Koala Safe Neighbourhood Project

2020-2021 Final Report (Year 3)

Prepared for Redland City Council

By the University of the Sunshine Coast, Detection Dogs for Conservation (DDC)

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USC Detection Dogs for Conservation

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Executive summary

Purpose

This report provides an update on the progress of Redland City Council's (RCC) Koala Safe Neighbourhoods (KSN) program, a major koala (*Phascolarctos cinereus*) conservation initiative of council. The primary aim of the KSN remains unchanged – to generate a greater sense of custodianship from residents in KSN areas toward their local koalas by informing, supporting, and empowering them to actively conserve koalas within urbanised landscapes. Central to the management of koalas within a KSN is the ongoing monitoring of the local koala population. The recruitment and monitoring of koalas for this program commenced in March 2019 and has resulted in the capture and/or monitoring of 51 koalas in Ormiston, Birkdale, Thornlands and Mount Cotton KSN to May 2021. The monitoring has several applied purposes, including collecting data on disease incidence and frequency of exposure to threats (dogs, cars). The end goal of the Koala Safe Neighbourhoods program is to rely on a citizen science component to enable the ongoing monitoring of the local koala population. Specific KSN program aims were to gain information on:

Monitoring technologies

a) test technology that allows fine-scale tracking of koala movement,
b) deploy innovative koala research techniques,
c) investigate how monitoring can be transitioned into an ongoing citizen science program,

Koala habitat utilisation

a) local movement and identification of areas that exacerbate/minimise threats to koalas,
b) home-ranges and core-ranges identification,

Health and genetics

a) refinement of current genetic sampling for koalas within the KSN catchment,
b) survival, mortality and recruitment for the population,
c) health and disease assessment,

Community Engagement

a) communicate a positive conservation message about koalas,
b) increase the profile of koalas in Koala Safe Neighbourhoods, especially through recruitment of citizen scientists and social media.

Findings

Monitoring

A total of 51 koalas have been recruited/captured since the program commenced in 2019. Koalas caught from the wild (n=43), by the Detection Dogs for Conservation (DDC), and found in good health were released with monitoring devices (n=24) or were fitted with tracking devices after successful treatment at Australia Zoo Wildlife Hospital (AZWH) or RSPCA or hand raised by a carer (n=8). One juvenile koala was released without a collar and one orphaned koala was still in care and yet to be collared.

However, 17.6 % of koalas captured for the program were in poor health and were humanely euthanised at their initial veterinary examination by Endeavour Veterinary Ecology (EVE) (n=2) and AZWH (n=3) or because they responded poorly to treatment (n=4). Additionally, eight koalas were opportunistically recruited from wildlife hospitals (AZWH=3; RSPCA=5) and collared before release to the wild.

During the course of monitoring the collared animals in the field, six koalas were recaptured and transferred to AZWH due to disease symptoms noted during regular field surveys. Four were successfully treated and two were euthanised.

In the year to May 2021, 14 koalas remain GPS collared (Benson, Blake, Blinky, Bob, Kimo, Lackey, Larissa, Liptus, Louise, Miles, Silkie, Squirrel, Thelma, Uka). Two koalas (Bruce and Rainbow) are being monitored by radio-tracking only (VHF ear tag). A total of 57 captures and almost 33,250 GPS location fixes were logged. Additionally, location data was recorded for 230 opportunistic sightings of uncollared koalas.

Home-range and core-range

Home-range (95% of the estimated distribution) and core-range (50% of the estimated distribution) were estimated for each of the currently monitored koalas with enough data (n=15; Appendix 2). Home-range varied from 0.33 ha to 101 ha (mean (*M)* = 23.81 ha, standard deviation (*SD)* = 28.31), while core-range varied from 0.07 ha to 21.4 ha (*M* = 5.09 ha, *SD* = 5.96). Home ranges for both males and females are likely overestimated as the analysis includes dispersal locations of two male and two female koalas. Home range sizes in this region are typically less than 20 ha – the influences of seasonality and release circumstances need to be considered when defining koala home ranges.

Movement Patterns

Koalas continue to display interesting movements in urban environments. Koala Benson, shortly after release, dispersed steadily north from his release location in a park in Thornlands, to the suburban streets of Cleveland. Koalas persist in these quieter residential areas where traffic speeds are lower, and some habitat is provided by footpath trees. There are currently four sub-adult koalas in the program that may start to show heightened activity and movements in the upcoming breeding season.

While the project has not recorded any confirmed morality from vehicle strike on any of the streets specifically monitored within the designated KSN, Wonky was suspected as having an injury from a possible vehicle strike. There were two records of domestic dog attack, one suspected attack in Thornlands (Benson), and the other in Ormiston resulting in mortality (Slinky). The findings from monitoring are a stark reminder of the threats to koalas moving and living in urban environments.

Implications for Conservation. Koalas seek a range of habitat types during their daily travels and can persist in very built-up areas with adequate food resources and low traffic volumes and speeds. The Koala Safe Neighbourhoods program is particularly suited to engaging the community to protect these vulnerable koalas.

Population health

Since the koala monitoring began in Ormiston in March 2019, 69 veterinary exams have been conducted across the four KSNs by Endeavour Veterinary Ecology. This includes 42 in Ormiston, 16 in Thornlands, five in Birkdale and six in Mount Cotton. In 30% of the cases, koalas were diagnosed as sick or injured with seven individuals being euthanised. Chlamydia was the most common disease found in the koalas examined. During welfare checks, three monitored koalas were found with disease (Banjo, Ted and Summer), and a further three koalas were detected by members of the public as sick (Liptus and Uka) or injured (Slinky).

Implications for Conservation. The level of chlamydia infection indicates vulnerability of the koala population in the Koala Safe Neighbourhood areas. In this scenario, ongoing monitoring becomes vital to identify and treat koalas before they die or become infertile. Additionally, monitoring can be important to detect "super spreader" koalas and decrease the rate of transmission.

The Redlands mainland has a relatively high density of urban koalas when compared to other areas in South East Queensland, therefore it is well placed to engage the community to promote guardianship over their local neighbourhood koalas.

Community engagement

Community engagement was severely impacted by regulations and restrictions, including gatherings and social distancing, linked to COVID-19. The current situation still does not encourage social interactions, so group engagement activities have been avoided.

Nonetheless, whenever safe and possible, the DDC team engaged in conversations about koala conservation with members of the public and brochures of the Redland Wildlife Rescue Service were provided to residents. The DDC team participated in four citizen scientist workshops (via Zoom and physically) and two public events (physically).

The Detection Dogs for Conservation team created content (information, images and videos) and shared with the Redland City Council for social media engagement and Council newsletters. The team also spent a day filming information videos to be used by Council to promote its koala conservation program.

1. Introduction

1.1 Scope of works

Redland City has a regionally significant koala population that, despite long-term management strategies by state and local government and community-based conservation organisations, has continued to undergo significant decline. To halt the decline and retain a viable koala population into the future, Redland City Council (Council) has adopted a range of management strategies relating to: research and monitoring; koala habitat protection and enhancement; preventing koala mortality and community engagement; awareness and citizen science. The implementation of these strategies is outlined in the *Koala Conservation Action Plan 2016-2021*.

Council is collaborating with the University of the Sunshine Coast's Detection Dogs for Conservation (DDC) to conduct koala monitoring and data collection within four designated Koala Safe Neighbourhoods (KSN). These actions provide information to better understand existing koala populations and inform management plans. Specifically, the project aims to:

- Gather up-to-date information on koala presence and numbers in KSN;
- Assess health of KSN koala populations;
- Community engagement.

In particular, the following activities inform the scope of the project:

1. Establishment of a comprehensive phased monitoring project that seeks to encompass all koalas and can be transitioned into an ongoing citizen science program;
2. Use of monitoring technology that allows fine-scale tracking of koala movement;
3. Development or trial of innovative koala monitoring techniques;
4. Undertake best practice capture methods;
5. Undertake best practice management and handling of koalas;
6. Regular visual tracking of the collared koalas;
7. Provision of a technique to identify individual koalas;
8. Establishment of minimum population size;
9. Collection of koala scats/tissue for refinement of current genetic sampling for koalas within the KSN catchment;
10. Health and disease assessment;

11. Determine survival, mortality and recruitment for the population;
12. Determine local movement and identification of areas that exacerbate/minimise threats to koalas;
13. Identify and investigate core areas of koala habitat utilisation and connectivity;
14. Engage with the community and communicate a positive conservation message about koalas;
15. Liaise, and work in collaboration with, Redland City Council's Koala Project Officer, Koala Education Officer and Wildlife Extension Officers and the community as required.

1.2 Background

Australia has the highest mammal extinction rate of any country in the world (Woinarski et al. 2015), therefore effective conservation and monitoring are of urgent priority. For instance, Koalas (*Phascolarctos cinereus*), despite their iconic status and economic value (potentially $3.2 billion per annum (Conrad 2014)), are experiencing an alarming sharp decline in the northern parts of their range (Queensland, New South Wales and the Australian Capital Territory). In Queensland, for example, land area occupied by koalas has contracted by an estimated 31% over the past century (Gordon et al. 2006) and the number of koalas has declined by approximately 43% (39-46% range) over a period of 20 years (McAlpine et al. 2015). In some areas of the state, documented declines have been even greater, including an 80% decline in the Mulga Lands bioregion over 14 years (Seabrook et al. 2011) and, within the South-East Queensland bioregion, declines of 80% and 54% within the Koala Coast and Pine Rivers populations respectively (Rhodes et al. 2015), these results were also prior to the mega 2019-2020 bushfire, which further impacted koala populations (Phillips et al. 2021). Of even further concern is evidence that the rates of decline in these areas are worsening over time (Rhodes et al. 2015).

The reasons for the koala population decline are well known: 1) habitat loss and fragmentation (which also reduces genetic diversity and connectivity), 2) infectious disease caused by the bacterial pathogen, Chlamydia (which causes blindness, sterility and potential death), and 3) the risks associated with koala movements in human-altered landscapes (including dog attacks and car strikes) (Rhodes et al. 2011, Polkinghorne et al. 2013, Burton and Tribe 2016), but evidence about how these factors are impacting specific populations and how to mitigate them is often not available to decision-makers, and this holds true for both State and local government authorities. This report provides information to the Redland City Council to help understand specifically the Redland Coast koalas and the threats they face. This collaboration accomplishes several of their proposed management intents set out in their Koala Conservation Strategy 2016 to include a) decisions based on science; b) protect and improve koala habitat; c) reduce koala deaths, and; d) what is the community thinking.

Particularly in urban environments, actions in favour of biodiversity are extremely affected by socio-political factors, in addition to economic and ecological factors (Nilsson et al. 2019). For this reason, conservation efforts that include a wide range of actors can present powerful positive impacts. Community engagement is particularly important. Since the 18th century, citizen science has been provided by members of the public. It has changed over the years, but the main principle remains the same - non-professional scientists contributing to research (Tripp, 1943).

The Citizen Science Research Model is currently the most used approach around the world. Participants are encouraged to collect data about a specific topic, for example, sightings of koalas in the Redland Coast. The data is publicly available, including to researchers who can analyse data and formulate predictions (Dickinson et al. 2010). This model also includes an important educational component. The knowledge and scientific practices are shared with the local communities that become empowered and can participate, with managers and researchers, in developing management strategies.

The long-term aim of Council's program is to engage the community and citizen scientists to have ownership of their local neighbourhood koalas and collect data to assist in the monitoring, data collection and health surveillance of local koala populations. Here, we deployed proven and cost-effective methodologies with the intent to collect and analyse data on koala presence, genetics, movement, health and population dynamics while trialling monitoring technologies (Bluetooth) for integration to KSN community engagement programs. Details are given below.

1) Innovative monitoring technologies

Since March 2019, we have monitored a total of 39 koalas released to the wild across the Redlands mainland using different types of tracking devices such as GPS, VHF and Bluetooth equipped ear-tags. We aimed to assess:

a) movement of the monitored koalas,
b) their health status,
c) the potential to develop a citizen science monitoring program,
d) pros and cons of different tracking techniques for ongoing koala monitoring within an urban setting.

2) Koala habitat utilisation

We estimated the extent of home range and core area of monitored koalas across the KSNs to assess:

a) habitat utilisation,
b) potential threats,
c) hotspots for further conservation initiatives (targeted education, dog control, tree plantings etc).

3) Koala population health assessment

We estimated a suite of demographic and health traits to assess the extent to which KSN's koalas are exposed to different threats. These included:

a) estimation of koala survival/mortality and reproduction rates based on the project sample size,
b) quantification of disease incidence for KSN koalas.

4) Community engagement

We engaged the local community with koala conservation through different approaches. These included:

a) participate in workshops promoted by the Redland City Council,
b) creation of content for the council to use in its communication with the general public,
c) developing close community relationships (texting, meeting, training, inviting to join koala releases etc) with specific groups of highly engaged and motivated citizen scientists,
d) engaging with interested citizens during fieldwork.

2. Methodology

2.1 Koala Search and Capture

Koalas were recruited to the program during periods of targeted search and capture where the DDC team would search koala habitat in KSN zones for koalas. Koala detections resulted from on-ground surveys, detection dog searches or thermal drone surveys. A minority of koalas were not captured from the wild but opportunistically recruited via wildlife hospitals. When koalas were detected and assessed as safe for the koala and capture team to attempt a capture, koalas were captured using two main techniques:

- A flag and/or climb method, where a qualified koala catcher/s use a telescopic pole with a 'halo' attachment on the end that is waved above the koala's head to encourage the animal to descend the tree. The primary flagger may often be required to ascend a ladder or climb into the tree with ropes and harness to reach the koala. Due to safety concerns, more koalas were found than were caught- koalas in large trees with a chance of falling out of trees overhanging roads, cement footpaths, water bodies, or houses with dogs, or near powerlines, for example, were typically not attempted.
- Deploy a koala trap using corflute to enclose the tree housing the koala, and with a treadle-operated cage trap placed within the wall of the structure to trap the koala once it descends the tree looking for an avenue of escape.

2.2 Monitoring Technologies

2.2.1 Devices

All healthy captured adult koalas were fitted with multiple monitoring devices prior to release. One juvenile koala raised by a carer after being orphaned, was released with Bluetooth Low Energy (BLE) ear tag, but not collared due to size constraints. The following technologies were fitted to koalas during their veterinary examination prior to release:

1. **Microchip**, inserted subcutaneously into the inter-scapular area to enable identification of individual koalas at any facility with a microchip scanner (e.g. wildlife hospital).
2. **Solar-powered Bluetooth Low Energy (BLE)** ear tag (<5g) to enable identification of individual koalas from near the base of its tree using any smartphone Bluetooth app.
3. Collar assembly incorporating a customised safety weak link (designed to break if koala becomes entangled).
4. Collar GPS. **GPS tracker** with up to 6 location fixes per day (4 pm, 8 pm, midnight, 4 am and 8 am), 6 month estimated battery duration with near-real-time location data. **GPS logger** with higher frequency but shorter battery life.

   The GPS tracker units were modified to decrease weight. This enabled them to be positioned in the prime GPS receiving position at the back of the neck facing toward the sky, ensuring higher success and accuracy of 3 to 6 attempted location fixes per day. Data from GPS loggers currently deployed (positioned under chin with VHF beacon) can only be accessed when collars are recovered.
5. Collar **VHF beacon** for periodic radio-tracking (welfare checks) and to enable locating of dropped collars.
6. Collar **altimeter** system providing 4-second interval data logging for up to 42 days.

2.2.2 Radio-tracking and welfare checks

Radio-tracking has continuously been performed once to twice per month for welfare checks of all collared koalas. This was to ensure that there were enough opportunities to clearly observe the animal at least once per month, according to animal ethics permit conditions. Welfare-related checks happened as frequently as every second day, particularly during the translocation of koalas to the Redlands and the intensive monitoring of koalas needing urgent capture for illness or collar checks. Koalas were observed with binoculars to try to ascertain: (1) sex, (2) external signs of chlamydial infection, often referred to as pink eye (for ocular infection/conjunctivitis) and wet or dirty bottom (for urinary tract infection), (3) presence of a joey, and (4) to ensure the fit and placement of the collar. Other data such as location, time, position in the tree, tree species (when known) and koala's behaviour were also recorded.

When a sick or injured koala was located during tracking events, whether it be a collared or opportunistic sighting of a wild koala, it was immediately reported to the Redlands Wildlife Rescue Service for further action. During this process, all opportunistic sightings of uncollared koalas were recorded in the project database and the Queensland State Government's Wildnet database.

2.3 Koala habitat utilisation

We have estimated home ranges for koalas fitted with GPS trackers, loggers and VHF devices. All location fixes with an accuracy of 30 m or less were included in the analysis.

The home-range of each collared koala was estimated using location data obtained to date. Home ranges were calculated as 95% and 50% (core-area) of the individual's estimated distribution based on fixed Kernel Density Estimators. To avoid bias caused by uneven sampling intervals during the home range calculation, a maximum of one location fix per day was used (last record of the day). Bandwidth smoothing parameters were calculated individually according to the method proposed by Worton, B. (1995). All smoothing parameters, home ranges, and home range areas were calculated using adehabitatHR package in R statistical software, and were mapped using the software ArcGIS version 10.8.1 (ESRI).

Limitations

Home ranges and areas presented in this report are a partial estimation only, calculated from data collected up to 28 May 2021. Therefore, they represent space used during the period each koala was wearing a collar (which differs between koalas) and is likely not indicative of that koala's entire home range over seasons and years.

We decided to use a daily time series instead of all available location fixes. This may reduce the precision of home ranges but avoids biases and incorrect assumptions caused by the highly variable frequency at which GPS location points were logged. For example, some individuals had GPS units set to log one geographic position every 15 minutes (the loggers), while others every few hours (the trackers). The variation occurred due to different research objectives such as:

- "real-time" tracking (the trackers) for community engagement,
- fine-scale (but shorter life) GPS mapping (the loggers) to determine movements especially across roads,
- definition of home-ranges and individual space use.

Location fixes recorded by GPS devices and radio-tracking represent only the period for which the koala was monitored.

2.3 Health examination

All veterinary procedures were conducted by or under the direct supervision of an experienced wildlife veterinarian (Drs Jon Hanger, Amy Robbins or Pip McKay) with the assistance of an experienced wildlife veterinary nurse. Veterinary procedures were conducted at the Council's Animal Shelter (Thornlands, QLD) and the EVE clinic (Toorbul, QLD).

After induction of general anaesthesia, all captured koalas received a full veterinary physical and clinical examination and the findings were recorded.

The following standardised veterinary procedures and diagnostic tests were performed:

- General physical exam: weight, body condition score, tooth wear (approximating koala age),
- Ear punch for DNA analyses (and fitting of ear tag when needed).

- Blood collection and processing for packed cell volume and total protein (PCV/TP) estimation and cytology.
- Bone marrow collection and cytology to detect any abnormalities, such as leukaemia.
- Abdominal fluid collection and cytology.
- Cystocentesis for urinalysis (Combur test, USG and urine sediment cytology).
- Ultrasound of kidneys, reproductive tract and bladder
- Swabs for the detection of Chlamydia from the following sites: conjunctiva, urogenital sinus (female koalas) or penile urethra (male koalas) and urine sediment.

While still under general anaesthesia, koalas were microchipped and fitted with a GPS/VHF collar with altimeter, and Bluetooth ear tag. Koalas were then transferred to a transport cage on recovery. Sub-adults were microchipped, but being smaller in size, a GPS collar was only fitted at the discretion of veterinary personnel. A recapture date was assigned to each koala based on its size/age and circumstances. Most adult koalas were rescheduled for a 6-monthly health check-up, whereas growing sub-adult koalas were rescheduled for a collar sizing check between 2 to 3 months. Veterinary examinations were rescheduled earlier than six months if possible underlying health issues were detected that required a follow-up health check.

If, in the judgement of the veterinary team, a koala was found with an illness that was unlikely to respond to treatment, the koala was euthanised before recovery from anaesthesia by intravenous injection of concentrated pentobarbitone sodium (Lethabarb). If, in the judgement of the veterinary team, a koala’s illness or injury warranted veterinary treatment or care, the koala was transferred to the Australia Zoo Wildlife Hospital. Unless veterinary treatment was required, captured koalas were released at the point of capture within 24 hours.

All collared koalas were visually observed with binoculars at least monthly by an experienced koala researcher (primarily Kye McDonald, secondarily Caio Santos Neto) to assess overt health, demeanour, collar fit and reproductive status of females. Koalas were also located in the field for welfare checks if satellite tag uploads indicated a potential problem with no uploads or uploads in an area with high threats. Koalas with a collar requiring adjustment, or that presented overt signs of illness, injury or distress were re-captured as soon as possible. Koalas with illness or injury were taken to Australia Zoo Wildlife Hospital (AZWH) for veterinary assessment.

It should be reinforced that all koala collars feature a customised safety weak link that is designed to break if the koala becomes entangled or hung-up on a branch. The collar has been specifically designed for koalas. Indeed, no collar-related incidents have been recorded to date.

2.4 Community engagement

A primary focus of the current project's citizen science engagement was the development and trial of solar-powered Bluetooth ear tag monitoring technology, which can then be integrated with a user-friendly smartphone App for use by local residents and tourists alike, who are interested in spotting and recording wild koalas.

Bluetooth ear tag performance was recorded during the course of each deployment period/per individual koala. Once a device was detected using the mobile platform application via a smartphone in the field, the distance between the base of the tree and the smartphone was calculated. Development of the Bluetooth device itself is continuing, with the device being at its 4th iteration.

Over the course of the koala monitoring projects, the Detection Dogs for Conservation team has attended events and workshops promoted by Council, actively endorsed koala conservation messages, and engaged and empowered the community when in the field.

Limitations

Many of the planned community engagement activities could not be delivered due to COVID-19 restrictions. We participated in community engagement activities as appropriate based on government health advice.

3. Results

> ***Note.*** This main body of the report focuses on giving general trends and analyses, and to preserve the flow, specific maps per koala are not included here but given in Appendix 2.

3.1 Koala Safe Neighbourhoods

3.1.1 Koala presence and numbers

Since March 2019 to the time of writing this report (May 2021), of 51 koalas that have been recruited to the program, 16 are still being monitored (14 with GPS collars and two VHF ear tags, Figure 1). As of July 2020, the Koala Safe Neighbourhoods project expanded from the Ormiston area to include to neighbourhoods in selected areas in Thornlands, Birkdale and Mount Cotton. In the year to May 2021, 24 koalas were recruited to the program. The recent recruitment of five Minjerribah koalas to the Mount Cotton KSN precinct significantly increased numbers in the program in May 2021.

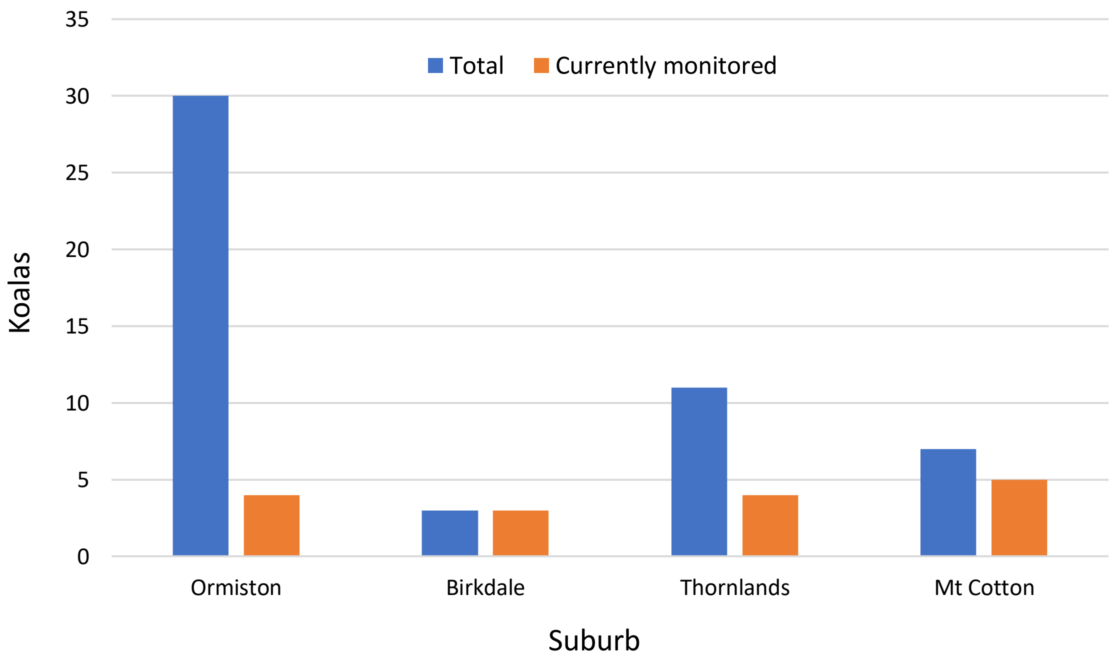

Figure 1. Total koala recruits and current number of monitored koalas in each Koala Safe Neighbourhood (up to May 2021)

Koala searches to find koala ambassador recruits were conducted on four separate occasions for a total of 17 days in August, September and December 2020 and April 2021. Searches were facilitated with drone acquired thermal imagery, visual spotting, and detection dogs to identify targets for capture. We aimed to catch and collar additional koalas to have four ambassador koalas in each of the four neighbourhoods. During searches for koalas to recruit, koala detections were more numerous in Ormiston, Birkdale and Thornlands compared to the Mount Cotton neighbourhood. This coincides with the higher incidence of public reporting of sick, injured, orphaned or dead koalas from these suburbs to the SEQ Wildlife Hospitals network (Figure 2). Cleveland, Ormiston and Thornlands each had over 30 koalas admitted to hospital between January 2020 and December 2021 (data not available for 2021).

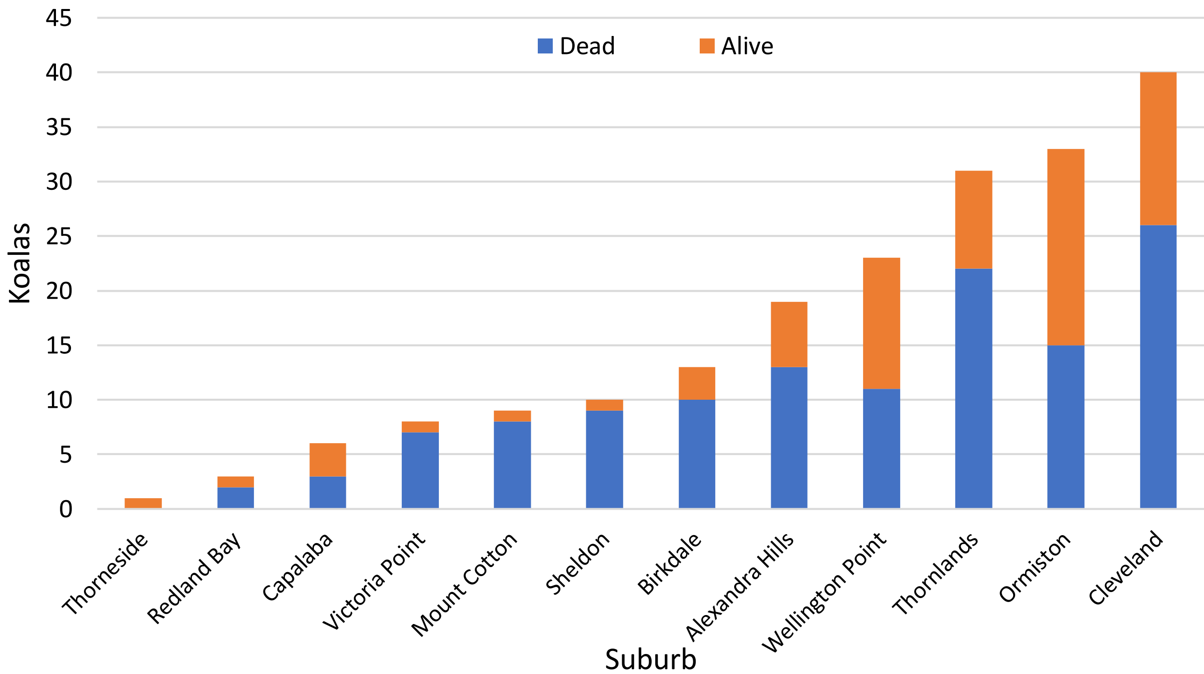

Figure 2. Sick, injured, orphaned or dead koalas admitted to South East Queensland Wildlife Hospitals in 2019 and 2020.

3.1.2 Health at capture/recapture

Since July 2020, there have been 35 veterinary examinations of 28 koalas conducted by EVE (69 since the start of the program). At least 20 initial veterinary examinations were also conducted at AZWH on koalas referred to the facility by EVE for treatment (note that multiple examinations for koalas undergoing treatment are not counted here).

Approximately three quarters (n=32; 74.4%) of the 43 koalas caught from the wild by the DDC team since the commencement of the KSN program were in good health at their initial veterinary examination and released immediately with monitoring devices (*n*=24, 75% %) or collared after a period of treatment/rehabilitation (*n*=8, 25%) and released back into the wild with monitoring devices. An additional eight koalas that were captured by other institutions were recruited before release. Long-term monitored koalas have had as many as three veterinary examinations conducted by EVE since monitoring commenced (Table 1). However, more than half of all koalas captured (58.8%) for the KSN program developed poor health at some point while being monitored i.e., Ted, Banjo and Summer were recaptured because of signs of disease, but initially were healthy (*n*=28 adults, following this breakdown: 9 euthanised at capture + 2 euthanised after recapture + 7 needed treatment (Ember, Lackey, Bob, Liptus, Uka, Banjo, Ted) + 8 sick / injured koalas rescued by different institutions + 2 hand raised by carers (dependent juveniles of diseased mothers) and were admitted to the Australia Zoo Wildlife Hospital.

Of the koalas admitted to the hospital, five females were euthanised at their initial veterinary examination due to severity of disease (Billie, Caraid, Daisy, Princess, Olive), and another four were euthanised after responding poorly to treatment (Banjora, Nugget, Pebbles, Saxon) (See Appendix 1 for AZWH clinical summaries) (Figure 3).

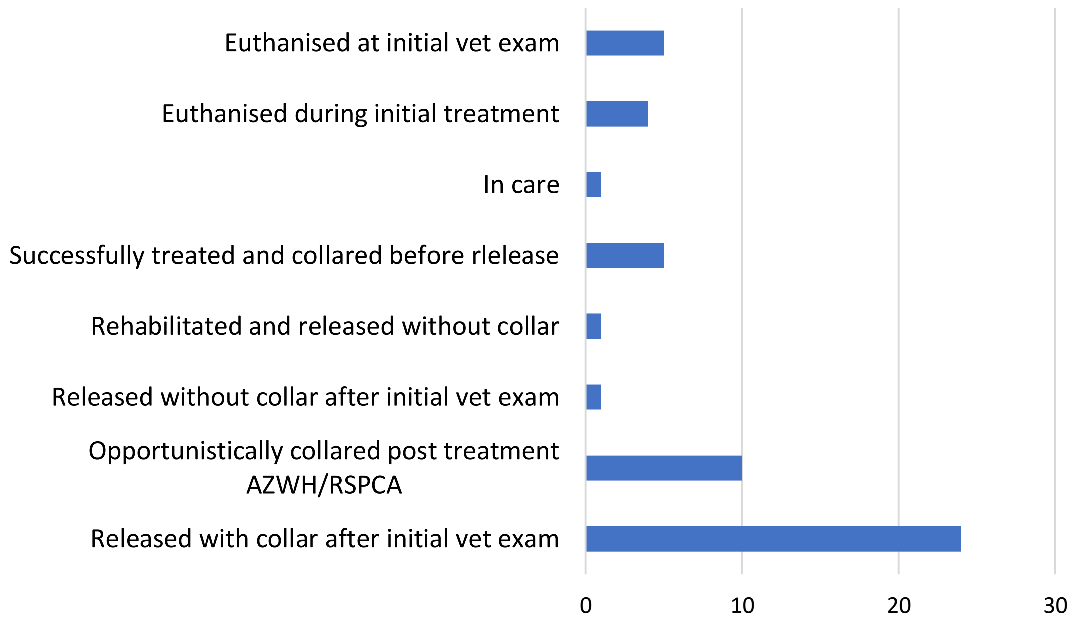

Figure 3. Recruitment breakdown of koalas entering the Koala Safe Neighbourhoods program.

Table 1. Veterinary summary of koalas captured for Koala Safe Neighbourhood project.

Name	Sex	Neighbourhood area	Date of first vet check	Age first capture	Weight (kg)	Initial diagnosis	No. vet checks
Brian	Male	Ormiston	17/04/2019	2.2	7.05	Healthy	2
Kimo	Female	Ormiston	17/04/2019	5	6.8	Healthy	3
Lucky	Male	Ormiston	17/04/2019	6.5	6.68	Healthy	1
Banjo	Male	Ormiston	24/04/2019	4	7.51	Healthy	2
Gumnut	Female	Ormiston	24/04/2019	1.9	4.11	Healthy	1
Lulu	Female	Ormiston	24/04/2019	2.5	5.06	Healthy	1
Bruce	Male	Ormiston	01/05/2019	3.33	8.3	Healthy	2
Cuddles	Female	Ormiston	01/05/2019	1.4	3.98	Healthy	1
Monty	Male	Ormiston	01/05/2019	4	9.19	Healthy	1
Billie	Female	Ormiston	01/05/2019	4	5.3	Diseased	1
Saxon	Male	Ormiston	01/05/2019	3.5	5.6	Diseased	1
Ted	Male	Ormiston	01/05/2019	4	7.3	Healthy	2
Rubin	Male	Ormiston	02/07/2019	2	5.72	Diseased	1
Chips	Male	Ormiston	21/08/2019	2.5	8.22	Healthy	1
Leaf	Female	Ormiston	21/08/2019	1.8	4.99	Healthy	1
Poppy	Female	Ormiston	21/08/2019	4	5.46	Healthy	1
Bilbo	Male	Ormiston	18/09/2019	5	8.66	Healthy	1
Ember	Female	Ormiston	18/09/2019	3	6.56	Diseased	1

Name	Sex	Neighbourhood area	Date of first vet check	Age first capture (yrs)	Weight (kg)	Initial diagnosis	No. vet checks
Wonky	Male	Ormiston	18/09/2019	6.5	7.84	Healthy	2
Pebbles	Female	Ormiston	25/09/2019	6.5	6.7	Diseased	1
River	Female	Ormiston	25/09/2019	0.8	1.01	Orphaned	1
Silkie	Female	Ormiston	25/09/2019	5.5	6.01	Healthy	3
Bluey	Male	Ormiston	30/10/2019	2.5	7.0	Healthy	1
Olive	Female	Ormiston	30/10/2019	6	4.75	Diseased	1
Milo	Male	Ormiston	30/10/2019	3.5	6.65	Healthy	1
Tally	Female	Ormiston	30/10/2019	6	5.97	Healthy	1
Bark	Male	Ormiston	16/06/2020	1.5	4.28	Healthy	1
Rainbow	Female	Birkdale	25/08/2020	6	6.23	Healthy	1
Uka	Female	Birkdale	25/08/2020	2.5	6.56	Healthy	3
Banjora	Female	Thornlands	02/09/2020	4.5	6.16	Diseased	1
Lackey	Male	Thornlands	02/09/2020	2.5	6.47	Diseased	3
Cariad	Female	Thornlands	03/09/2020	6	6.52	Diseased	1
Nibble	Female	Thornlands	03/09/2020	0.81	1.39	Healthy	1
Hazel	Female	Thornlands	9/9/20	0.7	0.8	Orphaned	1
Blake	Male	Thornlands	11/09/2020	2	6.74	Healthy	2
Daisy	Female	Thornlands	14/09/2020	3	5.48	Diseased	1
Sir Derek	Male	Thornlands	14/09/2020	0.8	3.15	Orphaned	2
Summer	Female	Thornlands	17/09/2020	3	6.16	Healthy	1
Slinky	Male	Thornlands	07/10/2020	1.8	5.06	Orphaned	1
Benson	Male	Thornlands	17/12/2020	2	5.78	Injured	1
Liptus	Male	Birkdale	22/01/2021	1.05	3.03	Healthy	1
Bob	Male	Mount Cotton	05/02/2021	5	7.93	Diseased	1
Name	**Sex**	**Neighbourhood area**	**Date of first vet check**	**Age first capture (yrs)**	**Weight (kg)**	**Initial diagnosis**	**No. vet checks**

Princess	Female	Thornlands	13/04/2021	11	6.43	Diseased	1
Nugget	Male	Mount Cotton	13/4/2021	5	4.7	Diseased	1
Squirrel	Male	Ormiston	15/04/2021	1.3	3.5	Orphaned	1
Larissa	Female	Mount Cotton	05/05/2021	4	5.03	Healthy	1
Olly	Female	Mount Cotton	05/05/2021	1.5	3.69	Orphaned	1
Thelma	Female	Mount Cotton	05/05/2021	9.25	5.98	Injured	1
Blinky	Male	Thornlands	10/05/2021	9	6.85	Diseased	2
Louise	Female	Mount Cotton	13/05/2021	1.5	3.78	Orphaned	1
Miles	Male	Mount Cotton	13/05/2021	2	4.39	Orphaned	1

3.1.3 Sources of recruitment

Rehabilitated koalas from wildlife hospitals accounted for eight koalas recruited to the program. Three of these koalas (Slinky, Benson and Squirrel) were opportunistically recruited after successful treatment at AZWH and collared before release. Five additional koalas were recruited from the RSPCA wildlife hospital (Thelma, Larissa, Olly, Louise and Miles). These koalas were all from Minjerribah, as they are currently not being returned to the island until state government quarantine processes have been put in place in liaison with Quandamooka Yoolooburrabee Aboriginal Corpration (QYAC). Council negotiated the inclusion of these animals in the KSN program before release back to the Redlands to ensure the health and wellbeing of the animals after release.

3.1.4 Koala captures

A total of 57 captures and re-captures have occurred since the commencement of the KSN program (Figure 4). Many more koalas were detected (n=72) during intensive search and capture field periods than were attempted for capture.

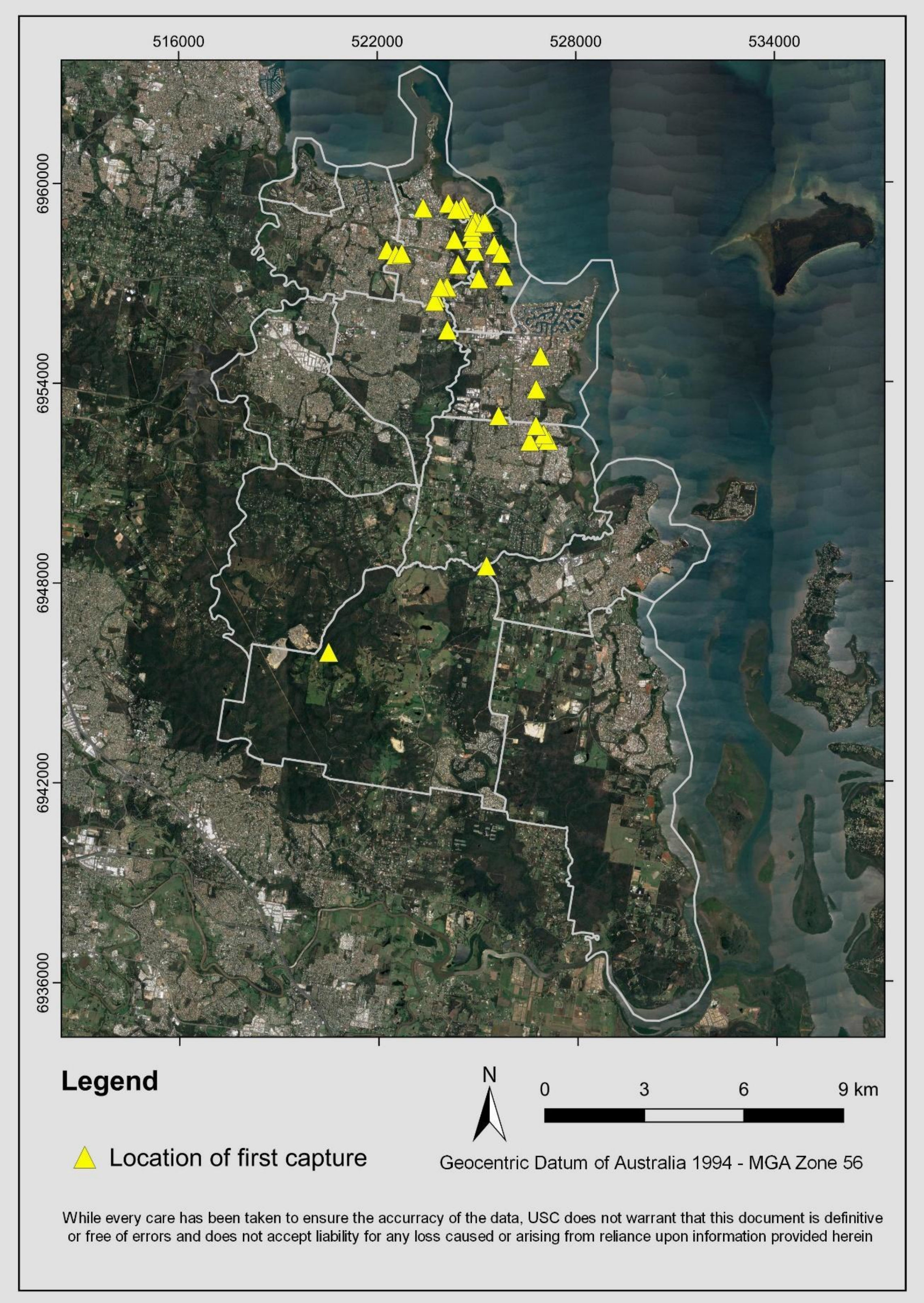

Figure 4. Location where koalas were captured for the first time. Note that this map does not include translocations.

3.2 Koala Habitat utilisation

3.2.1 Locational fixes via GPS and VHF trackers and field observations

Three tracking devices used to gather fine scale locational data for monitored koalas, consisting of VHF transmitters, GPS data loggers and GPS tracker, provided approximately 33,250 unique GPS locations. Field work provided an additional 230 opportunistic koala sightings of uncollared koalas during the project, including sightings of koalas that weren't suitable for capture and those encountered during routine field work. In-field welfare checks of monitored kolas approximately every fortnight, accounted for nearly half (47%, n-108) of these opportunistic sightings. A portion of these opportunistic sightings are likely multiple sightings of the same individuals.

3.2.2 Koala monitoring

A total of 40 koalas have been released with monitoring devices since the commencement of the project and were fitted with a combination of Bluetooth ear tag, VHF transmitter, data logger and GPS tracker (Table 2). Currently 16 koalas remain collared or VHF ear tagged and are monitored: Benson, Blake, Blinky, Bob, Bruce (VHF ear tag), Kimo, Lackey, Larissa, Liptus, Louise, Miles, Rainbow, Silkie, Squirrel, Thelma and Uka. Eighteen koalas have dropped their collars and are no longer being monitored; however, some of these animals (e.g. Ted, Cuddles, Tally, Ember, Sir Derek) continue to be intermittently sighted and have the potential to be recaptured and recruited back into the KSN program. Note that collar drop is an obligatory part of monitoring wildlife, and the collars are designed to break for animal welfare purposes to protect animals from being snagged and hung by collars.

Table 2. Name, monitoring duration and current status of each koala monitored in the Koala Safe Neighbourhoods project area.

Name	Suburb	Period	Status
Banjo	Ormiston	Apr 2019 – Oct 2020	Dropped collar
Bark	Ormiston/Wellington Pt.	Jul 2020 – Dec 2020	Dropped collar
Benson	Thornlands/Cleveland	Dec 2020 – Current	Monitored
Bilbo	Wellington Pt	Sep 2019 - Jul 2020	Dropped collar
Blake	Thornlands/Cleveland	Oct 2020 – Current	Monitored
Blinky	Thornlands/Cleveland	May 2021 - Current	Monitored
Bluey	Ormiston	Oct 2019 - Dec 2019	Dropped collar
Bob	Mt. Cotton	Feb 2021 - Current	Monitored
Brian	Ormiston	Apr 2019 - Dec 2019	Dropped collar
Bruce	Ormiston	May 2019 – Current	Monitored
Chips	Wellington Pt.	Aug 2019 - Feb 2020	Dropped collar
Cuddles	Ormiston	May 2019 - Oct 2019	Dropped collar
Ember	Ormiston	Nov 2019 - Jan 2020	Dropped collar
Gumnut	Wellington Pt.	Apr 2019 - Jan 2020	Dropped collar
Kimo	Wellington Pt.	Apr 2019 – Current	Monitored
Lackey	Thornlands/Cleveland	Nov 2020 – Current	Monitored

Larissa	Mount Cotton	May 2021 - Current	Monitored
Leaf	Ormiston	Aug 2019 - Sep 2019	Dropped collar
Liptus	Birkdale	Jan 2021 - Current	Monitored
Louise	Mount Cotton	May 2021 - Current	Monitored
Lucky	Ormiston	Apr 2019 - Apr 2019	Deceased
Lulu	Ormiston	Apr 2019 - Jul 2019	Deceased
Miles	Mount Cotton	May 2021 - Current	Monitored
Milo	Ormiston	Oct 2019 – Jan 2020	Dropped collar
Monty	Ormiston	May 2019 - Jan 2020	Dropped collar
Olly	Mount Cotton	May 2021 – May 2021	Dropped collar
Poppy	Ormiston	Aug 2019 - Jan 2020	Deceased
Rainbow	Birkdale	Sept 2020 – Current	Monitored
River	Ormiston	Joey raised and released	Bluetooth only
Rubin	Ormiston	Jul 2019 - Sep 2019	Dropped collar
Silkie	Ormiston	Sep 2019 - Current	Monitored
Sir Derek	Thornlands	Jan 2021 – Feb 2021	Dropped Collar
Slinky	Ormiston	Oct 2020 - Current	Deceased
Squirrel	Wellington Pt	Apr 2021 - Current	Monitored
Summer	Thornlands/Cleveland	Sept 2020 – Dec 2020	Deceased
Tally	Ormiston	Oct 2019 - Apr 2020	Dropped collar

Ted	Ormiston	May 2019 - Nov 2019	Dropped collar
Thelma	Mount Cotton	May 2021 - Current	Monitored
Uka	Birkdale	Sept 2020 - Current	Monitored
Wonky	Wellington Pt.	Sep 2019 - Apr 2020	Deceased
Total		40 koalas (one Bluetooth only)	16 currently monitored

3.2.3 Home range and core range

Home-range (95% of the estimated distribution) and core-range (50% of the estimated distribution) were calculated for each of the GPS/VHF monitored koalas (Table 3, Appendix 2), except for Olly who dropped the GPS collar in less than one month from the release date. Home-range size varied from 0.33 ha to 101 ha (M = 23.81 ha, SD = 28.31) while core-range varied from 0.07 ha to 21 ha (M = 5.09, SD = 5.96 ha). As expected, female koalas had a smaller core range and home range than male koalas – males had a mean home range size of 27.91 ha and core range of 6.01 ha, whereas females were nearly half the size of males with a home range of 17.4 ha and a core range of 3.6 ha. Note that these calculations are preliminary only, as they do not include all seasons for all koalas, and some koalas have displayed large post release movements which will be excluded from the home range analyses as we collect more data.

Table 3. Summary of home-range, core-range, for all koalas monitored from July 2020 to May 2021.

Name	Sex	Duration (days)	Core-range (ha)	Home-range (ha)
Bark	Male	217	18.23	83.17
Benson	Male	157	21.44	101.22
Blake	Male	62	5.82	26.71
Blinky	Male	18	2.77	11.7
Bob	Male	87	4.93	22.28
Kimo	Female	324	1.12	4.58
Lackey	Male	155	4.54	18.57
Liptus	Male	122	1.26	5.02
Sir Derek	Male	24	0.07	0.33
Rainbow	Female	113	2.9	14.52
Silkie	Female	276	1.56	6.7
Slinky	Male	69	0.79	10.27
Squirrel	Male	41	2.54	9.24
Uka	Female	214	1.07	5.1
Thelma	Female	22	1.8	7.8
Larissa	Female	20	9.53	53.35
Miles	Male	12	4.35	27.93
Louise	Female	12	7.55	29.61
Mean		**108**	**5.09**	**23.81**
SD		**97**	**5.96**	**28.31**

3.2.4 Movements and dispersal

The largest home ranges were displayed by koalas that had dispersed from their original capture/release point to other areas of habitat. Male koalas Bark (83 ha) and Benson (101 ha) dispersed up to 2.5 km to their current locations while the female Larissa moved up to 1.5 km (see home ranges in Appendix 2). These movements typically involved crossing through backyards and across roads, increasing the level of threat to these koalas. Benson has established a home range in suburbia, crossing streets daily to access food trees growing on street verges and footpaths (Figures 5 and 6). He left his release site in secure bushland for a very urban landscape, however this is a relatively quiet residential area where traffic speeds and volumes are low and minimal habitat/koala food trees remain in backyards, so encounters with domestic dogs might be lower than other urban areas. There are currently four sub-adult koalas (Miles, Olly, Louise and Squirrel) in the program that may start to show heightened activity and movements in the upcoming breeding season, and their movement and behaviour will be closely monitored.

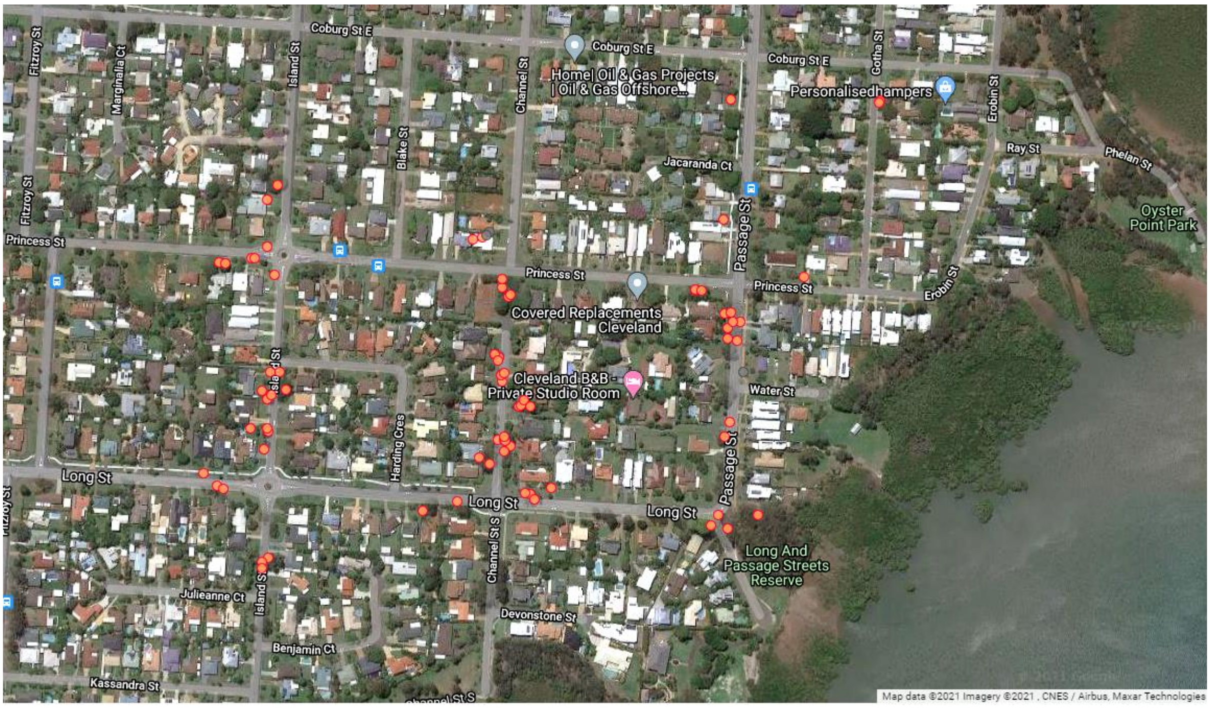

Figure 5. Benson's May 2021 GPS locations (orange dots) are shown on his satellite tracker's online user portal (Lightbug).

Figure 6. Benson spends considerable time on Chanel St where there are a number of large koala food trees.

A ‘translocation effect’ was also observed for some released koalas - we observed dispersal from point of release of some of the Minjerribah koalas released at Mount Cotton. Only one (Thelma) of the four koalas still monitored stayed within the vicinity of the release location. All other Minjerribah koalas have shown exploratory movements and dispersal to adjacent areas as they adjust to a new environment. This has expanded the koala’s use of habitat and home range. For example, Larissa, a translocated koala, quickly left her release site and dispersed over a kilometre and half to the south. She now resides in a small area of approximately 1 ha in size, in comparison to an area of 53 ha, encompassing the entire area of her range since release.

3.3 Fate of project koalas

Of the total koalas admitted to hospital for treatment after being caught and detected with disease, 38% were successfully treated and could be collared prior to release. Koalas with a grave prognosis for recovery were euthanised on humane grounds. Chlamydia-related disease was by far the leading cause of mortality of monitored koalas (Figure 7), accounting for 78.6% of deaths. Other causes of mortality included trauma from train strike and trauma inflicted by domestic dog. There have been no vehicle collisions with monitored koalas to date. While the fate is unknown for koalas with dropped collars, it is likely the public reporting system and council's Redlands Wildlife Network would be notified of ex-project koala incidents if they were made aware of such occurrence.

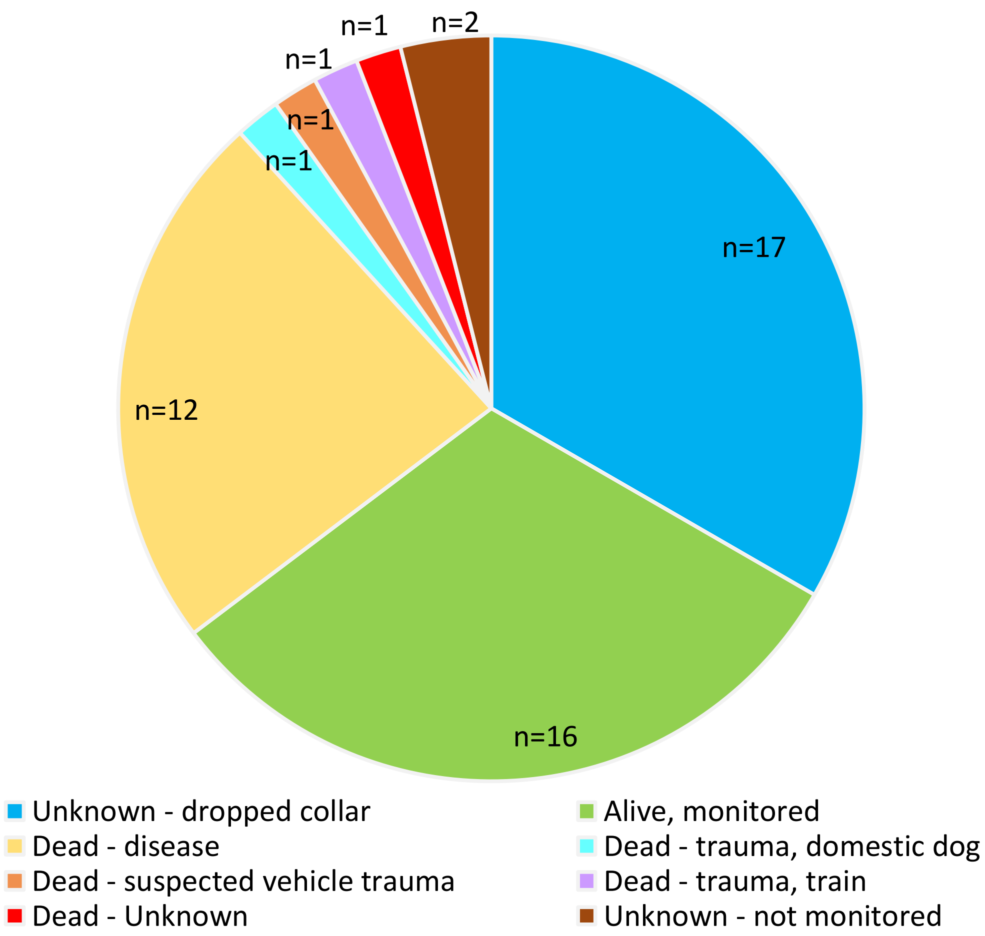

Figure 7. Current status of koalas recruited to the Koala Safe Neighbourhood program (up to May 2021).

Anthropogenic-related mortality from domestic dogs, vehicles and misadventure is common-place, yet was not seen in this project until this year when Slinky (who had dropped his collar) was found moribund on the ground by a member of the public and rescued by the Redlands Afterhours Wildlife Ambulance. His extremely poor prognosis resulted in his euthanasia and a necropsy conducted at AZWH definitively identified trauma from dog attack. Wonky also succumbed to a debilitating facial injury that is suspected to have been caused by a vehicle strike – he was euthanised on welfare grounds given his poor prognosis for recovery.

3.4 Community engagement

3.4.1 Bluetooth devices

The Bluetooth ear tag has been continuously improved through the project based on ongoing field testing (Table 4). Initially, the mean detection range was 5 m (*SD* = 13 m) measured from the device receiving the signal to the base of the tree where the monitored koala was located. Since the 25th August 2020, all captured koalas have received the new Bluetooth device and the results increased to 31 ± 13 m detection range. New versions of the Bluetooth ear tag, with the added antenna located within a mould shape to improve durability, were deployed in April 2021 (Figure 8). Testing and refinement of Bluetooth ear tags will continue.

Figure 8. Louise, Mount Cotton, with a range of monitoring devices including a solar charging Bluetooth ear tag in her right ear.

Table 4: Bluetooth ear tag evolution through the project

Version	Number of field deployment	Specifications/Issues	Tested in the field
V1 = unmodified circuit board chip antenna; glued to ear tag	18	● insufficient transmission range ● detaching from ear tag	deployed from 17/04/2019
V2 = white (insulated copper wire) external whip antenna; slide-lock moulded and glued to ear tag	9	● excellent transmission range ● remaining attached ● antenna breakage (resulting in no/limited transmission range)	deployed from 25/9/2019
V3 = black (plastic coated braided stainless steel) external whip antenna; slide-lock moulded and glued to ear tag	17	● excellent transmission range ● remaining attached ● better durability but still some antenna breakage (resulting in no/limited transmission range)	deployed from 25/08/2020
V4 = internal antenna Drop shape has longer internal antenna compared to round shape, but is slightly heavier, so we are trialling the two designs	9	● still in trial ● potential better antenna durability – but at a cost of range	Deployed from 12/04/2021

3.1 Community Engagement

Community engagement was severely impacted by regulations and restrictions, including gatherings and social distancing, linked to COVID-19, especially in 2020 and beginning of 2021.

However, whenever safe and possible, the Detection Dogs for Conservation team engaged in conversation about koala conservation with members of the public. Brochures of the Redland Wildlife Rescue Service were shared, four citizen-science workshops (virtual and in person), the 2021 Community Fair & Market on World Environmental Day (in person) and one more public event organised by the Redland City Council in 2021 (in person). We have provided the Redland City Council with information, images and videos that were posted in social media (Figure 9).

The team were active in providing RCC with social media content when recruiting and promoting the collared koala ambassadors within each KSN. In addition, the DDC team was approached to promote koala conservation and engagement at the Redlands College, and invited Griffith University's Social Marketing and Behaviour Change research group to participate in delivering a scientifically accurate conservation message through an entertaining media: a virtual character (Figure 9). The team also spent a day filming information videos to be used by Council to promote its koala conservation program.

Bluetooth ear tag details were shared with trusted members of the public (five local koala enthusiasts in Ormiston and the manager of the Karingal Scout Campsite). These are strong supporters of the projects who frequently observe koalas during their walks or in their own backyard.

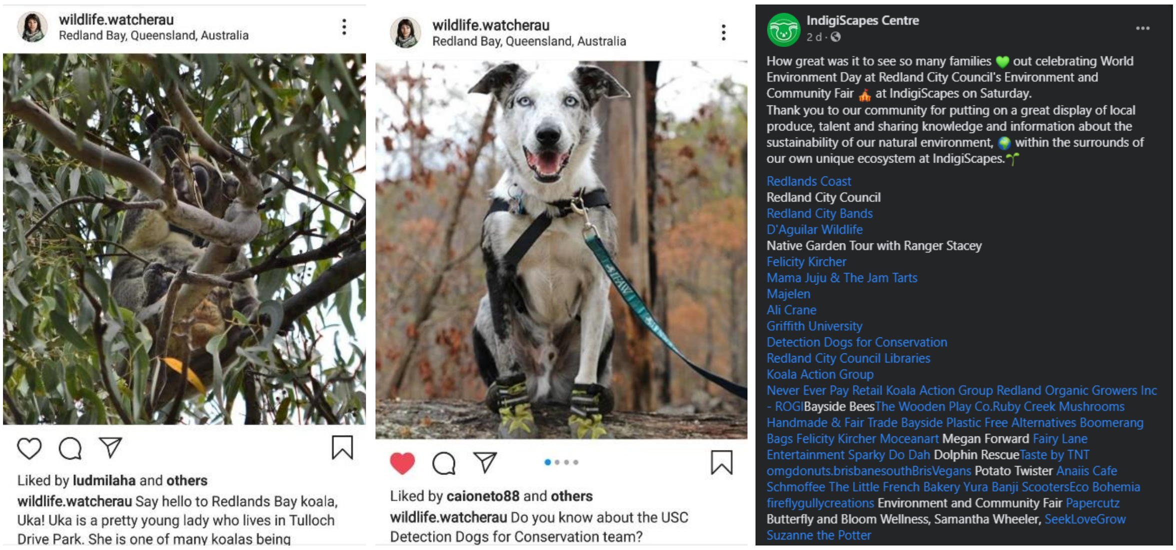

Figure 9. Social media posts of the virtual character including information provided by the Detection Dogs for Conservation (two figures on the left) and participation in event (Instagram, @wildlife.watcherau on the 16th and 11th May and https://www.facebook.com/IndigiScapes on 9th June of 2021).

4. Project Progress Discussion

The Koala Safe Neighbourhood program has recruited 51 ambassador koalas to date. A portion of these koalas continue to be monitored in the four neighbourhoods of Ormiston, Thornlands, Birkdale and Mount Cotton to gather current baseline data to better understand koala population distribution, abundance and dynamics, habitat utilisation to inform koala strategies and management plans. A key component of the program is community education, and the empowerment of residents and citizen scientists in the KSN to better protect and conserve their local koalas.

Koala populations in the Koala Safe Neighbourhoods

Koalas, or signs of their presence continue to be detected throughout the KSN during intensive search and capture or monitoring field work. However, some areas such as Ormiston and Thornlands tend to have higher densities of koalas, and based on historical (Dique et al. 2004) and current (KoalaBase records) data, these suburbs continue to be a stronghold for koalas in urban areas of the Redlands. State government koala hospitals data identify these coastal areas as having the largest proportion of public reports for sick, injured, orphaned and dead koala. While there is no guaranteed correlation between numbers of incidental reports and actual population numbers (due to some biases, e.g. higher reporting in urban areas), it is usually an accurate index of abundance (de Villiers 2015) and the data from this program supports there being larger populations of koalas in these suburbs.

Populations of koalas in residential areas are not often considered a priority for conservation by the State and Federal Governments (see EPBC Act 1999 and SEQ Koala Conservation Strategy 2020-2025). The high level of threats from vehicles, domestic dogs, and other ubiquitous anthropogenic influences are a management quandary as they are not easily mitigated. However, there have been very few ambassador koalas that have succumbed to injuries from these sources (e.g. Lulu and joey hit by a train, Benson / Slinky dog attack and Wonky a suspected vehicle strike). Rather, disease has been a significant cause of mortality for the Redland koalas, with nine koalas dying from primarily *Chlamydia*-related disease (Polkinghorne et al. 2013). Female koalas in the region, in particular, have significantly reduced fecundity (de Villiers 2015). This worrying decades-long trend has potentially limited population recruitment over the last 20+ years and is viewed as a large contributor to the decline of the Redlands koala population (de Villiers 2015, Rhodes et al. 2015). However, our three year study shows 58% of females of breeding age caught for this program had dependent young, which is an encouraging result.

The identification and then mitigation of key threats can have significant positive benefits for population recovery (Bayer et al. 2017). The targeted management of threats such as disease and dog attack can reverse an otherwise declining population trajectory and recover the population (Beyer et al. 2017). Council has limited capacity to intensively manage disease; however the informal management of sick koalas through council's Redland's 24hr Wildlife Rescue Service has helped to rescue and rehabilitate sick and injured koalas and return healthy breeding animals back to the wild that may otherwise have limited life expectancies. As discussed, only a small proportion of sick koalas admitted to AZWH for treatment were successfully rehabilitated. The remainder were euthanised at their initial exam due to severity of disease or euthanised during treatment due to a poor response to treatment or long-term prognosis and limited treatment options. In 2020, approximately 29% of sick koalas from the Redlands admitted to wildlife hospitals were successfully rehabilitated and released (SEQ Koala Hospitals Database). The earlier these animals are caught and treated, the higher the chances of recovery: this makes the citizen science part of the KSN program critical. The development of Chlamydia and Koala Retrovirus (KoRV) vaccines are ongoing bodies of work for multiple research institutions, and trials have and continue to be conducted to determine the efficacy of treatments and vaccines (Phillips et al. 2020; Polkinghorne et al. 2012), but these vaccines are a long way away from being able to reduce the incidence of disease in the Redlands.

As mentioned previously, there is some degree of bias to the recruitment/catching of koalas near roadsides, as these activities provide significant risk to both koala and personnel. However, many of the monitored koalas frequently cross suburban streets as part of their daily movements. Recently installed signage may have improved the road safety in these areas and contributed to reduced vehicle-related mortality. The highest speed road in a KSN is Mount Cotton Road, which bisects the Mount Cotton KSN and is a known koala hot spot for koala/vehicle collisions. Recent genetic results demonstrated the impact this road is having on gene flow in the population – genetic differentiation is becoming more pronounced between koala populations north and south of this major arterial road (see RCC / USC genetic monitoring report). Road mortality, particularly of healthy ‘future breeder’ dispersing sub-adult koalas only further exacerbates the population decline and genetic movement in the population.

Koala habitat utilisation

The large home ranges observed in the monitored koalas this year is in large part due to koalas’ release circumstances. Benson, with the largest home range of 101 ha, was released after being rehabilitated at the AZWH for five weeks for peritonitis associated with domestic dog or vehicle trauma sustain prior to joining the KSN program (he originated from Cleveland). Based on these findings, he was released into more secure bushland in the Thornlands KSN, over 3 km from his point of origin. However, almost immediately after release, Benson quickly dispersed over 2 km in a northward direction. This is one of the few koala movements that has resulted in an animal moving from a relatively secure bushland area to reside wholly in a residential area. He currently ranges in suburban Cleveland, using patches of street trees for food and a combination of native and exotic trees for shelter. His daily movements demonstrate the importance of the retention of street trees on footpaths and wide road reserves for connectivity and habitat for resident and dispersing koalas (Goldingay and Dobner, 2014).

Another cohort with larger than usual home ranges are the translocated Minjerribah koalas. Not surprisingly, many of the translocated koalas dispersed from their point of release, thus ranging over a large area. Once a stable home range is established, home range sizes will be more in line with those typical in this region (de Oliveira et al. 2014; Thompson, 2016). These koalas were in care for an extended period of time, being fed a diet of south-western browse species. These koalas have overcome three potential translocation issues: 1. A sudden change in diet; 2. A foreign environment with potentially novel threats; and 3. Intraspecific interactions – all which can affect the success of a translocation event (e.g. Blyton et al. 2019).

Dispersal behaviour provides a unique insight into fine scale habitat utilisation and movement paths of koalas. Male koalas, in particular, are highly likely to seek new habitat areas and mating opportunities in the upcoming breeding season (Dique et al. 2003). Koalas in this region have been recorded dispersing up to 14 km, traversing a range of habitats. Dispersal into and through foreign environment can expose koalas to multiple threats and, as such, the mortality rate from domestic dog and vehicle-related trauma in this cohort is exacerbated by on-ground movements through residential areas and across roads (Dexter et al. 2017; Gonzalez-Astudillo, 2019).

Community engagement

The use of the Bluetooth device has shown positive results and the future progress to a more robust and user-friendly platform will depend on the ability to secure funding for mass production and development of a public smartphone App. Nonetheless, this is a strategy worth pursuing: the interaction between research organisations, decision making institutions (Redland City Council) and the general public has been pointed out as an effective conservation tool (Cooper et al. 2007). The continuation of use of social media by the DDC team at USC, Griffith University and Redland City Council, as a means to boost public awareness, especially in times when social isolation, is recommended. Relevant information about the ongoing koala project was provided to social marketing experts and conservation managers who shared it to the public using more palatable communication means than scientific papers. The use of electronic platforms to encourage environmental-friendly behaviour has been extensively studied (Di Minin et al. 2015; Toivonen et al. 2019) and recommended to strength public awareness of biological conservation (Wu et al. 2018).

Future steps and management considerations

The following recommendations are based on the sample of data collected to date relating to koala population distribution, abundance, population dynamics, movements, habitat utilisation and threatening processes. While these recommendations broadly outline strategies to protect and recover the Redlands koala population, realistically, council cannot action these items in isolation – rather, they will require collaborations with state government, research institutions and community stakeholders to successfully implement these strategies.

1. Disease mitigation strategies to reduce the prevalence of disease in the population as disease continues to significantly impact on the health and fecundity of the population. Strategies to protect Redlands should include:
    a. The continuation of the public-driven Redlands 24hr Wildlife Rescue Service to ensure early detection of sick and injured koalas to improve the success of treatment and rehabilitation and release back to the wild to bolster the population;
    b. Collaborations with research institutions to better understand disease aetiology;

2. Domestic dog control must include compliance activities to ensure dogs remain on-leash, particularly where there is a known koala presence. Domestic dog attacks are arguably the most preventable premature cause of mortality for koalas and can be largely prevented with responsible dog ownership;
3. Revegetation of existing parks and the establishment and enhancement of corridors to facilitate koala/genetic movement of animals across the landscape. Neighbourhood residents can be more actively engaged in the protection and enhancement of habitat in their local area (e.g. bushcare);
4. Expand the Koala Safe Neighbourhoods program to encourage local residents to have an active involvement in the conservation of their local koalas. This program has already seen positive results with the engagement of local community members and is making a positive contribution to koala conservation in the Redlands;
5. Continue to use cutting edge monitoring technology to engage citizen scientists and the local community while gathering comprehensive data to continue to inform council's policies and management strategies.

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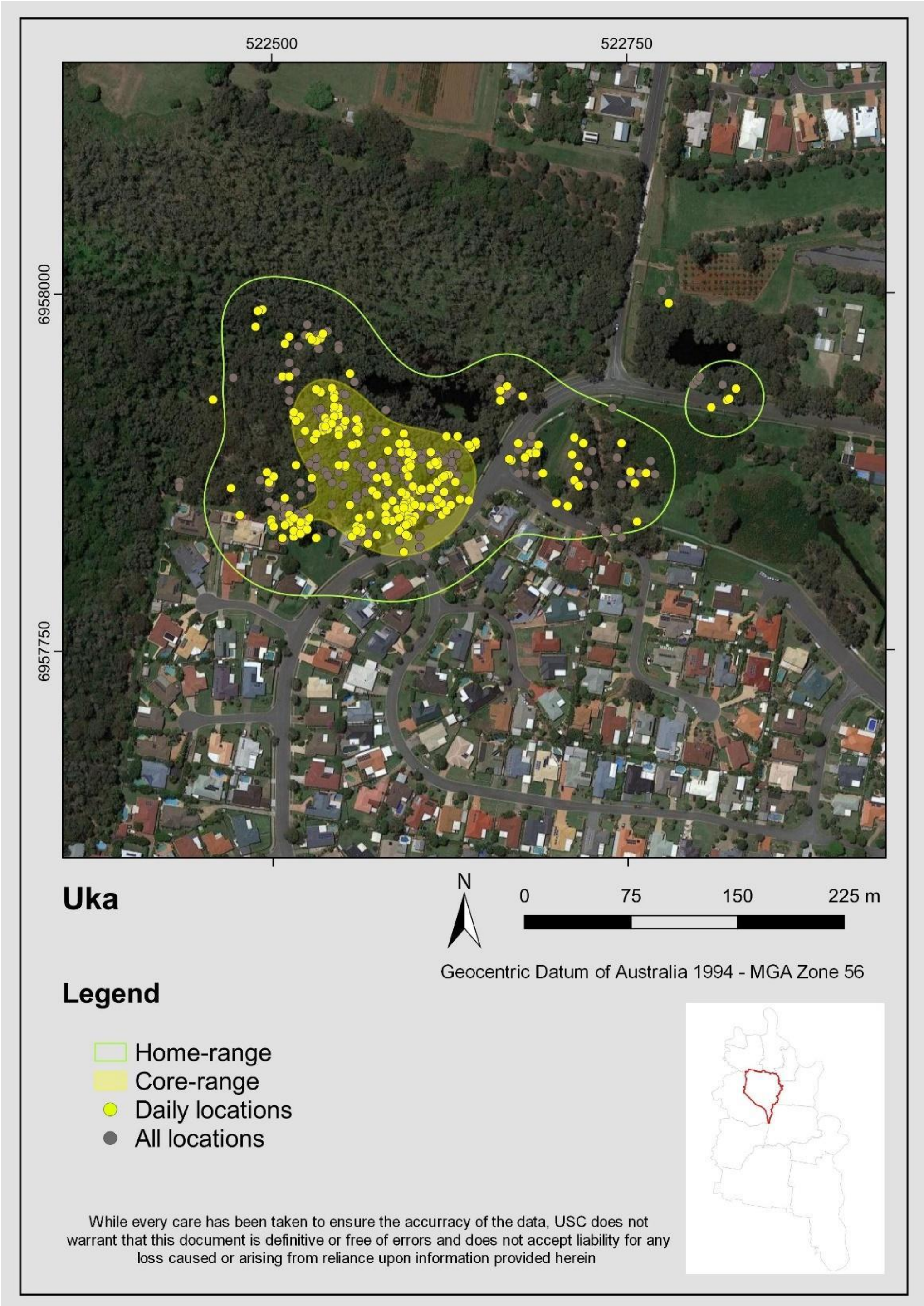
7. Appendices

Appendix 1: AZWH clinical summaries for euthanised koalas

Koala	Reason for hospital admission	Outcome	Clinical notes
Banjora	Unilateral reproductive disease	Treatment, euthanasia 23/9/20	Admitted to AZWH for treatment of chlamydial disease (unilateral reproductive disease). While undergoing treatment, she developed renal disease/oxalate nephrosis and was euthanased three weeks into treatment. Euthanased on grounds of poor prognosis.
Cariad	Bilateral reproductive disease	Euthanasia, 4/9/20	Hospitalised at EVE overnight prior to referral to AZWH for assessment and possible treatment of bilateral reproductive disease (bursal cysts). Cariad euthanased as she was considered to be a poor candidate for ovariohysterectomy (OHE) surgery.
Daisy	Aleukaemic leukaemia	Euthanasia	Admitted to EVE for possible treatment or euthanasia. Aleukaemic leukaemia. Bone marrow aspirate: highly cellular sample dominated by neoplastic blast cells. Blood smear: marked leucopaenia with no neutrophils seen on slide. Moderate to marked anisocytosis of lymphocytes. Fair to poor body condition (BCS 5). Euthanased due to grave prognosis associated with leukaemia. Splenomegaly: Spleen diffusely pale. Patches of pallor on surface of both kidneys, left worse than right. Approx. 9-10 month old, male joey "Sir Derek" (BCS 7, 1.44kg) – microchipped and placed in foster care.
Summer	Cystitis	Euthanasia, 10/12/20	Summer was noted by field personnel showing overt signs of disease (cystitis), noted with a very wet rump. She was caught for treatment and admitted to AZWH. Diagnosed with cystitis and reproductive tract disease (bursal cysts). Euthanased due to grave prognosis.
Slinky	Trauma – domestic dog	Euthanasia, 6/2/21	Slinky was reported by a member of the public sitting at the base of a tree and was rescued by the Redlands Afterhours Wildlife Ambulance. The RAWA rescuer noted an old injury to his rump and that he was in a poor state, with flies hanging around him. He was taken to

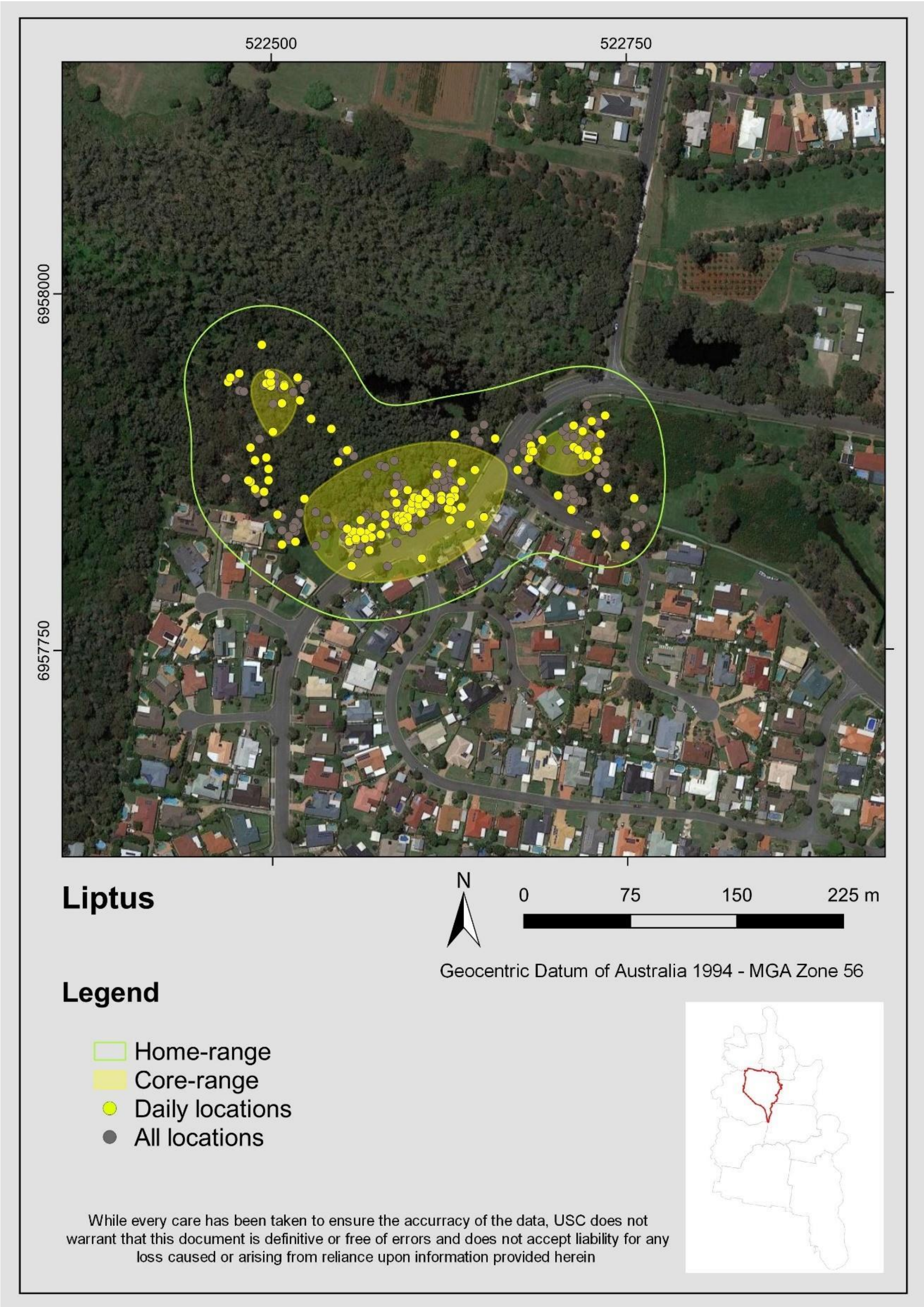
			Manly Rd 24hr veterinary hospital where he was assessed and euthanased. RAWA records indicate he had a 'research' ear tag (he had dropped his collar in Dec 2020). His body was retrieved a few weeks later and taken to AZWH for necropsy. Necropsy findings: penetrating wound through chest, punctures to caecum, stomach empty - likely attacked by domestic dog a few days to 1 week prior to being found on the ground. Lungs normal (had not had a recurrence of cryptococcal pneumonia).
Wonky	Trauma – facial wound	Euthanasia, 13/4/21	Assessment: Distended abdomen - haemoabdomen and gas in large intestine; Wound on mandible and suspected associated osteomyelitits and tooth root abscess; Emaciated body condition (BCS 3) and mild dehydration; Facial asymmetry and fractured lower incisors (pre-existing). Suspect that he has not been able to eat comfortably on this side hence the ulceration in his mouth which might explain low BCS. Aerophagia due to oral pain possible cause of gas in abdomen? Plan: admit to AZWH for further treatment but guarded prognosis. Ate poorly overnight in care at AZWH and on assessment under GA vet opted for euthanasia given poor prognosis.
Princess	Bilateral reproductive disease	Euthanasia, 13/4/21	Assessment: Bilateral reproductive disease with huge, palpable bursal cysts visible externally. Ultrasound shows 2 very large multiloculated bursal cysts, with echogenic material present in the right cyst lumen. Poor image of both uteri and bladder (empty?). Fair body condition (BCS 6). Opted for euthanasia due to severity of the reproductive disease and age. Euthanased under GA. Was first treated in 2012 for conjunctivitis and had a joey present so at least 11 years of age. UGT swab tested positive for C. pecorum.
Nugget	Cystitis	Euthanasia, 13/4/21	Caught showing overt signs of disease – cystitis. Admitted to AZWH for treatment of chlamydial disease. While undergoing treatment, Nugget developed ********* and was euthanased. Euthanased on grounds of poor prognosis.

Appendix 2: Home ranges 50% (core) and 95% KDE

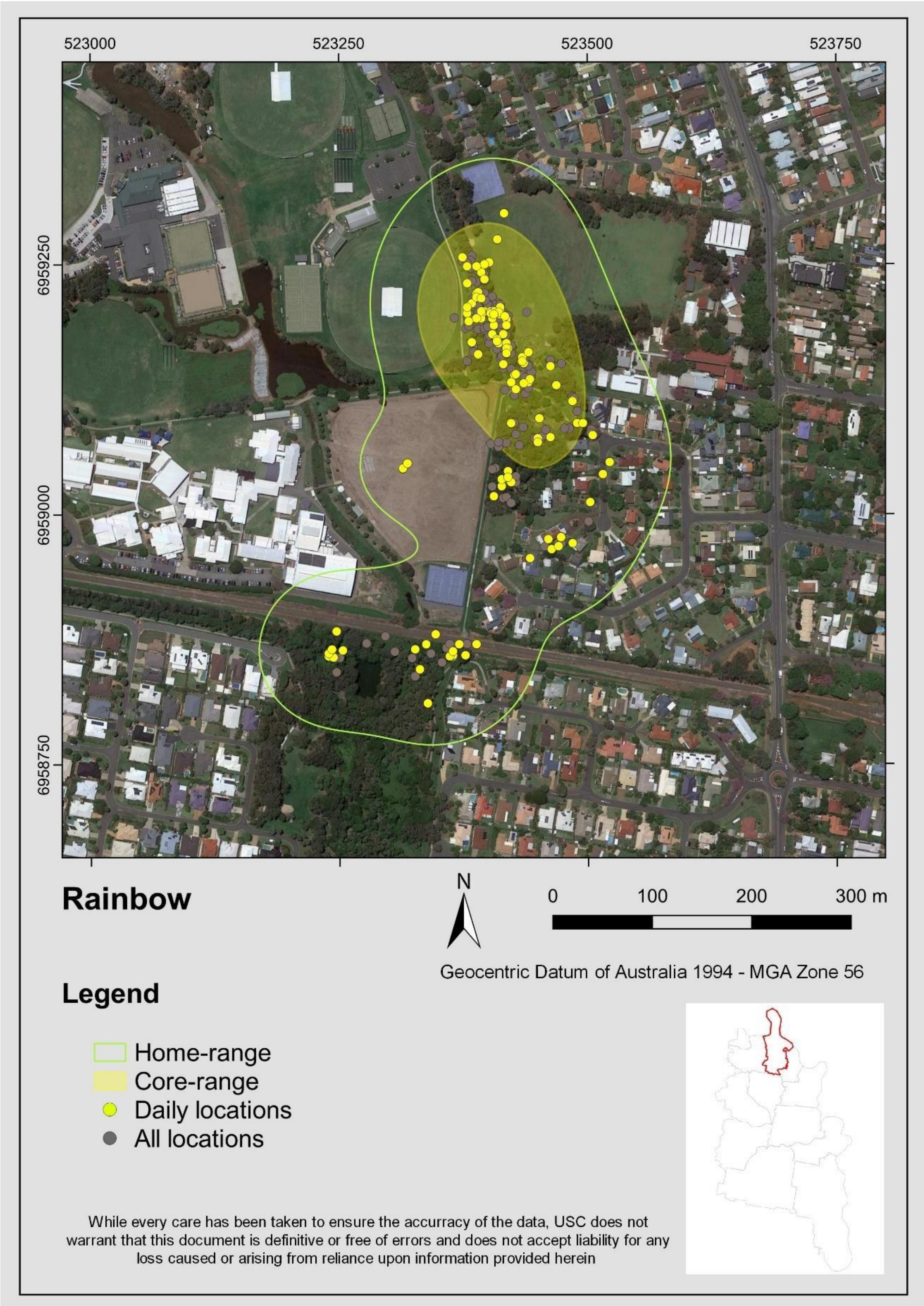


Koala Uka, Birkdale

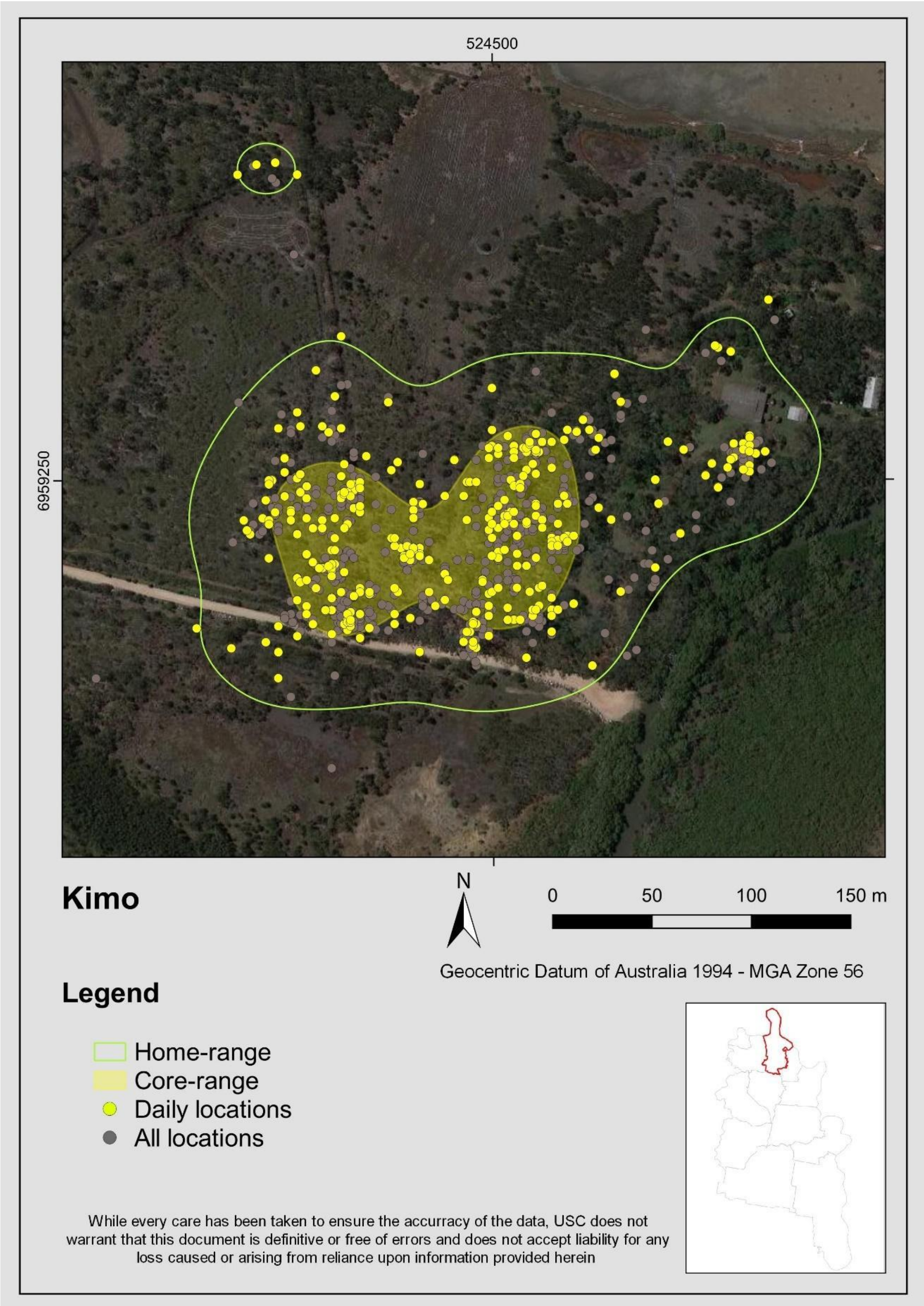
Detection Dogs for Conservation



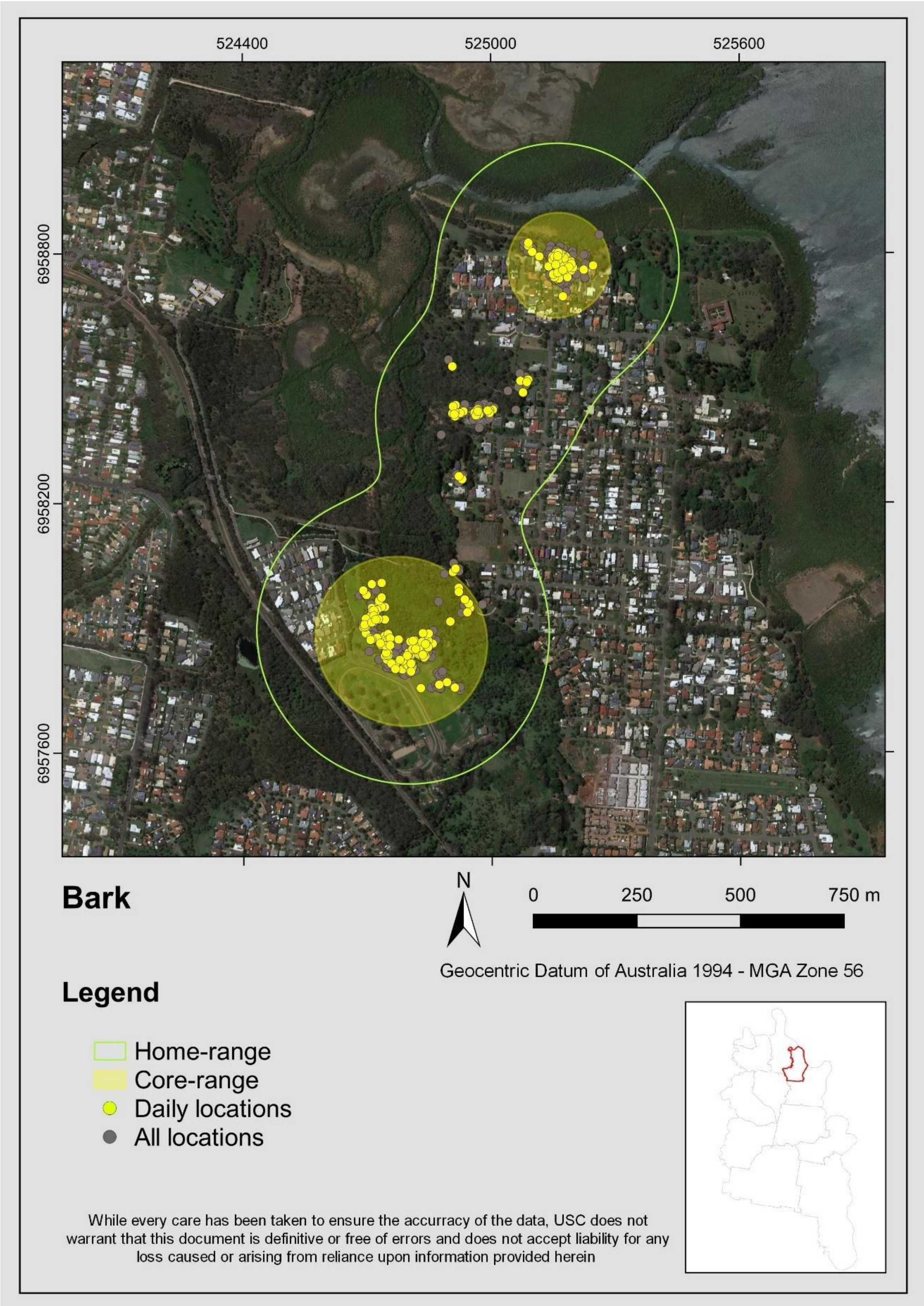
Koala Liptus, Birkdale



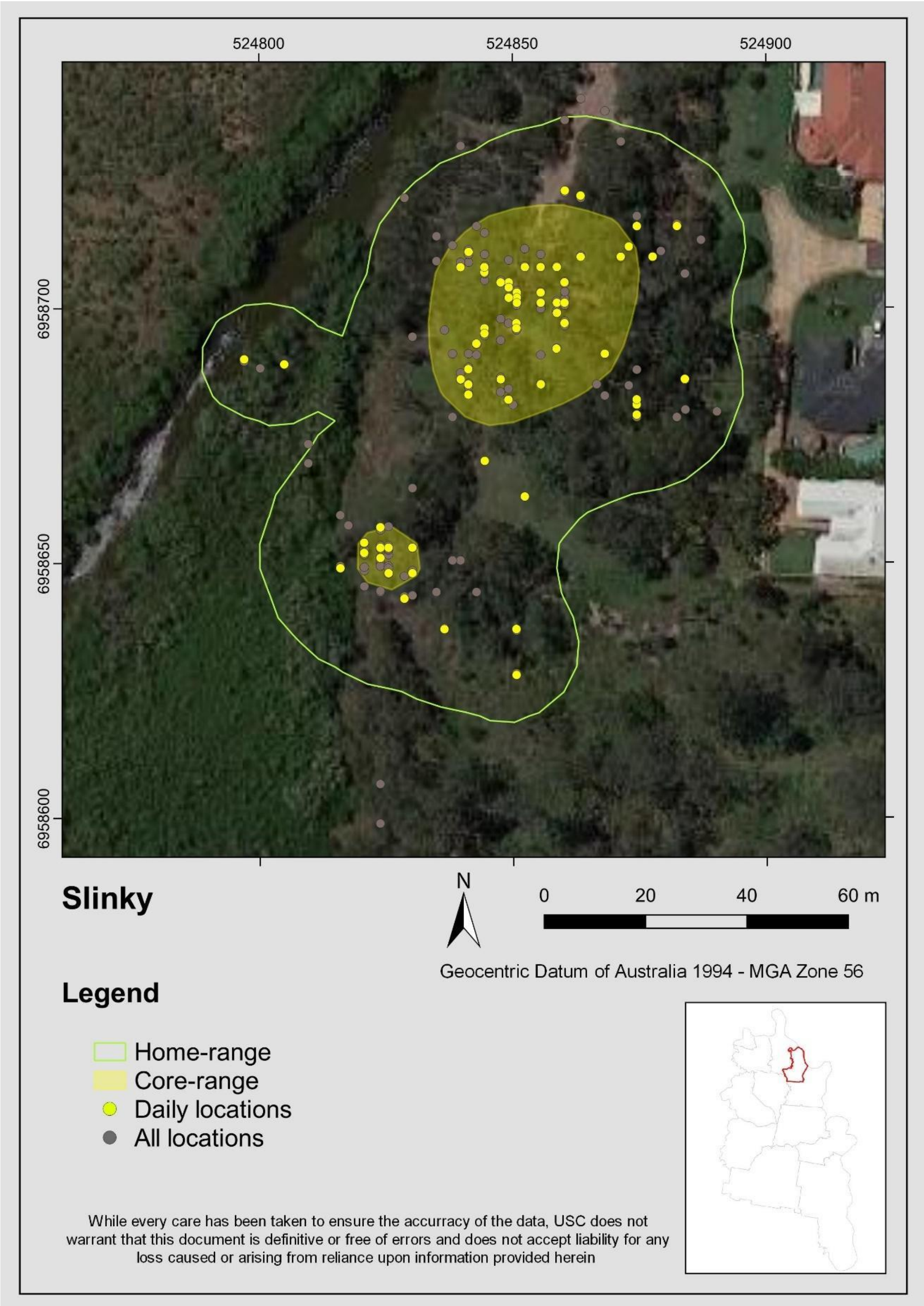
Koala Rainbow, Wellington Pt



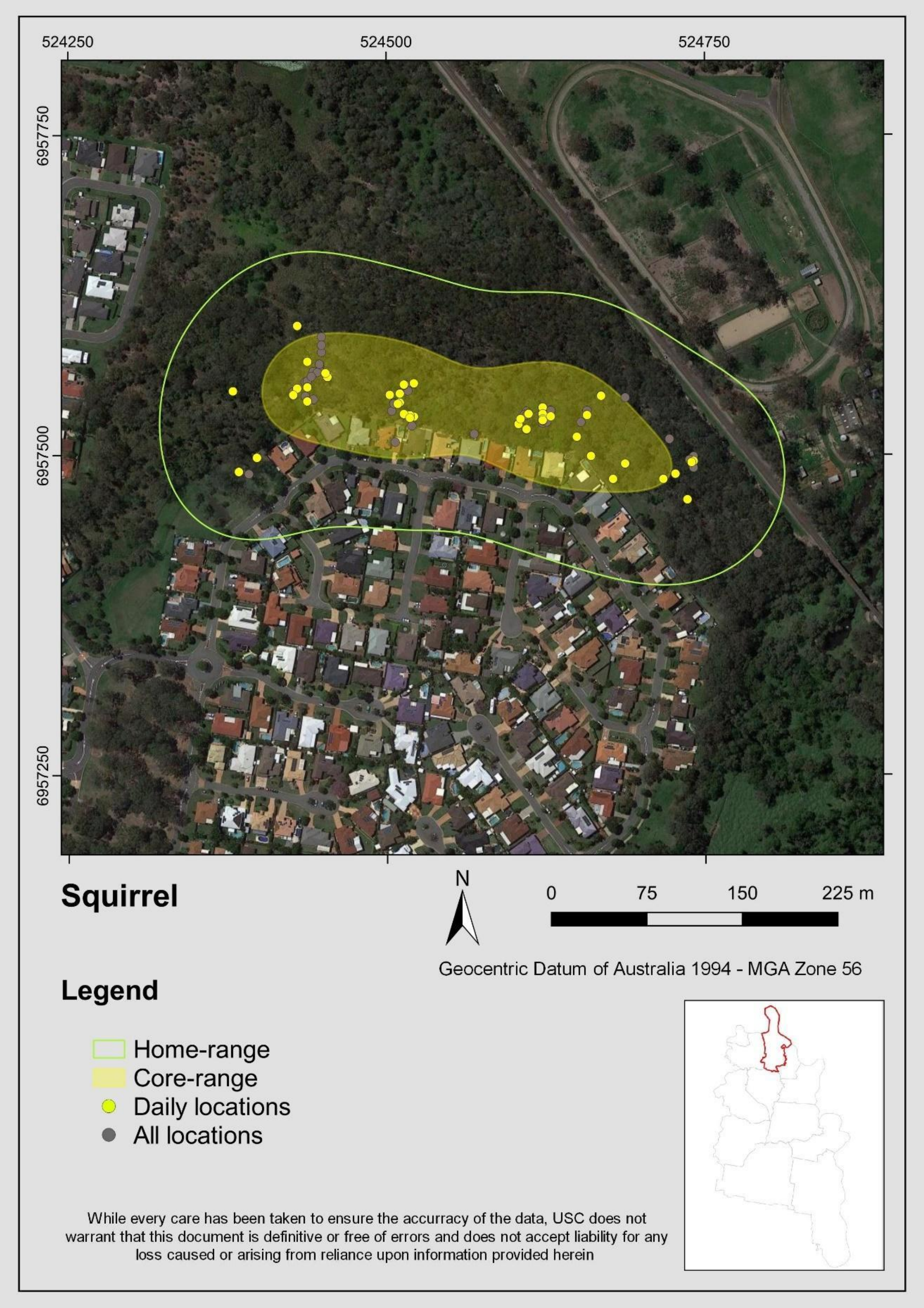
Koala Kimo, Wellington Pt



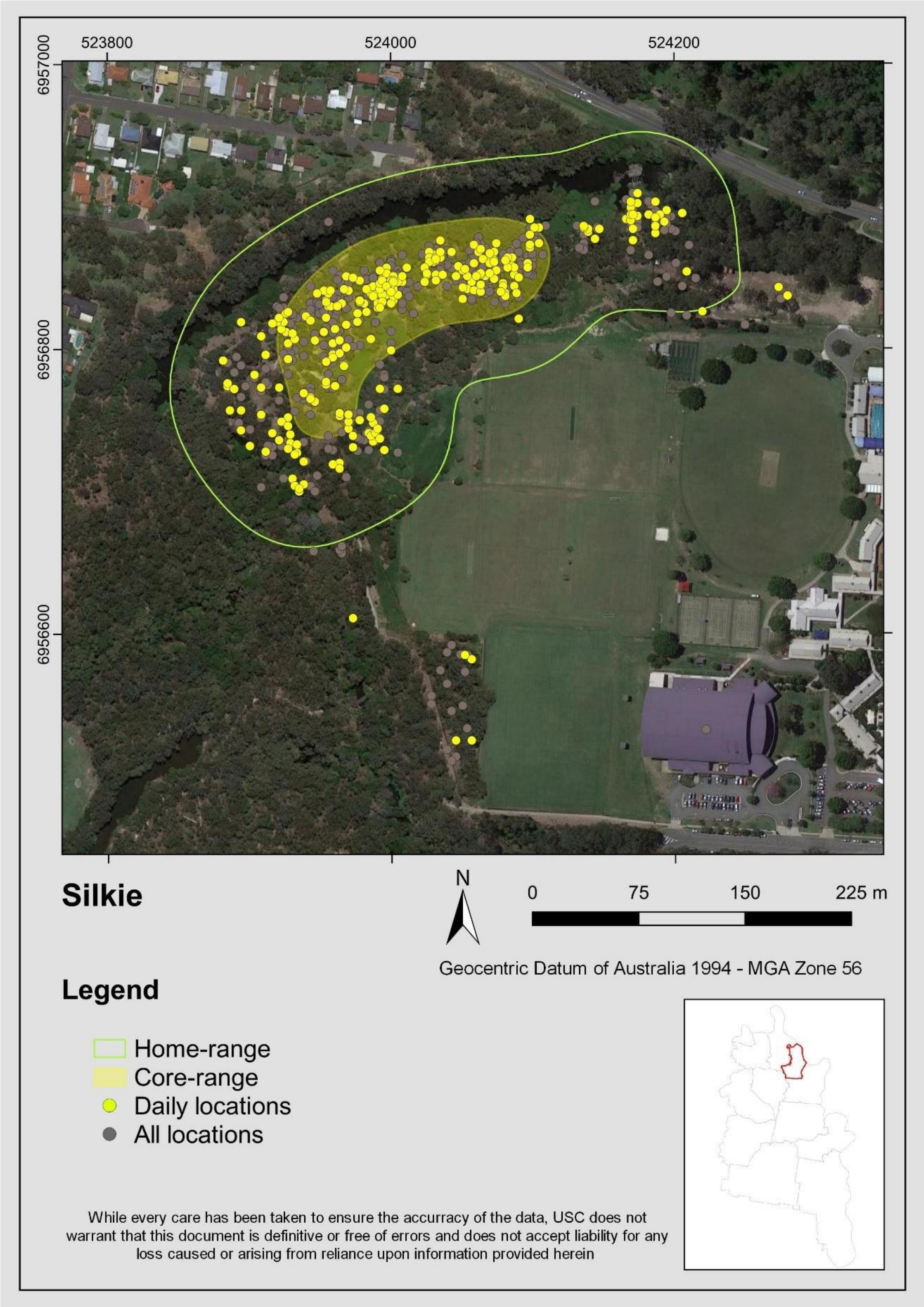
Koalas Bark, Ormiston



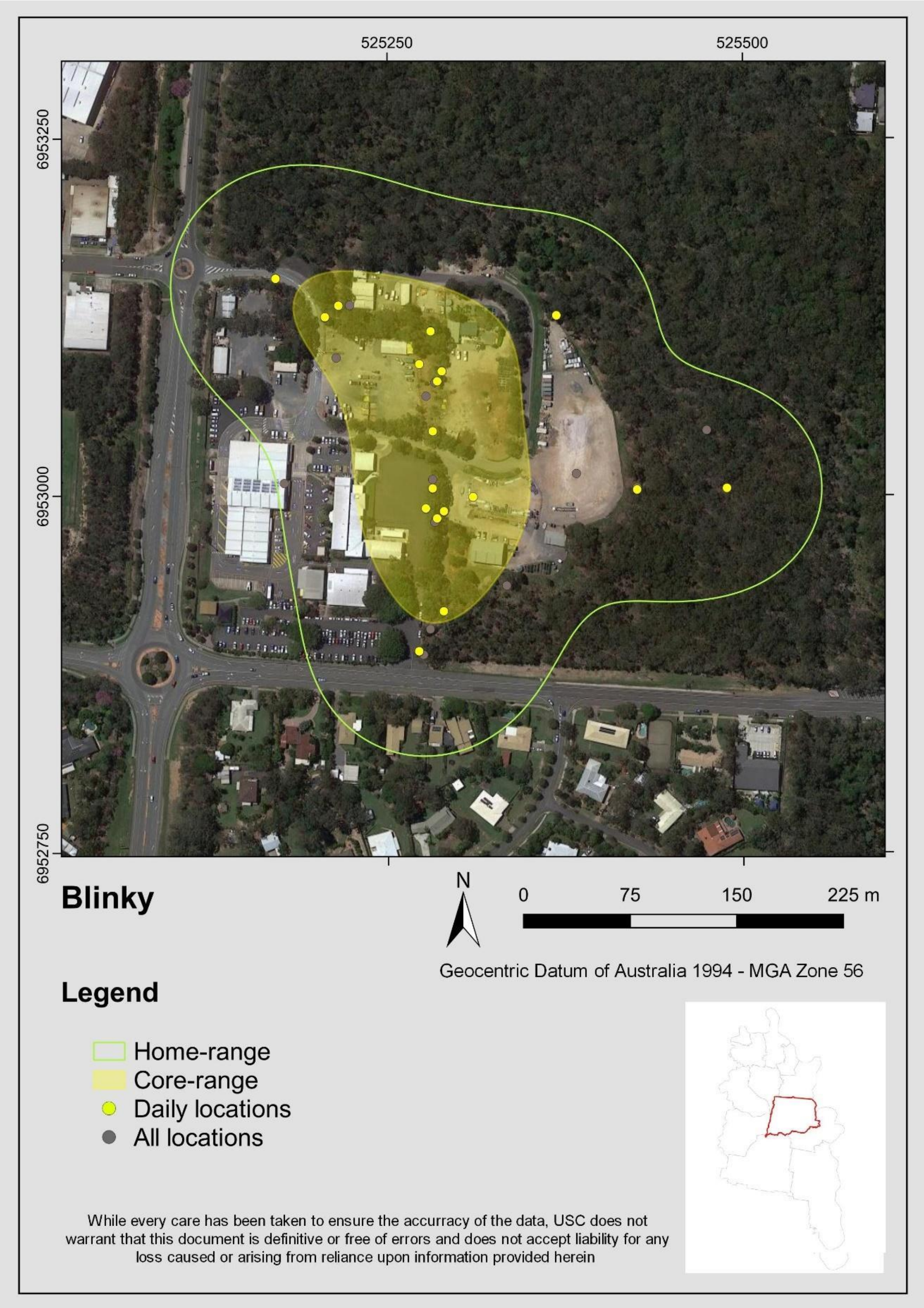
Koalas Bark, Ormiston



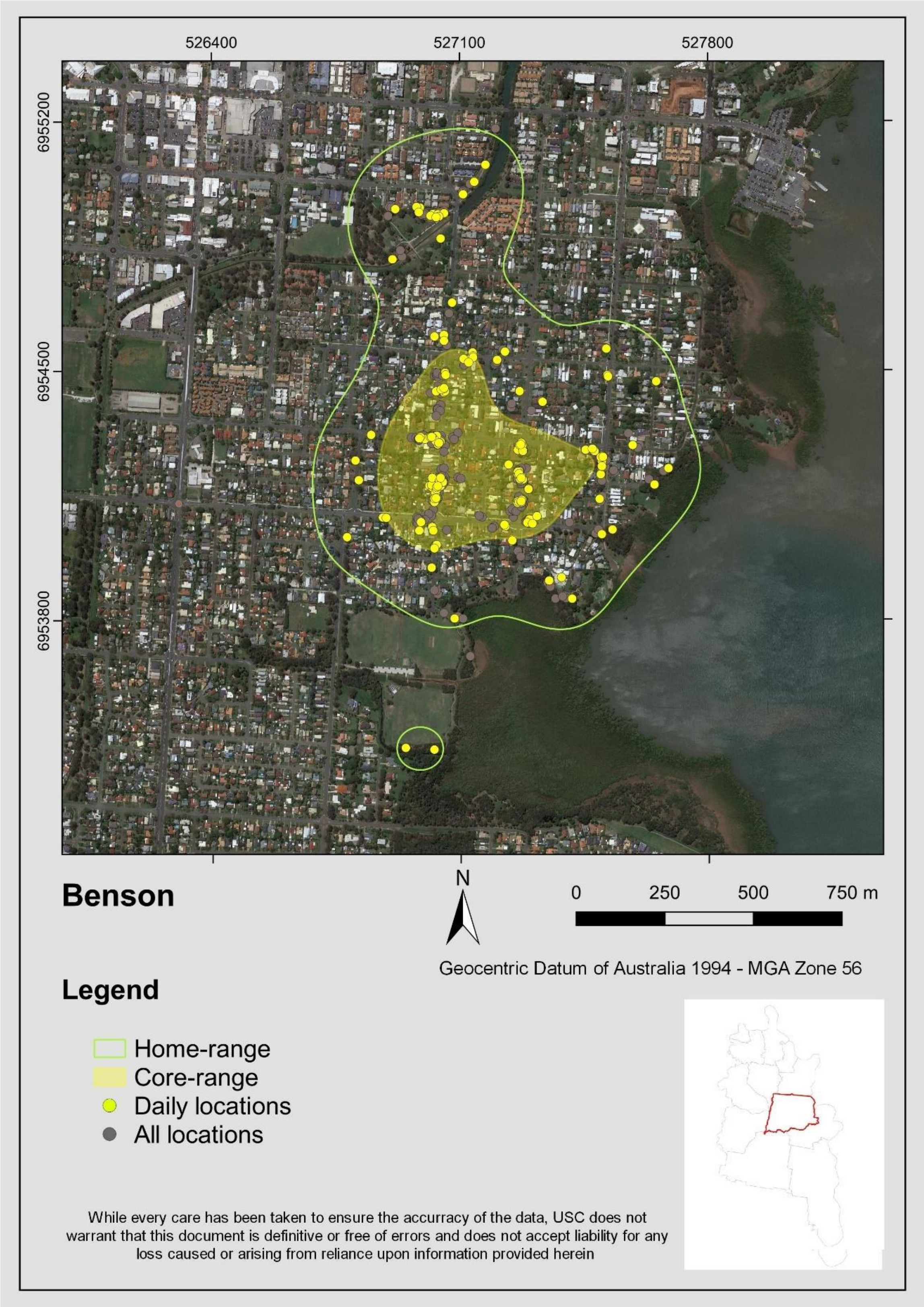
Koala Squirrel, Wellington Pt



Koala Silkie, Ormiston

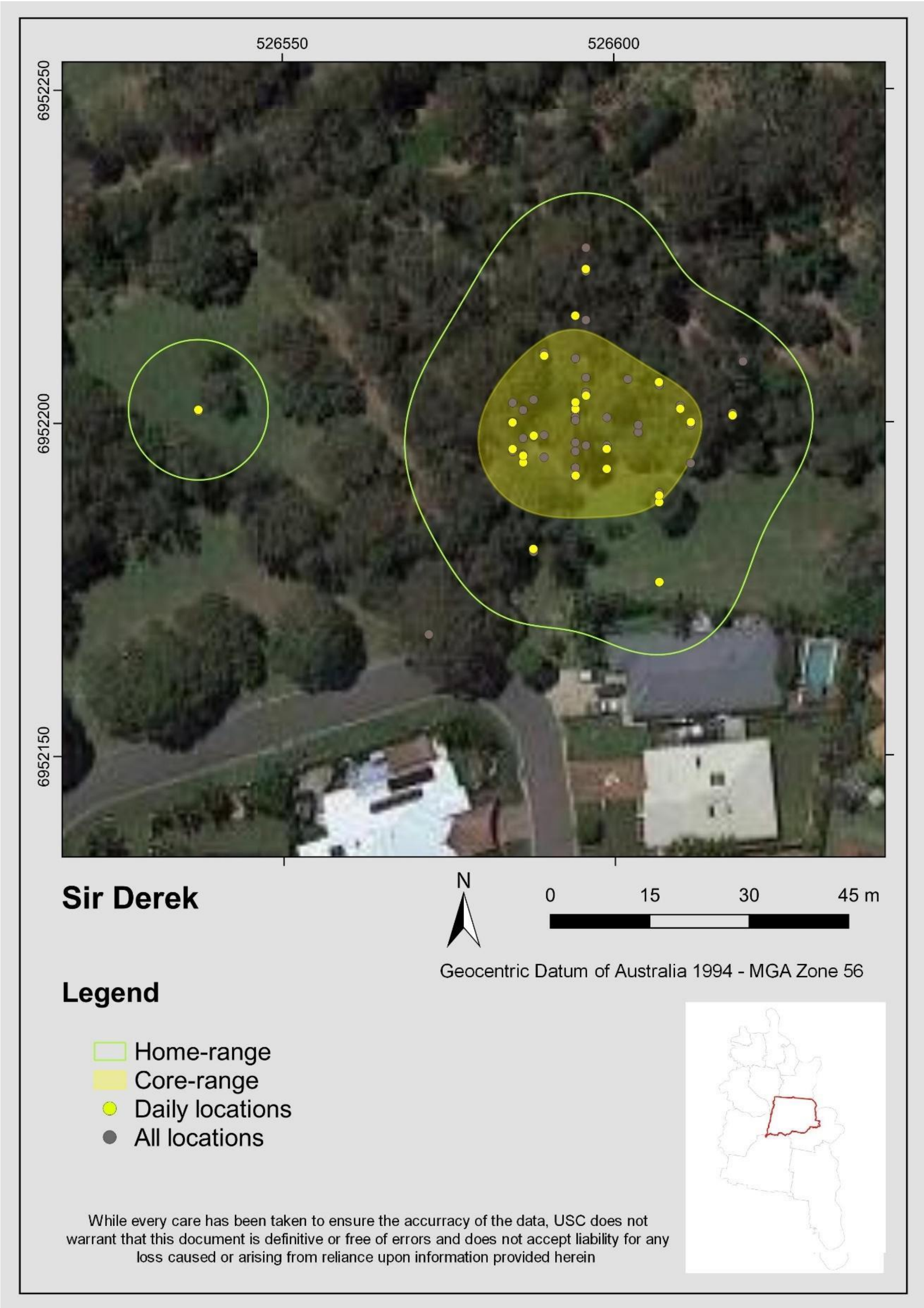


Koala Blinky, Cleveland

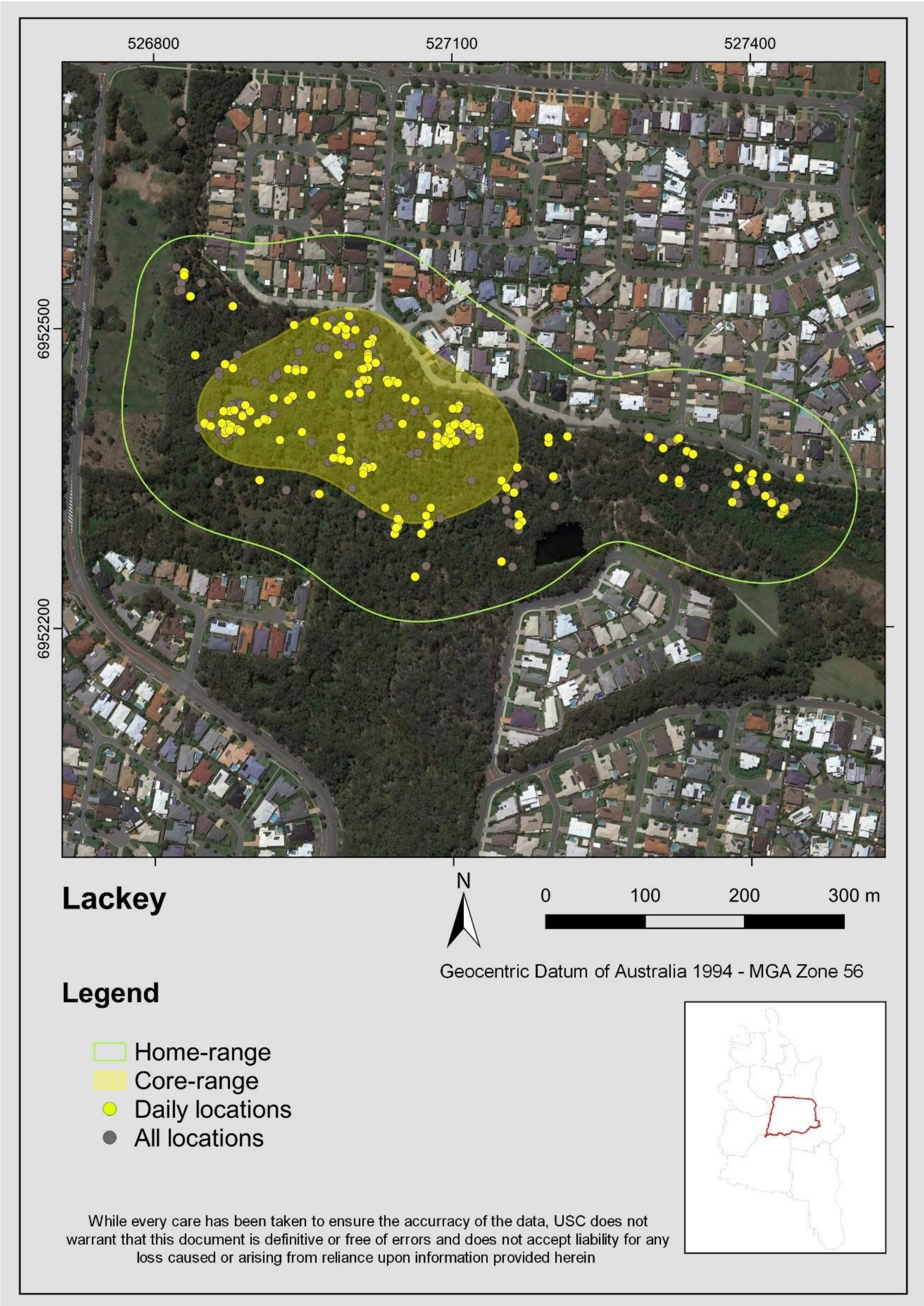


Koala Benson, Cleveland/Thornlands

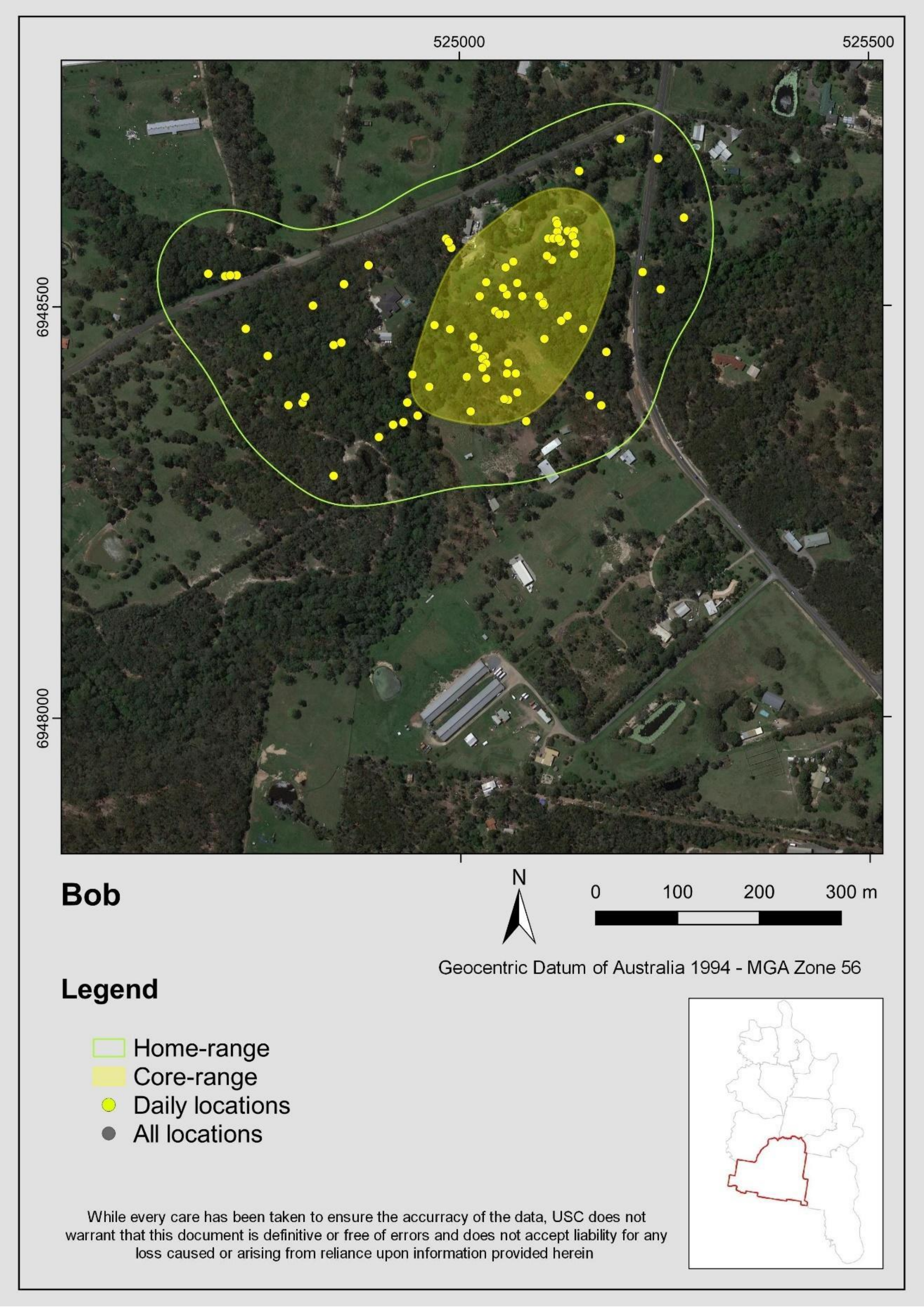
Koala Blake, Thornlands



Koala Sir Derek, Thornlands

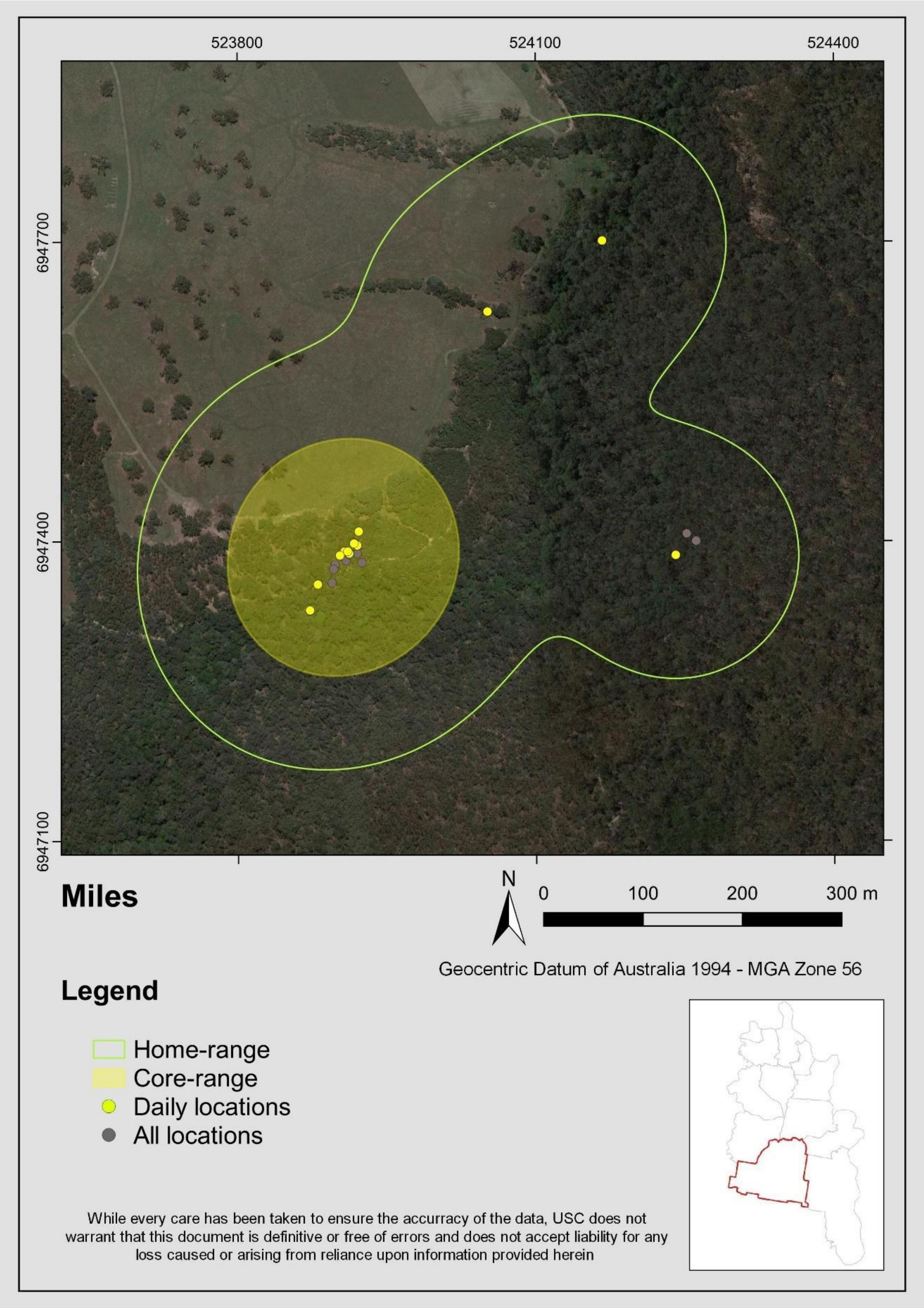


Koala Lackey, Thornlands

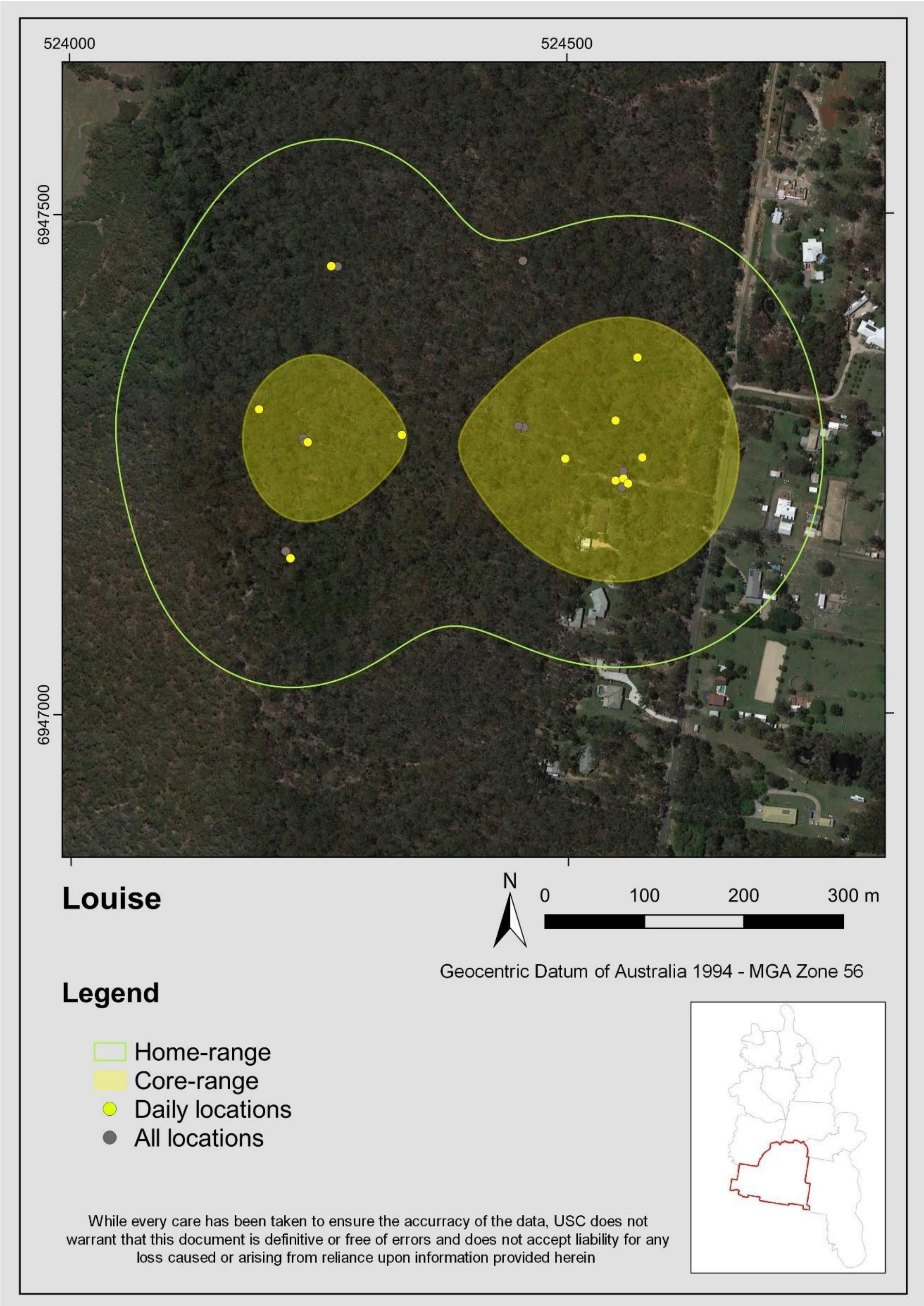


Koala Bob, Thornlands/Mount Cotton

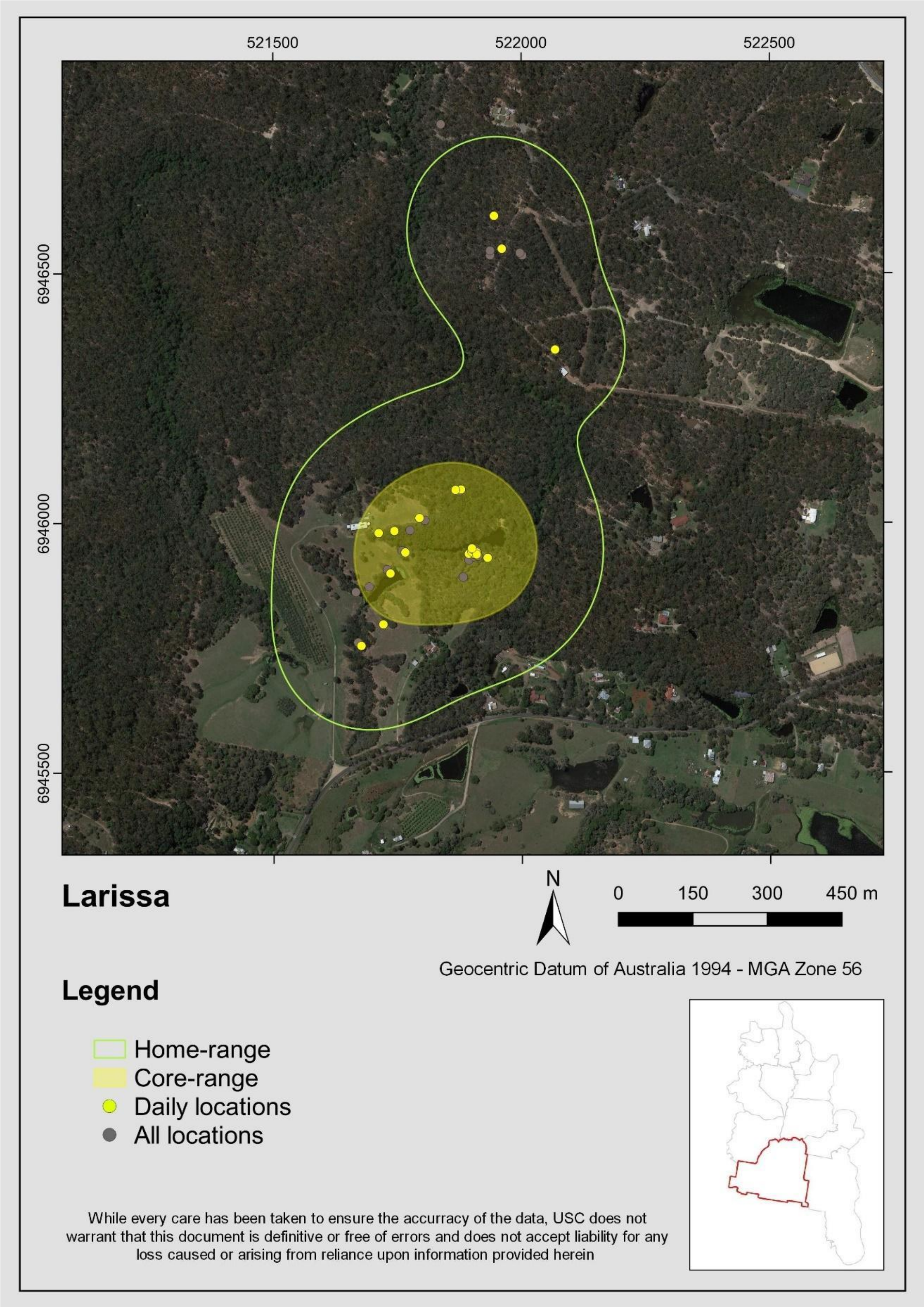
Detection Dogs for Conservation



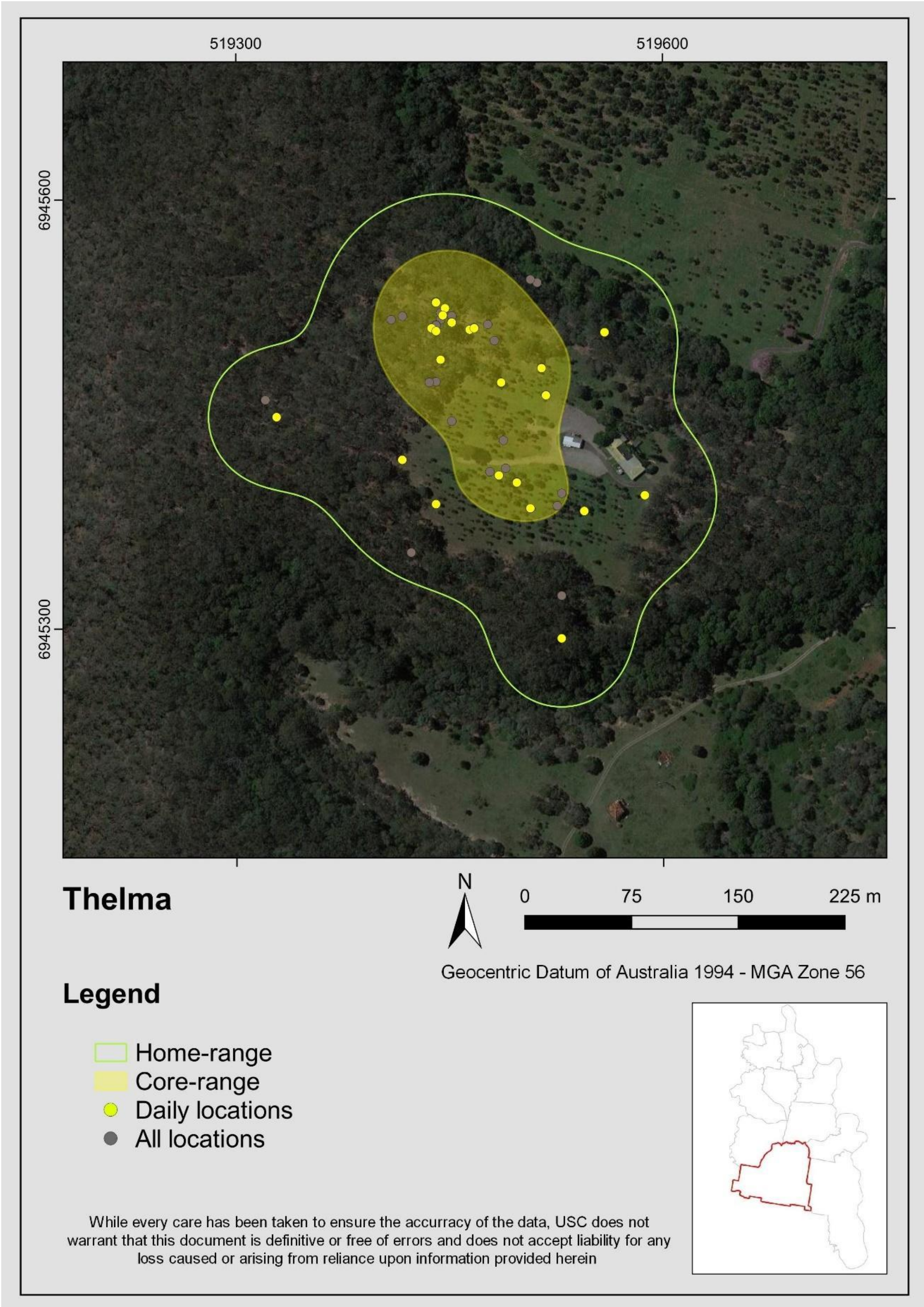
Koala Miles, Mount Cotton



Koala Louise, Mount Cotton



Koala Larissa, Mount Cotton



Koala Thelma, Mount Cotton