



Koala Monitoring 2022

Year 8 Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade

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Cover photograph: Koala recorded in Maria River State Forest during Spotted-tailed Quoll Monitoring in 2018 and Koala recorded in Underpass C32.35 during 2020 underpass monitoring.

Executive Summary

Context

This report documents findings from the spring-summer 2022 monitoring period for the Koala, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project).

Aims

The aim of the Koala monitoring program is to determine whether the Project is having an impact on Koala populations within the study area.

Methods

Each monitoring location was surveyed in accordance with the monitoring method and design specified in the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program (EMP, TfNSW 2022). Monitoring involved Spot Assessment Technique (SAT) plots and spotlighting. Surveys were undertaken in November 2022, December 2022, January 2023 and February 2023.

Key Results

- A total of 85 plots across 30 clusters were surveyed in spring-summer 2022. Koalas were found to be present within 10 of the 30 clusters (33%). This is lower than baseline, 2015, 2016, 2017, 2018, 2019 and 2020 surveys (83%, 45%, 37%, 52%, 52%, 74% and 57% respectively).
- The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 1.1% and ranged from 0 to 16.7%. This is similar to the mean activity recorded for plots during 2015, 2016, 2017 and 2020 surveys (2.0%, 0.7%, 1.8% and 1.9% respectively), but lower than the mean activity during baseline surveys (4.9%) and 2019 surveys (3.3%).
- Koalas were recorded more frequently at impact clusters (40%) than at control clusters (27%), which is consistent with results observed in the previous monitoring events.
- Koalas have been recorded using four of the 14 culverts (located within the vicinity of the monitoring sites) being monitored as part of the Fauna Underpass Monitoring for the Project.
- There was no significant change in the difference between Koala presence at control and impact clusters between 2022 and baseline surveys.
- There was no significant change in the difference between Koala presence at clusters with and without mitigation between 2022 and baseline surveys.
- Average plot activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level.
- There were no Koala road kill records during 2022/2023 monitoring.
- There has not been a notable alteration in Koala record distribution pre and post construction.
- Grids traversed by the Project corridor have the lowest Koala density, and grids adjacent to the Project corridor have the highest Koala density in both the pre-construction and post-construction periods. Average record density has increased for each group of grids post construction.

Conclusions

All performance measures have been met.

Management Implications

As no significant changes in Koala presence, distribution, density and activity levels from baseline surveys have been detected to date, and as Koalas have been detected using four dedicated fauna underpasses within the Project area, additional mitigation actions are not considered necessary.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (TfNSW 2022) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Koala was identified as requiring mitigation and monitoring during the Project's construction and operational periods.

1.1.1 Legal status

The Koala (*Phascolarctos cinereus*) is listed as endangered under both the NSW *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth EPBC Act. Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The design, methods and performance indicators that define the Koala monitoring program are specified in the EMP. The monitoring program specifies that monitoring of all sites would occur in Years 1, 2 and 3 (construction phase) once substantial construction had commenced. Following the completion of the Project, monitoring was to continue in Years 4, 5, 6 and 8 (operation phase) or until the mitigation measures can be demonstrated to have been effective for the Koala.

To date, these monitoring events have been conducted and reported on as follows:

- Spring-summer 2015: *Koala Monitoring. Year 1 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2016)
- Spring-summer 2016: *Koala Monitoring 2016. Year 2 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2017)
- Spring-summer 2017: *Koala Monitoring 2017. Year 3 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2018a)
- Spring-summer 2018: *Koala Monitoring 2018. Year 4 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2019a)
- Spring-summer 2019: *Koala Monitoring 2019. Year 5 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2020a)
- Spring-summer 2020: *Koala Monitoring 2019. Year 6 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2021a)
- Spring-summer 2022: Current report.

Construction monitoring was completed in spring-summer 2017. This report represents the fourth (Year 8) and final of the required operational monitoring reports.

1.1.3 Baseline data

In accordance with the EMP, baseline surveys for the Koala were undertaken in 2014 to provide baseline data that could be used to identify changes in habitat use before and after construction of the Project, and determine whether any changes can be reasonably attributed to the Project. Baseline monitoring was conducted by Lewis Ecological prior to the commencement of construction (Lewis 2014). Remote cameras were also opportunistically deployed (targeting other threatened species) in August 2013, while spotlighting and Spot Assessment Technique (SAT) plot surveys were undertaken in spring 2013.

1.1.4 Purpose of this report

This report details the findings obtained from the 2022 monitoring period. As mentioned previously, it represents the third of four monitoring reports for the operational phase of the Project.

The aim of this report is to summarise the methods and results of the spring-summer 2022 monitoring, and to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures should be considered.

1.2 Performance Measures

The EMP specifies the following performance measures for the Koala:

- *Monitoring is undertaken during baseline surveys from Year 1 – Year 6 & Year 8, or until mitigation measures are demonstrated to be effective.*
- *Monitoring during Year 1 – Year 6 & Year 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.*
- *Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.*
- *Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.*
- *Density: Koala spotlighting records are compared to and discussed with reference to the baseline records, with the baseline detection frequency rate of 1 Koala per spotlight hour considered as the baseline density, as recommended in the baseline report. Compare the NSW BioNet wildlife Atlas density ranking of 5 km² grids, as per the baseline report, between pre and post-construction at Year 8.*
- *Movement: Reduction in Koala road kill compared to the baseline of 1 Koala road kill per 8 weeks for an average baseline plot activity level of 5%, whereby proportional changes in average plot activity level may be reflected in the acceptable level of Koala road kill.*
- *Distribution: Compare the number of records and clustering of records, as per the baseline report, between pre-construction and construction/post-construction at Year 8.*
- *Habitat Use: Koala SAT activity levels will be compared to the baseline activity levels data (below) with a 10% tolerance level, as recommended in the baseline report, to account for variability:*
 - *Broader study area set at 5% activity*
 - *The treatment classes of mitigation set at 8.05%, no mitigation set at 2.64% and control / reference set at 4.03%*
 - *Comparison of percent tree use with baseline tree use.*

1.3 Monitoring Timing

Spotlighting is to occur in spring and SAT plot monitoring is to occur during spring-summer.

1.4 Reporting

Annual reporting of monitoring results will include:

- A detailed description of the monitoring methodology
- Results of the monitoring surveys
- Discussion of the results, including how the results compare against performance measures and if contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the NSW Department of Planning and Environment (DPE) and the NSW Environment Protection Authority (EPA) and the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW).

2. Survey Methodology

2.1 Koala Spot Assessment Technique (SAT)

2.1.1 Monitoring design

In accordance with the baseline monitoring surveys, eight broad areas within a 20 kilometre (km) radius of the Project were surveyed. These eight areas include South Sancrox, North Sancrox, Cairncross State Forest (South), Cairncross State Forest (North), Cooperabung Hill, Mingaletta Road to Smiths Creek, Kundabung Road to North of Pipers Creek and Maria River State Forest. Within each of these areas, three types of monitoring treatments were established:

- **Type A:** Impact with mitigation. Mitigation plots are located within 500 metres (m) of sufficiently large culverts (>1.8 m, to allow Koalas to pass under the Highway) that are paired with floppy top fencing.
- **Type B:** Impact without mitigation. Plots where mitigation has not been proposed or only partial mitigation is proposed. Partial mitigation plots are where only floppy top fencing is present but with obvious openings at interchanges or entry/exit points.
- **Type C:** Control or reference. These are located in areas at least 3 km, and often 5-10 km from the Project.

Each treatment type (A, B or C) is represented by a cluster of three SAT plots within each of the eight areas, resulting in nine SAT plots per area giving a total of 72 baseline SAT plots, established by Lewis (2014) (with the exception of Cairncross State Forest (South), which had an additional type B cluster during baseline surveys and Mingaletta to Smiths Creek where no type B cluster was established during baseline surveys). Of these 72 plots, 24 were mitigation (type A), three part mitigation and 21 no mitigation (type B) and 24 were control sites (type C). To ensure a balanced monitoring design between impact plots (mitigated and not mitigated) and control plots, an additional 24 control plots (type C) were established during the first monitoring event in 2015 (Niche 2016). In accordance with the baseline monitoring design these additional 24 control plots were established at least 3 km from the Project and were grouped in clusters of three plots, one cluster for each of the eight broad areas.

In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area.

Details of the 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1. During the 2022 monitoring, eight of the 93 monitoring plots were not monitored due to: six plots (KUNDABUNG 6, MIN-SMITHS CK3, COOPERABUNG 1, LAKE INNES1-3) being inaccessible due inability to contact landholder and two plots (SAT ST1 and SAT ST2) being inaccessible due to track damage.

Table 1: SAT monitoring plots

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
South Sancrox	Impact	No Mitigation	Baseline	1 Sancrox East - Cassegrains	483348	6521736
	Impact	No Mitigation	Baseline	2 Sancrox East - Cassegrains	483455	6521789
	Impact	No Mitigation	Baseline	3 Sancrox East - Cassegrains	483412	6521882

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
	Impact	Mitigation	Baseline_Niche relocation	1 Sancrox South	483299	6520671
	Impact	Mitigation	Baseline_Niche relocation	2 Sancrox South	483254	6520383
	Impact	Mitigation	Baseline_Niche relocation	3 Sancrox South	483196	6520217
	Control	Control	Baseline	1 Cowarra State Forest	480608	6519056
	Control	Control	Baseline	2 Cowarra State Forest	480658	6519496
	Control	Control	Baseline	3 Cowarra State Forest	481305	6519136
	Control	New Control	Niche	COWARRA NC1	479706	6518522
	Control	New Control	Niche	COWARRA NC2	479788	6517922
	Control	New Control	Niche	SAT COWARRA NC3	479795	6518227
North Sancrox	Impact*	No Mitigation	Baseline	1 Sancrox North - Expressway Spares	483042	6521731
	Impact*	No Mitigation	Baseline	2 Sancrox North - Expressway Spares	482869	6521683
	Impact*	No Mitigation	Baseline	3 Sancrox North - Expressway Spares	482999	6521818
	Impact	Mitigation	Baseline	1 Fernbank Creek	483101	6523362
	Impact	Mitigation	Baseline	2 Fernbank Creek	483032	6523223
	Impact	Mitigation	Baseline	3 Fernbank Creek	483056	6523123
	Control ⁺	Control	Baseline	1 Lake Innes	488124	6518469
	Control ⁺	Control	Baseline	2 Lake Innes	488047	6518398
	Control ⁺	Control	Baseline	3 Lake Innes	488228	6518390
	Control	New Control	Niche	COWARRA NC3 -SAT COW4	479674	6516436
	Control	New Control	Niche	SAT COW5	479704	6516174
	Control	New Control	Niche	SAT COW6	479667	6515913
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	1 Cairncross State Forest (South)	482428	6526536
	Impact	No Mitigation	Baseline	2 Cairncross State Forest (South)	482385	6526644
	Impact	No Mitigation	Baseline	3 Cairncross State Forest (South)	482393	6526416
	Impact	No Mitigation	Baseline	16 Cairncross State Forest (south)	481655	6527256
	Impact	No Mitigation	Baseline	17 Cairncross State Forest (south)	481590	6527316
	Impact	No Mitigation	Baseline	18 Cairncross State Forest (south)	481637	6527175
	Impact	Mitigation	Baseline	4 Cairncross State Forest (South)	482249	6525930
	Impact	Mitigation	Baseline	5 Cairncross State Forest (South)	482125	6526077
	Impact	Mitigation	Baseline	6 Cairncross State Forest (South)	482488	6526226
	Control	Control	Baseline	1 Limeburners Creek ""The Hatch""	487011	6529909
	Control	Control	Baseline	2 Limeburners Creek ""The Hatch""	487014	6529455
	Control	Control	Baseline	3 Limeburners Creek ""The Hatch""	487035	6528694
	Control	New Control	Niche	SAT PEVI1	476817	6528422
	Control	New Control	Niche	SAT PEVI2	476730	6528225
	Control	New Control	Niche	Cairncross NC1	475996	6528211
	Cairncross State Forest (north)	Impact	No Mitigation	Baseline_Niche relocation	7 Cairncross State Forest (North)	481346
Impact		No Mitigation	Baseline	8 Cairncross State Forest (North)	481695	6530786
Impact		No Mitigation	Baseline	9 Cairncross State Forest (North)	481184	6530864
Impact		Mitigation	Baseline	10 Cairncross State Forest (north)	481238	6530264

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
	Impact	Mitigation	Baseline	11 Cairncross State Forest (north)	481173	6530319
	Impact	Mitigation	Baseline	12Cairncross State Forest (north)	481438	6530335
	Control	Control	Baseline	13 Cairncross State Forest (Pembrooke)	473751	6528881
	Control	Control	Baseline	14 Cairncross State Forest (Pembrooke)	473464	6528969
	Control	Control	Baseline	15 Cairncross State Forest (Pembrooke)	473424	6529115
	Control	New Control	Niche	SAT RR1	475284	6532709
	Control	New Control	Niche	SAT RR2	475113	6532603
	Control	New Control	Niche	SAT RR3	474816	6532732
Cooperabung Hill	Impact ⁺	No Mitigation	Baseline	1 Cooperabung	482793	6537012
	Impact	No Mitigation	Baseline	2 Cooperabung	482755	6537093
	Impact	No Mitigation	Baseline	3 Cooperabung	482876	6537115
	Impact	Mitigation	Baseline_Niche relocation	4 Cooperabung	482481	6539327
	Impact	Mitigation	Baseline_Niche relocation	5 Cooperabung	482364	6539761
	Impact	Mitigation	Baseline	6 Cooperabung	482364	6538610
	Control	Control	Baseline	1 Cooperabung Hill (Gum Scrub)	475489	6541854
	Control	Control	Baseline	2 Cooperabung Hill (Gum Scrub)	475570	6541903
	Control	Control	Baseline	3 Cooperabung Hill (Gum Scrub)	475838	6541962
	Control	New Control	Niche	SAT FL1	473693	6542127
	Control [#]	New Control	Niche	SAT ST1	473346	6543256
	Control [#]	New Control	Niche	SAT ST2	473682	6542890
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	1 Mingaletta-Smiths Creek	483304	6543632
	Impact	Mitigation	Baseline	2 Mingaletta-Smiths Creek	483444	6543585
	Impact ⁺	Mitigation	Baseline	3 Mingaletta-Smiths Creek	483100	6543670
	Control	Control	Baseline	1 Ballengara State Forest (Gregs Road)	477750	6543274
	Control	Control	Baseline	2 Ballengara State Forest (Gregs Road)	477644	6543623
	Control	Control	Baseline	3 Ballengara State Forest (Gregs Road)	477551	6543709
	Control	New Control	Niche	SAT BR1	477010	6544693
	Control	New Control	Niche	SAT BR2	476890	6544832
	Control	New Control	Niche	SAT BR3	476777	6544973
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	1 Kundabung	483095	6549036
	Impact	No Mitigation	Baseline	2 Kundabung	482873	6549112
	Impact	No Mitigation	Baseline	3 Kundabung	483285	6549374
	Impact	Mitigation	Baseline	4 Kundabung	483369	6550655
	Impact	Mitigation	Baseline	5 Kundabung	483331	6550938
	Impact ⁺	Mitigation	Baseline	6 Kundabung	483083	6550608
	Control	Control	Baseline	1 Kumbatine National Park	476044	6549609
	Control	Control	Baseline	2 Kumbatine National Park	476165	6549738
	Control	Control	Baseline	3 Kumbatine National Park	475889	6549468
	Control	New Control	Niche	SAT MAC1	476538	6552784
	Control	New Control	Niche	SAT MAC2	476558	6552361

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
	Control	New Control	Niche	SAT MAC3	476481	6552612
Maria River State Forest	Impact	Part Mitigation	Baseline_Niche relocation	1 Maria River	483074	6554460
	Impact	Part Mitigation	Baseline	2 Maria River	482836	6554330
	Impact	Part Mitigation	Baseline_Niche relocation	3 Maria River	482993	6554024
	Impact	Mitigation	Baseline	4 Maria River	482886	6552623
	Impact	Mitigation	Baseline	5 Maria River	482754	6552462
	Impact	Mitigation	Baseline	6 Maria River	483135	6552449
	Control	Control	Baseline	1 Maria River National Park	486965	6554366
	Control	Control	Baseline	2 Maria River National Park	486971	6554479
	Control	Control	Baseline	3 Maria River National Park	487004	6554203
	Control	New Control	Niche	SAT CO1	486292	6552230
	Control	New Control	Niche	SAT CO3	486811	6552227
	Control	New Control	Niche	SAT MAR 1	486811	6552454

* not surveyed since baseline due to private landowner access restrictions; # not surveyed in 2022 due to track restrictions; + not surveyed in 2022 due to inability to contact landholder.

2.1.2 SAT Methodology

Surveys were undertaken following the SAT methodology (Phillips and Callaghan 2011) in accordance with the EMP monitoring procedure for Koala population monitoring. The SAT method involves a radial assessment of Koala activity within the immediate area surrounding a tree that is known to have been used by the species or is considered to be of importance to the species. The following describes the application of this technique:

1. Locate and mark a tree that is:
 - a) A tree of any species beneath which one or more Koala faecal pellets have been observed; and/or
 - b) A tree in which a Koala has been observed; and/or
 - c) Any other tree known or considered to be important for Koalas or of interest for other assessment purposes.
2. Identify and mark the 29 nearest trees to the tree marked initially.
3. Undertake a search for Koala faecal pellets beneath each of the 30 marked trees. Visually inspect the ground surface beneath trees to a distance of one metre from the trunk. If no pellets are observed, rake the leaf litter within the prescribed search area. Two person minutes per tree should be dedicated to the search for faecal pellets. The search should be ended once a single pellet is found or the search time has expired (whichever happens first). Faecal pellets should not be removed from the site unless verification is necessary.
4. Calculate the activity level of a site as the percentage of surveyed trees within the site (of 30 trees) that have a Koala faecal pellet recorded within its search area. The result is used to assess whether the site supports “Low”, “Medium (normal)” or “High” Koala activity.
5. Record the presence (or absence) of scats, along with a number of other attributes including the species of the tree under which the scat was located.

The selection criteria trees (SCTs) of each plot were marked (tagged) and have been used as the centre tree for the radial searches during each survey event.

2.1.3 Analysis

General SAT plot presence and activity results are presented for plot, cluster and area. More detailed analyses of impact vs. control sites and mitigation vs. no mitigation sites were undertaken using cluster presence/absence results. Plots within the same cluster are not independent from each other and therefore cannot be used for most statistical analyses. Between year activity levels were compared using mean plot activity results.

Based on the methods used to collect the data and the location of the plots, it was determined that a Chi-square test was the most suitable statistical test to assess differences in Koala presence between areas, treatments and years. This test compares the proportion of plots with and without Koala scats and so is suitable for presence/absence data. The Chi-square test also allows for analysis of data where sample sizes between categories may differ, as is the case here where there are an unequal number of impact and control sites.

2.2 Additional Surveys

Additional survey methods were adopted in 2019 as a result of the revision and adoption of an updated EMP (TfNSW 2022).

2.2.1 Spotlighting

Spotlighting surveys were undertaken as per baseline surveys at six sites across three locations: Cairncross State Forest, Ballengarra State Forest and Maria River National Park (Figure 1). Spotlighting locations have been set up in a paired Before After Control Impact (BACI) configuration comprising an impact site and a control site which exhibit similar vegetation/habitat type and landscape features. Field surveys involved a 10 minute listening period on arrival at site, followed by spotlighting performed by two observers using handheld variable beam ~100 watt spotlights whilst walking a 500 m transect over 30 minutes. These surveys are to be repeated on three separate occasions at least seven days apart.

2.2.2 NSW BioNet Wildlife Atlas

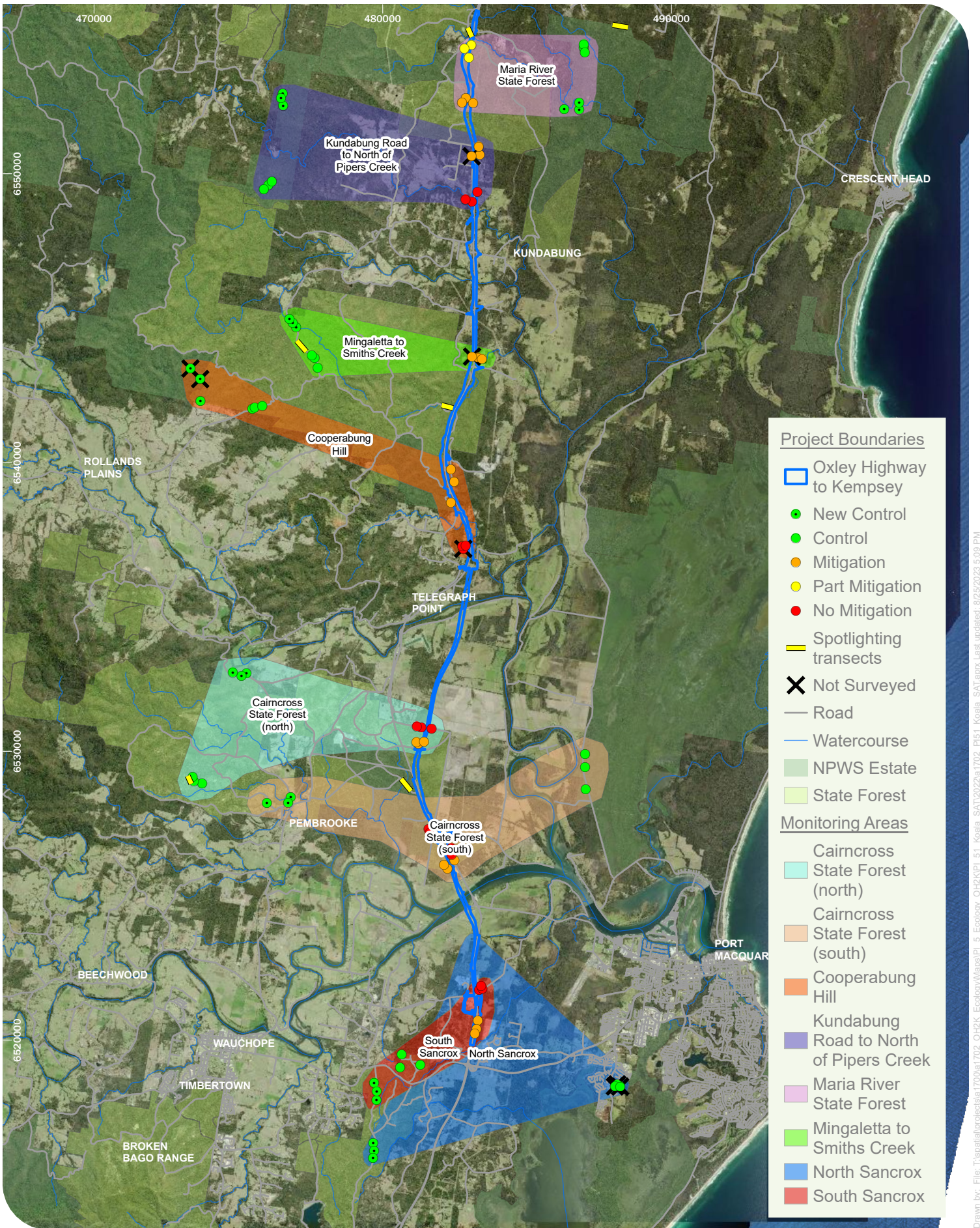
NSW BioNet wildlife Atlas records will be used to compare Koala distribution and density. A comparison of pre-construction records (i.e. 2004 - 2013 inclusive) to post-construction records at Year 8 (i.e. 2014 – 2022 inclusive) was undertaken, as per baseline methods.

Koala distribution: Koala distribution was measured using BioNet Wildlife Atlas records within 10 km of the study area so as to provide a comparison with the baseline monitoring distribution data. The Atlas data was divided into the following two chronological time scales:

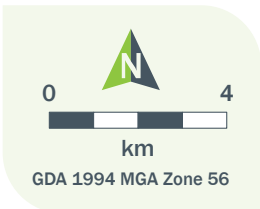
- Pre-construction: 2004-2013 inclusive
- Post-construction: 2014-2022 inclusive

Differences in Koala records between 2004-2013, and 2014-2022 were discussed with reference to obviously clustering of records as focal points for Koala populations.

Koala density: Koala density was measured using historic records from the BioNet Wildlife Atlas to describe reporting rates using a standardised 5 km² across the study area. The number of records within each grid was calculated for two time periods; pre-construction (2004-2013) as a baseline for comparison, and post-construction (2014-2022).



Drawn by: File: T:\spatial\project\1700\1702_0\H2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_51_Koala_SAT\2022\1702_Pi51_Koala_SAT.aprx Last updated: 8/25/2023 5:09 PM



SAT plot and spotlighting transect locations
 Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz
 Niche Proj. #: 1702 PI5.1
 Client: Roads and Maritime Services

Figure 1

3. Results

3.1 SAT Plots

Surveys were undertaken between 9 December 2022 and 28 February 2023. Field data for each SAT plot is presented in Annex 1. The DBH (diameter at breast height) is provided for the SCT.

A total of 85 accessible SAT plots were surveyed across the eight monitoring areas (Figure 1).

3.1.1 Presence/absence

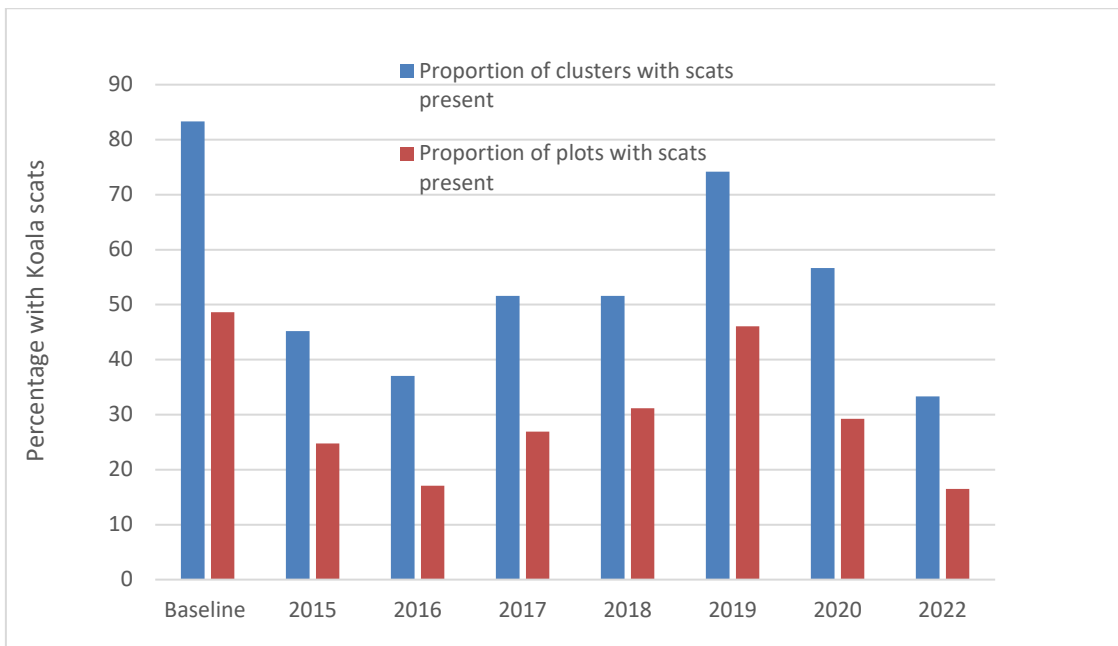
SAT plots

Table 2 provides a summary of presence/absence results for plots and clusters at each monitoring event. Graph 1 shows the percentage of plots and clusters with scats present for each monitoring period to date and Graph 2 shows the percentage of clusters within each area with scats present, for each monitoring period to date. Table 3 provides a detailed comparison of the activity level for each plot and presence/absence results of each cluster for each monitoring period to date and Figure 2 shows the SAT cluster presence/absence results for the 2022 monitoring (map reference ID for each cluster is listed in Table 3).

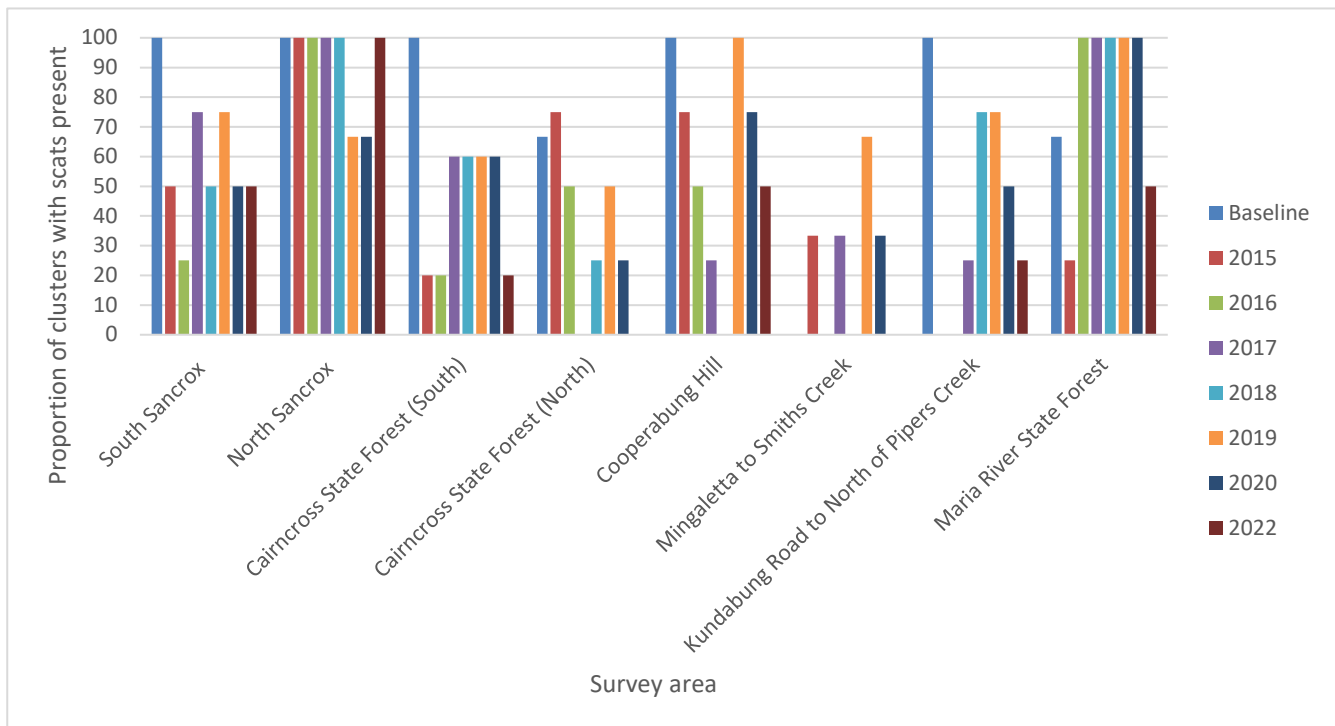
Of the 85 surveyed plots, Koala scats were recorded at 16.5% (14 of 85) of the individual plots. This is lower than previous surveys 2015, 2016, 2017, 2018, 2019 and 2020 surveys (25%, 17%, 27%, 31%, 46% and 29% respectively). This is also lower than the 49% recorded during baseline surveys. When grouped according to cluster, Koala scats were recorded at 33% of clusters (10 of 30). This is lower than baseline, 2015, 2016, 2017, 2018, 2019 and 2020 surveys (83%, 45%, 37%, 52%, 52%, 74% and 57% respectively).

Table 2: Presence/absence results

	Baseline	2015	2016	2017	2018	2019	2020	2022
Number of plots with scats present (n = plots surveyed)	35 (49%, n = 72)	23 (25%, n = 93)	14 (17%, n = 82)	25 (27%, n = 93)	29 (31%, n = 93)	41 (46%, n = 89)	26 (29%, n = 89)	14 (16.5%, n = 85)
Number of clusters with scats present (n = clusters surveyed)	20 (83%, n = 24)	14 (45%, n = 31)	10 (37%, n = 27)	16 (52%, n = 31)	16 (52%, n = 31)	23 (74%, n = 31)	17 (57%, n = 30)	10 (33%, n = 30)



Graph 1: Percentage of plots and clusters with scats present for each monitoring event to date



Graph 2: Koala presence in areas across all monitoring events

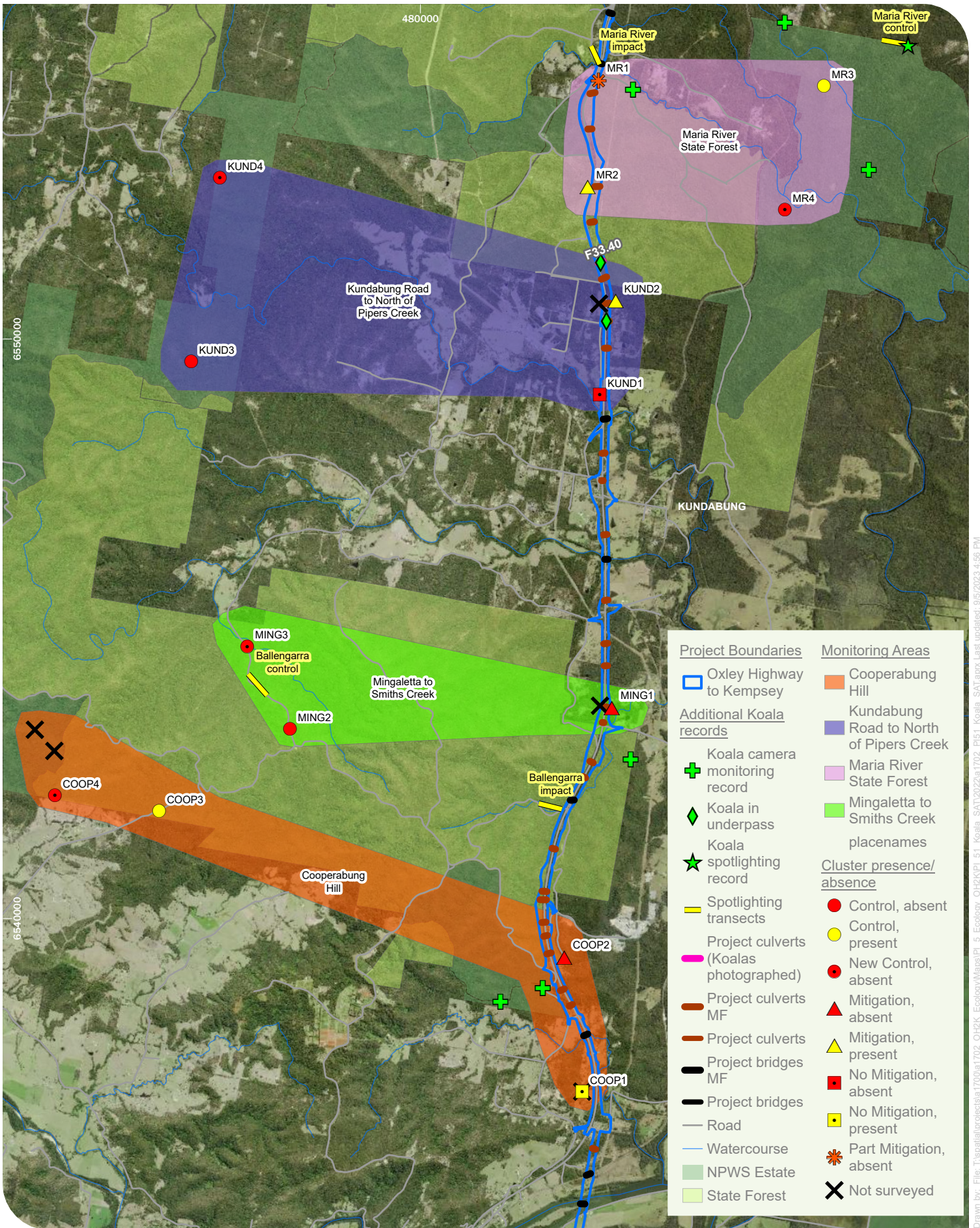
Table 3: SAT plot results baseline – 2022

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)								
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022	
South Sancrox	No Mitigation	Baseline	SANCROX E1	SSAN1	10.0	3.3	0.0	23.3	6.7	3.3	3.3	0.0	present	present	absent	present	present	present	present	absent	
			SANCROX E2		0.0	0.0	0.0	0.0	0.0	fire	0.0	0.0									
			SANCROX E3		0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0									
	Mitigation	Baseline_Niche relocation	SANCROX S1	SSAN2	13.3	0.0	0.0	3.3	0.0	fire	3.3	0.0	present	absent	absent	present	present	present	present	present	present
			SANCROX S2		3.3	0.0	0.0	0.0	6.7	fire	0.0	10.0									
			SANCROX S3		10.0	0.0	0.0	0.0	3.3	3.3	0.0	0.0									
	Control	Baseline	COWARRA SF1	SSAN3	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	present	absent	present	absent	absent	present	absent	absent	absent
			COWARRA SF2		3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
			COWARRA SF3		10.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0									
New Control	Niche	SAT COWARRA NC1	SSAN4	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	Not monitored	present	absent	present	absent	absent	absent	absent	present
		SAT COWARRA NC2		-	3.3	0.0	6.7	0.0	0.0	0.0	0.0										
		SAT COWARRA NC3		-	0.0	0.0	3.3	0.0	0.0	0.0	0.0										
North Sancrox	No Mitigation	Baseline	SANCROX N1	-	3.3	-	-	-	-	-	-	-	present	No access	No access	No access	No access	No access	No access	No access	
			SANCROX N2		0.0	-	-	-	-	-	-	-									
			SANCROX N3		0.0	-	-	-	-	-	-	-									
	Mitigation	Baseline	FERNBANK CK1	NSAN1	33.3	0.0	3.3	16.7	3.3	0.0	10.0	10.0	present	present	present	present	present	absent	present	present	
			FERNBANK CK2		30.0	0.0	6.7	6.7	0.0	0.0	0.0	10.0									
			FERNBANK CK3		23.3	6.7	3.3	13.3	6.7	0.0	3.3	0.0									
	Control	Baseline	LAKE INNES1	NSAN2	26.7	13.3	0.0	3.3	6.7	3.3	3.3	-	present	present	present	present	present	present	present	present	No access
			LAKE INNES2		13.3	6.7	3.3	6.7	3.3	0.0	3.3	-									
			LAKE INNES3		3.3	6.7	0.0	0.0	3.3	10.0	10.0	-									
New Control	Niche	SAT COW4	NSAN3	-	10.0	0.0	3.3	3.3	0.0	0.0	0.0	Not monitored	present	present	present	present	present	absent	absent	present	
		SAT COW5		-	0.0	0.0	0.0	0.0	3.3	0.0	0.0										
		SAT COW6		-	0.0	3.3	0.0	10.0	0.0	0.0	3.3										
		Baseline	CAINCROSS SF1	CCS1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	present	present	absent	absent	absent	present	present	absent	

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)									
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022		
Cairncross State Forest (South)	No Mitigation		CAINCROSS SF2		3.3	6.7	0.0	0.0	0.0	3.3	0.0	0.0										
			CAINCROSS SF3		0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.3	0.0									
	No Mitigation	Baseline		CAINCROSS SF16	CCS2	0.0	0.0	3.3	3.3	0.0	0.0	0.0	0.0	present	absent	present	present	present	absent	absent	absent	
				CAINCROSS SF17		0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0									
				CAINCROSS SF18		13.3	0.0	0.0	6.7	3.3	0.0	0.0	0.0									
	Mitigation	Baseline		CAINCROSS SF4	CCS3	3.3	0.0	0.0	3.3	6.7	13.3	3.3	3.3	present	absent	absent	present	present	present	present	present	
				CAINCROSS SF5		3.3	0.0	0.0	0.0	0.0	13.3	0.0	0.0									
				CAINCROSS SF6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
	Control	Baseline		LIMEBURNERS CK1	CCS4	0.0	0.0	0.0	3.3	0.0	0.0	-	0.0	present	absent	absent	present	absent	absent	absent	absent	
				LIMEBURNERS CK2		3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
			LIMEBURNERS CK3		0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0										
New Control	Niche		SAT PEVI1	CCS5	-	0.0	0.0	0.0	6.7	3.3	0.0	0.0	Not monitored	absent	absent	absent	present	present	present	absent		
			SAT PEVI2		-	0.0	0.0	0.0	3.3	0.0	3.3	0.0										
			SAT PEVI3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0										
Cairncross State Forest (north)	No Mitigation	Baseline_Niche relocation	CAINCROSS SF7	CCN1	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	absent	present	absent	absent	absent	present	absent	absent		
		Baseline	CAINCROSS SF8		0.0	20.0	0.0	0.0	0.0	3.3	0.0	0.0										
		Baseline	CAINCROSS SF9		0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0										
	Mitigation	Baseline		CAINCROSS SF10	CCN2	3.3	0.0	0.0	0.0	3.3	6.7	3.3	0.0	present	present	present	absent	present	present	present	absent	
				CAINCROSS SF11		3.3	0.0	3.3	0.0	0.0	0.0	0.0	0.0									
				CAINCROSS SF12		6.7	3.3	0.0	0.0	0.0	3.3	0.0	0.0									
	Control	Baseline		CAINCROSS SF13	CCN3	6.7	3.3	3.3	0.0	0.0	0.0	0.0	0.0	present	present	present	absent	absent	absent	absent	absent	
				CAINCROSS SF14		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
				CAINCROSS SF15		0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0									
	New Control	Niche		SAT RR1	CCN4	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent	absent	absent	absent	
			SAT RR2		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0										
			SAT RR3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0										

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)									
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022		
Cooperabung Hill	No Mitigation	Baseline	COOPERABUNG1	COOP1	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	-	present	present	present	absent	absent	present	present	present	
			COOPERABUNG2		0.0	23.3	3.3	0.0	0.0	3.3	0.0	0.0										
			COOPERABUNG3		10.0	0.0	0.0	0.0	0.0	10.0	10.0	3.3										
	Mitigation	Baseline_Niche relocation	COOPERABUNG4	COOP2	0.0	3.3	6.7	0.0	0.0	10.0	6.7	0.0	present	present	present	present	absent	present	present	absent		
			COOPERABUNG5		3.3	3.3	0.0	10.0	0.0	6.7	3.3	0.0										
			COOPERABUNG6		0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0										
	Control	Baseline	COOP HILL1	COOP3	6.7	0.0	0.0	0.0	0.0	3.3	0.0	0.0	present	absent	absent	absent	absent	present	present	present		
			COOP HILL2		0.0	0.0	0.0	0.0	0.0	6.7	3.3	3.3										
			COOP HILL3		0.0	0.0	0.0	0.0	0.0	10.0	13.3	3.3										
New Control	Niche	SAT FL1	COOP4	-	16.7	0.0	0.0	0.0	logged	0.0	0.0	Not monitored	present	absent	absent	absent	present	absent	absent			
		SAT ST1		-	0.0	0.0	0.0	0.0	10.0	0.0	-											
		SAT ST2		-	20.0	0.0	0.0	0.0	3.3	0.0	-											
Mingalett a to Smiths Creek	Mitigation	Baseline	MIN-SMITHS CK1	MING1	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	absent	absent	absent	absent	absent	present	present	absent		
			MIN-SMITHS CK2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0										
			MIN-SMITHS CK3		0.0	0.0	0.0	0.0	0.0	6.7	0.0	-										
	Control	Baseline	BALLENGARA SF1	MING2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	absent	absent	absent	absent	absent	present	absent	absent	
			BALLENGARA SF2		0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0										
			BALLENGARA SF3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0										
	New Control	Niche	SAT BR1	MING3	-	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Not monitored	present	absent	present	absent	absent	absent	absent	
			SAT BR2		-	0.0	0.0	3.3	0.0	0.0	0.0	0.0										
			SAT BR3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0										
Kundabung Road to North of Pipers Creek	No Mitigation	Baseline	KUNDABUNG 1	KUND1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	present	absent	absent	absent	present	present	present	absent		
			KUNDABUNG 2		10.0	0.0	0.0	0.0	6.7	3.3	3.3	0.0										
			KUNDABUNG 3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0										
	Baseline	KUNDABUNG 4	KUND2	33.3	0.0	fire	0.0	13.3	10.0	0.0	16.7	present	absent	Fire	present	present	present	present	present			

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)										
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022			
	Mitigation		KUNDABUNG 5		13.3	0.0	fire	3.3	16.7	13.3	6.7	3.3			Fire								
			KUNDABUNG 6		10.0	0.0	0.0	0.0	0.0	0.0	0.0	-			absent								
	Control	Baseline	KUMBATINE NP1	KUND3	3.3	0.0	0.0	0.0	0.0	3.3	0.0	0.0	present	absent	absent	absent	present	present	absent	absent			
					KUMBATINE NP2	0.0	0.0	0.0	0.0	0.0	0.0	0.0											
					KUMBATINE NP3	0.0	0.0	0.0	0.0	3.3	6.7	0.0										0.0	
	New Control	Niche	SAT MAC1	KUND4	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent	absent	absent	absent	absent	absent	
					SAT MAC2	-	0.0	0.0	0.0	0.0	0.0	0.0											
					SAT MAC3	-	0.0	0.0	0.0	0.0	0.0	0.0											
	Maria River State Forest	Part Mitigation	Baseline_Niche relocation	MARIA RIVER 1	MR1	0.0	0.0	fire	0.0	6.7	3.3	3.3	0.0	present	absent	No access - fire	present	present	present	present	present	absent	
Baseline			MARIA RIVER 2	3.3		0.0	fire	0.0	0.0	23.3	6.7	0.0											
Baseline_Niche relocation			MARIA RIVER 3	6.7		0.0	fire	16.7	13.3	10.0	0.0	0.0											
Mitigation		Baseline	MARIA RIVER 4	MR2	0.0	0.0	fire	6.7	6.7	10.0	6.7	0.0	absent	present	No access - fire	present	present	present	present	present	present	present	
					MARIA RIVER 5	0.0	0.0	fire	0.0	0.0	3.3	6.7											3.3
					MARIA RIVER 6	0.0	3.3	fire	0.0	3.3	0.0	0.0											0.0
Control		Baseline	MARIA NP1	MR3	0.0	0.0	0.0	3.3	20.0	10.0	10.0	0.0	present	absent	present	present	present	present	present	present	present	present	
					MARIA NP2	10.0	0.0	3.3	0.0	10.0	10.0	33.3											3.3
					MARIA NP3	10.0	0.0	3.3	3.3	36.7	13.3	3.3											16.7
New Control		Niche	SAT CO1	MR4	-	0.0	fire	6.7	10.0	13.3	-	0.0	Not monitored	absent	No access - fire	present	present	present	No access – roads blocked	absent	absent		
					SAT CO3	-	0.0	fire	3.3	0.0	3.3	-										0.0	
					SAT MAR 1	-	0.0	fire	6.7	3.3	6.7	-										0.0	



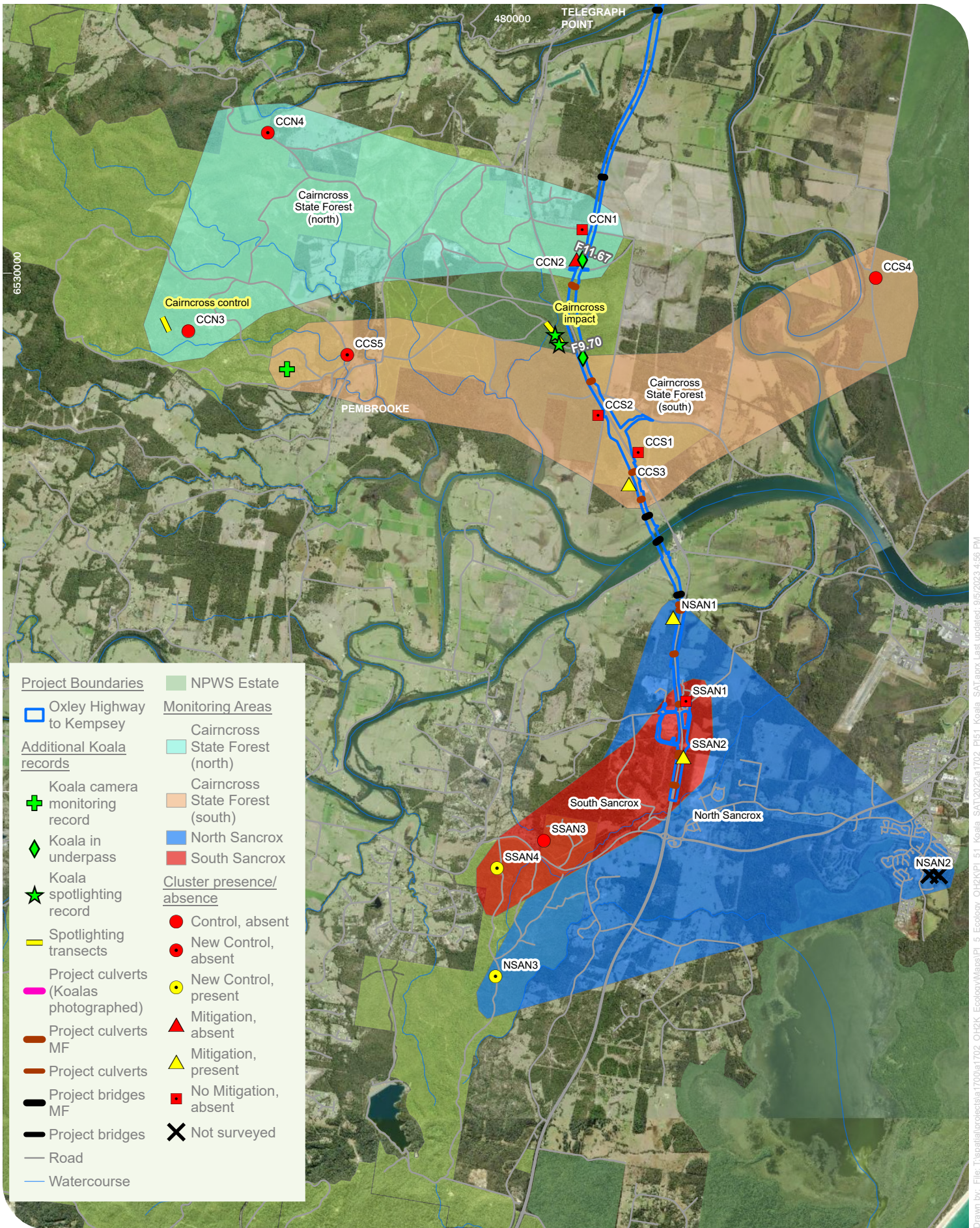
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SAT cluster results and Koala records 2022 - North
Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz
 Niche Proj. #: 1702 P15.1
 Client: Roads and Maritime Services

Figure 2a



3.1.2 Activity levels

Individual plot activity levels are provided above in Table 3. A summary of the SAT activity level for plots, clusters and areas in all monitoring events is provided in Table 4 and Table 5.

Plot and cluster activity

The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 1.1% (standard deviation (SD) of 3.2) and ranged from 0 to 16.7%. This is similar to the mean activity recorded for plots during 2015, 2016, 2017 and 2020 surveys (2.0%, 0.7%, 1.8% and 1.9% respectively), but lower than the mean activity recorded during baseline surveys (4.9%), 2018 surveys (2.5%) and 2019 surveys (3.3%).

Considering the activity level within active plots only, i.e. plots where scats were found to be present, the average activity level was 6.7% (SD 5.1), which is higher than or similar to the mean activity recorded for active plots during 2016, 2017 and 2020 (4.0%, 6.8% and 6.5% respectively), but lower than the mean activity recorded for active plots during baseline surveys (10.1%) and 2015, 2018 and 2019 (8.0%, 8.0% and 7.2% respectively).

The EMP requires interpretation of site activity levels to assess areas as supporting low, medium or high Koala activity. Phillips and Callaghan (2011) used NSW BioNet Atlas data to calculate activity levels of sites where Koala scats were recorded. These data were then used to define categories of habitat use in populations of varying densities. The Port Macquarie-Hastings and Kempsey LGAs support a significant Koala population, including a concentrated population in the coastal areas, east of the Pacific Highway and south of Hastings River, as well as pockets of higher density/activity in surrounding areas, including Maria River National Park (BioLink 2013, PMHC 2017). While Phillips and Callaghan (2011) use an arbitrary definition of population densities (low = ≤ 0.1 Koala/hectare), the study area naturally consists of areas of varying densities. Discussions with Port Macquarie-Hastings Council confirmed that population density varies throughout the region and therefore one general population density cannot be attributed to all sites. In addition, as site specific density data is not available for all sites, it is not possible to designate the sites as being low or high density populations according to Phillips and Callaghan. However, in compliance with the EMP, if we consider the habitat use category of Phillips and Callaghan (2011) for low density populations on the east coast, as per the baseline studies (Lewis 2014), using activity levels of SAT plots where scats were recorded, average SAT plot activity has consistency fallen into to the “medium (normal)” use category (3.3% - 12.6%) for populations in an east coast, low density area.

Table 4: Summary of SAT activity results

Average activity	Baseline	2015	2016	2017	2018	2019	2020	2022
Average activity per plot (n = plots surveyed)	4.9% (SD8.0, n = 72)	2.0% (SD4.6, n = 93)	0.7% (SD1.6, n = 82)	1.8% (SD4.1, n = 93)	2.5% (SD5.4, n = 93)	3.3% (SD4.7, n = 89)	1.9% (SD3.1, n = 89)	1.1% (SD3.2, n = 85)
Average activity per active plot (n = plots with activity)	10.1% (SD9.0, n = 35)	8.0% (SD6.3, n = 23)	4.0% (SD1.4, n = 14)	6.8% (SD5.3, n = 25)	8.0% (SD7.0, n = 29)	7.2% (SD5.8, n = 41)	6.5% (SD2.6, n = 26)	6.7% (SD5.1, n = 14)
Average activity per cluster (n = plots surveyed)	4.9% (SD6.9, n = 24)	2.0% (SD3.5, n = 31)	0.7% (SD1.1, n = 27)	1.8% (SD2.8, n = 31)	2.5% (SD4.5, n = 31)	3.3% (SD3.5, n = 31)	1.9% (SD3.1, n = 30)	1.2% (SD2.4, n = 30)
Average activity per active cluster (n = active clusters)	5.9% (SD7.1, n = 20)	4.4% (SD4.0, n = 14)	1.9% (SD1.1, n = 10)	3.5% (SD3.0, n = 16)	4.9% (SD5.5, n = 16)	4.5% (SD4.2, n = 23)	3.3% (SD4.0, n = 17)	3.5% (SD3.2, n = 10)
Average activity per area (n = 8)	4.8% (SD4.7)	2.1% (SD2.3)	0.9% (SD0.9)	1.9% (SD2.0)	2.6% (SD3.1)	3.4% (SD2.7)	2.1% (SD2.6)	1.3% (SD1.3)

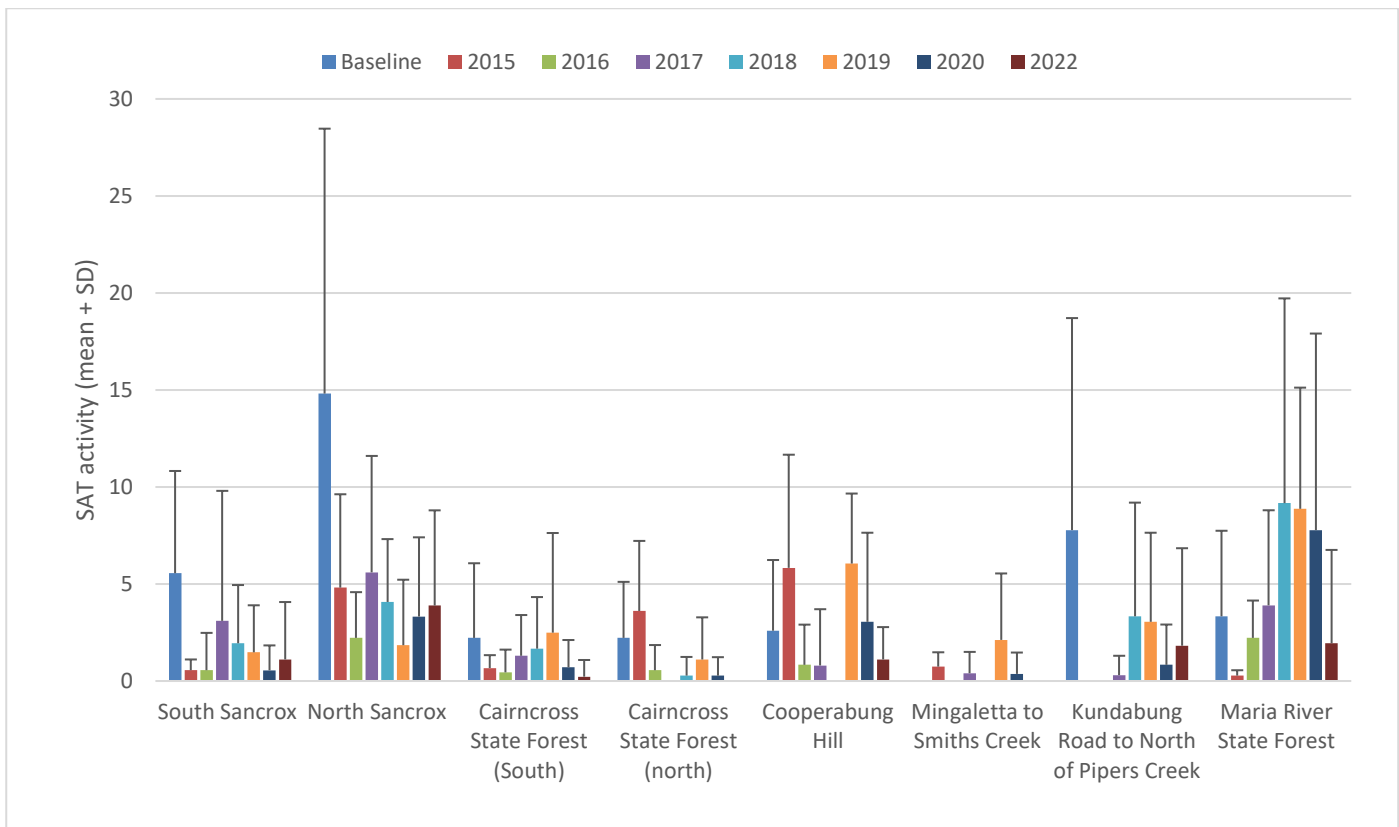
Area activity

Table 5 and Graph 3 show Koala activity at each of the eight monitoring areas. Area activity is the mean activity of all surveyed plots within the area. As for the 2018 and 2019 monitoring, SAT plot activity was highest at North Sancrox (3.9%), where scats were recorded at both of the two monitored clusters (two clusters were not monitored due to blocked access) and at three of the six SAT plots monitored.

To date, activity levels appear to fluctuate across the years within each monitoring area and a definitive increasing or decreasing activity trend within any one area is not apparent. Koala activity was recorded within six of the eight areas during the 2022 monitoring.

Table 5: Area activity levels

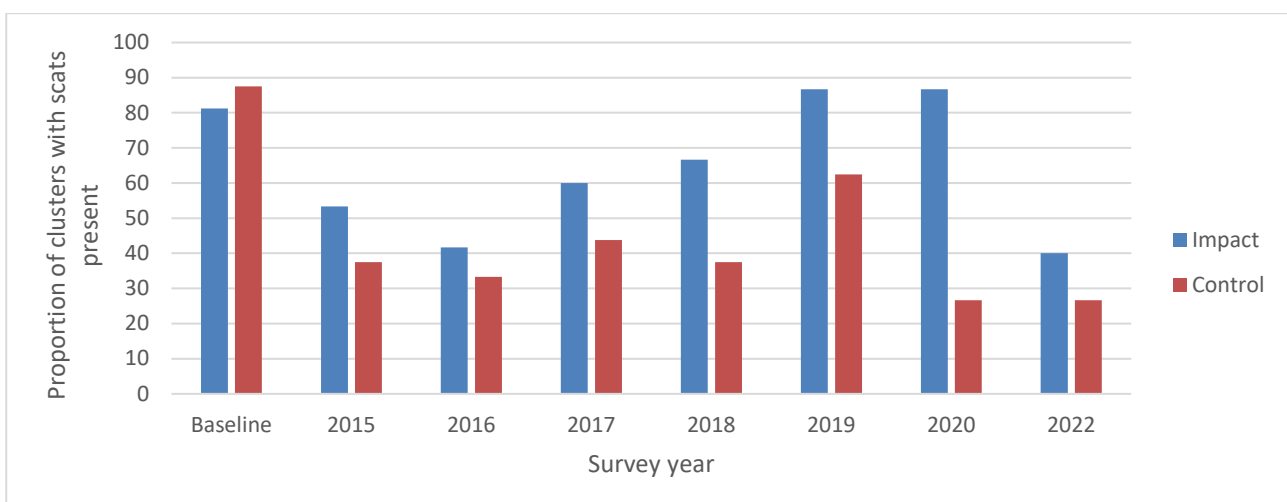
Monitoring area	Baseline	2015	2016	2017	2018	2019	2020	2022
South Sancrox	5.6% (SD5.3)	0.6% (SD1.3)	0.6% (SD1.9)	3.1% (SD6.7)	1.9% (SD3.0)	1.5% (SD2.4)	0.6% (SD1.3)	1.1% (SD3.0)
North Sancrox	14.8 (SD13.7)	4.8% (SD5.0)	2.2% (SD2.4)	5.6% (SD6.0)	4.1% (SD3.2)	1.8% (SD3.4)	3.3% (SD4.1)	3.9% (SD4.9)
Cairncross State Forest (South)	2.2% (SD3.8)	0.7% (SD1.9)	0.4% (SD1.2)	1.3% (SD2.1)	1.7% (SD2.7)	2.5% (SD5.1)	0.7% (SD1.4)	0.2% (SD0.9)
Cairncross State Forest (North)	2.2% (SD2.9)	3.6% (SD5.9)	0.6% (SD1.3)	0	0.3% (SD1.0)	1.1% (SD2.2)	0.3% (SD1.0)	0
Cooperabung Hill	2.6% (SD3.6)	5.8% (SD8.8)	0.8% (SD2.1)	0.8% (SD2.9)	0	6.1% (SD3.6)	3.1% (SD1.6)	1.1% (SD1.7)
Mingaletta to Smiths Creek	0	0.7% (SD2.2)	0	0.4% (SD1.1)	0	2.1% (3.4)	0.4% (SD1.1)	0
Kundabung Road to North of Pipers Creek	7.8% (SD10.9)	0	0	0.3% (SD1.0)	3.3% (SD5.9)	3.1% (SD4.6)	0.8% (SD2.1)	1.8% (SD5.0)
Maria River State Forest	3.3% (SD4.4)	0.3% (SD1.0)	2.2% (SD1.9)	3.9% (SD4.9)	9.2% (SD10.6)	8.9% (SD6.2)	7.8% (SD10.1)	1.9% (SD4.8)



Graph 3: Koala activity across the eight monitoring areas

3.2 Impact v Control Cluster Presence/Absence Analysis

A higher percentage of impact clusters had scats present than did control clusters during the 2022 monitoring period (40% cf 27%). This result is the same as that of the previous monitoring years (Graph 4). If we compare the Koala presence/absence results between control and impact clusters there is **no significant difference in Koala presence at impact and control clusters between the 2022 surveys and baseline, 2015, 2016, 2017, 2018, 2019 or 2020 surveys** ($\chi^2 = 0.112$, $df = 1$, $p > 0.05$; $\chi^2 = 0.854$, $df = 1$, $p > 0.003$; $\chi^2 = 0.656$, $df = 1$, $p > 0.05$; $\chi^2 = 0.795$, $df = 1$, $p > 0.05$; $\chi^2 = 0.588$, $df = 1$, $p > 0.05$; $\chi^2 = 0.814$, $df = 1$, $p > 0.05$; and $\chi^2 = 0.018$, $df = 1$, $p > 0.05$ respectively).

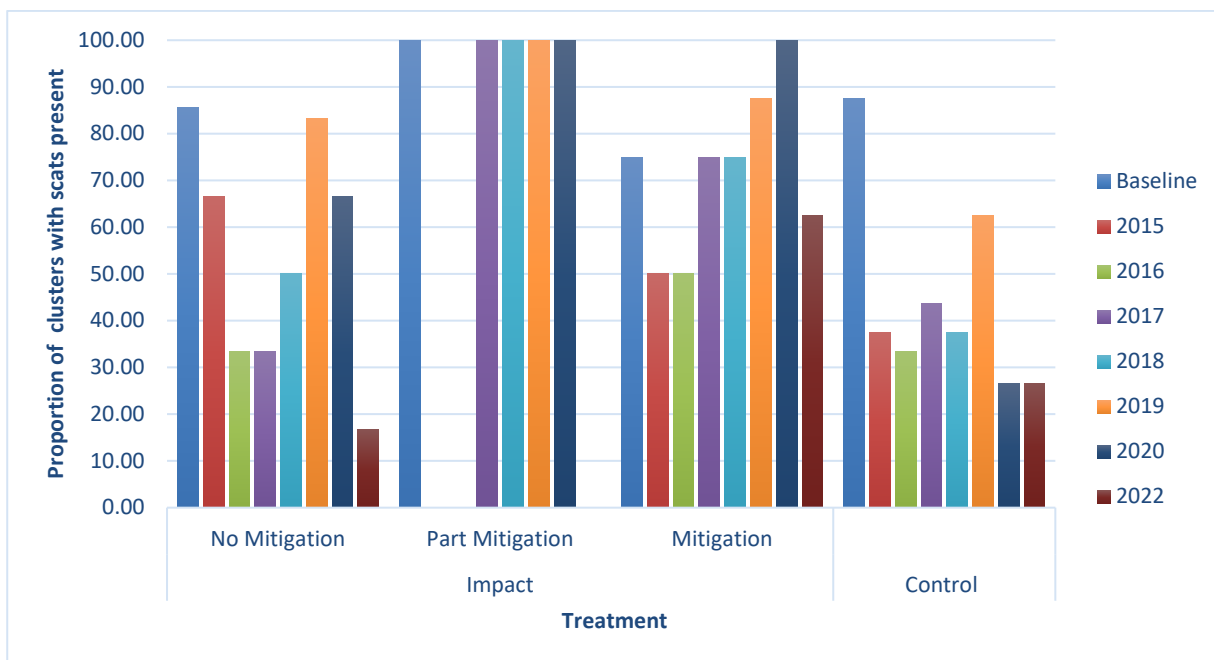


Graph 4: Koala presence at control and impact clusters

3.3 Mitigation v No Mitigation Analysis

3.3.1 Presence/absence analysis

Comparing Koala presence between mitigation and no-mitigation clusters shows **no significant difference between the 2022 surveys and baseline, 2015, 2016, 2017, 2018, 2019 or 2020 surveys** ($\chi^2 = 0.082$, $df = 1$, $p > 0.05$; $\chi^2 = 0.035$, $df = 1$, $p > 0.05$; $\chi^2 = 0.902$, $df = 1$, $p > 0.05$; $\chi^2 = 0.336$, $df = 1$, $p > 0.05$; $\chi^2 = 0.874$, $df = 1$, $p > 0.05$; $\chi^2 = 0.215$, $df = 1$, $p > 0.05$; and $\chi^2 = 0.858$, $df = 1$, $p > 0.05$, respectively). Graph 5 shows the percentage of clusters with scats present within different cluster types. There is no overall apparent trend between impact clusters with mitigation or without mitigation. While mitigation clusters appear to have a higher presence percentage in 2016, 2017, 2018, 2019, 2020 and 2022 than clusters with no mitigation, the presence percentage at clusters with no mitigation is similar to or greater than the presence percentage at control clusters during these years. This suggests that any difference is likely site specific and not necessarily related to construction activities.



Graph 5: Koala presence and cluster type

3.3.2 Treatment activity analysis

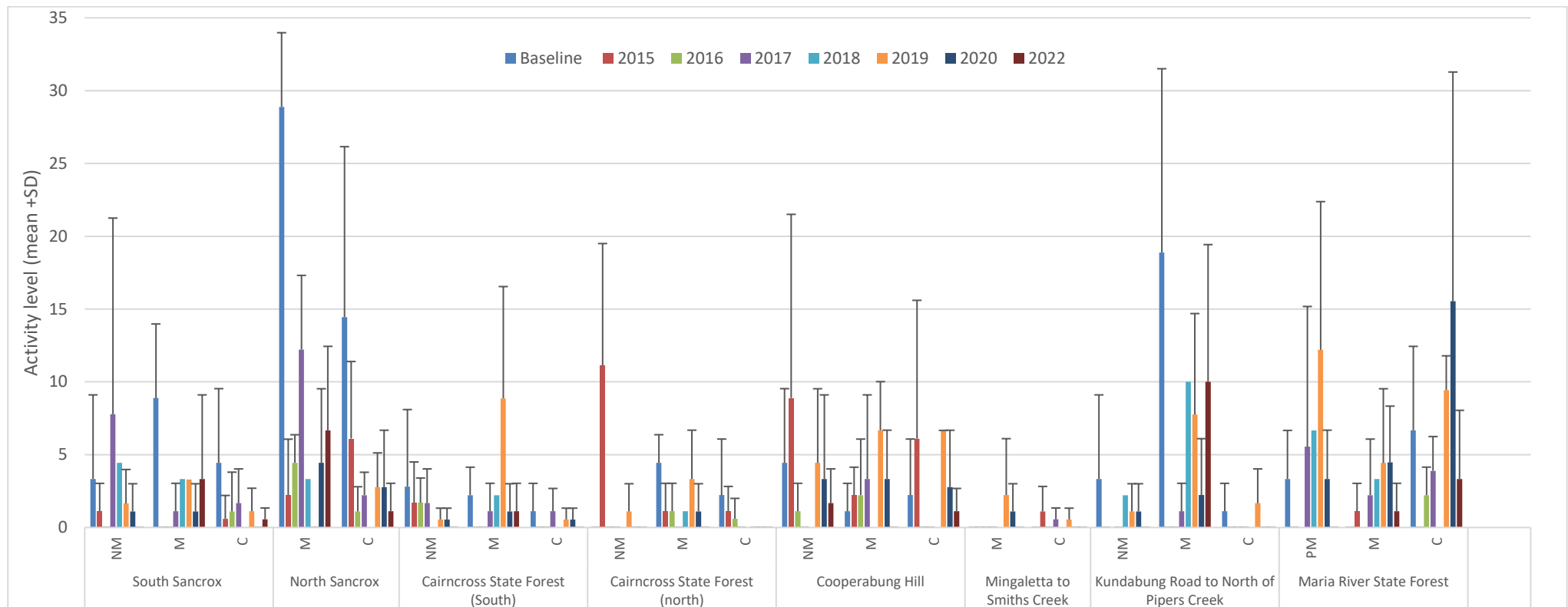
Koala activity (mean activity of plots) for the treatment types is provided in Table 6 and is shown for each area in Graph 6 (mean activity of all plots within each cluster type for each area). When considering all plots or active plots only (with scats present), average activity levels were lower than baseline levels for all treatment types. The 2022 monitoring plot activity levels were highest in clusters with mitigation and lowest in clusters with no mitigation. Lewis 2014 recommends that analyses should: *“Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:*

- *Broader study area set at 5% activity;*
- *The three treatment classes of Mitigation set at 8.05%, control reference set at 4.03% and no mitigation set at 2.64%.”*

When considering all plots or active plots only, activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level. Nor is there a greater than 10% difference between treatment types.

Table 6: Control, mitigation and no mitigation mean plot activity levels (%)

	Control								Mitigation								No Mitigation							
	Base	2015	2016	2017	2018	2019	2020	2022	Base	2015	2016	2017	2018	2019	2020	2022	Base	2015	2016	2017	2018	2019	2020	2022
All plots (n = plots surveyed)	4.0 (24) (SD6.4)	1.9 (38) (SD4.5)	0.5 (45) (SD1.4)	1.2 (48) (SD2.1)	2.5 (48) (SD6.4)	2.8 (47) (SD4.1)	1.9 (44) (SD5.7)	0.8 (43) (SD2.7)	8.1 (24) (SD11.0)	0.8 (24) (SD1.8)	1.2 (19) (SD2.3)	2.6 (24) (SD4.7)	2.9 (24) (SD4.5)	4.7 (22) (SD5.0)	2.4 (24) (SD3.0)	2.6 (22) (SD4.7)	2.6 (24) (SD4.2)	3.5 (21) (SD6.6)	0.6 (18) (SD1.3)	2.4 (21) (SD6.2)	2.1 (21) (SD3.7)	3.2 (20) (SD5.7)	1.4 (21) (SD2.7)	0.2 (20) (SD0.7)
Active plots (n = active plots)	8.8 (11) (SD6.9)	9.0 (10) (SD5.9)	3.9 (6) (SD1.4)	4.4 (13) (SD1.6)	9.2 (13) (SD9.5)	6.8 (19) (SD3.6)	9.2 (9) (SD9.8)	5.6 (6) (SD5.4)	12.9 (15) (SD11.5)	4.0 (5) (SD1.5)	4.7 (5) (SD1.8)	7.9 (8) (SD5.0)	7.0 (10) (SD4.6)	7.9 (13) (SD4.0)	5.1 (11) (SD2.3)	8.1 (7) (SD5.0)	7.0 (9) (SD3.9)	9.2 (8) (SD8.1)	3.3 (3) (SD0.0)	12.5 (4) (SD9.2)	7.2 (6) (SD3.3)	7.0 (9) (SD6.8)	5.0 (6) (SD2.0)	3.3 (1) (SD0)



Graph 6. Mean Koala activity for cluster type within areas (mean ± SD)

NM = no mitigation; M = mitigation; C = control; PM = part mitigation.

3.4 Tree Species Use

A total of 2,550 trees were assessed across the 85 plots (30 at each plot). Koala scats were recorded at 28 (1.1%) of the trees surveyed. Surveyed trees included 28 different tree species (Table 7). The most commonly surveyed tree species were Tallowwood (*Eucalyptus microcorys*, 19.5%), Coastal Blackbutt (*E. pilularis*, 9.9%), Small-fruited Grey-Gum (*E. propinqua*, 8.9%), and Pink Bloodwood (*Corymbia intermedia*, 8.4%), together representing 51.0% of all trees surveyed. Koala scats were recorded at nine (32.1%) of the 28 different species (Table 7). Considering the percentage of individual tree species where scats were recorded, Koala scats were most commonly recorded beneath, Forest Red Gum (*E. tereticornis*, 25.0%, n = 4), Tallowwood (2.8%, n = 543) and White Stringybark (*E. globoidea*, 2.3% n = 132). Diameter at breast height for SCTs are provided in Annex 1.

The baseline study (Lewis 2014) suggests comparing activity levels at Tallowwood trees given that they are widespread, are frequently surveyed and yielded relatively high activity scores during baseline surveys (i.e. 9.5%). Use of Tallowwoods (percent of surveyed Tallowwoods with scats) was 2.68%, 0.75%, 4.7%, 5.3%, 6.6%, 4.8% and 2.8% in 2015, 2016, 2017, 2018, 2019, 2020, and 2022 respectively. As such, compared to the baseline surveys, activity at Tallowwood trees has been consistently lower. This reflects the overall lower activity levels observed since the baseline studies were undertaken.

It should be noted that interpretation of these data should be undertaken with caution, as it is unlikely to reflect the actual use of tree species by Koalas. The detectability of Koala scats is largely determined by the level of leaf litter and fallen bark around the base of trees. For example, species such as Sydney Blue Gums (*E. saligna*) and Flooded Gum (*E. grandis*) shed substantial amounts of bark in comparison to species such as Tallowwoods, resulting in dense, layered groundcover and leaf litter, amongst which scats are more difficult to find.

Table 7: Tree species surveyed – 2022 monitoring

Common name	Species name	Total surveyed	No. with scats	Percent use
Prickly-leaved Tea Tree	<i>Melaleuca styphelioides</i>	7		
Swamp Mahogany	<i>Eucalyptus robusta</i>	7		
Small-fruited Grey Gum	<i>Eucalyptus propinqua</i>	248	3	1.21
Coastal Blackbutt	<i>Eucalyptus pilularis</i>	276	1	0.36
Pink Bloodwood	<i>Corymbia intermedia</i>	234	1	0.43
Tallowwood	<i>Eucalyptus microcorys</i>	543	15	2.76
Forest Oak	<i>Allocasuarina torulosa</i>	20		
Grey Ironbark	<i>Eucalyptus siderophloia</i>	66		
Turpentine	<i>Syncarpia glomulifera</i>	205	1	0.49
White Stringy bark	<i>Eucalyptus globoidea</i>	132	3	2.27
White Mahogany	<i>Eucalyptus acmenoides</i>	49	1	2.04
Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>	9		
Thin-leaved Stringybark	<i>Eucalyptus eugenioides</i>	84		
Flooded Gum	<i>Eucalyptus grandis</i>	28		
Sydney Blue Gum	<i>Eucalyptus saligna</i>	63		
Forest Red Gum	<i>Eucalyptus tereticornis</i>	4	1	25.00
Thick-leaved Mahogany	<i>Eucalyptus carnea</i>	60		

Common name	Species name	Total surveyed	No. with scats	Percent use
Red Mahogany	<i>Eucalyptus resinifera</i>	75		
Red Bloodwood	<i>Corymbia gummifera</i>	167	2	1.20
Brush Box	<i>Lophostemon confertus</i>	38		
	<i>Allocasuarina littoralis</i>	10		
	<i>Melaleuca linariifolia</i>	24		
Scribbly Gum	<i>Eucalyptus haemostoma</i>	26		
Spotted Gum	<i>Corymbia maculata</i>	38		
Grey Ironbark	<i>Eucalyptus paniculata</i>	65		
	<i>Melaleuca sp.</i>	8		
Scribly Gum	<i>Eucalyptus signata</i>	44		
Swamp sheoak	<i>Casuarina glauca</i>	4		
Total		2550	28	

3.5 Weather Conditions

Weather conditions during the field surveys were generally warm to hot (maximum temperatures between 21.6 and 31.0 degrees) with a few light to heavy rainfall events (Port Macquarie weather station 060168, Table 8).

Table 8: Weather conditions - 2022 monitoring

Date	Rainfall (mm)	Temp (°C) (min)	Temp (°C) (max)	Wind speed at 9am (km/h)
9/12/2022	0	15.3	21.6	9
13/12/2022	7.2	10.4	24.6	15
15/12/2022	0	9.0	25.2	22
16/12/2022	0	12.8	21.8	19
6/1/2023	16.8	17.0	25.5	11
10/1/2023	0	13.6	27.4	20
11/1/2023	0	16.5	28.0	17
12/1/2023	0	18.1	26.8	2
13/2/2023	0	21.2	27.9	15
15/2/2023	0	16.7	26.4	9
20/2/2023	0	16.9	29.5	13
21/2/2023	0	19.1	28.8	6
22/2/2023	0	15.7	28.6	13
23/2/2023	58.6	17.8	25.5	20
27/2/2023	0	19.0	31.0	7
28/2/2023	3	17.1	29.0	9
2/3/2023	0	20.8	28.1	15

3.6 Road Kill

There were no Koala road kill records in 2022/2023. One Koala was identified as road kill in October 2020, within a partially fenced area of the highway on the northbound left lane near Barry’s Creek. TfNSW inspected the area of the Koala road strike within days to review the fencing integrity. Minor tree limbs were removed from fauna fencing in the general area, but it was considered unlikely that these provided a potential access point. No holes or issues with the fencing were identified during the inspection. The individual likely entered the motorway from the unfenced intersection at Mingaletta Road or fallen tree limbs on the fauna fence near the U-turn bay at Barry’s Creek, crossed from the southbound lane to the northbound land where it was hit.

Lewis 2014 notes that “During the current baseline survey only one individual was recorded during the weekly surveys performed in October and January/February. Ad hoc monitoring which spanned a 7 month period revealed additional road killed individuals but was consistent with Koala being struck every 6-8 weeks during the breeding period”. As per recommendations with the baseline report, the baseline road kill has therefore been set to 1 individual every 8 weeks. Table 9 lists the Koala road kill for the Project recorded during road kill surveys for the Project and any additional records. There rate has not exceeded baseline rate however, in accordance with the performance measures, when considering a proportional reduction in Koala activity of 62% (from 5% to 1.9%) the adjusted road kill rate to reflect the reduced activity would be 1 Koala every 21 weeks. The 2022 Koala road kill rate has not exceeded the adjusted rate.

Table 9: Koala road kill records

Monitoring	Period	Date	Easting	Northing	Notes	Survey wks
Baseline*	2013-2014	4/10/2013	482178	6540579	Where the Project passes through Ballengarra State Forest	12
Clearing	2014-2015	17/11/2014	483187	6544354	Adult female struck on Tuesday/Wednesday (11/12th Nov)	35
		17/11/2014	483187	6544354	Young struck on Tuesday/Wednesday (11/12th Nov)	
		3/12/2014			300 m North of Yarrabee Rd	
		21/7/2015			200 m North of Yarrabee Rd	
Construction	2015-2016	22/12/2015			1 km north of Ravenswood Rd	50
Construction	2016-2017	5/10/2016	483413	6555959	Adolescent	49
		12/10/2016	482816	6553852	Adolescent	
Construction	2017-2018	Nil				14
Operational	2018-2019	17/9/2018			Young male. Barry’s Creek	12
Operational	2019-2020	Nil				12
Operational	2020-2021	Oct 2020			Barry’s Creek	12

* = An additional three Koala road kill were recorded between August 2013 and February 2014, outside of the monitoring period

3.7 Additional Survey Results

3.7.1 Spotlighting

Spotlighting surveys commenced in October 2019 and were again completed in November 2020 and November 2022 for the current monitoring period. Table 10 summarises the survey results to date. To date, only one Koala has been observed at the Cairncross impact and the Maria River control site (Figure 2) during the 2019 and 2020 monitoring, respectively.

As per the EMP, a detection frequency rate of 1 Koala/spotlight hour is considered as the baseline target density. To date baseline density has been recorded only at the Cairncross impact and Maria River control sites. Scats have also been recorded in these areas during SAT plot monitoring.

Koala presence at the Ballengarra and Maria River impact sites has been previously demonstrated via SAT plot monitoring at the nearest SAT plot clusters to these spotlighting transects. The absence of Koala observations during spotlighting surveys at the Ballengarra and Cairncross control sites is consistent with the predominantly absent records during SAT plot monitoring at the nearest clusters to these transects.

Table 10: 2022 spotlighting surveys results

Site	Survey#	# Koala 2019	# Koala 2020	# Koala 2022	Note
Ballengarra SF impact	1	0	0	0	
Ballengarra SF control	1	0	0	0	
Cairncross SF impact	1	0	0	0	
Cairncross SF control	1	0	0	0	
Maria River SF impact	1	0	0	0	
Maria River SF control	1	0	0	0	
Ballengarra SF impact	2	Not surveyed- fire	0	0	
Ballengarra SF control	2	Not surveyed- fire	0	0	
Cairncross SF impact	2	1	0	0	Observed
Cairncross SF control	2	0	0	0	
Maria River SF impact	2	Not surveyed- fire	0	0	
Maria River SF control	2	Not surveyed- fire	0	0	
Ballengarra SF impact	3	Not surveyed- fire	0	0	
Ballengarra SF control	3	Not surveyed- fire	0	0	
Cairncross SF impact	3	0	0	0	
Cairncross SF control	3	0	0	0	
Maria River SF impact	3	Not surveyed- fire	0	0	
Maria River SF control	3	Not surveyed- fire	1	0	Observed

3.7.2 Additional Koala records

Additional records of Koala presence have been obtained during surveys undertaken for other monitoring components of the Project. These records are summarised below and in Table 11. All occur in areas where Koalas were detected during SAT surveys.

Fauna underpass monitoring

There are a number of culverts and bridges along the length of the Project that may provide passage for Koalas (Figure 2). Fourteen of these are being monitored as part of the Fauna Underpass Monitoring component of the Project. Koalas have been photographed on remote cameras using four of the fauna underpasses to date and these are shown on Figure 2 (Niche 2019b, Niche 2021b).

Yellow-bellied Glider monitoring

A Koala was observed during spotlighting surveys undertaken as part of the Yellow-bellied Glider monitoring component of the Project within the Cairncross State Forest impact site (Figure 2) (Niche 2019c).

Spotted-tailed Quoll monitoring

Koalas have been photographed on remote cameras as part of the Spotted-tailed Quoll monitoring component of the Project within Cairncross State Forest, Ballengarra State Forest, and Maria River (Figure 2) (Niche 2018b and Niche 2020b).

Table 11: Additional Koala records

Monitoring type	Monitoring-specific site name	Date
Underpass	F9.70	16/12/2018
Underpass	F11.67	24/11/2018
Underpass	F33.40	23/11/2018
Yellow-bellied Glider	Cairncross SF impact	27/11/2018
Spotted-tailed Quoll	MM1B	Winter 2018
Spotted-tailed Quoll	MNM1D	Winter 2018
Spotted-tailed Quoll	MREF2D	Winter 2018
Spotted-tailed Quoll	BNM2B	Winter 2018
Spotted-tailed Quoll	BM1C	Winter 2018
Spotted-tailed Quoll	BM1A	Winter 2020
Spotted-tailed Quoll	CREF1B	Winter 2020
Spotted-tailed Quoll	MREF1A	Winter 2020
Underpass	C32.35	29/11/2020

3.8 NSW BioNet Wildlife Atlas

3.8.3 Distribution analysis

A total of 1611 Koala records within a 10 km buffer of the study area were reported as part of the baseline monitoring in 2014. The majority of these records (i.e. 1249 or 77%) were recorded between 2004-2014. In the current study, a total of 4808 Koala records occurred within 10 km buffer of the study area between

2004-2014 (inclusive), and 9087 Koala records occurred within 10 km buffer of the study area between 2014-2022 (inclusive). Records are shown in Figure 3.

Koala records from both periods are broadly distributed throughout the study area with a distinct clustering of records in the south-eastern precinct, which includes Port Macquarie, Lake Innes and Thrumster areas (Figure 3). A cluster of records between 2014-2022 is also evident to the west of Kundabung within Ballengarra State Forest (E1 and F1-F3). Records are consistently distributed throughout the Project corridor, concentrated in vegetated land parcels that the Project corridor bisects. A notable increase in post-construction records can be noted in the western portion of the study area around Cooperbung Hill and Mingaletta to Smiths Creek (grids E1, F1, F2 and F3).

There has not been a notable alteration in Koala record distribution pre and post construction.

3.8.4 Density analysis

As per the baseline analysis, a grid-based analysis of record density was used to assess density. Koala density for the pre-construction and post-construction periods are presented in Table 12 and Graph 7.

Koala record density has increased post-construction in 62% (36/58) of grids, with 33% (19/58) of grids decreasing in density (and 5% (3/58) showing no change in density (Graph 8)). Those grids with a decrease in record density consist of four of the 11 grids (36%) traversed by the Project, six of the 24 grids (25%) adjacent to the Project and nine of the 23 grids (39%) further from the Project.

Grids traversed by the Project corridor have the lowest Koala density, and grids adjacent to the Project corridor have the highest Koala density in both the pre-construction and post-construction periods (Graph 9). Average record density has increased for each group of grids post construction.

When considering mitigation treatments within grids that are intersected by the Project corridor, grids that feature a mix of mitigation and no mitigation sites had the highest pre-construction density and grids that feature either only mitigation or no mitigation sites had a similar density (Graph 10). Conversely, post-construction density was highest in grids that feature only mitigation sites and lowest in grids that contained no mitigation sites. All grids that feature mitigation sites increased in density post-construction, whereas 40% of grids that feature a mix of mitigation and no mitigation sites decreased in density post-construction and 50% of grids that feature no mitigation sites decreased in density post-construction (Graph 11).

The highest density of Koala records (pre and post-construction) occurs in the south-eastern portion of the study area in the vicinity of Port Macquarie (Figure 3).

Pre-construction records were highest in grid J4 (1034), followed by grid J5 (994) and grid K5 (846). The density within these grids has increased post-construction with the highest density and second greatest post construction increase in grid J5 (+449 to 1443), the second highest density and greatest post construction increase in grid K5 (+469 to 1315) and the third highest density and 6th greatest post construction increase in grid J4 (+254 to 1288). These results support the conclusions of the baseline report that these grids are likely to support high densities of Koala.

The neighbouring grids of K3 and K4 in the Lake Innes and Thrumster area recorded 158 and 378 pre-construction records respectively. Grid K3 features both mitigation and no mitigation sites for North and South Sancrox, while grid K4 features control sites for North Sancrox. While the number of records within grid K4 more than doubled post-construction (775), the greatest post-construction decrease in Koala density was observed in grid K3 (-59 from 158 to 99) which forms the southern extent of the Project

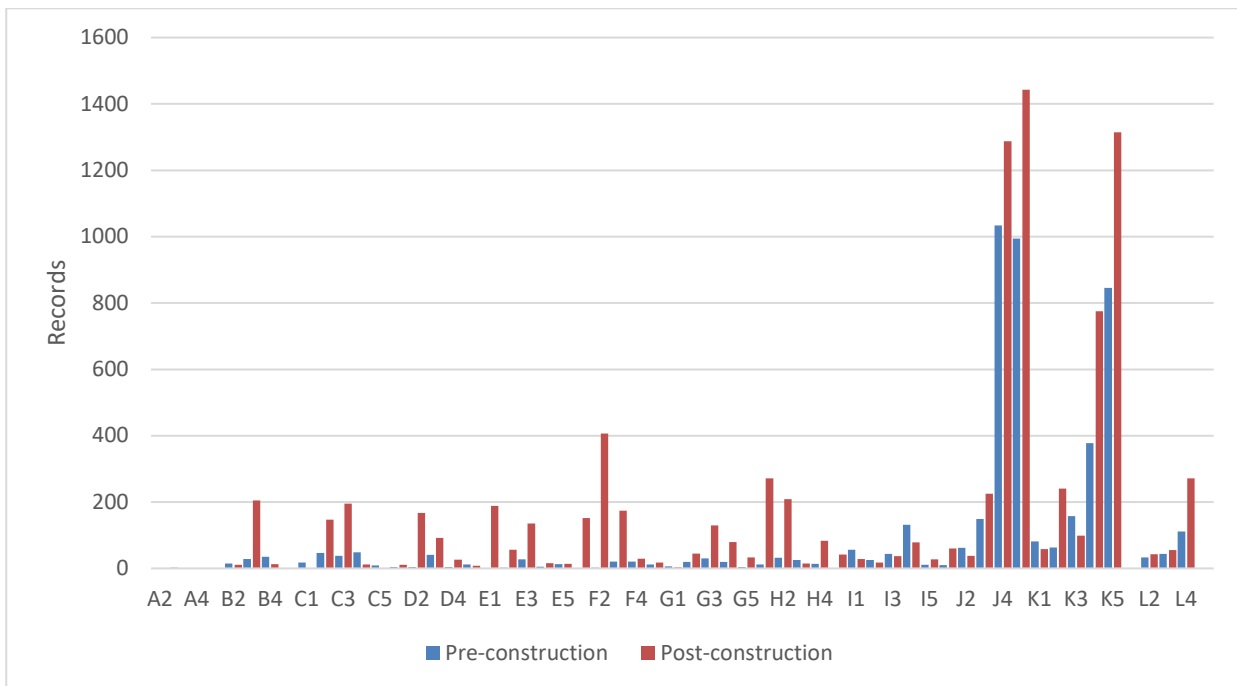
corridor. These results support the conclusions of the baseline report that these areas are likely to support medium to high densities of Koala.

Grid J3, which includes the Project corridor between Cairncross State Forest (south) and North Sancro and features both mitigation and no mitigation sites recorded the 6th highest pre-construction density with 149, and 9th highest post-construction density with 225. Grid I1 which features control sites for Cairncross State Forest (north) returned 132 pre-construction Koala records and saw the second greatest post-construction decrease in Koala density (-54 from 132 to 78). These results support the conclusions of the baseline report that these areas are likely to support medium densities of Koala.

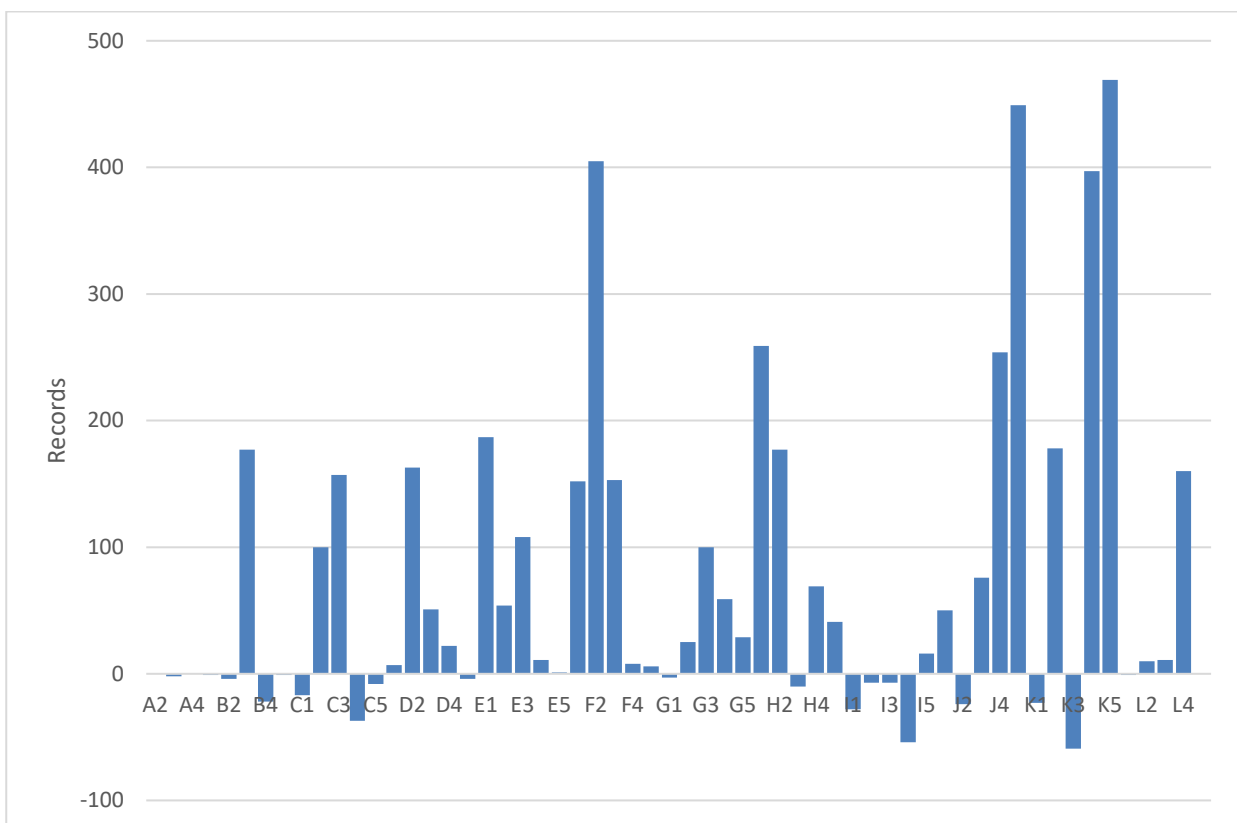
The majority of grids returned >10 records. 64% (37/58) of grids have >10 records both pre and post-construction, with 67% (39/58) of grids returning >10 pre-construction records, and 81% of grids returning >10 post-construction records.

Table 12: Koala density pre-construction and post-construction

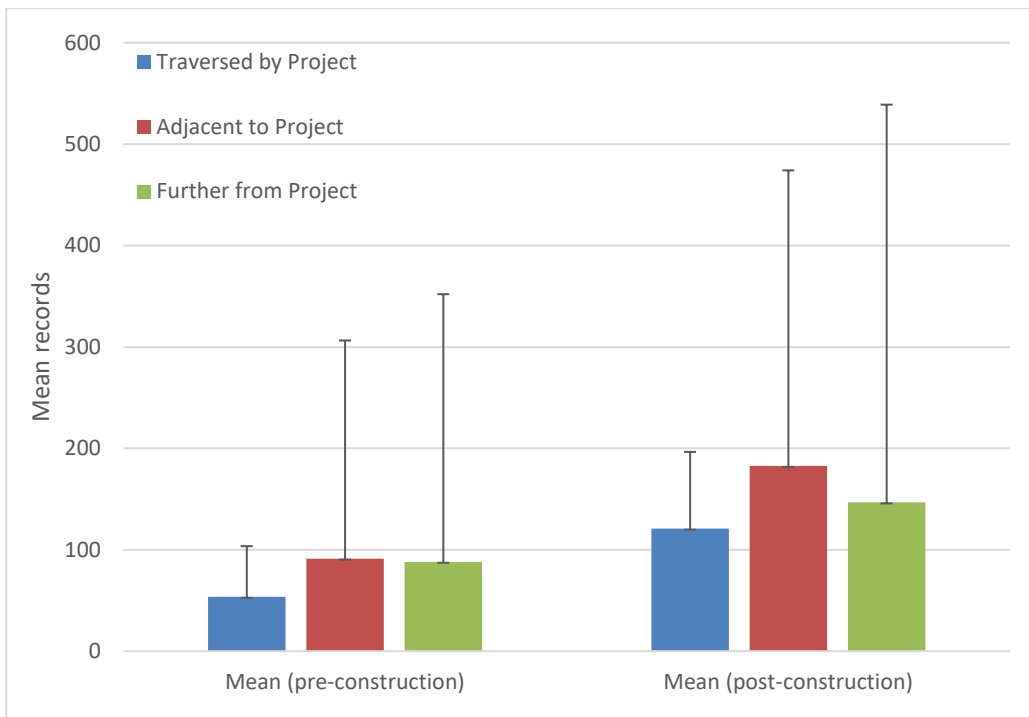
Grids traversed by Project (n = 11)		Grids adjacent to Project (n = 24)		Grids further from Project (n = 23)	
Grid	Pre-construction/post-construction (difference)	Grid	Pre-construction/post-construction (difference)	Grid	Pre-construction/post-construction (difference)
C3*	38/195 (+157)	B2	15/11 (-4)	A2	0/0 (no change)
D3^	41/92 (+51)	B3	28/205 (+177)	A3	2/0 (-2)
E3	27/135 (+108)	B4	35/13 (-22)	A4	0/0 (no change)
F3*	21/174 (+153)	C2	47/147 (+100)	B1	1/0 (-1)
G3^	30/130 (+100)	C4	49/12 (-37)	B5	1/0 (-1)
H2	32/209 (+177)	D2	4/167 (+163)	C1	18/1 (-17)
H3	25/15 (-10)	D4	4/26 (+22)	C5	9/1 (-8)
I2	25/18 (-7)	E2	2/56 (+54)	D1	4/11 (+7)
I3^	44/37 (-7)	E4	5/16 (+11)	D5	12/8 (-4)
J3^	149/225 (+76)	F2	2/407 (+405)	E1	1/188 (+187)
K3^	158/99 (-59)	F4	21/29 (+8)	E5	13/14 (+1)
		G2	20/45 (+25)	F1	0/152 (+152)
		G4	20/79 (+59)	F5	12/18 (+6)
		H1	12/271 (+259)	G1	6/3 (-3)
		H4	14/83 (+69)	G5	4/33 (+29)
		I1	56/28 (-28)	H5	1/42 (+41)
		I4	132/78 (-54)	I5	11/27 (+16)
		J2	62/38 (-24)	J1	10/60 (+50)
		J4	1034/1288 (+254)	J5	994/1443 (+449)
		K2	63/241 (+178)	K1	81/58 (-23)
		K4	378/775 (+397)	K5	846/1315 (+469)
		L2	33/43 (+10)	L1	1/0 (-1)
		L3	44/55 (+11)	L5	0/0 (no change)
		L4	111/271 (+160)		



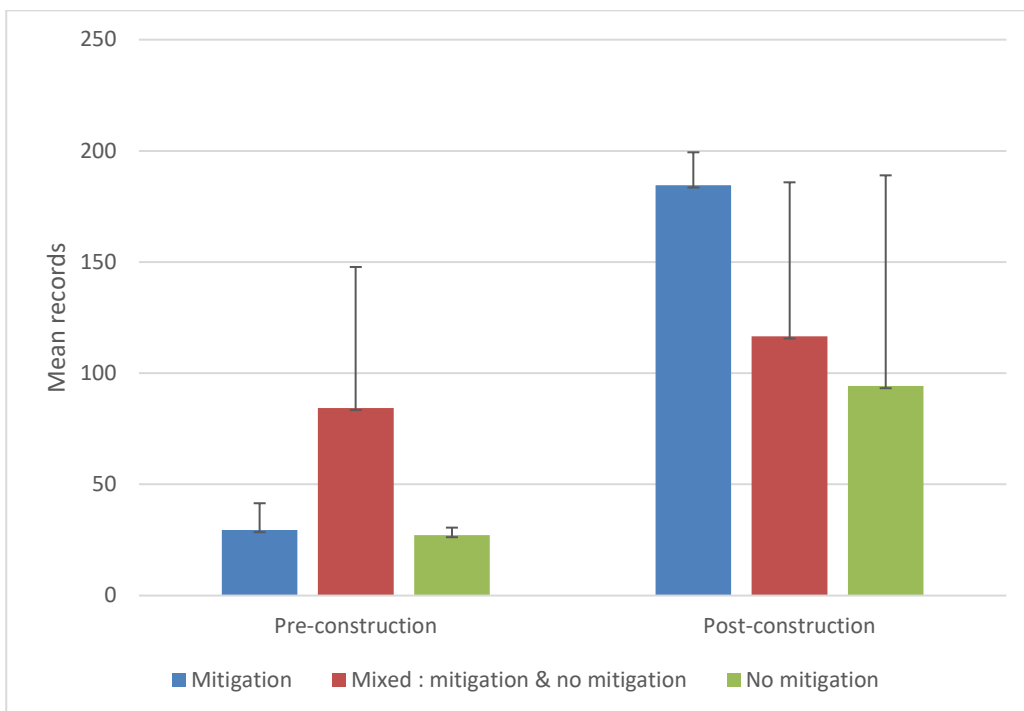
Graph 7: Koala density pre-construction and post-construction



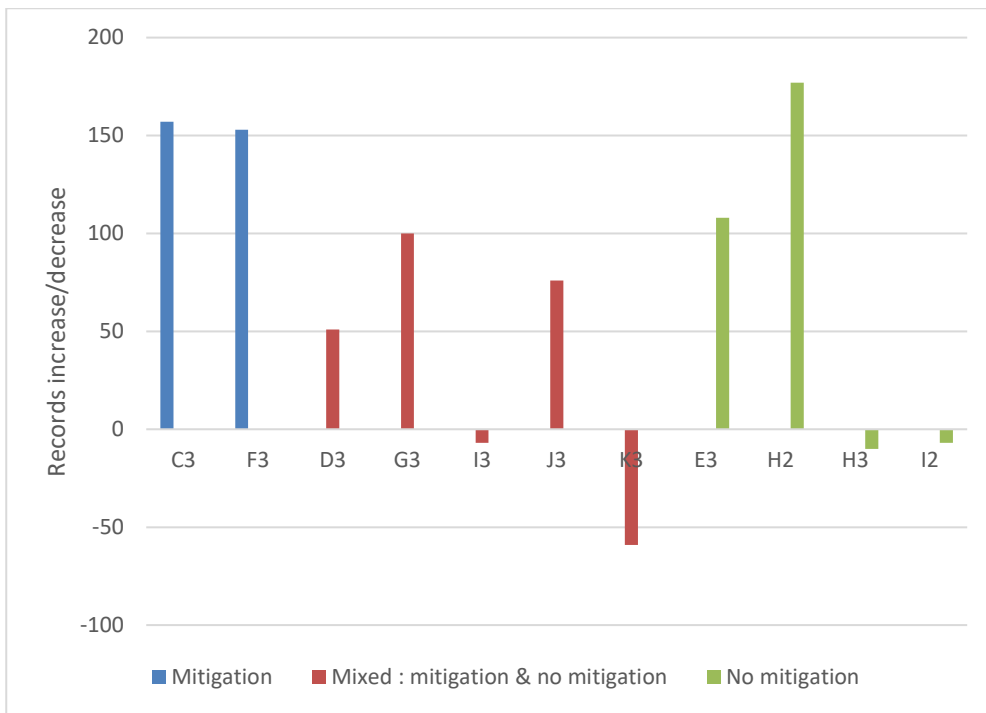
Graph 8: Koala record density increase/decrease post-construction



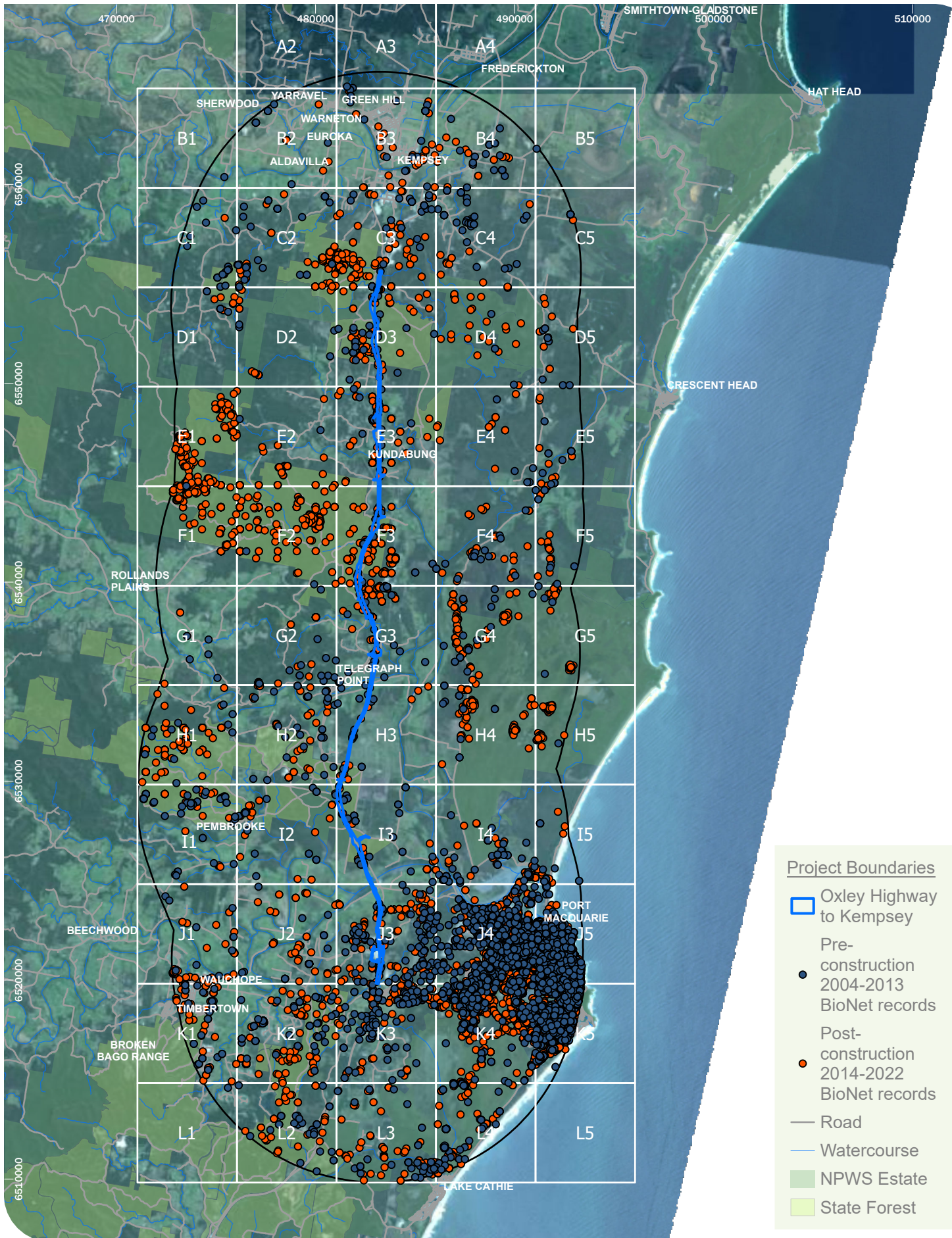
Graph 9: Koala density at different distances from the Project



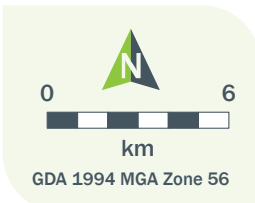
Graph 10: Koala density pre-construction and post-construction in grids traversed by the Project



Graph 11: Increase/decrease in Koala density post-construction in grids traversed by the Project



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BioNet Koala records distribution and density
 Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz
 Niche Proj. #: 1702 P15.1
 Client: Roads and Maritime Services

Figure 3

4. Discussion

4.1 Performance Measures

A discussion of the 2022 survey results in relation to the performance measures is provided in Table 13.

Table 13: Performance measures

Performance measure	Response
Monitoring is undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.	This performance measure has been met. To date, SAT plot monitoring has been undertaken during baseline, Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 4 (2018), Year 5 (2019), Year 6 (2020) and Year 8 (2022) of the Project.
Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.	This performance measure has been met. Monitoring was undertaken at the same sites as surveyed in baseline surveys where access was possible. In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Also, three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area. Details of all 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.
Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	This performance measure has been met. A summary of the efficacy of the mitigation measures to date in relation to treatment Type A: impact with mitigation (sufficiently large culverts and floppy top fencing), indicates: <ul style="list-style-type: none"> • Four of the 14 monitored culverts have recorded use by the Koala (Figure 2) • Since commencement of construction, nine Koalas have been recorded as road kill, four during clearing (2014-2015), three during construction (2015-2018) and two during operation (2018-current). The last construction Koala road kill occurred in October 2016, year 2 of the Project (Niche 2018c). The Project became operational in year 4, March 2018 and in September 2018 and October 2020 two separate Koala road kill events have occurred at Barry's Creek, between clusters MING1 and COOP2, with no recent records. In addition, areas of the Project where mitigation was implemented have all increased in Koala record density post construction.
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	This performance measure has been met. TfNSW have advised that fauna fencing is complete in all areas in accordance with Condition 3c and Schedule 3 of EPBC Approval 2012/6518.
Density: Koala spotlighting records are compared to and discussed with reference to the baseline records, with the baseline detection frequency rate of 1 Koala per spotlight hour considered as the baseline density, as recommended in the baseline report. Compare the NSW BioNet wildlife Atlas density ranking of 5 km ² grids, as per the baseline report, between pre and post-construction at Year 8.	<i>Spotlighting</i> This performance measure has been met at two sites to date: the Cairncross State Forest impact site and Maria River State Forest control site. While Koalas have not been detected during spotlighting surveys at the Maria River and Ballengarra impact sites, their presence has been previously demonstrated via SAT plot monitoring at the nearest SAT plot clusters to these spotlighting transects. <i>BioNet Atlas analysis</i> This performance measure has been met. Grids traversed by the Project corridor have the lowest Koala density, and grids adjacent to the Project corridor have the highest Koala density in both the pre-construction and post-construction periods. Average record density has increased for each group of grids post construction.

Performance measure	Response
<p>Movement: Reduction in Koala road kill compared to the baseline of 1 Koala road kill per 8 weeks for an average baseline plot activity level of 5%, whereby proportional changes in average plot activity level may be reflected in the acceptable level of koala road kill.</p>	<p>This performance measure has been met in 2022. There were no Koala road kill records during 2022/2023 monitoring.</p>
<p>Distribution: Compare the number of records and clustering of records, as per the baseline report, between pre-construction and construction/post-construction at year 8.</p>	<p>This performance measure has been met. The average density of records has increased in all areas and there has not been a notable alteration in Koala record distribution pre and post-construction.</p>
<p>Habitat Use: Koala SAT activity levels will be compared to the baseline activity levels data (below) with a 10% tolerance level, as recommended in the baseline report, to account for variability:</p> <ul style="list-style-type: none"> • Broader study area set at 5% activity; • The treatment classes of mitigation set at 8.05%, no mitigation set at 2.64% and control / reference set at 4.03% • Comparison of percent tree use with baseline tree use. 	<p>This performance measure has been met.</p> <p>When considering all plots or active plots only, activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level (4.9% to 1.1% and 10.1% to 6.7%). Nor is there a greater than 10% difference between treatment type (8.05% to 2.6%; 2.64% to 0.2% and 4.0% to 0.8%, for all plots).</p> <p>Use of Tallowwoods (percent of surveyed Tallowwoods with scats) was 2.68%, 0.75%, 4.7%, 5.3%, 6.6%, 4.8% and 2.8% in 2015, 2016, 2017, 2018, 2019, 2020, and 2022 respectively. As such, compared to the baseline surveys (9.5%), per cent use of Tallowwood trees has been consistently lower. This reflects the overall lower activity levels observed since the baseline studies were undertaken.</p>

All performance measures have been met.

5. Recommendations

5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Koala monitoring program are listed and discussed in Table 14. No additional mitigation actions are considered necessary based on the following:

- No significant changes from baseline surveys have been detected to date
- No significant change in the difference in activity between impact and control sites to date
- Koalas have been detected using four of the dedicated fauna underpasses within the Project area
- Average Koala record density has increased.

Table 14: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	<ul style="list-style-type: none"> • Investigate cause of decline in consultation with EPA and DoTE within two weeks of results reported by ecologist. • If the cause of the decline is considered most likely attributable to the upgrade of the highway, mitigation measures will be reviewed within two months of the above consultation. 	<p>This contingency measure is not considered relevant.</p> <p>No significant change has been detected in the difference in Koala presence at control and impact sites between baseline and subsequent monitoring events.</p>
Increase in road kill rate from baseline rates when considering 62% proportional decrease in Koala activity level	<ul style="list-style-type: none"> • Commence review/modification of fauna exclusion fencing design, location or extent depending on species struck by vehicles within two weeks of results reported by ecologist. • Inspect fence for breaches and inform maintenance as necessary within two weeks of results reported by ecologist. • Any damage to fauna fencing will be temporarily repaired within one week of a breach being identified. • Permanent repair to occur as soon as possible and within two months of the breach being identified. 	<p>This contingency measure is not considered relevant.</p> <p>There were no Koala road kill records during 2022/2023 monitoring.</p>

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Annex 1. Koala SAT results – 2022 monitoring

SCT = selection criteria tree; DBH = diameter at breast height in centimetres (cm); Radial = radial distance of search area from SCT in metres (m).

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
South Sancrox	Impact	No Mitigation	SANCROX E1	SSAN1	0.0	Tallowwood	45	28	
South Sancrox	Impact	No Mitigation	SANCROX E2		0.0	Tallowwood (not tagged)	60	20	
South Sancrox	Impact	No Mitigation	SANCROX E3		0.0	Tallowwood	48	30	
South Sancrox	Impact	Mitigation	SANCROX S1	SSAN2	0.0	Blackbutt	53	20	
South Sancrox	Impact	Mitigation	SANCROX S2		10.0	Thin-leaved Stringybark	56	20	
South Sancrox	Impact	Mitigation	SANCROX S3		0.0	Flooded Gum (noy tagged)	57	25	
South Sancrox	Control	Control	COWARRA SF1	SSAN3	0.0	Small-fruited Grey Gum (tag hacked off)	45	20	
South Sancrox	Control	Control	COWARRA SF2		0.0	Blackbutt	135	20	
South Sancrox	Control	Control	COWARRA SF3		0.0	Small-fruited Grey Gum	35	15	
South Sancrox	Control	New Control	SAT COWARRA NC1	SSAN4	3.3	Blackbutt	80	20	
South Sancrox	Control	New Control	SAT COWARRA NC2		0.0	<i>E. carnea</i>	37	20	
South Sancrox	Control	New Control	SAT COWARRA NC3		0.0	Blackbutt	39	25	
North Sancrox	Impact	No Mitigation	SANCROX N1						
North Sancrox	Impact	No Mitigation	SANCROX N2						
North Sancrox	Impact	No Mitigation	SANCROX N3						
North Sancrox	Impact	Mitigation	FERNBANK CK1	NSAN1	10.0	Tallowwood	75	25	
North Sancrox	Impact	Mitigation	FERNBANK CK2		10.0	Tallowwood	40	25	
North Sancrox	Impact	Mitigation	FERNBANK CK3		0.0	Tallowwood	50	20	
North Sancrox	Control	Control	LAKE INNES1	NSAN2		Tallowwood (not tagged)			
North Sancrox	Control	Control	LAKE INNES2			Swamp Mahogany			
North Sancrox	Control	Control	LAKE INNES3			Swamp Mahogany			
North Sancrox	Control	New Control	SAT COW4	NSAN3	0.0	Blackbutt	70	25	
North Sancrox	Control	New Control	SAT COW5		0.0	Small-fruited Grey Gum	25	25	
North Sancrox	Control	New Control	SAT COW6		3.3	<i>E. acmenoides</i>	36	25	

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF1	CCS1	0.0	Tallowwood	36	20	
Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF2		0.0	Tallowwood	50	20	
Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF3		0.0	Tallowwood	50	20	
Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF16	CCS2	0.0	Tallowwood	50	18	
Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF17		0.0	Tallowwood	36	15	
Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF18		0.0	Tallowwood (not tagged)	100	26	
Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF4	CCS3	3.3	Tallowwood	60	20	
Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF5		0.0	Tallowwood	70	18	
Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF6		0.0	Blackbutt	80	20	
Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK1	CCS4	0.0	Scribbly Gum (not tagged)	45	25	
Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK2		0.0	Scribbly Gum (not tagged)	180	30	
Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK3		0.0	Scribbly Gum (not tagged)	50	25	
Cairncross State Forest (South)	Control	New Control	SAT PEVI1	CCS5	0.0	Sydney Blue Gum	55	20	
Cairncross State Forest (South)	Control	New Control	SAT PEVI2		0.0	Sydney Blue Gum	55	18	
Cairncross State Forest (South)	Control	New Control	SAT PEVI3		0.0	Sydney Blue Gum		15	
Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF7	CCN1	0.0	Blackbutt	80	20	
Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF8		0.0	Forest Red Gum	50	20	
Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF9		0.0	Blackbutt	75	25	
Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF10	CCN2	0.0	Swamp Mahogany	35	20	
Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF11		0.0	Tallowwood	60	20	
Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF12		0.0	Tallowwood	75	15	
Cairncross State Forest (north)	Control	Control	CAINCROSS SF13	CCN3	0.0	Small-fruited Grey Gum	42	20	
Cairncross State Forest (north)	Control	Control	CAINCROSS SF14		0.0	Sydney Blue Gum	35	20	
Cairncross State Forest (north)	Control	Control	CAINCROSS SF15		0.0	Sydney Blue Gum (not tagged)	85	20	
Cairncross State Forest (north)	Control	New Control	SAT RR1	CCN4	0.0	Tallowwood	45	20	
Cairncross State Forest (north)	Control	New Control	SAT RR2		0.0	Small-fruited Grey Gum	57	20	
Cairncross State Forest (north)	Control	New Control	SAT RR3		0.0	Tallowwood	56	20	

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
Cooperabung Hill	Impact	No Mitigation	COOPERABUNG1	COOP1		Tallowwood			No Access-landholder no contact
Cooperabung Hill	Impact	No Mitigation	COOPERABUNG2		0.0	Small-fruited Grey Gum	55	30	
Cooperabung Hill	Impact	No Mitigation	COOPERABUNG3		3.3	Tallowwood	55	25	
Cooperabung Hill	Impact	Mitigation	COOPERABUNG4	COOP2	0.0	Tallowwood	33	20	
Cooperabung Hill	Impact	Mitigation	COOPERABUNG5		0.0	Tallowwood	24	18	
Cooperabung Hill	Impact	Mitigation	COOPERABUNG6		0.0	Tallowwood	67	20	
Cooperabung Hill	Control	Control	COOP HILL1	COOP3	0.0	Tallowwood	45	20	
Cooperabung Hill	Control	Control	COOP HILL2		3.3	Small Fruited Grey Gum	61	20	
Cooperabung Hill	Control	Control	COOP HILL3		3.3	Tallowwood	43	20	
Cooperabung Hill	Control	New Control	SAT FL1	COOP4	0.0	Red Mahogany	50	20	
Cooperabung Hill	Control	New Control	SAT ST1			Tallowwood			No access
Cooperabung Hill	Control	New Control	SAT ST2			Tallowwood			No access
Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK1	MING1	0.0	Blackbutt	55	18	Underscrubbed and cattle present.
Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK2		0.0	Tallowwood	85	30	Cattle and deep litter on creek line.
Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK3			Small-fruited Grey Gum			Property sold no access
Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF1	MING2	0.0	Tallowwood	40	25	Logged trees sparse
Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF2		0.0	Tallowwood	32	20	
Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF3		0.0	Tallowwood	45	20	
Mingaletta to Smiths Creek	Control	New Control	SAT BR1	MING3	0.0	Sydney Blue Gum	45	25	
Mingaletta to Smiths Creek	Control	New Control	SAT BR2		0.0	Sydney Blue Gum	59	20	
Mingaletta to Smiths Creek	Control	New Control	SAT BR3		0.0	Flooded Gum	68	20	
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 1	KUND1	0.0	Flooded Gum	24	25	
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 2		0.0	Tallowwood	90	25	
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 3		0.0	Pink Bloodwood	60	20	
Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 4	KUND2	16.7	Small Fruited Grey Gum	76	20	
Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 5		3.3	Blackbutt	37	18	

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 6			Grey Ironbark			No Access-landholder no contact
Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	KUND3	0.0	Tallowwood	30	20	
Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP2		0.0	Tallowwood	60	20	
Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP3		0.0	<i>E. carnea</i>	60	20	
Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC1	KUND4	0.0	Red Mahogany	80	20	
Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC2		0.0	Spotted Gum	50	20	
Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC3		0.0	Spotted Gum	45	20	
Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 1	MR1	0.0	Pink Bloodwood	35	25	
Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 2		0.0	Tallowwood	45	20	
Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 3		0.0	Tallowwood	26	22	
Maria River State Forest	Impact	Mitigation	MARIA RIVER 4	MR2	0.0	Thin-leaved Stringybark	40.5	20	
Maria River State Forest	Impact	Mitigation	MARIA RIVER 5		3.3	Tallowwood	66	25	
Maria River State Forest	Impact	Mitigation	MARIA RIVER 6		0.0	Tallowwood	36	20	
Maria River State Forest	Control	Control	MARIA NP1	MR3	0.0	Tallowwood	31	15	
Maria River State Forest	Control	Control	MARIA NP2		3.3	Tallowwood	63	20	
Maria River State Forest	Control	Control	MARIA NP3		16.7	Tallowwood	23	25	
Maria River State Forest	Control	New Control	SAT CO1	MR4	0.0	White Stringbark	40	27	
Maria River State Forest	Control	New Control	SAT CO3		0.0	Blackbutt	95	20	
Maria River State Forest	Control	New Control	SAT MAR 1		0.0	Tallowwood		20	

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