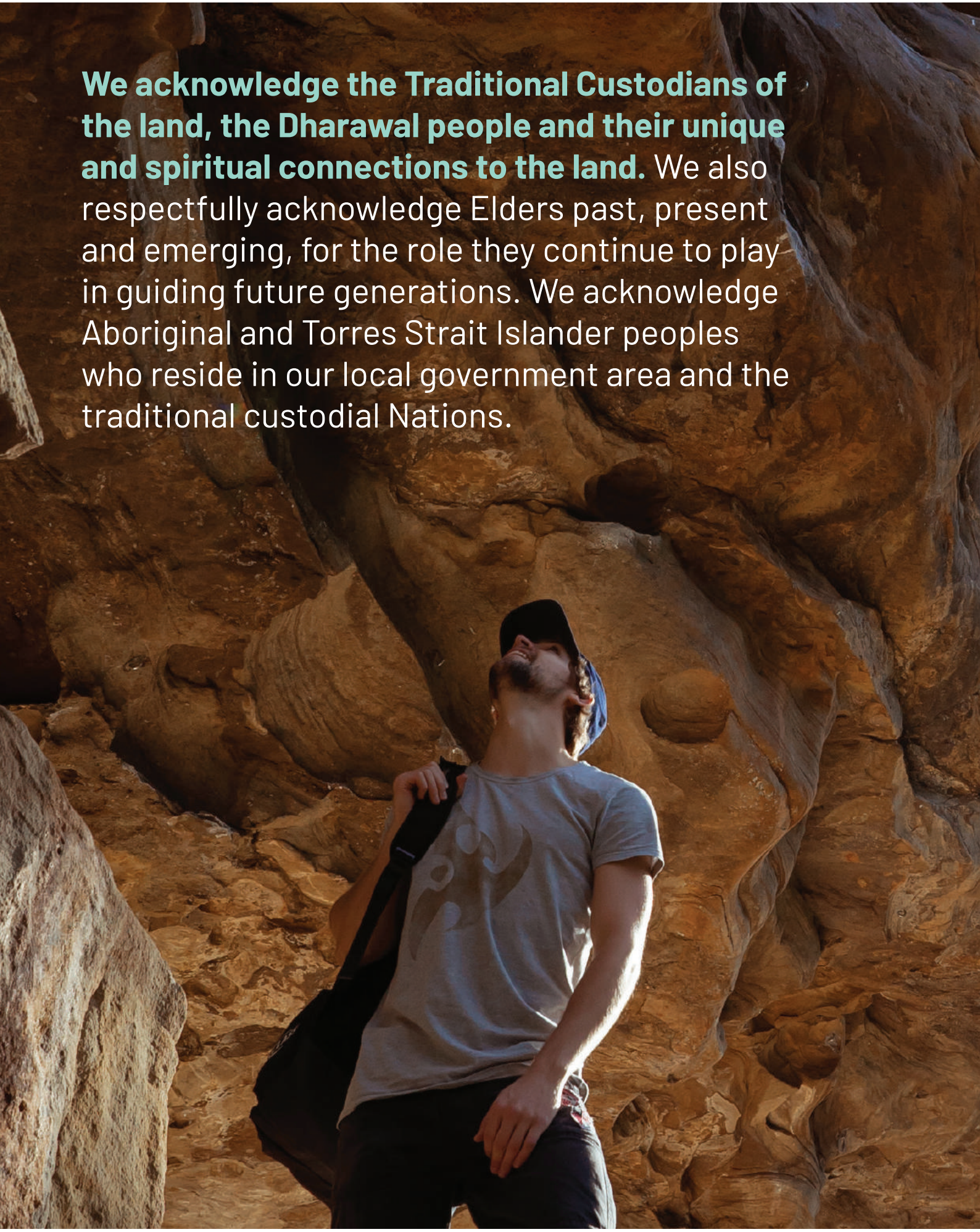
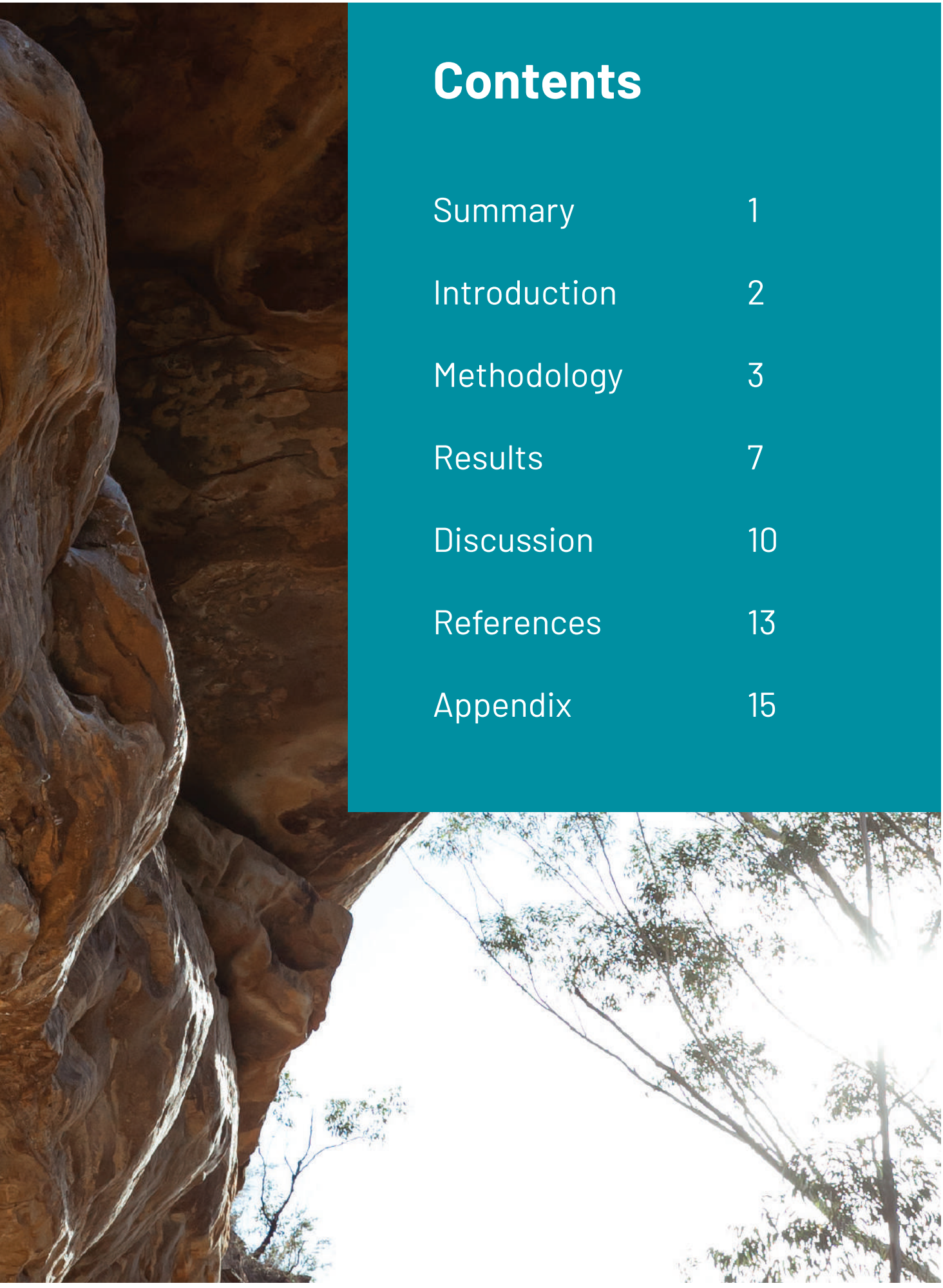
KOALA OCCUPANCY / POPULATION ASSESSMENT

Final Report March 2021

CAMPBELLTOWN



We acknowledge the Traditional Custodians of the land, the Dharawal people and their unique and spiritual connections to the land. We also respectfully acknowledge Elders past, present and emerging, for the role they continue to play in guiding future generations. We acknowledge Aboriginal and Torres Strait Islander peoples who reside in our local government area and the traditional custodial Nations.



Contents

Abbreviations

Abbreviation	Description
AoO	Area of Occupancy
CCC	Campbelltown City Council
CI	Confidence Interval
CKPoM	Comprehensive Koala Plan of Management
CCLGA	Campbelltown City Local Government Area
DBH	Diameter at Breast Height
DPIE	Department of Planning, Industry and Environment
EoO	Extent of Occurrence
GPA	Generational Persistence Assessment
IUCN	International Union for the Conservation of Nature
MCP	Minimum Convex Polygon
PKFTs	Preferred Koala Food Trees
PKH	Preferred Koala Habitat
Rapid-SAT	Rapid Spot Assessment Technique
SAT	Spot Assessment Technique
SD	Standard Deviation
SE	Standard Error

Biolink Pty Ltd and Campbelltown City Council prepared this report with on ground survey undertaken by Council and Biolink Pty Ltd staff.

We would like to thank the many residents and businesses of Campbelltown who provided us with access to their properties to complete the survey.

Summary

Koalas inhabiting the Campbelltown City Council (CCC) Local Government Area (LGA) have long been the focus of scientific and community interest. Available data indicates that the population has undergone a measure of recovery over the last 20 – 30 years.

A 2012 population estimate for the CCC LGA implied a koala population of less than 200 individuals, cautioning against complacency given the vulnerability of the recovering population to a fire event. This report further informs the conservation and management of the Campbelltown koala population with reference to the requirements of the Campbelltown Comprehensive Koala Plan of Management (CKPoM) and the need for development of an effective long-term monitoring strategy for the population.

Section 10.3 of the CKPoM outlines and defines the minimum survey requirements for koalas across the LGA. To this end a grid-based approach was initially used to identify potential sites for field survey, each of which were assessed using the Rapid Spot Assessment Technique (Rapid-SAT). Thirty-one (31) of 63 sampled field sites with Preferred Koala Food Trees (PKFTs) contained evidence of utilisation by koalas in the form of diagnostic faecal pellets. These data enabled a field-based naïve koala occupancy estimate of 49.21% ± 6.35% (SE) of the available habitat, a measure trending upwards but not statistically different from that predicted by earlier (2012) records analysis. Supporting this upward trend, an updated review of koala records further revealed a 27% increase in the Extent of Occurrence (EoO) across the Campbelltown LGA over the past three koala generations (2002 - 2019). Increases in the EoO are evident in the north near the boundary with the Liverpool LGA, and in the south-west of the LGA with koalas now occurring on both sides of Appin Road, as well as the Hume Highway. This increase in the geographic extent of koalas across the Campbelltown LGA informs a revised 2020 koala population estimate of 236 ± 60 (95% CI) individuals, an almost fifty percent increase in population size since 2012.

The baseline data collected by this study provides a robust backdrop against which the longer-term koala population monitoring for the Campbelltown koalas can now be consolidated and advanced. The monitoring grid established by this study can be expanded as required, both in scale and purpose, by collecting additional data at future survey events (e.g., koala activity levels, koala density) subject to available resources and stakeholder interests. Opportunities for citizen science can also be developed for incorporation into a longer-term monitoring strategy; a stakeholder workshop that includes interested community members is recommended as the next step towards consolidation of the monitoring program for the Campbelltown koalas.

Introduction

The conservation of koalas across the Campbelltown City Council Local Government Area (CCC LGA) has long been of interest to the local community. The Campbelltown koala population, now deemed to be recovering from near extinction event ~ 30 years ago, is now the focus of a Comprehensive Koala Plan of Management (CKPoM), that has been endorsed by CCC and recently approved by the State Government. Development of both a strategy and a capacity to monitor changes in the distribution and abundance of the Campbelltown koala population over time is an important component of effective longer-term conservation management, enabling CCC (as the primary custodian / steward) to report back to the community and other stakeholders, while also providing a basis for informed planning decisions regarding koalas and their habitat.

Previous studies have estimated population numbers and/or densities of koalas across the CCC LGA using several approaches. Biolink (2012) derived a density estimate of 0.056 koalas ha-1 using a formulaic combination of knowledge relating to the amount of available preferred habitat within the known koala Extent of Occurrence (EoO), along with a records-based estimate of the associated Area of Occupancy (AoO). This data were then used in combination with knowledge derived from radio-tracking (median female home range size), which was then further modified to reflect the spatial overlap between koala home ranges. These considerations informed a 2012 population estimate of 177 ± 18 (95% CI) koalas. More recently, and indirectly offering strong support for our formulaic approach, a statistically identical density estimate of 0.052 koalas ha-1 was obtained from a series of spotlighting transects distributed across the Wilton and Greater MacArthur Growth Areas (includes southern CLGA and a portion of Wollondilly LGA) (DPIE 2019).

The primary objective of this interim report is to provide the foundation for consolidation of a long-term koala monitoring strategy for Council, in accord with Section 10.3 (Monitoring, reporting and review) of the Campbelltown CKPoM which amongst other things defines minimum survey requirements. Ideally, the monitoring strategy should be amenable to expansion and responsive to available resources and stakeholder interests, including opportunities for citizen science to engage in the processes of informing koala conservation. The current report thus furnishes baseline measures of koala habitat occupancy and a revised population estimate that specifically relates to the CCC LGA, the results of which can then be communicated to stakeholders and the broader community with a view to developing an integrated and overarching monitoring strategy.

Methodology

Study Area

The CCC LGA is located approximately 30 km south-west of the Sydney metropolitan area and occupies a land surface area of 31,126 ha. The LGA comprises 39 suburbs from Glenfield in the north, Holsworthy in the east, Menangle Point in the west and Gilead and Wedderburn in the south. A portion of Dharawal National Park (est. 2012) falls within the CCC LGA, covering 1,187 ha in the south of the LGA. The Holsworthy Army base is under the stewardship of the Department of Defence and takes up a relatively large portion (9,760 ha) of the LGA in the east (Figure 1). Approximately 11,186 ha of the LGA supports mapped areas of native vegetation. These vegetated areas are most consolidated in the east becoming increasingly fragmented by urbanisation towards the centre of the LGA.

Field Survey

The CCC LGA was overlain with a 750 m grid, with grid-cell intersections becoming potential field survey sites where they occurred in areas of native vegetation.

Field sites were assessed using the Rapid Spot Assessment Technique (Rapid-SAT), a naïve occupancy assessment tool which focuses only on the presence/absence of koala faecal pellets within a prescribed search area of 1 m around the bases of 5 – 7 Preferred Koala Food Trees (PKFTs) ≥ 300 mm Diameter at Breast Height (DBH). Utilising the same search protocols (1 m search area; maximum 2-person minute search for scats) as those underpinning the SAT methodology of Phillips and Callaghan (2011), the Rapid-SAT approach offers a resource-effective survey technique predicated by knowledge that in areas being utilised by koalas, there is an approximately 50% probability of faecal pellets occurring within 1 m of the base of any PKFT ≥ 300 mm DBH (Phillips and Wallis 2016). This 50% probability of 'success' thus becomes an important metric for assessment purposes because it also allows utilisation of the probability of 'failure' (also 50%) to determine how many PKFTs without faecal pellets need to be recorded at a given sampling point to prescribe with a measure of statistical confidence that koalas are not using the habitat that is otherwise available in the immediate area.

Informed by the probability model of McArdle (1990), and further guided by the work of Kéry (2002) and Murn & Holloway (2016), Figure 2 illustrates the probability function curve based on a 50% failure metric. This graph and associated function confirm that the absence of koala faecal pellets from within the prescribed 1 m radial search area around the bases of a minimum of five and a maximum of seven PKFTs ≥ 300 mm DBH is sufficient to be 95% – 99% confident respectively that koalas are not using habitat in the immediate area. For Rapid-SAT purposes, survey work at a given sampling point thus ceases when one or more koala faecal pellets have been detected because the objective of the assessment – ascertaining koala presence - has been achieved. Conversely, if no pellets are detected via radial searches around the base of an identified PKFT after a period of two person-minutes, sampling ceases. Once a minimum of 5 to maximum of 7 nearest neighbour PKFTs with DBHs ≥ 300 mm have been assessed, these numbers affording a high level of statistical confidence (95% or 99% respectively), it is considered that koalas are not using habitat in the immediate vicinity of the site being assessed.

Flexibility with site placement was permitted to optimise the numbers of PKFTs being sampled, so long as spatial independence between sites was achieved (minimum 500 m separation). Universal Transverse Mercator (UTM) coordinates at each site were recorded using a handheld GPS and the centre PKFT was marked with a labelled tree tag and flagging tape. Assessment at a given sampling point ceased when one or more koala faecal pellets were detected or when 1 m radial searches of the bases of five to seven nearest neighbour PKFTs ≥ 300 mm DBH were performed, each tree being searched for two person-minutes. In the instance that no PKFTs were present at a defined site, a 15 person-minute radial search within a 50m radius around the base of the nearest Eucalyptus spp. > 300 mm DBH was conducted to achieve search time parity.

Within the CCC LGA, the Campbelltown CKPoM lists five PKFT species, these being Grey gum (Eucalyptus punctata), Woolybutt (E. longifolia), Forest red gum (E. tereticornis), Manna gum (E. viminalis) and Grey box (E. moluccana) (Phillips and Callaghan 2000; Phillips 2016). One or more of these species at a given site were thus the focus of Rapid-SAT assessments.

While other tree species are known to be utilised by the Campbelltown koalas, the particular focus on these 5 tree species for assessment purposes reflects current scientific knowledge regarding the process of preferential food tree selection by koalas.

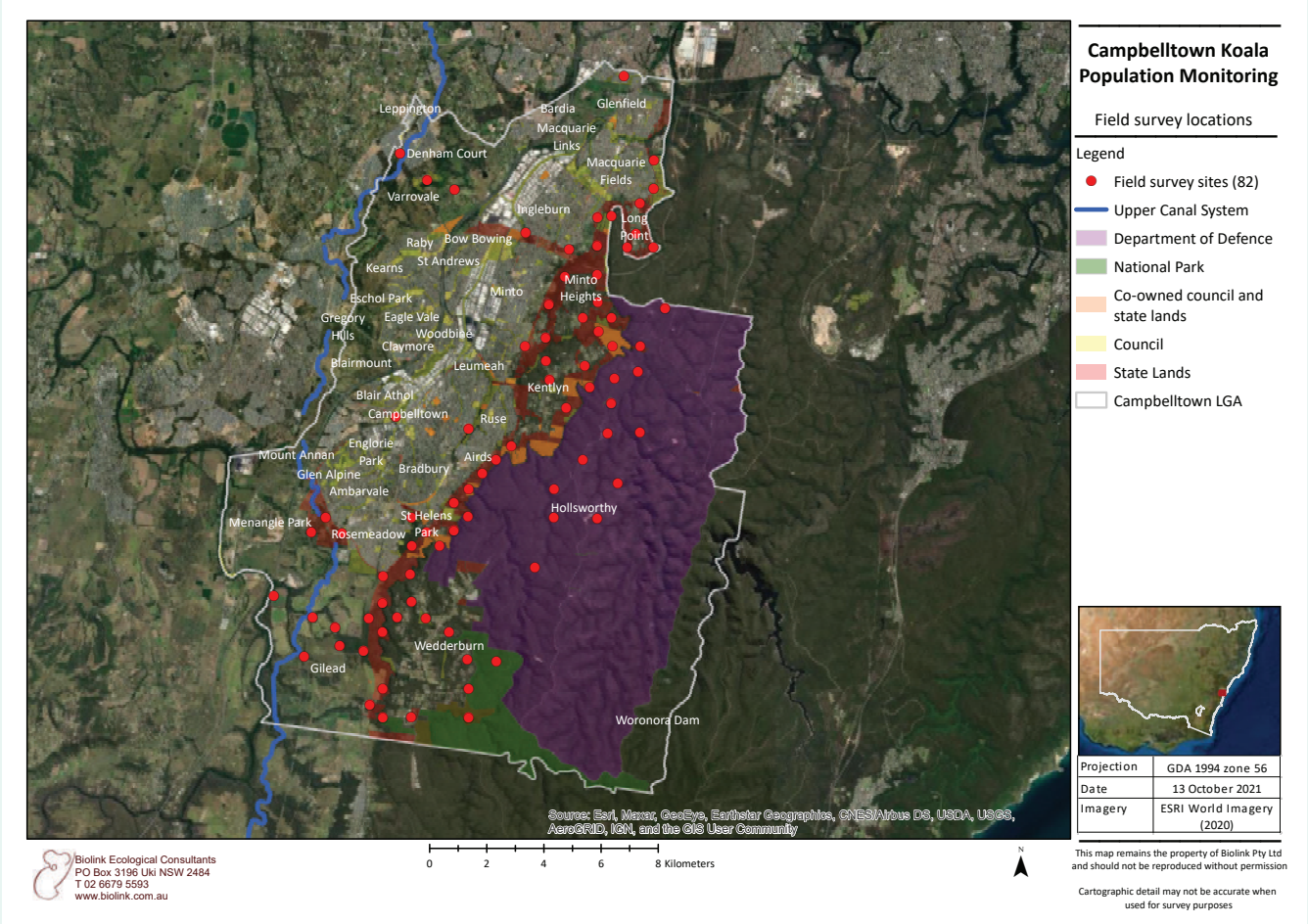


Figure 1. The Campbelltown City Council Local Government Area (CCC LGA) with 82 field survey sites (red dots and suburb locations labelled and the various land tenures shaded. Land tenure: Council (pale orange), State (red), Department of Defence (purple), co-owned State and Council lands (bright orange), and National Parks (green) are highlighted.

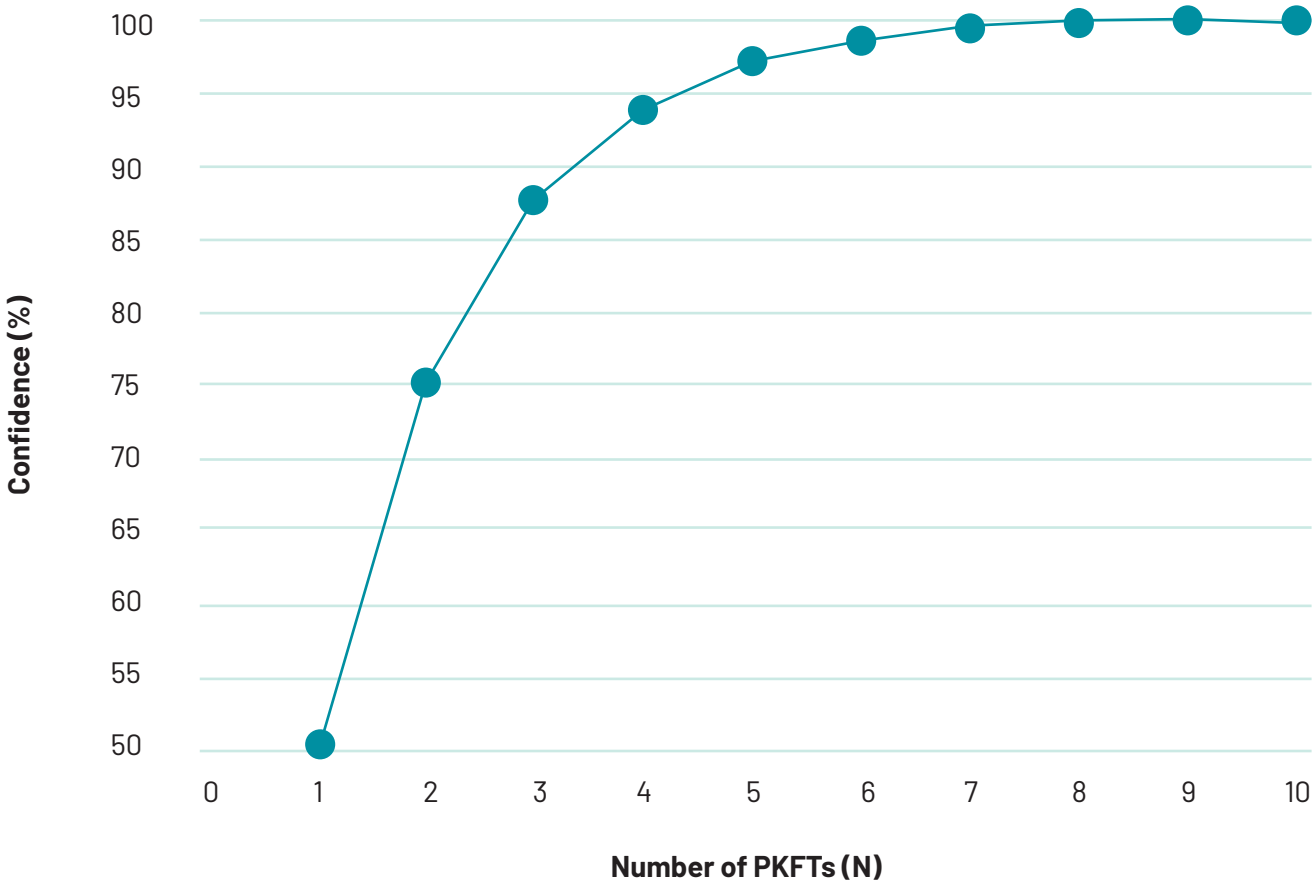


Figure 2: Statistical confidence in the probability of non-occurrence of koalas at an individual Rapid-SAT site based on the numbers of sampled PKFTs ≥ 300 mm DBH beneath which no koala faecal pellets have been detected, based on the methods of Phillips and Wallis (2016). Note the intersections of the x and y axes around the 95% - 99% Confidence measure.

Data Analysis

Habitat utilisation / naïve occupancy

Habitat utilisation / naïve occupancy was calculated according to the number of active sites containing PKFTs divided by the total number of sites with PKFTs. These data sets are distributed binomially. Hence and unless otherwise specified, the Standard Error (SE) was estimated using the following term:

$$SE = \sqrt{pq/n} \qquad \text{(Eqn 1)}$$

Where:
SE = standard error of the sample
p = the sample proportion
q = 1 – p
n = total sample size

The associated 95% confidence interval (CI) for the sample could then be estimated as SE * 1.96 (product of the Z-value for the required CI).

Population estimate

A population estimate was derived using the formulaic approach of Biolink (2012), replacing the naïve occupancy measure originally derived by records analysis with that of the naïve occupancy derived by field survey. The population estimate (N) was therefore calculated as follows;

N = [PKH x On (± 95% CI)]
D/2

where
N = Population estimate
PKH = amount of Preferred Koala Habitat (in ha) contained within the 2002 – 2019 EoO,
On = naïve occupancy estimate and associated CI (expressed as proportions), and
D = mid-point of range of female koala home range sizes, as determined by Ward (2002), divided by 2 (i.e. 18 ha).

To establish the amount of available habitat across the CLGA, the previously calculated EoO (Biolink 2012) was updated using koala records up to 2019, as outlined in sections; 2.3.2.1 and 2.3.2.2 below. The amount and extent of Preferred Koala Habitat (PKH) / available habitat within the EoO was informed by vegetation mapping and associated koala habitat coding underpinning the Campbelltown CKPoM (i.e., PCTs categorised according to the presence / absence / dominance of PKFTs).

Koala records

Three data sets of historical koala records were available for evaluation, namely the records used in Biolink (2012), those from the Bionet portal, and records from Close & Durnham (2016), each of which were variously linked and / or overlapped. Once the extent of the relationships between these records was determined a final data set was merged and uploaded into a Microsoft Access database where the records were again checked for duplication and spatial context.

Extent of Occurrence (EoO)

The resulting koala records data set for the CCC LGA was then partitioned to enable the updating of the EoO for comparison to that originally estimated by Biolink (2016). The EoO is the area contained within the shortest continuous boundary that encompasses all species records for a defined period and locality and is typically represented as the area enclosed by a Minimum Convex Polygon (MCP) constructed by connecting the outer-most koala records where no internal angle is greater than 180 degrees. The EoO for CCC LGA's koalas was determined for the most recent three koala generations (2002 – 2019), and for the preceding period (pre-2002) for comparative purposes. The time frames 2002 – 2007, 2008 – 2013 and 2014 – 2019 approximate the time intervals for the most recent three koala generations, the measure of which is known to be approximately six years (Phillips 2000). This approach was taken to be able to express the results of comparative analyses in the context of International Union for the Conservation of Nature (IUCN) criteria that place weight on the concept of population change over a period of three (taxon-specific) generations (WCUSSC 1994).

Results

Field Survey

Habitat utilisation / naïve occupancy

Field survey was completed over the period from 8–21 December 2020, during which time 82[1] field sites were assessed. Evidence of habitat utilisation by koalas in the form of diagnostic faecal pellets was recorded at 34 of the 82 surveyed field sites, thus inferring a habitat utilisation estimate of 41.46% ± 5.47% (SE) of the available forest / woodland cover.

Preferred Koala Food Trees (PKFTs) were present at 63 of the 82 sites that were assessed, and koala faecal pellets were recorded at 31 of these 63 sites, a measure considered more likely to be indicative of regular use by koalas. This results in a refined naïve occupancy rate of 49.21% ± 6.35% (SE) of available habitat that contains PKFTs. **Figure 1** illustrates the distribution of survey effort across the study area and **Appendix** provides a summary of the survey data.

Indirectly, this data confirm the strong relationship between koalas and their PKFTs, field sites with PKFTs returning a significantly higher number of positive sites than did sites without PKFTs.

Population estimate

The records indicate an EoO for the most recent three koala generations (2002 - 2019) of approximately 22,596 ha, this being the area captured by the MCP with vertices that intersect the outermost koala records in the dataset from the relevant period (**Figure 4**). The 2002 – 2019 EoO contains approximately 8,646 ha of PKH (**Figure 4**), 49.21% ± 6.35% (SE) of which has been estimated by field survey as being currently occupied by koalas (Section 3.1.1 above). Using the modified home range size of 18 ha, this results in a population estimate for the CCC LGA of 236 ± 60 (95% CI) koalas.

[1] Additional field sites have been assessed by Council staff but are not included in this report.

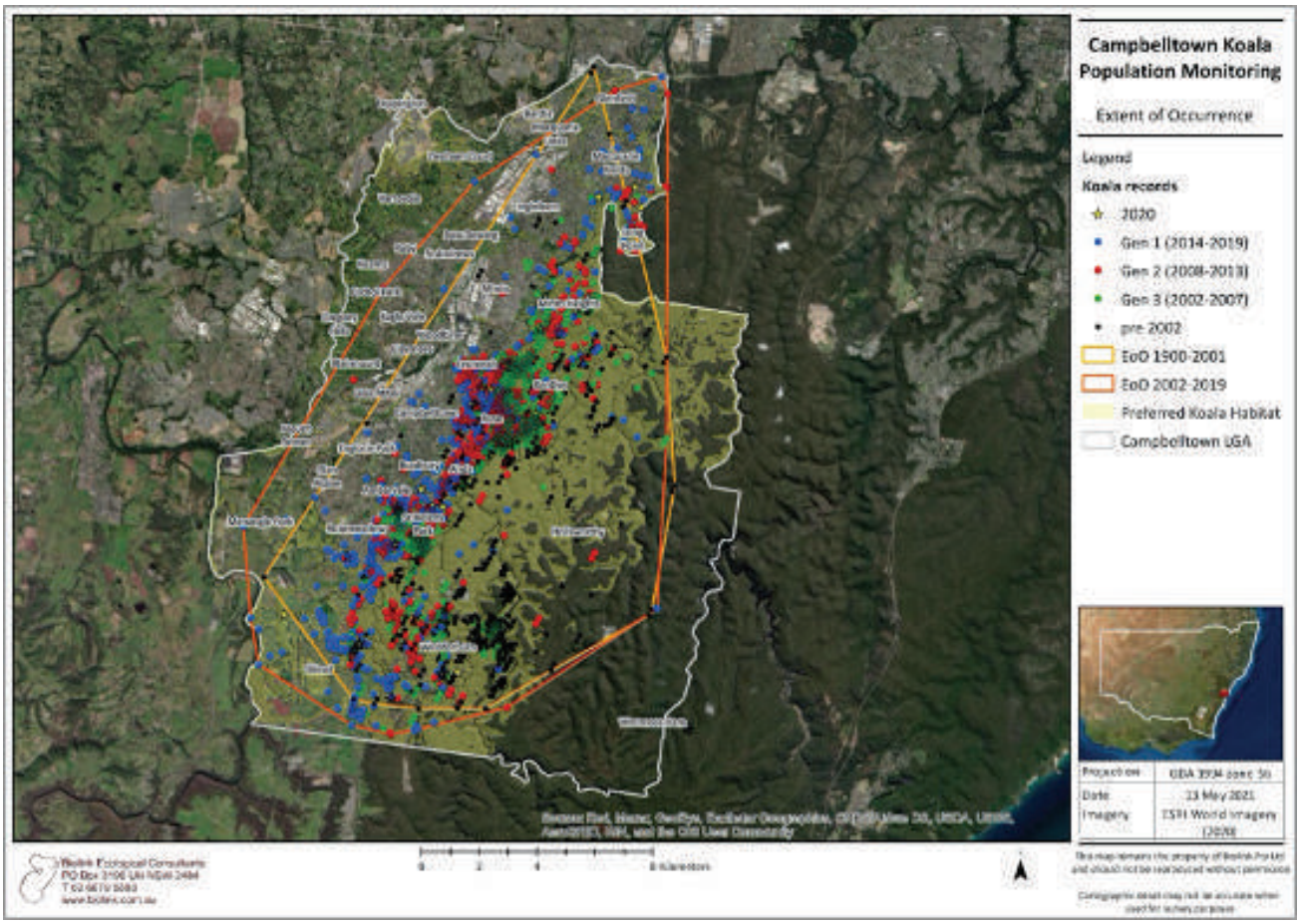


Figure 3. Extent of Occurrence (EoO) of koalas across the CLGA for the period 2002 - 2019 (dark orange) and previous EoO for the period 1900 - 2001 (light orange), representing the most recent three koala generations – those being generation 1 (blue dots), generation 2 (red dots) and generation 3 (green dots). Pre-2002 koala records (black dots) and Preferred Koala Habitat (PKH) (green) are also displayed.

Discussion

The outcomes arising from this report confirm the enduring presence of koalas across Campbelltown, particularly through the central portion of the LGA and eastwards into lands managed by the Department of Defence (Holsworthy). Field survey resulted in an estimated naïve occupancy rate of 49.21% ± 6.35% (SE) of the available habitat, which and while trending upwards, does not significantly differ from the AoO measure of 46.42% ± 5.58% (SD) estimated by Biolink (2012). This previous measure of occupancy was derived from records analysis which has been proven to function as a useful proxy for field-derived measures of occupancy. Indeed, AoO measures have successfully predicted the outcome of field survey across several LGAs including Ipswich (Biolink 2020), Redland Coast (Biolink, 2019b) and Port Macquarie (Biolink 2013). The current population estimate for CLGA of 236 ± 60 (95% CI) koalas represent a small increase from previous appraisals of less than 200 individuals (Biolink 2012) and is in accord with other recent reports of koala population increases across the CCC LGA (Biolink 2018b, Close et al. 2017; McAlpine et al. 2017). This population increase appears to primarily be driven by changes in the EoO, with more widespread koala records in the north near the Liverpool LGA, and in the south-west in the vicinity of Appin.

Future monitoring and reporting of changes in the occupancy status of koalas across the CLGA will be best informed by designation of the field sites established for this study as 'Permanent Monitoring Points' (PMPs) that can be used for repeat surveys. We thus envisage that Council commences the task of consolidating a long-term monitoring program for Campbelltown koalas, initially using the 63 sites where five to seven PKFTs were present in the 2020 field survey (**Figure 5**). In accord with provisions of the Campbelltown CKPoM, we propose that a minimum of 50 randomly selected sites be sampled from the pool of existing PMPs every two years. Given that access to private properties is likely to change over time because of changing ownership and landowner attitudes, we suggest that new consenting properties which adhere to the minimum 500 m spatial separation be added to the pool for random selection as they become available, whilst those that no longer consent to access are removed. Each monitoring event should include some private properties in order that measures of occupancy are not biased by land tenure. The random site selection process should in effect sample a relative proportion of all available land tenures.

The importance of continued monitoring across the Holsworthy defence site cannot be understated. Considered collectively, sites on land held by the Department of Defence had relatively high occupancy levels. This result was unexpected given the low nutrient sandstone soils which underlie most of these sites (Close & Durnham 2016). Soil quality is a predictor of koala density and fertile soils are associated with higher nutrient availability in PKFT leaves (Cork 1986; Cork & Braithwaite 1996; Moore et al. 2010; Phillips & Callaghan 2011). Continued inclusion and monitoring of the Holsworthy defence site is thus of importance for long-term monitoring purposes.

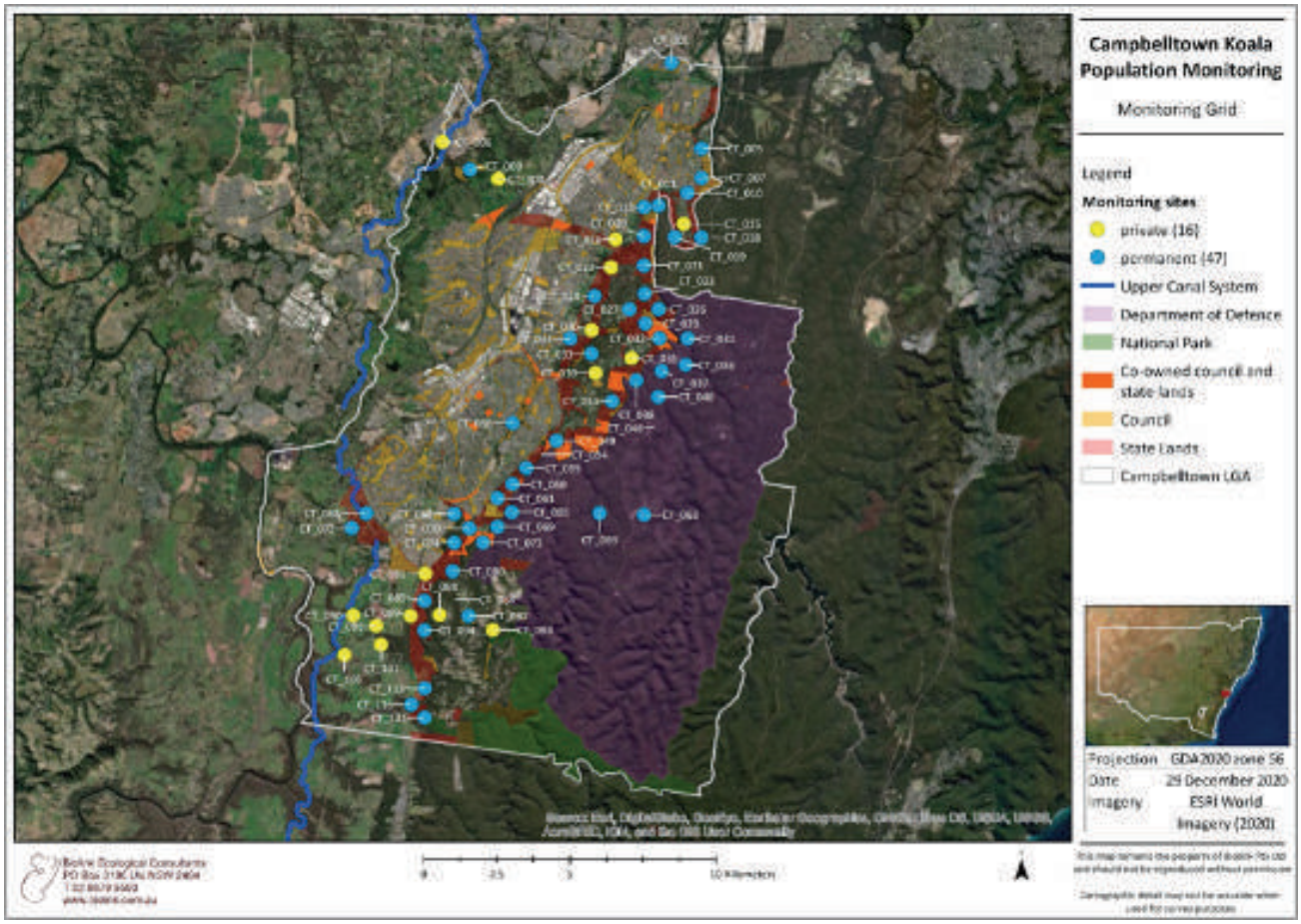


Figure 5. Location of 63 spatially independent Permanent Monitoring Points (PMPs) across a range of land tenures including private (yellow dots) and public (blue dots) lands.

Based on the preceding discussion the following recommendations are proposed for discussion through a stakeholder workshop concordant with Stage 2 of this project:

1. Koala habitat utilisation / naïve occupancy surveys are conducted using SAT / Rapid-SAT methodology at a minimum of 50 randomly selected PMPs every two years. We thus envisage future site-based monitoring events to be scheduled for 2022, 2024 and 2026.
2. Using the preceding approach, progressive declines in habitat utilisation / naïve occupancy measures over two consecutive intra-generational survey events triggers an assessment and review of threatening processes.
3. The field survey program is to be supported by a historical records analysis every koala generation (i.e., once every six years or at every third monitoring event). The most recent comprehensive records review occurred in 2012 and 2018 (the latter based on records up until 2017) and we would thus and to bring both monitoring be suggesting the next historical records analysis be performed in 2022.
4. Additional PMPs are to be progressively added to the pool of potential survey sites based on solicitation through Council's website, adhering to a minimum 500 m separation.
5. Opportunities for other survey techniques (such as spotlighting and the use of detection dogs and/or drones) should be explored for potential incorporation into the monitoring program, so long as they do not detract from the overriding need to gather meaningful habitat utilisation / naive occupancy data.
6. The potential role and contributions of citizen science should also be explored as a means of gathering further data on the CCC LGA's koala population.

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Appendix

Surveyed Field Sites: 2020 Baseline Monitoring Program (Note: coordinates for sites on private property have been redacted for privacy purposes).

Site name	Date	Easting	Northing	Tenure
CT_001	8/12/2020	305449	6239948	Council
CT_005	12/12/2020	306491	6237011	Council
CT_006	15/12/2020	-	-	private
CT_007	12/12/2020	306488	6236003	-
CT_008	9/12/2020	-	-	private
CT_009	9/12/2020	298555	6236299	Council
CT_010	12/12/2020	306000	6235496	State lands
CT_011	9/12/2020	305006	6235054	State lands
CT_013	9/12/2020	304520	6235004	State lands
CT_015	8/12/2020	-	-	private
CT_016	9/12/2020	-	-	private
CT_017	13/12/2020	302002	6234483	Council
CT_018	8/12/2020	306475	6233960	State lands
CT_019	15/12/2020	305564	6233970	State Lands
CT_020	13/12/2020	304508	6234009	State lands
CT_021	13/12/2020	304504	6233003	State lands
CT_022	8/12/2020	-	-	private
CT_023	13/12/2020	304533	6232032	State lands
CT_025	14/12/2020	306882	6231815	Department of Defence
CT_026	13/12/2020	305008	6231503	State lands

Site name	Date	Easting	Northing	Tenure
CT_027	12/12/2020	304007	6231499	State lands
CT_028	12/12/2020	302817	6231951	State lands
CT_029	15/12/2020	304554	6231013	Co-owned council and state lands
CT_030	8/12/2020	-	-	private
CT_031	14/12/2020	306013	6230498	Department of Defence
CT_032`	15/12/2020	305040	6230504	Co-owned council and state lands
CT_033	12/12/2020	302709	6229979	Indigenous Lands
CT_034	12/12/2020	301981	6230491	State lands
CT_035	9/12/2020	-	-	private
CT_036	14/12/2020	305934	6229598	Department of Defence
CT_037	14/12/2020	305117	6229380	Department of Defence
CT_038	12/12/2020	304242	6229064	Co-owned council and state lands
CT_039	9/12/2020	-	-	private
CT_040	14/12/2020	304999	6228496	Department of Defence
CT_041	15/12/2020	303419	6228349	State lands
CT_044	12/12/2020	297463	6228037	Council
CT_045	14/12/2020	306004	6227491	Department of Defence
CT_046	14/12/2020	304876	6227451	Department of Defence
CT_049	12/12/2020	301509	6226993	State lands
CT_051	14/12/2020	305225	6225712	Department of Defence

Site name	Date	Easting	Northing	Tenure
CT_052	14/12/2020	304002	6226517	Department of Defence
CT_054	11/12/2020	300968	6226514	State lands
CT_055	11/12/2020	300482	6226055	State lands
CT_056	13/12/2020	300007	6227600	Council
CT_057	14/12/2020	302998	6225501	Department of Defence
CT_060	11/12/2020	300007	6225503	Co-owned council and state lands
CT_061	11/12/2020	299495	6225016	State lands
CT_062	14/12/2020	304512	6224455	Department of Defence
CT_063	14/12/2020	302987	6224510	Department of Defence
CT_065	11/12/2020	299980	6224544	State lands
CT_066	11/12/2020	298012	6224491	Council
CT_068	11/12/2020	295000	6224504	State lands
CT_069	11/12/2020	299492	6224042	State lands
CT_070	10/12/2020	298527	6223989	State lands
CT_071	11/12/2020	295578	6223954	State lands
CT_072	11/12/2020	294505	6223996	State Lands
CT_073	10/12/2020	298995	6223505	Co-owned council and state lands
CT_074	10/12/2020	298016	6223498	State lands
CT_077	14/12/2020	302328	6222770	Department of Defence
CT_080	10/12/2020	297959	6222522	State lands
CT_081	21/12/2020	-	-	private
CT_084	8/12/2020	-	-	private

Site name	Date	Easting	Northing	Tenure
CT_085	10/12/2020	296990	6221503	State lands
CT_086	21/12/2020	-	-	private
CT_087	8/12/2020	298505	6220987	Council
CT_088	8/12/2020	-	-	private
CT_089	21/12/2020	-	-	private
CT_090	21/12/2020	-	-	private
CT_093	9/12/2020	-	-	private
CT_094	10/12/2020	296990	6220495	State lands
CT_095	21/12/2020	-	-	private
CT_100	21/12/2020	-	-	private
CT_101	10/12/2020	-	-	private
CT_103	13/12/2020	300982	6219458	NPWS
CT_104	13/12/2020	299956	6219537	NPWS
CT_105	21/12/2020	-	-	private
CT_111	13/12/2020	300003	6218495	NPWS
CT_113	10/12/2020	296998	6218508	State lands
CT_116	10/12/2020	296544	6217944	State lands
CT_118	13/12/2020	300007	6217501	NPWS
CT_120	11/12/2020	298000	6217504	State lands
CT_121	11/12/2020	297001	6217499	NPWS
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