Woolgoolga to Ballina Pacific Highway upgrade

Koala Monitoring Program

Annual Report 2019-20 (Year 3)

Version 2.0 (Final Report)

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Woolgoolga to Ballina (W2B) Pacific Highway Upgrade

Koala Monitoring Program

Annual Report 2019-20 (Year 3)

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Cover Photo: Koala (*Phascolarctos cinereus*) moving northward through a box culvert (KWmid) under Wardell Road on 29 October 2019.

Executive Summary

Sandpiper Ecological Surveys (SES) was contracted by Transport for NSW (TfNSW) to implement the Woolgoolga to Ballina (W2B) Pacific Highway upgrade koala monitoring program in accordance with section 8 of the approved Koala Management Plan (KMP) (RMS version 4.4, July 2016). The broad aim of the monitoring program is to determine the effectiveness of mitigation measures implemented in Sections 1-11 of the upgrade for koalas. The following report presents results of year three (2019/20) of the monitoring program and builds upon results of year one and year two monitoring (Sandpiper Ecological 2019a, 2019b).

Year three population surveys were completed at 100 sites – 50 each in Broadwater focal area (sections 8-9) and Bagotville focal area (section 10) – during spring 2019 and autumn 2020. Koala counts were higher at both focal areas compared to 2018/19 surveys. Bayesian estimation analyses of survey data suggest a relatively flat trend in density estimates at Bagotville and a slight upturn in a declining trend at Broadwater compared to baseline and year 1 & 2 levels albeit more years of population data will be required to reduce the level of uncertainty and improve the level of confidence in determining population trends. A prospective power analysis demonstrated that the koala population monitoring program at Bagotville was above the target level of statistical power (>0.7) whereas Broadwater was marginally below. The modelling exercises confirmed the challenge of sampling populations at very low densities and drawing conclusions from sparse counts. Subsequent monitoring years should improve the precision of density estimates.

In working towards achieving the key mitigation measure for section 10 to reduce koala mortality by 4-8 individuals per year, TfNSW have implemented a predator control program, installed six vehicle-activated signs at road mortality hot-spots across the broader section 10 study area, fenced Wardell Road and the existing Pacific Highway and installed crossing structures on Wardell Road. Since installation of fencing, no vehicle strikes have been reported on these two stretches of road compared to 10 in 2016/17 (FOK, unpublished data). However, one koala vehicle strike fatality was reported within the focal population areas during the monitoring year – the individual was struck on the Broadwater-Evans Head Road on 25/1/2020. No other koala vehicle strikes were detected during spring 2019 road mortality surveys conducted on the old Pacific Highway between Wardell Road and Coolgardie interchange, Wardell Road to Thurgates Lane or within sections 1-2 of the upgrade alignment.

Camera monitoring of 14 koala crossing structures (i.e. underpasses) – 11 within sections 1-2 and three along Wardell Road – during spring 2019 revealed three complete crossings of a box culvert on Wardell Road. Koala scats were also recorded in habitat adjacent to the underpass structures on Wardell Road. Other threatened species, namely the rufous bettong *Aepyprymnus rufescens* and long-nosed potoroo *Potorous tridactylus*, were also recorded using culvert structures. Complete crossings by dog and fox have increased from 2018/19 monitoring, particularly at culverts K1 and K8 in sections 1-2. No incidents of predation were detected by culvert cameras and no evidence of predation was observed during searches of culverts and adjoining habitat.

Year three monitoring activities were completed during a period of protracted drought (including the lowest annual rainfall total (2019) for the area since records began in 1977), wildfire that burnt through approximately 470 ha of the Ngunya Jargoon IPA, and a flood event in February 2020. The impact of these compounding events is largely unknown although one koala (possibly four) was confirmed to have perished during the wildfire (M. Mathes, pers. comm.) Other impacts outside the control of the project, such as local land development and clearing activities, present additional challenges for the focal area koala populations.

Acknowledgements

We wish to thank the landholders who approved access to their properties to conduct the population surveys. Numerous monitoring sites are on private property, so landholder support is critical to achieving the goals of the monitoring program. We also extend appreciation to the Jali Local Aboriginal Land Council for their approval, support, and involvement with surveys within the Ngunya Jargoon IPA.

We would also like to extend a special note of appreciation to Friends of the Koala (FOK), particularly Ros Irwin and Maria Mathes, for their tireless work in supporting the persistence of koalas in the region.

The final report was improved by comments from Pacific Complete and TfNSW

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1. Introduction

1.1 Background

Sandpiper Ecological Surveys (Sandpiper) was contracted by Transport for NSW (TfNSW) to implement the Woolgoolga to Ballina (W2B) Pacific Highway upgrade koala monitoring program in accordance with section 8 of the approved Koala Management Plan (KMP) (RMS version 4.4, July 2016), excluding phased resource reduction. The primary aims of the monitoring program are to: determine the effectiveness of mitigation measures implemented in Sections 1-11 of the upgrade for koalas; and monitor trends in the size of koala populations surrounding the alignment at Broadwater (Sections 8-9) and Coolgardie-Bagotville (Section 10; hereafter referred to as Bagotville).

The three main mitigation measures requiring monitoring are koala-proof fencing along the length of the upgrade; connectivity structures along the length of the upgrade; and koala food tree plantings (focus mainly in Section 10). Both population monitoring areas are described as focal populations which could be adversely affected by the highway upgrade (RMS 2016). The two focal areas featured the highest density of koala records along the W2B alignment during environmental assessment population surveys (RMS 2016).

Baseline data on the focal koala populations have come from a variety of sources. Population surveys of the Broadwater focal area were conducted during 2014 and 2015 (Ecosure 2014, 2015). The Bagotville koala focal population has been the subject of detailed field and laboratory studies (see Phillips and Chang 2013; Phillips *et al.* 2015), which informed the preparation of a Population Viability Analysis (PVA) (Kavanagh 2016). The PVA was conducted in accordance with the Commonwealth Conditions of Approval (CoA 5 and CoA 7) and its outcomes have been used to guide management of koalas within this area.

The PVA for the Bagotville focal population indicated that this population is projected to decline significantly over the next 50 years (Kavanagh 2016) unless key threatening processes are controlled. Monitoring of this population is considered important to determine whether mitigation actions have been effective in slowing population decline. As such, the Bagotville focal population will be assessed against the PVA predictions. The Broadwater population, which was not subjected to a PVA, will be assessed against a statistically significant decline at year 15 compared with baseline survey values (RMS 2016).

1.2 Scope of works, program objectives and performance indicators

The monitoring program is designed to provide reliable information with which to inform management of koalas *Phascolarctos cinereus* along the highway upgrade. Koalas are listed as vulnerable in NSW under both the NSW *Biodiversity Conservation* Act 2016 (BC Act) the Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC Act). The objectives of the monitoring program for sections 1-11 of the highway upgrade as stated in the KMP and expanded upon in the Ecological Services Brief (RMS 2017) are described below. Those applicable to year 3 (2019/20) are shown in italics.

1. *Evaluate the success of mitigation measures against the performance measures and corrective actions.*
2. *Assess the effectiveness of the fauna crossing structures and fauna exclusion fencing to facilitate movement of koalas across the upgraded highway.*
3. Determine whether there is a statistically significant decline at year 15 compared with no decline in section 8-9.
4. Determine whether the corrective actions of the KMP have been triggered by estimated population trends in section 10 in accordance with predictions of the Population Viability Analysis.

5. Provide information which supports a program review by RMS at years 5 and 10 in accordance with the KMP (years 5, 10 & 15).
6. Assess effectiveness of the revegetation program in providing additional habitat for koalas.

Based on the above objectives, the success or otherwise of the monitoring program shall be determined by program performance against relevant performance indicators (PI). In addition, scat sampling will be conducted every three years in section 10 for the purposes of genetic analysis. These analyses aim to provide information on distribution and relatedness of individuals across the study area.

Table 8-4 in the KMP details eight performance indicators and their corresponding thresholds, corrective actions and agency responsible. The performance indicators and corrective actions relevant to the current year 3 report are described in Table 1.

Table 1: KMP performance indicators and corrective actions relevant to current report.

Performance indicator	Performance threshold	Corrective actions
1. Road mortality	• No injury to an individual koala as a result of vehicle strike across all upgraded sections. • Section 10: no koala road mortality within the fenced areas of the upgrade, on existing Pacific Highway or Wardell Road.	• Examine fencing for breach or obstruction within 3 days of report & repair. • Retrofit exclusion fencing, or part there-of, with additional measures to deter koalas. • Section 10: RMS would consider erecting koala-proof fencing on Bruxner Hwy (a known koala roadkill black spot), in an effort to reduce koala mortality across the region.
2. Fauna crossing structures	• Evidence of at least one completed crossing by koalas at targeted fauna crossing structures. • Evidence of individual koalas using structures and/or breeding on either side of the highway, via scat analysis. • No evidence of high visitation/usage rates by exotic predators.	• Review monitoring methods. Consider increasing frequency, intensity and duration, to ensure individuals are identified. • Check fauna furniture associated with underpass for damage and rectify. • Investigate habitat adjoining underpass. Consider improving habitat condition and connectivity.
3. Fauna exclusion fence	• No breaches in fauna exclusion fence.	• Check fauna exclusion fencing and fauna crossing structures for damage/blockage and rectify.
4. Predator attack near fauna crossing structures	• No koala deaths or injuries due to predator attack in the vicinity of fauna crossing structures.	• Where monitoring indicates that predators are a threat to koala movement through crossing structures, RMS will engage with North Coast LLS, NSW NPWS (Grafton), RLP Board (North East) & adjacent landowners to identify and implement strategies to reduce this predation risk.

The following report describes the methods and results of the year 3 (2019/20) monitoring period and includes an assessment of statistical power of population surveys going forward. It represents year 3 of population monitoring (construction phase) and year 2 of the crossing structure monitoring (operation phase in sections 1-2). It also represents year 3 road mortality/exclusion fence monitoring in section 10 along Wardell Road and the existing Pacific Highway and year 2 road mortality/exclusion fence monitoring in sections 1-2. During the reporting period, sections 8-9 were still under construction and section 10 was mostly complete by the end of 2019, including completion of fauna crossing structures. Main alignment crossing structure monitoring is due to commence in spring 2021.

The report also addresses the monitoring objectives and assesses monitoring outcomes against the relevant performance indicators and whether thresholds have been breached and require corrective actions. The year 3 report builds upon year 1 and year 2 results and is regarded as a brief report. It will be used to inform a comprehensive program review at year 5.

2. Study area

The broader study area includes sections 1-11 of the W2B Pacific Highway upgrade alignment and adjoining habitat. The 155 km-long upgrade stretches from Woolgoolga in the south to Ballina in the north. It is wholly located within the NSW North Coast Bioregion, one of the most diverse in NSW (W2B Planning Alliance 2012). The project boundary is located within a landscape which has been either fragmented or cleared for agriculture and rural development although substantial areas of forest habitat persist across the broader study area (W2B Planning Alliance 2012).

For the purposes of the year 3 report, monitoring activities were conducted in sections 1-2 (crossing structure and road mortality monitoring) and sections 8-10 (population monitoring and road mortality monitoring) (Figures 1 & 2). In sections 8-9, the Broadwater focal population area extends 3-5 km either side of an 11 km portion of the highway upgrade from Lang Hill (northern part of section 8) north to the Richmond River (including all of section 9; Figure 2). The Richmond River forms a major movement barrier to the west and north. Within section 10, the Bagotville koala focal population area extends 13.5 km north of the Richmond River and includes the localities of Bagotville and Coolgardie west of Wardell (Figure 2).

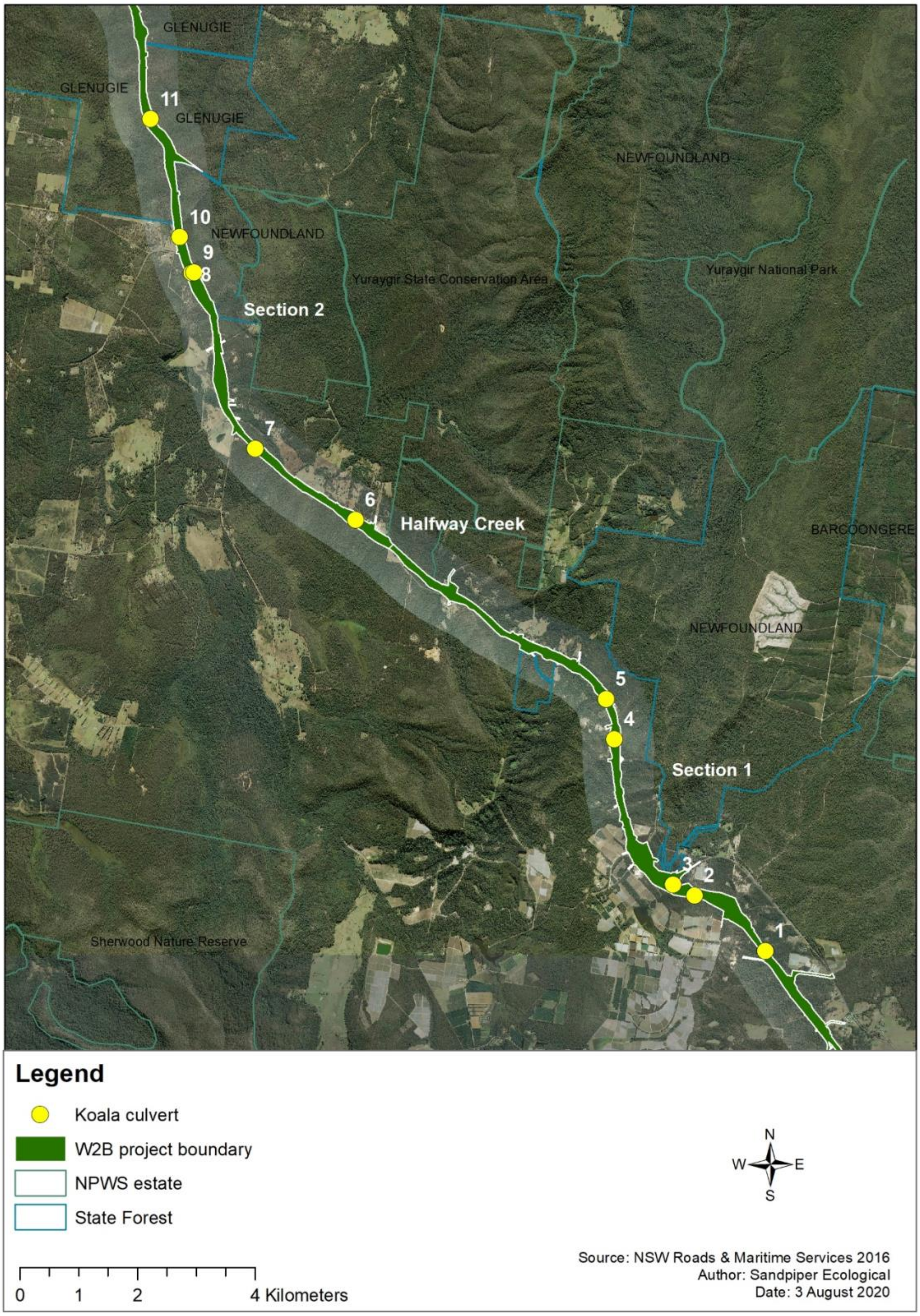

Figure 1: Sections 1-2 of the W2B Pacific Highway Upgrade.

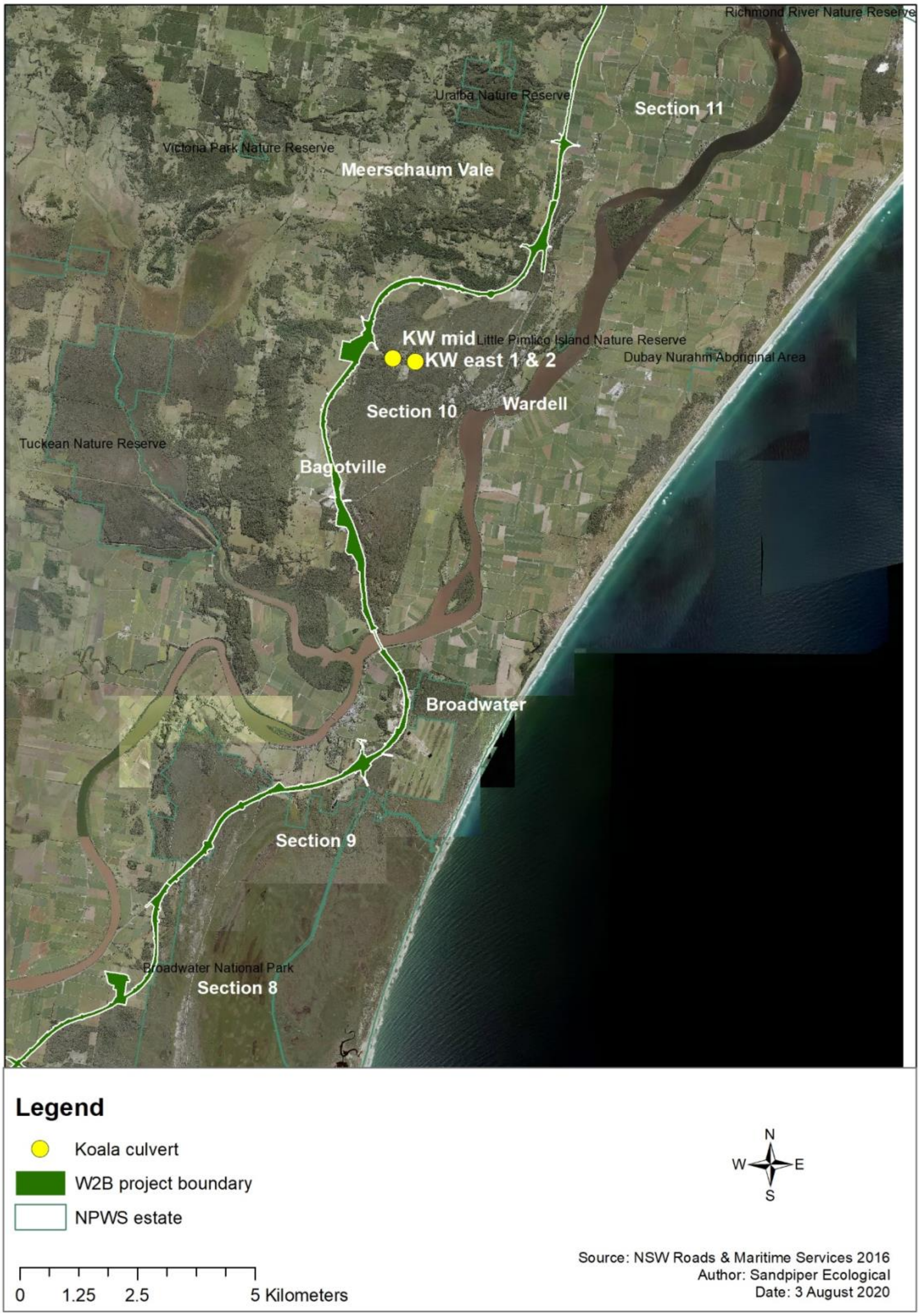

Figure 2: Sections 8-11 of the W2B Pacific Highway Upgrade.

3. Methods

3.1 Population surveys

Diurnal and nocturnal population surveys were conducted during spring 2019 and autumn 2020. Surveys covered 100 sites (50 each in Broadwater and Bagotville) and were completed by teams of three ecologists experienced in koala surveys (Figures 3 and 4). At each site two direct count methods were used:

1. **Transect searches**

   Direct counts on 250 m x 40 m transect (approximately 1 ha) involved three observers walking 20m apart – one on the center line and one either side. Observers were equipped with binoculars and searched trees for koalas.

2. **Radial searches**

   Direct counts within a radial area involved three observers slowly searching all trees within a 25m radius of the mid-point of the belt transect (approximately 0.196 ha). Radial areas and transects were conducted concurrently.

During year 1 and year 2 surveys, the same team completed diurnal followed by nocturnal surveys on the same day. To address concerns about inadequate survey independence, year 3 diurnal and nocturnal surveys were completed on non-consecutive days. Diurnal and nocturnal surveys were mostly completed two to five days apart. Due to delays arising from the COVID-19 outbreak in early autumn 2020, 11 nocturnal sites in Bagotville were surveyed up to 34 days after diurnal surveys.

All koala observations were recorded with a handheld GPS unit and data collected on individual characteristics (e.g. sex, age class, health status, behaviour, identifying features), tree species and diameter at breast height of tree. Handheld spotlights were used to assist with nocturnal surveys.

Spring 2019 surveys were completed between 28 October and 11 December 2019. Diurnal surveys were generally completed between 1100 hours and 1830 hours and nocturnal surveys between 1900 hours and 2330 hours. Weather conditions were mostly fine during the survey period although several surveys were completed during light showers. Temperatures ranged from 19°C to 31°C and winds were variable. Surveys within the Bagotville area were completed less than two weeks after a wildfire burnt through approximately 470 ha of the Ngunya Jargoon IPA, including areas of high-quality koala habitat.

Autumn 2019 population surveys were completed between 2 April and 25 May 2020. Diurnal surveys were generally completed between 0900 hours and 1700 hours and nocturnal surveys between 1730 hours and 2330 hours. Weather conditions were mostly fine during the survey period although several surveys were completed during light to moderate showers. Temperatures ranged from 11°C to 32°C and winds were mostly calm to moderate.

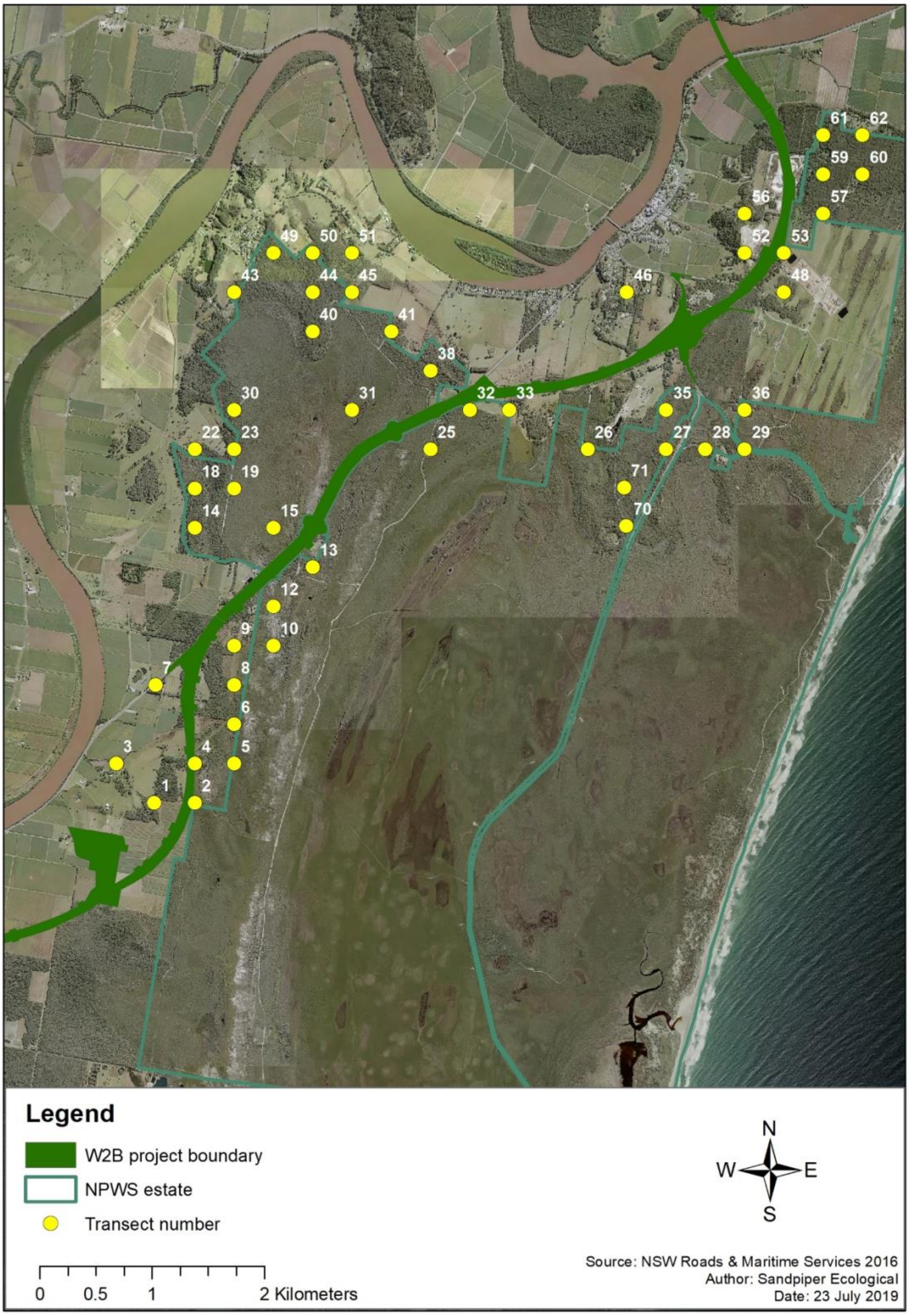

Figure 3: Broadwater (sections 8-9) sample sites.

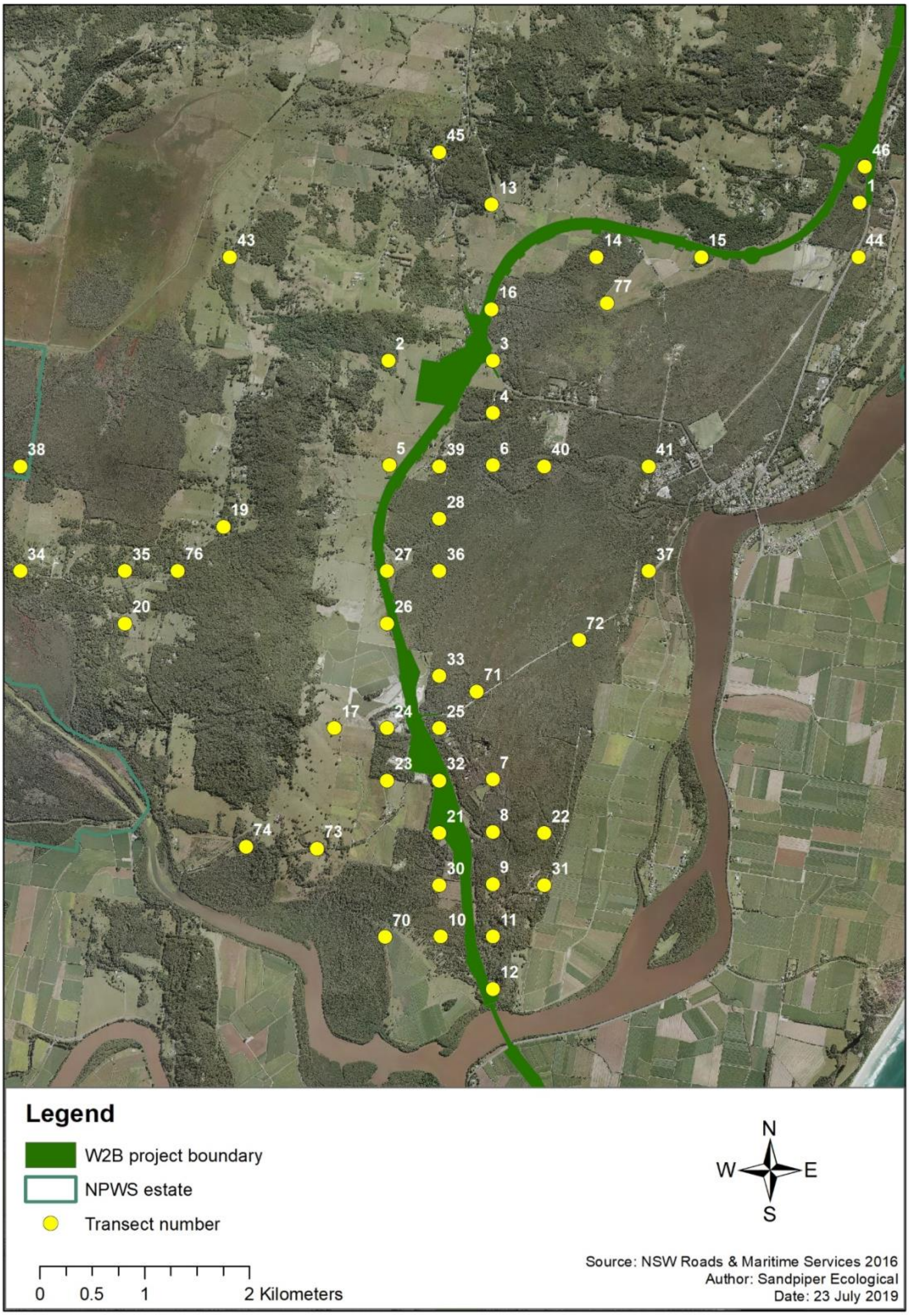

Figure 4: Bagotville (section 10) sample sites.

3.2 Koala density and population size estimates

3.2.1 Bayesian modelling

A Bayesian estimation exercise was used to estimate densities at Broadwater and Bagotville for year 3 spring and autumn, year 3 as a whole and to update year 1, year 2, and baseline estimates. The procedure included multi-model uncertainty for effects: night-time vs day-time effect, a radial- vs linear-transect effect; a seasonal effect; log-linear trend vs no trend vs each year having its own unique density, and five different amounts of overdispersion (excess count-variation). Each of these core specifications was repeated five times for five different Negative Binomial overdispersion priors (which broadly represented a spectrum of high-to-low overdispersion, the latter being equivalent to a Poisson). For this exercise, there were a total of 280 models. To acknowledge multi-model uncertainty, these models were model-averaged using posterior probabilities derived from the Watanabe-Akaike Information Criterion (Watanabe 2010, Gelman *et al.* 2014), as in previous reports (Sandpiper 2019a, 2019b).

In using the model-based approach, as described above, a Bayesian regression model is applied to the entire dataset to project the population back to Year zero based on the overall population trend. In so doing, this approach smooths-over the high natural-variation in counts and more accurately reflects the population density. The estimates include multiple sources of uncertainty resulting in conservative trend estimates. A disadvantage of this approach is that baseline and trend estimates need to be re-calculated as more data are acquired. By contrast, a ‘fixed baseline’ approach employs a simple descriptive statistic, calculated as the mean (and standard deviation) of the raw counts during the baseline year. The baseline value is not updated as more data are acquired.

A disadvantage of the fixed-baseline approach is that due to the large natural-variation in koala counts (i.e. much year-on-year variation) and the sparsity of koala counts (i.e. few koalas in any year) the fixed-baseline reflects the random-variation during the baseline year, rather than the overall population density. Because the fixed baseline is sensitive to high variation in counts, it is more alarmist as a decision-making tool. In contrast, the model-based baseline focuses on the magnitude of the overall population trend, rather than the exact density in any one year. The trend is less sensitive to alarmist changes in koala counts although it may react quickly to a catastrophic drop in density which is more likely with a fixed baseline approach. Due to high variability in counts between years and the focus on temporal population trends the model-based baseline approach was considered to be more consistent with the intent of the KMP/PVA.

For the Bagotville focal area, baseline density values derived from Bayesian modelling were then extrapolated across the total area of preferred koala habitat prior to clearing (i.e. 2,152 ha) and post-clearing/monitoring years (2,135 ha – as used in the PVA (Kavanagh 2016)), to derive a population size estimate for each period. To be consistent with the PVA population estimation methodology (Kavanagh 2016), a correction factor of 0.204 was then applied to Bagotville population estimates to account for the unsampled 0-1 year-old age cohort. The derived population estimates are referred to as ’revised population estimates’.

It should be noted that in applying the above approach, the Bagotville baseline population estimate presented in the PVA/KMP differs from the revised Bayesian modelling-derived baseline population estimate presented in the current report. Whereas population estimates are presented, determining population trends is focused on comparison of density estimates rather than population estimates. Focusing on density trends is more robust and reduces bias (Rhodes *et al*. 2015). Density estimates are also more reliable because the extrapolated area of preferred koala habitat differs between baseline and post-clearing (and differs between actual area cleared (i.e. 28 ha) and that predicted in the PVA (i.e. 17 ha)) and its quality and extent will likely change during the 15 year-long monitoring program.

For the Broadwater focal area, which is not informed by a PVA and is required to be assessed according to a statistically significant decline at year 15, population trends are assessed according to density estimates.

3.2.2 Supplementary analysis to estimate trend in density estimates

A supplemental analysis was conducted to further investigate evidence for or against the presence of a trend in density estimates. The intent of the supplementary analysis was to complement and contextualise the main results. The supplementary analysis used frequentist Negative-Binomial GLMs models and performed model-averaging by AICc weights (Akaike 1974, 1998, Schwarz 1978) to estimate the trends at Broadwater and Bagotville.

These models can be thought of as pseudo-Bayesian models whereby the i) priors-on-parameters have been weakened to zero-influence, and ii) priors-on-model-probabilities are adaptive (i.e., they become more conservative with less data, and more liberal with more data). In other words, the AICc "reacts" faster to new data as compared to the static Bayesian priors used in the main analyses. The trade-off is that: the AICc may be more sensitive to developing trends, but may result in some overfitting and be alarmist, as compared to the Bayesian models with stronger priors.

Full details of Bayesian estimation modelling and supplementary analyses are provided in Appendix A.

3.3 Prospective power analysis

The KMP includes background information on use of a Power Analysis (PA) to determine minimum survey effort to reliably detect a decline in focal koala populations. It states that survey effort which achieved 70% power (or confidence) to detect a 30% decline in the Bagotville population was acceptable (RMS 2016). Using baseline data for each focal population and a diurnal search detection probability of 1.0/observer, the KMP PA determined that to achieve the 70%/30% target 50 survey sites within each focal area would need to be double sampled (i.e. two surveys/session) every six months (J. Rhodes unpub. data).

A subsequent prospective PA, which included current density data, would then be completed at the end of each reporting period to determine the minimum survey effort required going forward. Whereas the PA used to inform the KMP was based on a frequentist/null hypothesis testing approach, the prospective PA used in the current and previous reporting periods was based on a Bayesian estimation analysis.

The prospective analysis uses a Monte Carlo simulation procedure. The goal of the power analyses is to estimate the rate of Type-II errors (falsely rejecting the hypothesis of a trend, $H_a: \beta_t \neq 0$) while detecting a -30% decline from baseline levels at Broadwater and Bagotville between years 2015 and 2031. The error rates were conditional on:

1. a negative trend of -30% from baseline levels until Year 15 of monitoring;
2. a cap on the rate of Type-I errors at $\alpha \leq 0.3$;
3. a monitoring effort of 400 transects per year each at Broadwater and Bagotville (i.e. 50 sites double-surveyed twice/season and two seasons/year at each area);
4. marginal effects for survey-design factors (day-time/night-time, spring/autumn, line-transect/radial-search transects) empirically derived from the Bayesian analysis;
5. baseline koala densities derived from the Bayesian estimation analysis.

The prospective analyses were conducted in the same manner as previous reports with no supplements. Because the prospective analysis assumed the (simulated) existence of 15 years of data, it was considered less sensitive to prior distributions and issues of small sample-sizes. However, because the analysis is conditional on some empirically estimated features, the results are still somewhat sensitive to the estimated baseline conditions and the models used to estimate those conditions.

Full details of the prospective power analysis are provided in Appendix A.

3.4 DNA analysis

3.4.1 Faecal pellet (scat) collection

Faecal pellets (i.e. scats) were collected from koalas observed in the Bagotville area during year 3 surveys for DNA analysis. When a koala was observed, the base of its tree was searched for fresh scats. If fresh scats were found, they were collected in accordance with the Collection of Scats Protocol and the methods for collection and storage described by Piggott (2004) and Wedrowicz *et al.* (2013). As per year 2 surveys, the collection method was refined to involve placement of scats into a paper bag which was then stored in an esky. Scats were then transferred to a freezer once field surveys were complete. Scat collection data included location, tree species, tree DBH, koala sex/health (if possible) and weather at time of collection. Effort was made to collect 75-100 scats for DNA analysis during the reporting period.

3.4.2 DNA extraction and analysis

Koala genetic material were isolated from presumptive mucosal epithelial cells using the scraping method outlined in Shultz *et al.* (2018). Genomic DNA was isolated using the NucleoSpin® DNA Stool kit (Macherey-Nagel, Germany) according to the manufacturer's instructions. Each DNA isolate was tested for quality and concentration using spectrophotometry (Nanodrop, ThermoFisher Scientific, VIC, Australia) and real time PCR for confirmation of presence of host DNA in the sample (koala beta-actin mRNA).

3.4.3 Genotypes and samples

Genotypes across 30 microsatellite loci for 24 koala scats were generated from genomic DNA. There were no departures from Hardy Weinberg Equilibrium from the population, therefore a total of 30 loci were retained for analysis. Detection of repeated genotypes within the dataset to identify duplicate samples was performed using the software GENALEX version 6.5 (Peakall and Smouse, 2012) which revealed two sets of identical multilocus genotypes present within the dataset. One of each duplicate genotype profile was removed from the dataset for further genetic analysis to ensure no bias of the data.

3.4.4 Genetic diversity

Analysis of genetic diversity was performed using the software GENALEX version 6.5 (Peakall and Smouse, 2012) to calculate mean number of alleles and observed and expected heterozygosity. FSTAT (Goudet, 2001) was used to calculate allelic richness, a measure of allelic diversity that takes into account differences in sample sizes by standardising to the smallest number of individuals typed for a locus in a sample, so as to enable comparison among populations. FSTAT was also use to estimate the inbreeding coefficient (F_{IS}) for which a positive value indicates that individuals in a population are more related than you would expect under a model of random mating, and a negative value indicating that individuals in a population are less related.

3.4.5 Pairwise genetic differentiation (F_{st})

Restrictions to gene flow among populations results in a genetic differentiation or divergence of the populations. F_{ST} is a measure of population genetic differentiation that quantifies the proportion of variance in allele frequencies among populations relative to the total variance. As a measure of genetic differentiation among populations, F_{ST} is calculated to evaluate how genetically different koala populations are to one another.

A common reason for koala populations becoming more genetically different is reduced breeding movements of individuals among populations. The greater the genetic differentiation between populations, the less breeding movements there are between them and the more isolated they are from one another. F_{ST} can range from zero to one, where zero means populations show no genetic separation; a value of 0.25 or greater indicates strong differences among populations. Assessment of genetic differentiation between koala populations was calculated using FSTAT (Goudet, 2001).

3.4.6 Genetic relatedness

Genetic relatedness was estimated to indicate the proportion of shared ancestry in pairs of individuals. Expected values are 0.5 for parent-offspring or full-sib pairs and 0.25 for half-sib pairs. However, genetic relatedness values will form a distribution around these expected values. Genetic relatedness of within-population individuals was calculated in GENALEX version 6.5 (Peakall and Smouse, 2012) using the Queller and Goodnight estimator of relatedness.

3.4.7 Population structure

The clustering of koalas into genetic populations, termed population structuring, was determined using the Bayesian clustering program STRUCTURE version 2.3.4 (Pritchard *et al.* 2000). STRUCTURE implements a model-based clustering method for inferring population structure using genotype data of unlinked markers. This method demonstrates the presence of population structure, identifies distinct genetic populations and assigns individuals to populations or clusters without any prior information about geographical location. The notion of a genetic cluster is that individuals within the cluster share on average more similar allele frequencies to each other than to those in other clusters.

Analysis of koala population genotype data involved 5 replicates of K = 1 to K = 10 (K = genetic cluster) using 100,000 iterations with 100,000 iterations discarded as burn-in. The number of K clusters was determined using both the maximum likelihood and the deltaK method of Evanno *et al.* (2005).

Full details of DNA extraction and analysis are provided in Appendix B.

3.5 Crossing structure monitoring

3.5.1 Camera traps

Fourteen connectivity structures or underpasses (11 box culverts in sections 1-2; one single pipe, one twin pipe and one box culvert in section 10) were monitored for three months during spring/summer 2019 (Table 2). Underpasses monitored in sections 1-2 were as per year 2 except the combined culvert at chainage 7280 (formerly K2) was not monitored. This culvert features in threatened mammal monitoring and is not required for koala monitoring (refer Sandpiper 2019c).

Box culverts in sections 1-2 featured timber post-and-rail (fauna) furniture through their length (Plate 1). Underpass floor substrate varied and included concrete (Kweast1, Kweast2 and Kwmind), concrete and raised gravel path (K1, K7-K10), timber mulch on concrete floor (K2-K5 and K11) and a combination of gravel and loose soil (K6). Underpass lengths at highway sites ranged from 18m at the split median (K8 & K9) to 57m at K4 (Table 2). Underpasses on Wardell Road were 15m long.

Table 2: Location of koala dedicated box culverts monitored in sections 1-2 (K1-11) and 10 (KWeast1, KWeast2, KWmid). All culverts featured wooden post-and-rail structures. Regrade refers to the % of underpass entrance visible from the horizontal level of the surrounding natural ground which is indicative of the perspective of an approaching terrestrial mammal.

Site No.	Chainage	Sctn	Easting	Northing	Dimensions H x W (m)	Length (m)	Floor substrate	Regrade (% east/west)
K1	6890	1	515767	6681254	3 x 3	45	Raised gravel path & concrete	0/100
K2	8470	1	514567	6682196	3 x 3	51	Mulch on concrete	25/0
K3	8800	1	514201	6682384	3 x 3	50	Mulch on concrete	100/100
K4	11710	1	513204	6684852	3 x 3	57	Mulch on concrete	55/80
K5	12420	1	513062	6685536	3 x 3	52	Mulch on concrete	95/70
K6	17710	1	508804	6688587	3 x 3	57	Gravel and dirt	0/50
K7	19880	2	507098	6689798	3 x 3	52	Raised gravel path & concrete	100/15
K8	23110 (west)	2	506010	6692784	3 x 2.4	18	Raised gravel path & mulch on concrete	90/40
K9	23110 (east)	2	506057	6692791	3 x 2.4	18	Raised gravel path & mulch on concrete	0/60
K10	23750	2	505811	6693395	3 x 2.4	21	Raised gravel path & mulch on concrete	50/50
K11	25850	2	505317	6695401	3 x 3	27	Mulch on concrete	100/95
KWeast1	152500	10	543646	6798096	1 x 1050	15	Single cell concrete pipe	
KWeast2	152500	10	543646	6798096	2 x 1200	15	Twin cell concrete pipe	
KWmid	152547	10	543646	6798187	2.4 x 2.4	15	Concrete	

Plate 1: Box culverts monitored in sections 1-2 contained fauna furniture and some featured mulch spread over the concrete floor.

Underpasses were monitored with either Swift 3C or Swift Enduro cameras (*Outdoor Cameras Australia*) for three months during spring/summer 2019. For box culverts in sections 1-2, two cameras were mounted on the central post of the fauna furniture – one positioned to capture animals moving along the furniture and the other positioned approximately 400mm above ground level to capture animals moving along the floor (Plate 2). Both cameras were oriented east. For the culvert on Wardell Road, a camera was mounted at approximately 400mm above ground level and just inside the entrance of each end and oriented inwards (Plate 2). For pipes on Wardell Road, a camera was mounted to a tree or post within 5m of the entrance of each end (Plate 2). All cameras were contained in security cases with padlocks.

Cameras at sites K1-11 in sections 1-2 were installed on 10/9/2019 and retrieved on 17/12/2019. Cameras in section 10 (KWeast1, KWeast2 and KWmid) were installed on 26/9/2019 and retrieved 19/12/2019. Cameras were set on medium sensitivity and programmed to take 10 seconds of video on activation. They were scheduled to turn on at 1700hr and turn off at 0600hr. Cameras were inspected during the middle of the session to change batteries and SD cards. Cameras affected by false triggers were assessed and, if necessary re-oriented to reduce false triggers. All cameras were active for the full duration of the monitoring session except KWeast2 north camera which experienced early battery fatigue during the second half of the session due to false triggering caused by moving vegetation (Table 3).

Camera monitoring targeting threatened mammals was also undertaken at nine koala underpasses (i.e. K1, K2, K4, K5, K7-11) during autumn/winter 2019 (i.e. 02/05/2019 – 1/07/2019) and summer 2020 (i.e. 14/01/20 – 1/04/2020). Any koalas recorded during threatened mammal monitoring are reported on separately in the results section.

Plate 2: Typical underpass camera set-up: box culvert within sections 1-2 (A); Wardell Road box culvert – camera at each end (B); Wardell Road twin-pipe – camera at each end (C).

Table 3: Koala underpass camera monitoring effort during year 3. For Wardell Road underpasses, 'floor/rail' refers to 'north/south' camera. ^{P} = Pipe.

Site No.	Chainage	Section	No. of videos (floor/rail)	Days active (floor/rail)	% of period active (floor/rail)
K1	6890	1	253/354	98/98	100/100
K2	8470	1	132/211	98/98	100/100
K3	8800	1	112/291	98/98	100/100
K4	11710	1	65/33	98/98	100/100
K5	12420	1	181/194	98/98	100/100
K6	17710	1	140/79	98/98	100/100
K7	19880	1	69/73	98/98	100/100
K8	23110 (west)	2	137/379	98/98	100/100
K9	23110 (east)	2	198/191	98/98	100/100
K10	23750	2	100/129	98/98	100/100
K11	25850	2	293/58	98/98	100/100
KWe1^{P}	Wardell Rd	10	150/23	84/84	100/100
KWe2^{P}	Wardell Rd	10	987/34	49/84	58/100
KWmid	Wardell Rd	10	175/208	84/84	100/100

3.5.2 Camera image analysis

Camera images were uploaded to a desk top computer and viewed using Windows Photo Viewer. Data recorded included: site, date, time, species, number of images and image numbers. An ecologist reviewed all images, with reference to standard field guides (i.e. Menkhorst & Knight 2010; Menkhorst *et al.* 2017; Swan *et al.* 2004) and senior staff. A hierarchical approach was adopted for species identification which included: species, genus or group. Identification accuracy was scored as either definite (90%+ certainty), probable (75-90% certainty) or possible (60-75% certainty).

To determine the likelihood of a culvert crossing, footage was scored according to the following criteria:

- *Complete crossing* - animal demonstrates directional movement along floor/furniture and does not return within 10 minutes.
- *Incomplete crossing* – animal demonstrates directional movement along floor/furniture but returns within *10* minutes or exhibits no directional movement along floor/furniture.

According to these definitions, a 'complete crossing' is inferred from display of strong directional movement and no evidence of return movement. For pipes, where cameras are installed at either end of the structure, the absence of concurrent footage at the other end of the pipe is presumed to be an instance of detection evasion. These definitions are consistent with other underpass investigations (see Goldingay *et al.* 2019), including other Pacific Highway upgrade sites (see Sandpiper 2017, 2018, 2019d, 2019e).

Totals for complete crossings were converted to a per week value to control for variation in camera effort between sites. Data were summarized according to underpass, native or introduced species, introduced predators (i.e. cat, dog, fox), and compared between monitoring years.

3.5.3 Scat and scratch searches

Scat and scratch searches were conducted at each underpass on three occasions during the monitoring period. Searches involved scanning the culvert floor and habitat within 50m of each underpass entrance for koala scats, predator scats and scratches on trees. Search effort was equivalent to 15 person-minutes/side. Any predator scats collected were sent to a recognised hair analyst for identification of mammal prey species.

3.6 Road mortality surveys and fauna fence inspections

Koala road mortality surveys were undertaken on two occasions during spring/summer of 2019 (15-16/08/2019 and 22-25/10/2019). Whereas year 1 and 2 surveys involved walking along the side of the highway, year 3 surveys were changed to car-based to address safety concerns. Car-based surveys were conducted in the section 10 area along Wardell Road (Lumleys Lane to Thurgates Lane – 1.54 km); along the existing Pacific Highway (Carlyle Street to the Coolgardie interchange – 3.3 km) and along sections 1-2 (28.6 km).

Car-based surveys entailed a driver and passenger/observer travelling the length of the subject road in both directions. The survey vehicle featured a 'Vehicle Frequently Stopping' sign on the back and flashing light and travelled at 80-90 km/h in the left-hand lane. Surveys involved the passenger scanning the road surface and road shoulder for animal carcasses. When a carcass was observed, the vehicle would pull over at the nearest safe location and the passenger would walk back to inspect and identify the carcass from behind the guard rail/rope. The exact location of each carcass was recorded on a data sheet and referred to in subsequent surveys to avoid double-counting. Unidentified mammal carcasses were scored as either small (e.g. rodent, bat, glider, brush-tailed phascogale), medium (i.e. long-nosed potoroo, rufous bettong, bandicoot, cat, spotted-tail quoll, possum), large (i.e. wallaby, kangaroo, dog, fox)

A hair sample was collected from any unidentifiable carcass suspected of being a threatened mammal. Samples were sent to a recognised hair analyst for identification. Road mortality results were supplemented by other data sources including incidental observations from Sandpiper staff while traveling focal roads, RMS staff, construction personnel and road mortality reports from Lismore-based Friends of the Koala (FOK). It is intended that these data are captured on the W2B Project Wide Koala Observations database curated by Pacific Complete. The fauna fence was inspected for breaches during road mortality surveys and during installation/retrieval of underpass cameras.

4. Results

4.1 Population survey koala observations

4.1.1 Broadwater focal area

During spring 2019 surveys, two koalas were observed on transects during diurnal searches and three on transects during nocturnal searches (Table 4; Figure 5). Two observations were of females with large back young. No individuals were observed within radial plot areas. A further six koalas were observed incidentally off-transect while moving between sites. The body condition of individuals that could be viewed was generally good although the tail of one individual (sex undetermined) at site 38 was dirty, indicating probable cystitis.

During autumn 2020 surveys, two koalas were observed on transects during diurnal searches, one of which was also within a radial plot area (Table 4). During nocturnal surveys, five individuals were observed on transects, two of which were also within radial plot areas. A further four koalas were observed incidentally off-transect while moving between sites. The body condition of individuals that could be viewed was generally good although the tail of one individual (probable male) near site 31 was moderately dirty.

Full details of Broadwater koala observations are provided in Table C1, Appendix C.

Table 4: Broadwater focal area koala observations for year 3 population surveys in spring 2019 and autumn 2020. Includes baseline and year 1 & 2 observations (shaded).

Survey session (no. of transects surveyed)	Diurnal transect	Nocturnal transect	Diurnal radial	Nocturnal radial	Incidental
Baseline (54)	7	NA	1	NA	1
Yr.1 spring (52)	1	2	0	0	2
Yr.1 autumn (50)	4	4	1	1	8
Yr.2 spring (50)	1	1	0	0	11
Yr.2 autumn (50)	1	2	0	0	3
Yr.3 spring (50)	2	3	0	0	6
Yr.3 autumn (50)	2	5	1	2	4

Figure 5: Broadwater survey sites and location of koalas observed during spring 2019 and autumn 2020 surveys.

4.1.2 Bagotville focal area

During spring 2019 surveys, six koalas were observed on transects during diurnal searches, one of which was also within a radial plot area (Table 5, Figure 6). During nocturnal surveys, five individuals were observed on transects and none within radial plot areas. One female was observed with a large back-young. A further six koalas were observed incidentally off-transect while moving between sites. The body condition of individuals' that could be viewed was generally good except three individuals (sites 34, 73 and near site 20) featured dirty tails, including one with evidence of conjunctivitis.

The 470-ha wildfire in the Ngunya Jargoon IPA area burnt out 30-100% (median = 80%) of 15 transects, including all or part of the upper canopy of 12 transects (Figure 7). No koalas or koala carcasses were observed within the recently burnt areas. Individual koalas were observed on unburnt sections of two transects (sites 71 and 33) where 40-80% of the remaining transect vegetation was burnt. Body condition of both individuals appeared good and neither showed evidence of burns. Friends of the Koala (FOK) reported one confirmed koala death directly attributed to the wildfire and a further three possible deaths (M. Mathes, pers. comm.).

During autumn 2020 surveys, five koalas were observed on transects during diurnal searches and four during night searches, including within habitat regenerating after the spring bushfire (Table 5). No individuals were observed within radial plot areas. A further three koalas were observed incidentally off-transect while moving between sites. The body condition of individuals that could be viewed was generally good except six individuals (sites 20, 34, 73, 74 and near sites 3, 10) featured dirty tails, including one with evidence of conjunctivitis.

Full details of Bagotville koala observations are provided in Table C2, Appendix C.

Table 5: Bagotville focal area koala observations for year 3 population surveys in spring 2019 and autumn 2020. Includes baseline and year 1 & 2 observations (shaded).

Survey session (no. of transects surveyed)	Diurnal transect	Nocturnal transect	Diurnal radial	Nocturnal radial	Incidental
Baseline (46)	3	NA	NA	NA	5
Baseline (42)	NA	NA	1	NA	?
Yr.1 spring (43)	2	3	0	0	5
Yr.1 autumn (50)	5	5	1	1	8
Yr.2 spring (50)	3	5	1	2	4
Yr.2 autumn (50)	3	3	0	0	3
Yr.3 spring (50)	6	5	1	0	6
Yr.3 autumn (50)	5	4	0	0	3

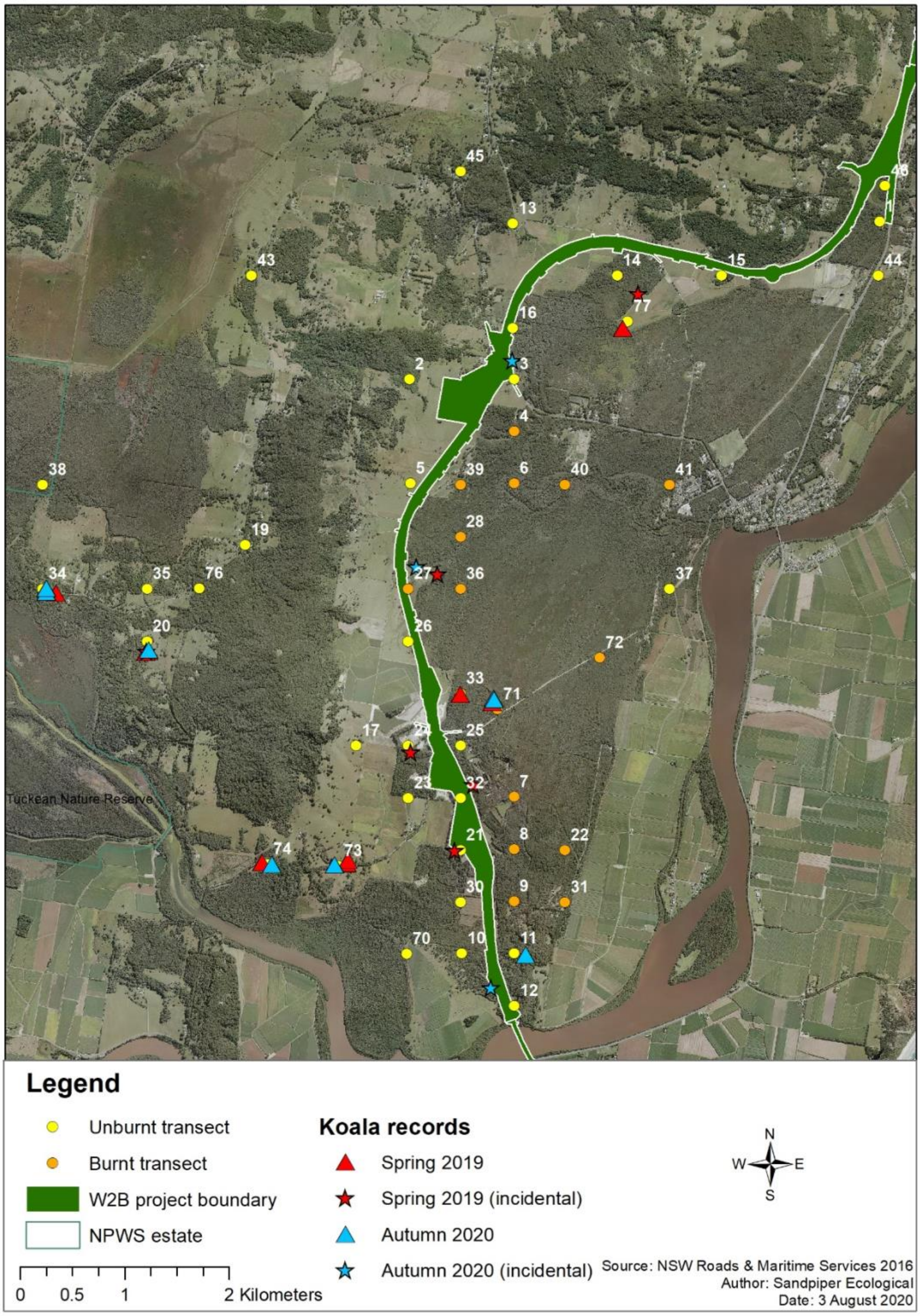

Figure 6: Bagotville survey sites and location of koalas observed during spring 2019 and autumn 2020 surveys including sites that were burnt during the spring 2019 wildfire.

4.2 Koala density, population size estimate and trend estimate

4.2.1 Broadwater

Based on the Bayesian estimation analysis, the density estimate for spring 2019 was 0.064 koalas ha^{-1} (95%CI: 0.041-0.096) and autumn 2020 was 0.064 koalas ha^{-1} (95%CI: 0.041-0.097). Overall, the Year 3 density estimate for Broadwater was 0.064 koalas ha^{-1} (95%CI: 0.041-0.096). This compares to a modelled baseline density estimate of 0.067 (95%CI: 0.044-0.095) koalas ha^{-1} (Figure 7).

The estimated trend in density estimates at Broadwater was a 1.6%/year decline (SE: 0.037; 95%CI -0.105-0.048) with a 0.628 posterior probability of a decline. The hypothesis-testing posterior odds ratio (Bayes Factor) was 1.172, which is slight evidence of a decline. However, according to conventional categories, a value of 1.172 is considered 'barely worth mentioning' (Jeffreys 1961; Kass & Raftery 1995).

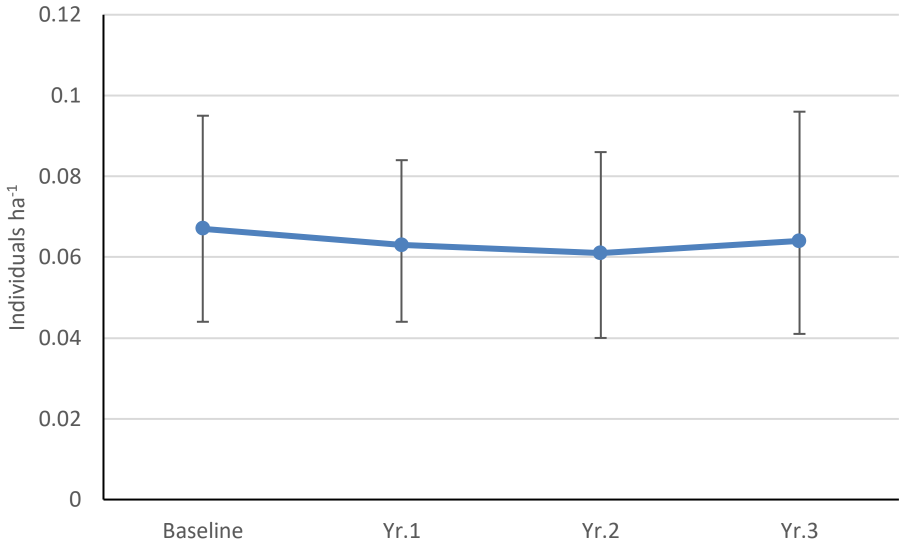

Figure 7: Comparison of Broadwater focal area density estimates (± 95%CI) for the modelled baseline and monitoring years.

4.2.2 Bagotville

Based on the Bayesian estimation analysis, the density estimate at Bagotville for spring 2019 was 0.076 koalas ha^{-1} (95%CI: 0.050-0.111) and for autumn 2020 was 0.077 koalas ha^{-1} (95%CI: 0.050-0.111). The overall Year 3 density estimate was 0.077 koalas ha^{-1} (95%CI: 0.050-0.111). This compares to a modelled baseline density estimate of 0.076 (95%CI: 0.053-0.103) koalas ha^{-1} (Figure 8).The estimated trend in density estimates at Bagotville was a 0.1%/year increase (SE: 0.029; 95%CI -0.068-0.073) with a 0.486 posterior probability of a decline. The hypothesis-testing posterior odds ratio (Bayes Factor) was 0.847, which is slight evidence against a decline. However, according to conventional categories, a value of 0.847 is considered 'barely worth mentioning' (Jeffreys 1961; Kass & Raftery 1995).

Extrapolated population size estimate for year 3 overall was 198 koalas (95%CI: 128-284) across 2,135 ha of preferred koala habitat (Figure 9). This compares to a modelled extrapolated baseline population estimate of 197 koalas (95%CI: 137-267) across 2,152 ha.

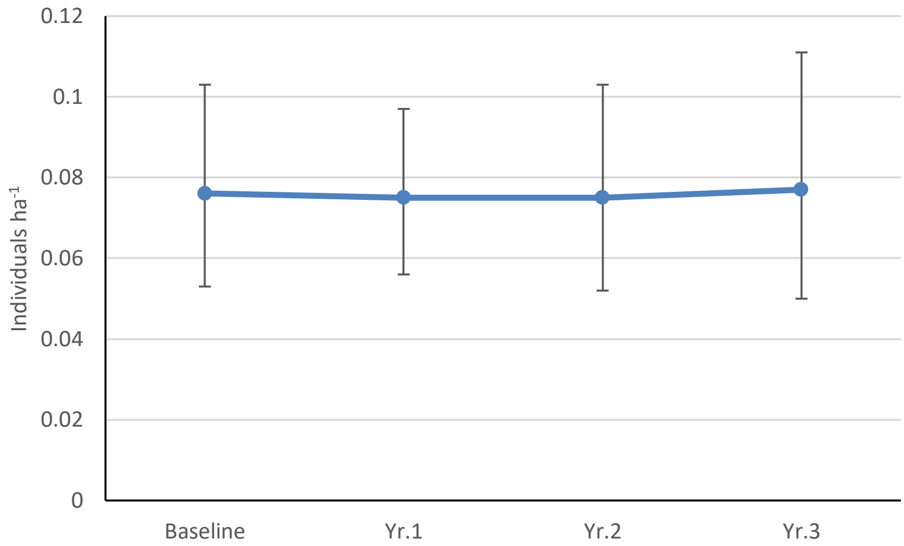

Figure 8: Comparison of Bagotville focal area density estimates (± 95%CI) for the modelled baseline and monitoring years.

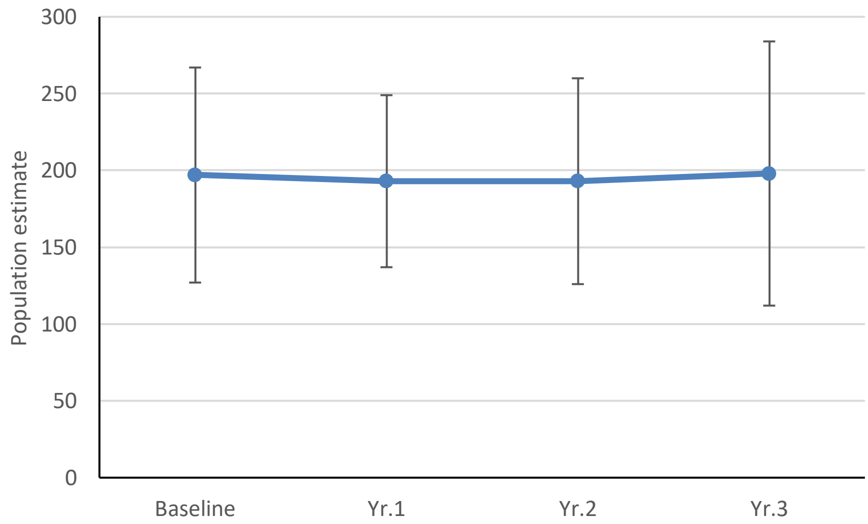

Figure 9: Comparison of Bagotville focal area population estimates (± 95%CI) for the modelled baseline and monitoring years. Population estimates are based on 2152 ha (baseline) and 2135 ha (monitoring years) of preferred koala habitat, as informed by the PVA (Kavanagh 2016).

4.3 Power analysis

For a maximum Type-I error rate of 0.3, the estimated power at Bagotville and Broadwater was 0.695 and 0.661, respectively (Figure 10). For a maximum Type-I error rate of 0.35, the estimated power for Bagotville and Broadwater were 0.731 and 0.7, respectively.

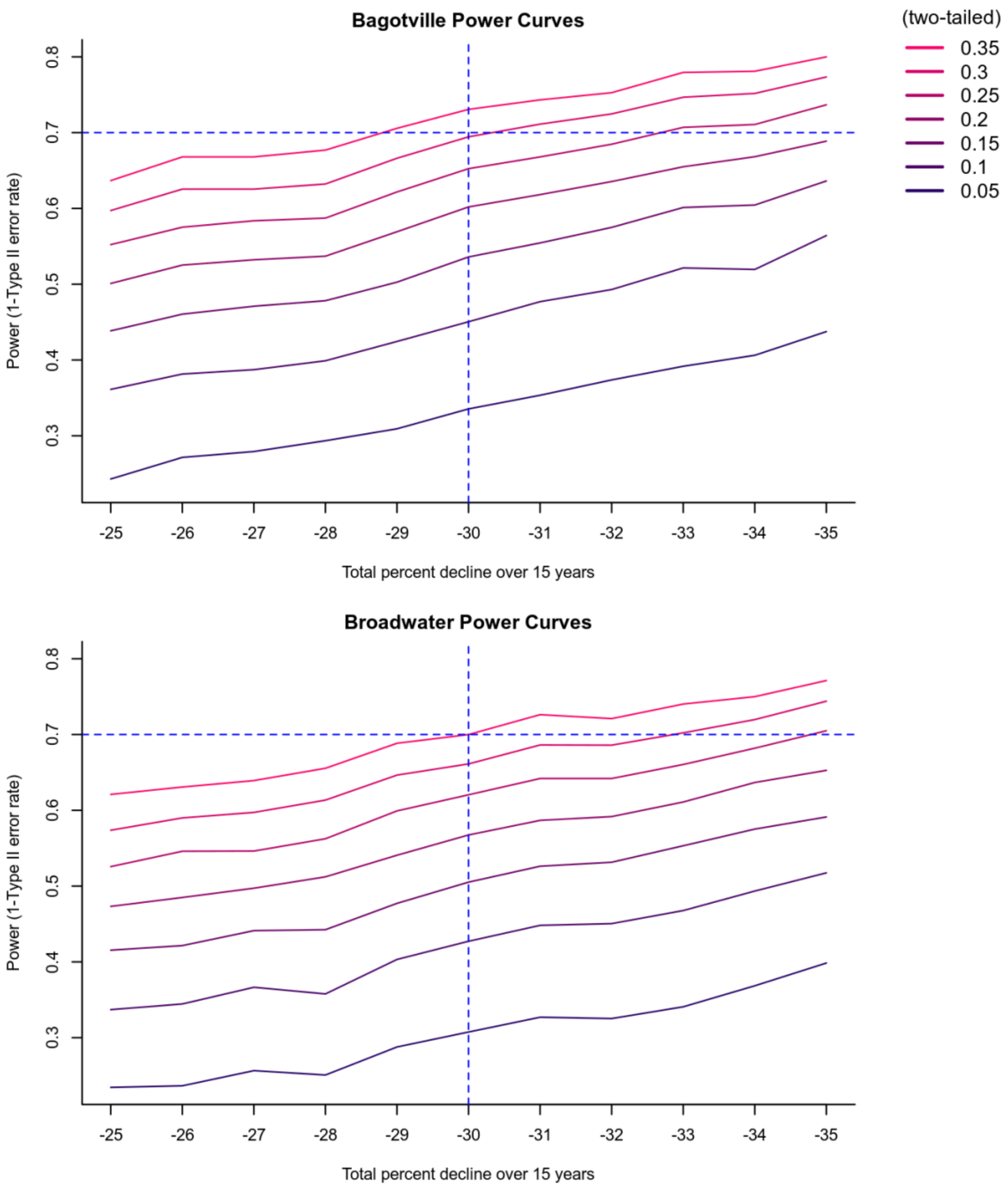

Figure 10: Statistical power to detect a 30% decline in baseline densities over a 15 year monitoring period for different maximum levels of Type-I errors (lines).

4.4 DNA extraction and analysis

4.4.1 Genetic diversity

Genetic diversity values were determined and compared with values derived from 2017/18 surveys (Table 6). The comparison showed there has been a reduction in genetic diversity as shown by a reduction in allelic diversity and subsequent decrease in expected heterozygosity between 2017/18 and 2019/20. However, there has been a significant reduction in inbreeding over the same period which suggests sufficient gene flow is occurring both within and between local koala populations, possibly including koalas outside the survey area.

Table 6: Genetic diversity statistics representing 2017/18 and 2019/20 Bagotville population based on 30 loci. Allelic richness, which is the number of alleles per locus corrected for sample size to enable comparison among populations, was estimated for n=11. N: Number of individuals sampled; A_{mean}: Mean number of alleles per locus; A_r: Allelic richness; H_o: Observed heterozygosity; H_e: Expected heterozygosity; F_{IS}: Inbreeding coefficient - the proportion of variance in a population that is contained within an individual; F_{IS} >0 indicates high levels of homozygosity and can suggest inbreeding.

Population	N	A_{mean}	A_r	F_{IS}	H_o	H_e
2017/18	19	8.2	7.57	0.214	0.571	0.726
2019/20	22	6.86	6.10	0.179	0.552	0.659

4.4.2 Genetic differentiation

There was weak differentiation between the 2019/20 and 2017/18 samples of the Bagotville population which indicates that gene flow is still occurring amongst koala populations within the range of the study area (Table 8). There is moderate differentiation between the Bagotville population and some close, regional populations (e.g. Tweed, Gold Coast) and strong differentiation between Bagotville and more distant regional Queensland populations, such as Oakey and St Bees (Table 7).

Table 7: Pairwise F_{ST} values between the Bagotville population and regional koala populations. <0.05 = weak genetic differentiation; 0.05-0.15 = moderate genetic differentiation; 0.15-0.25 = strong genetic differentiation; >0.25 = very strong genetic differentiation.

	Bagot 2017/18	Byron Bay	Lismore	Tweed	Hidden Vale	Sunshine Coast	Gold Coast	Clark Connors	Mt Byron	Oakey	St Bees	Yarrabilba
Bagotville 2019/20	0.044	0.120	0.108	0.072	0.096	0.078	0.082	0.153	0.148	0.172	0.214	0.093
Bagotville 2017/18		0.100	0.084	0.053	0.063	0.050	0.051	0.128	0.127	0.139	0.183	0.067
Byron Bay			0.058	0.066	0.108	0.121	0.072	0.102	0.095	0.120	0.158	0.065
Lismore				0.049	0.080	0.091	0.054	0.074	0.052	0.081	0.126	0.062
Tweed					0.038	0.063	0.021	0.091	0.082	0.090	0.142	0.052
Hidden Vale, QLD						0.048	0.024	0.126	0.125	0.164	0.198	0.081
Sunshine Coast, QLD							0.041	0.141	0.134	0.165	0.200	0.094
Gold Coast, QLD								0.089	0.098	0.108	0.165	0.054
Clark Connors, QLD									0.091	0.100	0.075	0.092
Mt Byron, QLD										0.071	0.155	0.084
Oakey, QLD											0.172	0.105
St Bees, QLD												0.156

4.4.3 Genetic relatedness

Genetic relatedness estimates revealed a wide distribution in relatedness values between koalas for both survey periods (Figure 12). The koala population for each collection period showed a mean relatedness that was higher than the confidence intervals, suggesting that koalas are significantly more related than expected.

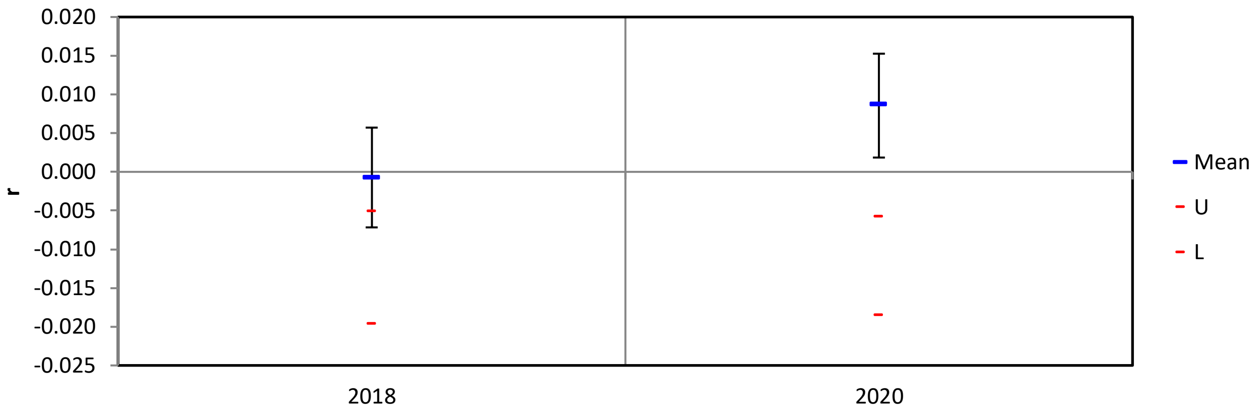

Figure 11. Mean genetic relatedness for the Bagotville population for the two sample periods. The red lines indicate the upper (U) and lower (L) 95% confidence interval expected for that population under the null hypothesis of no difference among populations; r = relatedness.

4.4.3 Population structure

STRUCTURE analysis identified three genetic clusters of koalas within the 2019/20 samples (K = 3, Figure 13) compared to two genetic clusters for the 2017/18 samples (K = 2, Figure 14). Identification of an additional genetic cluster within the 2019/20 samples is evidence of gene flow occurring between sub-populations. Figure 15 shows each scat sample location represented by a pie chart, which details that individual's proportional assignment to each of the clusters from the STRUCTURE analysis. Clusters are shown by colour and koalas are shown at their scat sample location. The clusters do not define the Bagotville koalas into genetically distinct sub-populations within the study area, providing further evidence of gene flow occurring between the sub-populations.

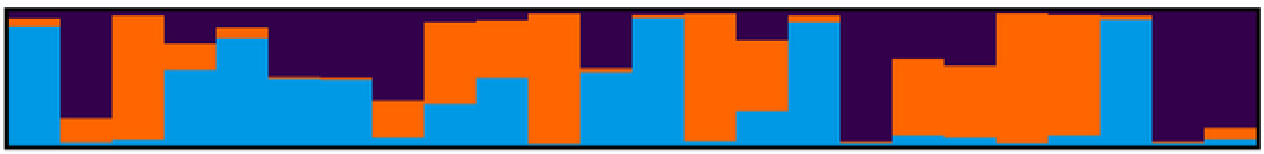

Figure 12. Population substructure of 2019/20 Bagotville population using STRUCTURE based on 30 loci (K = 3). Each bar represents an individual koala and colours indicate the proportion of the population cluster to which an individual was assigned.

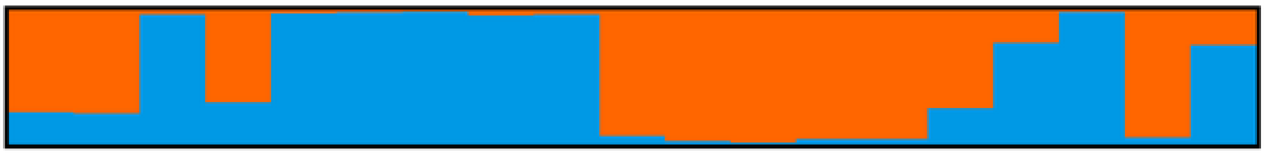

Figure 13. Population substructure of 2017/18 Bagotville population using STRUCTURE based on 30 loci (K = 2). Each bar represents an individual koala and colours indicate the proportion of the population cluster to which an individual was assigned.

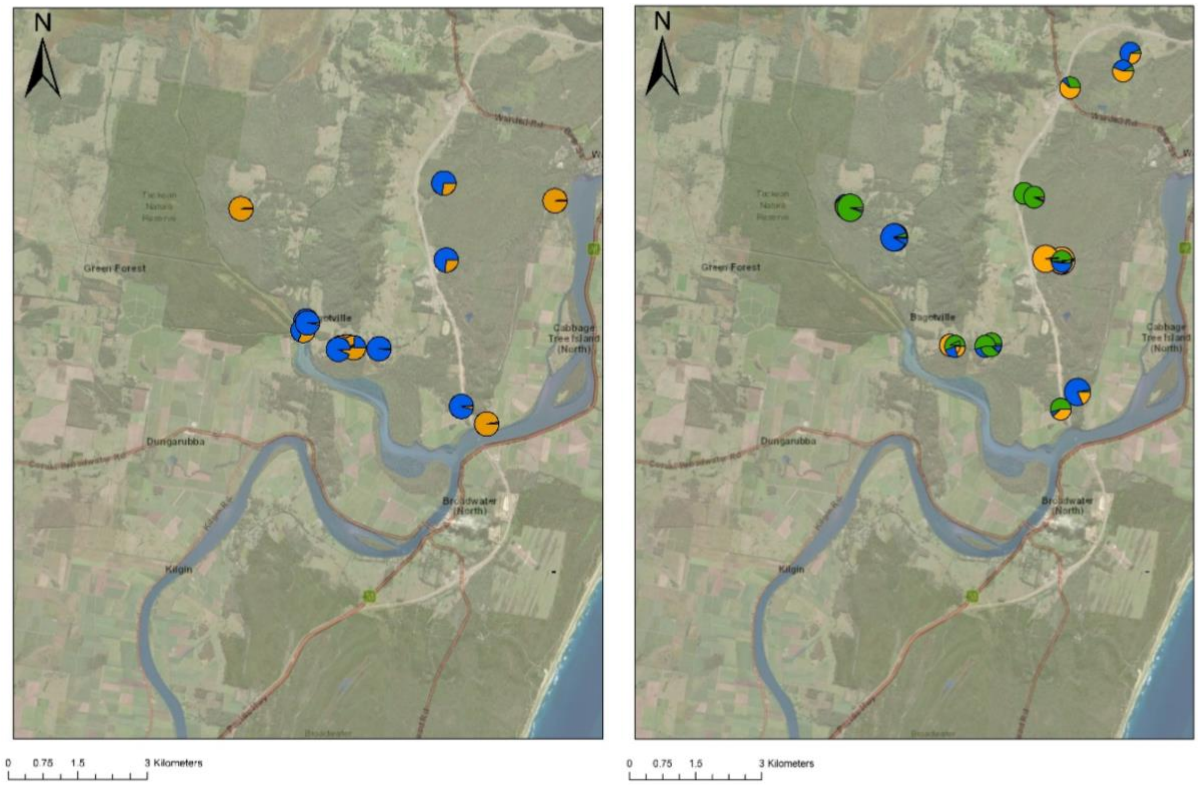

Figure 14. Inferred cluster assignments of 2017/18 (left) and 2019/20 (right) Bagotville koala scat samples. Each koala is represented by a pie chart, which details that individual's proportional assignment to each of the clusters from the STRUCTURE analysis (Figures 14 and 15), where clusters are shown by colour.

4.5 Crossings structure monitoring

4.5.1 Camera traps

Fauna crossings

Twenty species and nine fauna groups were confirmed using koala underpasses during the spring/summer monitoring period (Table 8). Overall, 46.51 fauna detections/week (i.e. sum of complete (cc) and incomplete (ic) crossings/week) were recorded with the majority of detections (90.8%) being complete crossings (42.21cc/week) at a rate of 3.07 ± 2.88cc/week/underpass (Table 8). Native species accounted for the majority of complete crossings at all underpasses except K1 which was dominated by black rat *Rattus rattus* (Table 8). Complete crossings that could be assigned to native taxa (i.e. excluding rodent spp., small mammal spp., and *Rattus* spp. because they include native and/or introduced species) were highest at culverts K8 (5.82cc/week), K3 (5.14cc/week) and K2 (2.93cc/week) (Figure 15). Pipe structures at Wardell (KWe1 and KWe2) recorded the lowest use by native fauna with <0.25cc/week (Figure 15). *Antechinus* spp. was the most frequently detected species/fauna group. It was recorded in 10 of the 14 underpasses at an overall rate of 17cc/week (Table 8).

An adult koala was recorded making a complete northward crossing at the Wardell Road culvert (KWmid) on three occasions (9/10/2019, 29/10/2019 and 8/12/2019) during the monitoring period (Plate 3). Colouration of the hind pelage suggest it may be same individual. Sex could not be determined but it did not show obvious signs of cystitis (i.e. wet/stained rump).

Other threatened species detected included long-nosed potoroo *Potorous tridactylus* and rufous bettong *Aepyprymnus rufescens* (Table 8). Long-nosed potoroo was recorded making 14 complete crossings and one incomplete crossing at the Wardell Road culvert with one individual featuring a pouch young (Plate 4). Rufous bettong was recorded making three complete crossings and one incomplete crossing at K8 and two complete crossings at K9. No koalas were recorded during threatened mammal underpass monitoring in sections 1-2 during autumn/winter 2019 and summer 2020.

Full details of underpass camera detections are provided in Table D1, Appendix D.

Introduced predator activity

Introduced predators were recorded at 12 of the 14 koala underpasses at an average rate of 0.29 ± 0.20cc/week/underpass (Table 8; Figure 15). Cat *Felis cattus* was recorded at nine of the 14 sites whereas fox *Vulpes vulpes* and dog *Canis lupus familiaris* were only each recorded at three sites (i.e. K6, K7, KWmid and K1, K2, K6, respectively) (Table 8). Fox recorded the highest detection rate of 0.11 ± 0.28cc/week/underpass with most crossings occurring at K6 (Figure 16; Table 8). Cat and dog each recorded similar detection rates of 0.09 ± 0.11 and 0.09 ± 0.30cc/week/underpass, respectively (Figure 16). Introduced predator activity was not recorded at K9 or K10. No footage showed evidence of predation and no evidence of predation was observed during scat and scratch searches.

Overall, the mean number of introduced predator cc/week/underpass has increased from 0.17 ± 0.20 to 0.29 ± 0.37cc/week/underpass between year 1 and year 2, an increase of 70.6% (Figure 17). In particular, the mean number of fox and dog cc/week/underpass increased substantially between year 1 and year 2 (Figure 16). The increase in crossings was most pronounced at sites K6 and K7 (fox) and K1 (dog) (Table 11). Complete crossings by cat decreased from 0.15 ± 0.20 to 0.09 ± 0.11 cc/week/underpass between year 1 and year 2 (Figure 16).

Table 8: Number of complete and incomplete crossings/week by mammals at 14 koala underpasses during spring/summer 2019. Floor and fauna furniture crossings have been pooled. KW=Wardell Rd structure; C = complete crossing/week; I = incomplete crossing/week; P = present within structure; ^{P} = pipe structure; * = includes native &/or introduced species. ** = introduced species. Threatened species in bold.

Species/group	Site and crossing type																													
	K1		K2		K3		K4		K5		K6		K7		K8		K9		K10		K11		KWe1^{P}		KWe2^{P}		KWmid		Total	Total
	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I
Short-beaked echidna			0.14		0.18				0.04				0.07														0.21		0.64	
Antechinus spp.	0.64	0.14	2.68	0.11	3.00	0.86	0.75		1.79				0.25	0.04	5.39		1.86	0.43	0.46	0.07	0.18								17.00	1.64
Northern brown bandicoot	0.07	0.04			0.18				0.07		0.04				0.07		0.04	0.07											0.46	0.11
Long-nosed bandicoot					0.04																0.04	0.04							0.07	0.04
Bandicoot spp.	0.61	0.07	0.04		1.14				0.54		0.14				0.07		0.14	0.04			0.21	0.04							2.89	0.14
Koala																											0.13		0.13	
Short-eared b'tail possum			0.04		0.25						0.04										0.04		0.04				0.13		0.52	
Common brushtail possum							0.82	0.04																					0.82	0.04
Brushtail possum spp.					0.29		0.04		0.04		0.07										0.04		0.08	0.08					0.55	0.08
Common ringtail possum																							0.13	0.04					0.13	0.04
Long-nosed potoroo																											0.58	0.04	0.58	0.04
Rufous bettong															0.04		0.07												0.11	
Swamp wallaby							0.07										0.07							0.13		0.05	1.67	0.13	1.81	0.30
Red-necked wallaby		0.04					0.04		0.04								0.04			0.04									0.11	0.07
Wallaby spp.	0.04						0.04		0.07						0.25		0.32										0.08	0.04	0.80	0.04
Eastern grey kangaroo	0.14										0.32	0.04							0.04										0.50	0.04
Large macropod spp.	0.14						0.04						0.04																0.21	
Microbat spp.	P		P		P		P				P		P		P		P		P		P									
Bush rat	0.07		0.04	0.04	0.07																								0.18	0.04
Rattus spp*	0.39				0.04												0.18					0.04							0.61	0.04
Rodent spp*	0.04		0.07		0.04				0.04								0.11	0.04											0.29	0.04
Small mammal spp*	0.14		0.07		0.11		0.04						0.04				0.11												0.50	
House mouse**	0.11								0.14								0.11				0.04								0.39	
Black rat**	6.71	0.71	0.18	0.07	1.14	0.32			0.21	0.07	0.04			0.04					0.04	0.04	0.29	0.11							8.61	1.36
Dog**	1.18		0.04								0.04																		1.25	
Fox**											1.00		0.43	0.04													0.08		1.51	0.04
Cat**			0.07		0.11		0.32		0.04						0.04						0.04		0.25	0.08	0.16	0.21	0.29	0.04	1.31	0.34
European Hare**									0.11		0.14																		0.25	
Total																													**42.21**	**4.41**

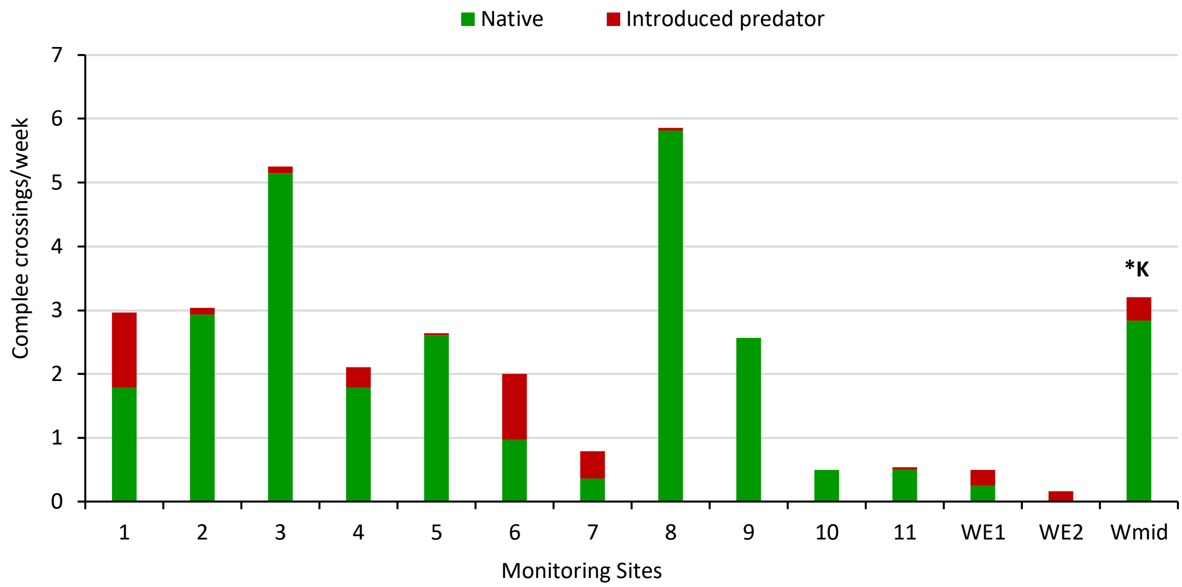

Figure 15. Complete crossings per week by native fauna and introduced predators (cat, dog, fox). ***K** = complete crossing by koala. Graph does not include taxa groups that include both native and/or introduced species (i.e. rodent spp., small mammal, and rattus spp.).

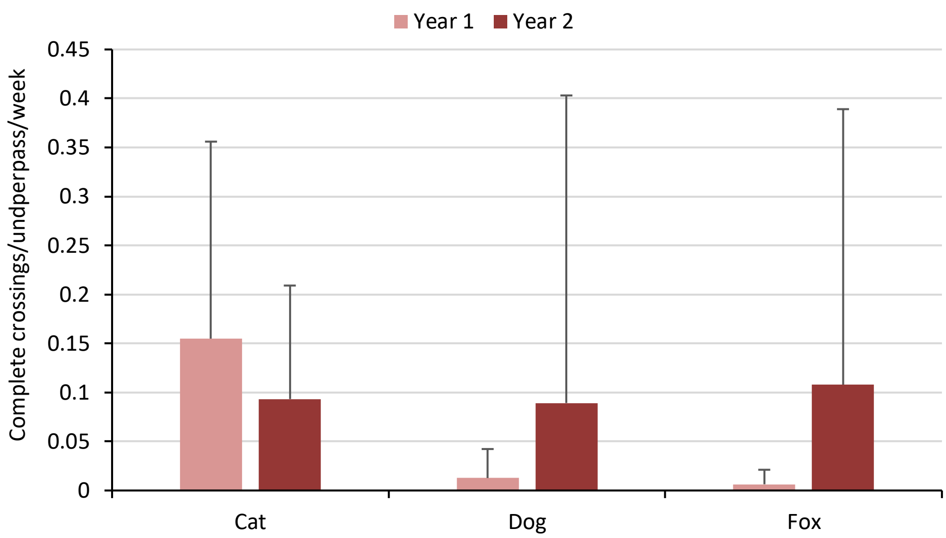

Figure 16. Mean (+SD) number of complete crossings/underpass/week for introduced predators during year 1 (2018) and year 2 (2019).

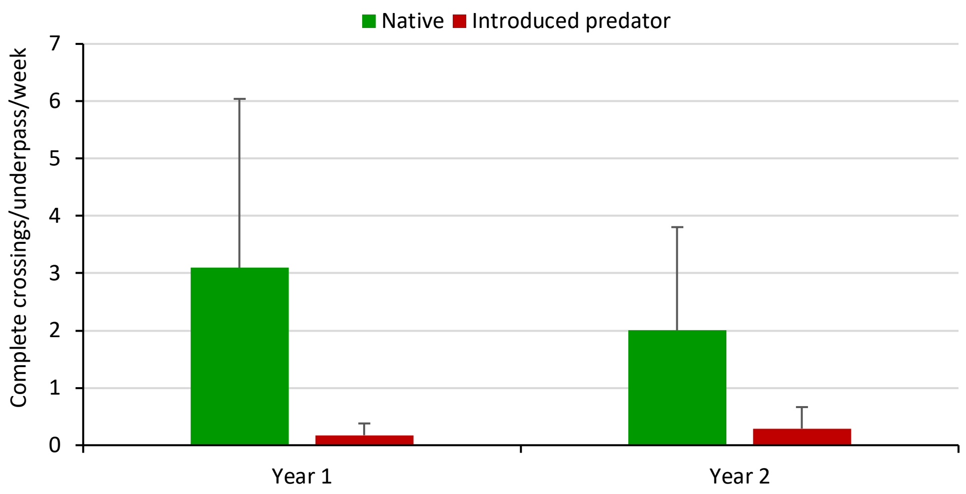

Figure 17. Mean (± SD) number of complete crossings/underpass/week for native species and introduced predator species (cat, dog, fox) during year 1 (2018) and year 2 (2019). Graph does not include taxa groups that include both native and/or introduced species (i.e. rodent spp., small mammal, and rattus spp.).

Plate 3: A koala was recorded making three crossings of the KWmid underpass, including a northward crossing on 29 October 2019.

Plate 4: Long-nosed potoroo were recorded making crossings of the KWmid underpass, including a female with pouch young.

4.5.2 Scat, track and scratch searches

Seven species and seven fauna groups were recorded during scat/track and scratch searches (Table 9). Old koala scats were found on the eastern and western sides of the Wardell Road pipe and culvert structures (i.e. KWe1, Kwe2, KWmid). Dog tracks were recorded in the Wardell Road culvert (i.e. KWmid) where cameras detected koala crossings.

Table 9: Scat/track (S/T) and scratch (Scr) records from three searches during the period of camera monitoring. W=Wardell; [P] = pipe structure, x = track or scat record * = scratch record.

Species/group	K1		K2		K3		K4		K5		K6		K7		K8		K9		K10		K11		KWe1[P]/ KWe2[P]		KWmid	
	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr	S/T	Scr
Antechinus spp.	X		X		X		X						X		X		X				X					
Bandicoot spp.									X		X															
Koala																							**X**		**X**	
Brushtail possum spp.	X								X				X													
Wallaby spp.	X		X		X		X		X		X		X		X		X		X				X		X	
Microbat spp.	X																									
Rodent spp.	X		X																							
Fox									X																	
Dog																									X	
Horse																					X					
Lace monitor		*				*		*			X			*		*		*							X	
Eastern water dragon											X															
Small bird spp.											X															

4.6 Road mortality surveys and fauna fence condition

4.6.1 Road mortality

Road mortality surveys detected 22 individuals representing 15 species/taxa groups at a rate of 0.33 individuals/km (Table 10). No koalas were recorded during the surveys. One koala road mortality was recorded in the Project Wide Koala Observations Register curated by Pacific Complete during the reporting period. It occurred on 25/1/2020 along Broadwater-Evans Head Road, approximately 110m east of the project boundary.

Mammals were the most frequently recorded taxa (n = 16), followed by birds (n = 4), and reptiles (n = 2). Swamp wallaby and common ringtail possum were the most frequently recorded species (two casualties each). Medium mammals recorded on sections 1-2 were not suspected to be threatened mammals (Table 10). Road-kill rates were highest along the Old Pacific Highway (1.06 individuals/km) followed by sections 1-2 (0.26 individuals/km). No road mortalities were reported along Wardell Road (Table 10).

Full details of road mortality surveys are provided in Table E1, Appendix E.

Table 10: Fauna road mortalities recorded during two surveys conducted in spring/summer 2019. Records are pooled for the two surveys.

Location (survey distance)	Fauna recorded	Number of roadkill	Roadkill/km
Wardell Road (1.54 km)	Nil	0	0
Old pacific highway (3.3 km)	Commmon ringtail possum x 2 Macropod spp. Black flying-fox Common tree snake Wood duck Tawny frogmouth	7	1.06
Sections 1-2 (28.6 km)	Swamp wallaby x2 Eastern grey kangaroo Northern brown bandicoot Medium mammal x5 Grey-headed flying-fox Cat Hare Carpet python Tawny frogmouth Unid. bird	15	0.26
Total (33.44 km)		**22**	**0.33**

4.6.2 Fauna fence

No detectable breaches were observed in fauna fence on Wardell Road, old Pacific Highway or along sections 1-2.

5. Discussion

5.1 Koala population surveys

5.1.1 Koala counts, density estimates and trend estimates

Broadwater

Counts of koalas in Broadwater focal area during year 3 were similar to levels recorded in year 1 and higher than those recorded during year 2. Despite the upturn, levels remain below those recorded during baseline surveys although survey effort was greater during the baseline period. Bayesian modelling of density, which largely controls for differences in survey effort between survey periods, confirmed this upward trend from year 2 to year 3 (i.e. from 0.061 koalas ha^{-1} (95%CI: 0.040-0.086) to 0.064 koalas ha^{-1} (95%CI: 0.041-0.096)) compared with the modelled baseline estimate (0.067 (95%CI: 0.044-0.095) koalas ha^{-1}).

An effect of the increase in density estimates between year 2 and year 3 was to reduce the magnitude of the estimated decline from -41.6%/year (year 2) to -1.6%/year (year 3). The inclusion of year 3 data also reduced the strength of evidence for a downward trend from an odds ratio/Bayes Factor of 31.82 in year 2, which is 'very strong', to an odds ratio of 1.172 in year 3, which is conventionally regarded as 'barely worth mentioning' (Jeffreys 1961; Kass & Raftery 1995).

Bagotville

Compared with Broadwater, counts for the Bagotville focal area have been relatively consistent across the survey periods. Density estimates rose marginally from year 2 (0.075 (95%CI: 0.052-0.103) to year 3 (0.077 (95%CI: 0.050-0.111) koalas ha^{-1}) and were above the modelled baseline estimate (i.e. 0.076 (95%CI: 0.053-0.103) koalas ha^{-1}).

The inclusion of year 3 data reinforced the largely flat trend in density estimates at Bagotville. The trend estimate at year 2 was -0.4%/year compared with 0.1%/year at year 3 with little or no evidence of a significant trend in either year. Similarly, the posterior odds ratio/Bayes Factor was 0.809 (year 2) and 0.847 (year 3), which are conventionally regarded as 'barely worth mentioning' (Jeffreys 1961; Kass & Raftery 1995). However, the credibility intervals of the density estimates are still very high which suggests that the absence of evidence against a trend is not necessarily evidence that there is no trend.

5.1.2 Power analysis

The current update to the prospective power analysis suggests that Bagotville is within a rounding error of the 0.70 target, while Broadwater is marginally below its target with an estimated power of 0.661. These values are similar to previous estimates. The power analysis relies heavily on the empirical estimates from the other analyses which, given the high uncertainty in the density estimates and covariate-effects, are likely contributing to a persistent inability to gain high statistical power.

5.1.3 Statistical uncertainty

Overall, there is a high level of uncertainty about the system (including sparse koala counts and uncertain estimates) which makes it difficult to resolve hypotheses and produce definitive statistical statements. This uncertainty has manifested in several analyses, such as high credibility-intervals in density estimates, weakening odds-ratios/Bayes Factors for hypotheses tests, and a slight decline in statistical power at

Broadwater. More years of data-collection will alleviate this problem, however additional within-season sampling may be required to produce the requisite power and clarity.

Interestingly, the current year experienced a slight increase in koala counts and empirical densities largely due to two observations of koalas on radial plots. This is important because koala detections on radial plots have occurred infrequently. Most detections to date have occurred on line-transects which feature a larger survey area. A consequence of rare-counts on small-area radial plots is that densities derived from such encounters will be much higher than the encounters on line-transects (i.e., a small denominator results in a high density values).

Considering that the statistical models are sensitive to density, rather than absolute counts, this years' estimates may be somewhat inflated as compared to data from other years. However, sampling effects should become less apparent over time which is why wildlife populations that experience large variations over time require longer time frames to detect meaningful trends (Krebs 2009). Such large temporal variations (and possible sampling effects) are apparent at Bagotville where baseline density estimates derived from 2013 and 2015 surveys varied by 42% (Phillips and Chang 2013; Phillips *et al.* 2015).

5.1.4 Catastrophic events and other exogenous factors

As with any long-term population monitoring program, the focal koala populations may be affected by a range of catastrophic events and exogenous factors outside of the control of the upgrade project. The wildfire that burnt through approximately 470 ha of the Ngunya Jargoon IPA was one such catastrophic event. It follows on from a wildfire in the eastern part of the Ngunya Jargoon IPA that burnt out 350 ha in September 2017. The PVA modelling for Bagotville estimated catastrophic fire events at a frequency of once every 35 years with each event encompassing only 10% (i.e. 215 ha) of the 2152 ha study area (Kavanagh 2016). However, within the first three years of the monitoring program wildfire has occurred twice and encompassed 16-22% of the study area. This suggests that the frequency and extent of wildfire modelled in the PVA may have been underestimated.

The other 'catastrophe' input in the PVA is drought (Kavanagh 2016). Drought is modelled to occur at a frequency of every 4-5 years. Records from the closest long-term weather station (i.e. Bureau of Meteorology Weather Station No. 58171, Meerschaum Vale) show that for the three reporting years of the monitoring program (i.e. July 2017 to June 2020) annual rainfall totals have been 16.4% - 21.8% below average. Moreover, the calendar year of 2019 was 44.2% below average and the later half of 2019 was by Bureau of Meteorology definitions a serious to severe drought. It was also the lowest annual rainfall total on record (since records began in 1977). Further monitoring years will be required to determine the veracity of PVA drought predictions.

Other exogenous factors may include local land development, clearing activities, euthanasia of diseased individuals, and the emergence of other diseases and/or pathogens. One such pathogen – myrtle rust – was observed in and around site 14 during autumn 2020 surveys. Myrtle rust is a fungal pathogen which infects plants in the Myrtaceae family, which includes plants of the genus *Eucalyptus* (DPI NSW 2015). The potential impact on koalas would primarily be the loss of food resources within infected areas. Infestations were not observed at other sites. To reduce the risk of spreading myrtle rust the site 14 transect will be shifted from the infestation area in subsequent surveys.

Predation by wild and domestic dogs is another well-known threat to koala persistence (e.g. Lunney *et al.* 2007, Gentle *et al.* 2019). A predator control program continued to operate within lands surrounding section 10 during the reporting year. The predator management, which was instigated by RMS at the start of the monitoring program, has resulted in removal of 22 wild dogs and foxes which should reduce the predation risk for koalas residing within and near section 10 (S. Wilson, pers. comm.).

5.2 DNA analysis

Genetic analysis of the 2019/20 scat samples revealed a decrease in diversity of the population compared with 2017/18 samples with a loss of alleles over time, possibly indicative of genetic drift within the population. However, the population still remains moderately diverse when compared to similar studies (e.g. Lee *et al.* 2010) and showed a significant reduction in inbreeding which is reflected in the wide distribution of relatedness values in the population. Two previous genetic studies within the focal area have similarly reported moderate levels of genetic diversity and negligible levels of inbreeding (Norman *et al.,* 2015; Neaves *et al.* 2015). Analysis with distant regional koala populations revealed moderate to strong genetic differentiation which is to be expected given the geographical distances between the populations.

Current analyses also demonstrate genetic sub-structuring into three distinct genetic clusters within the population, indicating an increase of gene flow within the population. This compares with 2017/18 results which indicated that two distinct sub-populations were present. Indeed, the increase in gene flow and absence of cluster segregation suggests that the highway upgrade corridor is not inhibiting east to west movement across the focal area. This result also corroborates with earlier genetic studies that similarly reported gene flow across the focal area (Norman *et al.,* 2015; Neaves *et al.* 2015).

5.23 Use of crossing structures

5.3.1 Use by koalas and other fauna

The absence of koala detections in underpasses within section 1-2 during the spring/summer 2019 monitoring period is broadly consistent with results of 2018 monitoring period during which a single crossing was recorded (site K4). Absent or infrequent use of underpasses by koalas has also been reported at other monitoring sites along the Pacific Highway upgrade (e.g. Sandpiper 2017, 2018, 2019d, 2019e). This is particularly so for sections featuring low koala densities in the adjoining habitat, which is the case for sections 1 and 2 (RMS 2016). In fact, no scats were detected in habitat adjoining underpasses in sections 1 and 2.

By contrast, section 10 features higher koala densities (RMS 2016). Indeed, all three underpass structures on Wardell Road featured koala scat in adjoining habitat on both sides of the road and an individual was detected making a complete crossing of the box culvert on three occasions.

The timing of the crossings at the Wardell Road culvert are particularly significant because they occurred around the time of the October 2019 wildfire in the Wardell/Ngunya Jargoon IPA area. Indeed, one record occurred prior to the fire and two records occurred after the fire. All crossings were in a northward direction away from the fire ground to the south of Wardell Road. Importantly, footage of the two post-fire crossings were of an individual who appeared to show good body condition and no obvious signs of burns.

Camera monitoring also revealed considerable use of both the underpass floor and rail furniture by 20 species and nine fauna groups. The diversity of species/fauna groups was similar to that recorded during the 2018 monitoring period (n = 25 species/fauna groups, Sandpiper 2019b). The diversity of species/fauna groups is also similar to that recorded at the Pacific Highway upgrade at Warrell Creek to Nambucca Heads (WC2NH) (n=25; Sandpiper 2019c); greater than that recorded at Nambucca Heads to Urunga (NH2U) (n = 16; Sandpiper 2019e); and, fewer than that recorded at Glenugie (n = 31; Sandpiper 2017).

Native species detections accounted for a majority of detections and was higher than that recorded at NH2U or WC2NH and largely explained by lower prevalence of black rat detections (Sandpiper 2019c, 2019e). Native species demonstrated high levels of use of fauna furniture (i.e. 62%), in particular *Antechinus* spp, which is consistent with reports from underpass monitoring on the Oxley Highway (Goldingay *et al.* 2019). Detection of underpass crossings by the threatened rufous bettong (K8 and K9) and long-nosed potoroo (KWmid), including one carrying pouch young, were important records. Both species are listed as vulnerable under the NSW *BC* Act and the long-nosed potoroo is also listed as vulnerable under the Commonwealth *EPBC* Act.

Pipe structures at Wardell demonstrated relatively low fauna detections (<0.25cc/week in total) in comparison to culvert structures (e.g. K8 = 5.82 and KWmid = 2.83). However, rate of use may improve as vegetation returns and thickens around the pipe entrance areas. Pipe underpasses at Sapphire to Woolgoolga (S2W) with established adjacent vegetation were used by >30 vertebrate species during two years of monitoring (Sandpiper 2018).

5.3.2 Use by exotic predators

Introduced predators were detected in most koala underpasses (i.e. 12 of the 14 crossing structures) and the frequency of crossings increased from year 1 camera monitoring although no evidence of predation was observed at the koala crossing structures or captured on video footage. Cat crossings were prevalent at several sites including the Wardell Road box culvert where a koala was detected. However, cats pose a low predation risk and we are not aware of any substantiated reports of koala predation by cats. Similarly, while fox was detected at three underpasses at an overall rate of 0.11cc/week/underpass, there is limited evidence to verify that foxes predate koalas although back young may be vulnerable when mothers are moving across the ground.

In contrast to cats and foxes, predation of koalas by wild and domestic dogs is well established (e.g. Lunney *et al.* 2004, 2007). Dog activity increased from an average of 0.01 (year 1) to 0.09cc/underpass/week (year 2). Most of the increase was attributed to frequent use by several individuals at K1 in section 1 where 95% of all crossings occurred. Predator control may be required at that site. A dog was also recorded at K2 and K6 (one complete crossing each) and tracks were recorded in the Wardell Road culvert, where the koala crossing occurred, prior to camera monitoring. No dogs were recorded within Wardell Road underpasses during camera monitoring.

5.3.3 Performance indicators

Fauna crossing structures.

1. Evidence of at least one completed crossing by koalas at targeted fauna crossing structures.
    a. *Three completed crossings at KWmid (Wardell road culvert).*
2. Evidence of individual koalas using structures and/or breeding on either side of the highway, via scat analysis.
    a. *Scats were detected in habitat adjacent to three structures on Wardell road (KWe1, KWe2 and KWmid)*
    b. *DNA analysis showed that there is gene flow across the focal area and no indication of a highway barrier effect.*
3. No evidence of high visitation/usage by exotic predators.
    a. *Low frequency use of most underpasses by cats; moderate frequency use of K6 & K7 by foxes; high frequency use of K1 by dogs.*
    b. *<u>Corrective action</u>: Targeted predator control at K1 may be required.*

Predator attack near fauna crossing structures.

1. No koala deaths or injuries due to predator attack in the vicinity of fauna crossing structures.
    a. *No evidence of koala deaths/injuries due to predator attack.*

5.4 Road mortality and fauna fence

5.4.1 Road mortality

Road mortality rates declined from 1.37 individuals/km during year 1 to 0.62 individuals/km in year 2. The decline in road mortality rates for year 2 may be an artefact of drought conditions which dominating much of year 2. It may also be an artefact of a reduced rate of detection with car-based surveys although detectability trials of car-based surveys found them to be highly effective at detecting medium-sized fauna (Taylor & Goldingay 2004). Importantly, no koala mortalities were recorded along survey road sections although one koala road mortality was reported for the broader study area. This is the same result as in year 1 and an improvement on year 2 when two fatalities were recorded in the broader study area.

The recording of 12 medium-to-large mammals (i.e. size of bandicoot up to eastern grey kangaroo) during the two monitoring surveys highlights the risk that vehicle strike poses to koalas and the importance of detecting breaches in the exclusion fence. Fence ends and road interchanges are also potential sources of wildlife access to the highway.

5.4.2 Fauna fence

The fauna fence was generally in good repair and no breaches were detected. Encouragingly, no roadkill was recorded at Wardell Road where 95 complete crossings, including by koalas and long-nosed potoroos, occurred through the three Wardell Road underpasses during a three month period. This highlights the importance of the combination of road/highway fencing and underpasses to prevent road mortalities and enable habitat connectivity.

5.4.3 Performance indicators

Road mortality

1. No injury to an individual koala as a result of vehicle strike across all upgraded sections.
    a. *No koala road mortalities observed or reported in sections 1-2.*
2. Section 10: no koala road mortality within the fenced areas of the upgrade, on existing Pacific Highway or Wardell Road.
    a. *No koala road mortalities observed or reported.*

Fauna exclusion fence.

1. No breaches in fauna exclusion.
    a. *No observable breaches detected.*

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Appendix A: Bayesian estimation analysis and power analysis report Year 3

Year 3 Monitoring Report: Updated Analysis of the W2B Koala Monitoring Programs in Bagotville and Broadwater, NSW, Australia.

13 July 2020

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under contract by Rankin Holdings, 1035179 Ontario Inc.

1 Summary

This report provides an updated analysis for Year 3 of the W2B Pacific Highway Upgrade koala population monitoring program being conducted in sections 8/9 (Broadwater) and 10 (Bagotville) in accordance with the Koala Management Plan (RMS 2017). The analyses have been updated using the latest data following completion of the spring 2019 and autumn 2020 field seasons.

This report presents four analyses: i) estimation of koala densities; ii) estimation of a possible emerging trend; iii) hypothesis-testing of a night-time *vs.* day-time effect; and iv) an updated prospective power analysis.

Summary of results:

- The estimated population densities (spring & autumn pooled) in 2019/20 at Broadwater and Bagotville were, respectively, 0.064 koala/ha (SE: 0.014; 95%CI: 0.041-0.096) and 0.077 koala/ha (SE: 0.015; CI: 0.050-0.111). Both estimates are higher than the Year 2 densities.
- The estimated trend at Broadwater was a decline of 1.6%/year ($\bar{\beta}t$= -0.016 per year; SE: 0.037; 95%CI -0.105-0.048). The estimated trend at Bagotville was a 0.1%/year increase ($\bar{\beta}t$= 0.001 per year; SE: 0.029; 95%CI -0.068-0.073). There was little to no evidence of a significant trend, according to Bayesian hypothesis testing.
- There was some slight evidence *against* the presence of a "night-time effect" (i.e. there was no meaningful difference between night-time and day-time surveys). However, the statistical evidence (Bayes Factor) to support this conclusion has weakened since the Year 2 analysis, implying that there is *less* statistical certainty about the absence of a night-time effect.
- The estimated power at Broadwater and Bagotville were 0.66 and 0.7, respectively.

2 Introduction

2.1 Background

This report presents the third statistical analysis of koala densities and trends, commissioned in support of Sandpiper Ecological Survey's ongoing koala population monitoring in sections 8/9 (Broadwater) and 10 (Bagotville) of the W2B Pacific Highway Upgrade which are being conducted in accordance with the Koala Management Plan (RMS 2017). The intent of these analyses is to evaluate the program's goal of being able to detect a potentially large decline in koala densities. Specifically, the survey effort and statistical modelling should be able to detect a 30% decline over 15 years with a power of at least 70% and Type-I error rate (α) of 0.30.

This report updates the statistical analyses of previous reports, including a Bayesian trend analysis and simulation-based power-analysis. The methodological details have been described in previous reports (Sandpiper Ecological 2019a,b), and will be summarised here.

2.2 Objectives

There are four objectives addressed in this report:

Objective #1. Update the koala population density estimates at Broadwater and Bagotville for Year 3, including segregated estimates for Spring (2019), Autumn (2020), and a pooled estimate for Year 3 (both seasons).

Objective #2. Update the trend analyses and evaluate the evidence of an emerging trend at either Broadwater or Bagotville. This objective has been addressed according to the original Bayesian trend estimation method proposed in the Year 1 report (Sandpiper Ecological 2019a), and has been supplemented with an alternative analytical paradigm (based on the AICc) that was explored in the Year 2 report (Sandpiper Ecological 2019b).

Objective #3. Evaluate whether there is an important difference between densities during night-time *vs.* day-time surveys.

Objective #4. Update the prospective power analyses; determine whether the program can detect a 30% decline over 15 years with a power of 0.70 ($\alpha \leq 0.3$ and $power > 0.3$).

3 Methods

The following sections will review major methodological features of the analyses. More details about the methodologies can be found in previous reports.

3.1 Statistical Model for Counts and Density

We are interested in modelling koala density $\eta_{l,t,j}$, using observations of the counts of koalas $y_{l,t,j}$ at location *l (Broadwater vs. Bagotville)*, in year *t*, at transect *j*. Each transect *j* also has a record for its area A_j, and indicator variables X_j denoting whether the survey occurred at night-time or daytime, whether it was a radial survey or line-transect, and whether the survey happened during the autumn or spring. We combine these variables into a log-linear GLM statistical model according to the following reasoning. We start with a formula for density (number of koalas per area):

$$\eta_{l,t,j} = \frac{N_{l,t,j}}{A_{l,t,j}} \iff N_{l,t,j} = \eta_{l,t,j} A_{l,t,j}$$

Where η is the density of koalas at location *l* at time *t* and transect *j; N* is the (true) number of koalas; and *A* is the area at transect *j*. We substitute *N* for its statistical expectation *E[y]* (from a count distribution like the Negative Binomial), and take the natural logarithm of both sides to yield:

$$\mathbb{E}[y]_{l,t,j} = \eta_{l,t,j} \cdot A_{l,t,j}$$
$$\log(\mathbb{E}[y]_{l,t,j}) = \log(\eta_{l,t,j}) + \log(A_{l,t,j})$$

Finally, we substitute the density term η for its linear-model decomposition ($\boldsymbol{\beta}^\intercal \mathbf{x}_{l,t,j}$), thus arriving at our familiar equation of a line with an area offset.

$$\log(\mathbb{E}[y]_{l,t,j}) = \boldsymbol{\beta}^\intercal \mathbf{x}_{l,t,j} + \log(A_{l,t,j})$$

This means we can use a Negative Binomial distribution to model counts *y* and perform linear regression to estimate parameters β, as well as estimate other interesting quantities, such as the koala densities for each year, location and season. Estimating the densities per year satisfies Objective #1, while a trend parameter in $\boldsymbol{\beta}$ helps satisfy Objective #2.

3.2 Parameters, Priors and MCMC

The regression parameters β and the covariates in the model-matrix *X* include different features such as: year, daytime *vs.* night-time effect, radial- *vs.* line-transects, and a seasonal effect. According to the Bayesian estimation paradigm, each of these parameters requires a prior distribution.

The priors used in this analysis were the same as used in the Year 1 & 2 reports[1]. The motivation and description of the priors can be found in the Year 1 report; the values are merely reported here without extensive expository detail.

Priors. The prior distribution on the trend parameters were set to $\pi(\beta_{t,l}) = \mathcal{N}(0, 0.05^2)$. The prior on the (log) baseline density at Bagotville was given a Gaussian distribution $\pi(\beta_0) = \mathcal{N}(\log(0.091), 0.41^2)$. The prior on the marginal difference between the Broadwater log-density *vs.* Bagotville was $\pi(\beta_l) = \mathcal{N}(0, 0.54^2)$. The prior on the marginal affect of the radial- *vs.* line-transects was $\pi(\beta_r) = \mathcal{N}(0, 0.54^2)$. The marginal effects of night-time *vs.* day-time, and autumn *vs.* spring, had the same prior mean and variance. Finally, for the Negative Binomial overdispersion parameter θ, a Gamma prior was used with a prior mean of 5. The strength of this prior was determined according to a model-selection exercise (see next section) where the shape and rate parameters of the Gamma distribution were: {(5,1), (10,2), (20,4), (40,8),(500,100)}, thereby allowing the models to vary between a near-Poisson distribution, or an overdispersed Negative-Binomial distribution.

MCMC. Given the data and the priors, the regression coefficients β could be estimated according to Monte Carlo Markov Chain (MCMC) algorithm, in particular, using the statistical package JAGS (Plummer 2007, 2014) in R (R Core Team 2016). Each model used 80000 MCMC samples plus a 5000 sample burn-in period. Posteriors were inspected for adequate mixing and convergence.

3.3 Multi-Model Inference

The regression analyses, there were a high number of plausible explanatory covariates which could influence population density (time, location, time-of-day, season, etc.), but a relatively small amount of survey data. In such

[1] In the Year 2 report, a major focus was the exploration the (possible) influence of other priors on the estimates and inferences. This has *not* been continued in this report. Based on those results, and in order to be consistent throughout all reports, this year's analysis has used the original priors from the Year 1 report (Sandpiper 2019a).

situations, it is common in ecological studies to employ "multi-model inference" (Johnson and Omland 2004). This technique was used in previous reports, and the technique is summarised here.

Briefly, the core idea is that one never knows which subset of covariates are "best" *a priori*, and so a prediction-based criteria, such as Watanabe-Akaike Information Criteria (Watanabe 2010), is useful to weight models and combine their estimates according to each models' predictive performance. Specifically, the "model-averaging" employed model-weights based on the WAIC criterion (Watanabe 2010, Link and Sauer 2015):

$$p(m|\mathbf{y}) \approx \frac{e^{-0.5\mathrm{WAIC}^{(m)}}}{\sum_m^M e^{-0.5\mathrm{WAIC}^{(m)}}}$$

where *m* indexes a particular model with its own unique specification of covariates β_m.

Model-averaging is important because some models are bad at prediction because they are *overfitting* the data (they have too many covariates with too little data) and some models are *underfitting* the data (they omit an important covariate). Using a predictive criteria, like the WAIC or AICc, helps find the best combination of parameters which yield the highest predictive accuracy, while minimising the influence of spurious covariates.

There were 280 possible models, which included various combinations of the following:

1. a night-time *vs.* day-time effect, or not;
2. a radial vs. line-transect effect, or not;
3. a season-effect, or not;
4. a log-linear trend *vs.* no trend *vs.* each year having its own unique density; and
5. 5 different amounts of overdispersion (excess count-variation).
6.

$$p(m|\mathbf{y}) \approx \frac{e^{-0.5\mathrm{WAIC}^{(m)}}}{\sum_m^M e^{-0.5\mathrm{WAIC}^{(m)}}}$$

7. β_m

3.4 Hypothesis Testing

Several objectives in this study (#2 and #3) pertained to evaluating hypotheses, such as: whether or not there was evidence of a trend, and whether there was a night-time *vs.* day-time effect.

As was developed in previous reports, these hypothesis-based objectives were addressed through a Bayesian quantitative technique called posterior odds-ratios (also known as Bayes Factors; Jeffreys 1961, Kass and Raftery 1995).

The odds ratios are calculated by calculating the ratio of two quantities, which, respectively, represent the strength of support for a hypothesis H_1 *vs.* its complimentary alternative hypotheses H_0 (i.e., a "null-hypothesis" of no effect). In this report, we used the sum of WAIC model probabilities for those models that supported the H_1 (the numerator of the odds-ratio), *vs.* those models that constituted the null hypothesis (the denominator of the odds-ratio). For example, the odds-ratio in favour of a trend would be:

$$BF_{\text{trend}>\text{no trend}} \approx \frac{\sum_{k\in\mathcal{M}_{\text{trend}}} \text{WAIC}_k}{\sum_{k\in\mathcal{M}_{\text{no trend}}} \text{WAIC}_k}$$

where $\mathcal{M}_{\text{trend}}$ represents the set of models that included a trend, and $\mathcal{M}_{\text{no trend}}$ represent models without a trend (and thereby act as a composite null hypothesis). The *BF* ratio must be substantially greater than 1 to provide evidence in favour of a trend. A *BF* of ~1 suggests that there is no meaningful difference between the H_1 and its compliment. A *BF* << 1, suggests strong refutation of the existence of a trend.

Similarly, another analysis used Bayesian odds-ratios to evaluate the evidence in favour of *no* night-time effect *vs.* evidence of a difference between night-time and day-time surveys.

As done in previous reports, the strength of the odds-ratios were evaluated against established quantitative cut-offs (Jeffreys 1961, Kass and Raftery 1995). For instance, a ratio above 10:1 is considered “strong” evidence in favour of a trend; a ratio above 3.2:1 is “substantial” evidence; and a ratio between 3.1:1 to 1 is considered “barely worth a mention”.

3.5 Prospective Power Analysis

The power analysis used the same Monte Carlo simulation method as introduced in the Year 1 report. The goal of the power analyses was to estimate the rate of Type-II errors (falsely rejecting the hypothesis of a trend, $H_a: \beta_t \neq 0$) while detecting a -30% decline from baseline levels at Broadwater and Bagotville between years 2015 and 2031. The error rates were conditional on:

1. a negative trend of -30% from baseline levels until Year 15 of monitoring;
2. a cap on the rate of Type-I errors at $\alpha \leq 0.3$;
3. monitoring effort of 400 transects per year per location (Broadwater and Bagotville separately);
4. marginal effects for other independent covariates (such as day-time/night-time, spring/autumn, and line-transect/radial-search transects) empirically derived from the Bayesian estimation analysis; and
5. baseline koala densities in 2015 derived from the Bayesian estimation analysis.

A key-point is item (4) whereby the Monte-Carlo procedure incorporates several sources of empirically-derived uncertainty. First, there is the uncertainty in the baseline densities at Bagotville and Broadwater, as quantified by the posterior distributions of Year 0 densities from the Bayesian estimation exercise (Objective #1). Secondly, there is the uncertainty in the magnitude of marginal effects (such as day-time/night-time, spring/autumn, and line-transect/radial-search). This uncertainty was incorporated by using the posterior distributions from the Bayesian estimation exercise. Finally, there is the *multi-model* uncertainty due to multiple candidate models for estimating statistical power. The latter point reflects the fact that a future analysts will want to improve their statistical accuracy by including or excluding certain covariates, and will likely perform model-selection by AIC (Akaike 1974, 1998). These three sources of uncertainty made the calculation of Type-II errors non-trivial and best estimated through Monte Carlo simulations. This Monte Carlo power analysis proceeded as follows:

1. set the annual percent decline to $-\delta$, and set parameters $\beta_t = \log(1-\delta),\ \beta_{t,bw} = 0$;
2. set the desired Type-I error rate to α;

3. for *i* in 1 to 4000 Monte Carlo iterations, do:

   I. get a sample parameter values from the Bayesian posteriors (e.g., baseline densities, overdispersion, marginal effects of day-time/night-time, spring/autumn, and line-transect/radial-search) $\boldsymbol{\beta}_{\neg t}^{(i)} \sim \pi(\boldsymbol{\beta}_{\neg t}|\mathbf{y}),\ \theta^{(i)} \sim \pi(\theta|\mathbf{y})$, and combine these samples with the specified trend in (1) above: $\boldsymbol{\beta}^{(i)} = (\boldsymbol{\beta}_{\neg t}^{(i)}, \beta_t, \beta_{t,bw})^{\intercal}$;

   II. simulate count data ***y*** using the linear model in Eqn. 1 and parameters $\boldsymbol{\beta}^{(i)}$

   $$y_{l,t,j}^{(i)} \sim \mathrm{NB}\left(e^{(\mathbf{x}_{l,t,j}\boldsymbol{\beta}^{(i)} + \log(p_d \cdot A_{l,t,j}))}, \theta^{(i)}\right);$$

   III. use the simulated data $\mathbf{y}^{(i)}$ to get maximum-likelihood estimates of the trend and standard error $(\hat{\beta}_t^{(i)}, \hat{\mathrm{se}}(\beta_t)^{(i)})$ for both Broadwater and Bagotville, including:

      i. option 1: use the Poisson *full-model* (model m_8 in Eqn. 2), or

      ii. option 2: use the best AIC Poisson model from models m_1 to m_8

      (this analysis proceeded with option 2, but I also ran option 1 for comparison purposes)

   IV. for each location *l* (Broadwater and Bagotville) compare the two-tailed Fisher p-value to α and calculate the score statistic *I*

   $$I_l^{(i)} = 2\left(1 - \mathrm{PDF}_{\mathcal{N}}\left(\frac{|\hat{\beta}_t^{(i)}|}{\hat{\mathrm{se}}(\beta_t)^{(i)}}\right)\right) \leq \alpha$$

   over all 4000 iterations, the estimated Type-II error rate (per *l* location Broadwater and Bagotville) was $\hat{b}_{l,\alpha,\beta_t} \approx \frac{1}{4000}\sum_{i=1}^{4000} I_l^{(i)}$ and the power is $1 - \hat{b}_{l,\alpha,\beta_t}$

3.6 Supplemental Analyses

The Year 2 report (2019) introduce several supplementary analyses to investigate alternative methods of estimating trends and evaluating evidence for or against the presence of a trend. These supplements varied according to the hypothetical strength of prior information, and merely helped to contextualise the main results. The present report continued with only one such supplementary technique which used the AICc as a model-averaging criteria.

3.6.1 Estimation According to AICc Model-Averaging

The one supplemental analysis used frequentist Negative-Binomial GLMs models and performed model-averaging by AICc weights (Akaike 1974, 1998, Schwarz 1978) to estimate the trends at Broadwater and Bagotville. As described in the Year 2 report, these models can be thought of as pseudo-Bayesian models whereby i) the priors-on-parameters have been weakened to zero-influence, and ii) priors-on-model-probabilities are adaptive (i.e., they become more conservative with less data, and more liberal with more data). In other words, the AICc "reacts" faster to new data compared to static Bayesian priors used in the main analyses. The trade-off is that: the AICc may be more sensitive to developing trends, but may result in some overfitting and be alarmist, as compared to the Bayesian models with stronger priors. See the Year 2 report (Sandpiper Ecological 2019b) for more discussion on the difference between the Bayesian-WAIC models and the frequentist-AICc models.

3.6.2 Hypothesis Testing According to AICc-Evidence Ratios

In the same way that one can garner evidence for or against a hypothesis according to Bayesian posterior odds-ratios (see above), the sum-of-AICc weights can also be used to produce odds-ratios (Lukacs *et al.* 2007). The AICc-based odds-ratios are analogous to the WAIC-based Bayes Factors but are simply called “evidence” ratios, according to the “Evidentialist” approach (Taper and Ponciano 2016) The interpretation is largely the same as for the Bayesian approach: high ratios > 1 are evidence in favour of a trend *vs.* no trend (except that the AIC controls Type-I errors more consistently across sample sizes, Taper and Ponciano 2016). The sum-of-AICc ratios was used to assess the evidence in favour of a trend *vs.* no-trend, to supplement the Bayesian odd-ratios.

4 Results

4.1 Descriptive Statistics

The following are descriptive summaries about the observed counts and (unmodelled) densities of koalas at Broadwater and Bagotville. Both time-series seem to reveal an uptick in counts and densities at both locations, especially in contrast to the Year 2 results.

At Broadwater, the total counts for the baseline, Year 1, Year 2 and Year 3 were, respectively, 8, 13, 5, and 15 koalas. The densities were: 0.117, 0.053, 0.013, and 0.069 koalas/ha, repectively.

At Bagotville, the counts for the baseline, Year 1, Year 2 and Year 3 were: 4, 17, 18, and 22 koalas. The densities were: 0.093, 0.048, 0.046, and 0.054 koalas/ha.

It should be noted, however, that due to the small areas of the radial-search transects, that even one or two observations of koalas can result in a high apparent density, as compared to the line-transects (i.e.,a small denominator results in a large density).

4.2 Results for Objective #1: Density Estimation

The following tables show the updated estimates for all years, segregated by location and season. Table 1 shows pooled estimates; Table 2 shows seasonal estimates. The estimates were calculated by model-averaging according to WAIC model probabilities.

Both locations showed a slight uptick in densities since the low during Year 2. Furthermore, the estimates for other years have also been revised slightly upward (e.g., Broadwater for Year 2 was previously estimated to be 0.051 koala/ha).

Table 1: Bayesian estimates densities (koalas/ha), pooled, per year and location

Location	Baseline	Year 1	Year 2	Year 3
Broadwater	0.067 (SE: 0.013; CI: 0.044-0.095)	0.063 (SE: 0.010; CI: 0.044-0.084)	0.061 (SE: 0.012; CI: 0.040-0.086)	0.064 (SE: 0.014; CI: 0.041-0.096)
Bagotville	0.076 (SE: 0.013; CI: 0.053-0.103)	0.075 (SE: 0.011; CI: 0.056-0.097)	0.075 (SE: 0.013; CI: 0.052-0.103)	0.077 (SE: 0.015; CI: 0.050-0.111)

Table 2: Bayesian estimates of densities (koalas/ha), per year and season

Location	Baseline	Year 1 Spring	Year 1 Autumn	Year 2 Spring	Year 2 Autumn	Year 3 Spring	Year 3 Autumn
Broadwater	0.067 (SE: 0.013; CI: 0.044-0.095)	0.063 (SE: 0.011; CI: 0.044-0.085)	0.063 (SE: 0.011; CI: 0.044-0.086)	0.061 (SE: 0.012; CI: 0.040-0.086)	0.061 (SE: 0.012; CI: 0.040-0.087)	0.064 (SE: 0.014; CI: 0.041-0.096)	0.064 (SE: 0.014; CI: 0.041-0.097)
Bagotville	0.076 (SE: 0.013; CI: 0.053-0.103)	0.075 (SE: 0.011; CI: 0.055-0.098)	0.076 (SE: 0.011; CI: 0.056-0.098)	0.075 (SE: 0.013; CI: 0.051-0.103)	0.075 (SE: 0.013; CI: 0.051-0.104)	0.076 (SE: 0.015; CI: 0.050-0.111)	0.077 (SE: 0.015; CI: 0.050-0.111)

4.2.1 Supplementary Analysis: AICc-based model-averaged model estimates

Table 3 shows the supplementary density estimates using AICc-based model weights to produce model-averaged estimates. The method also reveals a slight increase in koala density in Year 3 compared to Year 2, at both locations.

Table 3: AICc-based estimates of densities, by year and location.

Location	Baseline	Year 1	Year 2	Year 3
Broadwater	0.138 (SE: 0.060; CI: 0.053-0.280)	0.064 (SE: 0.016; CI: 0.033-0.098)	0.036 (SE: 0.018; CI: 0.010-0.073)	0.062 (SE: 0.021; CI: 0.026-0.106)
Bagotville	0.079 (SE: 0.042; CI: 0.026-0.186)	0.074 (SE: 0.020; CI: 0.031-0.106)	0.074 (SE: 0.020; CI: 0.031-0.104)	0.084 (SE: 0.023; CI: 0.035-0.121)

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4.3 Objective #2: Emerging Trends

4.3.1 Trend Estimate

The estimated log-linear trend at Broadwater was -0.016 per year (SE: 0.037; 95%CI -0.105-0.048), i.e., a 1.6%/year decline, with a 0.628 posterior probability of a decline. The estimated log-linear trend at Bagotville was 0.001 per year (SE: 0.029; 95%CI -0.068-0.073), i.e., a 0.1%/year increase, with a 0.486 posterior probability of a decline.

4.3.2 Trend Hypothesis-Testing

The trend at Broadwater had a posterior odds ratio (Bayes Factor) of 1.172 in favour of a trend *vs.* no-trend. This is slight evidence that there was a trend. However, according to the conventional categories for these ratios, 1.172 is considered 'barely worth mentioning' (Jeffreys 1961, Kass and Raftery 1995).

The trend at Bagotville had a posterior odds ratio (Bayes Factor) of 0.847, which is slight evidence *against* there being a trend. This ratio falls into the conventional descriptive bin 'barely worth mentioning'.

4.3.3 Supplementary Trend Analysis by AICc Model-Averaging

According to the frequentist AICc-based model-averaged estimates, the estimated log-linear trend at Broadwater was -0.259/year (SE: 0.177), i.e., a 25.9%/year decline. Despite the extreme trend, it is less extreme than the trend produced during the Year 2 report, which was previously estimated to be -43%/year. The variance was so high that the hypothesis testing statistics did not provide evidence in favour of a trend: the AICc-based odds-ratio in favour of a trend at Broadwater was 0.966 which is 'barely worth mentioning, and the Fisher p-value against a trend was 0.145.

The estimated AICc-based log-linear trend at Bagotville was 0.042/year (SE: 0.123), i.e., a 4.2%/year increase. At Bagotville, the AICc-based odds-ratio in favour of a trend was 0.389 which is 'barely worth mentioning'. The Fisher p-value against a trend was 0.731.

4.4 Objective #3: Day-Time vs. Night-Time Effect

A posterior odds-ratio (Bayes Factor) was employed to determine whether night-time surveys yielded meaningfully different densities than day-time surveys. In this case, the favoured hypothesis of *no*-difference constitutes the numerator of the odds-ratio, and the alternative hypothesis of *yes*-difference constitutes the denominator. Therefore, odds-ratios values above 1 support the conjecture that there is *no* difference between night-time and day-time surveys, and values <1 support the conjecture that there *is* a night-time effect.

The posterior odds-ratio was 1.369, i.e., there was some slight evidence against the presence of a night-time effect. However, this value is down from the posterior odds-ratio of 2.207 as calculated in the Year 2 report. This ratio is within the ratio-category which is conventionally described as "barely worth mentioning"(Kass and Raftery 1995).

4.5 Objective #4: Prospective Power Analysis

The results of the prospective power analysis are showing in figure 1.

For a maximum Type-I error rate of 0.3, the estimated power for Bagotville and Broadwater were 0.695 and 0.661 respectively. These are similar to the estimates from the previous year's report, which were 0.706 and 0.648 for Bagotville and Broadwater respectively. Year 3 results are down slightly for Bagotville, and up slightly for Broadwater.

For a maximum Type-I error rate of 0.35, the estimated power for Bagotsville and Broadwater were 0.731 and 0.700 respectively.

The Bayes' p-values for Bagotville and Broadwater were 0.928 and 0.916 respectively. In other words, if a Bayesian analyst were to decide whether or not there was a trend (and they were *not* concerned with frequentist Type-I or Type-II errors[2]), they would conclude that there was a 92.8% probability of a decline at Bagotville, and likewise a 91.6% probability at Broadwater.

[2] Frequentists are concerned about capping the Type-I error rate below some threshold, then maximizing the power (minimising the Type-II error rate), whereas Bayesian merely want the probability of a decline.

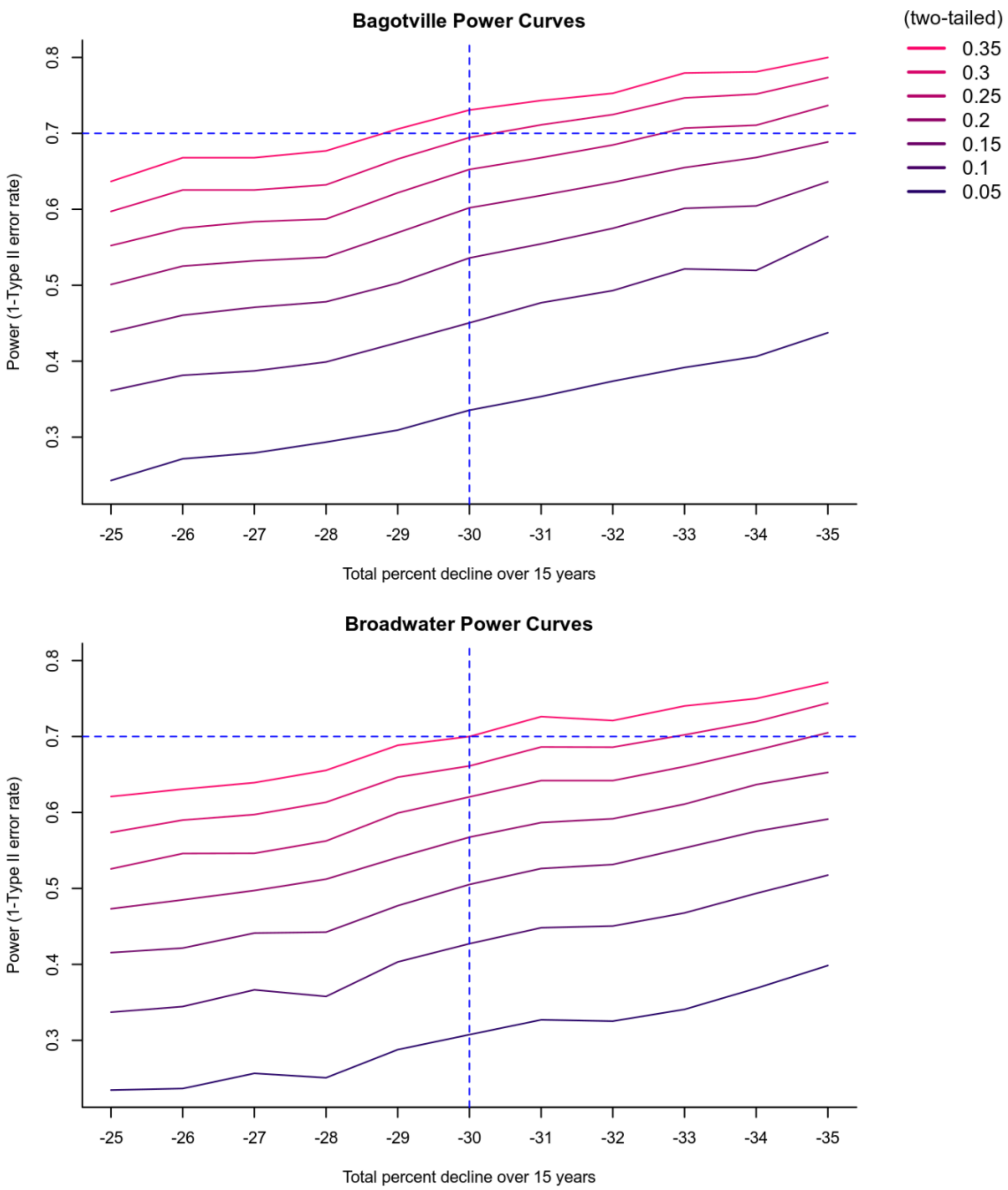

Illustration 1: Statistical power to detect a -30% drop in baseline densities vs. Year 15 of the monitoring program, for different maximum levels of Type-I errors (lines)

5 Discussion and Conclusions

This report presents a quantitative assessment of the Year 3 (2019/20) W2B Pacific Highway upgrade koala population monitoring program at Bagotville (section 10) and Broadwater (section 8/9). This report updates several estimates and hypothesis-tests pertaining to koala status and trends. Overall, a slight increase in koalas counts and densities have weakened the evidence of a negative population trend at Broadwater, but a lot of uncertainty remains.

5.1 Trends and Densities

At Bagotville, the pooled Year 3 density (0.077 koalas/ha, 95%CI: 0.050-0.111) has increased slightly from the Year 2 density (0.075 koalas/ha, 95%CI: 0.052-0.103), and is above the re-estimated density at Year 0 (0.076 koalas/ha, 95%CI 0.053-0.103). There is little evidence of a trend, which is estimated to be 0.1%/year. However, the credibility intervals of the density estimates are still very high, meaning that the absence of evidence against the trend is not necessarily evidence that there is no trend.

Overall, the densities were lower at Broadwater as compared to Bagotville. The Broadwater Year 3 density (0.064 koalas/ha, 95%CI: 0.041-0.096) is lower than the baseline density, but is higher than the Year 1 and 2 estimates. The trend is slightly negative at -1.6%/year. However, quantitative evidence of a trend (via the Bayes Factor statistic) has fallen from ~1.88 in the Year 2 analysis to 1.172; i.e., there is weakening evidence of a (negative) trend.

A supplemental analyses using frequentist GLM models and Fisher p-values have provided no evidence to reject the "no trend" null-hypothesis, at either location.

5.2 Night-Time Effects

This report revisited the question about whether there was a meaningful difference between night-time and day-time surveys. Previously, the odd-ratio statistic provided slight evidence *against* a night-time effect (2.21). Based on the updated data from Year 3, this statistic has reduced slightly to 1.369. In other words, there is not strong evidence to either support the idea of a night-time effect or not, and the evidence is weakening. Accordingly, there seems to be little concern that night-time surveys are providing materially different information compared to day-time surveys.

5.3 Prospective Power Analysis

The latest update to the prospective power analysis suggests that Bagotville is within a rounding error of the 0.70 target, while Broadwater is below its target with an estimated power of 0.661. These values are similar to previous estimates.

The power analysis relies heavily on the empirical estimates from the other analyses, and, given the high uncertainty in the density estimates and covariate-effects, these are likely contributing to a persistent inability to gain high statistical power.

5.4 Final Thoughts

Overall, there is a high level of uncertainty about the system (including sparse koala counts and uncertain estimates) which makes it difficult to resolve hypotheses and produce definitive statistical statements. This uncertainty has manifested in several analyses, such as high credibility-intervals in density estimates, weakening odds-ratios/Bayes Factors for hypotheses tests, and a slight decline in statistical power at Broadwater.

More years of data-collection will alleviate this problem, but it may be that more extensive within-season data is needed to produce the requisite power and clarity.

Finally, it is interesting to note that this year had a slight increase in the number of koala counts and empirical densities. The uptick contrasts with the Year 2 field season, in which there was a slight decrease in counts. Concomitantly, the trend estimates and density estimates have become less alarming, as compared to the Year 2 analyses.

However, it should be noted that the current uptick is in large part due to two observations of koalas on radial plots. This is important to note because it has been relatively rare to encounter koalas on radial plots (most koala detections have occurred on line-transects which feature a larger survey area). The consequences of rare-counts on small-area radial plots means that, mathematically, the densities derived from such encounters will be much higher than the encounters on line-transects (i.e., a small denominator results in a high density values). Considering that the statistical models are sensitive to density, rather than absolute counts, one should be aware that this years' estimates may be somewhat inflated as compared to data from other years.

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Appendix B: Koala DNA extraction and analysis report

Meta-Population Koala Genetics of Northern New South Wales

Prepared for Sandpiper Ecological Surveys Pty Ltd

July 2020

By Lyndal Hulse BAppSc MScAg

EXECUTIVE SUMMARY

This report presents the findings of a study into koala population genetics for 24 koala scats collected around Wardell in northern New South Wales during spring 2019 and autumn 2020, indicating koala activity within the survey area. Samples were collected as part of a requirement of the W2B Pacific Highway upgrade Koala Monitoring Program (RMS 2016). Scat samples representative of a koala population in this region were analysed for genetic diversity and relatedness, assessment of gene flow, population structure, and compared with regional koala population diversity values based on 30 microsatellite genetic markers.

Genetic analysis of the sampled population reveals a decrease in diversity of the population, compared with the 2018 genetic analysis survey of the same area, with the population currently showing moderate diversity with a loss of alleles over time and possibly indicative of genetic drift within the population. However, there has been a significant reduction in inbreeding which is reflected in the wide distribution of relatedness values in the population. Analysis with distant regional koala populations revealed moderate to strong genetic differentiation, to be expected given the geographical distances between the populations.

There is genetic sub-structuring into three distinct genetic clusters within the population, indicating an increase of gene flow occurring within the population, compared with 2018 genetic analysis whereby only two distinct sub-populations were present.

INTRODUCTION

Background

Sandpiper Ecological requested genetic analysis from koala scat samples collected during surveys around the Wardell area in Northern New South Wales during spring 2019 and autumn 2020 to predict the level of genetic diversity and population structure of koala sub-populations located within the range of the study. GPS coordinates of koala catch site locations were provided for each koala and presented in Figure 1.

For the purposes of this report, the selected samples collected are considered to genetically represent local koala sub-populations located within the study site, although there is the possibility that there is some bias in genetic diversity or divergence within the sample.

Purpose

The purpose of this study is to evaluate current koala presence/absence across the survey site and assess population structure and genetic diversity of a sub-sample of northern NSW koalas. This study aims to provide data that can be used to inform effective measures and strategies to conserve or recover koala populations in northern NSW.

Study Area

The study area is located adjacent to the W2B Pacific Highway upgrade around the towns of Wardell and Bagotville in northern NSW. Figure 1 depicts survey site and locations of koala scat retrieval between the months of November 2019 and May 2020, and January – May, 2018.

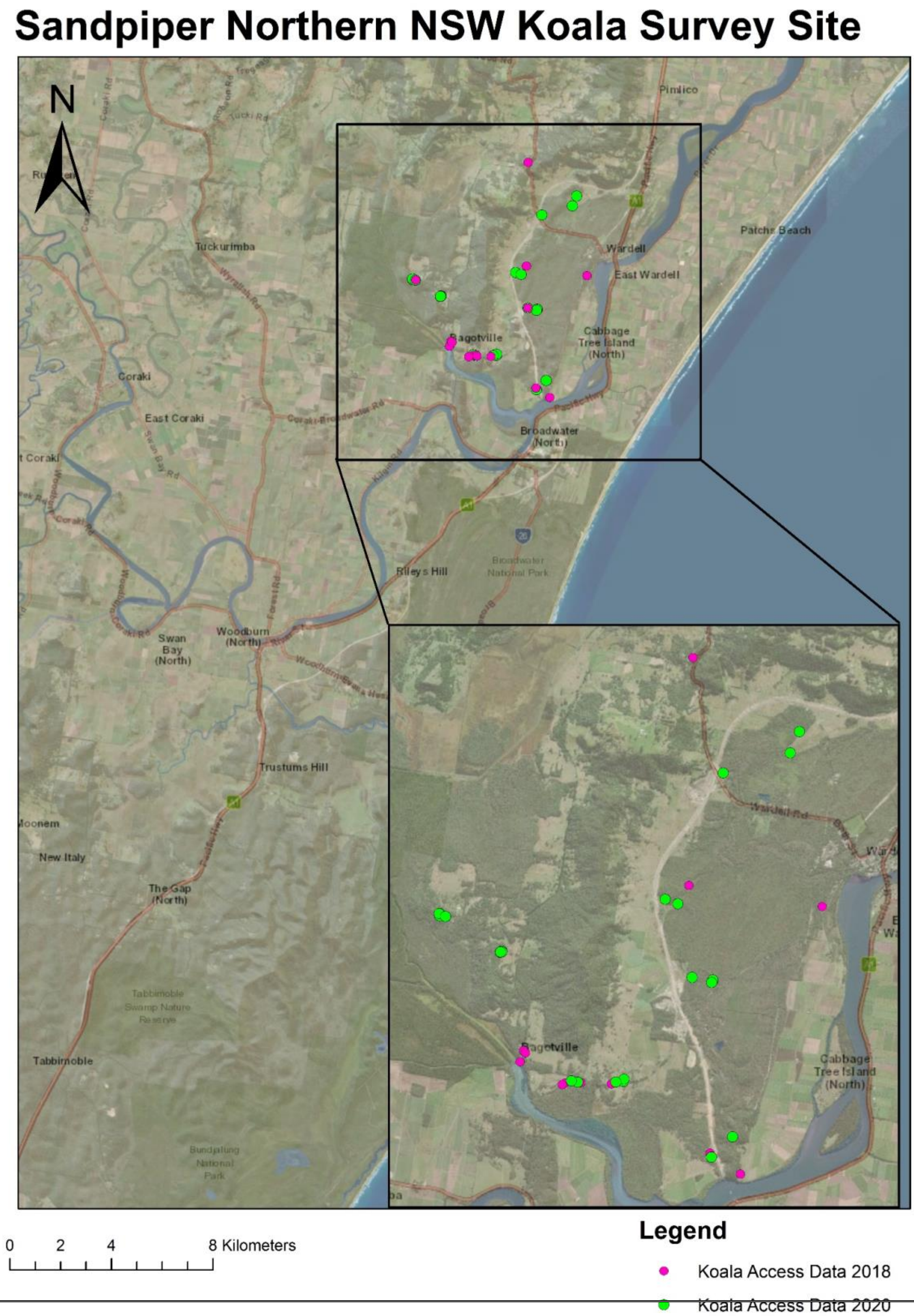


Figure 1. Northern NSW 2020 koala survey site.

SCAT ANALYSIS METHODOLOGY

Scat Analysis Protocol

Scats received via mail from Sandpiper Ecological were processed upon arrival. Koala DNA from presumptive mucosal epithelial cells was recovered by scraping the surface of the faecal sample with a scalpel blade.

DNA Isolation

Genomic DNA was isolated using the NucleoSpin® DNA Stool kit (Macherey-Nagel, Germany) according to the manufacturer's instructions. Each DNA isolate was tested for quality and concentration using spectrophotometry (Nanodrop, ThermoFisher Scientific, VIC, Australia) and real time PCR for confirmation of presence of host DNA in the sample (*Phascolarctos cinereus* beta-actin mRNA).

GENETIC ANALYSIS

Genotypes and Samples

Genotypes across 30 microsatellite loci for 24 koala scats were generated from genomic DNA. There were no departures from Hardy Weinberg Equilibrium from the population, therefore a total of 30 loci were retained for analysis. Detection of repeated genotypes within the dataset to identify duplicate samples was performed using the software GENALEX version 6.5 (Peakall and Smouse, 2012) which revealed two sets of identical multilocus genotypes present within the dataset. Duplicate sample pairs matching at all loci with location and date collected are presented in Table 1 and Figure 2. One of each duplicate genotype profile was removed from the dataset for further genetic analysis to ensure no bias of the data.

Table 111. Identity of koala scat sample duplicate genotype profiles.

Duplicate #	Sample ID	Scat Collection Date	Location		
			Transect #	**Easting**	**Northing**
1	BT-K8	22/04/2020	N34	538290	6796478
	SF-K7	11/12/2019	N34	538379	6796468
2	SF-K2	09/12/2019	N20	539238	6795904
	SF-K8	11/12/2019	N20	539265	6795911

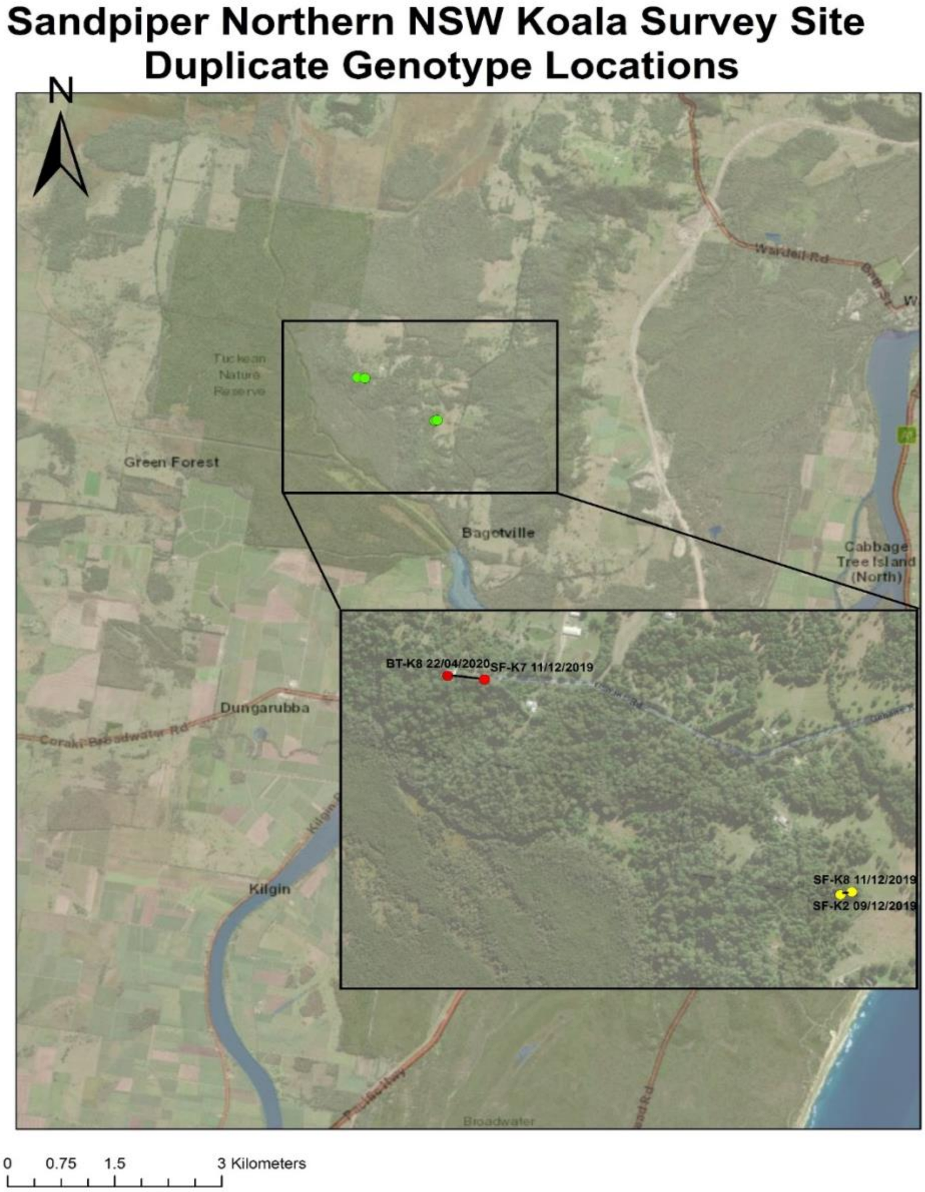


Figure 2. Northern NSW 2020 collection sites of koala scat sample duplicate genotype profiles.

Genetic Diversity

Genetic diversity is the variability of genes in a species; high genetic variability is associated with the potential fitness of a population and ultimately its long-term persistence. In population genetics, the concept of heterozygosity is commonly extended to refer to the population as a whole, i.e., the fraction of individuals in a population that are heterozygous for a particular locus. It can also refer to the fraction of loci within an individual that are heterozygous. High heterozygosity (closer to 1.0) indicates high genetic variability, whereas, low heterozygosity (closer to 0.0) means little genetic variability.

Gene diversity is affected by two elements; 1) the number of alleles and 2) the abundance (or evenness) of the alleles. Increases in either of these leads to an increase in the expected heterozygosity. If a population consists of an excess of homozygotes for different alleles this leads to a low observed heterozygosity but does not affect the expected heterozygosity calculated from Hardy-Weinberg Equilibrium.

Analysis of genetic diversity was performed using the software GENALEX version 6.5 (Peakall and Smouse, 2012) to calculate mean number of alleles and observed and expected heterozygosity. FSTAT (Goudet, 2001) was used to calculate allelic richness, a measure of allelic diversity that takes into account differences in sample sizes by standardising to the smallest number of individuals typed for a locus in a sample, so as to enable comparison among populations. FSTAT was also use to estimate the inbreeding coefficient (F_{IS}) for which a positive value indicates that individuals in a population are more related than you would expect under a model of random mating, and a negative value indicating that individuals in a population are less related.

Genetic diversity values, estimated through expected heterozygosity and allelic richness, were compared between the 2020 and 2018 surveys (Table 2). There has been a reduction in allelic diversity resulting in a decrease of expected heterozygosity between surveys conducted between 2018 and 2020. However, there has been a significant reduction of inbreeding over time suggesting there might be sufficient gene flow within and between local koala populations, possibly including koalas outside the survey region. Individual animal heterozygosity varies from 71.0% down to 44.8%, with a median value of 54.4%, compared to 2018 data where individual animal heterozygosity ranged from 70.0% down to 44.4%, with a median value of 60.7% further indicating a loss of allelic diversity. Figure 3 presents the frequency distribution of heterozygosity of individual scat samples collected in 2020.

Table 2. Genetic diversity statistics representing 2018 and 2020 northern NSW koala populations. (Based on 30 loci. Allelic richness, which is the number of alleles per locus corrected for sample size to enable comparison among populations, was estimated for n=11)

Population	N	A_{mean}	A_r	F_{IS}	H_o	H_e
2018 Survey	19	8.2	7.57	0.214	0.571	0.726
2020 Survey	22	6.86	6.10	0.179	0.552	0.659

N: Number of individuals sampled; $\mathbf{A_{mean}}$: Mean number of alleles per locus; $\mathbf{A_r}$: Allelic richness; $\mathbf{H_o}$: Observed heterozygosity; $\mathbf{H_e}$: Expected heterozygosity; $\mathbf{F_{IS}}$: Inbreeding coefficient - the proportion of variance in a population that is contained within an individual; $F_{IS}>0$ indicates high levels of homozygosity and can suggest inbreeding.

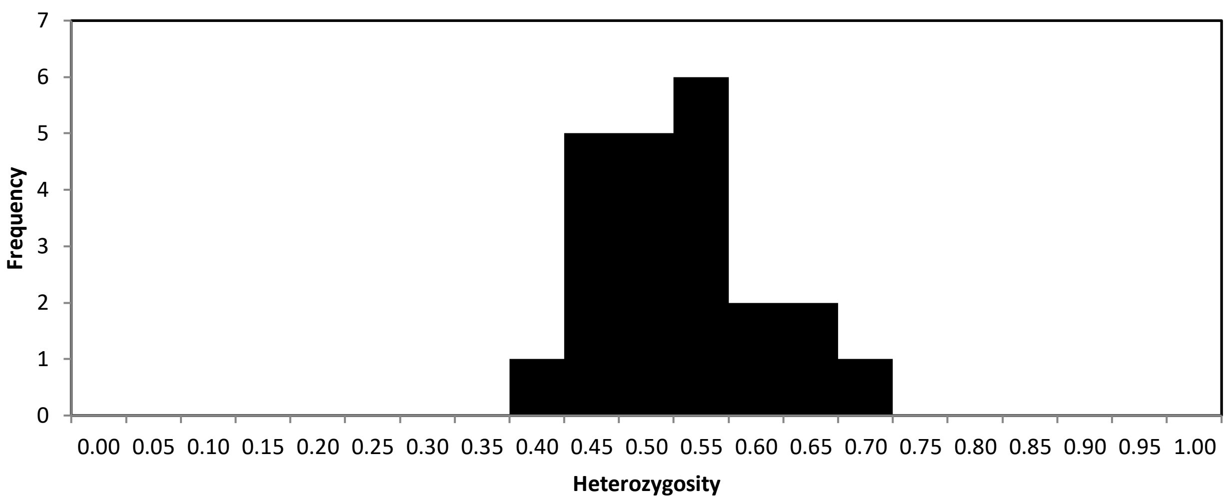


Figure 3. Frequency distribution of heterozygosity of individual scat samples collected in 2020.

Comparison of genetic diversity with previously typed regional koala populations provided further information as to the genetic health of the northern NSW koala population. Table 3 presents diversity values for previously typed regional koala populations located at Grandchester, QLD (N -27° 43’ 01.51”, E 152° 28’ 01.65), Sunshine Coast, QLD (N -26° 39’ 00.00”, E 153° 04’ 00.00”) Gold Coast, QLD (N -28° 01’ 66.67”, E 153° 39’ 99.96”), Clarke Connors Range, QLD

(N -21° 48’ 54.31”, E 150° 22’ 32.40”), Mt Byron, QLD (N -27° 14’ 79.55”, E 152° 64’ 63.75”), Oakey, QLD (N -27° 4’ 44.177”, E 151° 72’ 28.69”), St Bees, QLD (N -20° 55' 0.012”, E 149° 25' 59.988”) and Yarrabilba, QLD (N -27° 82’ 73.64”, E 153° 12’ 92.11”). These genetic data indicate that genetic diversity in the tested northern NSW koalas have a noticeably lower allelic richness and expected heterozygosity than all populations except Grandchester, Oakey and St Bees populations.

Table 3. Comparison of genetic diversity statistics within New South Wales and Queensland koala populations (Allelic richness was estimated for n=3).

Population	N	A_{mean}	A_r	F_{IS}	H_o	H_e
2018 Survey	19	8.20	7.57	0.214	0.571	0.726
Grandchester	26	6.89	5.87	0.102	0.609	0.694
Sunshine Coast	171	10.92	7.01	0.143	0.643	0.755
Gold Coast	210	11.77	7.12	0.185	0.627	0.772
Clarke Connors	54	9.65	7.07	0.231	0.582	0.737
Mt Byron	39	8.00	6.34	0.117	0.623	0.702
Oakey	16	6.19	5.78	0.042	0.623	0.662
St Bees	40	6.96	4.87	0.140	0.544	0.624
Yarrabilba	10	8.68	7.17	0.170	0.623	0.751
2020 Survey	*24*	*6.86*	*6.10*	*0.156*	*0.564*	*0.656*

Pairwise Genetic Differentiation (F_{ST})

Restrictions to gene flow among populations results in a genetic differentiation or divergence of the populations. F_{ST} is a measure of population genetic differentiation that quantifies the proportion of variance in allele frequencies among populations relative to the total variance. As a measure of genetic differentiation among populations, F_{ST} is calculated to evaluate how genetically different koala populations are to one another. A common reason for populations becoming more genetically different is reduced breeding movements of koalas among populations. The greater the genetic differentiation between populations, the less breeding movements there are between them and the more isolated they are from one another. F_{ST} can range from zero to one, where zero means populations show no genetic separation; a value of 0.25 or greater indicates strong differences among populations.

Assessment of genetic differentiation between koala populations was calculated using FSTAT (Goudet, 2001). Table 4 presents genetic differentiation between the 2020 northern NSW koala population and regional koala populations. There is weak differentiation between the 2020 and 2018 northern NSW populations indicating there is still gene flow occurring over time in koala populations within the range of the study site. There is moderate differentiation between the 2020 northern NSW population and regional populations, with the exception of Oakey and St Bees Island koalas, indicating evidence of genetic similarity between koalas in these regions.

Table 4. Pairwise F_{ST} values between 2020 northern NSW and regional koala populations.

	2018 Survey	Byron Bay	Lismore	Tweed	Hidden Vale	Sunshine Coast	Gold Coast	Clark Connors	Mt Byron	Oakey	St Bees	Yarrabilba
2020 Survey	0.044	0.120	0.108	0.072	0.096	0.078	0.082	0.153	0.148	0.172	0.214	0.093
2018 Survey		0.100	0.084	0.053	0.063	0.050	0.051	0.128	0.127	0.139	0.183	0.067
Byron Bay			0.058	0.066	0.108	0.121	0.072	0.102	0.095	0.120	0.158	0.065
Lismore				0.049	0.080	0.091	0.054	0.074	0.052	0.081	0.126	0.062
Tweed					0.038	0.063	0.021	0.091	0.082	0.090	0.142	0.052
Hidden Vale						0.048	0.024	0.126	0.125	0.164	0.198	0.081
Sunshine Coast							0.041	0.141	0.134	0.165	0.200	0.094
Gold Coast								0.089	0.098	0.108	0.165	0.054
Clark Connors									0.091	0.100	0.075	0.092
Mt Byron										0.071	0.155	0.084
Oakey											0.172	0.105
St Bees												0.156

<0.05 = **weak** genetic differentiation

0.05-0.15 = **moderate** genetic differentiation

0.15-0.25 = **strong** genetic differentiation

>0.25 = **very strong** genetic differentiation

Genetic Relatedness

Genetic relatedness was estimated to indicate the proportion of shared ancestry in pairs of individuals. Expected values are 0.5 for parent-offspring or full-sib pairs and 0.25 for half-sib pairs. However, genetic relatedness values will form a distribution around these expected values. Genetic relatedness of within-population individuals was calculated in GENALEX version 6.5 (Peakall and Smouse, 2012) using the Queller and Goodnight estimator of relatedness.

Genetic relatedness was estimated for both 2018 and 2020 northern NSW koala population separately. Figure 4 shows the average relatedness within each study area and revealed a wide distribution in relatedness values between koalas for both surveys. Noticeably, both koala populations for each collection time period showed a mean relatedness that was higher than the confidence intervals, suggesting that koalas are significantly more related than expected. A full list of individual pairwise genetic relatedness values for 2020, and combined 2018 and 2020 individuals are shown in Table 5 and 6, respectively.

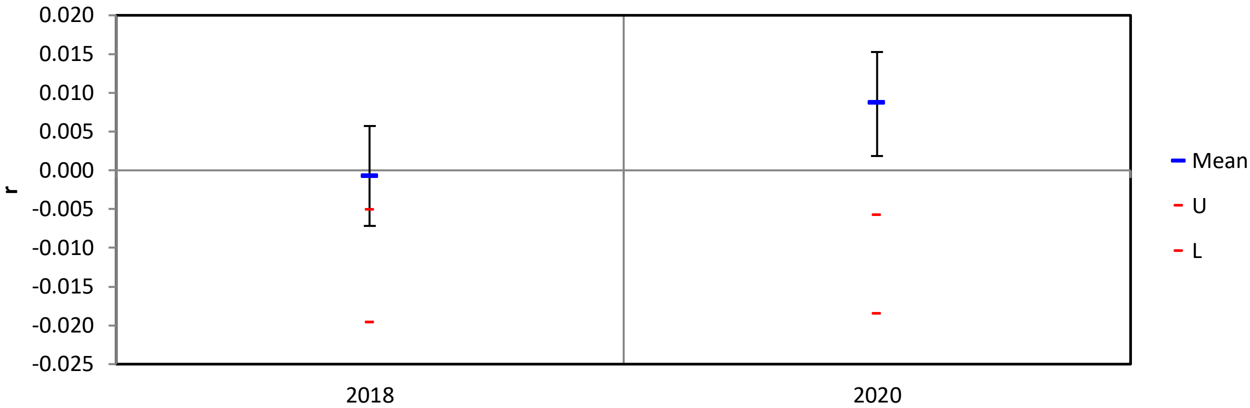


Figure 4. Mean genetic relatedness for koala catch sites.

The red lines indicate the upper (U) and lower (L) 95% confidence interval expected for that population under the null hypothesis of no difference among populations; r = relatedness.

Table 5. Labelled pairwise relatedness matrix for the 2020 northern NSW Koala Population. Pairs of individuals with high levels of genetic relatedness (i.e. values approximating those expected for full-sib pairs and parent-offspring, 0.5) are highlighted in yellow and those with genetic relatedness values approximating half-sib pairs (0.25) are highlighted in blue.

	BT-K1	BT-K10	BT-K11	BT-K12	BT-K13	BT-K14	BT-K2	BT-K3	BT-K4	BT-K5	BT-K6	BT-K7	BT-K8	BT-K9	SF-K1	SF-K10	SF-K2	SF-K3	SF-K4	SF-K5	SF-K6	SF-K9
BT-K1	0.000	0.000	0.000	0.158	0.253	0.087	0.283	0.000	0.000	0.147	0.000	0.142	0.192	0.000	0.032	0.257	0.000	0.000	0.000	0.000	0.000	0.000
BT-K10		0.000	0.000	0.162	0.016	0.250	0.285	0.194	0.000	0.000	0.000	0.235	0.003	0.000	0.000	0.000	0.482	0.086	0.000	0.000	0.000	0.157
BT-K11			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.290	0.022
BT-K12				0.000	0.185	0.201	0.273	0.191	0.043	0.000	0.000	0.366	0.205	0.000	0.000	0.057	0.161	0.000	0.000	0.000	0.000	0.043
BT-K13					0.000	0.140	0.293	0.000	0.000	0.044	0.000	0.147	0.117	0.000	0.052	0.392	0.000	0.006	0.000	0.000	0.000	0.016
BT-K14						0.000	0.396	0.153	0.017	0.000	0.000	0.764	0.171	0.000	0.014	0.100	0.280	0.073	0.035	0.000	0.000	0.157
BT-K2							0.000	0.168	0.000	0.000	0.000	0.334	0.009	0.000	0.000	0.267	0.215	0.092	0.000	0.000	0.000	0.172
BT-K3								0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.077	0.028	0.263	0.202	0.048	0.000	0.000	0.156
BT-K4									0.000	0.000	0.000	0.120	0.000	0.000	0.000	0.075	0.000	0.000	0.151	0.000	0.000	0.000
BT-K5										0.000	0.000	0.000	0.039	0.000	0.033	0.169	0.014	0.000	0.000	0.000	0.000	0.000
BT-K6											0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BT-K7												0.000	0.279	0.000	0.104	0.187	0.269	0.016	0.028	0.000	0.000	0.107
BT-K8													0.000	0.000	0.074	0.337	0.000	0.000	0.000	0.000	0.000	0.000
BT-K9														0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SF-K1															0.000	0.049	0.129	0.071	0.195	0.000	0.010	0.000
SF-K10																0.000	0.000	0.000	0.000	0.000	0.062	0.000
SF-K2																	0.000	0.173	0.142	0.000	0.000	0.387
SF-K3																		0.000	0.020	0.000	0.000	0.000
SF-K4																			0.000	0.000	0.000	0.007
SF-K5																				0.000	0.000	0.000
SF-K6																					0.000	0.000
SF-K9																						0.000

Table 6. Labelled pairwise relatedness matrix for both 2018 and 2020 northern NSW Koala Population. Pairs of individuals with high levels of genetic relatedness (i.e. values approximating those expected for full-sib pairs and parent-offspring, 0.5) are highlighted in yellow and those with genetic relatedness values approximating half-sib pairs (0.25) are highlighted in blue.

		2018																		
		BB-k01-DNA	BT-K2	BT-K3	BT-K4	BT-K5	SF-K05-DNA	SF-K06-DNA	SF-k07-DNA	SF-k08-DNA	SF-k09-DNA	SF-k10-DNA	SF-k11-DNA	SF-k12-DNA	SF-k13-DNA	SF-k14-DNA	SF-k15-DNA	SF-k16-DNA	KH3-DNA	KH4-DNA
	BB-k01-DNA	0.000	0.040	0.000	0.094	0.000	0.000	0.000	0.106	0.110	0.011	0.087	0.149	0.364	0.000	0.000	0.037	0.009	0.000	0.000
	BT-K2		0.000	0.118	0.195	0.000	0.000	0.000	0.174	0.233	0.349	0.278	0.112	0.005	0.008	0.000	0.222	0.001	0.018	0.000
	BT-K3			0.000	0.000	0.072	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.000
	BT-K4				0.000	0.000	0.000	0.000	0.313	0.217	0.268	0.098	0.147	0.164	0.024	0.000	0.170	0.000	0.000	0.000
	BT-K5					0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.130	0.000	0.000	0.055	0.178
	SF-K05-DNA						0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.107	0.000	0.000	0.017	0.058	0.053
	SF-K06-DNA							0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000
	SF-k07-DNA								0.000	0.465	0.299	0.163	0.210	0.315	0.037	0.000	0.464	0.030	0.000	0.000
	SF-k08-DNA									0.000	0.409	0.349	0.178	0.167	0.129	0.000	0.465	0.029	0.000	0.000
2018	SF-k09-DNA										0.000	0.348	0.387	0.169	0.018	0.000	0.245	0.013	0.000	0.000
	SF-k10-DNA											0.000	0.234	0.230	0.196	0.000	0.238	0.000	0.000	0.000
	SF-k11-DNA												0.000	0.268	0.007	0.000	0.107	0.146	0.000	0.000
	SF-k12-DNA													0.000	0.000	0.000	0.122	0.004	0.000	0.000
	SF-k13-DNA														0.000	0.000	0.018	0.009	0.000	0.011
	SF-k14-DNA															0.000	0.000	0.007	0.124	0.137
	SF-k15-DNA																0.000	0.000	0.000	0.000
	SF-k16-DNA																	0.000	0.000	0.000
	KH3-DNA																		0.000	0.078
	KH4-DNA																			0.000

		2020																					
		BT-K1	BT-K10	BT-K11	BT-K12	BT-K13	BT-K14	BT-K2	BT-K3	BT-K4	BT-K5	BT-K6	BT-K7	BT-K8	BT-K9	SF-K1	SF-K10	SF-K2	SF-K3	SF-K4	SF-K5	SF-K6	SF-K9
	BB-k01-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.000	0.018	0.000	0.459	0.000	0.000	0.000
	BT-K2	0.000	0.024	0.000	0.163	0.024	0.146	0.040	0.054	0.071	0.000	0.000	0.144	0.069	0.000	0.063	0.142	0.000	0.000	0.000	0.000	0.000	0.000
	BT-K3	0.000	0.020	0.012	0.000	0.000	0.000	0.000	0.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000
	BT-K4	0.000	0.097	0.000	0.000	0.032	0.000	0.053	0.000	0.000	0.045	0.000	0.000	0.000	0.000	0.004	0.023	0.016	0.110	0.000	0.000	0.000	0.000
	BT-K5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SF-K05-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.882	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000
	SF-K06-DNA	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000
	SF-k07-DNA	0.000	0.027	0.044	0.200	0.226	0.017	0.138	0.036	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.057	0.049	0.000	0.000	0.000	0.081	0.146
	SF-k08-DNA	0.023	0.000	0.000	0.000	0.048	0.046	0.269	0.000	0.000	0.007	0.000	0.030	0.000	0.000	0.000	0.273	0.031	0.000	0.000	0.000	0.037	0.039
2018	SF-k09-DNA	0.000	0.060	0.024	0.068	0.081	0.235	0.311	0.109	0.000	0.007	0.000	0.249	0.000	0.000	0.057	0.170	0.185	0.000	0.000	0.000	0.062	0.275
	SF-k10-DNA	0.123	0.000	0.000	0.000	0.018	0.061	0.044	0.000	0.000	0.000	0.000	0.091	0.000	0.000	0.000	0.304	0.004	0.000	0.000	0.000	0.000	0.012
	SF-k11-DNA	0.037	0.212	0.000	0.249	0.035	0.453	0.204	0.265	0.014	0.000	0.000	0.435	0.092	0.000	0.000	0.025	0.182	0.050	0.000	0.000	0.000	0.131
	SF-k12-DNA	0.008	0.000	0.000	0.003	0.000	0.041	0.028	0.165	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.075	0.000	0.000	0.000	0.000	0.085
	SF-k13-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
	SF-k14-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SF-k15-DNA	0.118	0.153	0.044	0.268	0.159	0.039	0.241	0.008	0.000	0.000	0.000	0.052	0.048	0.000	0.035	0.147	0.093	0.000	0.000	0.000	0.084	0.211
	SF-k16-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	KH3-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	KH4-DNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.000	0.000	0.000	-0.187	0.000	0.000	0.000	0.000
	BT-K1	0.000	0.048	0.000	0.264	0.347	0.243	0.369	0.000	0.094	0.246	0.000	0.261	0.264	0.000	0.171	0.349	0.026	0.000	0.000	0.000	0.000	0.036
	BT-K10		0.000	0.000	0.264	0.148	0.257	0.371	0.288	0.000	0.000	0.000	0.290	0.126	0.000	0.106	0.054	0.486	0.202	0.018	0.000	0.000	0.256
	BT-K11			0.000	0.059	0.000	0.000	0.000	0.117	0.000	0.000	0.000	0.002	0.033	0.000	0.000	0.098	0.000	0.000	0.000	0.000	0.366	0.104
	BT-K12				0.000	0.246	0.369	0.401	0.325	0.201	0.033	0.000	0.424	0.274	0.000	0.072	0.175	0.214	0.067	0.044	0.000	0.059	0.163
	BT-K13					0.000	0.202	0.333	0.076	0.003	0.167	0.000	0.200	0.204	0.000	0.242	0.464	0.111	0.143	0.048	0.000	0.000	0.142
	BT-K14						0.000	0.395	0.296	0.287	0.039	0.000	0.934	0.320	0.000	0.151	0.257	0.318	0.166	0.041	0.000	0.000	0.210
	BT-K2							0.000	0.307	0.088	0.125	0.000	0.402	0.161	0.000	0.085	0.356	0.394	0.211	0.000	0.000	0.034	0.271
	BT-K3								0.000	0.121	0.000	0.000	0.307	0.065	0.000	0.160	0.146	0.304	0.298	0.126	0.000	0.131	0.251
	BT-K4									0.000	0.080	0.000	0.321	0.005	0.000	0.043	0.180	0.051	0.001	0.212	0.000	0.086	0.000
	BT-K5										0.000	0.000	0.086	0.154	0.000	0.168	0.269	0.090	0.064	0.043	0.000	0.031	0.064
	BT-K6											0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	BT-K7												0.000	0.291	0.000	0.155	0.292	0.308	0.124	0.072	0.000	0.000	0.229
	BT-K8													0.000	0.000	0.205	0.371	0.138	0.137	0.000	0.000	0.027	0.000
	BT-K9														0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000
	SF-K1															0.000	0.184	0.221	0.208	0.354	0.000	0.089	0.073
	SF-K10																0.000	0.036	0.068	0.000	0.000	0.156	0.067
	SF-K2																	0.000	0.274	0.243	0.000	0.000	0.520
	SF-K3																		0.000	0.149	0.000	0.000	0.071
	SF-K4																			0.000	0.000	0.000	0.128
	SF-K5																				0.000	0.000	0.000
	SF-K6																					0.000	0.000
	SF-K9																						0.000

Population Structure

The clustering of koalas into genetic populations, termed population structuring, was determined using the Bayesian clustering program STRUCTURE version 2.3.4 (Pritchard et al. 2000). STRUCTURE implements a model-based clustering method for inferring population structure using genotype data of unlinked markers. This method demonstrates the presence of population structure, identifies distinct genetic populations and assigns individuals to populations or clusters without any prior information about geographical location. The notion of a genetic cluster is that individuals within the cluster share on average more similar allele frequencies to each other than to those in other clusters.

Analysis of koala population genotype data involved 5 replicates of K = 1 to K = 10 (K = genetic cluster) using 100,000 iterations with 100,000 iterations discarded as burn-in. The number of K clusters was determined using both the maximum likelihood and the deltaK method of Evanno et al. (2005).

STRUCTURE analysis identified three genetic clusters of koalas at the 2020 survey site (K = 3, Figure 5) compared to two genetic clusters at the 2018 survey site (K = 2, Figure 6). Identification of an additional genetic cluster at the 2020 survey site indicates evidence of gene flow occurring between sub-populations. Figure 7 depicts each scat sample location and represented by a pie chart, which details that individual's proportional assignment to each of the clusters from the STRUCTURE analysis, where clusters are shown by colour and koalas are shown at their provided sampling location. The clusters do not define northern NSW koalas into genetically distinct sub-populations within the study area, providing further evidence of gene flow occurring between the sub-populations.

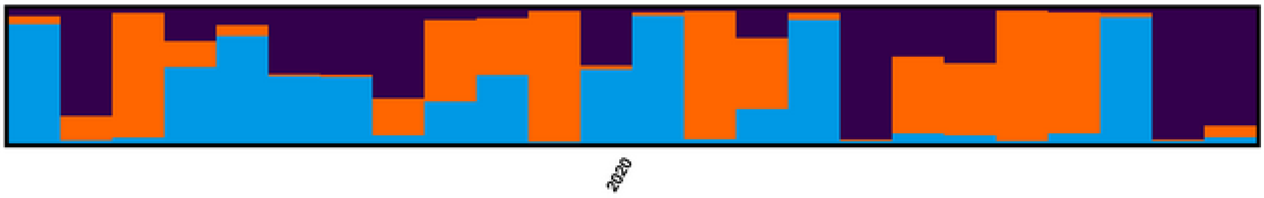


Figure 5. Population substructure of 2020 northern NSW koala populations using STRUCTURE based on 30 loci. Each bar represents an individual koala and colours indicate the proportion of the population cluster to which an individual was assigned. K = 3.

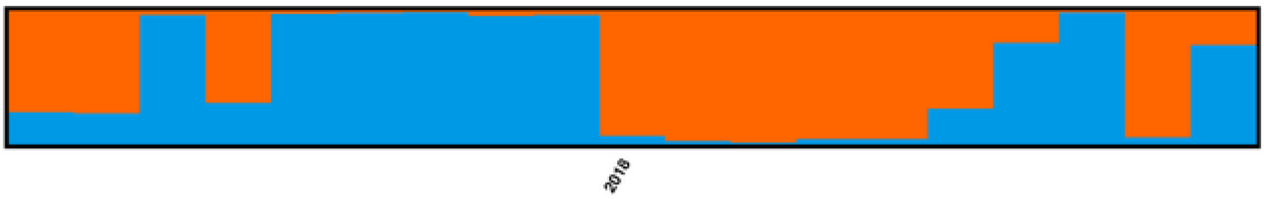
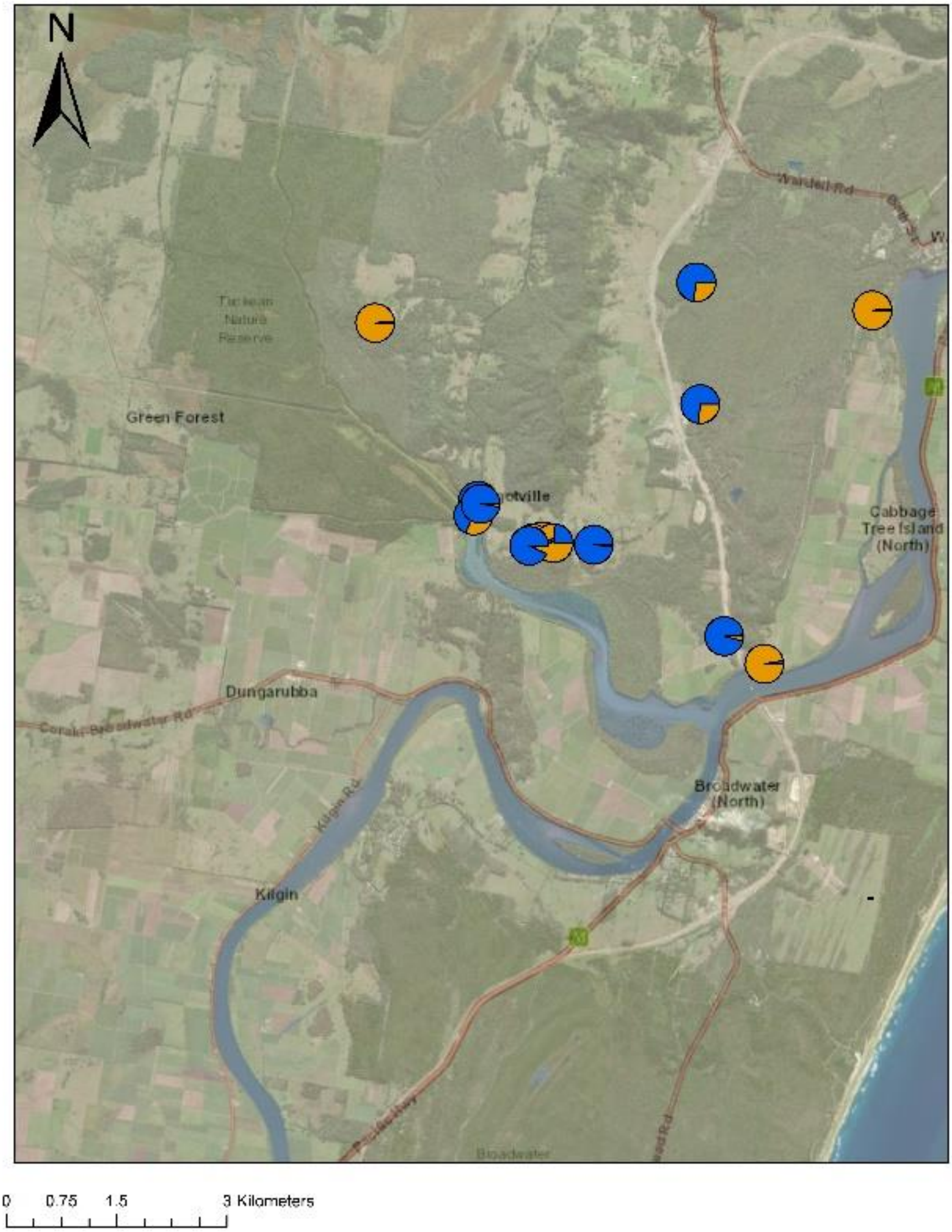


Figure 6. Population substructure of 2018 northern NSW koala populations using STRUCTURE based on 30 loci. Each bar represents an individual koala and colours indicate the proportion of the population cluster to which an individual was assigned. K = 2.

Sandpiper Northern NSW Koala Survey Site
2018 Genetic Clusters



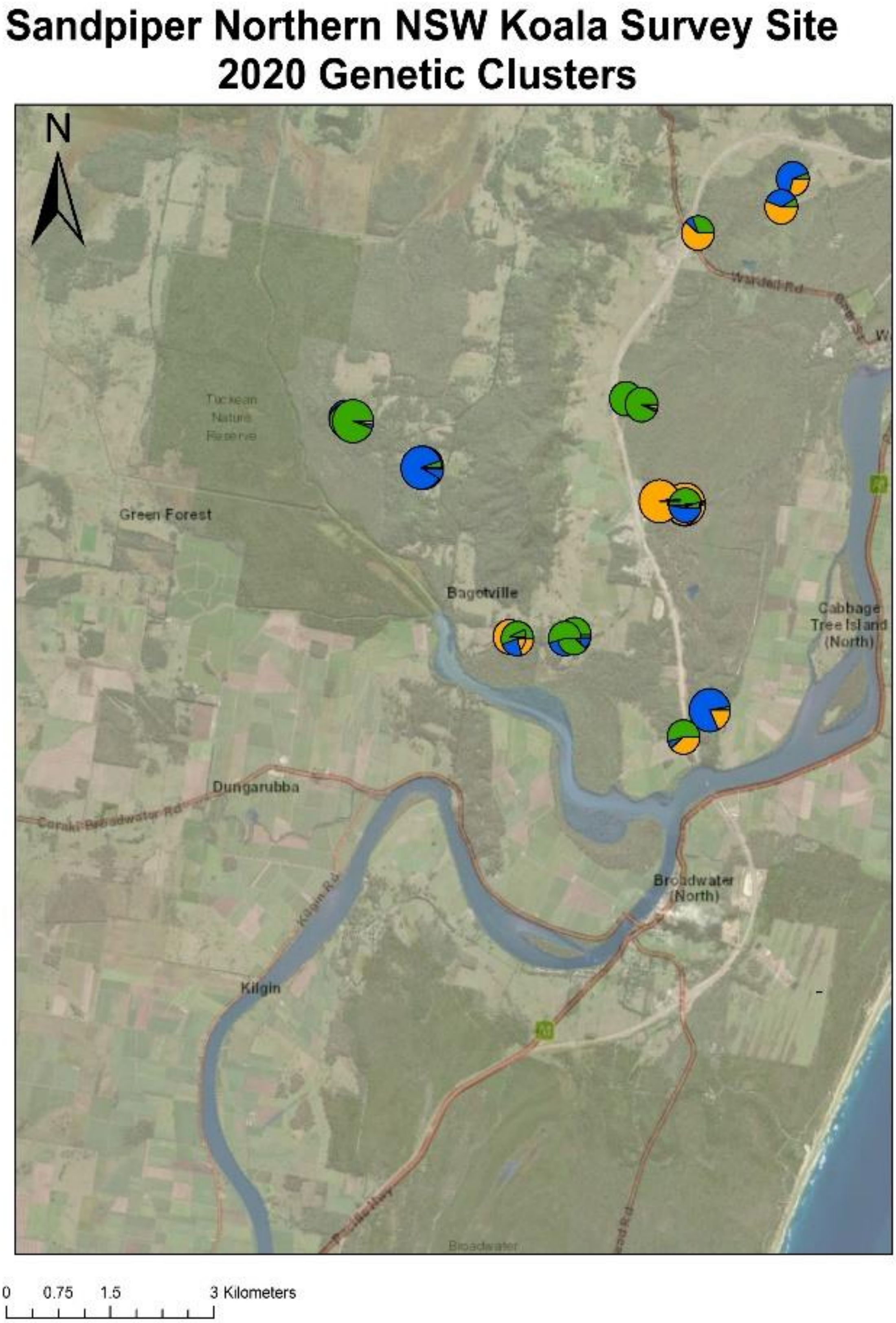


Figure 7. Inferred cluster assignments of 2017/18 (top) and 2019/20 (bottom) Bagotville koalas. Each koala is represented by a pie chart, which details that individual's proportional assignment to each of the clusters from the STRUCTURE analysis (Figures 5 and 6), where clusters are shown by colour.

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Appendix C: Population survey koala detections

Table C1: Details of koala observations during year 3 population monitoring in the Broadwater focal area.

Site	Date	Day/ Night	Koalas	Koala Easting	Koala Nthing	Tran, Rad, Incidental	Tree sp.	DBH	Sex	Notes/Condition
Spring 2019										
S15	31/10/19	D	1	539006	6787762	transect	M. quin	23	?	eyes ok. no large joey, rumo ok. no tags
S15	29/10/19	N	1	538988	6787769	Transect	Mel. quin	43	F	Female w Large back young (sex?). Both good eye shine, rump ok. No ear tag.
s15	29/10/19	N	1	538927	6787794	Transect	E. robusta	37	F	No ear tags. Joey on back (sex?). Eyes ok. rump ok.
S38	31/10/19	N	1	540225	6789174	Transect	E. racemosa	46	?	Dirty rump, good eye shine, unknown sex
S53	28/10/19	D	1	543381	6790191	Transect	Mel. quin	28	F	Looks ok, was found as moving across ground. eyes ok, rump ok. no ear tags.
s35a	28/10/19	N	1	542269	6788742	Incidental	E. robusta	83	?	Rump ok. eyes good eye shine. unkniwn sex
s38a	29/10/19	D	1	540415	6789071	Incidental	E. robusta	65	F?	Rump ok. eyes good. most likely female. near transect s38 day time
s38b	31/10/19	N	1	540371	6789095	Incidental	E. robusta	37	?	Rumo ok, good eye shine, no ear tags
s09	1/11/19	D	1	538513	6786697	Incidental	M. quin	27	?	Eyes, rump clear. just off transect, no ear tags. unsure if sex possibly female
s15a	31/10/19	D	1	538607	6787495	Incidental	E. robusta	60	M	Rump ok, large sternal gland, eyes ok. no tags. Just off Monties track near the entrance and horse paddock
s15b	29/10/19	N	1	538909	6787660	Incidental	E. robusta	?	?	Good eye shine, could not access koala.
Autumn 2019										
S10	2/4/20	D	1	538823	6786724	Tran	Swamp mahog	30	M	Healthy & robust, clean bum, clear eyes
S15	16/4/20	N	1	538930	6787775	Tran	Swamp mahog	35	F?	robust, clean bum, strong eyeshine
S25	8/4/20	N	1	540294	6788529	Tran	Swamp mahog	30	M?	Clean bum, robust
S25	8/4/20	N	1	540269	6788482	Tran/rad	Swamp mahog	35	F	Clean bum, good eyeshine
S32	9/4/20	D	1	540612	6788858	Tran/rad	Swamp mahog	10	M	Clean bum, eyes clear, no tags
S43	15/4/20	N	1	538539	6789888	Tran/rad	Black butt	35	?	Clean bum?, strong eyeshine
S44	15/4/20	N	1	539198	6789810	Tran	Red mahog	45	?	Obscured
S8a	8/4/20	N	1	538436	6786438	Off	Swamp box	52	?	Obscured
S15a	9/4/20	D	1	538918	6787820	Off	Swamp mahog	22	M	Bum clean, robust
S31a	9/4/20	D	1	539563	6788805	Off	Swamp mahog	12	M?	Bum stain, eyes?
S15a	16/4/20	N	1	538942	6787805	Off	Swamp mahog	19	M?	robust, clean bum, strong eyeshine

Table C2: Details of koala observations during year 3 population monitoring in the Bagotville focal area.

Site	Date	Day/ Night	Koalas	Koala Easting	Koala Nthing	Tran, Rad, Incidental	Tree sp.	DBH	Sex	Condition/Notes
Spring 2019										
N20	11/12/19	D	1	539265	6795911	Trànsect	Tallow	33	M	Likely male, eyes ok, no tags, rump ok. A second koala in tree approx 20m away.
N20	09/12/19	N	1	539238	6795904	Transect	Brushbox	32	?	Dirty rump, eyes good shine, no ear tags
N33	10/12/19	D	1	542250	6795501	Rad/Tran	Tallow	46	F	koala climbed well, looked unburnt, eyes ok, no tags, rump ok.
N34	11/12/19	D	1	538379	6796468	Transect	Bloodwood	33	M	Left eye partially closed, infected. RE fully closed. rump slight staining. No tags
N34	09/12/19	N	1	538282	6796511	Transect	Tallow	50	F?	Good eye shine, rump looked ok. no obvious ear tags.
N71	10/12/19	D	1	542553	6795421	Transect	Swamp mahog	37	M	eyes ok, rump ok, has some black ash ok koala. climbed ok, no tags
N73	11/12/19	D	1	541159	6793878	tran	camphor laurel	21	M	clean bum (same M as on 25Nov?)
N73	25/11/19	N	1	541163	6793880	Tran	Swamp box	45	M	Clean bum, strong eye shine
N73	25/11/19	N	1	541173	6793915	Tran	Swamp box	50	F	Dirty bum
N74	10/12/19	N	1	540349	6793893	tran	E. terittecornis	80	F	Back young, eyes clear. cannot see rump. No ear tags.
N77	10/12/19	D	1	543802	6799003	Transect	Swamp mahog	50,5 5,23, 34	M	no tags, eyes ok, rump ok,; NO FIRE
N20b	11/12/19	D	1	539243	6795911	incidental	bloodwood	61	F	Eyes ok, no tags, rump stained
N36a	11/12/19	N	1	542028	6796652	Incidental	Black butt	62	?	Good eye shine, rump ok. Too high to see details
N07a	02/12/19	D	1	542372	6794637	Incidental	Mel.quinque n	18	?	Clean bum, no burns, robust
N14a	02/12/19	N	1	543949	6799336	Incidental	Swamp mahog	35	?	Clean bum, no burns, robust.
N21a	26/11/19	N	1	542192	6794004	Incidental	.?	?	?	Heard call, location an approx (couldn't find)
N24a	25/11/19	N	1	541775	6794947	Incidental	tallowood	42	?	Obscured, no scats
Autumn 2020										
N11	23/4/20	N	1	542875	6793010	Tran	Grey ibk	38	?	Clean bum
N20	27/4/20	N	1	539265	6795926	Tran	Tallowood	25	F?	Dirty bum
N34	22/4/20	D	1	538290	6796478	Tran	Tallowood	42	M	Gunky eyes
			1	538289	6796514	Tran	N-l ibk	15	F	Eyes scarred. Red R ear tag
N71	21/4/20	D	1	542571	6795462	Tran	Swamp mahog	42	F	Clean bum
N71			1	542571	6795462	Tran	Swamp mahog	42	ind yng	?
N71	25/5/20	N	1	542575	6795452	Tran	Swamp mahog	33	.?	?
N73	22/4/20	D	1	541047	6793870	Tran	Swamp mahog	53	F	Dirty bum
N74	28/4/20	N	Nil	540448	6793871	Tran	For red gum	110	F	Dirty bum
N3a	20/4/20	D	1	542747	6798695	Off	F.r gum	17	F	Stained bum

Site	Date	Day/ Night	Koalas	Koala Easting	Koala Nthing	Tran, Rad, Incidental	Tree sp.	DBH	Sex	Condition/Notes
N10a	21/4/20	D	1	542542	6792691	Off	F.r gum	55	M	Stained,dry bum, gunky R eye, no ear tags
N36a	25/5/20	N	1	541830	6796723	Off	Sw mahog	62	?	?

Appendix D: Culvert camera detections

Table D1: Details of camera detections at 14 koala underpasses on W2B sections 1, 2, and 10 (Wardell Road) during year 3 monitoring. FF = fauna furniture. W = Wardell Road underpasses.

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Floor	10/09/2019	1808	Dog	D	C	E	3	
1	Floor	10/09/2019	1920	Dog	D	C	W	4	
1	Floor	11/09/2019	0256	Dog	D	C	E	5	
1	Floor	11/09/2019	0404	Dog	D	C	W	6	
1	Floor	11/09/2019	2236	Dog	D	C	E	7	
1	Floor	12/09/2019	0050	Dog	D	C	W	8	prey in mouth?
1	Floor	12/09/2019	0226	Dog	D	C	W	9	
1	Floor	12/09/2019	0546	Dog	D	C	W	10	
1	Floor	12/09/2019	1823	small mammal	D	C	E	11	
1	Floor	12/09/2019	2038	Dog	D	C	W	12	
1	Floor	13/09/2019	1749	Dog	D	C	E	13	
1	Floor	13/09/2019	1844	Rattus spp	D	C	E	14	
1	Floor	14/09/2019	0014	Dog	D	C	E	16	
1	Floor	14/09/2019	0131	Dog	D	C	W	17	
1	Floor	14/09/2019	1920	Dog	D	C	E	18	
1	Floor	14/09/2019	2119	Dog	D	C	W	19	
1	Floor	15/09/2019	0337	Dog	D	C	W	20	
1	Floor	15/09/2019	1920	Dog	D	C	W	21	
1	Floor	16/09/2019	0308	Dog	D	C	W	22	
1	Floor	16/09/2019	1835	Bandicoot spp	D	I	E-W	23-24	
1	Floor	16/09/2019	2328	Dog	D	C	W	26	
1	Floor	17/09/2019	0246	Dog	D	C	E	27	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Floor	17/09/2019	1831	Dog	D	C	E	28	
1	Floor	18/09/2019	0207	Large Macropod spp	D	C	E	29	
1	Floor	18/09/2019	0548	Large Macropod spp	D	C	W	31	
1	Floor	18/09/2019	0651	Large Macropod spp	D	C	W	32	
1	Floor	19/09/2019	0045	Dog	D	C	W	33	prey in mouth
1	Floor	19/09/2019	0359	Dog	D	C	E	35	
1	Floor	19/09/2019	1857	small mammal	D	C	E	36	
1	Floor	20/09/2019	0002	Dog	D	C	E	38	
1	Floor	20/09/2019	0426	Dog	D	C	E	38	
1	Floor	20/09/2019	0656	Dog	D	C	W	40	small macropod in mouth
1	Floor	20/09/2019	1909	Bandicoot spp	Pr	C	E	41	
1	Floor	20/09/2019	1931	small mammal	D	C	E	42-43	
1	Floor	21/09/2019	0533	Dog	D	C	W	44	
1	Floor	21/09/2019	0546	Dog	D	C	W	45	
1	Floor	22/09/2019	1910	Rattus spp	D	C	E	46	
1	Floor	22/09/2019	2025	Rattus spp	D	C	E	47	
1	Floor	24/09/2019	1801	Dog	D	C	E	48	
1	Floor	26/09/2019	2308	Dog	D	C	E	51	
1	Floor	30/09/2019	2014	Rattus spp	Pr	C	E	56	
1	Floor	1/10/2019	0048	Dog	D	C	E	57	
1	Floor	1/10/2019	0236	Dog	D	C	W	58	
1	Floor	5/10/2019	0521	Dog	D	C	E	62	
1	Floor	6/10/2019	0123	Black rat	Pr	C	W	63	
1	Floor	12/10/2019	2217	Dog	D	C	E	72	
1	Floor	13/10/2019	0536	EG kangaroo	Pr	C	E	73	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Floor	14/10/2019	0219	Rattus spp	Pr	C	E	76	
1	Floor	15/10/2019	2247	Rattus spp	Pr	C	E	78	
1	Floor	17/10/2019	2053	Black rat	D	C	E	79	
1	Floor	18/10/2019	2103	Northern brown bandicoot	D	C	E	81	
1	Floor	19/10/2019	2327	Bandicoot spp	Pr	C	E	83	
1	Floor	21/10/2019	0003	Bandicoot spp	Pr	C	E	86	
1	Floor	21/10/2019	0523	EG kangaroo	Pr	C	W	87-88	
1	Floor	21/10/2019	1956	Black rat	Pr	C	E	89	
1	Floor	22/10/2019	1941	Large macropod	D	C	E	92	
1	Floor	22/10/2019	2022	Black rat	Pr	C	E	93	
1	Floor	24/10/2019	2119	Rodent spp	Pr	C	E	3	
1	Floor	24/10/2019	2312	Bandicoot spp	Pr	C	E	4	
1	Floor	25/10/2019	2247	Black rat	Pr	C	E	6	
1	Floor	26/10/2019	0238	Bandicoot spp	Pr	C	E	9	
1	Floor	26/10/2019	2037	Black rat	Pr	C	E	10	
1	Floor	27/10/2019	0050	Black rat	D	C	W	11	
1	Floor	27/10/2019	2030	Black rat	Pr	C	E	13	
1	Floor	27/10/2019	2358	Black rat	D	C	W	14	
1	Floor	28/10/2019	0044	Black rat	Pr	C	E	15	
1	Floor	28/10/2019	0149	Black rat	D	C	W	17	
1	Floor	28/10/2019	0323	Black rat	Pr	C	E	18	
1	Floor	28/10/2019	2315	Black rat	Pr	C	W	21	
1	Floor	29/10/2019	0249	Bandicoot spp	Pr	C	E	22	
1	Floor	29/10/2019	2150	Black rat	Pr	C	E	24	
1	Floor	30/10/2019	2142	Black rat	Pr	C	E	30	
1	Floor	31/10/2019	0154	Bandicoot spp	Pr	C	E	31	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Floor	31/10/2019	2133	Black rat	Pr	C	E	32	
1	Floor	31/10/2019	2339	Black rat	Pr	C	W	34	
1	Floor	1/11/2019	0207	Bandicoot spp	Pr	C	E	35	
1	Floor	2/10/2019	0252	Bandicoot spp	Pr	C	E	36	
1	Floor	3/11/2019	0256	Black rat	Pr	C	E	39	
1	Floor	4/11/2019	0354	Bandicoot spp	Pr	C	E	42	
1	Floor	4/11/2019	2046	Bandicoot spp	Pr	I	E-W	43-44	
1	Floor	4/11/2019	2130	Bandicoot spp	Pr	C	W	45	
1	Floor	5/11/2019	0013	Bandicoot spp	Pr	C	E	46-47	
1	Floor	8/11/2019	0342	Bandicoot spp	Pr	C	E	52	
1	Floor	8/11/2019	1936	Black rat	Pr	I	W-E	55,56	
1	Floor	9/11/2019	0314	Bandicoot spp	Pr	C	E	60	
1	Floor	9/11/2019	2247	Black rat	D	C	W	64	
1	Floor	10/11/2019	0048	Antechinus spp	Pr	C	E	65	
1	Floor	10/11/2019	2137	Black rat	D	C	E	66	
1	Floor	11/11/2019	1909	Rattus spp	Pr	C	E	69	
1	Floor	12/11/2019	0117	Black rat	D	C	E	71	
1	Floor	13/11/2019	0328	Bandicoot spp	Pr	C	E	75	
1	Floor	13/11/2019	1930	Black rat	D	I	NDM	76	
1	Floor	15/11/2019	0225	Black rat	Pr	C	E	78	
1	Floor	16/11/2019	0239	Black rat	Pr	C	E	80	
1	Floor	16/11/2019	2009	Black rat	Pr	C	W	82	
1	Floor	16/11/2019	2236	Black rat	Pr	C	W	83	
1	Floor	16/11/2019	2243	Black rat	Pr	C	W	86	
1	Floor	17/11/2019	2007	Black rat	Pr	C	W	89	
1	Floor	18/11/2019	0138	Black rat	Pr	C	E	91	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Floor	18/11/2019	1927	Black rat	Pr	C	E	92-93	
1	Floor	18/11/2019	1943	Black rat	Pr	C	W	94	
1	Floor	18/11/2019	2125	Black rat	Pr	C	E	95	
1	Floor	19/11/2019	0541	EG kangaroo	D	C	E	98	x 2 ind.
1	Floor	19/11/2019	2026	Rattus spp	D	C	W	100	
1	Floor	20/11/2019	0337	Black rat	Pr	C	E	101-102	
1	Floor	21/11/2019	0248	Black rat	Pr	C	E	103	
1	Floor	21/11/2019	1931	Black rat	Pr	C	E	104	
1	Floor	21/11/2019	2017	Black rat	Pr	I	E-W	105-106	
1	Floor	22/11/2019	0259	Black rat	D	C	E	110-111	
1	Floor	22/11/2019	2045	Black rat	D	I	E-W	114-115	
1	Floor	23/11/2019	0123	Black rat	D	C	E	116	
1	Floor	23/11/2019	0337	Black rat	Pr	C	E	118	
1	Floor	23/11/2019	2124	Black rat	Pr	C	E	120	
1	Floor	24/11/2019	0112	Black rat	Pr	C	E	123	
1	Floor	24/11/2019	0305	Bandicoot spp	Pr	C	E	124	
1	Floor	24/11/2019	1928	small mammal	D	C	E	125	
1	Floor	24/11/2019	2028	Black rat	D	C	W	126	
1	Floor	25/11/2019	0140	Black rat	D	C	E	129	
1	Floor	25/11/2019	0516	EG kangaroo	Pr	C	W	130	2 x ind.
1	Floor	26/11/2019	2057	Black rat	Pr	C	E	131	
1	Floor	27/11/2019	2021	Rattus spp	D	C	E	132	
1	Floor	27/11/2019	2255	Black rat	D	C	W	133	
1	Floor	28/11/2019	2141	Rattus spp	D	C	E	135	
1	Floor	30/11/2019	0202	Northern brown bandicoot	Pr	C	E	136	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Floor	1/12/2019	0303	Black rat	Pr	C	W	137	
1	Floor	1/12/2019	1949	Black rat	Pr	C	E	138	
1	Floor	1/12/2019	2047	Black rat	Pr	C	E	139	
1	Floor	3/12/2019	0006	Black rat	Pr	I	W-E	140-141	
1	Floor	3/12/2019	0546	Wallaby spp	D	C	E	145	
1	Floor	4/12/2019	0159	Red-necked wallaby	Pr	I	W-E	146-147	
1	Floor	7/12/2019	0117	Northern brown bandicoot	Pr	I	E-W	149-150	
1	Floor	7/12/2019	0313	Bandicoot spp	D	C	E	151	
1	Floor	9/12/2019	1943	Black rat	Pr	C	W	154	
1	Floor	10/12/2019	2030	House mouse	Pr	C	E	155	
1	Floor	10/12/2019	2211	House mouse	Pr	C	E	157	
1	Floor	12/12/2019	2325	House mouse	Pr	C	E	158-159	
1	Floor			microbat	present				
1	Furniture	14/09/2019	0446	Black rat	D	Complete	W	14	
1	Furniture	14/09/2019	2053	Black rat	D	C	E	15-17	
1	Furniture	15/09/2019	1733	Antechinus spp	Pr	C	E	22	
1	Furniture	15/09/2019	1826	Antechinus spp	Pr	C	E	23	
1	Furniture	15/09/2019	1854	Black rat	D	C	W	24	
1	Furniture	15/09/2019	2227	Black rat	D	C	E	26	
1	Furniture	16/09/2019	1902	Black rat	Pr	C	W	30	
1	Furniture	17/09/2019	1950	Black rat	D	I	W-E	33-35	
1	Furniture	18/09/2019	1820	Black rat	Pr	C	W	36	
1	Furniture	18/09/2019	2134	Black rat	Pr	C	E	37	
1	Furniture	19/09/2019	0242	Black rat	Pr	C	W	39	
1	Furniture	19/09/2019	0310	Antechinus spp	Pr	C	E	40	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	20/09/2019	2007	Black rat	Pr	I	W-E	45-47	
1	Furniture	20/09/2019	2028	Black rat	D	C	W	48	
1	Furniture	20/09/2019	2236	Black rat	D	C	E	49	
1	Furniture	22/09/2019	2015	Black rat	Pr	C	E	53	
1	Furniture	22/09/2019	2109	Black rat	Pr	C	W	54	
1	Furniture	22/09/2019	2209	Black rat	Pr	C	E	55	
1	Furniture	23/09/2019	1835	Black rat	D	C	W	56	
1	Furniture	23/09/2019	2316	Black rat	D	C	E	57	
1	Furniture	24/09/2019	2312	Black rat	D	C	E	59	
1	Furniture	26/09/2019	2048	Black rat	D	I	E-W	60-61	
1	Furniture	26/09/2019	2121	Black rat	D	C	E	62	
1	Furniture	26/09/2019	2145	Black rat	Pr	C	W	63	
1	Furniture	26/09/2019	2342	Black rat	D	C	W	64	
1	Furniture	27/09/2019	0040	Black rat	D	C	E	65	
1	Furniture	28/09/2019	2006	Black rat	D	C	E	70-71	
1	Furniture	29/09/2019	2123	Antechinus spp	D	C	W	75	
1	Furniture	29/09/2019	2138	Antechinus spp	D	C	E	76	
1	Furniture	29/09/2019	2147	Black rat	D	I	E-W	77-78	
1	Furniture	30/09/2019	0306	Black rat	D	I	W-E	79-80	
1	Furniture	30/09/2019	2030	Antechinus spp	D	C	W	82	
1	Furniture	30/09/2019	2048	Black rat	D	C	E	83	
1	Furniture	30/09/2019	2113	Antechinus spp	D	C	E	84	
1	Furniture	30/09/2019	2146	Black rat	D	C	W	85-86	
1	Furniture	2/10/2019	0142	Black rat	Pr	C	E	88	
1	Furniture	3/10/2019	0022	Black rat	Pr	C	E	90	
1	Furniture	3/10/2019	0055	Black rat	D	C	W	91	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	3/10/2019	2011	Black rat	D	C	W	93	
1	Furniture	3/10/2019	2301	Black rat	D	C	E	94	
1	Furniture	3/10/2019	2350	Black rat	Pr	C	W	95	
1	Furniture	4/10/2019	0116	Black rat	Pr	C	E	96	
1	Furniture	4/10/2019	0141	Black rat	Pr	C	W	97	
1	Furniture	4/10/2019	2134	Black rat	Pr	C	E	98	
1	Furniture	5/10/2019	2147	Black rat	Pr	C	E	100	
1	Furniture	6/10/2019	0000	Black rat	D	C	W	101	
1	Furniture	6/10/2019	0023	Black rat	Pr	C	E	102	2 x ind.
1	Furniture	6/10/2019	0110	Black rat	Pr	C	W	103-105	
1	Furniture	6/10/2019	2316	Black rat	D	C	E	106	
1	Furniture	6/10/2019	2335	Black rat	D	C	W	107	
1	Furniture	7/10/2019	2332	Black rat	D	C	E	108	
1	Furniture	8/10/2019	0045	Black rat	D	C	W	109-111	
1	Furniture	8/10/2019	2054	Black rat	D	C	E	113	
1	Furniture	9/10/2019	0205	Black rat	D	C	E	114	
1	Furniture	10/10/2019	0330	Black rat	Pr	C	E	116	
1	Furniture	10/10/2019	0355	Black rat	D	C	W	117	
1	Furniture	11/10/2019	2244	Black rat	Pr	C	E	121	
1	Furniture	11/10/2019	2315	Black rat	D	C	W	122	
1	Furniture	12/10/2019	1944	Black rat	Pr	C	E	123	
1	Furniture	12/10/2019	2118	Black rat	D	C	W	124	
1	Furniture	13/10/2019	1932	Black rat	Pr	C	E	126	
1	Furniture	13/10/2019	2109	Black rat	D	C	W	127	
1	Furniture	14/10/2019	1902	Black rat	Pr	C	E	128	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	16/10/2019	1909	Antechinus spp	D	I	W-E	130-131	
1	Furniture	16/10/2019	1932	Black rat	Pr	C	E	132	
1	Furniture	16/10/2019	2229	Black rat	D	C	W	133	
1	Furniture	17/10/2019	2123	Black rat	D	C	W	135	
1	Furniture	18/10/2019	0216	Black rat	D	I	E-W	136-137	
1	Furniture	18/10/2019	0302	Black rat	D	I	E-W	138-142	
1	Furniture	18/10/2019	2149	Black rat	D	C	E	143	
1	Furniture	19/10/2019	2110	Black rat	Pr	C	W	144	
1	Furniture	19/10/2019	2146	Black rat	D	C	E	145	
1	Furniture	20/10/2019	2336	Black rat	D	C	W	146	
1	Furniture	21/10/2019	0127	Black rat	D	C	E	147-148	
1	Furniture	21/10/2019	0146	Black rat	D	C	W	149	
1	Furniture	21/10/2019	0352	Black rat	D	C	W	150	
1	Furniture	21/10/2019	1954	Black rat	D	C	E	151	
1	Furniture	22/10/2019	0010	Black rat	D	C	W	152	
1	Furniture	22/10/2019	0327	Black rat	D	C	W	153	
1	Furniture	22/10/2019	2005	Black rat	D	C	E	155	
1	Furniture	22/10/2019	2319	Black rat	D	C	W	156	
1	Furniture	23/10/2019	0333	Black rat	D	C	W	157-159	
1	Furniture	23/10/2019	1920	Black rat	D	C	E	160	
1	Furniture	23/10/2019	2314	Black rat	D	C	E	161-162	
1	Furniture	24/10/2019	0335	Black rat	D	C	W	163	
1	Furniture	24/10/2019	1949	Black rat	Pr	C	E	1	
1	Furniture	24/10/2019	2334	Rattus spp	D	C	W	2	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	25/10/2019	0133	Black rat	D	C	E	3	
1	Furniture	25/10/2019	0303	Black rat	D	C	W	4	
1	Furniture	25/10/2019	0334	Black rat	D	C	W	5	
1	Furniture	25/10/2019	1936	Black rat	D	C	E	6-7	
1	Furniture	26/10/2019	0344	Black rat	D	C	W	8	
1	Furniture	26/10/2019	1936	Black rat	D	C	E	9	
1	Furniture	27/10/2019	0333	Black rat	Pr	C	W	10	
1	Furniture	28/10/2019	1936	Black rat	Pr	C	E	11	
1	Furniture	29/10/2019	0236	Antechinus spp	D	I	WE	12-13	
1	Furniture	29/10/2019	0359	Black rat	Pr	C	W	14	
1	Furniture	29/10/2019	2342	Black rat	D	C	W	15	
1	Furniture	30/10/2019	0347	Black rat	D	C	W	16	
1	Furniture	30/10/2019	1942	Black rat	D	C	W	18	
1	Furniture	30/10/2019	2153	Black rat	D	C	W	21	
1	Furniture	31/10/2019	0317	Black rat	D	C	W	23	
1	Furniture	31/10/2019	2356	Black rat	D	C	E	24	
1	Furniture	2/11/2019	0140	Black rat	D	C	E	25	
1	Furniture	2/11/2019	0339	Black rat	D	C	W	26	
1	Furniture	3/11/2019	0346	Black rat	D	C	W	27	
1	Furniture	4/11/2019	0050	Black rat	D	C	E	28	
1	Furniture	4/11/2019	0051	Black rat	D	C	W	29	
1	Furniture	4/11/2019	2050	Black rat	D	C	E	30	
1	Furniture	4/11/2019	2122	Black rat	D	C	W	31	
1	Furniture	4/11/2019	2211	Black rat	D	C	E	32	
1	Furniture	5/11/2019	0028	Black rat	D	C	W	34	
1	Furniture	8/11/2019	0357	Black rat	D	C	W	37	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	8/11/2019	2113	Antechinus spp	D	I	EW	40-41	
1	Furniture	8/11/2019	2135	Black rat	D	C	E	42-44	
1	Furniture	9/11/2019	0132	Antechinus spp	D	C	E	45	
1	Furniture	9/11/2019	0207	Antechinus spp	D	C	E	47	
1	Furniture	9/11/2019	0253	Black rat	Pr	I	NDM	49	On top of camera
1	Furniture	9/11/2019	2221	Black rat	D	I	EW	50-52	On top of camera
1	Furniture	10/11/2019	2146	Black rat	D	I	EW	54-57	
1	Furniture	10/11/2019	2311	Black rat	D	C	E	58-59	
1	Furniture	11/11/2019	0058	Antechinus spp	Pr	C	E	61	
1	Furniture	11/11/2019	0205	Black rat	D	I	EW	63-64	
1	Furniture	12/11/2019	0134	Black rat	D	C	W	65	
1	Furniture	12/11/2019	2215	Black rat	D	C	E	67-69	
1	Furniture	13/11/2019	0007	Black rat	D	C	W	70	
1	Furniture	13/11/2019	0045	Black rat	D	I	WE	71-72	
1	Furniture	14/11/2019	2024	Black rat	D	C	W	73	
1	Furniture	14/11/2019	2113	Black rat	D	C	W	74-75	
1	Furniture	16/11/2019	0358	Black rat	D	C	E	76	
1	Furniture	17/11/2019	2132	Black rat	Pr	C	E	77	
1	Furniture	18/11/2019	0129	Black rat	Pr	C	E	78-79	
1	Furniture	18/11/2019	0332	Black rat	Pr	C	E	81	
1	Furniture	20/11/2019	2024	Black rat	D	C	W	86	
1	Furniture	20/11/2019	2147	Black rat	Pr	C	W	87-88	
1	Furniture	21/11/2019	0231	Black rat	D	C	E	89-99	2 x ind.
1	Furniture	22/11/2019	1816	Black rat	D	C	E	100-102	
1	Furniture	22/11/2019	2034	Black rat	D	C	E	103-104	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	23/11/2019	2238	Antechinus spp	D	C	E	105	
1	Furniture	23/11/2019	2250	Black rat	D	C	W	106-107	
1	Furniture	23/11/2019	2302	Antechinus spp	D	C	W	108	Bark in mouth
1	Furniture	23/11/2019	2343	Black rat	D	C	E	109-110	On top of camera-goes east
1	Furniture	24/11/2019	0116	Antechinus spp	D	C	E	111	
1	Furniture	24/11/2019	0131	Black rat	D	C	W	112	
1	Furniture	24/11/2019	0132	Antechinus spp	D	C	W	113	
1	Furniture	24/11/2019	0224	Black rat	D	C	W	114	
1	Furniture	24/11/2019	0350	Black rat	D	C	E	116-118	
1	Furniture	25/11/2019	1751	Black rat	D	C	E	120-122	
1	Furniture	25/11/2019	2104	Black rat	D	C	W	123	
1	Furniture	25/11/2019	2119	Black rat	D	C	E	124-125	
1	Furniture	25/11/2019	2308	Black rat	D	C	W	126	
1	Furniture	25/11/2019	2335	Black rat	D	C	E	127-128	
1	Furniture	26/11/2019	0211	Antechinus spp	D	I	EW	131-132	
1	Furniture	26/11/2019	0304	Black rat	D	C	W	133	
1	Furniture	26/11/2019	2016	Black rat	D	C	E	134	
1	Furniture	26/11/2019	2337	Black rat	D	C	W	135-136	
1	Furniture	27/11/2019	1942	Black rat	D	C	E	137	
1	Furniture	28/11/2019	2239	Black rat	D	C	E	138-140	
1	Furniture	28/11/2019	2259	Black rat	D	C	E	141	
1	Furniture	28/11/2019	2304	Bush rat	Pr	C	E	142	
1	Furniture	29/11/2019	0018	Bush rat	Pr	C	W	143	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
1	Furniture	29/11/2019	0230	Black rat	D	C	WE	144-146	
1	Furniture	30/11/2019	0126	Antechinus spp	D	C	E	147	
1	Furniture	30/11/2019	0151	Black rat	D	C	W	148	
1	Furniture	30/11/2019	1955	Black rat	D	C	E	150	
1	Furniture	30/11/2019	2056	Black rat	D	C	W	151	
1	Furniture	1/12/2019	0130	Antechinus spp	Pr	C	E	152	
1	Furniture	1/12/2019	2147	Antechinus spp	Pr	C	E	153	
1	Furniture	1/12/2019	2208	Black rat	D	I	WE	154-155	
1	Furniture	2/12/2019	0007	Black rat	D	I	WE	156-158	
1	Furniture	2/12/2019	0257	Black rat	Pr	C	E	159	
1	Furniture	2/12/2019	2022	Black rat	Pr	C	E	161	
1	Furniture	3/12/2019	2226	Black rat	Pr	C	W	164	
1	Furniture	5/12/2019	0104	Black rat	D	C	E	165-166	
1	Furniture	5/12/2019	2048	Black rat	D	C	E	167-169	
1	Furniture	5/12/2019	2308	Black rat	D	C	W	170-172	
1	Furniture	5/12/2019	2325	Black rat	D	C	E	173	
1	Furniture	9/12/2019	2007	Black rat	D	C	E	184	
1	Furniture	9/12/2019	2212	Black rat	D	C	E	186	
1	Furniture	9/12/2019	2344	Black rat	Pr	I	WE	187-188	
1	Furniture			microbat	present				
2	Floor	10/09/2019	2015	Echidna	D	C	E	1	
2	Floor	12/09/2019	2321	Dog	D	C	W	4	
2	Floor	19/09/2019	0254	Echidna	D	C	W	8	
2	Floor	5/10/2019	0210	Rodent spp	D	C	E	16	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
2	Floor	19/10/2019	2214	SEBtP	Pr	C	E	34	
2	Floor	20/10/2019	2142	Bush rat	Pr	I	NDM	35	
2	Floor	26/10/2019	0250	Cat	D	C	E	4	
2	Floor	27/10/2019	0306	small mammal	D	C	E	6	
2	Floor	29/10/2019	2141	small mammal	Pr	C	E	11-12	
2	Floor	31/10/2019	2135	Bush rat	Pr	C	E	13	
2	Floor	11/11/2019	1916	Bandicoot spp	Pr	C	E	26	
2	Floor	14/11/2019	0417	Cat	D	C	E	30	
2	Floor	22/11/2019	1910	Echidna	D	C	E	51	
2	Floor	23/11/2019	0115	Echidna	D	C	E	52	
2	Floor			microbat	present				
2	Furniture	10/09/2019	1821	antechinus spp	D	I	E-W	1-2	
2	Furniture	10/09/2019	2358	antechinus spp	Pr	C	E	4	
2	Furniture	11/09/2019	0058	antechinus spp	Pr	C	E	5	
2	Furniture	11/09/2019	0431	antechinus spp	Pr	C	E	8	
2	Furniture	12/09/2019	0226	antechinus spp	Pr	C	E	11	
2	Furniture	12/09/2019	0323	antechinus spp	D	C	E	12	
2	Furniture	12/09/2019	0510	antechinus spp	Pr	C	E	14	
2	Furniture	12/09/2019	1925	antechinus spp	D	C	E	16	
2	Furniture	13/09/2019	1848	antechinus spp	Pr	C	E	20	
2	Furniture	14/09/2019	1921	antechinus spp	Pr	C	E	22	
2	Furniture	15/09/2019	1924	antechinus spp	Pr	C	E	23	
2	Furniture	15/09/2019	2148	antechinus spp	Pr	C	E	25	
2	Furniture	16/09/2019	0232	Black rat	D	C	W	26	
2	Furniture	17/09/2019	1859	antechinus spp	Pr	C	E	29	
2	Furniture	17/09/2019	2253	Black rat	D	C	W	26	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
2	Furniture	18/09/2019	1818	Rodent spp	Pr	C	E	33	
2	Furniture	19/09/2019	1922	antechinus spp	Pr	C	E	36	
2	Furniture	20/09/2019	1927	antechinus spp	Pr	C	E	38	
2	Furniture	21/09/2019	1903	antechinus spp	Pr	C	E	40	
2	Furniture	22/09/2019	0049	antechinus spp	Pr	C	E	42	
2	Furniture	22/09/2019	1812	antechinus spp	Pr	C	E	44	
2	Furniture	23/09/2019	1922	antechinus spp	Pr	C	E	46	
2	Furniture	24/09/2019	2252	antechinus spp	Pr	C	E	51	
2	Furniture	25/09/2019	1908	antechinus spp	Pr	C	E	53	
2	Furniture	26/09/2019	1907	antechinus spp	Pr	C	E	55	
2	Furniture	26/09/2019	2342	antechinus spp	Pr	C	E	57	
2	Furniture	27/09/2019	0350	antechinus spp	Pr	C	E	59	
2	Furniture	27/09/2019	1825	antechinus spp	Pr	C	E	60	
2	Furniture	30/09/2019	0244	antechinus spp	Pr	C	E	66	
2	Furniture	30/09/2019	1749	antechinus spp	Pr	C	E	67	
2	Furniture	3/10/2019	0304	antechinus spp	Pr	C	E	69	
2	Furniture	3/10/2019	1852	antechinus spp	D	C	E	71	
2	Furniture	4/10/2019	0134	antechinus spp	Pr	C	E	73	
2	Furniture	4/10/2019	2125	antechinus spp	Pr	C	E	75	
2	Furniture	6/10/2019	0223	antechinus spp	Pr	C	E	77	
2	Furniture	6/10/2019	2235	Black rat	D	C	E	79	
2	Furniture	7/10/2019	2356	antechinus spp	Pr	C	E	81	
2	Furniture	10/10/2019	0317	antechinus spp	Pr	C	E	86	
2	Furniture	12/10/2019	0211	antechinus spp	Pr	C	E	92	
2	Furniture	13/10/2019	0226	antechinus spp	Pr	C	E	94	
2	Furniture	14/10/2019	0259	antechinus spp	Pr	C	E	96	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
2	Furniture	18/10/2019	1916	antechinus spp	Pr	C	E	103	
2	Furniture	18/10/2019	1908	antechinus spp	Pr	C	E	106	
2	Furniture	21/10/2019	1923	antechinus spp	Pr	C	E	108	
2	Furniture	22/10/2019	1841	antechinus spp	Pr	C	E	110	
2	Furniture	22/10/2019	2255	antechinus spp	D	C	W	111	
2	Furniture	23/10/2019	0012	Black rat	D	I	W-E	112-116	back and fourth multiple times
2	Furniture	23/10/2019	1846	antechinus spp	Pr	C	E	117	
2	Furniture	24/10/2019	1847	Antechinus spp	D	C	E	1-2	
2	Furniture	25/10/2019	1848	Antechinus spp	Pr	C	E	4	
2	Furniture	26/10/2019	1854	Antechinus spp	Pr	C	E	7	
2	Furniture	27/10/2019	2023	Black rat	D	C	E	10-12	
2	Furniture	27/10/2019	2040	antechinus spp	D	C	W	13	
2	Furniture	27/10/2019	2047	Black rat	Pr	C	E	14	
2	Furniture	28/10/2019	0329	antechinus spp	Pr	C	E	16	
2	Furniture	28/10/2019	1849	antechinus spp	Pr	C	E	18	
2	Furniture	29/10/2019	0318	antechinus spp	Pr	C	E	20	
2	Furniture	29/10/2019	0400	antechinus spp	D	C	W	21	
2	Furniture	29/10/2019	1837	antechinus spp	Pr	C	E	22	
2	Furniture	30/10/2019	1851	antechinus spp	Pr	C	E	24	
2	Furniture	31/10/2019	1843	antechinus spp	Pr	C	E	26	
2	Furniture	1/11/2019	1839	antechinus spp	D	C	E	28	
2	Furniture	2/11/2019	1901	antechinus spp	Pr	C	E	30	
2	Furniture	3/11/2019	0323	antechinus spp	D	C	E	32	
2	Furniture	5/11/2019	1909	antechinus spp	Pr	C	E	33	
2	Furniture	11/11/2019	0257	antechinus spp	D	C	E	38	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
2	Furniture	11/11/2019	0335	antechinus spp	D	I	EW	39-40	
2	Furniture	11/11/2019	1855	antechinus spp	Pr	C	E	41	
2	Furniture	12/11/2019	0329	antechinus spp	Pr	C	E	43	
2	Furniture	12/11/2019	1842	antechinus spp	Pr	C	E	45	
2	Furniture	14/11/2019	1843	antechinus spp	D	C	E	49	
2	Furniture	15/11/2019	1859	antechinus spp	Pr	C	E	53	
2	Furniture	16/11/2019	1900	antechinus spp	D	C	E	56	
2	Furniture	17/11/2019	1851	antechinus spp	Pr	C	E	58	
2	Furniture	18/11/2019	1850	antechinus spp	Pr	C	E	60	
2	Furniture	19/11/2019	1910	antechinus spp	Pr	C	E	62	
2	Furniture	22/11/2019	1913	antechinus spp	Pr	C	E	68	
2	Furniture	24/11/2019	1909	antechinus spp	Pr	C	E	69	
2	Furniture	25/11/2019	1919	antechinus spp	Pr	C	E	71	
2	Furniture	27/11/2019	1855	antechinus spp	Pr	C	E	73	
2	Furniture	27/11/2019	2214	antechinus spp	Pr	C	E	75	
2	Furniture	28/11/2019	0300	antechinus spp	Pr	C	E	79	
2	Furniture	28/11/2019	2152	antechinus spp	Pr	C	E	84	
2	Furniture	28/11/2019	2200	antechinus spp	D	C	W	85	
2	Furniture	4/12/2019	0127	Black rat	Pr	I	EW	86-87	
2	Furniture	7/12/2019	1920	antechinus spp	D	I	EW	90-91	
2	Furniture			microbat	present				
3	Floor	14/09/2019	2004	Bandicoot spp	Pr	C	E	7	
3	Floor	15/09/2019	2201	Echidna	D	C	E	8	
3	Floor	17/09/2019	1905	Rodent spp	D	C	W	9	
3	Floor	19/09/2019	1849	Long-nosed bandicoot	Pr	C	E	11	
3	Floor	19/09/2019	2032	Bandicoot spp	Pr	C	E	13	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Floor	20/09/2019	1806	Antechinus spp	Pr	C	W	14	
3	Floor	21/09/2019	2118	Bandicoot spp	Pr	C	E	18	
3	Floor	22/09/2019	1903	SEBtP	Pr	C	E	19	
3	Floor	22/09/2019	2039	Bandicoot spp	D	C	E	21	
3	Floor	23/09/2019	0015	SEBtP	Pr	C	W	22	
3	Floor	23/09/2019	0223	Bandicoot spp	D	C	W	23	
3	Floor	23/09/2019	2234	Bandicoot spp	D	C	E	24	
3	Floor	25/09/2019	1912	antechinus spp	Pr	C	E	25	
3	Floor	26/09/2019	0359	antechinus spp	Pr	C	E	26	
3	Floor	26/09/2019	2009	Bandicoot spp	D	C	W	27	
3	Floor	27/09/2019	1943	SEBtP	Pr	C	E	28	
3	Floor	1/10/2019	0040	Bandicoot spp	Pr	C	E	32	
3	Floor	2/10/2019	2205	Bandicoot spp	Pr	C	E	33	
3	Floor	3/10/2019	1854	Bandicoot spp	Pr	C	W	34	
3	Floor	3/10/2019	2113	SEBtP	Pr	C	E	35	
3	Floor	4/10/2019	2058	SEBtP	Pr	C	E	36	
3	Floor	5/10/2019	0235	SEBtP	D	C	E	37	
3	Floor	24/10/2019	2107	Bush rat	Pr	C	E	1	
3	Floor	25/10/2019	0122	Bandicoot spp	Pr	C	E	2	
3	Floor	25/10/2019	0352	Antechinus spp	Po	I	NDM	3	
3	Floor	25/10/2019	1904	small mammal	D	C	E	4	
3	Floor	25/10/2019	2058	Bandicoot spp	Pr	C	E	5	
3	Floor	29/10/2019	2144	Bandicoot spp	Po	C	W	11	
3	Floor	2/11/2019	2041	small mammal	D	C	E	12	
3	Floor	2/11/2019	2225	Cat	D	C	W	14	
3	Floor	3/11/2019	0449	Cat	D	C	E	15	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Floor	4/11/2019	2219	Bandicoot spp	D	C	E	16	
3	Floor	5/11/2019	2227	Bandicoot spp	Pr	C	W	17	
3	Floor	7/11/2019	0008	Echidna	D	C	E	18	
3	Floor	7/11/2019	2038	Rattus spp	D	C	W	19	
3	Floor	9/11/2019	2105	BtPoss spp	D	C	E	20	
3	Floor	9/11/2019	2230	BtPoss spp	D	C	W	21	
3	Floor	15/11/2019	2040	Bandicoot spp	D	C	E	24	
3	Floor	17/11/2019	0304	Echidna	D	C	E	26-27	
3	Floor	20/11/2019	1938	BtPoss spp	D	C	E	30	
3	Floor	20/11/2019	2141	BtPoss spp	D	C	W	31	
3	Floor	20/11/2019	2211	Bandicoot spp	D	C	E	32	
3	Floor	21/11/2019	1932	Bandicoot spp	Pr	C	W	33	
3	Floor	22/11/2019	0452	Cat	D	C	E	34	
3	Floor	23/11/2019	2239	Bandicoot spp	D	C	E	35	
3	Floor	24/11/2019	1943	Bandicoot spp	Pr	C	W	36	
3	Floor	25/11/2019	2050	Bandicoot spp	D	C	E	38	
3	Floor	25/11/2019	2216	BtPoss spp	D	C	E	39	
3	Floor	26/11/2019	0104	SEBtP	Pr	C	W	40	
3	Floor	26/11/2019	0309	Echidna	D	C	E	41	
3	Floor	27/11/2019	2028	Bandicoot spp	D	C	E	42	
3	Floor	29/11/2019	2046	Bush rat	Pr	C	W	43	
3	Floor	30/11/2019	2218	Bandicoot spp	D	C	E	45	
3	Floor	1/12/2019	0205	Bandicoot spp	D	C	E	46	
3	Floor	1/12/2019	0332	Northern brown bandicoot	Pr	C	W	47	
3	Floor	1/12/2019	2111	Northern brown bandicoot	Pr	C	W	49	
3	Floor	1/12/2019	2156	small mammal	D	C	E	50	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Floor	1/12/2019	2344	Northern brown bandicoot	Pr	C	E	51	
3	Floor	2/12/2019	0008	BtPoss spp	D	C	W	52	
3	Floor	3/12/2019	0440	Indian peafowl	D	I	E-W	54-55	
3	Floor	3/12/2019	0555	Indian peafowl	D	I	E-W	56-57	
3	Floor	3/12/2019	2253	Bandicoot spp	D	C	E	58	
3	Floor	4/12/2019	0149	Bandicoot spp	D	C	E	60	
3	Floor	4/12/2019	2349	Bandicoot spp	Pr	C	E	62	
3	Floor	5/12/2019	0102	Echidna	D	C	E	63	
3	Floor	9/12/2019	0240	Bandicoot spp	D	C	E	65	
3	Floor	11/12/2019	0159	Northern brown bandicoot	Pr	C	W	67	
3	Floor	12/12/2019	1931	Bandicoot spp	D	C	W	69	
3	Floor	12/12/2019	2055	BtPoss spp	D	C	E	70	
3	Floor	12/12/2019	2241	BtPoss spp	D	C	W	71	
3	Floor	14/12/2019	2100	Bandicoot spp	D	C	E	72	
3	Floor	15/12/2019	0336	Bandicoot spp	D	C	W	73	
3	Floor	16/12/2019	2209	Bandicoot spp	D	C	E	74	
3	Floor	17/12/2019	0056	Northern brown bandicoot	Pr	C	W	75	
3	Floor			microbat spp	present				
3	Furniture	10/09/2019	1927	Antechinus spp	D	C	W	1	
3	Furniture	14/09/2019	0451	Antechinus spp	D	C	W	4	
3	Furniture	15/09/2019	1837	Antechinus spp	Pr	C	E	5	
3	Furniture	15/09/2019	2109	Black rat	D	I	W-E	6-8	
3	Furniture	16/09/2019	1921	Antechinus spp	Pr	C	E	9	
3	Furniture	17/09/2019	1750	Antechinus spp	Pr	C	E	11	
3	Furniture	19/09/2019	2013	Antechinus spp	D	C	W	14	
3	Furniture	19/09/2019	2020	Antechinus spp	Pr	C	E	15	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Furniture	20/09/2019	2009	Antechinus spp	Pr	C	E	17	
3	Furniture	20/09/2019	2023	Antechinus spp	Pr	C	E	18	
3	Furniture	20/09/2019	2039	Antechinus spp	Pr	C	W	19	
3	Furniture	21/09/2019	1907	Antechinus spp	D	C	E-W	20-21	
3	Furniture	21/09/2019	1924	Antechinus spp	D	C	E	23	
3	Furniture	21/09/2019	1956	Antechinus spp	D	C	W-E	24-26	
3	Furniture	21/09/2019	2009	Antechinus spp	Pr	C	E	28	
3	Furniture	21/09/2019	2043	Antechinus spp	Pr	C	W	29	
3	Furniture	21/09/2019	2113	Antechinus spp	Pr	I	E-W	30-31	
3	Furniture	21/09/2019	2246	Antechinus spp	D	C	W	33	
3	Furniture	21/09/2019	2319	Antechinus spp	Pr	C	E	34	
3	Furniture	22/09/2019	1852	Antechinus spp	D	C	E-W	35-36	
3	Furniture	22/09/2019	1912	Antechinus spp	Pr	C	E	37	
3	Furniture	22/09/2019	1939	Antechinus spp	D	C	E	38	
3	Furniture	22/09/2019	2013	Antechinus spp	Pr	C	E	39	
3	Furniture	23/09/2019	0104	Antechinus spp	Pr	C	E	40	
3	Furniture	23/09/2019	0128	Antechinus spp	D	C	W	41	
3	Furniture	23/09/2019	0247	Antechinus spp	D	C	E	42	
3	Furniture	23/09/2019	0336	Antechinus spp	Pr	C	W	43	
3	Furniture	24/09/2019	0347	Antechinus spp	Pr	C	E-W	45-46	
3	Furniture	24/09/2019	0510	Antechinus spp	Pr	C	E	49	
3	Furniture	24/09/2019	2342	Antechinus spp	Pr	C	E	50	
3	Furniture	25/09/2019	0004	Antechinus spp	Pr	C	E	51	
3	Furniture	25/09/2019	0022	Antechinus spp	D	I	W-E	52-53	
3	Furniture	25/09/2019	0336	Antechinus spp	D	C	E	55	
3	Furniture	25/09/2019	1900	Antechinus spp	D	I	E-W	56-57	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Furniture	25/09/2019	1943	Antechinus spp	D	I	W-E	60-62	
3	Furniture	25/09/2019	2126	Antechinus spp	D	C	E	63	
3	Furniture	25/09/2019	2136	Antechinus spp	D	C	E	65-67	Carrying bark
3	Furniture	26/09/2019	0330	Antechinus spp	D	C	E	68	
3	Furniture	26/09/2019	0358	Antechinus spp	D	I	E-W	70-71	
3	Furniture	26/09/2019	0434	Antechinus spp	Pr	C	E	73	
3	Furniture	26/09/2019	1825	Antechinus spp	Pr	C	E	75,76	
3	Furniture	26/09/2019	1853	Antechinus spp	D	C	W	78	
3	Furniture	26/09/2019	1932	Antechinus spp	Pr	C	E	79	
3	Furniture	26/09/2019	2119	Antechinus spp	Pr	C	E	82,85	
3	Furniture	26/09/2019	2225	Antechinus spp	Pr	C	E	88	
3	Furniture	27/09/2019	0133	Antechinus spp	Pr	C	E	90	
3	Furniture	27/09/2019	0152	Antechinus spp	Pr	C	W	91	
3	Furniture	27/09/2019	1807	Antechinus spp	Pr	C	E	93	
3	Furniture	27/09/2019	1856	Antechinus spp	Pr	I	W-E	94-95	
3	Furniture	27/09/2019	1914	Antechinus spp	Pr	I	W-E	96-97	
3	Furniture	27/09/2019	1930	Antechinus spp	Pr	C	E	99	
3	Furniture	28/09/2019	0330	Antechinus spp	Pr	C	W	102	
3	Furniture	28/09/2019	1953	Antechinus spp	Pr	C	E	104	
3	Furniture	29/09/2019	1806	Antechinus spp	Pr	C	E	107	
3	Furniture	29/09/2019	1810	Antechinus spp	D	C	W	108	
3	Furniture	29/09/2019	1938	Antechinus spp	D	I	W-E	109-112	Pulling off bark
3	Furniture	30/09/2019	0425	Antechinus spp	D	C	W	114	
3	Furniture	30/09/2019	0445	Antechinus spp	D	C	E	115	Pulling off bark
3	Furniture	30/09/2019	0513	Antechinus spp	D	C	W	120	
3	Furniture	30/09/2019	0524	Antechinus spp	D	C	E	121	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Furniture	30/09/2019	1851	Antechinus spp	D	C	W	122	
3	Furniture	1/10/2019	0144	Antechinus spp	Pr	C	E	124	
3	Furniture	2/10/2019	0420	Antechinus spp	Pr	I	E-W	125-126	
3	Furniture	4/10/2019	0224	Antechinus spp	Pr	C	E	132	
3	Furniture	4/10/2019	0232	Black rat	D	I	E-W	133-134	
3	Furniture	4/10/2019	1842	Antechinus spp	D	E	E	135	
3	Furniture	5/10/2019	0228	Antechinus spp	D	C	E	136	
3	Furniture	5/10/2019	0347	Antechinus spp	D	C	E	138	
3	Furniture	6/10/2019	0041	Black rat	D	C	E	139	
3	Furniture	8/10/2019	0109	Black rat	D	C	E	140-141	
3	Furniture	8/10/2019	1846	Black rat	D	C	W	143	
3	Furniture	10/10/2019	1938	Black rat	D	C	E	145	
3	Furniture	10/10/2019	2013	Black rat	D	I	E-W	146-149	
3	Furniture	12/10/2019	0358	Antechinus spp	Pr	C	E	151	
3	Furniture	13/10/2019	1844	Antechinus spp	Pr	C	E	153	
3	Furniture	13/10/2019	1918	Antechinus spp	D	I	W-E	154-155	
3	Furniture	14/10/2019	0352	Black rat	D	C	E	156	
3	Furniture	14/10/2019	0522	Antechinus spp	D	C	E	157	
3	Furniture	15/10/2019	2244	Antechinus spp	D	I	E-W	159-160	
3	Furniture	16/10/2019	1945	Antechinus spp	D	I	E-W	162-163	
3	Furniture	17/10/2019	1926	Antechinus spp	D	I	E-W	164-165	
3	Furniture	17/10/2019	1938	Antechinus spp	D	C	E	166-167	
3	Furniture	17/10/2019	2005	Antechinus spp	D	I	W-E	168-169	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Furniture	17/10/2019	2122	Antechinus spp	Pr	C	W	170	
3	Furniture	19/10/2019	2330	Black rat	D	I	E-W	172-173	
3	Furniture	21/10/2019	2030	Black rat	Pr	C	W	174	
3	Furniture	21/10/2019	2310	Black rat	Pr	C	E	175	
3	Furniture	21/10/2019	2331	Black rat	Pr	C	W	176	
3	Furniture	22/10/2019	1921	Antechinus spp	D	C	E	177-178	
3	Furniture	23/10/2019	1934	Black rat	D	C	W	179	
3	Furniture	23/10/2019	2213	Black rat	D	C	E	180	
3	Furniture	24/10/2019	0011	Black rat	D	I	W-E	181-182	
3	Furniture	24/10/2019	1926	Antechinus spp	D	C	E	1-2	
3	Furniture	24/10/2019	1937	Antechinus spp	D	C	W	3	
3	Furniture	24/10/2019	2042	Black rat	D	C	E	4	
3	Furniture	24/10/2019	2122	Black rat	D	C	W	5	
3	Furniture	25/10/2019	0346	Antechinus spp	D	C	E	6	
3	Furniture	27/10/2019	2125	Black rat	D	I	E-W	7-8	
3	Furniture	2/11/2019	2026	Antechinus spp	D	C	E	9	
3	Furniture	4/11/2019	1919	Antechinus spp	D	I	W-E	13-15	
3	Furniture	5/11/2019	0027	Antechinus spp	D	I	E-W	16-17	
3	Furniture	8/11/2019	0301	Antechinus spp	D	C	E	18	
3	Furniture	8/11/2019	2104	Black rat	D	C	E	20	
3	Furniture	8/11/2019	2140	Black rat	D	C	W	21-25	Climbing on camera
3	Furniture	9/11/2019	0057	Antechinus spp	D	I	EW	26-27	
3	Furniture	11/11/2019	0301	Black rat	D	C	E	29	
3	Furniture	15/11/2019	0250	Antechinus spp	D	I	EW	31-32	
3	Furniture	15/11/2019	1943	Antechinus spp	D	C	E	36	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Furniture	15/11/2019	1959	Antechinus spp	D	C	W	37	
3	Furniture	16/11/2019	2334	Antechinus spp	D	C	W	39	
3	Furniture	17/11/2019	2356	Antechinus spp	D	I	EW	41-42	
3	Furniture	18/11/2019	2211	Antechinus spp	D	I	EW	43-44	
3	Furniture	18/11/2019	2232	Antechinus spp	Pr	C	E	45	
3	Furniture	19/11/2019	0118	Antechinus spp	Pr	C	E	47	
3	Furniture	19/11/2019	0258	Antechinus spp	Pr	I	EW	49-50	
3	Furniture	19/11/2019	0333	Antechinus spp	Pr	C	E	51	
3	Furniture	19/11/2019	2212	Antechinus spp	Pr	C	E	53	
3	Furniture	20/11/2019	0108	Antechinus spp	Pr	C	E	55	
3	Furniture	21/11/2019	0237	Black rat	D	C	E	57	
3	Furniture	21/11/2019	2006	Black rat	Pr	I	EW	58-59	
3	Furniture	21/11/2019	2235	Antechinus spp	Pr	C	E	61	
3	Furniture	21/11/2019	2335	Black rat	D	I	EW	63-64	
3	Furniture	22/11/2019	0032	Black rat	D	C	W	65	
3	Furniture	22/11/2019	0140	Black rat	Pr	C	E	66	
3	Furniture	22/11/2019	0249	Black rat	Pr	C	E	67	
3	Furniture	23/11/2019	0056	Black rat	Pr	C	E	69	
3	Furniture	23/11/2019	0351	Antechinus spp	D	C	E	70	
3	Furniture	25/11/2019	0059	Black rat	Pr	C	E	72	
3	Furniture	28/11/2019	2134	Antechinus spp	D	I	WE	74-75	
3	Furniture	29/11/2019	2006	Black rat	Pr	C	E	77	
3	Furniture	29/11/2019	2222	Black rat	D	C	E	78-79	Climbs on camera
3	Furniture	29/11/2019	2237	Black rat	D	C	W	80	
3	Furniture	29/11/2019	2358	Black rat	D	C	E	81-82	
3	Furniture	30/11/2019	2113	Antechinus spp	D	I	WE	83-84	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
3	Furniture	1/12/2019	2213	Black rat	D	C	W	85	
3	Furniture	2/12/2019	0008	Black rat	D	C	E	86	
3	Furniture	2/12/2019	2121	Black rat	D	C	E	89	
3	Furniture	3/12/2019	2046	Black rat	D	C	E	90-91	
3	Furniture	3/12/2019	2114	Black rat	D	C	W	92	
3	Furniture	5/12/2019	0341	Antechinus spp	D	C	W	93	
3	Furniture	7/12/2019	0336	Black rat	D	C	E	95	
3	Furniture	13/12/2019	0348	Black rat	D	C	W	101	
3	Furniture	15/12/2019	2116	Antechinus spp	D	C	W	102	
3	Furniture	15/12/2019	2123	Antechinus spp	D	C	E	103	
3	Furniture	16/12/2019	2144	Black rat	D	I	EW	104-108	back and fourth multiple times
4	Floor	12/09/2019	2006	CBtP	Pr	C	E	2	
4	Floor	15/09/2019	0033	Swamp wallaby	Pr	C	W	3	
4	Floor	15/09/2019	1912	Small mammal	D	C	E	4	
4	Floor	16/09/2019	2318	Cat	D	C	W	5	
4	Floor	21/09/2019	2014	CBtP	D	C	E	7-9	
4	Floor	22/09/2019	0058	CBtP	D	C	W	10	
4	Floor	24/09/2019	2004	CBtP	Pr	C	E	11	
4	Floor	25/09/2019	2328	Cat	Pr	C	W	13	
4	Floor	29/09/2019	1848	CBtP	Pr	C	E	15	
4	Floor	29/09/2019	1948	Swamp wallaby	Pr	C	E	16	
4	Floor	29/09/2019	2031	CBtP	Pr	C	W	17	
4	Floor	3/10/2019	0141	Cat	D	C	E	18	
4	Floor	3/10/2019	0218	Cat	D	C	W	19	
4	Floor	3/10/2019	2014	CBtP	D	C	E	20	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
4	Floor	4/10/2019	0048	CBtP	Pr	C	W	21	
4	Floor	6/10/2019	1901	CBtP	D	C	E	22	
4	Floor	7/10/2019	0113	CBtP	D	C	W	23	
4	Floor	8/10/2019	1945	CBtP	Pr	C	E	24	
4	Floor	11/10/2019	0407	Cat	D	C	E	26	
4	Floor	11/10/2019	1857	CBtP	Pr	C	E	27	
4	Floor	15/10/2019	1912	CBtP	D	C	E	28	
4	Floor	17/10/2019	1934	CBtP	D	C	E	29	
4	Floor	20/10/2019	1905	CBtP	D	C	E	30	
4	Floor	20/10/2019	2304	CBtP	D	C	W	31	
4	Floor	23/10/2019	0428	Cat	D	C	E	32	
4	Floor	23/10/2019	2126	CBtP	D	C	E	33	
4	Floor	24/10/2019	2341	CBtP	Pr	C	W	1	
4	Floor	29/10/2019	1953	CBtP	Pr	C	E	4	
4	Floor	5/11/2019	1917	CBtP	Pr	C	E	6	
4	Floor	6/11/2019	1838	Red necked	D	C	W	7	
4	Floor	10/11/2019	1917	CBtP	Pr	I	E-W	8-9	
4	Floor	16/11/2019	2115	CBtP	Pr	C	E	12	
4	Floor	17/11/2019	0102	Large macropod spp	D	C	W	13	
4	Floor	18/11/2019	1852	Cat	D	C	E	14	
4	Floor	23/11/2019	1951	BtPoss spp	D	C	W	15	
4	Floor	28/11/2019	2101	Cat	D	C	E	17	
4	Floor	3/12/2019	0618	Wallaby spp	Pr	C	E	22	
4	Floor	4/12/2019	1922	Cat	D	C	W	26	
4	Floor	10/12/2019	0635	Human w dog				29-30	Shakes camera
4	Floor	14/12/2019	2111	CBtP	Pr	C	E	31	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
4	Floor	15/12/2019	2231	CBtP	D	C	W	32	
4	Furniture	10/09/2019	1821	Antechinus spp	Pr	C	E	1	
4	Furniture	11/09/2019	1753	Antechinus spp	Pr	C	E	3	
4	Furniture	13/09/2019	2100	Antechinus spp	Pr	C	E	7	
4	Furniture	17/09/2019	450	Antechinus spp	Pr	C	E	10	
4	Furniture	17/09/2019	2058	Antechinus spp	D	C	E	11	
4	Furniture	17/09/2019	2113	Antechinus spp	D	C	W	12	
4	Furniture	22/09/2019	1920	Antechinus spp	D	C	E	13	
4	Furniture	22/09/2019	1943	Antechinus spp	D	C	W	14	
4	Furniture	22/09/2019	2024	Antechinus spp	D	C	W	15	
4	Furniture	28/09/2019	1950	Antechinus spp	D	C	E	17	
4	Furniture	28/09/2019	2010	Antechinus spp	D	C	E	18	
4	Furniture	5/10/2019	0242	Antechinus spp	Pr	C	E	22	
4	Furniture	8/10/2019	0422	Antechinus spp	D	C	E	24	
4	Furniture	11/10/2019	0418	Antechinus spp	D	C	E	26	
4	Furniture	14/10/2019	0357	Antechinus spp	D	C	E	28	
4	Furniture	16/10/2019	2019	Antechinus spp	D	C	E	30	
4	Furniture	16/10/2019	2030	Antechinus spp	Pr	C	W	31	
4	Furniture	23/10/2019	2341	Antechinus spp	Pr	C	W	32	
4	Furniture	30/10/2019	0211	Antechinus spp	D	C	E	1	
4	Furniture	30/10/2019	0229	Antechinus spp	Pr	C	W	2	
4	Furniture	6/11/2019	0023	Antechinus spp	Pr	C	E	3	
4	Furniture			microbat	present				
5	Floor	13/09/2019	0525	Hare	D	C	E	2,4,6	
5	Floor	13/09/2019	1800	Hare	D	C	E	8	
5	Floor	13/09/2019	2138	Hare	D	C	E	9	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
5	Floor	21/09/2019	2008	Echidna	D	C	W	16	
5	Floor	23/09/2019	2059	Bandicoot spp	D	C	E	21	
5	Floor	23/09/2019	2333	Bandicoot spp	D	C	W	23	
5	Floor	2/10/2019	2129	Bandicoot spp	Pr	C	E	43	
5	Floor	2/10/2019	2208	Bandicoot spp	D	C	E	44	
5	Floor	2/10/2019	2344	Bandicoot spp	D	C	E	45	
5	Floor	5/10/2019	2306	Bandicoot spp	D	C	E	47,48	
5	Floor	6/10/2019	2344	Rodent spp	Pr	C	W	50	
5	Floor	13/10/2019	0217	House mouse	Pr	C	E	74	
5	Floor	19/10/2019	1931	Northern brown bandicoot	Pr	C	W	86	mum and young following
5	Floor	19/10/2019	2237	Northern brown bandicoot	Pr	C	E	87-91	back and fourth
5	Floor	22/10/2019	0117	BtPoss spp	D	C	E	93	
5	Floor	24/10/2019	0046	Black rat	Pr	C	E	99	
5	Floor	1/11/2019	2232	Antechinus spp	Po	C	E	8	
5	Floor	7/11/2019	0046	House mouse	Po	C	E	12	
5	Floor	7/11/2019	0357	Wallaby spp	D	C	E	14	
5	Floor	11/11/2019	0157	Wallaby spp	D	C	E	20	
5	Floor	15/11/2019	0141	Bandicoot spp	Pr	C	E	32	
5	Floor	20/11/2019	2246	Bandicoot spp	Pr	C	E	42	
5	Floor	27/11/2019	2148	Cat	D	C	W	47	
5	Floor	28/11/2019	0243	Bandicoot spp	Pr	C	E	48	
5	Floor	1/12/2019	0224	Bandicoot spp	Pr	C	E	49	
5	Floor	3/12/2019	0233	Black rat	D	C	W	54	
5	Floor	3/12/2019	2123	Bandicoot spp	Pr	C	E	58	
5	Floor	3/12/2019	2146	House mouse	Po	C	E	59	
5	Floor	4/12/2019	0210	Bandicoot spp	Pr	C	E	64	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
5	Floor	9/12/2019	2203	Black rat	Pr	C	E	73	
5	Floor	12/12/2019	0129	Bandicoot spp	Pr	C	E	76	
5	Floor	16/12/2019	2136	Red necked wallaby	D	C	E	78	
5	Floor	16/12/2019	2146	Bandicoot spp	D	C	E	79	
5	Floor	16/12/2019	2351	Bandicoot spp	Pr	C	E	80	
5	Floor	17/12/2019	0215	House mouse	Po	C	E	81	
5	Furniture	19/09/2019	2353	Antechinus spp	D	C	E	2	
5	Furniture	20/09/2019	0008	Antechinus spp	D	C	E	7	
5	Furniture	26/09/2019	2252	Antechinus spp	D	C	E	15	
5	Furniture	28/09/2019	2146	Antechinus spp	D	C	E	16	
5	Furniture	28/09/2019	2350	Antechinus spp	Pr	C	E	18	
5	Furniture	3/10/2019	2325	Antechinus spp	D	C	E	28	
5	Furniture	4/10/2019	1819	Antechinus spp	D	C	E	32,34	
5	Furniture	4/10/2019	1842	Antechinus spp	D	C	E	36	
5	Furniture	6/10/2019	1806	Antechinus spp	D	C	E	39	
5	Furniture	6/10/2019	1824	Antechinus spp	D	C	E	41	
5	Furniture	6/10/2019	2348	Antechinus spp	D	C	E	42	
5	Furniture	7/10/2019	1755	Antechinus spp	D	C	E	47	
5	Furniture	7/10/2019	2310	Antechinus spp	D	C	E	49,51	
5	Furniture	8/10/2019	2155	Antechinus spp	D	C	E	53	
5	Furniture	15/10/2019	1910	Antechinus spp	D	C	E	79	
5	Furniture	15/10/2019	1944	Antechinus spp	D	C	E	81-83	
5	Furniture	16/10/2019	2122	Antechinus spp	D	C	E	84	
5	Furniture	17/10/2019	1844	Antechinus spp	D	C	E	88	
5	Furniture	17/10/2019	1858	Antechinus spp	D	C	E	89	
5	Furniture	17/10/2019	2308	Antechinus spp	D	C	E	92	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
5	Furniture	18/10/2019	1849	Antechinus spp	Pr	C	E	97	
5	Furniture	20/10/2019	1853	Antechinus spp	Pr	C	E	100	
5	Furniture	21/10/2019	0423	Antechinus spp	D	C	W	101	
5	Furniture	21/10/2019	1820	Antechinus spp	D	C	W	102	
5	Furniture	23/10/2019	1856	Antechinus spp	D	C	E	112	
5	Furniture	2/11/2019	1938	Antechinus spp	Pr	C	E	8	
5	Furniture	3/11/2019	2111	Antechinus spp	Pr	C	E	10	
5	Furniture	4/11/2019	1948	Antechinus spp	D	C	E	12	
5	Furniture	4/11/2019	2207	Antechinus spp	D	C	E	14	
5	Furniture	5/11/2019	0146	Antechinus spp	D	C	E	15	
5	Furniture	5/11/2019	0222	Antechinus spp	D	C	E	17	
5	Furniture	6/11/2019	0336	Antechinus spp	Pr	C	E	18	
5	Furniture	7/11/2019	0130	Antechinus spp	Pr	C	E	22	
5	Furniture	7/11/2019	1929	Antechinus spp	D	C	E	23-24	
5	Furniture	7/11/2019	1951	Antechinus spp	Pr	C	E	25	
5	Furniture	8/11/2019	0041	Antechinus spp	Pr	C	E	27	
5	Furniture	8/11/2019	0152	Antechinus spp	Pr	C	E	28	
5	Furniture	8/11/2019	1911	Antechinus spp	D	C	W	29	
5	Furniture	8/11/2019	2245	Antechinus spp	D	C	E	30	
5	Furniture	9/11/2019	0218	Antechinus spp	D	C	W	31	
5	Furniture	10/11/2019	0236	Antechinus spp	Pr	C	E	35-36	
5	Furniture	11/11/2019	0232	Antechinus spp	Pr	C	E	38	
5	Furniture	11/11/2019	1929	Antechinus spp	Pr	C	E	40	
5	Furniture	12/11/2019	1908	Antechinus spp	D	C	W	41	
5	Furniture	22/11/2019	2028	Antechinus spp	D	C	E	42	
5	Furniture	24/11/2019	1943	Antechinus spp	Pr	C	E	55	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
5	Furniture	30/11/2019	0250	Antechinus spp	D	C	E	57	
5	Furniture	30/11/2019	2021	Antechinus spp	D	C	E	59	
5	Furniture	3/12/2019	0203	Black rat	D	C	E	63-65	
5	Furniture	3/12/2019	0225	Black rat	D	I	EW	70-71	
5	Furniture	5/12/2019	2340	Black rat	Pr	C	E	84-86	
5	Furniture	9/12/2019	2145	Black rat	Pr	I	W-E	88-91	
5	Furniture	9/12/2019	2217	Black rat	Pr	C	E	92	
5	Furniture	11/12/2019	2339	Antechinus spp	D	C	E	97	
				microbat	present				
6	Floor	12/09/2019	56	BtPoss spp	D	C	E	1-2	
6	Floor	14/09/2019	2040	Hare	Pr	C	W	7	
6	Floor	14/09/2019	2122	Hare	Pr	C	E	9-10	
6	Floor	15/09/2019	2053	Bandicoot spp	Pr	C	E	13-14	
6	Floor	15/09/2019	2345	Black rat	Pr	C	W	15-18	
6	Floor	18/09/2019	1809	Northern brown bandicoot	Pr	C	W	23-24	
6	Floor	18/09/2019	2224	Bandicoot spp	D	C	E	25-26	
6	Floor	18/09/2019	2340	Hare	D	C	W	27	
6	Floor	19/09/2019	0139	Hare	D	C	E	29-30	
6	Floor	29/09/2019	2229	SEBtP	D	C	E	45-48	
6	Floor	5/10/2019	2253	BtPoss spp	D	C	E	53-54	
6	Floor	12/10/2019	2029	Fox	Pr	C	E	61-62	
6	Floor	14/10/2019	0131	Fox	Pr	C	E	63-64	
6	Floor	23/10/2019	2255	Bandicoot spp	Pr	C	E	67-68	
6	Floor	1/11/2019	0511	Dog	Pr	C	E	1	
6	Floor	1/11/2019	2230	Fox	Pr	C	E	2	
6	Floor	3/11/2019	2023	Fox	Pr	C	E	4	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
6	Floor	3/11/2019	2255	Fox	Pr	C	E	5	
6	Floor	4/11/2019	2205	Fox	Pr	C	E	6	
6	Floor	9/11/2019	0052	Fox	Pr	C	E	7	
6	Floor	12/11/2019	0321	Fox	Pr	C	E	11	
6	Floor	14/11/2019	0241	Fox	Pr	C	E	13	
6	Floor	15/11/2019	2052	Bandicoot spp	Pr	C	E	21	
6	Floor	17/11/2019	0132	Fox	Pr	C	E	24	
6	Floor	18/11/2019	2351	Fox	D	C	W	28	
6	Floor	21/11/2019	0332	Fox	Pr	C	W	29	
6	Floor	21/11/2019	0352	Fox	Pr	C	E	31	
6	Floor	21/11/2019	2302	Fox	Pr	C	E	32	
6	Floor	24/11/2019	0105	Fox	D	C	W	34	
6	Floor	24/11/2019	2109	Fox	Pr	C	E	35	
6	Floor	26/11/2019	1849	Fox	D	C	E	37	
6	Floor	27/11/2019	2210	Fox	D	C	W	39	
6	Floor	28/11/2019	1700	EG kangaroo	Pr	C	E	41	2 x ind
6	Floor	29/11/2019	0100	Fox	Pr	C	W	42	
6	Floor	29/11/2019	1712	EG kangaroo	Pr	C	W	43	juvenile
6	Floor	29/11/2019	2241	Fox	Pr	C	E	44	
6	Floor	1/12/2019	0604	EG kangaroo	Pr	C	E	46	2 x ind
6	Floor	2/12/2019	0309	Fox	Pr	C	E	47	
6	Floor	2/12/2019	0428	EG kangaroo	Pr	I	E-W	48-52	3 x ind.
6	Floor	3/12/2019	2227	Fox	Pr	C	E	54	
6	Floor	6/12/2019	0203	Fox	Pr	C	E	55	
6	Floor	7/12/2019	0138	EG kangaroo	Pr	C	E	56	
6	Floor	7/12/2019	2346	EG kangaroo	Pr	C	E	59-61	3 x ind.

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
6	Floor	8/12/2019	0002	EG kangaroo	Pr	C	W	62	2 x ind
6	Floor	8/12/2019	0406	Fox	Pr	C	E	63	
6	Floor	9/12/2019	0003	Fox	Pr	C	E	64	
6	Floor	9/12/2019	0026	EG kangaroo	Pr	C	E	65-66	3 x ind.
6	Floor	10/12/2019	0256	Fox	D	C	E	68	
6	Floor	11/12/2019	2059	Fox	D	C	E	69	
6	Floor	12/12/2019	2224	Fox	D	C	E	70	
6	Floor	17/12/2019	0311	EG kangaroo	Pr	C	E	71	3 x ind.
6	Floor	17/12/2019	0353	EG kangaroo	Pr	C	W	72	
6	Furniture			microbat	present				
6	Furniture	9/12/2019	1724	Carpet python	D	C	W	41-42	checking out camera
7	Floor	14/09/2019	0537	Fox	Po	C	E	5	
7	Floor	17/09/2019	2245	Small mammal	D	C	E	6	
7	Floor	23/09/2019	0427	Fox	Pr	C	E	12	
7	Floor	26/09/2019	2321	echidna	D	C	E	14	
7	Floor	30/09/2019	1900	Black rat	Pr	I	EXM	15-16	
7	Floor	1/10/2019	2346	Fox	Pr	C	E	18	large prey in mouth
7	Floor	3/10/2019	0008	Fox	Pr	C	E	20	
7	Floor	4/10/2019	0358	Fox	Pr	C	E	21	
7	Floor	4/10/2019	2125	Fox	Pr	C	E	22	
7	Floor	8/10/2019	0023	Fox	Pr	C	E	23	
7	Floor	13/10/2019	0509	Fox	Pr	C	E	24	
7	Floor	13/10/2019	1849	Fox	D	C	W	25	
7	Floor	18/10/2019	2136	Fox	D	C	E	27	
7	Floor	16/11/2019	0246	Echidna	D	C	E	13	
7	Floor	18/11/2019	0236	Fox	D	C	W	16	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
7	Floor	19/11/2019	2053	Fox	D	I	E-W	19-20	
7	Floor	28/11/2019	2329	Fox	Pr	C	E	28	
7	Floor	13/12/2019	1713	Large macropod	D	C	E	40	
7	Furniture	28/09/2019	1952	Antechinus spp	D	C	E	21	
7	Furniture	2/10/2019	0444	Antechinus spp	D	C	W	25	
7	Furniture	6/10/2019	2136	Antechinus spp	D	C	W	27	
7	Furniture	22/10/2019	2146	Antechinus spp	D	C	E	34	
7	Furniture	27/10/2019	0325	Antechinus spp	Pr	C	W	1	
7	Furniture	29/10/2019	0302	Antechinus spp	D	C	E	2	
7	Furniture	7/12/2019	0351	Antechinus spp	D	C	E	38	
7	Furniture	17/12/2019	0139	Antechinus spp	D	I	EXM	41	
7	Furniture			microbat	present				
8	Floor	25/09/2019	0016	Rufous bettong	Pr	C	E	12	
8	Floor	6/10/2019	1826	Wallaby spp	Pr	C	E	15	
8	Floor	8/10/2019	2033	Wallaby spp	Pr	C	E	20	
8	Floor	12/10/2019	0528	Wallaby spp	Pr	C	E	23	
8	Floor	15/10/2019	0236	Wallaby spp	Pr	C	W	24	
8	Floor	16/10/2019	0117	Wallaby spp	Pr	C	E	25	
8	Floor	23/10/2019	1917	Antechinus spp	Pr	C	E	1	
8	Floor	31/10/2019	0132	Northern brown bandicoot	Pr	C	W	6	
8	Floor	2/11/2019	0417	Bandicoot spp	Pr	C	W	8	
8	Floor	21/11/2019	2324	Antechinus spp	D	C	W	39	
8	Floor	23/11/2019	0627	Wallaby spp	Pr	C	E	51	
8	Floor	28/11/2019	0022	Wallaby spp	Pr	C	E	58	
8	Floor	8/12/2019	1814	Cat	D	C	W	94	black with white paws
8	Floor	16/12/2019	2121	Bandicoot spp	D	C	E	103	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
8	Floor	16/12/2019	2143	Northern brown bandicoot	Pr	C	W	104	
8	Furniture	15/09/2019	530	Antechinus spp	Pr	C	E	8	
8	Furniture	16/09/2019	1900	Antechinus spp	Pr	C	E	10	
8	Furniture	20/09/2019	1904	Antechinus spp	Pr	C	E	15	
8	Furniture	20/09/2019	2142	Antechinus spp	Pr	C	E	17	
8	Furniture	21/09/2019	1805	Antechinus spp	Pr	C	E	20	
8	Furniture	22/09/2019	0147	Antechinus spp	Pr	C	E	23	
8	Furniture	22/09/2019	1830	Antechinus spp	Pr	C	E	26	
8	Furniture	23/09/2019	0244	Antechinus spp	Pr	C	E	29	
8	Furniture	24/09/2019	0119	Antechinus spp	Pr	C	E	31	
8	Furniture	25/09/2019	0430	Antechinus spp	Pr	C	E	40	
8	Furniture	25/09/2019	2118	Antechinus spp	Pr	C	E	42	
8	Furniture	26/09/2019	1830	Antechinus spp	Pr	C	E	45	
8	Furniture	26/09/2019	2217	Antechinus spp	Pr	C	E	47	
8	Furniture	27/09/2019	1907	Antechinus spp	Pr	C	E	49	
8	Furniture	27/09/2019	2206	Antechinus spp	Pr	C	E	50	
8	Furniture	28/09/2019	1841	Antechinus spp	Pr	C	E	52	
8	Furniture	28/09/2019	2355	Antechinus spp	Pr	C	E	54	
8	Furniture	29/09/2019	1906	Antechinus spp	Pr	C	E	56	
8	Furniture	29/09/2019	2135	Antechinus spp	Pr	C	E	58	
8	Furniture	30/09/2019	1957	Antechinus spp	Pr	C	W	60	
8	Furniture	1/10/2019	1833	Antechinus spp	Pr	C	E	62	
8	Furniture	3/10/2019	2107	Antechinus spp	Pr	C	E	67	
8	Furniture	5/10/2019	0501	Antechinus spp	Pr	C	E	71	
8	Furniture	6/10/2019	0500	Antechinus spp	Pr	C	E	74	
8	Furniture	7/10/2019	0146	Antechinus spp	Pr	C	E	76	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
8	Furniture	7/10/2019	1822	Antechinus spp	Pr	C	E	79	
8	Furniture	8/10/2019	0145	Antechinus spp	Pr	C	E	81	
8	Furniture	9/10/2019	0313	Antechinus spp	Pr	C	E	85	
8	Furniture	11/10/2019	0349	Antechinus spp	Pr	C	E	87	
8	Furniture	12/10/2019	0232	Antechinus spp	Pr	C	E	90	
8	Furniture	12/10/2019	1822	Antechinus spp	Pr	C	E	92	
8	Furniture	13/10/2019	0316	Antechinus spp	Pr	C	E	94	
8	Furniture	15/10/2019	0144	Antechinus spp	Pr	C	E	98	
8	Furniture	15/10/2019	1822	Antechinus spp	Pr	C	E	100	
8	Furniture	16/10/2019	0425	Antechinus spp	Pr	C	E	103	
8	Furniture	17/10/2019	0111	Antechinus spp	Pr	C	E	105	
8	Furniture	17/10/2019	1835	Antechinus spp	Pr	C	E	107	
8	Furniture	18/10/2019	0404	Antechinus spp	Pr	C	E	108	
8	Furniture	18/10/2019	1846	Antechinus spp	Pr	C	W	113	
8	Furniture	19/10/2019	1836	Antechinus spp	Pr	C	E	114	
8	Furniture	20/10/2019	0414	Antechinus spp	Pr	C	E	116	
8	Furniture	21/10/2019	0032	Antechinus spp	Pr	C	E	118	
8	Furniture	22/10/2019	0421	Antechinus spp	D	C	W	122	
8	Furniture	23/10/2019	0445	Antechinus spp	D	C	W	124	
8	Furniture	24/10/2019	0134	Antechinus spp	Pr	C	E	5	
8	Furniture	24/10/2019	1917	Antechinus spp	D	C	E	6	
8	Furniture	24/10/2019	2047	Antechinus spp	Pr	C	E	8	
8	Furniture	26/10/2019	0226	Antechinus spp	D	C	W	12	
8	Furniture	26/10/2019	0432	Antechinus spp	D	C	E	13	
8	Furniture	26/10/2019	2248	Antechinus spp	D	C	E	14	
8	Furniture	28/10/2019	2002	Antechinus spp	D	C	E	17	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
8	Furniture	28/10/2019	2135	Antechinus spp	D	C	E	18	
8	Furniture	28/10/2019	2328	Antechinus spp	D	C	E	20	
8	Furniture	29/10/2019	0308	Antechinus spp	D	C	E	22	
8	Furniture	30/10/2019	2124	Antechinus spp	D	C	E	28	
8	Furniture	31/10/2019	0356	Antechinus spp	D	C	E	30	
8	Furniture	1/11/2019	0009	Antechinus spp	D	C	E	31	
8	Furniture	2/11/2019	0346	Antechinus spp	Pr	C	E	38	
8	Furniture	3/11/2019	0044	Antechinus spp	Pr	C	E	40	
8	Furniture	3/11/2019	2330	Antechinus spp	Pr	C	E	45	
8	Furniture	4/11/2019	0139	Antechinus spp	Pr	C	E	47	
8	Furniture	4/11/2019	0417	Antechinus spp	Pr	C	E	49	
8	Furniture	4/11/2019	2043	Antechinus spp	Pr	C	W	50	
8	Furniture	5/11/2019	0420	Antechinus spp	Pr	C	E	51	
8	Furniture	6/11/2019	0135	Antechinus spp	D	C	E	64	
8	Furniture	7/11/2019	0355	Antechinus spp	Pr	C	E	75	
8	Furniture	8/11/2019	0053	Antechinus spp	Pr	C	E	77	
8	Furniture	9/11/2019	0026	Antechinus spp	Pr	C	E	79	
8	Furniture	9/11/2019	0338	Antechinus spp	Pr	C	E	82	
8	Furniture	10/11/2019	0403	Antechinus spp	Pr	C	W	85	
8	Furniture	10/11/2019	0441	Antechinus spp	Pr	C	E	86	
8	Furniture	10/11/2019	1949	Antechinus spp	Pr	C	E	95	
8	Furniture	11/11/2019	1955	Antechinus spp	Pr	C	E	101	
8	Furniture	12/11/2019	0201	Antechinus spp	Pr	C	E	104	
8	Furniture	13/11/2019	0355	Antechinus spp	D	C	E	106	
8	Furniture	13/11/2019	2219	Antechinus spp	D	C	E	108	
8	Furniture	14/11/2019	0130	Antechinus spp	D	C	E	109	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
8	Furniture	14/11/2019	2023	Antechinus spp	D	C	E	111	
8	Furniture	14/11/2019	2223	Antechinus spp	Pr	C	E	113	
8	Furniture	16/11/2019	2004	Antechinus spp	Pr	C	E	118	
8	Furniture	16/11/2019	2205	Antechinus spp	Pr	C	E	121	
8	Furniture	16/11/2019	2354	Antechinus spp	Pr	C	E	123	
8	Furniture	17/11/2019	1946	Antechinus spp	Pr	C	E	127	
8	Furniture	17/11/2019	2251	Antechinus spp	Pr	C	E	128	
8	Furniture	18/11/2019	0412	Antechinus spp	Pr	C	E	129	
8	Furniture	19/11/2019	0343	Antechinus spp	Pr	C	E	130	
8	Furniture	19/11/2019	2050	Antechinus spp	Pr	C	E	132	
8	Furniture	19/11/2019	2304	Antechinus spp	Pr	C	E	134	
8	Furniture	20/11/2019	0218	Antechinus spp	Pr	C	E	136	
8	Furniture	20/11/019	2155	Antechinus spp	Pr	C	E	140	
8	Furniture	20/11/2019	2323	Antechinus spp	Pr	C	E	142	
8	Furniture	21/11/2019	0056	Antechinus spp	Pr	C	E	144	
8	Furniture	21/11/2019	2009	Antechinus spp	D	C	E	146	
8	Furniture	21/11/2019	2246	Antechinus spp	D	C	E	151	
8	Furniture	22/11/2019	2012	Antechinus spp	D	C	E	152	
8	Furniture	22/11/2019	2122	Antechinus spp	Pr	C	E	153	
8	Furniture	23/11/2019	0229	Antechinus spp	Pr	C	E	155	
8	Furniture	23/11/2019	2030	Antechinus spp	Pr	C	E	156	
8	Furniture	23/11/2019	2147	Antechinus spp	Pr	C	E	158	
8	Furniture	23/11/2019	2340	Antechinus spp	Pr	C	E	160	
8	Furniture	24/11/2019	2042	Antechinus spp	D	C	E	162	
8	Furniture	25/11/2019	0032	Antechinus spp	D	C	E	164	
8	Furniture	25/11/2019	0206	Antechinus spp	Pr	C	E	165	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
8	Furniture	25/11/2019	2021	Antechinus spp	Pr	C	E	167	
8	Furniture	25/11/2019	2157	Antechinus spp	Pr	C	E	169	
8	Furniture	25/11/2019	2335	Antechinus spp	Pr	C	E	170	
8	Furniture	26/11/2019	0340	Antechinus spp	Pr	C	E	174	
8	Furniture	27/11/2019	0038	Antechinus spp	Pr	C	E	177	
8	Furniture	27/11/2019	0219	Antechinus spp	Pr	C	E	178	
8	Furniture	27/11/2019	2023	Antechinus spp	Pr	C	E	180	
8	Furniture	27/11/2019	2230	Antechinus spp	D	C	E	182	
8	Furniture	28/11/2019	0017	Antechinus spp	D	C	E	184	
8	Furniture	28/11/2019	2001	Antechinus spp	Pr	C	E	186	
8	Furniture	29/11/2019	0416	Antechinus spp	Pr	C	E	187	
8	Furniture	29/11/2019	1937	Antechinus spp	D	C	E	188	
8	Furniture	29/11/2019	2213	Antechinus spp	Pr	C	E	191	
8	Furniture	30/11/2019	0117	Antechinus spp	Pr	C	E	193	
8	Furniture	30/11/2019	2124	Antechinus spp	Pr	C	E	195	
8	Furniture	30/11/2019	2237	Antechinus spp	Pr	C	E	197	
8	Furniture	1/12/2019	0128	Antechinus spp	Pr	C	E	199	
8	Furniture	1/12/2019	2140	Antechinus spp	D	C	E	200	
8	Furniture	2/12/2019	1944	Antechinus spp	Pr	C	E	208	
8	Furniture	2/12/2019	2128	Antechinus spp	Pr	C	E	209	
8	Furniture	3/12/2019	2004	Antechinus spp	Pr	C	E	212	
8	Furniture	4/12/2019	2007	Antechinus spp	Pr	C	E	214	
8	Furniture	4/12/2019	2343	Antechinus spp	Pr	C	E	216	
8	Furniture	5/12/2019	0150	Antechinus spp	Pr	C	E	218	
8	Furniture	5/12/2019	2040	Antechinus spp	Pr	C	E	222	
8	Furniture	6/12/2019	0031	Antechinus spp	Pr	C	E	223	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
8	Furniture	6/12/2019	2218	Antechinus spp	D	C	E	224	
8	Furniture	7/12/2019	0002	Antechinus spp	Pr	C	E	225	
8	Furniture	7/12/2019	2031	Antechinus spp	Pr	C	E	227	
8	Furniture	8/12/2019	2029	Antechinus spp	Pr	C	E	229	
8	Furniture	8/12/2019	2237	Antechinus spp	Pr	C	E	231	
8	Furniture	9/12/2019	2018	Antechinus spp	Pr	C	E	233	
8	Furniture	9/12/2019	2139	Antechinus spp	Pr	C	E	234	
8	Furniture	10/12/2019	0256	Antechinus spp	Pr	C	E	235	
8	Furniture	10/12/2019	0409	Antechinus spp	Pr	C	E	236	
8	Furniture	11/12/2019	0215	Antechinus spp	Pr	C	E	238	
8	Furniture	12/12/2019	1951	Antechinus spp	Pr	C	E	240	
8	Furniture	13/12/2019	2017	Antechinus spp	Pr	C	E	242	
8	Furniture	14/12/2019	2002	Antechinus spp	D	C	E	244	
8	Furniture	15/12/2019	0140	Antechinus spp	Pr	C	E	245	
8	Furniture	15/12/2019	0403	Antechinus spp	Pr	C	E	246	
8	Furniture	15/12/2019	1959	Antechinus spp	Pr	C	E	251	
8	Furniture	16/12/2019	0122	Antechinus spp	Pr	C	E	252	
8	Furniture	16/12/2019	2104	Antechinus spp	Pr	C	E	253	
8	Furniture	16/12/2019	2319	Antechinus spp	D	C	E	254	
8	Furniture	17/12/2019	0216	Antechinus spp	Pr	C	E	255	
8	Furniture			microbat	present				
9	Floor	12/09/2019	1838	Antechinus spp	Po	C	W	1	
9	Floor	20/09/2019	1849	small mammal	D	C	W	5	
9	Floor	20/09/2019	1904	Antechinus spp	Pr	Incomplete	EW	6	
9	Floor	24/09/2019	2345	Rufous bettong	Pr	C	W	11	
9	Floor	25/09/2019	0013	Rufous bettong	Pr	C	E	12	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
9	Floor	28/09/2019	1952	Rattus spp	Pr	C	EW	16	
9	Floor	28/09/2019	2209	Rattus spp	D	C	W	17	
9	Floor	30/09/2019	1924	Bandicoot spp	Pr	C	E	19	
9	Floor	5/10/2019	2215	Rattus spp	D	C	E	22	
9	Floor	5/10/2019	2350	Rattus spp	D	C	E	23	
9	Floor	6/10/2019	0021	Rattus spp	D	C	E	24	
9	Floor	6/10/2019	1739	Wallaby spp	D	C	W	25	
9	Floor	8/10/2019	1753	Wallaby spp	D	C	W	27	
9	Floor	8/10/2019	2001	Wallaby spp	D	C	E	28	
9	Floor	10/10/2019	0536	Wallaby spp	D	C	W	29	
9	Floor	12/10/2019	0258	Wallaby spp	D	C	W	30	
9	Floor	15/10/2019	0242	Wallaby spp	D	C	W	33	
9	Floor	17/10/2019	1746	Wallaby spp	D	C	W	35	
9	Floor	18/10/2019	0027	small mammal	D	C	W	36	
9	Floor	18/10/2019	0420	Wallaby spp	D	C	E	37	
9	Floor	19/10/2019	0003	Wallaby spp	D	C	W	38	
9	Floor	23/10/2019	1901	Rodent spp	D	I	EXM	1	
9	Floor	23/10/2019	2110	House mouse	Pr	C	E	2	
9	Floor	24/10/2019	2214	Antechinus spp	Pr	I	EXM	3	
9	Floor	25/10/2019	2034	small mammal	D	C	E	4	
9	Floor	25/10/2019	2126	Rodent spp	D	C	W	5	
9	Floor	25/10/2019	2328	Rodent spp	D	C	E	7	
9	Floor	28/10/2019	2032	Rodent spp	D	C	E	10	
9	Floor	29/10/2019	0320	Antechinus spp	Pr	C	W	11	
9	Floor	29/10/2019	2240	Antechinus spp	Pr	I	WE	14-15	
9	Floor	31/10/2019	0209	Northern brown bandicoot	Pr	C	W	16	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
9	Floor	1/11/2019	0030	Antechinus spp	Pr	C	W	18	
9	Floor	3/11/2019	0121	Antechinus spp	Pr	C	W	19	
9	Floor	5/11/2019	1748	Swamp wallaby	Pr	C	W	27	
9	Floor	8/11/2019	2035	House mouse	D	C	E	30	
9	Floor	12/11/2019	0426	Bandicoot spp	D	I	WE	39	
9	Floor	23/11/2019	2214	Antechinus spp	Pr	C	W	52	
9	Floor	27/11/2019	1716	Swamp wallaby	Pr	C	W	80	
9	Floor	28/11/2019	0012	Red-necked wallaby	Pr	C	W	81-83	
9	Floor	12/12/2019	2209	House mouse	Pr	C	W	137	
9	Floor	13/12/2019	1943	Bandicoot spp	D	C	W	138	
9	Floor	4/12/2019	0112	Northern brown bandicoot	D	I	EW	139-140	
9	Floor	15/12/2019	2019	Bandicoot spp	D	C	W	146	
9	Floor	16/12/2019	1952	Northern brown bandicoot	Pr	I	WE	147-148	
9	Floor	16/12/2019	2145	Bandicoot spp	D	C	W	149	
9	Furniture	17/09/2019	2018	Antechinus spp	D	C	E	219	
9	Furniture	17/09/2019	2227	Antechinus spp	Pr	C	E	222	
9	Furniture	19/09/2019	1937	Antechinus spp	Pr	C	E	225	
9	Furniture	20/09/2019	1839	Antechinus spp	Pr	I	W-E	226-227	
9	Furniture	20/09/2019	2129	Antechinus spp	Pr	C	E	231	
9	Furniture	20/09/2019	0209	Antechinus spp	Pr	C	E	232	
9	Furniture	21/09/2019	1900	Antechinus spp	Pr	C	E	234	
9	Furniture	23/09/2019	0453	Antechinus spp	D	I	W-E	238-239	
9	Furniture	24/09/2019	0411	Antechinus spp	D	I	W-E	240-241	
9	Furniture	25/09/2019	1922	Antechinus spp	D	C	W	242	
9	Furniture	28/09/2019	0412	Antechinus spp	D	I	W-E	246-	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
								247	
9	Furniture	1/10/2019	0317	Antechinus spp	D	I	W-E	252-253	
9	Furniture	4/10/2019	0300	Antechinus spp	D	C	E	260	
9	Furniture	5/10/2019	0415	Antechinus spp	D	C	E	261	
9	Furniture	7/10/2019	0340	Antechinus spp	D	C	E	262	
9	Furniture	11/10/2019	0419	Antechinus spp	Pr	C	E	273	
9	Furniture	15/10/2019	0051	Antechinus spp	Pr	C	E	275	
9	Furniture	15/10/2019	0422	Antechinus spp	Pr	C	E	277	
9	Furniture	15/10/2019	1858	Antechinus spp	Pr	C	E	278	
9	Furniture	16/10/2019	2053	Antechinus spp	D	C	E	280	
9	Furniture	19/10/2019	1923	Antechinus spp	Pr	C	E	288	
9	Furniture	19/10/2019	1936	Antechinus spp	D	C	W	289	
9	Furniture	21/10/2019	0401	Antechinus spp	D	I	NDM	290	
9	Furniture	24/10/2019	2216	Antechinus spp	Pr	C	E	211	
9	Furniture	28/10/2019	0243	Antechinus spp	D	I	WE	215-216	
9	Furniture	29/10/2019	0350	Antechinus spp	D	C	W	217	
9	Furniture	31/10/2019	1944	Antechinus spp	D	I	EW	219-220	
9	Furniture	2/11/2019	2151	Antechinus spp	D	C	W	222	
9	Furniture	3/11/2019	0400	Antechinus spp	D	I	WE	223-224	
9	Furniture	3/11/2019	2108	Antechinus spp	Pr	C	E	225	
9	Furniture	8/11/2019	0233	Antechinus spp	D	C	E	229	
9	Furniture	8/11/2019	0253	Antechinus spp	D	C	E	230	
9	Furniture	9/11/2019	0027	Antechinus spp	D	C	E	232	
9	Furniture	14/11/2019	1948	Antechinus spp	D	C	W	244-245	
9	Furniture	16/11/2019	1859	Antechinus spp	Pr	C	E	250	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
9	Furniture	16/11/2019	1940	Antechinus spp	Pr	C	E	251	
9	Furniture	17/11/2019	0631	Antechinus spp	Pr	C	E	252	
9	Furniture	18/11/2019	2306	Antechinus spp	D	C	E	253	
9	Furniture	19/11/2019	1913	Antechinus spp	Pr	C	E	254	
9	Furniture	20/11/2019	1911	Antechinus spp	Pr	C	E	257	
9	Furniture	21/11/2019	2215	Antechinus spp	Pr	C	E	258	
9	Furniture	22/11/2019	1907	Antechinus spp	Pr	C	E	259	
9	Furniture	23/11/2019	2218	Antechinus spp	Pr	C	E	262	
9	Furniture	24/11/2019	1939	Antechinus spp	D	C	W	263	
9	Furniture	24/11/2019	2219	Antechinus spp	Pr	C	E	264	
9	Furniture	25/11/2019	2306	Antechinus spp	Pr	C	E	266	
9	Furniture	26/11/2019	1909	Antechinus spp	Pr	C	E	272	
9	Furniture	27/11/2019	2321	Antechinus spp	Pr	C	E	276	
9	Furniture	28/11/2019	2036	Antechinus spp	Pr	C	E	279	
9	Furniture	6/12/2019	0007	Antechinus spp	D	C	W	298	
9	Furniture	6/12/2019	1957	Antechinus spp	Pr	C	E	300	
9	Furniture	7/12/2019	0213	Antechinus spp	Pr	C	E	301	
9	Furniture	8/12/2019	2052	Antechinus spp	Pr	C	E	306	
9	Furniture	9/12/2019	1943	Antechinus spp	D	C	W	307	
9	Furniture	10/12/2019	1845	Antechinus spp	Pr	C	E	308	
9	Furniture	16/12/2019	2045	Antechinus spp	Pr	C	E	314	
9	Furniture			microbat	present				
10	Floor	24/10/2019	0603	Eastern grey kangaroo	Pr	C	E	38	
10	Floor	12/11/2019	2205	Red necked wallaby	Pr	I	W-E	17	
10	Floor	7/12/2019	0111	Black rat	Pr	I	NDM	50	
10	Furniture	11/09/2019	0002	Antechinus spp	Pr	C	E	2	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
10	Furniture	16/09/2019	1832	Antechinus spp	Pr	C	E	11	
10	Furniture	16/09/2019	1916	Antechinus spp	D	C	W	12	
10	Furniture	17/09/2019	2014	Antechinus spp	Pr	C	E	15	
10	Furniture	18/09/2019	2015	Antechinus spp	Pr	C	E	19	
10	Furniture	19/09/2019	1904	Antechinus spp	Pr	C	W	26	
10	Furniture	19/09/2019	1918	Antechinus spp	Pr	C	E	27	
10	Furniture	19/09/2019	2155	Antechinus spp	Pr	C	W	29	
10	Furniture	19/09/2019	2350	Antechinus spp	Pr	I	E-W	30-31	
10	Furniture	4/10/2019	1944	Antechinus spp	Pr	C	E	46	
10	Furniture	4/10/2019	2050	Antechinus spp	Pr	C	W	47	
10	Furniture	8/10/2019	0054	Antechinus spp	Pr	C	E	49	
10	Furniture	19/10/2019	1858	Antechinus spp	Pr	C	E	63	
10	Furniture	19/10/2019	1915	Antechinus spp	D	C	W	64	
10	Furniture	26/10/2019	1949	Antechinus spp	D	I	EW	3-4	
10	Furniture	7/12/2019	0128	Black rat	D	C	W	22-27	Back and fourth few times
10	Furniture			microbat	present				
11	Floor	15/09/2019	1946	Cat	D	C	W	97	
11	Floor	22/09/2019	2122	Bandicoot spp	Pr	C	E	108	
11	Floor	4/10/2019	2352	SEBtP	Pr	C	W	132	
11	Floor	7/10/2019	0303	BtPoss spp	D	C	E	135	
11	Floor	8/10/2019	0114	Long-nosed bandicoot	Pr	C	E	140	
11	Floor	9/10/2019	0057	Bandicoot spp	D	I	EXM	143	
11	Floor	10/10/2019	0439	Bandicoot spp	D	C	E	147	
11	Floor	21/10/2019	0019	Bandicoot spp	Pr	C	E	173	
11	Floor	22/10/2019	0058	Bandicoot spp	Pr	C	E	176	
11	Floor	19/11/2019	2231	Bandicoot spp	D	C	W	66	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
11	Floor	20/11/2019	0011	Bandicoot spp	D	C	E	67	
11	Floor	26/11/2019	2120	Long-nosed bandicoot	Pr	I	EXM	117-120	
11	Floor	29/11/2019	2048	House mouse	Pr	C	E	123	
11	Floor	10/12/2019	0009	Black rat	D	C	E	160-161	
11	Floor	11/12/2019	2116	Black rat	Pr	C	E	170	
11	Floor	11/12/2019	2206	Rattus spp	D	I	NDM	171	ontop of camera
11	Floor	12/12/2019	0206	Black rat	Pr	C	E	174	
11	Floor	13/12/2019	2027	Black rat	Pr	C	W	179	
11	Floor	15/12/2019	0319	Black rat	Pr	C	E	183	
11	Floor	16/12/2019	0138	Black rat	Pr	C	E	187	
11	Floor	16/12/2019	2057	Black rat	D	C	E	198	
11	Floor	17/12/2019	0029	Black rat	Pr	C	E	199	
11	Floor			microbat	present				
11	Furniture	17/10/2019	2125	Antechinus spp	D	C	E	16-18	
11	Furniture	17/10/2019	2241	Antechinus spp	D	C	E	20	
11	Furniture	19/11/2019	2146	Antechinus spp	D	C	E	6-7	
11	Furniture	23/11/2019	0323	Antechinus spp	D	C	E	8-9	
11	Furniture	24/11/2019	0052	Antechinus spp	D	C	E	11	
11	Furniture	26/11/2019	0113	Black rat	D	I	WE	12-13	
11	Furniture	29/11/2019	2314	Black rat	D	I	WE	15-18	
11	Furniture	12/12/2019	2209	Black rat	D	I	WE	29-35	
Weast1	North	16/10/2019	0337	Swamp wallaby	D	Incomplete	EXM	19-21	Foraging
Weast1	North	18/10/2019	2114	Swamp wallaby	D	Incomplete	EXM	26-41	Foraging looks like same individual
Weast1	North	23/10/2019	0223	Swamp wallaby	D	Incomplete	EXM	43-94	Foraging looks like same individual

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
Weast1	North	28/10/2019	2319	RtPoss	D	Complete	South	3-4	
Weast1	North	1/11/2019	0129	RtPoss	D	Complete	South	7	
Weast1	North	7/11/2019	2303	Cat	D	Complete	South	10	
Weast1	North	10/11/2019	0049	RtPoss	D	Complete	South	13	
Weast1	North	16/11/2019	0501	Cat	D	Incomplete	EXM	19	ginger with white and ginger striped tail
Weast1	North	22/11/2019	0020	Cat	D	Incomplete	EXM	25	dark coloured- same as collared one before
Weast1	North	25/11/2019	0030	BtPoss spp	Pr	Incomplete	EXM	30	can only see end of tail
Weast1	North	25/11/2019	2154	RtPoss	Pr	Incomplete	EXM	33	
Weast1	North	27/11/2019	2020	Cat	D	Complete	South	34-35	
Weast1	North	6/12/2019	2239	BtPoss spp	D	Incomplete	EXM	43	
Weast1	North	8/12/2019	1943	Cat	D	Complete	South	46	
Weast1	South			nil					
Weast1	South	7/11/2019	2303	Cat	D	Complete	South	3	
Weast1	South	8/11/2019	0137	Cat	D	Complete	North	4	
Weast1	South	25/11/2019	0026	BtPoss spp	D	Complete	North	9	
Weast1	South	27/11/2019	2019	Cat	D	Complete	South	10-11	
Weast1	South	3/12/2019	0032	BtPoss spp	D	Complete	North	14	
Weast1	South	6/12/2019	0134	SEBtP	D	Complete	South	15	
Weast2	North	20/10/2019	2153	Swamp wallaby	Pr	Incomplete	EXM	8-9	
Weast2	North	21/10/2019	0213	Cat	D	Incomplete	NDM	10-12	Dark coloured, has collar on
Weast2	North	30/10/2019	0058	Cat	D	Complete	South	2	Same indiv. as above
Wmid	North	2/10/2019	2319	Wallaby spp	D	Incomplete	EXM	11	
Wmid	North	4/10/2019	2344	Swamp wallaby	Pr	Incomplete	EXM	22	
Weast2	South			nil					

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
Weast2	South	30/10/2019	0054	Cat	D	Complete	North	2-4	
Weast2	South	30/10/2019	0102	Cat	D	Incomplete	EXM	5	
Weast2	South	14/11/2019	0133	Cat	D	Complete	North	11	
Weast2	South	22/11/2019	0010	Cat	D	Incomplete	EXM	12-13	
Weast2	South	27/11/2019	2026	Cat	D	Incomplete	NDM	16	
Wmid	North	29/10/2019	110	Cat	D	Complete	North	2	
Wmid	North	30/10/2019	2328	Wallaby spp	D	Complete	South	3	
Wmid	North	2/11/2019	0122	Wallaby spp	D	Complete	South	5	
Wmid	North	3/11/2019	2350	Swamp wallaby	D	Complete	North	9	
Wmid	North	5/11/2019	2317	Swamp wallaby	D	Complete	South	30	
Wmid	North	6/11/2019	0029	LN potoroo	D	Complete	South	32	
Wmid	North	6/11/2019	0204	Cat	D	Complete	North	34	
Wmid	North	7/11/2019	0226	LN potoroo	D	Complete	South	36	Probable joey in pouch
Wmid	North	10/11/2019	0552	Swamp wallaby	D	Complete	South	52	
Wmid	North	15/11/2019	1846	Swamp wallaby	D	Complete	South	59	
Wmid	North	19/11/2019	0141	LN potoroo	D	Complete	North	72	
Wmid	North	22/11/2019	0325	Swamp wallaby	D	Complete	South	78	
Wmid	North	24/11/2019	2003	Swamp wallaby	D	Complete	North	84	
Wmid	North	29/11/2019	2225	Cat	D	Complete	North	98	Ginger
Wmid	North	3/12/2019	0359	Swamp wallaby	D	Complete	North	100	
Wmid	North	5/12/2019	0216	Swamp wallaby	D	Complete	North	103	
Wmid	North	9/12/2019	0305	Swamp wallaby	D	Complete	South	113-114	
Wmid	North	12/12/2019	0113	Swamp wallaby	D	Complete	North	118	
Wmid	North	15/12/2019	0449	Swamp wallaby	Pr	Complete	South	121	
Wmid	North	18/12/2019	2227	Swamp wallaby	Pr	Complete	South	129	
Wmid	North	19/12/2019	0413	Swamp wallaby x 2	D	Complete	South	130,132	2 individuals

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
Wmid	South	27/09/2019	0141	SEBtP	D	Complete	North	1	
Wmid	South	2/10/2019	2155	Fox	D	Complete	North	161	
Wmid	South	4/10/2019	2132	Swamp wallaby	D	Incomplete	N-S	164	
Wmid	South	4/10/2019	2349	Swamp wallaby	D	Complete	North	165-166	
Wmid	South	6/10/2019	0206	Swamp wallaby	D	Complete	North	170	
Wmid	South	9/10/2019	0127	Fox	D	Complete	North	179	
Wmid	South	9/10/2019	0151	Koala	D	Complete	North	180	
Wmid	South	17/10/2019	2249	Cat	D	Complete	South	183	
Wmid	South	26/10/2019	2253	LN potoroo	Pr	Complete	North	1	
Wmid	South	29/10/2019	111	Cat	D	Complete	North	149	
Wmid	South	29/10/2019	2010	Koala	D	Complete	North	156	
Wmid	South	29/10/2019	2018	LN potoroo	D	Complete	South	157	
Wmid	South	1/11/2019	2354	LN potoroo	D	Complete	South	160	
Wmid	South	2/11/2019	0352	Swamp wallaby	D	Complete	North	162	
Wmid	South	2/11/2019	0441	Swamp wallaby	D	Complete	North	164	
Wmid	South	3/11/2019	0107	Swamp wallaby	D	Complete	South	165	
Wmid	South	3/11/2019	0153	LN potoroo	Pr	Complete	North	166	
Wmid	South	3/11/2019	2351	Swamp wallaby	D	Complete	North	169	
Wmid	South	5/11/2019	2318	Swamp wallaby	D	Complete	South	180	
Wmid	South	6/11/2019	0029	LN potoroo	D	Incomplete	S-N	181-182	
Wmid	South	6/11/2019	0205	Cat	D	Complete	North	183	
Wmid	South	7/11/2019	0147	Echidna	D	Complete	North	184	
Wmid	South	7/11/2019	0227	LN potoroo	D	Complete	South	185	
Wmid	South	7/11/2019	0310	LN potoroo	Pr	Complete	North	186	
Wmid	South	8/11/2019	0211	LN potoroo	Pr	Complete	North	187	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
Wmid	South	8/11/2019	0216	Cat	D	Incomplete	N-S	188	
Wmid	South	8/11/2019	2026	Cane toad	D	Complete	South	189	
Wmid	South	8/11/2019	2341	Cane toad	D	Complete	North	190	
Wmid	South	10/11/2019	0216	LN potoroo	D	Complete	North	195	
Wmid	South	10/11/2019	0345	Swamp wallaby	D	Complete	North	196	
Wmid	South	10/11/2019	0553	Swamp wallaby	D	Complete	South	204	
Wmid	South	11/11/2019	0229	LN potoroo	D	Complete	North	207	
Wmid	South	13/11/2019	0158	Swamp wallaby	D	Complete	North	209	
Wmid	South	15/11/2019	0008	Swamp wallaby	D	Complete	North	213	
Wmid	South	15/11/2019	1847	Swamp wallaby	D	Complete	South	221	
Wmid	South	16/11/2019	0316	Cane toad	D	Complete	North	222	
Wmid	South	17/11/2019	2326	LN potoroo	Pr	Complete	North	223	
Wmid	South	19/11/2019	0142	LN potoroo	D	Complete	North	225	
Wmid	South	19/11/2019	0656	Swamp wallaby	Pr	Complete	North	226	
Wmid	South	22/11/2019	0326	Swamp wallaby	D	Complete	South	232	
Wmid	South	23/11/2019	0336	Swamp wallaby	D	Complete	North	238-39	
Wmid	South	24/11/2019	0352	Swamp wallaby	D	Incomplete	NDM	243	
Wmid	South	24/11/2019	2003	Swamp wallaby	D	Complete	North	244	
Wmid	South	24/11/2019	2130	Swamp wallaby	D	Complete	South	245	
Wmid	South	29/11/2019	2226	Cat	D	Complete	South	258	
Wmid	South	3/12/2019	0400	Swamp wallaby	D	Complete	South	262	
Wmid	South	4/12/2019	0248	Swamp wallaby	D	Complete	North	263	
Wmid	South	4/12/2019	2016	Echidna	D	Complete	South	264	
Wmid	South	5/12/2019	0145	Echidna	D	Complete	North	265	
Wmid	South	8/12/2019	0115	Koala	D	Complete	North	275-278	
Wmid	South	9/12/2019	0306	Swamp wallaby	D	Complete	North	279	

Site No.	Cam position	Date	Time	Species	Accuracy	Crossing type	Movem't direction	Image No's	Comments
Wmid	South	11/12/2019	2151	Echidna	D	Complete	North	280	
Wmid	South	12/12/2019	0114	Swamp wallaby	D	Complete	South	281	
Wmid	South	15/12/2019	0039	Swamp wallaby	D	Complete	North	293	
Wmid	South	16/12/2019	0237	Swamp wallaby	D	Complete	North	285	
Wmid	South	16/12/2019	2352	SEBtP	D	Complete	South	287	
Wmid	South	17/12/2019	0049	Swamp wallaby	D	Complete	North	288	
Wmid	South	17/12/2019	0219	Swamp wallaby	D	Complete	South	289	
Wmid	South	17/12/2019	0300	SEBtP	D	Complete	North	290	
Wmid	South	17/12/2019	0337	Cane toad	D	Complete	North	291	
Wmid	South	17/12/2019	2001	Echidna	D	Complete	South	294	
Wmid	South	18/12/2019	0510	Purple swamp hen	D	Complete	South	295	
Wmid	South	19/12/2019	0413	Swamp wallaby	D	Complete	South	297	

Appendix E: Road mortality surveys

Table E1: Details of road mortality surveys adjacent koala culverts monitored on W2B sections 1 & 2 and a segment of Wardell Road and Old Pacific Highway, Wardell, 2019.

Road	Date	Spr/Sum survey no.	Observer	Start	End	Carriageway	Species recorded	Age	Easting	Northing	Cleared off Rd	Live fauna on Rd edge	Location on road	Notes	Weather	Comments	Fence conditions
Wardell Rd	16/08/2019	1	DR&SR	735	740	N/A	Nil						N/A		Fine, 13deg, 81% RH, nil wind, nil rain	Lumleys Ln to Thurgates Ln (1.54km)	
Wardell Rd	25/10/2019	2	NP	0855	0905	N/A	Nil						N/A				
Old Pac Hwy	16/08/2019	1	DR&SR	745	800	N/A	Northern Brown Bandicoot	Adult	545406	6797579	No	No	N/A	30m from fence end	Fine, 13deg, 81% RH, nil wind, nil rain	Carlyle St to Coolgardie I'change (3.3km)	
Old Pac Hwy	25/10/2019	2	NP	0815	0855	N/A	CRtP	A	546366	6800112	No	Nil	N/A	60m from Kay's Rd	Fine	Permanent and temp fauna fence installed, prob accessed via Kay's Rd	
Old Pac Hwy	25/10/2019	2	NP			N/A	Macropod spp.	?	546364	6800067	No	Nil	N/A	20m from Kay's Rd	Fine	Prob accessed via Kay's Rd, very old, >6 months	
Old Pac Hwy	25/10/2019	2	NP			N/A	Black FF	A	546339	6799803	Yes	Nil	N/A		Fine		
Old Pac Hwy	25/10/2019	2	NP			N/A	Wood duck	A	546074	6799246	No	Nil	N/A		Fine	Between carriageways	
Old Pac Hwy	25/10/2019	2	NP			N/A	Prob tawny Frogmouth	A	546348	6799978	No	Nil	N/A		Fine		
Old Pac Hwy	25/10/2019	2	NP			N/A	CRtP	A	546286	6799657	No	Nil	N/A		Fine	Between carriageways	
Old Pac Hwy	25/10/2019	2	NP			N/A	Common tree snake	A	545500	6797764	No	Nil	N/A		Fine		
S1 and 2	15/08/2019	1	DR& SR	915	1145	NB	Medium mammal	>1month	506405	6692012	No	No	Left lane	No	Fine, 13deg, smoke haze, rh 84%, cc - nil, wind -	On small bridge	Good

Road	Date	Spr/Sum survey no.	Observer	Start	End	Carriageway	Species recorded	Age	Easting	Northing	Cleared off Rd	Live fauna on Rd edge	Location on road	Notes	Weather	Comments	Fence conditions
															nil		
S1 and 2	15/08/2019	1	DR& SR			NB	Medium mammal	>1month	506447	6691678	Yes	Fairy wrens	Shoulder	Yes		Poss echidna	15
S1 and 2	15/08/2019	1	DR& SR			NB	Medium mammal	>1month	514898	6682154	No	No	Right lane	No		Poss fox	Good
S1 and 2	15/08/2019	1	DR& SR			NB	Unid bird	<2weeks	517942	6675754	No	No	Left lane	No			Good
S1 and 2	15/08/2019	1	DR& SR			NB	Hare	<2weeks	514605	6682206	No	No	Median	No			Fence gap
S1 and 2	15/08/2019	1	DR& SR			NB	Swamp wallaby	<1month	513232	6684339	Yes	No	Shoulder	Yes			
S1 and 2	15/08/2019	1	DR& SR			NB	Cat	<2months	512266	6686206	Yes	No	Shoulder	Yes			
S1 and 2	15/08/2019	1	DR& SR			NB	Grey-headed flying-fox	<7days	510876	6687049	No	Passerines	Right lane	No			
S1 and 2	15/08/2019	1	DR& SR			NB	Tawny frogmouth	<24hrs	508022	6689052	No	No	Shoulder	No			Good
S1 and 2	15/08/2019	1	DR& SR			NB	Eastern grey kangaroo	<7days	506952	6689945	No		Shoulder	No		Prob entered at Kungala Rd	
S1 and 2	15/08/2019	1	DR& SR			NB	Northern Brown Bandicoot	<7dys	505644	6694303	No		Shoulder	No			No fence
S1 and 2	22/10/2019	2	NP & SR			NB	Carpet Python	<7 days	518081	6676419	No	Passerines	Shoulder	No			
S1 and 2	22/10/2019	2	NP & SR			NB	Swamp Wallaby	>7 days	516829	6679786	No		Shoulder	No			
S1 and 2	22/10/2019	2	NP & SR			NB	Medium mammal	>7 days	509494	6688074	No	Passerines	Shoulder	No			
S1 and 2	22/10/2019	2	NP & SR			SB	Medium animal	<7 days	505511	6695134	No		Left lane	No		Smudge	Good