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Thermal drone surveys of the western City of Newcastle local government area

Prepared for: City of Newcastle, Planning and Environment, Environment and Sustainability

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NVE Project Ref: NVE_067

EXECUTIVE SUMMARY

The City of Newcastle (CN) engaged Nightvision Ecology to conduct thermal drone surveys across the western extent of the City of Newcastle Local Government Area (LGA) to assess occupancy, distribution, and relative abundance of the Endangered Koala (*Phascolarctos cinereus*).

Between April and June 2025, we conducted repeat surveys of 553 hectares of remnant vegetation using DJI Matrice 30T drones equipped with thermal cameras and spotlights, following BAM guidelines to detect Koalas and other incidental mammals and birds. Surveys covered Council-managed land (Summerhill Waste Management Centre, Minmi Cemetery, riparian corridors), National Parks and Wildlife Services (NPWS) reserves (Blue Gum Hills Regional Park, Stockrington State Conservation Area), and Transport for NSW (TfNSW) road corridor (Figure 1).

Key Results:

1. **Confirmed Koala presence**: 17 detections representing at least 5 individuals in Blue Gum Hills Regional Park and Stockrington State Conservation Area
2. **Resident populations indicated**: Koalas detected in consistent locations across surveys one month apart
3. **High biodiversity value confirmed**: 706 fauna detections across 31 species, including threatened Grey-headed Flying-fox and potential Squirrel Glider
4. **Identify critical research, monitoring, and management**: priorities including the need for wildlife corridors, road mitigation measures, and targeted conservation strategies to address fragmentation impacts from the Pacific Motorway and urban development.

Integrated monitoring and research through acoustic methods, continued drone surveys, genetic sampling, and GPS tracking are recommended. These approaches will clarify Koala dynamics, population health, and connectivity, thereby enhancing future management recommendations. The findings underline critical management implications including habitat preservation, establishment of wildlife corridors, and considering effective road mitigation strategies to reduce road-strike risks.

Enhanced community awareness initiatives, coupled with strategic revegetation using preferred local feed-tree species, are advised to support habitat continuity and community engagement. Cross-boundary cooperation between adjacent Lake Macquarie and Cessnock LGAs, as well as regional landholders including NPWS, and TfNSW is essential to maintain viable Koala populations in the broader regional context.

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DOCUMENT CONTROL

Version - date	Purpose	Author/s	Reviewer	Approved by
V1 – 30/06/2025	Draft for Client review	Rebecca Seeto, Nathan Stewart, and Oliver Brynes	Stephen Mahony	Stephen Mahony
V2 – 08/08/2025	Final for submission	Rebecca Seeto, Nathan Stewart, and Oliver Brynes	Stephen Mahony	Stephen Mahony

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1 Introduction

A series of recent Koala (*Phascolarctos cinereus*) records on BioNet has raised fresh questions about whether a resident population persists in the remnant bushland on the western edge of the City of Newcastle (CN) Local Government Area (LGA). Submitted primarily by Hunter Wildlife Rescue from 2023 to 2024, these records mostly involve Koalas hit by vehicles or spotted by residents in backyards. While these records provide valuable evidence of Koala presence in the area, they primarily document animals in distress or displaced from their natural habitat, raising questions about the broader population dynamics and habitat use patterns in the remnant bushland of this rapidly developing urban fringe.

The Koalas' status as Endangered within New South Wales under the *Biodiversity Conservation Act 2016* (BC Act), and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) underscored the importance of clarifying the species' current occupancy and habitat use in the area. Given the ongoing development pressures, approved development yet to be commenced, and infrastructure expansion planned for the western CN LGA, establishing a clear understanding of Koala presence and distribution patterns has become a conservation priority. Understanding current occupancy is essential for informing land-use planning decisions, development assessment processes, and habitat management strategies across the LGA.

CN engaged Nightvision Ecology (NVE) to undertake surveys of bushland parcels and the vegetation that forms CN's "blue-green grid" (https://newcastle.nsw.gov.au/living/environment/blue-green-grid), aiming to determine Koala occupancy and coarse scale abundance in the area. This investigation represents the first systematic, technology-enhanced survey effort specifically targeting Koalas across the western extent of the LGA, designed to provide crucial baseline data for future monitoring and management decisions. The study aimed to:

- Confirm detections of Koalas within CN LGA
- Determine if any detections represent a population
- Contribute knowledge to biodiversity of the western corridor of the CN LGA
- Identify future research, monitoring and management priorities

Between April and June 2025, NVE surveyed approximately 553 ha of the roughly 2,050 ha of remnant bushland in the western extent of the CN LGA (Figure 1). The survey area was made up of multiple large bushland blocks owned or managed by CN, National Parks and Wildlife Service (NPWS), and Transport for NSW (TfNSW), split into surveys derived from a 25 hectare (ha) grid system (Figure 2). While additional remnant bushland exists within the immediate area, it was not able to be surveyed due to lack of permission from private land owners, or access constraints.

These surveys were conducted using drones equipped with a thermal camera and spotlight. Drones represent a new, rapidly emerging technology in fauna survey, having the capacity to detect endotherms (warm blooded mammals and birds) across relatively large areas in a short time frame (Beranek et al., 2020; Howell et al., 2021). Importantly they can detect canopy-dwelling animals that are not easily detected from the ground, including koalas (Beranek et al., 2020; Witt et al., 2020).

The landscape of the western CN LGA contains many existing barriers to Koala movement, with proposals for expanding infrastructure, and development set to increase these barriers over coming years. Motorways, arterial and local roads, and rural-residential lots reduce the connectivity among bushland patches. Approved or proposed new urban estates will potentially further reduce and fragment habitat, reducing Koala connectivity between bushland patches. Accordingly, this study aimed not only to confirm Koala presence but, through repeat drone flights, to generate a coarse estimate of occupancy and distribution in this part of the LGA. These findings establish a baseline for directed research and will inform practical actions such as wildlife-corridor design, bushland-management priorities, strategic placement of fauna crossings and signage, and the assessment of future development proposals, while subsequent studies can refine and update these recommendations.

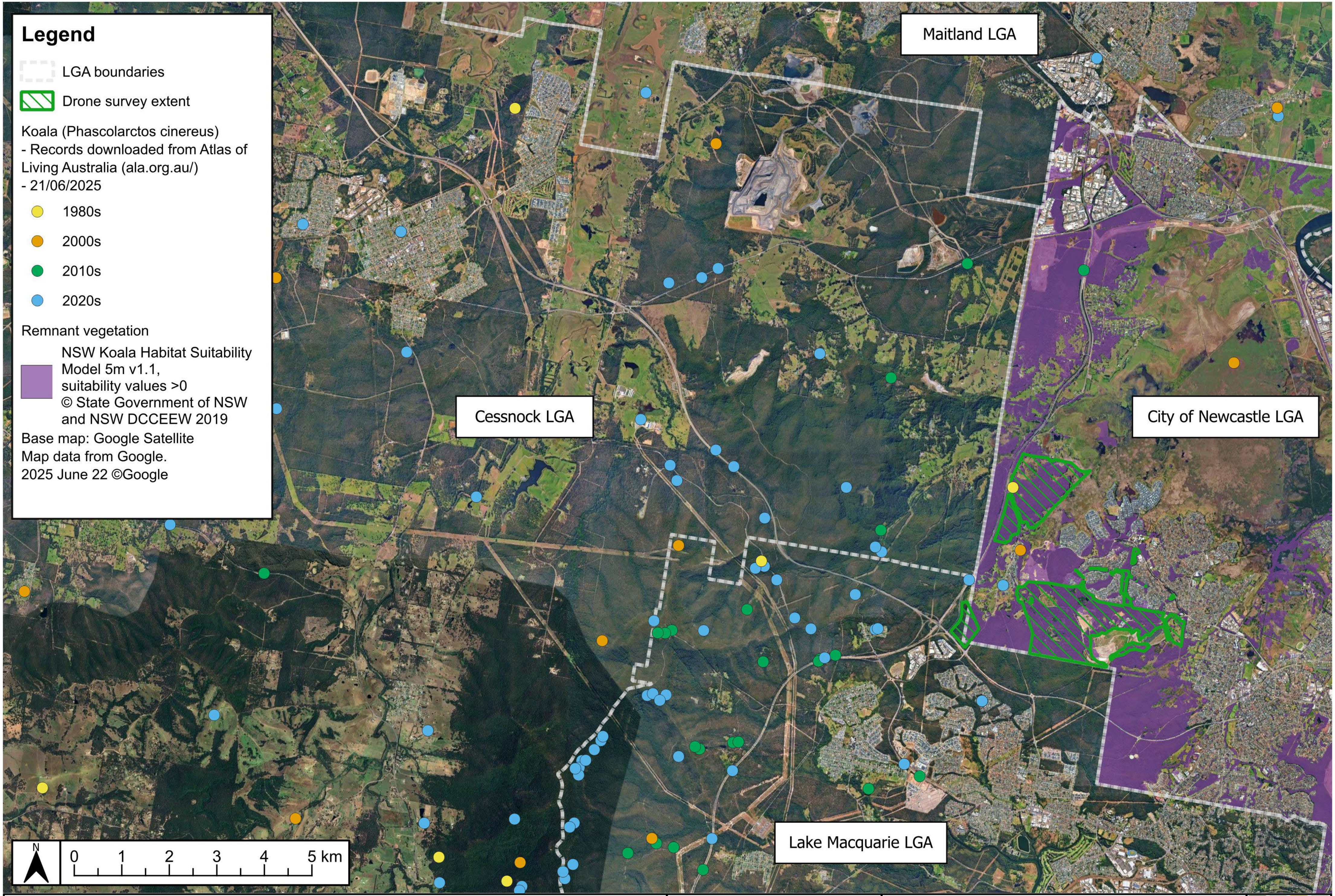

Figure 1: Drone survey coverage within remnant vegetation corridors of western City of Newcastle Local Government Area	Client: City of Newcastle Job ref.: NVE_067	Nightvision Ecology PTY LTD (ABN: 62668513700) Contact: Stephen.Mahony@nightvision-eco.com.au

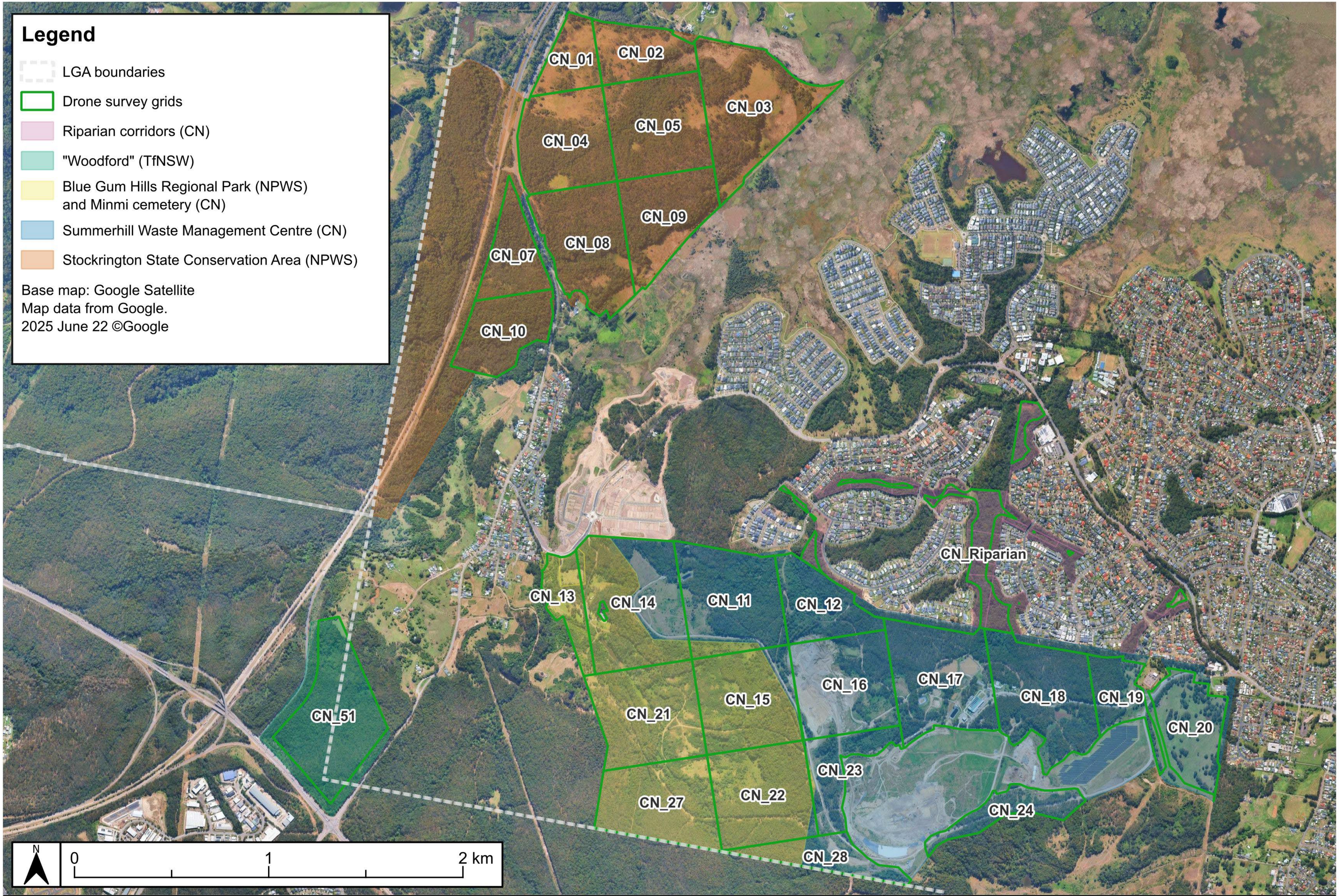

Figure 2: Land tenure area of interest supplied by CN with resulting labelled survey grids

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2 Methodology

2.1 Personnel

All drones were operated by qualified staff (drone pilots) who hold a valid Civil Aviation Safety Authority (CASA) Remote Pilots Licence (RePL), and Aeronautical Radio Operator Certificate (AROC). Drone pilots have completed various additional industry specific training in faunal drone surveys by teams including the NSW Wildlife Drone Hub, Department of Climate Change, Energy, the Environment and Water (DCCEEW), and NPWS Koala survey team, as well as induction onto the NPWS Remote Operator Certificate (ReOC).

Each faunal identification was made by an ecologist with more than 5 years' experience in threatened mammal surveys including spotlighting, and camera trapping of the likely target species (Table 1).

Table 1. Personnel qualifications

Personnel	Qualifications	Role
Stephen Mahony (Pilot / Ecologist)	- Completed training in Koala drone survey under NSW Wildlife Drone Hub, DCCEEW. - Over 450 drone flight hours for Koala and arboreal mammal survey. - Nine years' experience in threatened mammal surveys including spotlighting for Koala, Squirrel Gliders and other arboreal mammals. - Bachelor of Science Major in Biology, University of Newcastle - RePL. ARN: 1196087 Multirotor <25kg, Powered Lift <25kg	Drone Pilot Ecologist
Nathan Stewart (Pilot / Ecologist)	- Trained in Koala drone and arboreal mammal survey under Stephen Mahony, Nightvision Ecology. - Six years' experience in threatened mammal surveys including spotlighting for Koala, Squirrel Gliders and other arboreal mammals. - Over 80 drone flight hours for Koala and arboreal mammal survey. - Bachelor of Environmental Science and Management, University of Newcastle - RePL. ARN: 1248149 Multirotor <25kg	Drone pilot Ecologist
Rebecca Seeto (Pilot / Ecologist)	- Completed training in Koala drone survey under NSW Wildlife Drone Hub, DCCEEW. - Over 350 drone flight hours for Koala and arboreal mammal survey. - Seven years' experience in threatened mammal surveys including spotlighting for Koala, Squirrel Gliders and other arboreal mammals. - Bachelor of Biotechnology (Hons), University of Newcastle - RePL. ARN: 1221096 Multirotor <25kg	Second-observer Ecologist
Oliver Brynes (Pilot / Ecologist)	- Completed training in Koala drone survey under NSW Wildlife Drone Hub, DCCEEW. - Over 130 drone flight hours for Koala and arboreal mammal survey. - Five years' experience in threatened mammal surveys including spotlighting for Koala, Squirrel Gliders and other arboreal mammals. - Bachelor of Environmental Science and Management (Hons), University of Newcastle - RePL. ARN: 1197984 Multirotor <7kg	Second-observer Ecologist
Nicholas Gale (Graduate ecologist)	- Nine years' experience in fauna surveys; four years' experience in mammal surveys. - Bachelor of Science, Major in Biological Science (Hons), Latrobe University	Second-observer Ecologist
Savannah Morgan-Ward (Graduate ecologist)	- Completed training in Koala drone survey under Dr. Ryan Witt, the University of Newcastle - Three years' experience in fauna surveys including roles as thermal drone survey assistant for Koala projects, and processing of small mammals. - Bachelor of Biotechnology (Hons), University of Newcastle	Second-observer Ecologist

2.2 Survey Methodology

2.2.1 Drone Methodology

Surveys followed guidelines outlined in section 4.5.3 of the *'Koala (Phascolarctos cinereus) BAM Survey Guide'* (DPE, 2022a). The drones were flown along pre-programmed linear transects in a systematic 'lawnmower' pattern, spaced 50 metres apart, maintaining a constant altitude of 65 metres above ground level and a maximum speed of 8 m/s. These specifications were adapted from the aforementioned guide and published drone survey methodologies for Koalas (Beranek et al., 2020; Witt et al., 2020).

Surveys were undertaken between approximately 21:00 and 06:00, specifically on nights forecasted to reach minimum temperatures of ≤18°C. These conditions allowed heat to dissipate from environmental structures (e.g., trees and rocks), enhancing thermal contrast and visibility of fauna thermal hotspots (DPE, 2022a). Experienced drone pilots assessed and confirmed suitable thermal conditions before initiating each survey.

During transect flight, the controller display is toggled to the thermal camera mode, with the pilot actively scanning for potential thermal detections. When potential fauna were identified via thermal imaging, the flight mission was paused and the drone manually pointed towards the detection and the spotlight activated, the camera was switched to colour (RGB) zoom mode, enabling real-time visual identification from the controller digital display. Thermal and zoom video recordings were simultaneously captured and stored for each detection. For improved visual confirmation where necessary, the drone was lowered to a distance ≥20 metres, from the detected animal and hovered with the light on to observe animal movements not exceeding 2 minutes, for identification.

Survey123 software was used to log survey locations, weather conditions measured with a Kestrel 5000 Environmental Meter, identification of detections, and timestamps. Post-survey, NSW Wildlife Drone Hub compiled data using drone flight information (video, SRT files), controller GPS pins, and Survey123 entries. Locations of non-threatened fauna detections were taken directly from the drone's GPS logs. For confirmed detections of threatened species, the drone's laser rangefinder recorded more precise GPS coordinates, with an accuracy of approximately ≤5 m.

2.2.2 Survey Approach

The City of Newcastle provided an initial mapped 'area of interest' encompassing bushland patches in the western CN LGA. Survey areas were provided in two stages:

- **April 2025**: Included Council-managed land at Summerhill Waste Management Centre (SWMC) and Minmi Cemetery, and NPWS-managed land in Blue Gum Hills Regional Park (RP) and Stockrington State Conservation Area (SCA).
- **May 2025**: Included an additional land parcel near Woodford Street, Minmi (TfNSW road reserve), and requested a single survey pass over several narrow riparian corridors (CN managed).

Each provided land parcel was refined to suitable habitat by excluding treeless areas, infrastructure (major powerlines and roads with a 40 m buffer), and residential zones with a 40 m buffer. A 25 ha survey grid was then overlaid, with small resultant polygons merged for optimal drone flight coverage efficiency.

Two replicates (surveys on separate nights) of the initial survey sites were conducted in April. A further two replicates were conducted in late May or early June 2025, covering all initial sites and the additional land near Woodford Street. Narrow riparian corridors in Fletcher were near houses, restricting survey coverage; consequently, only a single pass was conducted in early June to check for Koala presence. Conducting two replicates per period in each full plot aimed to maximise Koala detection probability and assess consistency of Koala presence, providing preliminary insights into potential resident or transient behaviour.

2.2.3 Drone Specifications

All surveys were conducted with DJI Matrice 30T drones, equipped with a white-light spotlight, exact specifications in Table 2**.**

Table 2. Specifications of drones, and equipment used in thermal survey

Make and Model	Serial Number and ID	Year of Manufacture	Thermal Camera Specifications
Drone DJI Matrice 30T	SN: 1581F5BKB23C700F016A ID: NVEM30T001	2023 – 2024	**DJI M30T Thermal Camera Sensitivity:** ≤50 mK@F1.0 **Temperature Measurement Range:** High Gain Mode: -20° to 150° C **Spectral Range:** 12 µm **Resolution:** Infrared Image Super-resolution Mode: 1280×1024 (used) @30 Hz Normal Mode: 640×512 **Focal Length:** 9.1 mm (equivalent: 40 mm)
	SN: 1581F5BKB23C300F006C ID: SCM30T016		
	SN: 1581F5BKB23C300F004R ID: SCM30T015		
	SN: 1581F5BKD229D00D49J4 ID: SCM30T014		
Spotlight CZI LP12	2PNL309ATA ID: NVE_LP12_001	2023 – 2024	**Control:** on/off PSDK switch **Luminous Flux:** 2122±3%lm **Searchlight FOV:** 13° **Spot Diameter:** 34m (distance: 150m), 22.8m (distance: 100m), 29.6m (distance: 130m), 11.4m (distance: 50m) **Central Illuminance:** 25Lux (distance: 50m), 6.3Lux (distance: 100m), 2.5Lux (distance: 130m), 1.7Lux (distance: 150m)
	2PNL411G88 ID: NVE_LP12_002		
Spotlight JZ Quick Search Kit	T6SEUF583000CEF0 ID: NVE_JZ_001	2024	**Control: on/off PSDK switch** **Lighting Power:** 60W **Luminous flux:** 4068lm (est.) **Searchlight FOV:** 14° **Spot Diameter:** 113m^2 (distance: 50m), 471m^2 (distance: 100m), 1063m^2 (distance: 150m) **Central Illuminance:** 36Lux (distance: 50m), 8.7Lux (distance: 100m), 3.7Lux (distance: 150m)

3 Results

3.1 Survey and Meteorological Conditions

Thermal drone surveys were completed over two periods: late April (21st April – 30th April) and between late May and early June (23rd May – 6th June). Conditions were favourable for thermal drone surveys with start times around ~21:00 allowing environmental cooling for thermal contrast. Over the late April period, two replicates of the SWMC, Minmi Cemetery, Blue Gum Hills RP and Stockrington SCA were completed. During this period, the temperature ranged from 14°C to 21.3°C. A replicate attempted on the 24th April was not completed due to unfavorable weather conditions of heavy rain beginning part way through.

Over the late May and early June period, two replicates of the SWMC, Minmi Cemetery, Blue Gum Hills RP and Stockrington SCA were completed. Additionally, two replicates of "Woodford" and one replicate of approved riparian corridors were also surveyed in this period. Temperatures throughout this period were cooler with temperatures during surveys ranging from 7°C to 16.7°C. The resulting good thermal conditions across the survey area resulted in obvious thermal signatures even of small species such as Feather-tailed Gliders *Acrobates* sp. (**S4 Media examples**). Full survey conditions are presented in **S1 Survey conditions**.

3.2 Fauna Detections

3.2.1 Overall Fauna Detections

Overall, during the survey 706 detection events were logged across the survey sites (Figure 3), comprising of 31 species (Table 3). Some detections could not be identified to a species level but could be grouped at a higher classification e.g. Feather-tailed Gliders (*Acrobates* sp.) or unidentified Bird (Aves). Use of white-light spotlight and zoom lens enabled confident identification of each detection that could have plausibly been a Koala (*Phascolarctos cinereus*), and most arboreal mammals, full details of each detection and identification confidence is provided in **S2 All detections**.

Koalas (*Phascolarctos cinereus*) were detected on surveys (n=17; S.3.2.4 Koalas). Five total species of arboreal mammal were identified across the sites (Table 3) as well as several gliders that could not be split between morphologically similar species. The most prevalent species detected were the Common Brushtail Possum (*Trichosurus vulpecula*) (n=349) and Common Ringtail Possum (*Pseudocheirus peregrinus*) (n=135), which were common across all sites. Gliders were also abundant with Sugar Glider (*Petaurus breviceps*) (n=51) and Feather-tailed Glider (*Acrobates* sp.) (n=4) both observed across all sites. A single *Petaurus* was identified as most likely a Squirrel Glider (*Petaurus norfolcensis*) based on thick tail-base and snout shape, although a number of other gliders were indeterminate between Sugar or Squirrel Glider (*Petaurus* sp.) (n=18).

Terrestrial mammals were not specifically targeted. Several ground detections were opportunistically logged including Eastern Grey Kangaroo (*Macropus* (*Osphranter*) *giganteus*), Short-beaked Echidna (*Tachyglossus aculeatus*), Swamp Wallaby (*Wallabia bicolor*), and the invasive Red Fox (*Vulpes vulpes*), which was also observed crossing roads in SWMC.

Table 3. Summary of total fauna detected.

Common name	Scientific name	Count
Arboreal Mammals		
Common Brushtail Possum	*Trichosurus vulpecula*	349
Common Ringtail Possum	*Pseudocheirus peregrinus*	135
Feather-tailed Glider	*Acrobates* sp.	4
Koala	*Phascolarctos cinereus*	17
Sugar Glider	*Petaurus breviceps*	51
Squirrel Glider	*Petaurus norfolcensis*	1
Sugar or Squirrel Glider	*Petaurus* sp.	18
Possum (unspecified)	Phalangeriformes	3
Birds		
Australian Brush-turkey	*Alectura lathami*	3
Australian King Parrot	*Alisterus scapularis*	16
Eastern Rosella	*Platycercus eximius*	11
Galah	*Eolophus roseicapilla*	2
Laughing Kookaburra	*Dacelo novaeguineae*	8
Magpie	*Gymnorhina tibicen*	10
Noisy Miner	*Manorina melanocephala*	1
Pied Currawong	*Strepera graculina*	1
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	1
Southern Boobook	*Ninox boobook*	1
Straw-necked Ibis	*Threskiornis spinicollis*	9
Sulphur-crested Cockatoo	*Cacatua galerita*	2
Topknot Pigeon	*Lopholaimus antarcticus*	1
Unidentified Corvid	Corvidae	9
Whistling Kite	*Haliastur sphenurus*	8
White-faced Heron	*Egretta novaehollandiae*	3
White-headed Pigeon	*Columba leucomela*	1
White-winged Chough	*Corcorax melanorhamphos*	1
Bird (unspecified)	Aves	12
Brown Cuckoo-dove	*Macropygia phasianella*	2
Bats		
Black Flying-fox	*Pteropus alecto*	1
Grey-headed Flying-fox	*Pteropus poliocephalus*	13

Common name	Scientific name	Count
Native Terrestrial Mammals (incidental detections)		
Bush Rat	*Rattus fuscipes*	1
Eastern Grey Kangaroo	*Macropus (Osphranter) giganteus*	2
Short-beaked Echidna	*Tachyglossus aculeatus*	1
Swamp Wallaby	*Wallabia bicolor*	3
Rat (unspecified)	Rodentia	1
Introduced Fauna		
Black Rat	*Rattus rattus*	3
Red Fox	*Vulpes vulpes*	1
Grand Total		706

3.2.2 Threatened Fauna Detections

In addition to confirmed Koala (*Phascolarctos cinereus*), thermal drone surveys recorded two other threatened species: Grey-headed Flying-fox (*Pteropus poliocephalus*) and potential Squirrel Glider (*Petaurus norfolcensis*), both listed as Vulnerable in NSW (BC Act).

Grey-headed Flying-fox (n=13) were primarily recorded from Stockrington SCA, the semi-open areas in the east of SWMC, and the riparian corridors, with observations of feeding behavior on tree blossoms.

Potential Squirrel Glider observations (n=1 probable, n=18 indeterminate) clustered around Blue Gum Hills RP, with some detections also at SWMC. Due to morphological similarities, many glider detections could not be definitively separated between Sugar and Squirrel Glider species using visual assessment alone. But probable detection suggests they should be considered a target of further fauna work within this area.

3.2.3 Non-Native Species Detections

Two non-native species were recorded on site: the Black Rat (*Rattus rattus*) and the Red Fox (*Vulpes vulpes*). Both species were initially detected during thermal drone surveys, with multiple Red Fox individuals subsequently observed traversing and occupying various areas of SWMC. Additional sightings were reported by on-site security personnel, indicating continued presence across the site.

Figure 3: Drone survey coverage and faunal detections in area of interest

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3.2.4 Koalas

Koalas (*Phascolarctos cinereus*) were recorded in Blue Gum Hills RP and Stockrington SCA (Figure 3). Across the habitat surveyed, seventeen detections representing Koalas were made, with at least five Koalas detected on the same night, or far enough apart to represent distinct individuals (minimum known alive). Each Koala was able to be clearly viewed for species identification using white-light spotlight and 16-30x zoom magnification with examples provided in Figure 4, and video of each detection within **S4 Media examples**.

All land parcels provided by CN in April had at least four distinct replicates flown, with all Koala detections ultimately resulting from these land parcels. The consistent occurrence of Koalas in detected areas was indicated by repeated detections across multiple survey replicates including those a month apart and within relatively tight spatial areas. (Figure 5). Within Blue Gum Hills RP, one Koala detection was consistently made during three replicates of plot CN_27 along the southern property boundary. Fourteen Koala detections were recorded in Stockrington SCA, with 13 mapped in Figure 5 representing times a full replicate was completed. One Koala detection was excluded from Figure 5 due to a survey which was cancelled after minimal plot coverage due to poor weather, not constituting an entire replicate. Detections in Stockrington SCA were across four survey plots, three within the 'tank paddock' east of Lenaghans Drive (CN_03, CN_05, CN_08), and one plot (CN_10) located between the Pacific Motorway and west of Lenaghans Drive. Although identification of specific individuals is not possible with current drone technology, detection GPS pins clustered mostly under 200 m between replicates, likely represent at least some of the same Koala(s) on different nights.

Figure 4. Example Koala detection photos with unique detection code, and location. With example of zoom and thermal camera footage.

Figure 5: Replicate detections of Koalas across repeated surveys

Legend

LGA boundaries

Drone survey extent

Koala (Phascolarctos cinereus)
- Records downloaded from Atlas of Living Australia (ala.org.au/) -21/06/2025

1980s

2000s

2020s

NVE survey detections

Koala

NSW Koala Habitat Suitability Model 5m v1.1, suitability values >0
© State Government of NSW and NSW DCCEEW 2019

0.9 (high habitat suitability)

>0 (low habitat suitability)

Base map: Google Satellite Map data from Google. 2025 June 22 ©Google

N

0 0.5 1 1.5 km

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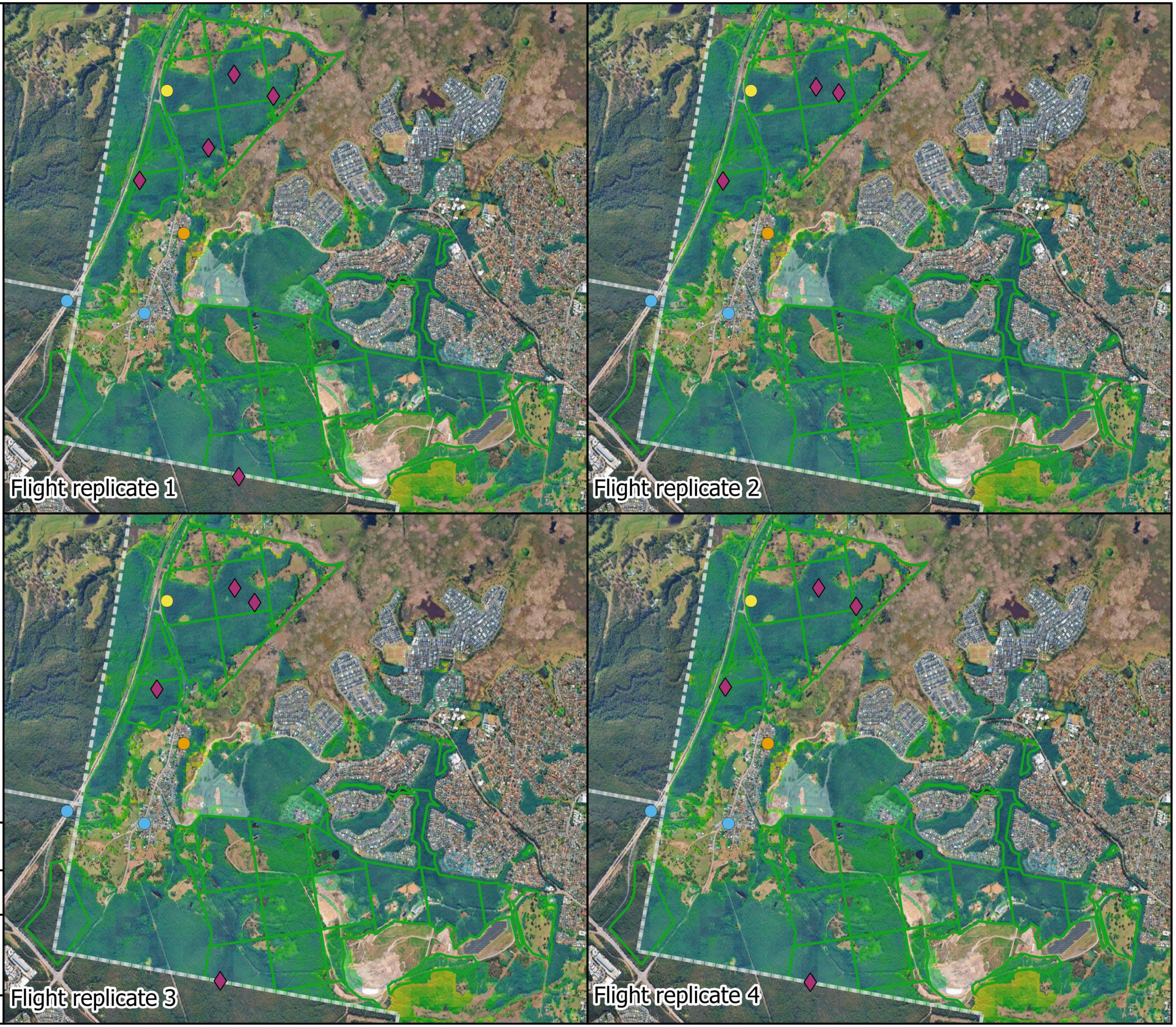

4 Discussion

4.1 Outcomes

The survey specifically targeted the Koala (*Phascolarctos cinereus*), with populations in NSW listed as Endangered under the BC Act and EPBC Act, with the aim of assessing the population status as measures of occupancy, abundance and distribution within the western CN LGA. Thermal drone flights recorded 17 detections that represent at least five Koalas distributed across three habitat units—Stockrington SCA "tank paddock" east of Lenaghans Drive, Stockrington SCA west of Lenaghans Drive, and Blue Gum Hills RP south of Minmi—each separated by at least one road. Repeated paired surveys one month apart recorded similar numbers of Koalas in relatively consistent locations.

These surveys were conducted outside what is generally considered the breeding season of Koalas in the "central coast region" (DPIE, 2019), which generally peaks from September to December (Ellis et al., 2011). Higher movement of Koalas has been documented to occur in the breeding seasons with timing of this varying across the whole distribution (DAWE, 2022; Dique et al., 2003). Koala movement ecology is not fully understood with tracking data indicating that Koala home ranges can vary from tens of hectares in the east coast, to hundreds of hectares further inland (Davies et al., 2013; DAWE, 2022). Home range use varies, and Koalas may spend extended times in sub-sections of their home range or move more generally around their home range. While some dispersal is linked to younger Koalas (1-3 years) or males during the breeding season, other times individuals can seemingly randomly leave their home range travelling kilometres to a new site (DAWE, 2022; Dique et al., 2003).

Determining whether animals detected in this study constitute a population requires a working definition of "population", a concept that varies across ecological disciplines and can hinge on demographic independence, genetic connectivity, or habitat continuity (Lowe & Allendorf, 2010; Waples & Gaggiotti, 2006). Within the Koala's legislative context, the *National Recovery Plan for the Koala* defines a population as "*a set of individuals that live in the same habitat patch and interact with one another, commonly forming a breeding unit within which the exchange of genetic material is more or less unrestricted*" (DAWE, 2022). In this recovery plan, this definition sits within a metapopulation perspective: each occupied patch is a population, yet nearby patches are linked by occasional dispersal, so low-level gene flow keeps them from being fully isolated even though it is less frequent than breeding within a single patch.

The State Environmental Planning Policy (Koala Habitat Protection) 2020 (hereafter SEPP, 2020) does not define the term "population". However, does establish the concept of core Koala habitat: land that supports a resident Koala population, evidenced by breeding females with young, and corroborated by recent and historical sightings (SEPP, 2020). All occupancy surveys, including thermal drone flights, cannot reliably identify breeding status. The presence of back-young or joeys can be evidence of breeding however young may sometimes be hidden. To determine breeding status, capture is often required to check pouch or conduct ultrasounds.

The observations of this survey provided some results supporting a population, with Koalas being present within clustered areas over a month period, not indicative that they were just passing through. However, the total number detected was relatively low, and sightings in Blue Gum Hills RP widely disjunct from Stockrington SCA (~3 km). The lack of survey of other large privately owned bushland parcels in the area leaves an information gap in the potential connectivity between the habitat patches where Koalas were detected, and the presence and interaction to Koalas in adjacent habitat. Likely, the western CN LGA supports one or more interacting Koala populations within the meaning of the National Recovery Plan (DAWE, 2022). What is referable as a population in this sense may not be restricted to the CN LGA, with habitat patches in this area continuing into both Lake Macquarie City LGA and Cessnock City LGA.

Current technologies such as drones provide massive increases in Koala detection probability compared to historic spotlighting and human searches for Koala scats (Beranek et al., 2020), which has enabled this study to show greater temporal use of the western CN LGA by Koalas compared to previous observations. There are still many knowledge gaps in this landscape and targeted research on movement and gene flow is needed to clarify population and metapopulation dynamics with Koalas in larger bushland blocks west and south-west of the motorway (ALA, 2025; Ryan et al., 2025), and among fragmented remnants within western CN itself. Further monitoring and targeted survey including continued drone survey, and acoustic survey is recommended during different seasons to elucidate continued habitat use patterns and potential Koala breeding, including confirming young, with relevance to "core Koala habitat" (SEPP, 2020).

4.2 Limitations

While providing valuable advancements in the spatial and temporal components of fauna surveys, drone-based methods can present several limitations. To comply with CASA and privacy regulations, buffer areas were applied to the edges of drone survey grids to maintain safe distances from roads, public infrastructure, and residential areas. As a result, these buffers slightly reduced the total area of available habitat surveyed.

While drones are effective at recording Koalas across large areas through real-time snapshots, they are unable to identify individual animals. This restricts the ability to assess factors associated with the individual such as breeding status, movement patterns or home ranges. Accordingly, a combination of specific research methodologies such as acoustic detection, scat analysis, and potentially individual tracking are necessary to quantify broader population dynamics such as gene flow or disease status. The identification of specific individuals could also advance statistical modelling avenues such as capture-mark-recapture for abundance estimates.

Due to restricted private landholder access, several sizeable remnant patches along the western corridor of CN LGA had to be excluded from the survey. Nonetheless, these ecologically important areas are broadly classified as suitable habitat by the NSW Koala Habitat Suitability Index (DPIE, 2019; NKHIS, 2025); therefore, the absence of survey effort should not be interpreted as an absence of Koalas. Their ecological importance stems from the extensive bushland connections they share with adjacent landscapes to the west (Cessnock City LGA) and south (Lake Macquarie City LGA), both modelled as potentially suitable Koala habitat (NKHIS, 2025) and supported by recent ALA records (ALA, 2025). Collectively, these unsurveyed patches likely contain additional individuals and serve as functional movement corridors between some of the patches surveyed herein, and further habitats more broadly in the region.

Given the buffer constraints and unsurveyed remnant patches, the survey results provide evidence of occupancy and some abundance information, but further work is required to answer key questions related to management actions. While replicated drone flights increase confidence in detecting presence or absence, the approach does not constitute detailed abundance modelling (e.g., N-mixture or mark recapture methods; (Ryan et al., 2025)). The relatively low number of Koala detections, site shape, size, and unsurveyed areas adjacent to grids may limit the ability to accurately estimate abundance across the broader landscape. Consequently, while this study demonstrates Koala presence and provides baseline occupancy data, the limitations outlined above highlight how integrated monitoring and research (S.4.3) would address the current methodology to improve abundance estimates and understand population parameters essential to inform conservation management decisions.

4.3 Monitoring and Research

This survey confirmed the presence of an apparent Koala population within several remnant bushland patches of the western CN LGA. However, this study's inferences are limited to repeated presence detections over a brief period and coarse indices of abundance and distribution. To underpin future management and conservation, an integrated monitoring and research programme should target four key objectives:

1. **Occupancy dynamics** – detect Koala presence in additional patches and track site-level fluctuations over time.
2. **Genetic connectivity** – assess gene flow, relatedness and overall genetic health (e.g. population heterozygosity).
3. **Health and disease status** – determine prevalence of pathogens (e.g., *Chlamydia pecorum*, Koala retrovirus) and overall body condition.
4. **Movement and barriers** – quantify dispersal pathways, barrier permeability and home-range extents.

A range of monitoring tools are available (Table 4), with the application of multiple techniques providing information in different ways or different information to complement other techniques. A variety of techniques are described below for context into future monitoring directions.

Table 4. Summary of monitoring and research methods, additional information can also be found In "A review of koala habitat assessment criteria and methods" (Youngentob et al., 2021).

Method	Summary	Limitations	Cost	Suitability
Thermal Drone Surveys	Provides high detection probability of individual Koalas for a real time snapshot over 100-200 ha per night	Works better in cooler months Cannot be conducted in restricted airspaces or over populous areas	Medium	Real-time Koala individual detection Occupancy survey Enable abundancy modelling
Detection Dogs	Provides high detection probability of Koala scats, including older scats to provide a broader temporal window of occupancy survey than other techniques Can also be trained on Koala fur scent	Dogs limited to terrain they and handler can cover Reduced area coverage compared to drones or acoustics	Medium	Occupancy survey Detecting scats for other research
Acoustic Monitoring	Detects Koala vocalization (mainly males) from large distance. Provides information about habitat use in breeding season and potential breeding behaviours	Requires post-analysis which may be more difficult in noisy environments Primarily detects males during breeding season Cannot differentiate individuals without targeted methods	Medium	Occupancy survey Abundance survey (if set in arrays; emerging, more expensive)
Camera Traps	Targeted use can identify Koala movement patterns, such as use of road underpasses or along fence-lines	Requires post-processing, low detection probability unless targeted to understand movement, otherwise detections are incidental Difficult to differentiate individuals without prior marking	Low	Targeted movement patterns

Scat Collection	Fresh scats can be analyzed for chlamydia, or identify individual Koalas through genetics	Requires initial Koala detection to collect fresh scats. Best paired with drones or detection dogs. Additional analysis may add cost	Low	Disease screen Strengthen abundance estimates Population genetic demography
Capture and Health Assessment	Capture of Koalas for a detailed veterinary inspection of health, can reveal a variety of diseases, and population demographic information	Best paired with detection methods (e.g. drones) to detect Koalas	High	Detailed population health and demography information
Tracking (GPS or VHF)	Fitting of GPS or VHF collars to Koalas to study movement information in higher detail	Generally paired with capture, and health assessment	High	Detailed individual or population movement patterns

4.3.1 Occupancy and Monitoring Survey

Determining the extent of occupancy is an important first step in understanding target biodiversity, in this instance, Koalas. Once occupancy is determined, further research into habitat monitoring will increase understanding of utilization of current habitat and population dynamics. While each monitoring technique has distinct advantages and limitations, an integrated approach leveraging multiple methodologies provides the most comprehensive understanding of Koala populations.

For a basic understanding, we recommend monitoring Koalas in the western CN LGA through a combination of acoustic recorders, drone surveys, and making use of citizen science (S.4.4.1). These methodologies are highly complementary, with acoustic recorders displaying the highest per-deployment detection probability, and a larger temporal sampling window (Beranek et al., 2024). This, coupled with sightings from citizen scientists/members of the public, can be utilized to identify potential Koala populations/hotspots, in which drone surveys applied at regular intervals can be used to determine relative abundance, tracking population fluctuations and trends. This methodology further pairs well with other research aims, where drones locate individual Koalas at regular intervals which could facilitate scat collection and analysis, individual health assessment (S.4.3.2.2), or tracking studies (S.4.3.3.1).

4.3.1.1 Acoustic monitoring

Acoustic monitoring is a non-invasive, highly scalable way to survey Koalas because adult males advertise their presence with loud bellows audible to roughly 300 m under forest conditions (Law et al., 2021). Deploying a single recorder in each 500 × 500 m grid (noting that this coverage varies between different styles and brands of recorder for optimum coverage) for one to two weeks in early breeding season captures nightly variation in calling and the wider ranging of males at that time of year (Beranek et al., 2024; Hagens et al., 2018; Law et al., 2018). A further advantage in urban fringe habitat is that well-placed recorders sample the edges of patches that thermal drones cannot fly safely. The drawback is a higher detection rate of traffic and domestic noise, which increases post-processing effort and expense despite machine-learning filters (Beranek et al., 2024; Law et al., 2018).

Because acoustic recorders offer higher overall detection probability, multi-night coverage, and enhanced detection of roaming males during the breeding season (Beranek et al., 2024), their results can guide more targeted thermal-drone surveys. If deployed strategically (such as in arrays), acoustic recorders can also determine density or abundance (Law et al., 2024; Marques et al., 2013). Instead of re-flying every grid we recommend priority areas are identified from acoustic detections; drones are then concentrated in these hot-spots to estimate relative abundance and to support follow-up methods that require close-range evidence (e.g. scat collection). This staged approach balances wide-area coverage and high detection probability with focused effort that delivers individual-level data, maximising overall survey efficiency.

4.3.1.2 Drones

To build on these initial thermal drone surveys, we recommend conducting additional surveys across multiple timepoints to refine estimates of Koala abundance and track seasonal shifts in activity. Thermal drones still offer the highest nightly detection probability and survey area coverage (Beranek et al., 2024) and are able to deliver real-time confirmation of individual Koalas; however, each flight covers only the single nights temporal window, so effort is best concentrated on grids highlighted by previous detections, acoustic hotspots or verified public sightings. Drones can also be used with emerging abundance-modelling techniques such as N-mixture models (Ryan et al., 2025), and determining locations for the collection of fresh scats for use in genetic analysis and thus may enable mark-resight modelling (Keem et al., 2024). We recommend revisiting priority grids two or three times each year to match both Koala biology (DPIE, 2019; Ellis et al., 2011) and the practical limits of thermal imagery (Beranek et al., 2024). To optimize survey effectiveness within thermal imaging limitations while capturing key koala breeding behaviors, the recommended schedule is:

- **Early breeding season (late August–September)** Temperatures are still cool enough for a strong thermal contrast, and males are beginning to roam and call, providing a first abundance index.
- **Mid-breeding season (October–early November)** Calling and mating activity peak; flights in the cooler part of the night can capture the season's highest density of Koala movement, warmer temperatures can be accounted for in detection probability analysis.
- **Late summer to autumn (March–May)** Daytime heat has eased, allowing reliable thermal detection; females may be carrying young, giving a snapshot of post-breeding distribution.

Repeating flights on this timetable will track seasonal shifts in abundance and range use while staying within the temperature envelope required for clear thermal images. Each drone round can be coupled with complementary methods, such as collecting fresh scats for genetic analysis (S.4.3.2.1), to add individual-level data without increasing flight effort. This sequenced, efficiency-focused approach blends the wide temporal coverage of acoustics with targeted drone counts, yielding a more complete and cost-effective picture of Koala population dynamics.

4.3.2 Genetics and Disease

As well as determining the presence and location of Koalas, acquiring information relating to genetics and fitness of local Koalas is also important in informing decision making relating to conservation and infrastructure actions: habitat retention and connectivity, disturbances (including developments of roads and housing), and more active conservation (including genetic rescue, translocations (Frankham, 2015; Frankham et al., 2017)). Assessing the genetics of the population to understand genetic composition and gene flow can also allow the prediction of changes over time in combination with anthropogenic changes (van Strien et al., 2014).

Naturally, genetics is often studied in conjunction with the fitness of a population, such as the presence of diseases. Koalas are susceptible to many diseases including Koala retrovirus, Cryptococcosis (primarily from infections with the fungi, *Cryptococcus gattii*) and chlamydia (from infections with the bacteria, *Chlamydia pecorum*). Chlamydia is recognised in the National Koala Recovery Plan as a major driver of population decline (DAWE, 2022). Published surveys show prevalence ranging from zero to nearly ninety per cent in NSW Koala groups, depending on habitat quality and disturbance history (McLennan et al., 2025). To date, no systematic disease screening has been undertaken in the local metapopulation; samples handled by Hunter Wildlife Rescue from injured or deceased Koalas have yielded only one confirmed chlamydia positive Koala from Cooranbong (Ting, pers. comms. 2025). Establishing an accurate baseline of local disease prevalence is essential for judging population viability and for deciding whether interventions such as vaccination are justified (DAWE, 2022).

4.3.2.1 Scat analysis

Genotyping DNA extracted from Koala scat provides a non-invasive way to meet several information needs at once. Microsatellite and SNP panels validated for scat DNA (Schultz et al., 2018) allow:

- identification of individuals, supporting estimates of population size, genetic diversity and site fidelity;
- simultaneous screening for chlamydia and Koala retrovirus; and
- assessment of relatedness, which is important in fragmented urban landscapes.

Recent field programs have combined thermal-drone detections with immediate or next-day collection of fresh scats to deliver linked visual and genetic data. In the Cumberland Plain, 129 scats under drone-detected Koalas yielded 96 unique genotypes and concurrent chlamydia screening (DPHI, 2024). A similar workflow could be adopted in western CN LGA. Scat genotyping is also an emerging method for mark-recapture or density modelling, where individual marking is not viable. Keem et al. (2024) used fox scats to derive spatially explicit capture–recapture estimates, demonstrating that non-invasive genotyping can replace traditional trapping for robust density estimates. Applying the same principles to Koala scats collected beneath drone-verified trees would tighten abundance estimates and track movement of known individuals across survey rounds.

Pairing thermal-drone surveys with targeted scat collection therefore offers a practical, and relatively inexpensive way to integrate disease screening, genetics and population monitoring without handling animals, complementing the wide-area acoustic and drone program already described.

4.3.2.2 Capture and health assessment

Capture and physical examination of Koalas is a more demanding technique than acoustic or drone surveys, requiring a veterinary professional and assistants, but it provides the most comprehensive data on individual health and body condition. Standard procedures may involve anaesthesia by a veterinary professional followed by various assessments such as determining morphometrics, scoring body condition, assessing reproductive status, and collection of biological samples (including biopsies, blood, swabs, faeces) for laboratory screening of *C. pecorum*, Koala retrovirus and presence of other pathogens (DPIE, 2020; Nyari et al., 2017). Whole-genome or SNP genotyping can also be performed from blood or tissue to augment scat-based genetics (S.4.3.2.1).

Capture is particularly valuable when detailed movement studies are required (see S.4.3.3.1), because collars can be installed at the same handling event. Advances in tracking technology from the typical VHF tracking to more recent uses of GPS integration into collars has been utilised in a variety of Koala population across the distribution of Australia (Richardson et al., 2022). Linking GPS movement data with contemporaneous health, disease and genetic profiles provides context for any mortality or range shifts detected by tracking and informs risk assessments for potential vaccination or translocation programs.

4.3.3 Movement and Home Range

4.3.3.1 GPS collaring and tracking

Radio-tracking with VHF collars has long been used to monitor individual home-range behaviour (Law et al.,2024; Radford et al., 2006). An emerging alternative is GPS-based tracking; recent lightweight collars such as Endeavour Veterinary Ecology's K-tracker and Global Satellite Engineering's GSatSolar can now log high-resolution positional fixes without a field team in pursuit. The K-tracker can log a fix every 30 minutes when within range of a base station (~5km), while GSatSolar transmits fewer fixes directly via satellite and is better suited for wide-ranging individuals.

Although the information that can be acquired from tracking is invaluable in monitoring the finer movement behaviors of individuals, GPS tracking is more expensive than scat collection or camera trapping and still requires acoustics or drones to locate Koalas for initial capture. Collars must be fitted by experienced specialists under permits and follow best-practice welfare guidelines (DPIE, 2020). Each unit incurs purchase or lease costs, plus monitoring for collar fit and battery status. The K-tracker in particular also requires the purchase and set up of a base station/s, as well as a subscription model for accessing the interface and data. Nonetheless, GPS (or VHF) collars remain the only techniques that deliver continuous movement chronologies for known individuals, often spanning many months. Combining this method with health screening at capture would yield a powerful dataset linking space use, body condition and disease status.

4.3.3.2 Camera trapping underpasses

A key question for the western CN LGA is whether Koalas are crossing the Pacific Motorway and, if so, at which locations. Such information is critical for defining the population or metapopulation, planning road-mitigation measures, and evaluating potential gene flow. A recent road-killed Koala was found on the motorway just west of the Stockrington study area by Hunter Wildlife Rescue (Ting, pers. comms. 2025), indicating at least occasional movement between the remnant habitat east of the Pacific Motorway surveyed here and the more extensive forest to the west.

Targeted camera trapping offers a low-disturbance method for documenting Koala use of existing crossing structures such as culverts and land-bridge underpasses. Infra-red triggered units (for example Reconyx or Bushnell) can run unattended for several months, collecting time-stamped images that reveal the direction, frequency, and timing of crossings (Dexter et al., 2016; Soanes et al., 2015).

We recommend installing paired cameras at each culvert and underpass beneath the Pacific Motorway near Stockrington SCA, where major habitat blocks west of the motorway abut smaller patches to the east. Continuous monitoring at these chokepoints will clarify current Koala use of the structures and provide evidence to guide future retrofits or vegetation linkages designed to improve functional connectivity across the transport corridor (Taylor & Goldingay, 2010).

4.4 Management Implications

This survey confirms that Koalas occupy several remnant patches in the western CN LGA and are unlikely to be purely vagrants or wide-ranging individuals. While the limitations outlined (S.4.2) constrain detailed population assessments, the confirmed presence and distribution data provide sufficient evidence to inform some immediate management actions. These findings enable targeted decision-making regarding habitat protection, corridor design, community engagement, road mitigation measures, and strategic revegetation programs using locally appropriate feed tree species. The responsibility for these decisions will fall across a variety of landowners and managers including CN, TfNSW, NPWS, and development projects.

The surveyed habitat patches lie within a fragmented land matrix of roads and suburbs. Such barriers likely already restrict Koala dispersal as evidenced by Hunter Wildlife Rescue records of a Koala within a Minmi backyard (Ting, pers. comms. 2025). Developments that are under construction or already approved within, and adjacent to, the survey area (Figure 6) may exacerbate fragmentation, reflecting trends seen in other urban Koala populations (McAlpine et al., 2017; Whisson et al., 2020). For example, land zoned R2 within the Minmi area (Figure 6) will be cleared and developed, potentially disrupting current corridors between Blue Gum Hills RP and Stockrington SCA. Additionally, the NSW Government is investigating the Eden Estate site (Figure 6) for up to 4,200 dwellings, which may increase pressure on Koalas within the western CN LGA.

Given the fragmented landscape, establishing corridors that genuinely enable Koala movement and gene flow is a key management priority. Retaining existing native vegetation, and restoring it where feasible, will help maintain the broad, continuous links needed to prevent in-breeding depression (DPE, 2022b). Practical options include safeguarding remnant bushland and identifying key strategic gaps where native feed tree planting could occur (S.4.4.3). A potential opportunity for increasing Koala habitat comes from within NPWS managed lands, where Koalas were recorded. Sections of both Blue Gum Hill RP and Stockrington SCA are open and grassy or dominated by shrubby regrowth. Investigating whether targeted Koala feed-tree plantings in these reserves would meet existing management plans and provide functional Koala habitat while simultaneously strengthening corridor connectivity.

Increasing fragmentation from development is likely to pose flow-on risks for Koalas such as increased traffic and road strike risk, as well as potential negative Koala and pet dog interactions. Reducing road-strike and dog-related mortality can hinge both on community behaviour as well as infrastructure and planning (OEH, 2016). Targeted awareness campaigns can increase local awareness of Koalas, promoting their safety, and additionally increase records which flows into monitoring and research (S.4.3). Parallel dog-owner education, promoting night-time confinement, leash requirements on bush-edge trails and subsidised obedience training, has proven effective in other peri-urban Koala landscapes by reducing chase injuries and fatal interactions (DAWE, 2022). Critically, framing these measures as a community-led stewardship effort not only decreases direct mortality but also generates citizen-science reports that feed back into corridor mapping and future road-mitigation design, creating a virtuous cycle of awareness, data and adaptive management.

Habitat now identified to have Koalas in the CN LGA forms the eastern edge of a broader network that extends into Lake Macquarie and Cessnock City LGAs. These adjoining patches contain additional Koala records (ALA, 2025; Ford & Lake Macquarie City, 2023; Ryan et al., 2025) and therefore represent both an opportunity and a management challenge. Stockrington SCA, which yielded the highest number of detections during this survey, is separated from habitat farther west in Cessnock by the Pacific Motorway, a route where a road-killed Koala was recorded in 2024 (Ting, pers. comms. 2025), highlighting the existing risk of roads to Koalas (S.4.4.2). Approved developments such as DA2087/2018 Rev, located immediately south of Blue Gum Hills RP in Lake Macquarie LGA (Figure 6), could further narrow the remaining linkage if implemented without appropriate mitigation measures. Maintaining functional connections, therefore, will require a coordinated, cross-boundary approach that aligns habitat protection, corridor enhancement and road-safety engineering across the three LGAs.

Land Use Zoning Context

This map shows the land use zones within the study area across the Newcastle, Lake Macquarie and Cessnock LGA boundaries, and a site being investigated by the NSW Government for rezoning. This map is intended for general context to support this report only and should not be relied upon for any other purposes.

Legend

R2	Low Density Residential
R3	Medium Density Residential
MU1	Mixed Use
E1	Local Centre
E4	General Industrial
E5	Heavy Industrial
RE1	Public Recreation
RE2	Private Recreation
RU6	Transition
C1	National Parks & Nature Reserves
C2	Environmental Conservation
C3	Environmental Management
C4	Environmental Living
SP2	Infrastructure
– – –	Eden Estate rezoning investigation land (by NSW Government)
——	Local Government Area Boundaries

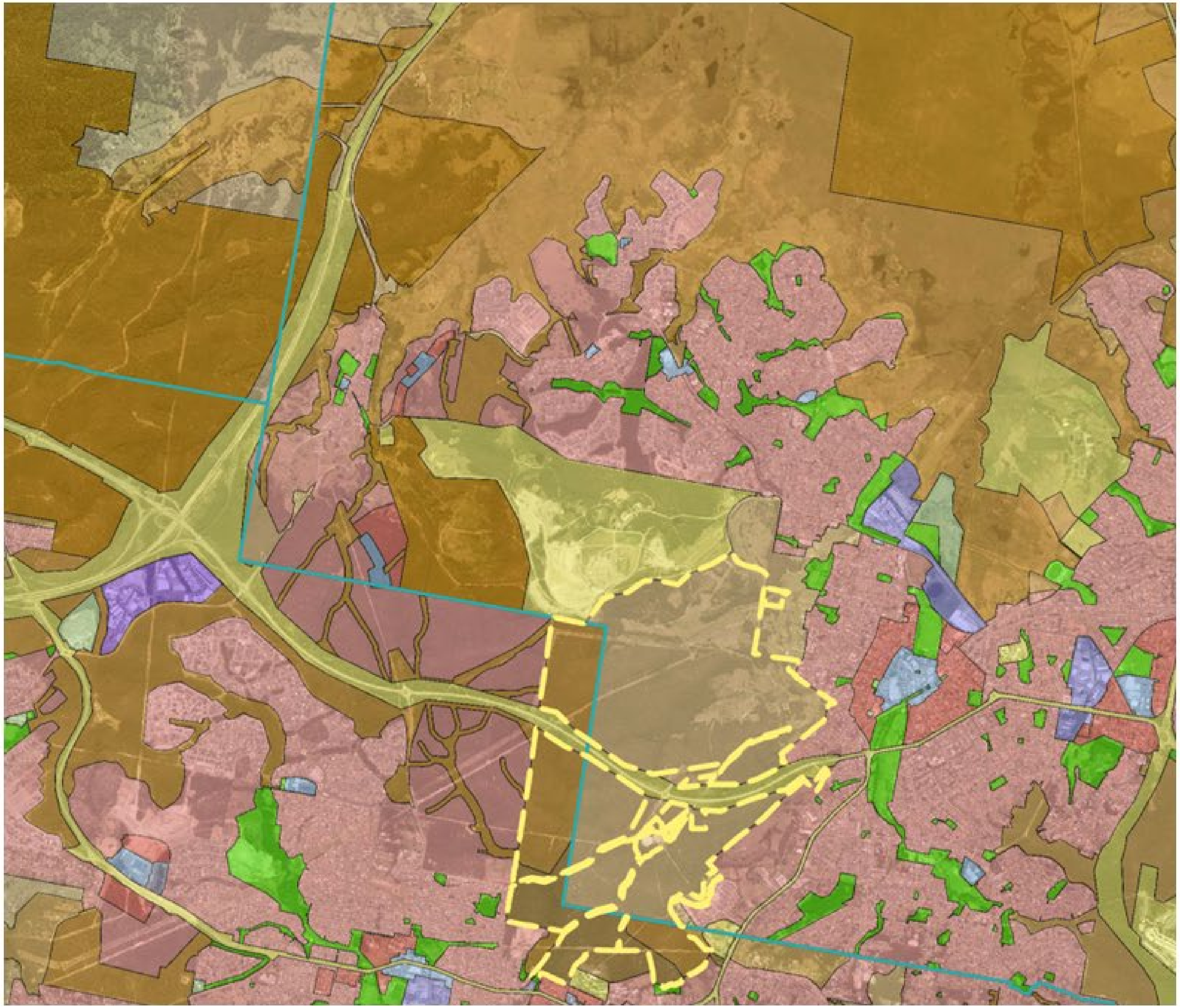

Figure 6. Land use zoning within the western extent of CN LGA, mapping provided by CN and NSW Planning Portal.

The following mitigation recommendations outline potential measures to reduce impacts to Koalas and their habitat. However, it is important to recognise that implementation will depend on a range of factors including feasibility, funding, and resourcing priorities. While CN plays a key role in local planning and management, many of the responsibilities identified fall across different land tenures. This includes TfNSW in relation to the Pacific Motorway and other major roads, NPWS where recommendations relate to land under their management such as Blue Gum Hills RP and Stockrington SCA; and private land holders in relation the development areas. Potential opportunities also exist for collaboration with the current NSW Koala Strategy team, or future state and federal Koala research programs, to align local efforts with broader initiatives. Recommendations are summarized in Table 5, and each is outlined in further detail below. Building on the detections recorded in this survey, we propose initiating a staged, partnership-led program that prioritises key actions such as community awareness, habitat protection, and further research now while scoping longer-term corridors and road mitigation works.

Table 5. Summary of potential mitigation implications, and possible management actions

Method	Summary	Actions	Considerations
Community awareness	Community information and events foster engagement, increase sightings data, and build long-term stewardship.	Support community events such as bushwalks, workshops and bioblitzes. Install locally relevant signage along public trails linking to "I Spy Koala" initiative.	Earlier initiation is preferred to maximise incidental data collection and extended public involvement.
Road mitigation measures	More expensive mitigations measures such as exclusion fencing, underpasses, and canopy crossings are most effective for reducing incident rates. Installations should be targeted to key areas, particularly based on understanding local Koala movement.	Identify key koala movement areas through monitoring to guide infrastructure planning. Implement koala exclusion/directional fencing and crossing structures. Implement koala road signage if deemed necessary.	Requires targeted implementation based on further local Koala movement understanding. Consider during development planning process based on potential impacts.
Habitat usage	Adequate corridor widths support Koala population and metapopulation connectivity. Revegetation works should be targeted to key areas, particularly based on understanding local Koala movement.	Identify key koala movement areas and barriers through additional monitoring to guide habitat protection and enhancement. Apply mitigation measures in development approvals to support corridor retention. Implement revegetation of habitat and corridors.	Identify key potential corridors or land for habitat retention, revegetation, or improvements. Consider during development planning process based on potential impacts.
Threat prevention	Adequate corridor designs will reduce key threat processes to koalas. Installations should be targeted to key areas, particularly based on understanding local Koala movement.	Tailor corridor design to reduce threats to Koalas from developments, roads, or domestic animals. Apply mitigation measures in development approvals to support corridors and reduce negative interactions between Koalas, humans, and domestic animals. Implement designs for fencing and consider undesireable barriers to movement.	Requires targeted implementation based on further local Koala movement understanding. Consider during development planning process based on potential impacts.

Introduced species management	Management of pest species such as foxes can reduce predation risks to koalas. Consider coordinated fox control measures and pest activity monitoring over time. Collaborate across land tenures to ensure consistent, landscape-scale management using best-practice guidelines.	Determine key locations to implement fox control measures, and whether fox control is likely to succeed. Collaborate across different land tenures for maximum results. Implement and monitor appropriate fox control measures.	Consider implementation and cost compared to feasibility.
Disease management	Identify disease presence and spread in local area.	Local research required.	Currently lacking detailed information.

4.4.1 Community Awareness

Despite being so identifiable, Koalas are not generally seen by members of the community. This can be due to a variety of reasons such as tendency to be inactive during day-time hours, highly arboreal lifestyle residing high up in dense canopy and the ability to camouflage within their surroundings. Often people don't even know that Koalas exist in nearby areas. As such, it is important to improve awareness of Koalas as this can lead to more active searching for the Endangered species, theoretically resulting in increased sightings and a reduction of threats like dog attacks or vehicle strikes, as well as support for habitat restoration.

Community events such as targeted workshops, guided bushwalks or larger BioBlitz gatherings provide an effective avenue for showcasing local Koala populations while uniting residents, land managers and species experts (OEH, 2016; Whitburn et al., 2023). More than one-off information sessions, these events create a two-way exchange: participants hear up-to-date insights on koala ecology, log sightings for citizen-science databases, and workshop practical actions such as choosing feed-tree species or managing dogs near habitat. Organisers, in turn, capture valuable local knowledge and cultivate a pool of motivated volunteers for future monitoring or planting days. By pairing education with hands-on activities, each event fosters an enduring sense of stewardship that persists well beyond the day itself (Whitburn et al., 2023).

Generating Koala community awareness through the installation of signage (Figure 6) along community walking trails or bushland areas is also a great, cost-effective way to promote Koalas in the community and simultaneously generate passive occurrence records of Koalas through community reports such as through the "*I Spy Koala*" app (an app developed in 2019 by DCCEEW). It is recommended to install signage with locally relevant information on walking trails in Blue Gum Hills RP, walking trails near Stockrington SCA such as the Richmond Vale Rail Trail, and along walking paths in riparian corridors in Minmi and Fletcher.

Figure 7. Example Koala information signage pointing to "I Spy Koala".

4.4.2 Road Mitigation Measures

Vehicle strike is a known issue locally, with Hunter Wildlife Rescue reporting a dead Koala on the Pacific Motorway east of Minmi, in November 2024 (Ting, pers. comms. 2025). This issue is only likely to be exacerbated with increasing traffic and busier roads from developments within the area.

Road mitigation strategies vary significantly in their cost, complexity, and demonstrated effectiveness. For example, static warning signs, while being the simplest and least expensive mitigation measure, have limited and questionable long-term effectiveness (Huijser et al., 2009; Rytwinski et al., 2016). Conversely, combined mitigation strategies such as wildlife-exclusion fencing paired with dedicated crossing structures (underpasses or overpasses) consistently demonstrate greater success in reducing wildlife mortality (Rytwinski et al., 2016).

However, the effective implementation of such targeted mitigation infrastructure depends fundamentally on detailed knowledge of local koala movement patterns and high-frequency crossing locations (Rytwinski et al., 2016). Existing structures such as drainage culverts or underpasses represent immediate opportunities for evaluation through camera trapping (S.4.3.3.2), and the potential addition of even more detailed collar-based movement studies (S.4.3.3.1). This approach can rapidly provide the empirical data necessary to inform strategic placement of more expensive permanent structures, reducing the risk of investment in ineffective locations.

Until these data gaps are addressed, decisions regarding the placement and type of road mitigation measures remain challenging. Consequently, it is recommended that further targeted monitoring be prioritised to inform evidence-based infrastructure investment.

4.4.3 Corridors and Revegetation

4.4.3.1 Habitat usage

Although Koalas can persist in remnant vegetation and fragmented habitats, removing or reducing habitat can isolate populations, further increase risks from roads and predation, and limit genetic flow. Thus, effective corridor establishment and habitat revegetation are crucial management strategies for maintaining viable Koala populations within fragmented landscapes. The principles of selecting appropriate trees, variety of appropriate trees, and incorporating infrastructure to prevent negative interaction with potential threats are equally relevant to both the establishment of movement corridors or revegetation patches.

The Koala is a specialised folivore with a diet dominated by eucalyptus species, although dietary preferences vary regionally depending on available species. Koalas also occasionally consume supplementary food items such as bark and non-eucalypt species (Au et al., 2017). Local variations in soil composition can influence nutrient content and palatability, leading to differential feeding preferences even among populations of the same species (Au et al., 2017; Moore & Foley, 2005; Moore et al., 2005). Therefore, a key consideration for revegetation planning is the selection of tree species. Habitat quality profoundly affects koala movement, diet, and shelter from predators like dogs and foxes. Habitat loss or degradation from land-use changes can exacerbate fragmentation, making connectivity increasingly difficult and potentially reducing gene flow among koala populations (DPE, 2022b; Melzer et al., 2000).

Research suggests that as well as food, certain trees may be sought after due to specific thermal properties that may provide shade, sun, or shelter in different season and weather conditions to assist in thermoregulation (Briscoe et al., 2014; Ellis et al., 2002). This includes non-eucalypt species. Properties such as bark type, tree size, and canopy density may be favoured for resting (Youngentob et al., 2021). Sheltering plants help in temperature regulation of the habitat, including the ground area for movement between cover. This can play an important part in situations like extreme heat, and drought, as well as protection from predation (Melzer et al., 2000). Maintaining natural habitat heterogeneity may be important for sustaining of Koala populations for the long term (Youngentob et al., 2021).

Optimising revegetation efforts requires planting a diverse mix of tree species that cater to nutritional and ecological requirements. It is critical to prioritise feed trees that are regionally relevant and recognised for consistent use by Koalas when planning habitat restoration. In areas lacking data on what trees Koalas prefer, we make educated guesses using the closest relevant information. The selection process involves cross-referencing data from the *Koala Habitat Information Base Technical Guide* (KHIBTG) (DPIE, 2019) the *Australian Koala Foundation: National Koala Tree Planting List* (Mitchell, 2015) and occurrence records from the Atlas of Living Australia, focusing particularly on species recorded within a 10 km radius of the study area.

Table 6 presents a summary of recommended feed tree species, prioritised according to regionally relevant koala feeding preferences documented within the local area. Those trees identified as “High Preferred Use” and “High Use” are the more reliably utilised species, while “Significant Use” species can further enhance habitat quality through food and shelter (DPIE, 2019). Utilising seed stock sourced locally is advised to improve genetic compatibility and promote long-term adaptation to specific local environmental conditions (Bussell et al., 2006). The plantings should also prioritise species that are also relevant to the Plant Community Types (PCT) present within the restoration areas to ensure compatibility with habitats present.

There is no definite answer regarding the proportion of feed trees required in a habitat to support koalas. Values change throughout the distribution of Koalas due to soil changes and thus nutritional changes of the local vegetation. The KHIBTG proposes a threshold of ≥15% food trees in potential koala habitat, whereas the EPA (2016) ranks habitats into classes and suggests a threshold of ≥30% "first class ranking", ≥15-30% "second class ranking", and <15% "third class ranking" habitat. Other assessments divide food trees into a system where trees are ranked as primary and secondary/supplementary (DECC, 2008; Phillips & Callaghan, 2011). Scattered trees can act as "stepping stones" between remnant vegetation, providing Koalas protection (and potentially energy) between periods of traversing for possibly tens or hundreds of metres across the ground during dispersal (Marsh et al., 2014; Ramsay, 1999). Movement across the ground, and between trees within respective home ranges are a regular behavioural tendency of Koalas with individuals known to disperse up to 10 km (Dique et al., 2003; Matthews et al., 2016; White, 1999).

4.4.3.2 Threat prevention

While optimising retention and revegetation of movement corridors for koalas, consideration must be guided by strategies that prevent or reduce threatening processes within the landscape. To ensure the corridors function effectively, it is critical to address key threats such as predation by pest species, attacks by domestic pets including cats and dogs, and road mortality due to vehicle collisions. Integrating appropriate measures during the design and planning stages will support viable, long-term koala movement through the area.

While specific koala movement patterns and home range sizes vary across populations (DAWE, 2022) broader koala corridor research recommends corridor widths of at least 100 m, with 390 m preferred where possible (DAWE, 2022; DPE, 2022b). Areas identified as having particularly high risk, such as proximity to roads or urban edges, should ideally be fenced with suitable koala exclusion or directional fencing. This will mitigate threatening processes, maximising the corridor's long-term effectiveness. Where necessary, fence designs should be guided by the *Draft Design Guidelines for Koala-Exclusion Fencing (*DPHI, 2025*)*.

To ensure the effectiveness of movement corridors, efforts should be made to maintain these areas as pet-free zones. Wherever feasible, fence designs for corridors should exclude pets entirely. Considerations for the planning and approval stage of development can support this by prohibiting pet ownership in lots bordering key habitat or by establishing dedicated pet-free precincts.

While koalas are capable climbers and can, in some cases cross fences, certain fence types can still impede koala movement and increase their vulnerability to threats such as predation and entrapment (BCT, 2024). A probable barrier to koala movement has been identified in the form of the security fencing surrounding the perimeter of the SWMC site, which may account for the absence of koalas within otherwise suitable habitat. While the fence is mandated under EPA licensing conditions for site security, there is potential to investigate targeted modifications to improve habitat connectivity. Potential mitigation measures may include the integration of strategically placed fauna underpasses or overpasses, in the form of fauna friendly gates, angled logs on fence lines, or elevated bridge crossings as outlined in the *Rural Fencing Modifications for Koala Movement (*BCT, 2024*)*.

Table 6. Summary of suggested suitable feed tree species. Cross referenced between the "Koala Habitat Information Base Technical Guide" (DPIE, 2019), "National Koala Tree Planting List" (Mitchell, 2015) *and ALA records within 10 km of the study area*

Scientific name	Common name	Rank (Koala Habitat Information Base Technical Guide)	Source
Eucalyptus canaliculata	Large-fruited Grey Gum	High Preferred Use	a, b, c
Eucalyptus microcorys	Tallowwood	High Preferred Use	a, c, d
Eucalyptus moluccana	Grey Box	High Preferred Use	a, b, c, d
Eucalyptus parramattensis	Drooping Red Gum	High Preferred Use	a, c, d
Eucalyptus propinqua	Small-fruited Grey Gum	High Preferred Use	a, c, d
Eucalyptus punctata	Grey Gum	High Preferred Use	a, b, c, d
Eucalyptus robusta	Swamp Mahogany	High Preferred Use	a, b, c, d
Eucalyptus tereticornis	Forest Red Gum	High Preferred Use	a, b, c, d
Eucalyptus grandis	Flooded Gum	High use	a, b, c, d
Eucalyptus crebra	Narrow-leaved Ironbark	Significant use	a, c, d
Eucalyptus racemosa	Narrow-leaved Scribbly Gum	Significant use	a, b, c
Eucalyptus signata	Scribbly Gum	Significant use	a
Eucalyptus resinifera	Red Mahogany	Significant use	a, b, c, d

Source: a) (DPIE, 2019), **b)** (Mitchell, 2015), **c)** (SEPP, 2021), **d)** (OEH, 2018)

4.4.4 Introduced Species Management

Foxes (*Vulpes vulpes*) represent a significant predation threat to Koalas, particularly targeting vulnerable individuals such as juveniles and injured animals during ground-based movement between fragmented habitat patches (DAWE, 2022). The SWMC facility's provision of consistent food sources and shelter creates favorable conditions that may attract fox populations, potentially increasing predation pressure on native wildlife. This predation risk is particularly concerning in landscapes with low habitat connectivity, where koalas are forced to traverse ground more frequently, exposing them to heightened vulnerability and contributing to localized population declines.

Foxes were recorded both incidentally from thermal drones and in person whilst traversing SWMC and also mentioned by SWMC staff such as security personnel. During surveys a fox approached personnel at close range, interacting with survey equipment, indicating a high level of habituation to human activity. Such behaviour suggests reduced wariness, which can facilitate increased access to resources and movement across disturbed landscapes within the study area. This boldness may also heighten the predation risk to native fauna, particularly those species that are already vulnerable due to habitat fragmentation, which increases exposure to threats such as dog attacks and other introduced predators (DAWE, 2022; OEH, 2016).

The detection of foxes at SWMC highlights the need for integrated pest management strategies to mitigate risks to vulnerable native wildlife. Given the site's proximity to Blue Gum Hills RP, effective fox control measures are particularly important to prevent potential edge effects and the spread of predation pressure into adjacent, high-value bushland known to be used by Koalas. Coordinated management between sites may be critical in reducing the ecological impacts of foxes and supporting broader landscape-scale conservation outcomes (OEH, 2024). Combining multiple control strategies (such as baiting, trapping, shooting) within a coordinated framework enhances the success of fox control programs (OEH, 2024).

Ongoing management will be essential to evaluate the effectiveness of control efforts and respond to changes in pest species activity over time. Given the habitat connectivity across multiple different land holdings, collaboration may be required between all relevant stakeholders (including NPWS, CN and private land holders) to ensure suitable approaches to pest management. For detailed guidance to refer to the *Best Practice Guidelines for Fox Control for the Conservation of Biodiversity* (OEH, 2024) and the *NSW Threat Abatement Plan 2010: Predation by the red fox (Vulpes vulpes)* (OEH, 2010), which outline evidence-based methods tailored to a range of land uses and ecological contexts across New South Wales.

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6 Data

Supplementary data: The following supplementary data has been provided as part of this report and is available by written request to City of Newcastle, Environment and Sustainability, Environmental Strategy Team.

- **S1 Survey conditions** table provides comma delimited weather and survey conditions for each survey plot
- **S2 All detections** table provides comma delimited information on each faunal detection
- **S3 All detections** layer provides zipped ESRI geodatabase in GDA2020 of all faunal detections
- **S4 Media examples** provides selected videos (mp4) and images (jpg) of detections including all observed Koala (Phascolarctos cinereus).
  File naming format “detectionID_description_dronefilename”:
  - detectionID: a unique detection identifier from S2_All detections.csv
  - description: type of animal e.g. Koala
  - dronefilename: file name recorded by the drone as media was produced
- **Figures** provides individual files of each figure presented within this report in PNG and JPEG formats