	2018	2028	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	27	2	10/10/2023	9	2319	2349	Nil	Nil	Nil	Nil	Nil	GHFF	Nil	Tallowwood
N	27	3	14/11/2023	1	2015	2025	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	28	1	21/08/2023	10	20:50	21:00	Nil	Nil	Nil	Nil	Nil	nil	Nil	Nil
N	28	2	10/10/2023	7	2145	2215	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tallowwood

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	28	3	14/11/2023	8	2242	2252	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	29	1	21/08/2023	8	21:45	21:55	Nil	Nil	Nil	Nil	Nil	wallaby spp. HM, microbats sm	Nil	Nil
N	29	2	10/10/2023	5	2116	2136	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tallowwood
N	29	3	14/11/2023	12	1200	1210	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	30	1	21/08/2023	5	20:20	20:35	Nil	Nil	Nil	Nil	Nil	Microbats SM	Nil	Nil
N	30	2	12/10/23	1	2250	2300	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
N	30	3	14/11/2023	6	2155	2215	Nil	Nil	Nil	Nil	Nil	Sug SE	Nil	Nil
N	31	1	21/08/2023	4	1922	1942	Nil	Nil	Nil	Nil	Nil	Nil	campers at mid point	Nil
N	31	2	12/10/23	2	2305	2315	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	31	3	14/11/2023	2	1959	2019	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	32	1	21/08/2023	6	20:50	21:00	Nil	Nil	Nil	Nil	Nil	nil	Nil	Nil
N	32	2	12/10/23	3	2318	2328	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	32	3	14/11/2023	1	2022	2042	Nil	Nil	Nil	Nil	Nil	Nil	Nil	ironbark
N	33	1	21/08/2023	2	18:45	18:55	Nil	Nil	Nil	Nil	Nil	GHFF HC, microbats SM	nil	nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	33	2	12/10/23	6	0012	0022	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	33	3	14/11/2023	2	2019	2039	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	34	1	21/08/2023	1	18:13	18:23	Nil	Nil	Nil	Nil	Nil	grey headed flyingfox hc, rattus spp. sm, macropod spp. hm, microbats SM	nil	nil
N	34	2	12/10/2023	4	0001	0021	Nil	Nil	Nil	Nil	Nil	Sug SE	Nil	Tallowwood
N	34	3	14/11/2023	1	1956	2014	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	35	1	21/08/2023	4	19:00	19:45	Nil	Nil	Nil	Nil	Nil	GHFF HC, macropod HM, owlet nightjar HC	nil	nil
N	35	2	12/10/2023	3	2333	2352	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tallowwood
N	35	3	14/11/2023	4	2108	2138	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	36	1	21/08/2023	3	19:00	19:15	Nil	Nil	Nil	Nil	Nil	microbats SM	two vehicles on track	nil
N	36	2	12/10/23	5	2357	2407	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	36	3	14/11/2023	3	2041	2051	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
N	37	1	21/08/2023	7	18:55	19:05	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	37	2	12/10/23	4	2337	2347	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	37	3	14/11/2023	5	2138	2158	Nil	Nil	Nil	Nil	Nil	Nil	Nil	E. siderophloia
N	38	1	21/08/2023	2	1838	1858	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	38	2	12/10/2023	1	2244	2304	Nil	Nil	Nil	Nil	Nil	WTNJ	Nil	Tallowwood
N	38	3	14/11/2023	3	2045	2105	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	39	1	21/08/2023	3	1902	1915	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
N	39	2	12/10/2023	2	2306	2326	Nil	Nil	Nil	Nil	Nil	WTNJ, GHFF SE	Nil	Tallowwood
N	39	3	14/11/2023	4	2107	2127	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
N	40	1	21/08/2023	1	1804	1824	Nil	Nil	Nil	Nil	Nil	GHFF	Nil	Nil
N	40	3	14/11/2023	5	2131	2151	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Ironbark
N	40	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	Log over road >500m, fire	
U	1	1	23/08/2023	9	2209	2229	Nil	Nil	Nil	Nil	Nil	OnJ	Nil	Nil
U	1	2	11/10/2023	10	0001	0016	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	1	3	15/11/2023	NR	0023	0033						BB		

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	2	1	23/08/2023	12	2202	2212	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	2	2	11/10/2023	14	2343	2353	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	2	3	15/11/2023	12	2352	0002	Nil	Nil	Nil	Nil	Nil	OnJ hc		
U	3	1	23/08/2023	9	21:50	22:10	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	3	2	11/10/2023	13	2330	2340	Nil					OnJ hc	Nil	Nil
U	3	3	15/11/2023	11	2338	2348	Nil	Nil	Nil	Nil	Nil	SuG sm, Onj hc, GhFf hc	Nil	Iron bark
U	4	1	23/08/2023	11	2145	2155	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	4	2	11/10/2023	12	2313	2323	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
U	4	3	15/11/2023	8	0023	0033	Nil	Nil	Nil	Nil	Nil	Nil		
U	5	1	23/08/2023	8	2141	2201	Nil	Nil	Nil	Nil	Nil	OnJ	Nil	Nil
U	5	2	11/10/2023	11	2256	2306	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
U	5	3	15/11/2023	7	0003	0023	Nil	Nil	Nil	Nil	Nil	Nil	Nil	NiL
U	6	1	23/08/2023	10	21:30	21:40	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	6	2	11/10/2023	9	2318	2340	Nil	Nil	Nil	Nil	Nil	Water rat Observed, onj heard	Nil	Nil
U	6	3	15/11/2023	8	2328	2358	Nil	Nil	Nil	Nil	Nil	ONJ	GBF HC and seen in creek	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	7	1	23/08/2023	7	20:40	21:00	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	7	2	11/10/2023	8	2251	2314	Nil	Nil	Nil	Nil	Nil	barn owl, onj, cbt poss on ground, sugar glider in tree.	Nil	Nil
U	7	3	15/11/2023	10	2338	2358	Nil	Nil	Nil	Nil	Nil	Sug HC	Nil	Nil
U	8	1	23/08/2023	7	2058	2118	Nil	Nil	Nil	Nil	Nil	GG 200n75e	Nil	Nil
U	8	2	11/10/2023	9	2310	2330	Nil	Nil	Nil	Nil	Nil	SuG HC x2, SuG SE, Gg SE	Nil	Nil
U	8	3	15/11/2023	9	2313	2333	Nil	Nil	Nil	Nil	Nil	Sug HC , Sug se, onj	Nil	Nil
U	9	1	23/08/2023	8	21:25	21:45	Nil	Nil	Nil	Nil	Nil	SE.BTP SE, owlet nightjar HC		
U	9	2	11/10/2023	8	2247	2307	Nil	Nil	Nil	Nil	Nil	FTG sg.	Koala scat on transect	Nil
U	9	3	15/11/2023	8	2251	2311	Nil	Nil	Nil	Nil	Nil	Sooty owl, WTNJ, ONJ	Nil	Nil
U	10	1	23/08/2023	6	2021	2041	Nil	Nil	Nil	Nil	Nil	OnJ, SuG SE	Nil	Nil
U	10	2	11/10/2023	7	2222	2232	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	10	3	15/11/2023	7	2227	2247	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	11	1	23/08/2023	6	20:05	20:25	nil	nil	nil	nil	nil		Nil	Nil
U	11	2	11/10/2023	6	2153	2214	Nil	Nil	Nil	Nil	Nil	onj heard	Nil	Nil
U	11	3	15/11/2023	6	2204	2224	Nil	Nil	Nil	Nil	Nil	Nil	~50% to total transect area cleared for fence	Nil
U	12	1	23/08/2023	5	19:36	19:56	nil	nil	nil	nil	nil	SE BTP. x2 SE owlet nightjar HC	nil	nil
U	12	2	11/10/2023	5	1921	1947	Nil	Nil	Nil	Nil	Nil	perons tree frog onj x1 heard	gg x 1 eye shine in tree 476549 6584718	
U	12	3	15/11/2023	5	2141	2201	Nil	Nil	Nil	Nil	Nil	GG SE 20n10w, SuG SG, ONJ	~50% to total transect area cleared for fence	Nil
U	13	1	23/08/2023	4	19:10	19:30	nil	nil	nil	nil	nil	frog mouth SE x2, Com BTP SE, SuG x3 SE	Nil	Nil
U	13	2	11/10/2023	4	2049	2112	Nil	Nil	Nil	Nil	Nil	1x cbt poss eye shine in tree	Nil	Nil
U	13	3	15/11/2023	4	2114	2134	Nil	Nil	Nil	Nil	Nil	SuG SE, CBTP SE x 2	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	14	1	23/08/2023	3	18:45	19:05	nil	nil	nil	nil	nil	SE BTP. x2 Com. BTP. x1 SE, owlet nightjar HC	Nil	Nil
U	14	2	11/10/2023	3	2020	2022	Nil	Nil	Nil	Nil	Nil	owlet nj heard	Nil	Nil
U	14	3	15/11/2023	3	2049	2109	Nil	Nil	Nil	Nil	Nil	boobook heard	Nil	Nil
U	15	1	23/08/2023	2	17:55	18:15	nil	nil	nil	nil	nil	nil	nil	nil
U	15	2	11/10/2023	2	1950	2010	Nil	Nil	Nil	Nil	Nil	gg x se in tree	474503 6585567	
U	15	3	15/11/2023	2	2025	2045	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	16	1	23/08/2023	1	18:20	18:40	nil	nil	nil	nil	nil	nil	dropped new point and flagging wasnt 200m	nil
U	16	2	11/10/2023	1	1925	1945	Nil	Nil	Nil	Nil	Nil	ggx1 se in tree	474851 6585929	nil
U	16	3	15/11/2023	1	2002	2022	Nil	Nil	Nil	Nil	Nil	FtG SE, WTNJ	Nil	Nil
U	17	1	23/08/2023	5	1952	2002	Nil	Nil	Nil	Nil	Nil	OnJ, SuG SE	Nil	Nil
U	17	2	11/10/2023	6	2133	2153	Nil	Nil	Nil	Nil	Nil	GG SE 200Nw	Nil	Nil
U	17	3	15/11/2023	6	2200	2220	Nil	Nil	Nil	Nil	Nil	SuG SE		

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	18	1	23/08/2023	4	1853	1913	2	HC	After	1933	185n0e, 185n100w	SuG HC, OnJ	Individual glided above track	Nil
U	18	2	11/10/2023	5	2106	2126	Nil	Nil	Nil	Nil	Nil	Nil	Clearing has occurred on transect affecting 20%	
U	18	3	15/11/2023	5	2135	2155	Nil	Nil	Nil	Nil	Nil	Nill		
U	19	1	23/08/2023	2	1823	1843	Nil	Nil	Nil	Nil	Nil	OnJ, SuG SE	Nil	Nil
U	19	2	11/10/2023	3	2009	2029	Nil	Nil	Nil	Nil	Nil	ONJ, WTNJ, se Sooty owl	Nil	Nil
U	19	3	15/11/2023	4	2113	2133	Nil	Nil	Nil	Nil	Nil	Onj	Nil	Nil
U	20	1	23/08/2023	1	1757	1817	Nil	Nil	Nil	Nil	Nil	OnJ, SuG HC	Nil	Nil
U	20	2	11/10/2023	2	1945	2005	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	20	3	15/11/2023	3	2046	2106	Nil	Nil	Nil	Nil	Nil	TF, OnJ	Nil	Nil
U	21	1	23/08/2023	9	2054	2104	1	HC	After	2058	25e80n	SuG hc	Nil	Nil
U	21	2	11/10/2023	8	2134	2144	Nil	Nil	Nil	Nil	Nil	3xOnJ hc	Nil	Nil
U	21	3	15/11/2023	8	2225	2235	Nil	Nil	Nil	Nil	Nil	SuG hc,OnJ hc, TFM si	Nil	Nil
U	22	1	23/08/2023	8	2026	2036	Nil	Nil	Nil	Nil	Nil	GG hm 40e5s, OnJ hc	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	22	2	11/10/2023	7	2114	2124	1	HC	During & after PB	2113	100e30n	OnJ hc	Nil	Nil
U	22	3	15/11/2023	7	2206	2216	2	HC,HC	After PB,after pb	2207,2216	100e40n,0m50w	OnJ hc	Nil	Nil
U	23	1	23/08/2023	7	2009	2019	Nil	Nil	Nil	Nil	Nil	GG se 0.30e, koala hc 0.100ne	Nil	Nil
U	23	2	11/10/2023	6	2001	2011	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	23	3	15/11/2023	6	2149	2159	Nil	Nil	Nil	Nil	Nil	2 x OnJ, TFM	Nil	Nil
U	24	1	23/08/2023	6	1957	2007	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	24	2	11/10/2023	5	2046	2056	Nil	Nil	Nil	Nil	Nil	FtG sm	Nil	Nil
U	24	3	15/11/2023	5	2128	2138	Nil	Nil	Nil	Nil	Nil	BtPoss spp. SE, OnJ hc, TFM SI	Nil	Nil
U	25	2	11/10/2023	9	2152	2202	Nil	Nil	Nil	Nil	Nil	OnJx3 hc		
U	25	3	15/11/2023	9	2243	2253	Nil	Nil	Nil	Nil	Nil	SuG hc	Nil	Nil
U	25	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	gate locked	
U	26	2	11/10/2023	10	2206	2216	Nil	Nil	Nil	Nil	Nil	OnJ hc,BbO hc		
U	26	3	15/11/2023	10	2300	2310	Nil	Nil	Nil	Nil	Nil	OnJ x 3 hc		

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	26	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	gate locked	
U	27	1	23/08/2023	5	1934	1944	Nil	Nil	Nil	Nil	Nil	OnJ hc, PO hc 200s500sw	Nil	Nil
U	27	2	11/10/2023	4	2030	2040	1	HC	After PB	2035	200S100s	OnJ hc	Nil	Nil
U	27	3	15/11/2023	4	2111	2121	Nil	Nil	Nil	Nil	Nil	FtG SG, OnJ hc	Nil	Nil
U	28	1	23/08/2023	4	1914	1924	1	HC	During PO pb & after pb	1913	80s40e	Nil	During PO pb & after pb	Nil
U	28	2	11/10/2023	3	2003	2013	1	HC	During & after PB	2002	100S5e	Koala HC 100s50w, FtG HG, OnJ hc	Nil	Nil
U	28	3	15/11/2023	3	2053	2103	1	HC	Before, during and after	2053	100S5e	FtG x 2 sm	Nil	Nil
U	29	1	23/08/2023	3	1855	1905	Nil	Nil	Nil	Nil	Nil	TFm hc	Nil	Nil
U	29	2	11/10/2023	2	1941	1951	Nil	Nil	Nil	Nil	Nil	PO SE 80n,1e	Nil	Nil
U	29	3	15/11/2023	2	2030	2040	Nil	Nil	Nil	Nil	Nil	OnJ hc, CBtP se	Nil	Nil
U	30	1	23/08/2023	2	1840	1850	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
U	30	2	11/10/2023	1	1925	1935	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
U	30	3	15/11/2023	1	2017	2027	Nil	Nil	Nil	Nil	Nil	OnJ hc	Nil	Nil
U	31	1	23/08/2023	1	1820	1830	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Acacia
U	31	2	11/10/2023	1	1918	1938	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U	31	3	15/11/2023	1	2014	2034	Nil	Nil	Nil	Nil	Nil	SUG SE x2, CBTP Se, Koala HC	Koala call 477021, 6579622	Nil
U	32	1	23/08/2023	3	1853	1913	1	HC	After	1901	160n60w	Nil	Nil	Nil
U	32	2	11/10/2023	4	2037	2057	1	HC	After	2049	100n100w	2 x GG Se. 0s30e both, GHFF.	GG close together	Uk stringybark
U	32	3	15/11/2023	2	2014	2034	Nil	Nil	Nil	Nil	Nil	ONJ, TF	Nil	Nil
Y	1	1	22/8/23	2	1831	1841	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	1	2	12/10/23	2	2002	2022	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tallowwood
Y	1	3	13/11/2023	9	2237	2247	Nil	Nil	Nil	Nil	Nil	BB	Nil	Nil
Y	2	1	22/8/23	3	1849	1859	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	2	2	12/10/23	3	2025	2045	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	2	3	13/11/2023	7	2155	2205	Nil	Nil	Nil	Nil	Nil	TF, BB	Nil	Nil
Y	3	1	22/8/23	4	1904	1914	Nil	Nil	Nil	Nil	Nil	BB x 2 HC	Nil	Nil
Y	3	2	12/10/23	4	2054	2116	Nil	Nil	Nil	Nil	Nil	BB HC x2, SuG HC	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
Y	3	3	13/11/2023	6	2135	2145	Nil	Nil	Nil	Nil	Nil	BB	Nil	Nil
Y	4	1	22/8/23	5	1921	1931	Nil	Nil	Nil	Nil	Nil	BB x 2 HC	Nil	Nil
Y	4	2	12/10/23	5	2123	2143	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	4	3	13/11/2023	5	2118	2128	1	HC	A	2127	200n80e	BB	Nil	Nil
Y	5	1	22/8/23	6	1938	1948	Nil	Nil	Nil	Nil	Nil	BB SE, SuG HC	Nil	Nil
Y	5	2	12/10/2023	1	1932	1952	Nil	Nil	Nil	Nil	Nil	Bbo	Nil	Nil
Y	5	3	13/11/2023	4	2104	2114	Nil	Nil	Nil	Nil	Nil	BB	Nil	Nil
Y	6	1	22/8/23	7	1959	2009	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	6	2	12/10/2023	2	2002	2022	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	6	3	13/11/2023	3	2049	2059	Nil	Nil	Nil	Nil	Nil	SuG HC	Nil	Nil
Y	7	1	22/8/23	8	2016	2026	2	HC	after	2019	150e30N,	BB, OnJ	Nil	Nil
Y	7	2	12/10/2023	3	2025	2045							Nil	Nil
Y	7	3	13/11/2023	2	2034	2044	Nil	Nil	Nil	Nil	Nil	nil	Nil	Nil
Y	8	1	22/8/23	9	2040	2050	Nil	Nil	Nil	Nil	Nil	BB	Nil	Nil
Y	8	2	12/10/2023	4	2054	2116	1	HC	After	2112	100n502	OnJ	ybg, 4944728, 6593899	Nil
Y	8	3	13/11/2023	1	2012	2022	Nil	Nil	Nil	Nil	Nil	BB, ONJ	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
Y	9	1	22/8/23	8	2013	2023	Nil	Nil	Nil	Nil	Nil	SuG x 2 hc, OnJ x 2 hc	Nil	Nil
Y	9	2	12/10/2023	5	2123	2143	Nil	Nil	Nil	Nil	Nil	Sug SE, ONJ	Nil	Nil
Y	9	3	13/11/2023	10	2301	2311	Nil	Nil	Nil	Nil	Nil	3x SeBtP, FF spp. HC	Nil	Nil
Y	10	1	22/8/23	9	2035	2045	Nil	Nil	Nil	Nil	Nil	SuG x 2 hc, OnJ x 2 hc	Nil	Nil
Y	10	2	12/10/23	6	2151	2211	Nil	Nil	Nil	Nil	Nil	WTNJ	Nil	Nil
Y	10	3	13/11/2023	8	2319	2329	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	11	1	22/8/23	10	2051	2101	Nil	Nil	Nil	Nil	Nil	SuG hc, OnJ hc	Nil	Nil
Y	11	2	12/10/23	8	2138	2148	Nil	Nil	Nil	Nil	Nil	FtG SM,OnJx3,GhFF HC	Nil	Nil
Y	11	3	13/11/2023	11	2319	2329	Nil	Nil	Nil	Nil	Nil	Onj	Nil	Nil
Y	12	1	22/8/23	7	1956	2006	Nil	Nil	Nil	Nil	Nil	OnJ x 2 hc, SBbO hc	Nil	Wonga vine
Y	12	2	12/10/23	7	2114	2224	Nil	Nil	Nil	Nil	Nil	SBbO hc, GhFF hc, OnJ hc	Nil	Nil
Y	12	3	13/11/2023	7	2248	2308	1	HC	After	Nil	120,40	OnJ	YbG 495788, 6593976	Nil
Y	13	1	22/8/23	6	1940	1950	Nil	Nil	Nil	Nil	Nil	SBbO hc, SuG hc	Some of transect burnt	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
Y	13	2	12/10/23	6	2052	2102	Nil	Nil	Nil	Nil	Nil	SBbO hc, SuG SE	Nil	Nil
Y	13	3	13/11/2023	6	2221	2241	1	HC	Before	2228	80n50w	FtG SM, Bbo	YbG 495943, 6593457	Nil
Y	14	1	22/8/23	5	1915	1925	Nil	Nil	Nil	Nil	Nil	SO hc, SBbO hc	Some of transect burnt	Nil
Y	14	2	12/10/23	5	2035	2045	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	14	3	13/11/2023	5	2149	2209	1	HC	After	2208	200e50n	BB HC, ONJ HC.	YbG 496745, 6593188	Nil
Y	15	1	22/8/23	3	1840	1850	Nil	Nil	Nil	Nil	Nil	Nil	Some of transect burnt	Nil
Y	15	2	12/10/23	3	2000	2010	Nil	Nil	Nil	Nil	Nil	BtPoss spp. SE	Nil	Nil
Y	15	3	13/11/2023	3	2027	2047	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	16	1	22/8/23	2	1823	1833	Nil	Nil	Nil	Nil	Nil	Nil	Some of transect burnt	Nil
Y	16	2	12/10/23	2	1949	1959	Nil	Nil	Nil	Nil	Nil	CBTP SE	Nil	Nil
Y	16	3	13/11/2023	2	2052	2112	Nil	Nil	Nil	Nil	Nil	nil	Nil	Nil
Y	17	1	22/8/23	1	1804	1814	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	17	2	12/10/23	1	1933	1943	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	17	3	13/11/2023	1	2004	2024	Nil	Nil	Nil	Nil	Nil	CbtP SE, FtG se	Nil	Nil

Transect	Site	Suvey No.	Date	Order	Start (24hr)	Finish (24hr)	YbG (no. ind's)	Obseravtion type (HC, SE, SG,SM)	Before or after PB	Time	Bearing (eg 120n40e)	Other species	Comments	Flowering
Y	18	1	22/8/23	4	1856	1906	Nil	Nil	Nil	Nil	Nil	Nil	Some of transect burnt	Nil
Y	18	2	12/10/23	4	2018	2028	Nil	Nil	Nil	Nil	Nil	PO hc 50n100e	Nil	Nil
Y	18	3	13/11/2023	4	2119	2139	Nil	Nil	Nil	Nil	Nil	BB HC, GG SE 100n10e	Nil	Nil
Y	19	1	22/8/23	10	2102	2112	Nil	Nil	Nil	Nil	Nil	BB	Nil	Nil
Y	19	2	12/10/23	9	2151	2201	Nil	Nil	Nil	Nil	Nil	OnJ	Nil	Nil
Y	19	3	13/11/2023	12	2333	2343	Nil	Nil	Nil	Nil	Nil		Nil	Nil
Y	20	1	22/8/23	1	1814	1824	Nil	Nil	Nil	Nil	Nil	GHFF, RtP	Nil	Nil
Y	20	2	12/10/23	1	1932	1952	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Y	20	3	13/11/2023	8	2222	2232	Nil	Nil	Nil	Nil	Nil	BB	Nil	Nil

Appendix B – Song meter deployment data

Table B1: Song meter deployment data for 2023/24 year six monitoring period.

Site No.	Forest Block	Easting	Northing	Install	Check Date	Status	Collect Date	Status	Days Active	Notes
SM1	S	497127	6609463	24/08/2023	20/11/23	A	22/2/24	A	182	
SM2	S	497643	6609308	24/08/2023	20/11/23	A	22/2/24	A	182	
SM3	S	496914	6609169	24/08/2023	20/11/23	A	22/2/24	A	182	
SM4	S	495500	6606980	24/08/2023	20/11/23	A	22/2/24	A	182	
SM5	S	496730	6607147	24/08/2023	20/11/23	A	22/2/24	A	182	
SM6	NW	495517	6607987	24/08/2023	20/11/23	A	22/2/24	A	182	
SM7	NW	496204	6608540	24/08/2023	20/11/23	A	22/2/24	A	182	
SM8	NW	496890	6610107	24/08/2023	20/11/23	A	22/2/24	A	182	
SM9	NW	495333	6611184	24/08/2023	20/11/23	A	22/2/24	A	182	
SM10	NW	496345	6610236	24/08/2023	20/11/23	A	22/2/24	A	182	
SM11	NW	495445	6610199	24/08/2023	20/11/23	A	22/2/24	A	88	SD format error- NO data for first period
SM12	S	497064	6608479	24/08/2023	20/11/23	A	22/2/24	A	182	
SM13	NE	498950	6612723	24/08/2023	20/11/23	A	22/2/24	A	182	
SM14	NE	498181	6611637	24/08/2023	20/11/23	A	22/2/24	A	182	
SM15	NE	499184	6611800	20/11/2023	N/A	A	22/2/24	A	94	Late install
SM16	NE	500154	6611271	24/08/2023	20/11/23	A	22/2/24	A	182	
SM17	NE	500154	6612164	20/11/2023	N/A	A	22/2/24	A	94	Late install
SM18	NE	500653	6611684	24/08/2023	20/11/23	A	22/2/24	A	182	