Sydney Basin Bioregion: Koala habitat and population assessment

Report for the Total Environment Centre

Biolink Ecological Consultants

February 2023

PO Box 673, Murwillumbah, NSW, 2484
Tel: + 61 (02) 6679 5523
www.biolink.com.au

Table of Contents

Abbreviations

Abbreviation	Description
ALA	Atlas of Living Australia
AoO	Area of Occupancy
ARKS	Areas of Regional Koala Significance
CKPoM	Comprehensive Koala Plan of Management
EDO	Environmental Defenders Office
EoO	Extent of Occurrence
GEEBAM	The Google Earth Engine Burnt Area Map
GP	Generational Persistence
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for the Conservation of Nature
KMA	Koala Management Areas
LGA	Local Government Area
MCP	Minimum Convex Polygon
NSW	New South Wales
PCT	Plant Community Type
PKFT	Preferred Koala Food Tree
PKH	Preferred Koala Habitat
SBKN	Sydney Basin Koala Network
SE	Standard Error
TEC	Total Environment Centre
WIRES	NSW Wildlife Information Rescue and Education Service

Biolink

Senior Ecologist Amanda Lane
Conservation Analyst Kirsty Wallis
Advising Consultant Stephen Phillips

Acknowledgements

We commend the Total Environment Centre (TEC) and Sydney Basin Koala Network (SBKN) for undertaking this project and acknowledge TEC / SBKN staff for their enthusiasm and support, particularly Jeff Angel, Stephanie Carrick, Jade Peace, Rianti Bieler and Marijs Vrancken. We thank Cerin Loane from the Environmental Defenders Office (EDO) for her insightful discussion and we also thank NSW Wildlife Information Rescue and Education Service (WIRES) for their continued patronage of koala conservation programs.

How to cite this report

Biolink. (2023). Sydney Basin Bioregion: Koala habitat and population assessment. Report for Total Environment Centre by Biolink Ecological Consultants, Pottsville, NSW.

Photo credit

Kirsty Wallis. Koala sighted in a Swamp mahogany (*Eucalyptus robusta*) during field survey on 7/6/2022.

Executive Summary

This report describes the status of the koala (*Phascolarctos cinereus*) across the Sydney Basin bioregion, a diverse landscape of 3,622,737 ha stretching from Nowra, north to Nelson Bay and west almost as far as Mudgee, and provides a consolidated vegetation map for the region, coded for Preferred Koala Habitat. Vegetation was characterised according to the dominance of Preferred Koala Food Tree species in the canopy, producing a four-tiered habitat categorisation of Primary, Secondary A, Secondary B, Secondary C habitat types. Each of these categories reflect differing koala carrying capacities with areas of Primary koala habitat capable of sustaining high density populations, whereas Secondary C can only sustain low density koala populations. Preferred Koala Habitat was identified broadly across the Sydney Basin, totaling 1,605,511 ha and accounting for 44.32% of the total land surface area. The majority of this habitat falls into the Secondary B and Secondary C habitat categories which collectively account for 88.16% of mapped habitat. These habitat categories are typically associated with moderate to low underlying soil fertility and a landscape that necessitates large koala home ranges and lower associated carrying capacities.

To understand the distribution, abundance and locations of historical and contemporaneous koala populations across this region we conducted historic records analysis using fauna sightings records downloaded from BioNet and Atlas of Living Australia. Analysis of 8,011 historic records from the period 1884 - 2021 confirms the enduring presence of koalas across the Sydney Basin. Spatial analysis indicates stability in the key range parameter *Extent of Occurrence* when records for the time period leading up to 2003 are compared to those of the most recent three koala generations (2004 – 2021) with the *Extent of Occurrence* incorporating almost the entire Sydney Basin. The related and more informative measure, *Area of Occupancy* implies low overall koala occupancy when considering the proportional area within the *Extent of Occurrence* which is actually occupied by koalas, with a small but significant increase from 7.46% ± 0.06% (SE) for the period prior to 2003, to 9.84% ± 0.11% (SE) for the time period 2004 – 2021. This is likely to be due at least in part to the recent recovery of the Campbelltown koala population which is expanding to the north, west and south-west. Despite these localised gains, overall koala occupancy remains low and Generational Persistence - the re-occurrence of koala records within a localised area over inter-generational time spans - indicates that long-standing resident and/or source populations are limited to a small proportion of the Sydney Basin. Examining changes in the location of areas of Generational Persistence over time reveals dynamic metapopulation boundaries and the likely loss of koala populations from the Central Coast.

The aforementioned range parameters *Extent of Occurrence*, *Area of Occupancy* and Generational Persistence are aligned with International Union for the Conservation of Nature (IUCN) and

Commonwealth-based conservation criteria, which place weight on the concept of population change over three consecutive (taxon-specific) generations, a period of six years being accepted as a single koala generation.

The intense fires which burned across large parts of the Sydney Basin in late 2019 and early 2020 fell within the most recent koala generation (2016 – 2021) and therefore its impacts are not best measured using the otherwise useful generational approaches. We addressed the likely impacts of the extreme fire events of 2019/2020 with reference to the extent of fire using GEEBAM (Google Earth Engine Burnt Area Map) and the location of known koala populations and koala habitat. The sole area of koala Generational Persistence in Shoalhaven was subject to 'High' and 'Very High' fire severity raising the possibility that this source population has perished or been dramatically reduced, a notion supported by the absence of koala sightings from this Local Government Area since 2019. Hawkesbury Local Government Area also suffered substantial fire impacts with 78.66% of its koala habitat impacted and the locations of half the identified areas of koala Generational Persistence overlapping with fire extent. Wollondilly and adjacent Wingecarribee Local Government Areas which combined support close to half the koala Generational Persistence in the Sydney Basin, had impacts to 57.93% and 29.76% of their koala habitat respectively and some overlap with the location of known koala populations. Overall, fires within the Sydney Basin impacted 1,286,503 ha (35.51%) of the total land surface which included 71.02% of mapped koala habitat in National Parks. In the absence of field surveys, the impacts of the 2019/2020 fire events on koala populations in the Sydney Basin are yet to be fully realised though estimates of reduction in koala occupancy within fire grounds in northern NSW implies substantive declines.

Koalas inhabiting the most urbanised parts of the Sydney Basin Bioregion escaped the bulk of the impacts of the 2019/2020 fire events however they remain increasingly vulnerable to fire risks in addition to the challenge of existing at the peri-urban interface where they are impacted by a growing human population. Vehicle strikes on koalas in south-west Sydney are substantive with at least 130 vehicle related koala mortalities recorded across the adjoining LGAs of Campbelltown, Wollondilly, Liverpool, Sutherland, and Wingecarribee over the period 2016-2021 - a figure likely to be an underestimate as several studies infer that ~50% of vehicle strikes on koalas are reported. This level of mortality may be unsustainable in the low carrying capacity landscape. There is a need to build resilience in the south-west Sydney koala populations so that they are better able to withstand the impacts of future development, as well as stochastic impacts such as fire. In order to achieve this viable linkages of adequate size and associated habitat patches need to be secured.

Despite their enduring presence across the Sydney Basin, koala numbers have reduced dramatically state-wide over the preceding 20 years, resulting in the species being up-listed from Vulnerable to Endangered status in NSW, Qld and the ACT under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Endangered under the *Biodiversity Conservation Act 2016 (NSW)* (BC Act).

1. Introduction

1.1. Koala ecology and conservation status

The koala (*Phascolarctos cinereus*) is Australia's largest arboreal marsupial folivore with a distribution that is restricted to eucalypt woodlands and forests in the east of the continent. Within this area koalas exhibit strong preferences for individual tree species within the Genus *Eucalyptus* (Martin & Handasyde 1999; Phillips *et al.* 2000; Callaghan *et al.* 2011; Wu *et al.* 2012). Other non-preferred eucalypts and genera such as *Corymbia*, *Angophora*, *Callitris* and *Lophostemon* may also be incorporated into their diet as supplementary browse or used for other purposes including shelter (Lee & Martin 1988; Phillips 1990; Hasegawa 1995; Phillips 1999; Phillips *et al*. 2000; Phillips & Callaghan 2000). To obtain the greatest amount of nutrients from their otherwise nutrient-poor browse, koalas preferentially choose trees with high nitrogen levels and low toxin levels (Stalenberg *et al.* 2014), the underlying nutrient levels of the soils ultimately affecting leaf palatability (Reed *et al.* 1988; Moore *et al.* 2004). Because of this highly specialised diet, food availability is considered a key determinant of koala distribution, however forest area and landscape configuration also play a role (McAlpine *et al.* 2006) as do aspects of koala socio-biology (Phillips 2000).

Though frequently overlooked in population management and conservation planning, koalas have a highly defined social structure. Studies of free-ranging koalas have established that those in local populations at demographic equilibrium arrange themselves in stable breeding aggregations which comprise a matrix of overlapping home range areas, typically with a dominant male and several females (Lee & Martin 1988; Faulks 1990; Mitchell 1990; Kavanagh *et al.* 2007). Home range sizes vary according to koala sex and size, with larger males maintaining the largest home ranges (White 1999; Phillips 1999). Habitat quality also determines home range size with a sparser distribution of preferred food trees necessitating a larger home range area to meet the metabolic needs of individuals (Callaghan *et al.* 2011). Koalas do not have a high reproductive output; females reach sexual maturity between 18 months and two years of age and can theoretically produce one offspring each year, though on average females in wild populations breed every second year over the term of their reproductive lives (McLean and Hanasyde 2006). The longevity of individuals in the wild appears to average 8 – 10 years for most mainland populations and the generation time for koalas is considered to be 6.02 ± 1.93 (SD) years (Phillips 2000), a measure which is now applied to all koala populations in eastern Australia (TSSC 2012). Juveniles of both sexes disperse at around 18 – 36 months, eventually attaching themselves to another koala aggregation and thereby maintaining the genetic integrity of the local population (Dique *et al.* 2004). Long-term fidelity to the home range area is typically maintained by all adult koalas in a resident local population that is at demographic equilibrium and dissolution of the existing social fabric of such resident populations may contribute to population declines (Mitchell 1990, Phillips 2000). Maintenance of existing social structure must therefore be a consideration in the development of conservation management strategies.

The size and connectivity of patches of koala habitat are paramount to conservation planning and the configuration of habitat becomes increasingly important as the forest area itself declines (McAlpine *et al.* 2006). Small isolated populations tend to suffer higher extinction risks and the survival of meta-populations relies on the ability of individuals to recolonize habitat patches where a sub-population has become locally extinct (Hanski 1998). This recolonization process can operate in both direction – source populations in large areas of consolidated habitat can provide individuals to smaller habitat patches which have undergone local extinction and *vice versa* koalas in smaller habitat patches on private lands tend to be better protected from wildfire and can re-establish populations in larger areas of consolidated habitat that have been heavily impacted by fire events (Biolink 2019).

The conservation status of koalas across their broader distribution has been subject to recent change. Koala populations in Queensland, New South Wales (NSW) and the Australian Capital Territory (ACT) were formerly listed as Vulnerable under the Federal *Environmental Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) but were upgraded to Endangered status in 2022 due to widespread population declines across this range, inclusive of the impacts of the 2019/20 fire season among other threatening processes. Koalas are further listed as Endangered at the state level in NSW under the *Biodiversity Conservation 2016* (BC Act). It has been estimated that koala populations in NSW have declined by >29% over the preceding three koala generations (18 years) (Lane *et al.* 2020), with the primary threats being those associated with increasing urbanisation including habitat loss and fragmentation, fire, vehicle strike, dog attack and disease (DECC 2008; OEH 2017; OEH 2018; Phillips *et al*. 2021). The Parliamentary inquiry into Koala Populations and Habitat in NSW also highlighted the cumulative impacts of logging in both private and public native forests and the compounding impacts of climate change on the severity of other threats (NSW Parliament 2020).

1.2. Previous koala studies in the Sydney Basin Bioregion

Koalas have a long history of occupancy across the Sydney Basin Bioregion – a broad landscape stretching from Nowra, north to Newcastle and west almost to Mudgee. Estimated by expert elicitation to contain 10.44% of the total NSW population (Adams-Hosking *et al.* 2016), the bioregion supports Areas of Regional Koala Significance (ARKS), those being broad areas that are considered to support significant koala source populations (Rennison and Fisher 2019, Biolink 2021a). A review of the conservation status of NSW koala populations estimated that the Sydney Basin Bioregion had likely undergone a decline in koala numbers of ~22% over the period 2001 to 2020, largely due to the effects of severe bushfire events in late 2019 and early 2020 which impacted 35.72% of the total land area of the bioregion (Lane *et al*. 2020).

Comprehensive field surveys for koalas across the Sydney Basin Bioregion are lacking, though there have been smaller studies, generally focussed on Local Government Areas (LGAs) which are known to support resident koala populations (*e.g.* Biolink 2021b), as well as site-based surveys in areas that are subject to potential development or are proposed as Biodiversity Stewardship Sites (*e.g.* EMM 2020, Biolink 2021c). The majority of koala survey in the Sydney Basin occurs at the peri-urban interface of south-western Sydney, in Campbelltown and adjacent Wollondilly LGAs (DPIE 2019). Field survey data indicates that the koala population in this region has demonstrated a measure of recovery over recent decades after a near extinction event ~30 years ago, making this population unique in NSW being only known expanding koala population and one that is free of the clinical signs of chlamydia (Biolink 2016, 2021b). Koala surveys also occur with some regularity in Port Stephens LGA which intersects partially with the Sydney Basin Bioregion (PSC 2002), and there has been recent survey of koalas in the Blue Mountains region (see https://www.scienceforwildlife.org/ for detail).

1.3. Koala sightings records

One outcome of heightened public interest in koalas is the ongoing input of koala sightings into publicly accessible databases such as BioNet (https://www.environment.nsw.gov.au/atlaspublicapp/ui_modules/atlas_/atlassearch.aspx) and Atlas of Living Australia (https://www.ala.org.au/). Consequently, analyses of historical koala records are increasingly being used to inform planning outcomes (Phillips *et al.* 2011, Predavec 2016). The range parameters *Extent of Occurrence* (EoO) and *Area of Occupancy* (AoO) are two measures pertaining to the spatial distribution of a species, the EoO being the area encapsulating the outermost geographic limits in which the species can be found, while the AoO is the proportional area within the EoO in which the species actually occurs (Gaston *et al.* 2011). Historical records can also be used to examine the persistence of koalas over time. Generational Persistence (GP) assessment examines historical data for records of koalas reoccurring in a localised area over a time period which exceeds the lifespan individual animals, so identifying the likely presence of long-standing source populations. These approaches are aligned with the International Union for Conservation of Nature (IUCN) and Commonwealth-based conservation criteria, which place weight on the concept of population change over a time period of three consecutive (taxon-specific) generations (WCUSSC 1994).

1.4. Objectives

The purpose of the current project being undertaken on behalf of Sydney Basin Koala Network (SBKN) is to address the following objectives as they pertain to the Sydney Basin Bioregion:

- Prepare a consolidated vegetation map categorised in terms of koala habitat.
- Conduct historical records analysis including *Extent of Occurrence* (EoO), *Area of Occupancy* (AoO), as well as identification of areas of koala Generational Persistence (GP).
- Conduct a broad-scale threats analysis inclusive of vehicle strike and dog attack.
- Intersect fire mapping from the 2019/2020 bushfire season with koala habitat mapping and the location of long-standing koala populations.
- Identify key Focal Areas of known koala occupancy which will be the subject of further detailed reporting.
- Present best practice for koala habitat corridors.
- Develop a template for koala protection progress reports.

2. Methodology

2.1. Study Area

The Sydney Basin bioregion, hereafter referred to as the study area, is one of nine Interim Biogeographic Regionalisation for Australia (IBRA) bioregions within NSW (IBRA v7, SEWPaC 2008), extending from Nowra, north to Nelson Bay and almost as far west as Mudgee (**Figure 1**). The study area covers a broad landscape of 3,622,737 ha which is dominated by a temperate climate characterised by warm summers with no dry season. A distinct sub-humid climate occurs across the north-east and a montane climate zone is located in the west around the Blue Mountains. Rainfall varies across the broad expanse of the study area, with wetter areas being closer to the coast and / or at higher altitudes. Minimum and maximum average monthly temperatures range from -1.4 – 8.1°C to 22.4 – 31.9°C respectively, with a mean annual rainfall of 522 – 2,395 mm (BoM 2021).

The study area includes a significant portion of the catchments of the Hawkesbury-Nepean, Hunter and Shoalhaven River systems, as well as the smaller catchments of Lake Macquarie, Lake Illawarra, Hacking, Georges and Paramatta Rivers. It is geologically diverse, consisting of a geological basin filled with sandstones and shales of the Permian and Triassic age. The sedimentary rocks have been subject to uplift with folding and minor faulting during the formation of the Great Dividing Range. Erosion by coastal streams has subsequently created a landscape of gorges and plateaus as well as coastal cliffs, beaches and estuaries. The study area now supports a diverse array of vegetation communities including rainforests, grasslands, shrublands, heathlands, wetlands and extensive tracts of eucalypt forests and woodlands. National Parks comprise 39.87% of the study area and State Forests account for a further 3.59%. Other major land uses include agriculture, industry and urban development, particularly along the coast. Fifty-eight (58) (LGAs intersect the study area, 38 in their entirety and 20 partially, with this overlap ranging from 0.02% (MidCoast) to 95.52% (Blue Mountains) (**Appendix 1**). As well as Sydney itself, major urban centres include Wollongong, Nowra, Newcastle, Cessnock, Muswellbrook and Katoomba. The region is home to the Yuin, Gundungurra, Tharawal, Dharug, Eora, Kuring-gai, Awabakal, Darkinung, Wiradjuri, Worimi, and Wonnarua First Nations people.

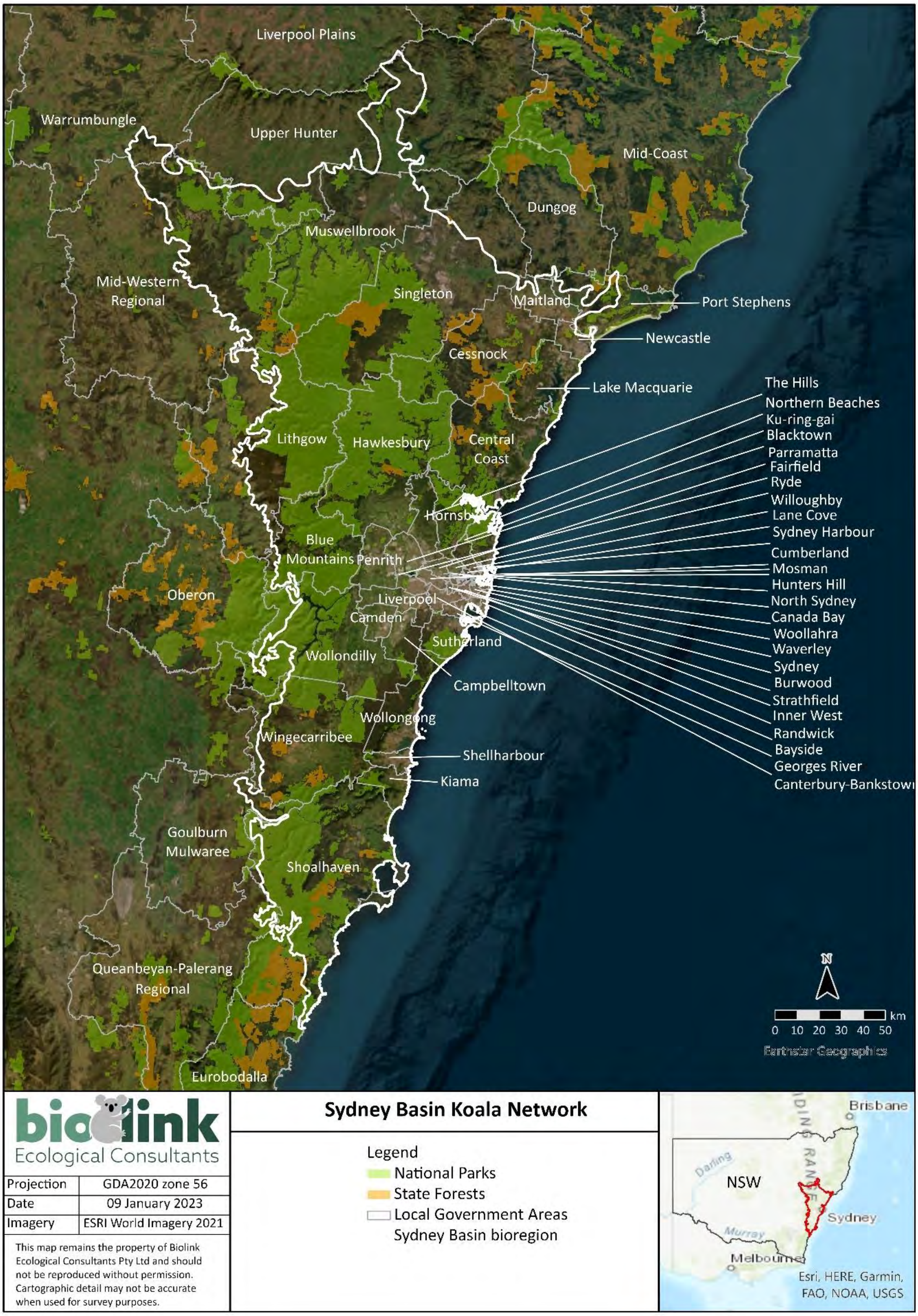

Figure 1. The study area (white outline) comprising the Sydney Basin Bioregion. Local Government Areas (LGAs) are delineated by white outlines, National Parks are shown in green and State Forests in orange. Inset shows the location in NSW.

2.2. Preferred Koala Habitat (PKH) mapping

Preferred Koala Habitat (PKH) mapping utilizes the recently released NSW-wide vegetation mapping layer "NSW Version cCM11m1" downloaded from the SEED spatial database (https://www.seed.nsw.gov.au).

2.2.1. Preferred Koala Habitat (PKH) Classification

We present a four-tiered, hierarchical koala habitat classification system with habitat quality classes based on the relative abundance (dominance) of Preferred Koala Food Tree (PKFT) species, the presence of which were determined from Plant Community Type (PCT) vegetation descriptions available on BioNet. Each of the habitat classifications in **Table 1** reflect differing koala carrying capacities of the associated vegetation communities, areas of 'Primary' Koala Habitat capable of sustaining high density populations (*i.e.* > 0.5 koalas ha^{-1}), whereas Secondary (Class C) / Marginal Koala Habitat can only sustain low density populations (*i.e.* < 0.1 koalas ha^{-1}). Collectively, 'Primary' and 'Secondary' habitat classifications function to identify areas of PKH.

Table 1. Four-tiered koala habitat classification hierarchy criteria as applied to vegetation mapped across the study area.

Koala habitat type	Classification criteria
Primary koala habitat	Forest and/or woodland PCTs occurring on soils of medium to high nutrient value whereupon primary PKFTs are dominant or co-dominant components of the tallest stratum.
Secondary (Class A) koala habitat	Forest and/or woodland PCTs occurring on soils of medium to high nutrient value whereupon primary PKFTs are sub-dominant components of the tallest stratum.
Secondary (Class B) koala habitat	Forest and/or woodland PCTs occurring on soils of low to medium nutrient value whereupon primary PKFTs are absent, the tallest stratum instead dominated or co-dominated by secondary food tree species only.
Secondary (Class C) / marginal koala habitat	Forest and/or woodland PCTs occurring on soils of low to medium nutrient value whereupon primary food tree species are absent and secondary food tree species are sub-dominant components of the tallest stratum.
Other	Forest and/or woodland PCTs that do not contain PKFTs.
Unknown	Vegetation not currently mapped or described.

Habitat categorisations were based on considerations relating to the presence/absence of PKFTs, which for the study area comprised the following species as they apply to Koala Management Area (KMA) Central Coast – which encompasses the study area (**Table 2**).

Table 2: NSW Preferred Koala Food Trees (PKFTs) in the context of NSW Koala Management Areas (KMAs). The study area corresponds to the Central Coast KMA.

	North Coast	Central Coast	South Coast	Northern Tablelands	Central and southern Tablelands	Western slopes and plains	Far west and south-west
Primary PKFT							
Tallowwood	■						
Forest Red Gum*	■	■	■	■	■		
Swamp Mahogany	■	■					
Parramatta Red Gum		■					
Manna Gum*		■	■	■	■		
Red Gum (all species)	■	■	■	■	■	■	■
Secondary PKFT							
Tallowwood	■						
Grey gums (all spp)	■	■					
Mountain Grey Gum			■	■	■		
All Boxes	■	■	■	■	■	■	■
Woollybutt		■	■				
Southern Blue Gum group			■	■	■		
Tenterfield Woollybutt				■			

* High nutrient sites only

Note 1: Preferred Koala Food Trees (PKFTs) are a discrete suite of species in the Genus *Eucalyptus* which, as the term implies, are the subject of preferential utilisation (*i.e.* statistically significant levels of use by koalas when compared to the relative abundance of that tree species in the landscape being assessed). Techniques for identifying PKFTs include replicated Goodness of Fit tests that compare the proportion of tree species '*x*' occupied by radio-tracked koalas to that of the relative abundance of tree species '*x*' in the same study area (Phillips 1999) and/or statistical analyses of tree species / faecal pellet presence/absence data (Phillips *et al*. 2000; Phillips & Callaghan 2000; Phillips & Callaghan 2011). While casual observations of feeding behaviour and techniques such as cuticle-scale analyses can provide information about tree species being used by koalas in a given area, such data when presented in isolation (*e.g*. Woodward *et al*. 2008; Cristescu *et al*. 2011; Melzer *et al*. 2014) cannot readily be partitioned in terms of those tree species being preferentially utilised (as defined above) and those being the subject of more opportunistic levels of use.

The need to distinguish between PKFTs and other tree species used by koalas is important but all too often understated; vegetation communities without PKFTs simply cannot permanently sustain free-ranging koala populations, while the removal of PKFTs from within areas being utilised by koala's can result in nutritional stress, elevated levels of disease and a reduced reproductive output.

Note 2: The terms "Primary" and "Secondary" koala food tree species[1] as used in the classifications outlined in Table 3 below are based on the mathematical models of PKFT utilisation described by Phillips (2000b). Ongoing analyses of koala activity data from low nutrient substrates (Phillips and Allen 2014) has provided the basis for further partitioning of lower carrying capacity habitat types based on differences in the abundance of secondary food tree species. Specifically, vegetation communities wherein secondary food tree species are a dominant or co-dominant component of the tallest stratum support significantly higher koala activity levels (and hence a higher koala carrying capacity) than do vegetation communities wherein secondary food tree species occur at lower densities (Phillips and Allen 2014). This knowledge has informed the need to recognise a further habitat category - Secondary (Class C) Koala Habitat.

2.2.2.Mapping accuracy

Mapping accuracy of the vegetation layer "NSW Version cCM11m1" was estimated for the northern-most portion of the NSW-wide mapping area by comparing the floristic data recorded at 349 field survey sites (surveyed as part of the Northern Rivers Regional Koala Assessment: Biolink 2022) with the PCT descriptions that apply to the mapped polygon in which the site is located. In order to derive an overall accuracy estimate, polygons were scored as follows:

- '100%' (*i.e*. correctly typed) where there was agreement between the tallest stratum tree species recorded at field sites and PCT descriptions for the mapped polygons
- '50%' when the polygon appeared incorrectly typed but a corresponding PCT appeared within 100 m and/or the species was otherwise considered to be both diagnostic and a dominant component of the overstorey but was sub-dominant at the assessed site, or
- '0%' (*i.e.* not correctly typed) when no conformity was apparent.

An estimate of mapping accuracy along with an associated 95% CI was then determined by dividing the sum of scores by the number of contributing field sites. As there are no recent field sites within

[1] Primary Food Tree requires preferential use by koalas to be significantly higher than other congeners with utilisation that is independent of size class (Phillips *et al*. (2000) refers) whereas a Secondary Food Tree also requires a level of use that is significantly higher than other congeners but with a utilisation model that is typically size-class dependent (Phillips and Callaghan (2000) refers).

the Sydney Basin, accuracy of the mapping layer in the Northern Rivers region is considered indicative of mapping accuracy NSW-wide.

2.3. Historical Records Analysis

Koala sightings records were downloaded from BioNet and ALA databases for the study area. These two data sets were variously linked and/or displayed overlap. Once the extent of these relationships was determined and duplications were removed, a final data set of records were merged and uploaded into a Microsoft Access database where *inter alia* they were checked for the presence of radiotracking data (which can produce hundreds of records for a single animal) and spatial context. Radiotracking data was determined where the column "Sightingnote" in the attribute table had the name of the animal and "Collared as part of the Southern Highlands Koala Conservation Project" in the description. For radiotracking data, a single data point was used for each individual koala for each 2 km grid-cell in which that koala was present, in order to prevent swamping the data. The resulting data set was then partitioned chronologically to enable comparisons *post* 2004 - the time frames 2004 – 2009, 2010 – 2015 and 2016 – 2021 approximating the time intervals for the most recent three koala generations, the measure of which is estimated to be approximately six years (Phillips 2000). This approach was taken in order to express the results of analyses in the context of the 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).

2.3.1. Extent of Occurrence (EoO)

The EoO is the area contained within the shortest continuous boundary that can be drawn to encompass all species records for a defined time period and locality. This 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 for each of the time periods and localities being considered. The following EoOs were determined:

a) all koala records (Historical EoO),

b) koala records from the date of first record to 2003,

c) koala records for the most recent three koala generations (2004 – 2021).

2.3.2. Area of Occupancy (AoO)

The AoO is an estimate of the proportional area within the EoO and study area boundary that is occupied by the taxon of interest, reflecting the fact that a species will not usually be occupying the entire EoO. Historical koala records must be carefully considered when estimating the AoO because of their tendency to typically reflect observer density more so than koala density, the latter being best assessed via more systematic, unbiased survey effort. In most areas, there is also a tendency for the reporting rate to increase over time. Consequently, and unless corrected prior to analyses such as we have detailed below, range parameters such as AoO can potentially miscalculate the scale of any change that has occurred over time.

In order to estimate the AoO, a 2 km x 2 km fixed-grid overlay constrained by the boundaries of the historical EoO was used to create a series of cells for sampling purposes, the primary assessment tool being whether or not a koala record for the period being investigated was either present or absent within a cell. In order to correct for changes in reporting frequency over time, the numbers of koala records utilised for analysis in each instance was determined with regard to the smaller representative data set being analysed (*i.e.* if there were only 100 records in one of the two data sets being compared and the other was represented by 250 records, then 100 records were randomly selected from the latter data set). Fifty percent (50%) of the grid-cells in the fixed-grid overlay were then randomly selected through each of 10 iterations for each time period of interest. Following each iteration, the number of cells within which koala records were present were recorded to estimate the proportion of the historical EoO that was occupied. A mean AoO with bounds could then be calculated for both time periods, the associated variances tested for homogeneity prior to being compared using two-sample *t*-tests. Area of Occupancy estimates were calculated for the following time periods:

a) from the date of first record to 2003,

b) for the most recent three koala generations (2004 – 2021).

2.3.3. Generational Persistence (GP)

Koala records were examined for re-occurrence in the same localised area over time frames that extended beyond the life-spans of individual koalas in order to show the location of long-standing resident populations. For the purposes of GP assessment, 'localised' occurrence was considered to be the area falling within a 2 km x 2 km grid cell. Generational Persistence was determined for each grid-cell based on a requirement for the presence of one or more koala records for each of the three most recent koala generations 1 (2016 – 2021), 2 (2010 – 2015) and 3 (2004 – 2009). The initial timeframes were then compared to generations 4 (1998 - 2003), 5 (1992 - 1997) and 6 (1986 - 1991) as well as generations 7 (1980 - 1985), 8 (1974 - 1979) and 9 (1968 - 1973) in order to extend the timeframe over which change is measured.

2.4. Threats analysis

2.4.1. Vehicle strike

Vehicle strike was determined using the BioNet fauna sightings database by using the "Observation Type" column in the attributes table of koala sightings records. Codes "R" and "RI" are defined as road kill. Data was partitioned into koala generation times and the location of these vehicle strikes was mapped onto the study area, intersected with LGA's. Those LGA's with the highest numbers of vehicle strikes on koalas were identified.

2.4.2. Dog attack

Dog attack was determined using the BioNet fauna sightings database by using the "Observation Type" column in the attributes table of koala sightings records. Codes "D" and "DI" are defined as dog kill. Data was partitioned into koala generation times and the location of dog kills was mapped onto the study area, intersected with LGA's. Those LGA's with the highest numbers of dog kills were identified.

2.4.3. 2019 / 2020 fire mapping

The Google Earth Engine Burnt Area Map (GEEBAM) v3.1 shapefile was intersected with LGAs across the study area to display results in the context of the 2019 / 2020 extreme fire events which consisted of wild fires which burnt across NSW during late 2019 and early 2020[2]. Mapping was downloaded from SEED spatial database (https://datasets.seed.nsw.gov.au/dataset/). The associated fire categories used in layer are described in the NSW Government GEEBAM Factsheet dated 23rd March 2020 in Table 3 of that factsheet, now modified and presented below (**Table 3)**.

[2] GEEBAM *pre* fire image dates 01/08/2019-15/10/2019 and *post* fire image dates 01/01/2020-23/03/2020.

Table 3. Fire intensity categories (0 – 6) represented in the 'Burnt Area Class' column, with associated descriptions of each class. Thresholds were selected based on air photo interpretation to summarise the data.

Pixel Value	Burnt Area Class	Description
0	0 - No Data	No data provided.
2	2 - Low	Burnt understorey with unburnt canopy. For grasslands without a canopy it represents unburnt grass.
3	3 - Medium	The canopy is partially burnt. A mix of burnt and unburnt canopy vegetation. May act as a refugia within the fire ground for native fauna. The understorey may be burnt.
4	4 - High	The canopy and understorey are likely to be completely burnt.
5	5 - Very High	The canopy or highest stratum have been completely consumed.
6	6 - Not native vegetation	Not mapped as native vegetation*.

* Does not define fire intensity.

3. Results

3.1. Preferred Koala Habitat (PKH) mapping

There is 1,605,511 ha of koala habitat mapped across the study area, accounting for 44.32% of the total land surface area. Within each of the LGAs the percentage of PKH ranges from 0% in the City of Sydney, Inner West, North Sydney and Waverley, to 78.50% of the portion of Mid-Western Regional Council that intersects the study area (**Table 4, Figure 2**). The koala habitat category with the greatest coverage across the study area is Secondary C (2C) accounting for 21.67% of the land surface area, followed by Secondary B (2B) at 17.37%, Secondary A (2A) at 3.34% and Primary at 1.91%. The proportion of all PKH across the study area which is mapped in National Parks and State Forests is 51.45% and 4.37% respectively. Conversely the proportion of National Parks within the study area which comprise PKH is 57.44% and the proportion of State Forests which comprise PKH is 53.80%, **Appendix 2** displays all PCTs which are mapped within the study area with their associated PKH categories and **Appendix 3** shows the proportions of each PKH category, split by LGAs and land tenure where known (National Parks and State Forest).

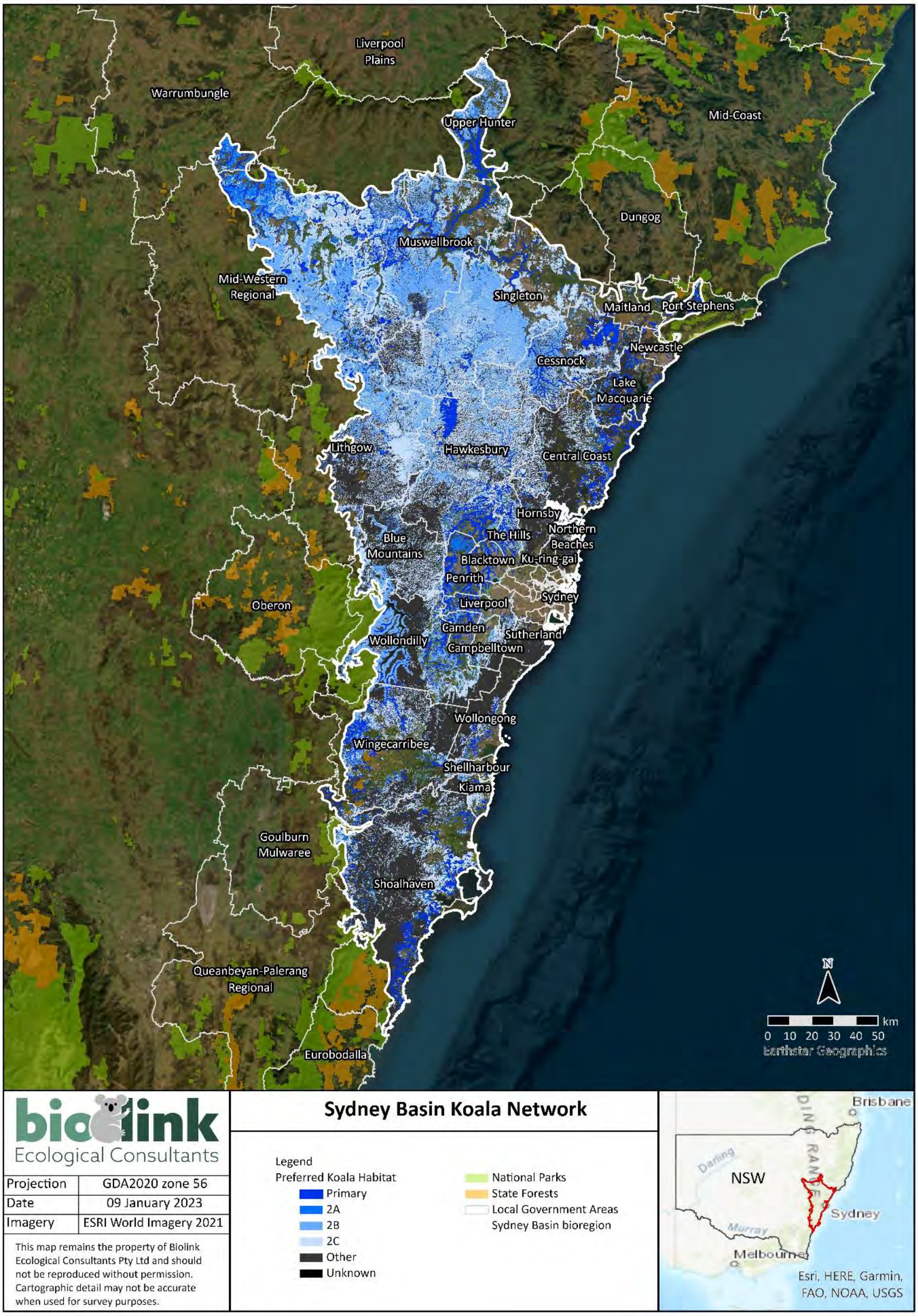

Figure 2. NSW vegetation mapping for the study area, coded according to Preferred Koala Habitat (PKH) classifications. Note that "Primary" is the only category with polygons outlined to ensure visibility because it is so geographically limited.

Table 4. NSW vegetation mapping layer showing the area (ha) of koala habitat categories in each Local Government Area (LGA) and the total for the study area, with the percentages of the total landmass for each Preferred Koala Habitat (PKH) category. See Section 2.3.1 for descriptions of each of the koala habitat categories. Small discrepancies in column totals may be present due to the rounding of decimals.

LGA	Preferred Koala Habitat (PKH) categories (ha)							% mapped vegetation	% PKH
	Primary	2A	2B	2C	Other	Unknown	**TOTAL**		
Bayside Council	1	19		1	66		**87**	1.85	0.45
Blacktown City Council	1,156	107	2,304		1,184		**4,751**	19.78	14.85
Blue Mountains City Council	53	1,447	9,483	37,578	77,297		**125,858**	95.02	36.66
Camden Council	893	15	3,815	28	248		**5,000**	24.89	23.65
Campbelltown City Council	127	117	3,014	6,688	7,693		**17,641**	56.68	31.96
Canterbury-Bankstown Council	6	87	82	167	326		**668**	6.01	3.08
Central Coast Council	3,075	1,668	3,736	30,870	90,771		**130,120**	72.13	21.81
Cessnock City Council	5,296	5,185	43,070	54,816	49,360		**157,727**	80.27	55.15
City of Canada Bay Council				18	15		**33**	1.68	0.91
City of Parramatta Council	12	44	19	224	425		**723**	8.63	3.56
Council of the City of Sydney					1		**1**	0.05	0.00
Cumberland Council		48	59	0	57		**164**	2.29	1.49
Dungog Shire Council		32		191	422		**645**	35.31	12.23
Eurobodalla Shire Council	8			121	225		**354**	71.12	25.95
Fairfield City Council	90	216	711		33		**1,050**	10.34	10.01
Georges River Council	3	2		82	205		**292**	6.63	1.97
Goulburn Mulwaree Council	295	1,143	113	3,228	9,519		**14,299**	71.44	23.88
Hawkesbury City Council	7,707	407	45,997	104,324	90,945		**249,379**	89.86	57.09
Inner West Council					9		**9**	0.25	0.00
Ku-ring-gai Council				699	2,664		**3,363**	39.38	8.18
Lake Macquarie City Council	2,547	3,079	3,626	2,153	32,858		**44,263**	58.59	15.10
Lane Cove Municipal Council				11	110		**121**	11.61	1.09
Lithgow City Council	1,436	6,952	49,302	76,544	80,204		**214,439**	95.76	59.94
Liverpool City Council	1,028	719	4,366	2,345	2,515		**10,974**	35.85	27.64
Liverpool Plains Shire Council		6	249	106	89		**449**	69.99	56.15
Maitland City Council	261	457		1,609	3,824		**6,151**	17.36	6.57
Mid-Coast Council		60		68	79		**207**	90.98	56.46

LGA	Preferred Koala Habitat (PKH) categories (ha)							% mapped vegetation	% PKH
	Primary	2A	2B	2C	Other	Unknown	TOTAL		
Mid-Western Regional Council	8,373	42,277	107,232	70,287	10,268	12	**238,449**	82.04	78.50
Mosman Municipal Council				3	127		**130**	15.61	0.38
Muswellbrook Shire Council	10,551	12,916	95,550	74,213	27,611		**220,841**	70.95	62.08
Newcastle City Council	77	177		957	5,216		**6,427**	32.46	6.12
North Sydney Council					46		**46**	4.36	0.00
Northern Beaches Council	58	106	21	2,375	12,633		**15,193**	59.36	10.00
Oberon Council		3	43	1	143		**190**	99.95	24.68
Penrith City Council	2,388	4,339	4,454	1,576	2,482		**15,240**	37.74	31.59
Port Stephens Council	1,094	1,074	163	1,932	6,079		**10,343**	41.83	17.24
Queanbeyan-Palerang Regional Council	1	256	318	927	4,357		**5,859**	99.88	25.59
Randwick City Council	2	7			217		**226**	6.33	0.26
Ryde City Council				93	346		**439**	10.85	2.30
Shellharbour City Council	103	464	1,301	2,360	1,902		**6,130**	39.81	27.46
Shoalhaven City Council	7,103	9,831	3,004	64,842	212,270	1	**297,051**	83.29	23.77
Singleton Council	2,821	9,681	120,956	114,747	42,979	1	**291,184**	74.95	63.89
Strathfield Municipal Council				1	4		**6**	0.43	0.11
Sutherland Shire Council	13	80	110	2,092	22,312		**24,607**	70.13	6.54
The Council of the Municipality of Hunters Hill				3	36		**39**	6.90	0.54
The Council of the Municipality of Kiama	77	22	1,084	6,577	6,924		**14,684**	57.05	30.15
The Council of the Shire of Hornsby	131	29	2,006	5,202	29,697		**37,065**	78.10	15.52
The Hills Shire Council	2,100	3	5,175	12,787	5,055		**25,120**	65.04	51.96
Unincorporated - Sydney Harbour Area				1	62		**62**	2.43	0.03
Upper Hunter Shire Council	3,359	4,796	42,214	31,276	7,488		**89,133**	62.79	57.51
Warrumbungle Shire Council	462	6,942	2,182	742	57		**10,386**	53.47	53.18
Waverley Council					3		**3**	0.32	0.00
Willoughby City Council				44	274		**318**	14.33	1.96
Wingecarribee Shire Council	3,724	5,064	20,649	37,428	86,328	1	**153,194**	65.75	28.70
Wollondilly Shire Council	2,179	678	51,980	26,675	71,824		**153,336**	77.54	41.22
Wollongong City Council	466	520	1,033	6,921	39,169		**48,110**	67.61	12.56
Woollahra Municipal Council	1				38		**39**	3.26	0.05
TOTAL	**69,078**	**121,079**	**629,419**	**785,935**	**1,047,096**	**14**	**2,652,620**	**73.22**	**44.32**

3.1.1. Mapping accuracy

A 30-tree sample obtained from 349 field sites surveyed by Biolink was used to ground truth the accuracy of the "NSW Version cCM11m1" vegetation mapping layer, resulting in an overall accuracy estimate of 69.77% ± 2.07% (SE) (**Appendix 4).** Of the 349 vegetation polygons which intersected a field site, 200 scored '1' meaning that they were correctly typed (agreement between the tallest stratum tree species recorded at field sites and PCT descriptions for the mapped polygons; 87 scored '0.5' meaning that they were in partial agreeance (incorrectly typed but a corresponding PCT appeared within 100m); and 62 scored '0' meaning that they were incorrectly typed (no conformity was apparent).

3.2. Historical Records Analysis

There were 8,011 historic koala records within the study area, the chronological distribution of these records is illustrated in **Figure 3**. The earliest record is from 1884, located 6.6 km north-west of Nowra, within the Shoalhaven LGA. The number of annual records substantially increases from 1980 onwards, with three distinct peaks occurring in the years 1991 (*n* = 232), 2004 (*n* = 369) and 2021 (*n* = 531) (**Figure 3**). There was a clear decline in the number of records between 2005 – 2013, a period which averaged only 115 records annually, representing a >65% decline when compared to the preceding year (2004). It should be noted that 2022 was an incomplete year at the time of analysis so for generational partitioning purposes, generation 1 finishes at the end of 2021. By partitioning the records into koala generations (6-year periods), it is revealed that the most recent koala generation (generation 1: 2016-2021) has 2,571 koala records, the largest concentration of which are situated west of Wollongong in Wingecarribee, with the remaining records scattered across the central and eastern portions of the study area (**Figure 4**).

3.2.1. Extent of Occurrence (EoO)

The records indicate an historical EoO (all records) of approximately 4,884,529 ha, this being the area captured by a MCP with vertices that intersect the outermost koala records in the dataset for the time-period 1884 – 2021 (**Figure 4**). The distribution of these records further imply that the EoO has changed little over time, being estimated at 4,775,056 ha for the period 1884 – 2003 and 4,726,088 ha for the three most recent koala generations (2004 - 2021) with the slight reduction due to a lack of records in the very north of the study area (**Figure 5**).

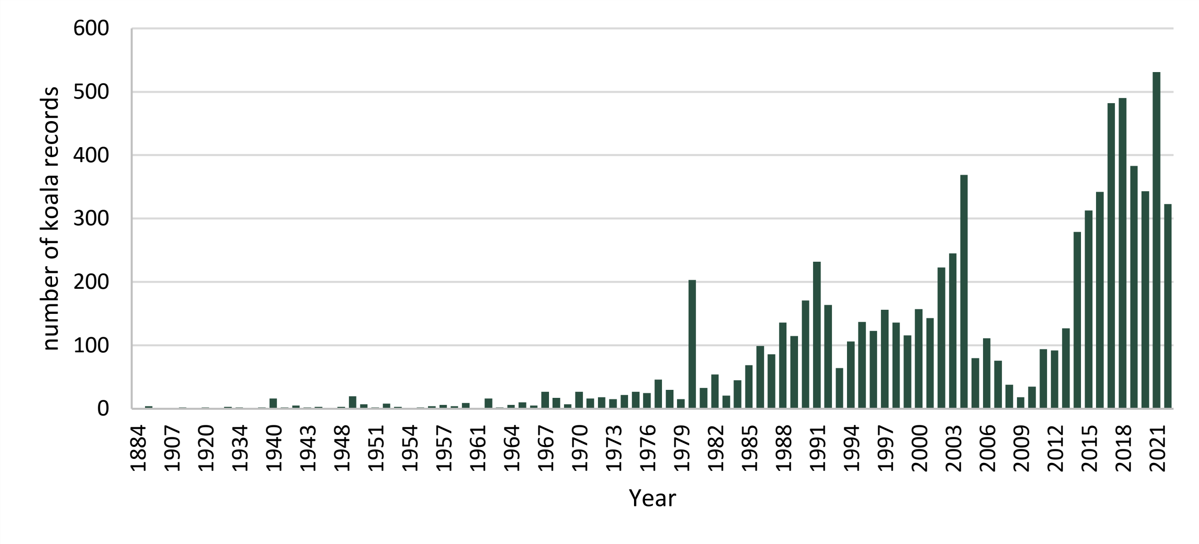

Figure 3. Frequency histogram detailing chronological distribution of 8,011 koala records for Sydney Basin bioregion for the period 1884-2022.

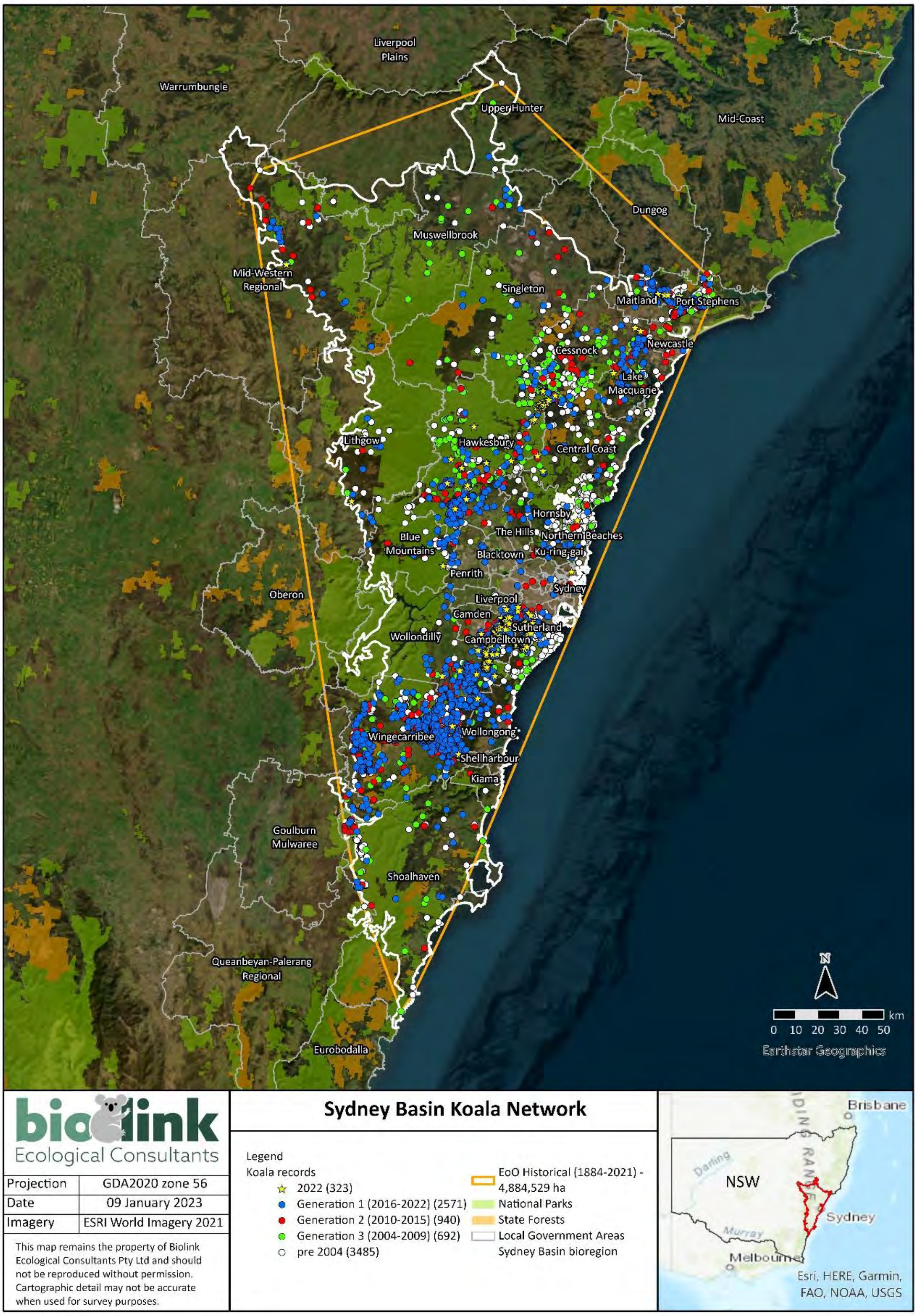

Figure 4. Distribution of 8,011 koala records across the study area, with 2022 records (yellow stars), generation 1: 2016-2021 (blue circles), generation 2: 2010-2015 (red circles), generation 3: 2004-2009 (green circles) and records prior to 2004 (white circles). The historical Extent of Occurrence (EoO) (1884-2021) is denoted by an orange polygon.

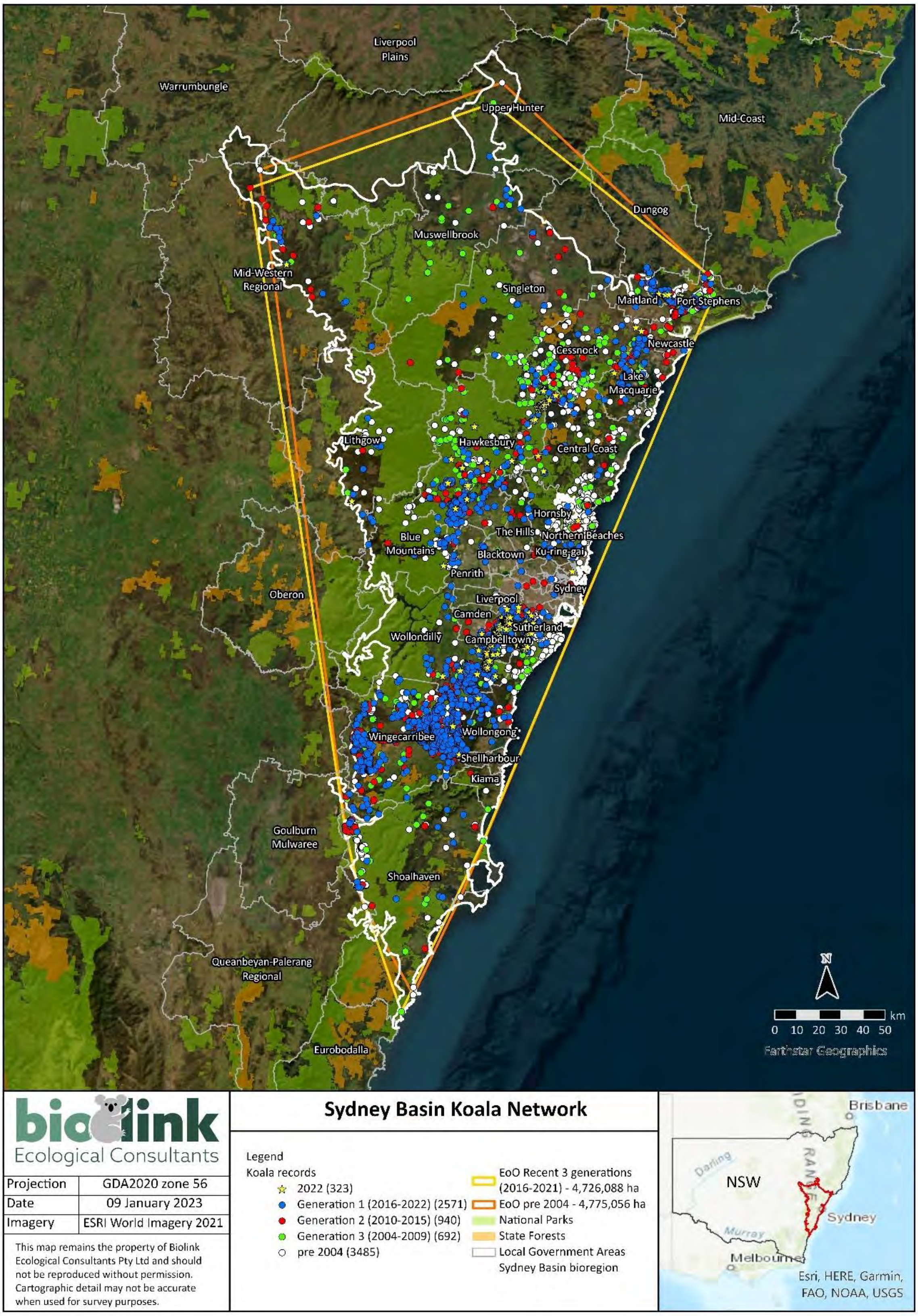

Figure 5. Distribution of 8,011 koala records across the study area, with 2022 records (yellow stars), generation 1: 2016-2021 (blue circles), generation 2: 2010-2015 (red circles), generation 3: 2004-2009 (green circles) and records prior to 2004 (white circles). The most recent three generations Extent of Occurrence (EoO) (2016-2021) denoted by light orange polygon and pre 2004 EoO denoted by darker orange polygon.

3.2.2. Area of Occupancy (AoO)

Nine thousand, four hundred and seventy-one (9,471) 2 km x 2 km grid-cells covered the historical EoO, intersected with the study area. The occupancy rate was estimated from 3,485 records for the time-period 1884 – 2003 compared to a subset of 3,485 randomly selected records for the time-period 2004 – 2021. Randomly sampling 50% of the 9,471 grid cells within the historical EoO over 10 iterations for each of these two time periods returned the following results:

1884 – 2003: AoO estimated at 7.46% ± 0.06% (SE) of available habitat

2004 – 2021: AoO estimated at 9.84% ± 0.11% (SE) of available habitat

A comparative analysis of the data-sets informing the preceding outcomes implies that occupancy has been consistently low since records began and there has been a small but significant increase in the proportional amount of habitat being utilised by koalas when comparing the last three koala generations (2004 - 2021) to the period preceding this (1884 - 2003) (Levene's test: F = 3.803, P = 0.030, 9*df*; t = 18.897, P < 0.001, 13 *df*).

3.2.3. Generational Persistence (GP)

For the three koala generations covering the time period 2004 – 2021, 91 of the 9,470 2 km x 2 km grid cells reflecting the historical EoO contained one or more koala records for generations 1 (2016 – 2021), 2 (2010-2015) and 3 (2004 – 2009). This result (*i.e*. 91/9,470) implies that approximately 0.96% of the study area was supporting resident koala populations over this time period. **Figures 6a, 6b, 6c** and **6d** illustrate the distribution of areas of GP across the study area, with the largest interconnected area (1,800 ha) occurring in the vicinity of Campbelltown LGA extending into the northern parts of Wollondilly LGA with more scattered GP moving into Liverpool LGA to the north and Sutherland LGA to the east. Another consolidated area of GP is located at the northern perimeter of the study area, in Port Stephens LGA. Wingecarribee LGA supports a large amount of interconnected GP, stretching from Mount Murray in the south to Mount Lindsay in the north, as well as more scattered GP throughout the remainder of the LGA. Sparser, isolated areas of GP are situated in the central and northern parts of the study area around Hawkesbury, Cessnock, Lake Macquarie and Shoalhaven. Within the study area there are 12 LGAs (of a possible 58) that have GP when considering generations 1, 2 and 3 (**Table 5**) ranging from 111 ha in The Hills to 6,392 ha in Wingecarribee. Of these 12 LGAs, there are four grid cells of GP that are represented in each of generations 1, 2, 3, 4, 5, 6, 7, 8 and 9 showing very long-term GP, all of which are located in Port Stephens LGA with two cells at Medowie and two cells at Raymond Terrace (**Figure 6b**). There are eight grid cells of GP that are represented in each of generations 1, 2, 3, 4, 5 and 6, seven of which are located in Campbelltown LGA and one of which is at the intersection of Liverpool, Sutherland and Canterbury-Bankstown LGAs (**Figure 6c**).

There are 25 grid cells that have lost GP, *i.e.* do not have records for generations 1, 2 and 3, but do have records for either generations 4, 5 and 6, and/or 7, 8 and 9 (**Table 5** and **Figures 6a, 6b, 6c, 6d**). These are spread across 12 LGAs and range in area from 53 ha within Cessnock LGA to 2,747 ha in the Central Coast LGA. Three LGAs have lost GP entirely, those being the Central Coast in which there is an interconnected patch of six grid cells (2,400 ha) extending from Patonga in the west to Pearl Beach in the east and overlapping with the southern parts of Brisbane Water National Park; Lithgow with one grid cell (400 ha); and Maitland LGA with a partial overlap of one grid cell.

Table 5. The 12 Local Government Areas (LGAs) that show Generational Persistence (GP) by area with long term GP (at least one record in each of generations 1-9), medium-term GP (at least one record in each of generations 1-6), and recently detected GP (at least one record in each of generations 1-3). Loss of GP (two additional LGAs) indicates that there was previous GP in generations 4-6 and / or generations 7-9 but without GP in generations 1-3.

LGA	long term GP	medium term GP	Recent GP	loss of GP
Campbelltown City Council*		2,800 ha	4,935 ha	1,600 ha
Canterbury-Bankstown Council		125 ha		
Central Coast Council				2,747 ha
Cessnock City Council			800 ha	53 ha
Hawkesbury City Council			1,489 ha	400 ha
Lake Macquarie City Council			400 ha	400 ha
Lithgow City Council				400 ha
Liverpool City Council		32 ha	713 ha	399 ha
Maitland City Council				227 ha
Port Stephens Council*	1,600 ha		2,400 ha	1,373 ha
Shoalhaven City Council			400 ha	
Sutherland Shire Council		244 ha	400 ha	1,601 ha
The Hills Shire Council			111 ha	
Wingecarribee Shire Council			6,392 ha	400 ha
Wollondilly Shire Council			3,560 ha	400 ha
TOTAL	**1,600 ha**	**3,200 ha**	**21,600 ha**	**10,000 ha**

* LGA has a Comprehensive Koala Plan of Management (CKPoM).

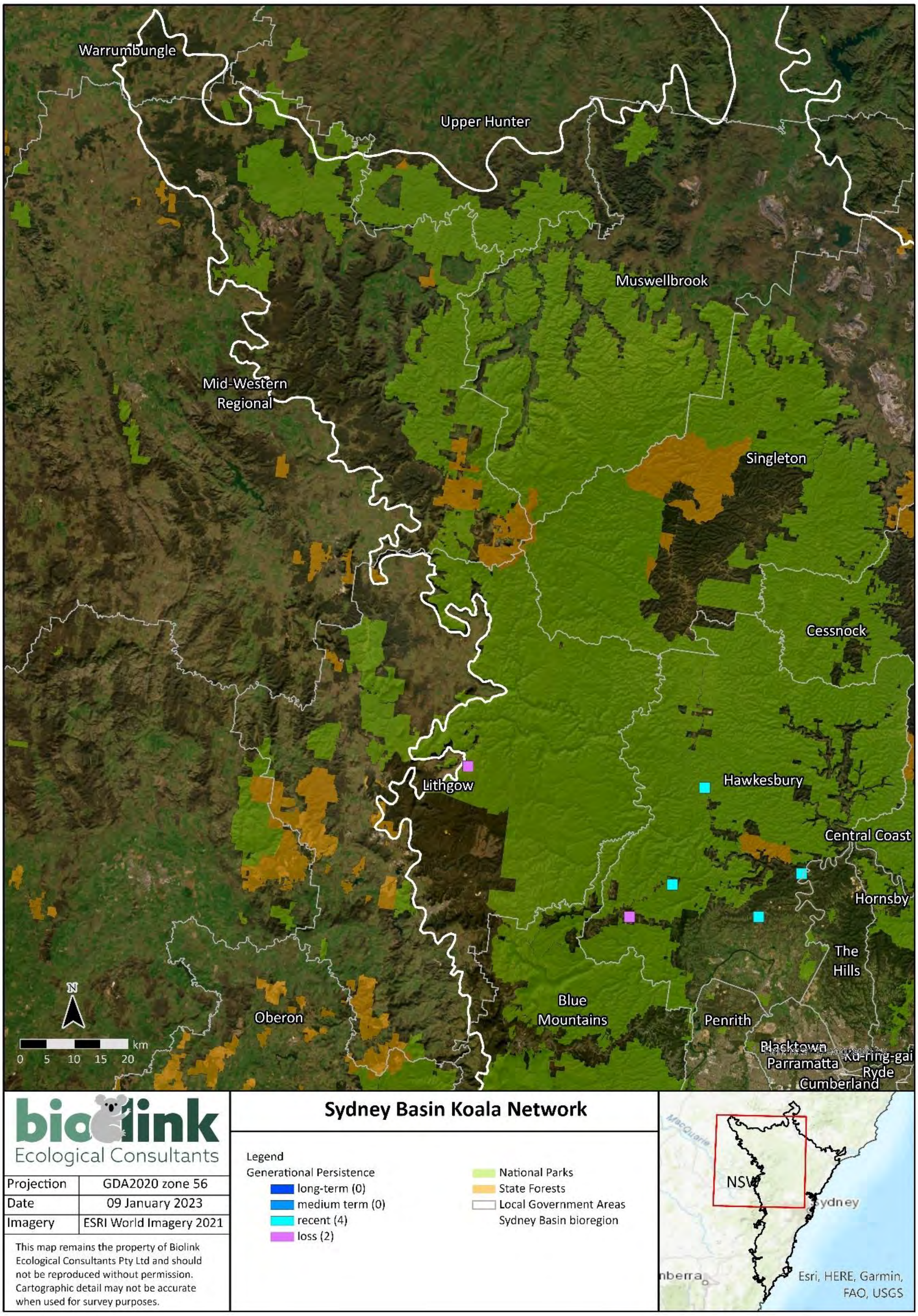

Figure 6a. Areas of Generational Persistence (GP) across the north-west of the study area (see inset for location indicated by red box), showing GP (generations 1-3: aqua). Areas which had GP in generations 4-6 and / or generations 7-9 but lack GP in generations 1-3 are shown in purple.

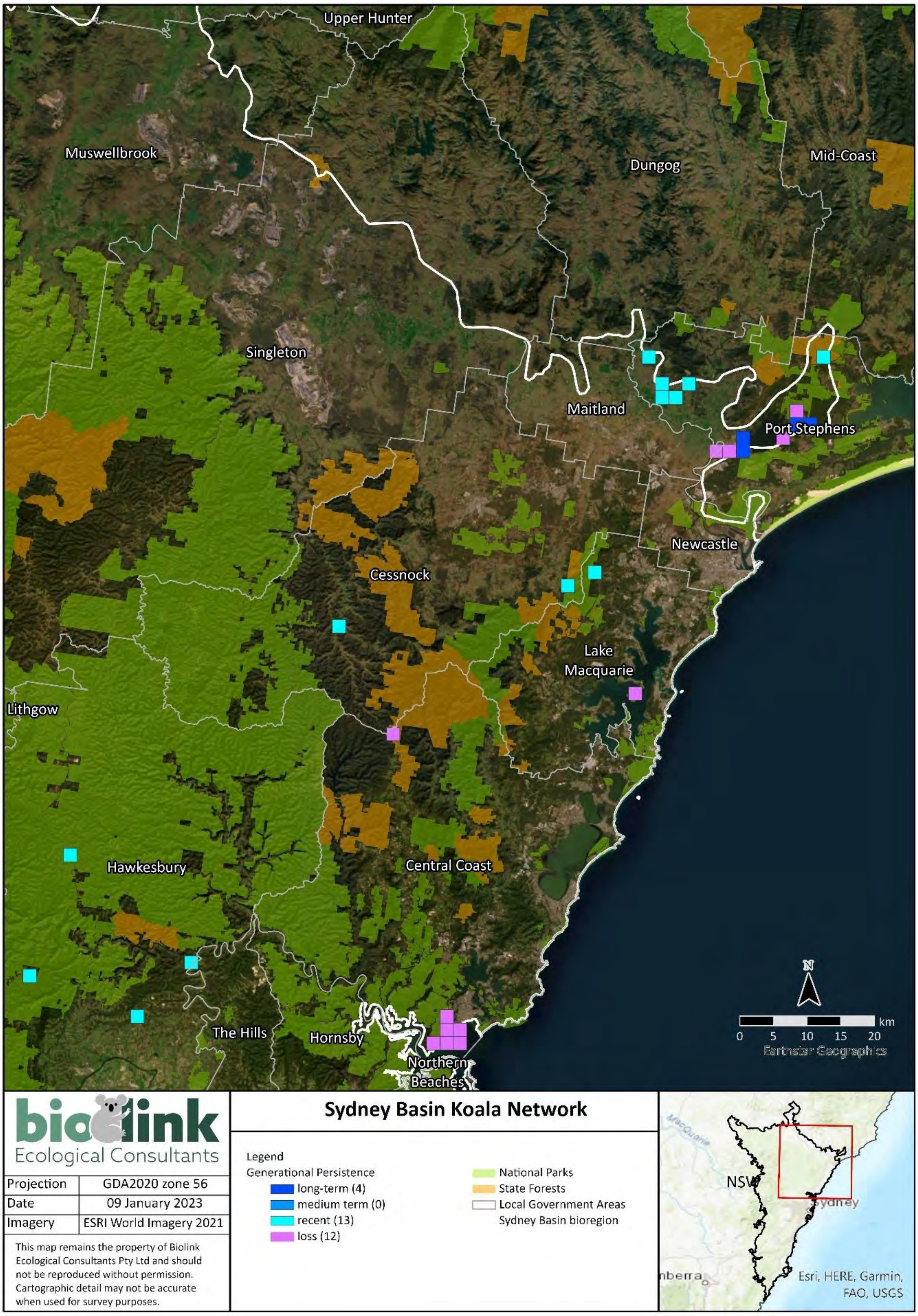

Figure 6b. Areas of Generational Persistence (GP) across the north-east of the study area (see inset for location indicated by red box), showing long term GP (generation 1-9: dark blue), and more recently detected GP (generations1-3: aqua). Areas which had GP in generations 4-6 and / or generations 7-9 but lack GP in generations 1-3 are shown in purple.

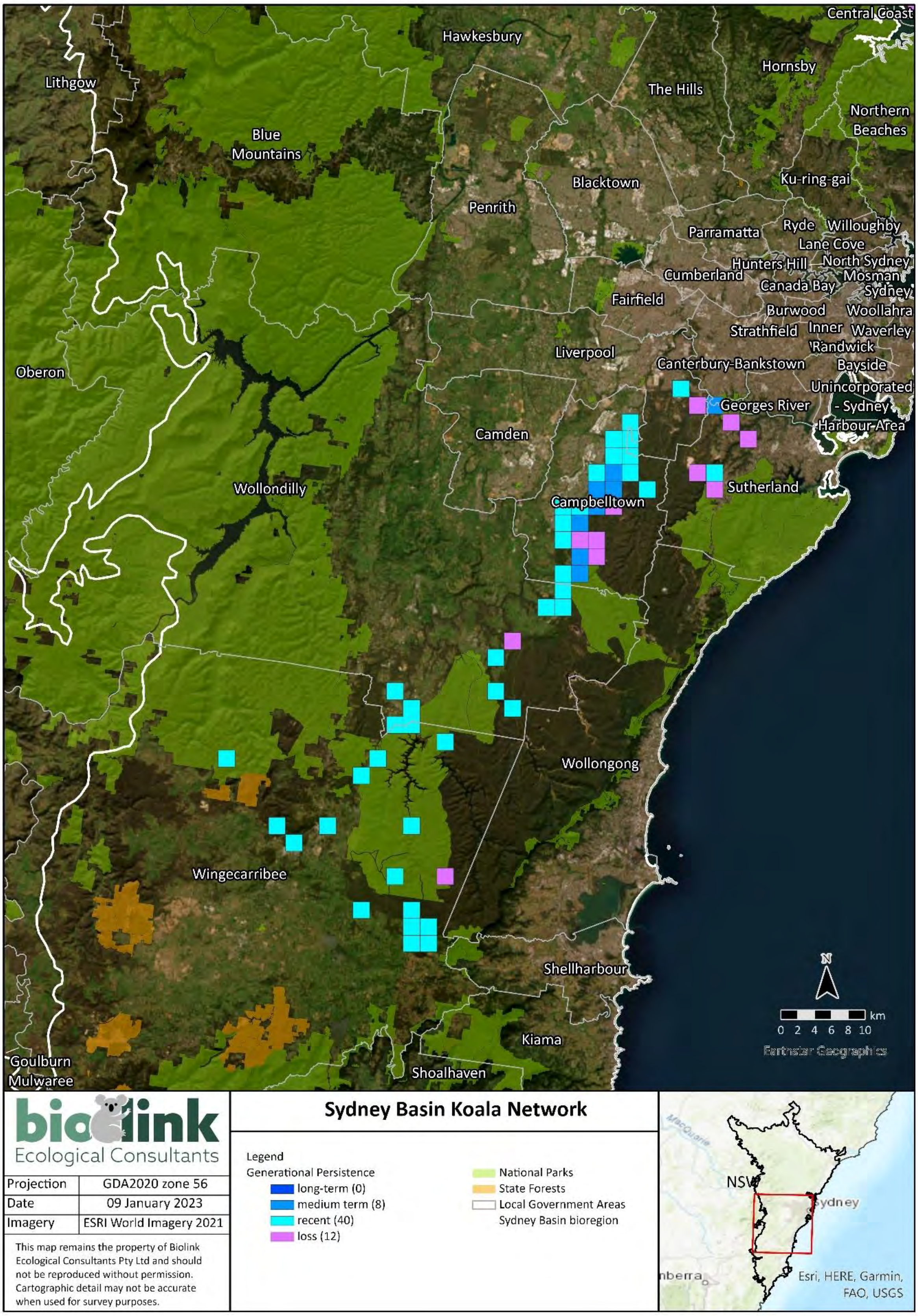

Figure 6c. Areas of Generational Persistence (GP) across the central portion of the study area (see inset for location indicated by red box), showing medium term GP (generations 1-6: medium blue) and more recently detected GP (generations 1-3: aqua). Areas which had GP in generations 4-6 and / or generations 7-9 but lack GP in generations 1-3 are shown in purple.

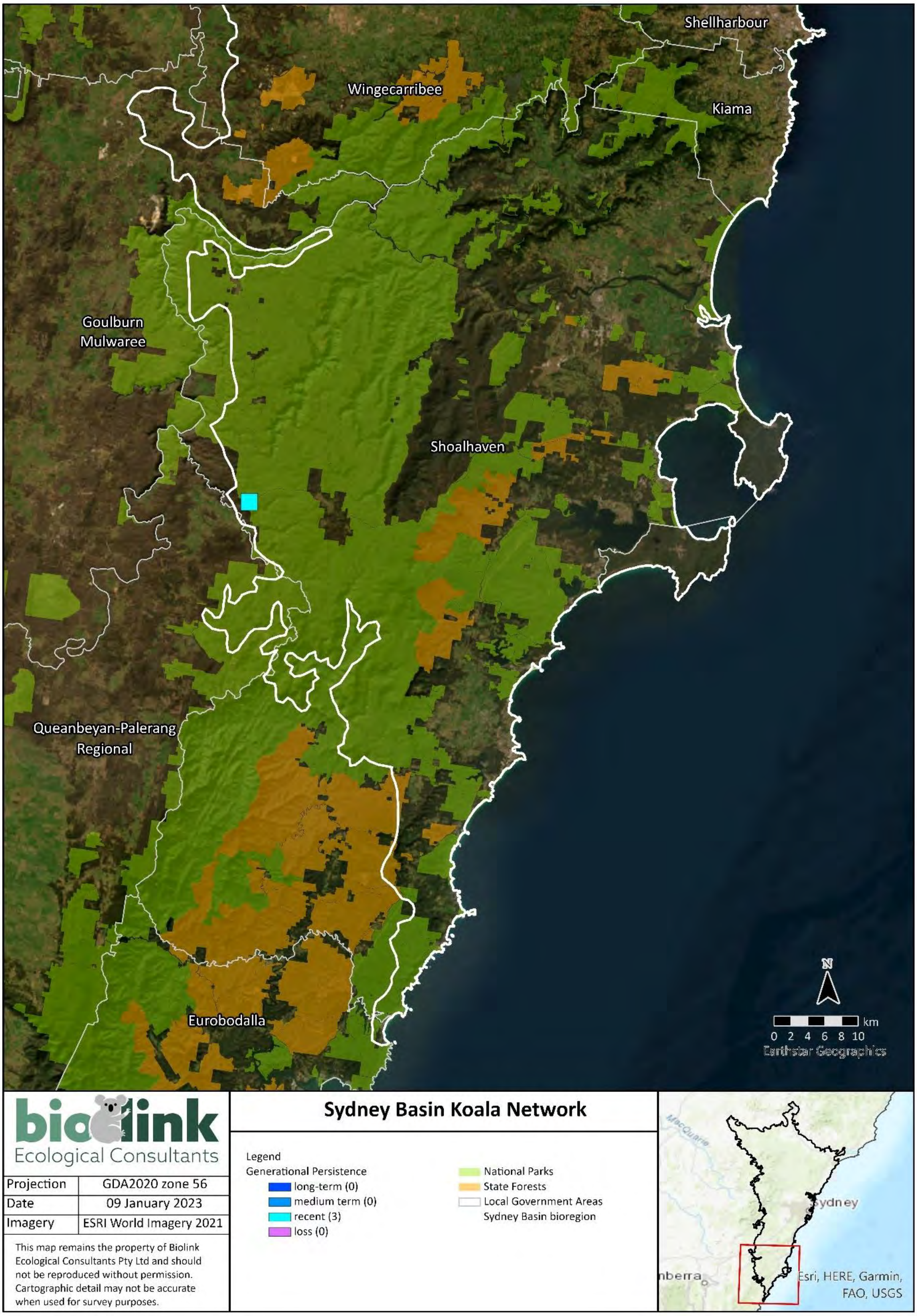

Figure 6d. Areas of Generational Persistence (GP) across the southern portion of the study area (see inset for location indicated by red box), showing GP (generations 1-3: aqua).

3.3. Threats analysis

3.3.1. Vehicle strike

There were 306 koala records downloaded from BioNet that were classified as vehicle strike, with 81.37% (*n* = 249) of these recorded over the last three koala generations (2004 – 2021). Vehicle strikes were distributed amongst 21 LGAs, ranging from a single vehicle strike in each of eight LGA's (Blacktown, Central Coast, City of Sydney, Dungog, Lithgow, Maitland, Northern Beaches and Shellharbour) to 83 recorded in Wollondilly LGA (**Table 6**). The distribution of vehicle-strikes within the study area is illustrated in **Figure 7**. We note that this is likely to be an underestimate with more accurate data currently being sought from the NSW Department of Planning and Environment (DPE).

Table 6. The number of vehicle-strikes within each Local Government Area (LGA) partitioned into koala generations (a period of six years).

Local Government Area	2022	Generation 1 (2016-2021)	Generation 2 (2010-2015)	Generation 3 (2004-2009)	*pre* 2004	Grand Total
Blacktown City Council		1				1
Blue Mountains City Council					2	2
Campbelltown City Council	2	39	22	3		66
Central Coast Council				1		1
Cessnock City Council		3	1	1		5
Council of the City of Sydney			1			1
Dungog Shire Council			1			1
Hawkesbury City Council		3	8	1	3	15
Lake Macquarie City Council		4	1		2	7
Lithgow City Council		1				1
Liverpool City Council		4	2		2	8
Maitland City Council		1				1
Northern Beaches Council					1	1
Port Stephens Council		2	3	1	32	38
Shellharbour City Council			1			1
Shoalhaven City Council		1			2	3
Singleton Council		1			1	2
Sutherland Shire Council		20	4	1		25
Wingecarribee Shire Council		26	5	5	2	38
Wollondilly Shire Council	1	41	23	8	10	83
Wollongong City Council		3	1			4
TOTAL	**3**	**151**	**74**	**21**	**57**	**306**

Figure 7. Distribution of 306 vehicle-strike records (obtained from BioNet) within the study area, with Local Government Areas (LGAs) marked in thin grey outline and major roads marked in orange. 2022 records (yellow stars), generation 1: 2016-2021 (blue circles), generation 2: 2010-2015 (red circles), generation 3: 2004-2009 (green circles) and records prior to 2004 (white circles).

3.3.2. Dog attack

There were 53 koala records downloaded from BioNet that were classified as being associated with a dog attack. These were distributed amongst nine LGAs, ranging from single dog attacks recorded in both Hawkesbury and the Upper Hunter to 23 recorded in Campbelltown City Council (**Table 7**). The distribution of dog attacks within the study area is illustrated in **Figure 8**. We note that this is likely to be an underestimate with more accurate data currently being sought from the NSW Department of Planning and Environment (DPE).

Table 7. The number of dog attacks within each Local Government Areas (LGAs) partitioned into koala generations (a period of six years).

Local Government Area	2022	Generation 1 (2016-2021)	Generation 2 (2010-2015)	Generation 3 (2004-2009)	*pre* 2004	Grand Total
Campbelltown City Council		10	11	2		23
Cessnock City Council					3	3
Hawkesbury City Council		1	1	1		3
Northern Beaches Council					1	1
Port Stephens Council			4		13	17
The Council of the Shire of Hornsby					1	1
Upper Hunter Shire Council		1				1
Wingecarribee Shire Council			2			2
Wollondilly Shire Council			1		1	2
TOTAL	**0**	**12**	**19**	**3**	**19**	**53**

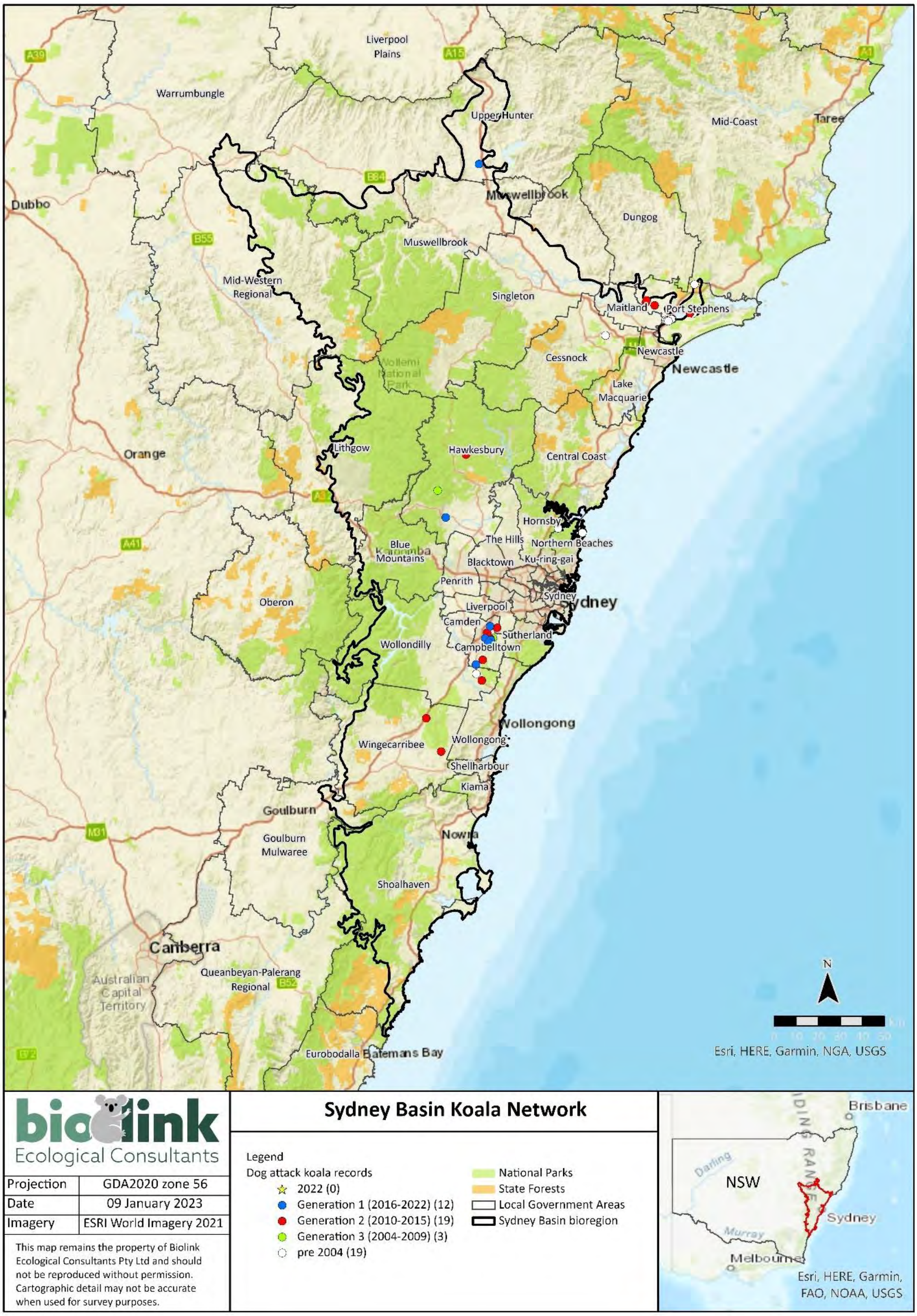

Figure 8. Distribution of 53 dog attack records (obtained from BioNet) within the study area, with Local Government Areas (LGAs) marked in thin grey outline and 2022 records (yellow stars), generation 1: 2016-2021 (blue circles), generation 2: 2010-2015 (red circles), generation 3: 2004-2009 (green circles) and records prior to 2004 (white circles).

3.3.3. 2019 / 2020 fire mapping

According to GEEBAM fire mapping, the 2019 / 2020 fire event impacted 35.51% of the total land mass of the study area (1,286,503 ha). Fire impacts are mapped across 31 of the 58 LGAs that intersect the study area ranging from very minor impacts in Fairfield LGA where two hectares (ha) was burnt, to Lithgow LGA which had 93.09% of its land mass burnt. Within Lithgow LGA 25.81% of the total land area is of category 3 (Medium) having its canopy partially affected and a further 69.56% had its canopy fully affected (category 4: High or 5: Very High) (**Table 8**, **Figure 9**). All LGAs supporting areas of GP had some fire impacts and the fire extent overlaps with areas of GP at several locations, perhaps most notably in Shoalhaven LGA where the sole cell of GP has been subject to 'High' and 'Very High' fire impacts. There were also fire impacts on areas of GP in Wollondilly, Wingecarribee and Hawkesbury LGAs and impacts which are proximal to one of the two cells of GP located in Cessnock LGA (**Figure 9**). In terms of impacts on National Parks and State Forests, the fire event burnt 993,754 ha (68.67%) of National Parks across the study area and 68,128 ha (52.28%) of State Forests. Considering PKH across the study area, 71.02% of PKH in National Parks was fire impacted, as was 56.67% of PKH in State Forests.

Table 8. Intersect of the 2019 / 2020 fire event with Local Government Areas (LGAs) across the study area displayed in terms of area impacted (ha). *** Indicates that the impacted LGA supports at least one recent cell of Generational Persistence (GP). Small discrepancies in the total (ha) are due to rounding errors.

LGA	2: Low (ha)	3: Medium (ha)	4: High (ha)	5: Very High (ha)	6: Non native vegetation (ha)	**TOTAL (ha)**	% burnt
Blacktown City Council	7	6	1		54	**68**	0.28
Blue Mountains City Council	5,058	13,617	13,938	22,751	5,449	**60,814**	45.91
Campbelltown City Council ***	0	4	4		11	**20**	0.06
Central Coast Council	8,680	12,300	5,523	1,902	690	**29,095**	16.13
Cessnock City Council ***	8,869	28,807	13,852	6,016	953	**58,497**	29.77
Cumberland Council		0	1	0	35	**36**	0.50
Eurobodalla Shire Council	9	11	22	6	14	**61**	12.23
Fairfield City Council		0	0		1	**2**	0.02
Goulburn Mulwaree Council	181	469	1,078	3,286	130	**5,144**	25.70
Hawkesbury City Council ***	24,798	93,089	45,299	31,752	3,748	**198,687**	71.60
Ku-ring-gai Council	0	0	0	1	0	**1**	0.02
Lake Macquarie City Council ***	442	513	469	285	157	**1,866**	2.47
Lithgow City Council	6,083	53,793	73,770	71,229	3,583	**208,458**	93.09
Liverpool City Council ***	8	21	29	16	13	**86**	0.28
Maitland City Council ***		1	0		15	**15**	0.04
Mid-Western Regional Council	3,251	19,245	31,140	9,500	653	**63,789**	21.95
Muswellbrook Shire Council	4,892	32,547	34,432	16,782	198	**88,850**	28.54
Northern Beaches Council	22	6	2	0	2	**32**	0.12
Oberon Council	0	30	70	90	0	**190**	100.00

LGA	2: Low (ha)	3: Medium (ha)	4: High (ha)	5: Very High (ha)	6: Non native vegetation (ha)	**TOTAL (ha)**	% burnt
Penrith City Council	24	156	75	1	31	**287**	0.71
Port Stephens Council ***	1	26	14	0	1	**42**	**0.17**
Queanbeyan-Palerang Regional Council	20	112	1,392	4,305	25	**5,855**	99.81
Shoalhaven City Council ***	17,192	18,368	42,529	138,835	8,187	**225,111**	63.12
Singleton Council	13,597	94,496	46,679	23,063	431	**178,266**	45.89
Sutherland Shire Council ***	23	17	1		1	**41**	0.12
The Council of the Shire of Hornsby	0	0			0	**1**	0.00
The Hills Shire Council ***	50	101	26		6	**183**	0.47
Upper Hunter Shire Council	162	2,806	4,465	3,215	10	**10,657**	7.51
Wingecarribee Shire Council ***	3,231	10,876	16,267	18,161	2,297	**50,833**	21.82
Wollondilly Shire Council ***	5,727	29,529	32,866	28,694	2,637	**99,453**	50.29
Wollongong City Council	13	36	13		1	**62**	0.09
TOTAL	**102,340**	**410,984**	**363,956**	**379,891**	**29,333**	**1,286,503**	

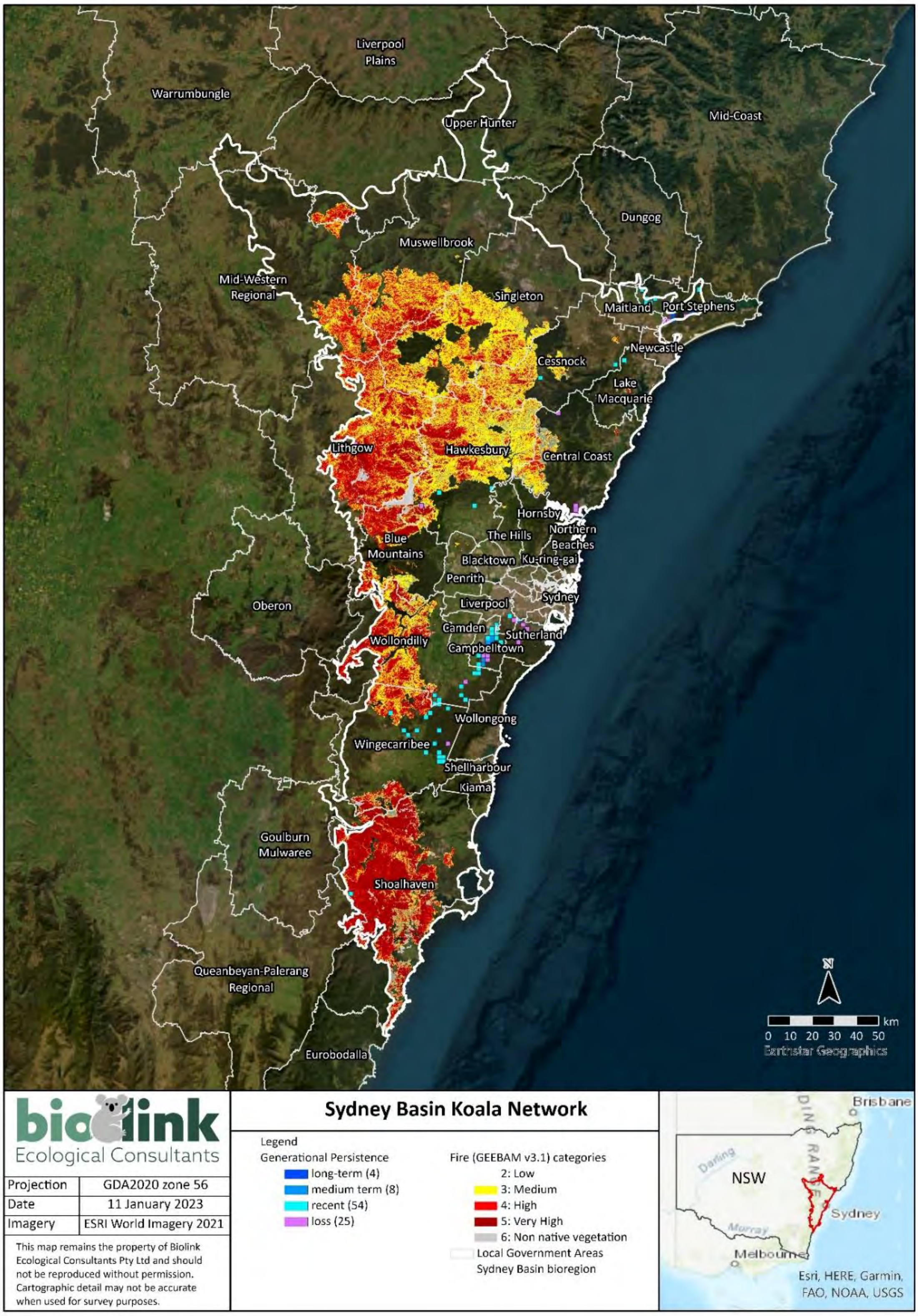

Figure 9. GEEBAM v.3.1 fire mapping for the 2019/2020 fire event across the study area, with Local Government Areas (LGAs) marked in grey outline. Fire intensity is represented by colours grading from white to dark red, indicative of low – very high burn intensity. Areas of Generational Persistence (GP) are overlaid, with long term GP (generation 1-9: dark blue), medium term GP (generations 1-6: medium blue) and more recently detected GP (generations 1-3: aqua). Areas which had GP in generations 4-6 and / or generations 7-9 but lack GP in generations 1-3 are shown in purple.

4. Discussion

Preferred Koala Habitat (PKH) is mapped extensively across the study area, totaling 1,605,511 ha and accounting for 44.32% of the total land surface area (**Figure 2**). The majority of this habitat falls into the Secondary C and Secondary B habitat categories which collectively account for 88.16% of the mapped PKH (**Table 4**). These habitat categories are typically associated with moderate to low underlying soil fertility and the dominance and sub-dominance of Secondary PKFTs. Such a landscape necessitates larger home ranges by koalas in order to meet their nutritional needs and lower associated carrying capacities when compared to areas of Primary habitat[3]. This outcome is aligned with independent measures of koala density across Campbelltown and Wollondilly LGAs which evidenced low densities of koalas in the order of 0.052 koalas ha^{-1} (DPIE 2019) and 0.056 koalas ha^{-1} (Biolink 2012).

While the amount of mapped koala habitat across the study area is extensive, occupancy by koalas is low as demonstrated by the key range parameter, *Area of Occupancy* (AoO). Across the total geographic range of koalas in the study area, 9.84% ± 0.11% (SE) of this area is estimated to be occupied by koalas for the time period 2004 – 2021. This measure has undergone a small but significant increase *post* 2003, rising from 7.46% ± 0.06% (SE) for the preceding period (1884 – 2003). This is likely to be due at least in part, to the recent recovery of the Campbelltown koala population which historic records analysis and field survey indicate is expanding to the north, west and south-west (Biolink 2016, Close and Durman 2019, Biolink 2021c). Despite these localised gains, overall koala occupancy remains low and Generational Persistence (GP) (the re-occurrence of koala records within a localised area over inter-generational time spans) indicates that long-standing resident and/or source populations are limited to ~1% of the study area (**Figures 6a-d**). The largest consolidated area of GP is located in Campbelltown and adjacent Wollondilly LGAs, with widespread but scattered GP in Wingecarribee LGA to the south. The portion of Port Stephens LGA which intersects the study area also shows very long-standing areas of GP which stretch back as far as nine consecutive koala generations, as well as more recently detected koala source populations in areas corresponding with the location of known koala hubs at Medowie, Tomago and Brandy Hill (Biolink 2017a). Isolated cells of GP occur in Sutherland, Liverpool, Hawkesbury, Cessnock, Lake Macquarie and Shoalhaven LGAs.

Generational Persistence (GP) assessment reveals the dynamic nature of koala occupancy across areas of suitable habitat and how the boundaries of these populations may change over time. Comparing

[3] Primary habitat is capable of sustaining > 0.5 koalas ha^{-1}, whereas Secondary C habitat sustains < 0.1 koalas ha^{-1}.

current cells of GP to those from previous time periods (prior to the most recent three koala generations) demonstrates that with the exception of Shoalhaven LGA, LGAs currently supporting local koala source populations evidence both gains and losses in areas of GP. In contrast to these shifting patterns of occupancy which are an expected consequence of metapopulation dynamics, is the complete loss of GP from the Central Coast LGA. This region previously supported an interconnected patch of six grid cells (2,400ha) of GP extending from Patonga in the west to Pearl Beach in the east and overlapping with the southern parts of Brisbane Water National Park. Not only do these areas no longer evidence GP, but there are no other areas within the LGA that now meet this criteria, with the closest cell of GP being ~35 km distant, at the intersect of The Hills and Hawkesbury LGAs (**Figure 6b**). Interrogation of BioNet records confirms a small number of recent koala sightings in Central Coast LGA (**Appendix 1**) and we suggest that while some koalas may remain in the area, the population has drastically declined and no longer appears to be acting as a local source population.

Generational Persistence (GP) assessment is a useful tool for identifying important source populations and quantifying change over time, however it does not encompass or show the location of every breeding aggregate of koalas across the study area. It is important to acknowledge that large numbers of koalas also exist outside the bounds of these cells. It is also important to appreciate that population boundaries are dynamic, as discussed above, and that areas of empty habitat or lower occupancy by koalas (*i.e.* non-GP) are vital in a landscape to allow populations to shift in response to external factors and/or to provide new home range areas for dispersing individuals. The advantage of GP assessment is that it focusses the attention of researchers, policy-makers and the community on areas which are most likely to be currently supporting long standing koala source populations, to inform management and ensure that potential impacts in these areas and their surrounds are rigorously examined. It is in this light that we consider the 2019/2020 extreme fire events.

All LGAs supporting koala GP had some impacts from the 2019/2020 bushfires and cells of GP overlapped with fire extent at several locations. In Shoalhaven LGA the sole cell of GP was subject to 'High' and 'Very High' fire severity and 218,663 ha (59.67%) of its koala habitat was fire impacted, raising the possibility that this source population has perished or been dramatically reduced (**Figure 9**). There has been no recorded koala sighting in Shoalhaven LGA since the fire events, the most recent records being six koala sightings in 2019 (**Appendix 1**). Hawkesbury LGA suffered substantive fire impacts with 198,687 ha, corresponding to 78.66% of its mapped koala habitat, burnt. Two of the four cells of koala GP in Hawkesbury overlap with fire extent (**Figure 9**). The majority of fires in Hawkesbury LGA burned in environmentally zoned lands, namely Wollomi and Yengo National Parks as well as Parr State Conservation Area. Wollondilly and adjacent Wingecarribee LGAs had impacts to 57.93% and

29.76% of their mapped koala habitat respectively (**Figure 9**). The fires which burned through these consolidated areas of habitat were also primarily in environmentally zoned lands, namely Blue Mountains, Nattai and Morton National Parks as well as Burragorang and Bargo State Conservation Areas. Areas of GP were largely proximal to these fires, though some cells were encompassed. One of the two cells of GP in Cessnock LGA was proximal to the fire extent.

The full impacts of the 2019 / 2020 fire events on koala populations in the study area are yet to be realised. *Pre* and *post* fire survey of koala populations on the north coast of NSW concluded a median reduction in koala occupancy of 71% across fire grounds with koala survival estimated to be five times greater in areas with partially burnt or unburnt canopies compared to areas where canopies where fully burnt (Phillips *et al*. 2021). The implications of this metric when considering the size, severity and location of fires with reference to koala habitat and koala source populations is substantial, excepting koala populations inhabiting the most urbanised parts of the study area. It is important to note that key range parameters used in this report (EoO, AoO and GP) are aligned with IUCN criteria for measuring population change over species-specific generational time frames and are unlikely to detect impacts until a full koala generation time (six years) has elapsed. In the intervening time period and in the absence of field survey data, informed assumptions about koala declines can be based on fire mapping in relation to the location of known koala populations.

Though they have been less impacted by fire, koalas in urbanised portions of the study area are subject to high levels of threat from vehicle strike. Campbelltown, Liverpool, Sutherland, Wingecarribee and Wollondilly LGAs have recorded 130 koala road-kills over the period 2016-2021 (**Table 4**), though we consider it likely that this is an under-estimate as several studies infer that ~50% of vehicle strikes on koalas are reported (Phillips and Fitzgerald 2014, Phillips *et al*. 2015). Vehicle strike rates in the order of 3% of the population annually can drive population decline / extirpation (Phillips *et al.* 2007).

4.1. Areas of Regional Koala Significance (ARKS)

The concept of ARKS was first promoted by Rennison and Fisher (2019) with the objective of identifying the locations and extent of important koala populations across NSW and enabling management of these areas; guiding conservation actions and investment by targeting areas known to be occupied by significant koala populations. This process has been iteratively refined and updated with new data and the study area for this report supports several ARKS (Biolink 2021a) (**Figure 10**). Consistent with the over-riding objective of ARKS to guide conservation investment, constituent areas have been identified as requiring either 'Immediate investment' or 'Filling knowledge gaps' by the NSW Koala Strategy (DPE 2022). Overlaying the refined ARKS boundaries (updated to 2021: Biolink

2021) with outputs from the current study, it is seen that all cells of GP are encompassed within an ARKS boundary, though the ARKS cover a broader area than GP as they operate on different scales of 5km and 2km respectively (**Figure 10**). Koala populations across Campbelltown, Wollondilly and Wingecarribee are identified as requiring 'Immediate investment' which is supported by the outcomes of this report. This is also the case for Port Stephens. The Blue Mountains is identified as an area for 'Immediate investment' though it does not intersect a current ARKS boundary or support cells of current GP (**Figure 10**). Koala populations in Shoalhaven, Hawkesbury, Central Coast and Cessnock/Lake Macquarie are identified as requiring 'Filling knowledge gaps". The implications of the current report are that the Central Coast and Shoalhaven koala populations are greatly diminished and may be functionally extinct.

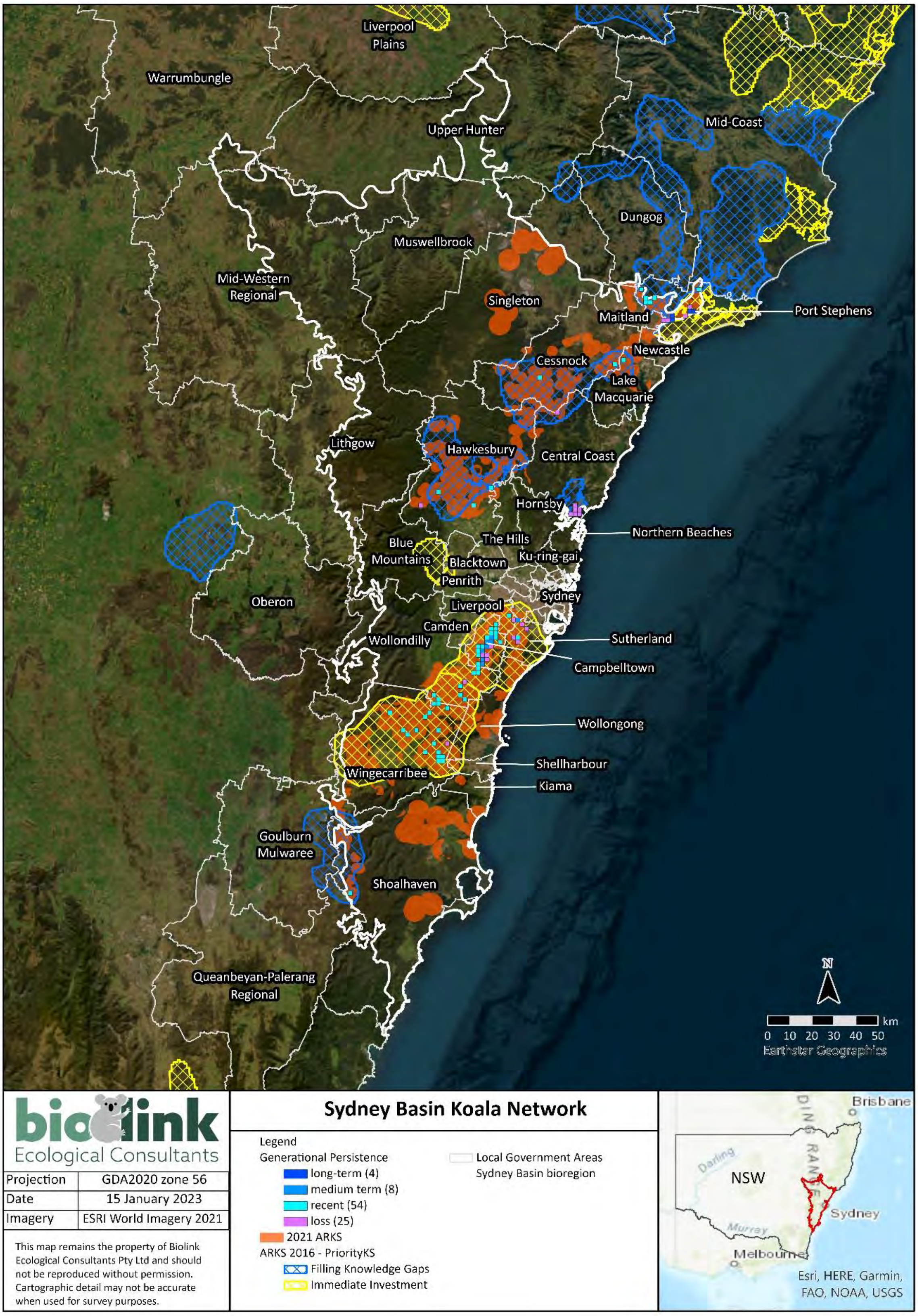

Figure 10. Areas of Regional Koala Significance (ARKS) updated to 2021, shown in orange. Cells of Generational Persistence (GP) are overlaid; long term GP (generation 1-9: dark blue), medium term GP (generations 1-6: medium blue) and more recently detected GP (generations 1-3: aqua). Areas which had GP in generations 4-6 and / or generations 7-9 but lack GP in generations 1-3 are shown in purple. Areas identified by the NSW Koala Strategy 2020 as requiring 'Immediate investment' are shown in yellow cross-hatch and areas requiring 'Filling knowledge gaps' are shown in blue cross-hatch.

4.2. Focal Areas

An objective of this report is to identify key Focal Areas of known koala occupancy to be the subject of further detailed reporting and to inform Local, State and Commonwealth government bodies about the existence, conservation status and threats to koala populations, as well as to support community advocacy. The spatial scale that we use for identification Focal Areas is LGA, that being a unit at which management actions and government policy can be directed. Identification relies on a decision pathway informed by the outcomes of our analysis, primarily guided by areas supporting PKH and GP. Adjacent LGAs are considered part of the same Focal Area where there is contiguous habitat and / or interconnected GP, though this is not the case when such LGAs have disparate management priorities. Acknowledging the potentially complicating factor of LGA boundaries not aligning with study area boundaries, only LGAs principally encompassed by the study area are considered.

Based on the preceding information and the analytical outcomes of this report we identify the following LGAs as key Focal Areas;

1. Campbelltown/Wollondilly
2. Liverpool
3. Sutherland
4. Wingecarribee
5. Hawkesbury
6. Cessnock/Lake Macquarie

1) The Campbelltown City Council and Wollondilly Shire LGAs are located in the Macarthur region of south-western Sydney, an area undergoing considerable urban expansion and development. Available information based on consideration of historical koala records analyses (Biolink 2016) and field survey (DPIE 2019, Biolink 2021b) implies that the two populations are in fact one and the same, with recent sightings along the eastern edge of the more southerly Wollondilly Shire LGA commensurate with a known recovery trend in the north (Campbelltown). Mapped areas of GP in these two LGAs adjoin and the koala habitat is contiguous. Koalas in both LGAs share the same ecological traits such as food tree preferences. Over the past several years the on-going trend of koala population recovery in this area is manifesting itself in greater numbers of koalas being struck on the arterial road network between Campbelltown, Appin and Wilton. Correlated with this trend is an extension of areas of GP from the Wedderburn area to habitat west of Appin Road where koalas have not previously been reported. The implications of this knowledge, now supported by field assessments, are that koala populations in the Nepean and Georges River catchments that up until recently were considered to be separate

populations for management purposes are now in direct contact (Biolink 2017b, 2018). For these reasons (interconnectedness of the population, subject to the same threats) the koala population inhabiting Campbelltown City Council and Wollondilly Shire LGAs are best considered together as one Focal Area for management and advocacy purposes. Campbelltown City Council has an endorsed Comprehensive Koala Plan of Management (CKPoM) and Wollondilly Shire Council currently has a Koala Management Strategy. The LGAs are also considered collectively in the NSW government initiative "Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas".

2. Liverpool City Council LGA supports a growing koala population located primarily in the south-east of the LGA where it abuts Campbelltown City Council LGA. This population has seen a four-fold increase in its geographic extent across Liverpool City Council LGA since 2002 (Biolink 2021d), the result of a process of recovery and expansion, presumably by way of recruitment from Campbelltown. Though cells of GP are not interconnected across the LGA boundary with Campbelltown, koala habitat is contiguous and koala population expansion is largely occurring along the Georges River where fertile soils support koala habitat. Koalas in this region escaped the bulk of the fire impacts in the 2019-2020 bushfire season however remain increasingly vulnerable to fire risks and the challenge of existing at the peri-urban interface where they are impacted by an increasing human population. Though there is some history of koala occupancy in this LGA, albeit at a very low density, substantial recent increases in koala residency necessitate planning to manage and conserve the expanding population. Liverpool Shire LGA lacks a CKPoM and differs in its management priorities to Campbelltown / Wollondilly in that there is not a long history of scientific study of resident koalas, or the existence of any known management strategies.

3. Sutherland Shire Council LGA supports a small koala population, with analysis of historical records indicating the loss of areas of GP across the LGA *post* 2010. Koalas have been sighted from Barden Ridge to Loftus, Worona, Heathcote and Engadine and in the adjoining National Parks of Heathcote and Royal. Genetic analysis of these koalas confirms that they are connected to the expanding south-west Sydney population (C. Hogg pers comm). The Campbelltown City Council LGA is situated directly to the west and though cells of GP are not interconnected across these LGAs, mapped koala habitat is contiguous. Similar to the adjacent areas of Campbelltown/Wollondilly, Sutherland has a significant vehicle strike problem as well as other challenges associated with proximity to urban areas. Despite a history of koala occupancy, the LGA lacks a CKPoM and differs in its management priorities to Campbelltown / Wollondilly in that there is not the same degree of scientific and / or community interest, or the existence of any known management strategies.

4. Wingecarribee Shire Council LGA is situated in the Southern Highlands, directly to the south of Wollondilly Shire LGA. The LGA supports substantial amounts of koala GP, particularly in the northern half of the LGA where GP is interconnected with that in Wollondilly Shire. This LGA is considered separately from nearby LGAs as management priorities are likely to be different across this predominantly rural and forested landscape, compared to the northerly koala populations which exist at the peri-urban interface. Koalas have a long, documented history across this LGA and conservation management in the area is driven by the Southern Highlands Koala Conservation Project (an initiative of the Save Our Species program of the NSW government) and it is not bound by a CKPoM.

5. Hawkesbury Shire LGA supports a small, scattered amount of mapped koala GP and a large amount of mapped koala habitat. Field assessments across this LGA are limited though the group 'Science for Wildlife' has conducted some recent work here. The LGA is dominated by native vegetation and areas of National Park which suffered extreme impacts during the 2019/2020 fire events. The LGA lacks a CKPoM or other known koala strategy.

6. The adjoining LGAs of Cessnock City Council and Lake Macquarie City Council have one cell each of GP located within the same contiguous habitat in Sugarloaf State Conservation Area which spans both LGAs. Cessnock City Council LGA also has another cell of koala GP further to the west. Neither LGA has a CKPoM or other known koala strategy.

We explicitly do not consider Shoalhaven LGA as a Focal Area despite a single cell of GP being identified therein, due to substantial fire impacts in 2019/2020 potentially rendering this source population extinct. Koala sightings records indicate that the Shoalhaven population was likely to be declining prior to the 2019/2020 fire event with less than a third (23.17%) of koala sightings from the most recent three koala generations (2004 - 2021) contained in the most recent generation (2016 – 2021) (**Appendix 1**). This runs counter to expectations as there is a tendency for records to increase over time as access to these public databases becomes more accessible - in a stable population at least one third of the records from generations 1- 3 are expected to be from generation 1. A field survey program would be the most effective way to ascertain if this population is still extant.

Port Stephens LGA is also not considered a Focal Area despite the presence of known koala population hubs in Medowie, Tomago and Brandy Hill, as reflected in GP assessment and Port Stephens own koala management strategies (PSC 2002, Biolink 2017a). The study area intersects 25.14% of this LGA and while we acknowledge the importance of these populations, directing advocacy and conservation policy to a portion of an LGA, which moreover has a koala conservation strategy in the form of an endorsed CKPoM, may be problematic.

Detailed Focal Area reports to be produced by Biolink will provide:

- Mapping of potential and core koala habitat
- Individual historic records analysis to show local changes in EoO, AoO and GP
- Detailed threats analysis including identification of vehicle strike black spots
- Exploration of the amount of PKH subject to differing development pathways, *eg.* how much is secure from a conservation perspective versus how much is subject to Development Applications, Private Native Forestry *etc* (requires collaboration with EDO).

5. Koala habitat corridors: best practice

The importance of landscape scale connectivity of koala habitat across the Sydney Basin has long been recognised by various initiatives of NSW and Local government including the *Koala Linkage Project* (DECC 2007) and the Strategic Linkage Areas outlined in both the *Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas* (DPE 2019) and the Campbelltown CKPoM (Phillips 2018). While there is no official definition of a koala habitat corridor, it is accepted as being distinct from small local dispersal pathways such as single lines of trees, which increase the permeability of the landscape from a koala's perspective, but do not comprise a 'habitat corridor' *per se*. Rather, koala habitat corridors are accepted as being of a size sufficient to support koala residency and therefore koala home ranges (DPIE 2019, Biolink 2020). The spatial delineation of koala habitat corridors consequently requires consideration and application of knowledge regarding koala home range size, specific to the local area.

As discussed in **Section 3.1** of this report, koala habitat within the study area is principally Secondary B and Secondary C, categories which are typically associated with moderate to low underlying soil fertility and a landscape that necessitates large koala home ranges. Using an area within the Sydney Basin for which there is reliable information available on koala home range sizes, radio tracking of koalas in the Campbelltown / Wollondilly area evidenced median and average home range sizes of 36 ha (females) (Biolink 2020), 38 ha (females) and 114 ha (males) (DPIE 2019). If the intent is to accommodate a breeding aggregation of two adult females and one adult male with overlapping home ranges, estimates for the amount of habitat required are 100 ha (DPIE 2019) - 105 ha (Biolink 2020). The 105 ha estimate is based on median female home range sizes with some overlap and an additional (nominal), non-overlapping 35 ha allowance for the male. While the mechanics of the 100 ha calculation (DPIE 2019) are not known, the congruence of these two independently derived measures is somewhat validating. Ideally corridors should also contain some unoccupied habitat[4] to allow for dispersal and recruitment over time and to prevent corridors being functionally blocked by dominant males.

Given the preceding minimum requirements for corridor size, the width of a corridor is associated with its length. By way of example, if a corridor is to be 3.5 km in length and a minimum 105 ha in size, it must necessarily have an average width of 300 m (or 600 m if allowing for an optimal 50% habitat occupancy benchmark). This begs the question of what an adequate corridor width needs to be, as using the logic above, very long corridors can also be very thin. This runs counter to considerations of buffer requirements for koala home range areas. Strategic Linkage Areas are defined in the Campbelltown CKPoM (Phillips 2018) as having an optimal average width of 425 m. This 425 m measure originally arose from considerations of buffer requirements for areas of koala Generational Persistence (koala residency / home ranges) and was calculated using the 36 ha median female home range as;

$W = \sqrt{(\text{home range (in meters)}/2^1)} = 425$ m

This calculation has been revised with additional data on koala home range sizes in Campbelltown / Wollondilly (Lunney et al. 2010, Close and Durman 2019) to give a figure of 409 m (Biolink 2020).

The definition of Strategic Linkage Areas in the Campbelltown CKPoM is problematical as it refers to an optimal average corridor width and it can be interpreted that a corridor can contain lesser widths at a number of locations with no minimal limit so long as the average width is realised, thus enabling the creation of pinch-points that could compromise the corridors' function. Achieving optimal functional requirements should be the objective of any habitat corridor and water quality considerations alone (with habitat corridors being principally situated in riparian areas) would support a minimum / pinch-point width of 250 m, regardless of overall corridor size. A best practice approach would also apply the optimal average corridor width as described.

The preceding discussion relies on data gathered in the low carrying capacity landscape of Campbelltown and Wollondilly LGAs. While this is generally representative of the study area there will be local deviations within the landscape which also supports areas of Secondary A and Primary koala

[4] 50% habitat occupancy benchmark has been demonstrated through several field-based assessments and is the subject of a publication currently in review.

habitat. In cases where koala habitat is of a higher carrying capacity, the minimal threshold values for corridors will decrease commensurately.

Case Study: The Greater Macarthur Growth Area

The issue of koala habitat corridors has been particularly contentious in the Greater Macarthur Growth Area (GMGA) a portion of southern Campbelltown City Council LGA and northern Wollondilly Shire LGA which is about to undergo a period of further urban expansion and development. This is also the area in which a documented koala population recovery and expansion is occurring and there is a need to build resilience into these recovering populations so that they are better able to withstand the impacts of future development, as well as stochastic impacts such as fire. In order to achieve this viable linkages and associated habitat patches need to be secured.

Using the GIS-based analytical framework of the Generalised Approach to Planning Connectivity at Local and Regional Scales (GAPCLoSR) to examine issues of landscape-scale habitat fragmentation and connectivity across the GMGA confirms the importance of the consolidated linear linkages of PKH that skirt the eastern parts of the GMGA, along the Georges River from Long Point through Kentlyn and Wedderburn and Appin down to the east of Wilton and Bargo in the south (see **Appendix 5** for analytic detail). In the area from Long Point in the Campbelltown City Council LGA to the east of Appin, the aforementioned analysis independently identified the habitat patch matrix that currently connects the Nepean and Georges Rivers catchments in the vicinity of the Beulah biobanking site as amongst the most important, with other east-west linkages also identified at Appin, Rosemeadow South / Noorumba Reserve and Ousedale-Mallaty.

References

Adams-Hosking C., McBride M.F., Baxter G., Burgman M., De Villiers D., Kavanah R., Lawler I., Lunney D., Melzer A., Menkhorst P. and Molsher R. (2016). Use of expert knowledge to elicit population trends or the koala (*Phascolarctos cinereus*). *Diversity and Distributions* **22**(3): 249-262.

Biolink. (2022). Northern Rivers Regional Koala Activity Assessment. Draft report to WWF and Tweed Shire Council. Biolink Ecological Consultants, Pottsville, NSW.

Biolink. (2021a). Identifying Areas of Regional Koala Significance (ARKS): a methodological review and recommendations for refinement. Final report to Department of Planning, Industry and Environment. Biolink Ecological Consultants, Pottsville, NSW.

Biolink. (2021b). Campbelltown City Council: Baseline koala occupancy / population assessment. Report to Campbelltown City Council. Biolink Ecological Consultants, Pottsville, NSW.

Biolink. (2021c). Assessment of Lot 21/1000643 Campbelltown: koala occupancy and habitat. Report to Travers Bushfire and Ecology. Biolink Ecological Consultants, Pottsville, NSW.

Biolink. (2021d). Business case for a koala / wildlife hospital and sanctuary in the Liverpool Local Government Area. Report to Liverpool City Council. Biolink Ecological Consultants, Pottsville, NSW.

Biolink. (2020). Gilead Stage 2: Commentary on the koala carrying capacity and corridor review reports prepared by Eco Logical Australia on behalf of Lend Lease Communities, Fig Tree Hill) Pty. Ltd. Report to Campbelltown City Council. Biolink Ecological Consultants, Uki, NSW.

Biolink. (2019). The Kiwarrak and Khappinghat ARKS: Aspects of the distribution and abundance of koalas. Report for MidCoast Council by Biolink Ecological Consultants, Uki, NSW.

Biolink. (2018). Review of koala generational persistence across the Campbelltown City Council Local Government Area 2012 – 2017. Report to Campbelltown City Council. Biolink Ecological Consultants Uki, NSW.

Biolink. (2017a). Saving our Species Report: Managing koala populations for the future: the Port Stephens LGA. Report to Port Stephens Council. Biolink Ecological Consultants, Uki, NSW.

Biolink. (2017b). South Campbelltown Koala Connectivity Study. Report to Campbelltown City Council (updated 2018). Biolink Ecological Consultants, Uki, NSW.

Biolink. (2016). Analysing the historical record: aspects of the distribution and abundance of koalas in the Campbelltown City Council Local Government Area 1900 – 2012. Report to Campbelltown City Council, revised and updated October 2016. Biolink Ecological Consultants, Uki, NSW.

Biolink. (2012).

Callaghan J., McAlpine C., Mitchell D., Thompson, J., Bowen M., Rhodes J., de Jong C., Domalewski R. and Scott A. (2011). Ranking and mapping koala habitat quality for conservation planning on the basis of indirect evidence of tree-species use: a case study of Noosa Shire, south-eastern Queensland. *Wildlife Research*, *38*(2), pp.89-102.

Close R. and Durnam B. (2019). Campbelltown Koala Research and Database 1989 – 2016. Report prepared for Campbelltown City Council Library.

Cristeau, R. Ellis, W., de Villiers, D., Lee, K., Woosnam-Merchez, O., Frere, C., Banks, P.B. Dique, D., Hodgkison, S., Carrick, H., Carter, D., Smith, P. and Carrick, F. (2011). North Stradbroke Island: an island ark for Queensland's koala population? *Proceedings of the Royal Society of Queensland* **117**, pp. 309-334.

Department of Environment and Climate Change (DECC). (2007). Terrestrial vertebrate fauna of the greater southern Sydney region. Department of Environment and Climate Change, Hurstville.

Department of Environment and Climate Change - DECC. (2008) *Approved Recovery Plan for the Koala* (*Phascolarctos cinereus*). Department of Environment and Climate Change, Sydney, NSW.

Department of Planning, Industry and Environment NSW (DPIE). (2019). Conserving Koala in the Wollondilly and Campbelltown Local Government Areas.

Department of Planning and Environment (DPE). (2022). NSW Koala Strategy 2022: Towards doubling the number of koalas in NSW by 2050.

Dique D.S., Preece H.J., Thompson J. and De Villiers D.L. (2004). Determining the distribution and abundance of a regional koala population in south-east Queensland for conservation management. *Wildlife Research*, **31**(2), pp.109-117.

EMM. (2020). Wilton Koala Plan of Management. Prepared for Walker Corporation by EMM.

Faulks J. (1990). A preliminary investigation of the distribution of koalas and their potential habitat in the Tweed Shire, and implications for management. *Australian Zoologist* **27**, pp. 1-13.

Gaston K.J. He F., Maguran A. and McGill B. (2011). Species occurrence and occupancy. *Biological diversity: frontiers in measurement and assessment*: 141-151.

Hanski I. (1998). Metapopulation dynamics. *Nature* **396**: 41-49.

Hasegawa M. (1995). Habitat utilisation by koalas (*Phascolarctos cinereus*) at Point Halloran, Queensland. M.Sc. Thesis. The University of Queensland, Brisbane, QLD.

Kavanagh R.P., Stanton M.A. and Brassil T.E. (2007). Koalas continue to occupy their previous home-ranges after selective logging in *Callitris–Eucalyptus* forest. *Wildlife Research* **34**, pp. 94–107.

Lane, A., Wallis, K., and Phillips, S. (2020). *A review of the conservation status of New South Wales populations of the Koala (Phascolarctos cinereus) leading up to and including part of the 2019/20 fire event*. Report to International Fund for Animal Welfare (IFAW). Biolink Ecological Consultants, Uki NSW.

Lee A. & Martin R. (1988). *The Koala - A Natural History*. University of New South Wales Press, Sydney, NSW.

Lunney D., Close R., Bryant V.J. *et al.* (2010). The koalas of Campbelltown, south-western Sydney: does their natural history foretell of an unnatural future? Pp 339-370 in *The Natural History of Sydney*, edited by Daniel Lunney, Pat Hutchings and Dieter Hochuli. Royal Zoological Society of NSW, Mosman, NSW, Australia.

Martin R. and Handasyde K. (1999). The Koala: Natural History, Conservation and Management. 2nd edn. Australian Natural History Series. University of New South Wales Press, Sydney, NSW.

McAlpine C., Rhodes J.R., Callaghan J.G., Bowen M.E., Lunney D., Mitchell D.L., Pullar D.V. and Possingham H.P. (2006). The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. *Biological Conservation* **132**: 153-165.

McLean N. and Handasyde K. (2006). Sexual maturity, factors affecting the breeding season and breeding in consecutive seasons in populations of overabundant Victorian koalas (*Phascolarctos cinereus*). *Australian Journal of Zoology* **54**, pp. 385-392.

Melzer, A., Cristescu, R., Ellis, W. Fitzgibbon, S. and Manno, G. (2014). The habitat and diet of koalas (*Phascolarctos cinereus*) in Queensland. *Australian Mammalogy* **36**, pp. 189-199.

Mitchell P. (1990). The home ranges and social activity of koalas - a quantitative analysis. pp. 177-187 in Lee, A.K., Handasyde, K.A. and Sanson, G.D. (Eds). *Biology of the Koala*. Surrey Beatty and Sons, NSW.

Moore B.D., Wallis I.R., Marsh K.J. and Foley W.J. (2004). The role of nutrition in the conservation of the marsupial folivores of eucalypt forests. In: Lunney D. (ed) Conservation of Australia's Forest Fauna, second edition, pp. 549 – 575, Royal Zoological Society of New South Wales, Sydney, NSW.

NSW Parliament. 2020. Koala populations and habitat in New South Wales. Portfolio Committee No. 7 – Planning and Environment. Report 3, June 2020. NSW Legislative Council.

Office of Environment and Heritage (OEH). (2017). Saving Our Species Iconic Koala Project 2017–21.

Office of Environment and Heritage (OEH). (2018), NSW Koala Strategy 2016 Koala (*Phascolarctos cinereus*) population between the Tweed and Brunswick Rivers east of the Pacific Highway - endangered population listing.

Phillips S. (2000). Population trends and the koala conservation debate. *Conservation Biology* **14**(3):650-659.

Phillips S. (2018). Campbelltown Comprehensive Koala Plan of Management. Prepared by Biolink for Campbelltown City Council.

Phillips S. (1999). Habitat utilisation by the Koala *Phascolarctos cinereus* - towards a new approach for effective management & conservation. Ph.D. Thesis, School of Resource Science, Southern Cross University.

Phillips S. (1990). Koalas, the Little Australians We'd All Hate to Lose. Australian Government Publishing Service, Canberra, ACT.

Phillips S. and Allen C. (2014).

Phillips S. and Callaghan J. (2011). The spot assessment technique: a tool for determining localized levels of habitat use by koalas *Phascolarctos cinereus*. *Australian Zoologist* **35**: 774-780.

Phillips S. and Callaghan J. (2000). The tree species preferences of koala (*Phascolarctos cinereus*) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, NSW. *Wildlife Research* **27**(1), pp. 1-10.

Phillips S. and Fitzgerald M. (2014). Review of koala road-kill data and issues relating to underpass use by koalas: Pacific Highway upgrades from Clothier's Creek to Ewingsdale, NSW. Report to NSW Roads and Maritime Services.

Phillips S., Brearley G. and Callaghan J. (2015). Koala Population Survey – Woolgoolga to Ballina Pacific Highway Upgrade Section 10 (Wardell to Coolgardie). Report to NSW Roads and Maritime Services.

Phillips, S., Hopkins, M. and Shelton, M. (2011). Tweed Coast Koala Habitat Study. Unpublished reports to Tweed Shire Council prepared by Biolink Ecological Consultants, Uki, NSW.

Phillips S., Hopkins M. and Callaghan J (2007) Conserving koalas in the Coomera-Pimpama Koala Habitat Area –a view to the future. Report to Gold Coast City Council. Biolink Ecological Consultants, Uki, NSW.

Phillips S., Callaghan J., and Thompson V. (2000). The tree species preferences of koalas (*Phascolarctos cinereus*) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, New South Wales. *Wildlife Research* **27**, pp. 1-10.

Port Stephens Council (PSC). (2002). Port Stephens Council Comprehensive Koala Plan of Management (CKPoM). Prepared by Port Stephens Council with the Australian Koala Foundation.

Predavec M. (2016). NSW koala population case studies. Prepared for the Independent Review into the decline of koala populations in key areas in NSW.

Reed P.C., Lunney D. and Walker P. (1988). A 1986-1987 Survey of the Koala, *Phascolarctos cinereus* (Goldfuss), in New South Wales and an Ecological Interpretation of its distribution. Paper presented to the Third Symposium on the Biology of the Koala, Melbourne, Vic.

Rennison B. and Fisher M. (2019). Framework for the Spatial Prioritisation of Koala Conservation Actions in NSW – A report for Save our Species Iconic Koala Project. Report to the NSW Office of Environment and Heritage.

SEWPaC (2012) Interim biogeographic regionalisation for Australia (IBRA), Version 7. Australian Government Department of Sustainability Environment Water Population and Communities. https://www.environment.gov.au/land/nrs/science/ibra#ibra.

Stalenberg E., Wallis I.R., Cunningham R.B., Allen C. and Foley W.J. (2014). Nutritional correlates of koala persistence in a low-density population. *PLoS One*, *9*(12), p.e113930.

Threatened Species Scientific Committee (TSSC). (2012). Listing advice for *Phascolarctos cinereus* (Koala). Available from http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-listing-advice.pdf

Woodward, W., Ellis, W.A., Carrick, F.N. Tanizaki, M., Bowen, D. and Smith, P. (2008). Koalas on North Stradbroke Island: diet, tree use and reconstructed landscapes. *Wildlife Research* **35**, pp. 606-611.

WCUSSC. (1994). IUCN red list categories. World Conservation Union Species Survival Commission, Gland, Switzerland.

White N.A. (1999). Ecology of the koala (*Phascolarctos cinereus*) in rural south-east Queensland, Australia. *Wildlife Research*, **26**(6), pp.731-744.

Wu H., McAlpine C. and Seabrook L. (2012). The dietary preferences of koalas, *Phascolarctos cinereus*, in southwest Queensland. *Australian Zoologist*, **36**(1), pp.93-102.

Appendix 1 – Local Government Areas (LGAs)

Local Government Areas (LGAs), with their size (ha), the area that is contained within the Sydney Basin IBRA, the percent of each LGA within the Sydney Basin and the number of koala records in each timeframe being; 2022, generation 1-9, *pre* 1968 (*i.e. pre* generation 9) and the total number of koala records.

Local Government Area	LGA area (ha)	Area within Sydney Basin (ha)	LGA in Sydney Basin (%)	2,022	Generation 1 (2016-2021)	Generation 2 (2010-2015)	Generation 3 (2004-2009)	Generation 4 (1998-2003)	Generation 5 (1992-1997)	Generation 6 (1986-1991)	Generation 7 (1980-1985)	Generation 8 (1974-1979)	Generation 9 (1968-1973)	pre 1968	Total	% Records in Gen1 compared to Gen1,2 and3
Bayside Council	5,715	4,724	100.00													0.00
Blacktown City Council	24,019	24,019	100.00		3		1			1					5	75.00
Blue Mountains City Council	143,158	132,456	92.52	1	22	10	2	16	7	8	2	4		5	77	64.71
Burwood Council	714	714	100.00					16	7	8	2	4		5	42	0.00
Camden Council	20,090	20,090	100.00	1	5	2									8	71.43
Campbelltown City Council	31,121	31,121	100.00	95	747	191	229	607	243	142	25	2	4	1	2,286	64.01
Canterbury-Bankstown Council	11,104	11,104	100.00		1	3									4	25.00
Central Coast Council	184,543	180,392	100.00	2	15	6	28	46	89	24	38	2	2	12	264	30.61
Cessnock City Council	196,492	196,492	100.00	9	33	33	83	34	41	11	52	2		2	300	22.15
City of Canada Bay Council	1,980	1,980	100.00		1									1	2	100.00
City of Parramatta Council	8,380	8,380	100.00											1	1	0.00
Council of the City of Sydney	2,645	2,640	100.00			2									2	0.00
Cumberland Council	7,163	7,163	100.00		1	1									2	50.00
Dungog Shire Council	224,980	1,827	0.81		4	1	1		2						8	66.67
Eurobodalla Shire Council	342,987	498	0.15						2						2	0.00
Fairfield City Council	10,156	10,156	100.00		1										1	100.00
Georges River Council	4,408	4,408	100.00		1	1				1					3	50.00
Goulburn Mulwaree Council	322,268	20,016	6.21		8	2	3				1				14	61.54
Hawkesbury City Council	277,508	277,508	100.00	44	240	104	74	13	48	5	10	2	1	8	549	57.42
Inner West Council	3,517	3,517	100.00			1									1	0.00
Ku-ring-gai Council	8,540	8,540	100.00		5						1	1	2		9	100.00

Local Government Area	LGA area (ha)	Area within Sydney Basin (ha)	LGA in Sydney Basin (%)	2,022	Generation 1 (2016-2021)	Generation 2 (2010-2015)	Generation 3 (2004-2009)	Generation 4 (1998-2003)	Generation 5 (1992-1997)	Generation 6 (1986-1991)	Generation 7 (1980-1985)	Generation 8 (1974-1979)	Generation 9 (1968-1973)	pre 1968	Total	% Records in Gen1 compared to Gen1,2 and3
Lake Macquarie City Council	75,741	75,553	100.00	1	42	11	8	1	2	1	12	3	3	4	88	68.85
Lane Cove Municipal Council	1,044	1,044	100.00					1	2	1	12	3	3	4	26	0.00
Lithgow City Council	451,191	223,937	49.63	1	8	1	2	4	12	1	1	2		1	33	72.73
Liverpool City Council	30,607	30,607	100.00	18	71	23	5	11	11	2	2				143	71.72
Liverpool Plains Shire Council	508,551	642	0.13					11	11	2	2				26	0.00
Maitland City Council	39,262	35,432	90.25		4	1	1	1		2	2				11	66.67
Mid-Coast Council	1,005,861	228	0.02			1									1	0.00
Mid-Western Regional Council	875,211	290,655	33.21	1	17	13	2	1		1	1	1	1	3	41	53.13
Mosman Municipal Council	851	835	100.00					1		1	1	1	1	3	8	0.00
Muswellbrook Shire Council	340,486	311,278	91.42		5	2	16	1	2					2	28	21.74
Newcastle City Council	21,520	19,799	92.01		2	4	2	1		2	1				12	25.00
North Sydney Council	1,049	1,044	100.00	1											1	0.00
Northern Beaches Council	27,721	25,594	100.00	1	9	2	5		5	5		18	27	27	99	56.25
Oberon Council	362,446	190	0.05						5	5		18	27	27	82	0.00
Penrith City Council	40,387	40,387	100.00		5			2			2				9	100.00
Port Stephens Council	97,356	24,726	25.40	4	122	77	52	9	123	549	194	53	41	90	1,314	48.61
Queanbeyan-Palerang Regional Council	532,068	5,866	1.10						2						2	0.00
Randwick City Council	3,743	3,580	100.00		1										1	100.00
Ryde City Council	4,051	4,051	100.00													0.00
Shellharbour City Council	15,511	15,397	100.00		5	2									7	71.43
Shoalhaven City Council	468,524	356,645	76.12		14	21	24	99	8	3	6	1		2	178	23.73
Singleton Council	489,281	388,503	79.40		9	9	15	6	12	2	6			2	61	27.27
Strathfield Municipal Council	1,386	1,386	100.00			1									1	0.00
Sutherland Shire Council	36,854	35,086	100.00	112	176	23	14	40	56	18	11	8	5	9	472	82.63
The Council of the Municipality of Hunters Hill	562	562	100.00					40	56	18	11	8	5	9	147	0.00
The Council of the Municipality of Kiama	25,880	25,740	100.00			1	1				4				6	0.00
The Council of the Shire of Hornsby	49,958	47,461	100.00	1	10	1	0	2	3		1	7	9	6	40	90.91
The Hills Shire Council	38,620	38,620	100.00		6	6	2		5	1				1	21	42.86

Local Government Area	LGA area (ha)	Area within Sydney Basin (ha)	LGA in Sydney Basin (%)	2,022	Generation 1 (2016-2021)	Generation 2 (2010-2015)	Generation 3 (2004-2009)	Generation 4 (1998-2003)	Generation 5 (1992-1997)	Generation 6 (1986-1991)	Generation 7 (1980-1985)	Generation 8 (1974-1979)	Generation 9 (1968-1973)	pre 1968	Total	% Records in Gen1 compared to Gen1,2 and3
Unincorporated - Sydney Harbour Area	7,769	2,568	100.00						5	1				1	7	0.00
Upper Hunter Shire Council	809,615	141,963	17.53		1	1	1				1			2	6	33.33
Warrumbungle Shire Council	1,236,007	19,424	1.57								1			2	3	0.00
Waverley Council	938	893	100.00								1			2	3	0.00
Willoughby City Council	2,218	2,218	100.00								1			2	3	0.00
Wingecarribee Shire Council	268,940	232,984	86.63	3	620	293	70	84	42	45	43	56	5	2	1,263	63.07
Wollondilly Shire Council	255,626	197,748	77.36	28	321	83	35	32	29	12	5	1		4	550	73.12
Wollongong City Council	71,525	71,154	100.00	0	36	7	16	10	8	3	4	2		2	88	61.02
Woollahra Municipal Council	1,219	1,193	100.00													0.00
TOTAL	**10,031,069**	**3,622,737**		**323**	**2,571**	**940**	**692**	**1,089**	**838**	**875**	**456**	**199**	**136**	**242**	**8,361**	

Appendix 2 – Plant Community Types (PCTs)

Koala habitat categorization of each constituent Plant Community Type (PCT) in the Sydney Basin bioregion according to the "NSW Version cCM11m1" vegetation mapping layer, plus its associated area (ha).

PCT ID	PCT Name	Koala Habitat	Area (ha)
3166	Northern Escarpment Brush Box-Tallowwood-Maple Wet Forest	Primary	45
3264	Wollemi Basalt Red Gum Forest	Primary	224
3291	Bondo Montane Valley Flats Forest	Primary	0
3303	Central Tableland Ribbon Gum Sheltered Forest	Primary	270
3305	Sydney Montane Basalt Moist Forest	Primary	4,861
3328	Lower Hunter Red Gum-Paperbark Riverflat Forest	Primary	842
3334	Western Hunter Flats Red Gum Sedge Forest	Primary	2,335
3339	Guyra Basalt Snow Gum Woodland	Primary	418
3347	Southern Tableland Creekflat Ribbon Gum Forest	Primary	1,141
3387	Central West Creekflat Grassy Woodland	Primary	105
3445	Lower North Coastal Hills Red Gum Grassy Forest	Primary	2
3483	Central Gorges Box-Red Gum Grassy Forest	Primary	498
3493	Southern Highlands Red Gum Forest	Primary	2,091
3517	Northwest Creekflat Blakelys Red Gum Shrub-Grass Forest	Primary	35
3519	Northwest Ranges Rocky Tumbledown Gum Scrub	Primary	4
3530	Western Hunter Sandy Riparian Red Gum Shrub Forest	Primary	3,097
3531	Western Hunter Trachyte Spinifex Forest	Primary	1,529
3630	Kurri Sand Heathy Woodland	Primary	1,520
3631	Kurri Sand-Clay Woodland	Primary	2,162
3633	Mellong Sand Swamp Woodland	Primary	5,130
3774	Western Hunter Dwyers Red Gum-Pine Woodland	Primary	7,833
3983	Central Coast Flats Mesic Swamp Forest	Primary	659
3986	Coastal Sands Swamp Mahogany Rush Forest	Primary	130
3996	Coastal Sand Swamp Mahogany Dry Forest	Primary	25
3998	Lower North Creekflat Mahogany Swamp Forest	Primary	1,601
4002	Northern Lowland Orange Gum Dry Swamp Forest	Primary	17
4006	Northern Paperbark-Swamp Mahogany Saw-sedge Forest	Primary	1,098
4008	Northern Sands Swamp Mahogany Shrubby Rush Forest	Primary	6
4009	Shoalhaven Lowland Flats Wet Swamp Forest	Primary	4,450
4012	Tomago Drooping Red Gum Swamp Woodland	Primary	0
4020	Coastal Creekflat Layered Grass-Sedge Swamp Forest	Primary	3,661
4021	Coastal Creekline Dry Shrubby Swamp Forest	Primary	840
4025	Cumberland Red Gum Riverflat Forest	Primary	8,897
4047	Northern Swamp Mahogany-Bottlebrush Swamp Forest	Primary	56
4052	South Coast Low Hills Red Gum Grassy Forest	Primary	1,616
4057	Sydney Creekflat Swamp Mahogany-Paperbark Forest	Primary	2,376
4058	Sydney Hinterland Red Gum Riverflat Forest	Primary	3,536

PCT ID	PCT Name	Koala Habitat	Area (ha)
4081	Northwest River Oak-River Red Gum Forest	Primary	990
4089	Namoi-Upper Hunter River Red Gum Forest	Primary	4,970
4156	Maroota Sands Swamp Forest	Primary	6
3078	Illawarra Lowland Wet Vine Forest	2A	1,375
3171	Northern Lowland Viney Wet Forest	2A	415
3198	Western Blue Mountains Creekline Paperbark Forest	2A	8
3210	Blue Mountains Cool Wet Eucalypt Forest	2A	934
3225	Western Blue Mountains Colluvial Apple Forest	2A	5,364
3228	Wollondilly-Shoalhaven Siltstones Sheltered Forest	2A	8,309
3301	Southeast Tableland Ranges Snow Gum Sheltered Forest	2A	27
3304	Southern Tableland Swamp Flats Shrub Woodland	2A	1,191
3359	New England Hills Stringybark-Box Woodland	2A	3
3373	Goulburn Tableland Box-Gum Grassy Forest	2A	21
3376	Southern Tableland Grassy Box Woodland	2A	527
3396	Northwest Flats Box-Blakelys Red Gum Forest	2A	5,704
3397	Northwest Flats Yellow Box Woodland	2A	3,249
3398	Northwest Slopes Box-Apple Woodland	2A	13
3403	Western Hunter Creekflat Apple Grassy Forest	2A	1,874
3406	Southwest Ranges White Box Woodland	2A	126
3499	Yerranderie Enriched Forest	2A	18
3525	Upper Hunter Box-Blakelys Red Gum Grassy Forest	2A	1,728
3528	Western Hunter Flats Apple-Gum Shrub Forest	2A	11,302
3579	Blue Mountains Scribbly Gum Swamp Woodland	2A	2,643
3628	Castlereagh Shrubby Swamp Woodland	2A	82
3629	Castlereagh Scribbly Gum Woodland	2A	4,686
3632	Mellong Sand Scribbly Gum Woodland	2A	446
3746	Southern Tableland Snow Gum-Candlebark Shrub Forest	2A	916
3766	Ulan Sandstone Damp Shrubland	2A	5
3773	Western Hunter Currawang Low Forest	2A	1,979
3781	Ulan Sandstone Ironbark-Pine Woodland	2A	19,872
3782	Western Hunter Rockplate Micromyrtus Heath	2A	1,058
3784	Western Hunter Rocky Scrub	2A	5,688
3866	Wollemi Rockplate Scrub	2A	12,873
3906	Northern Lowland Clay Wet Heath	2A	464
3907	Lower North Sands Swamp Scrub	2A	4
3908	Lower North Sands Wallum Bottlebrush Swamp Heath	2A	14
3909	Mellong Creekflat Wet Heath	2A	12
3915	Northern Sands Prickly Tea-tree Wet Shrubland	2A	2
3921	Coastal Sydney Sand Saw-sedge Wet Shrubland	2A	68
3922	Sydney Coastal Sand Swamp Scrub	2A	90
3959	Coast Sands Baumea articulata Sedgeland	2A	14
3960	Coast Sands Cladium Sedgeland	2A	4
3961	Coast Sands Lepironia Sedgeland	2A	3
3972	Sydney Creekflat Wetland	2A	97
3985	Coastal Floodplain Swamp Paperbark Scrub	2A	328

PCT ID	PCT Name	Koala Habitat	Area (ha)
3988	Far North Mesophyll Paperbark Swamp Forest	2A	23
3995	Hunter Coast Paperbark-Swamp Mahogany Forest	2A	469
3997	Hunter Coast Sandplain Sedge Paperbark Wetland	2A	16
4000	Northern Estuarine Paperbark Sedge Forest	2A	71
4004	Northern Melaleuca quinquenervia Swamp Forest	2A	89
4013	Wyong Paperbark-Woollybutt Swamp Forest	2A	283
4019	Coastal Alluvial Bangalay Forest	2A	4,535
4023	Coastal Valleys Swamp Oak Riparian Forest	2A	4,354
4024	Cumberland Blue Box Riverflat Forest	2A	642
4036	Hunter Coast Lake Flats Apple Forest	2A	751
4038	Hunter Estuarine Melaleuca nodosa Scrub	2A	238
4039	Hunter Range Creekflat Apple-Red Gum Forest	2A	7,613
4042	Lower North Riverflat Eucalypt-Paperbark Forest	2A	3,885
4044	Northern Creekflat Eucalypt-Paperbark Mesic Swamp Forest	2A	781
4048	Northern Swamp Oak-Paperbark Forest	2A	0
4050	South Coast Floodplain Wetland Paperbark Scrub	2A	216
4072	Hunter River Oak Mesic Forest	2A	791
4079	Northern Hinterland Grassy River Oak Forest	2A	301
4080	Northwest River Oak-Apple Forest	2A	450
4083	Southeast Tableland Rocky Riparian Scrub	2A	1,601
4145	Northwest Olive-Wilga Vine Thicket	2A	310
4146	Illawarra Sands Littoral Rainforest	2A	125
3115	Western Hunter Sandstone Grey Gum-Grey Myrtle Forest	2B	3,116
3119	Upper Hunter White Box Vine Thicket	2B	126
3141	Central Coast Dolerite Hills Wet Forest	2B	114
3160	Lower North Turpentine-Tallowwood-Grey Gum Forest	2B	841
3185	Far South Riverflat Wet Forest	2B	38
3193	South Coast Stringybark-Monkey Gum Wet Forest	2B	20
3219	Southeast Mountain Wet Fern Forest	2B	0
3221	Southern Escarpment Messmate Forest	2B	118
3223	Southern Highlands Shale-Basalt Wet Forest	2B	6,562
3224	Southern Highlands Swamp Forest	2B	516
3227	Western Blue Mountains Sheltered Shale Forest	2B	283
3235	Hunter Escarpment Enriched Moist Forest	2B	420
3239	Hunter Range Sheltered Grey Gum Forest	2B	46,370
3240	Lower North Escarpment Red Gum Grassy Forest	2B	0
3250	Northern Foothills Blackbutt Grassy Forest	2B	9,700
3253	Northern Hinterland Grey Gum-Turpentine Mesic Forest	2B	433
3260	Sydney Foreshores Shale Forest	2B	24
3289	West Barrington Granitoid Outcrop Forest	2B	61
3313	Araluen Scarp Grassy Forest	2B	82
3314	Central Hunter Slopes Grey Box Forest	2B	16,457
3318	Cumberland Moist Shale Woodland	2B	2,849
3319	Cumberland Shale Hills Woodland	2B	6,587
3320	Cumberland Shale Plains Woodland	2B	21,158

PCT ID	PCT Name	Koala Habitat	Area (ha)
3327	Illawarra Lowland Red Gum Grassy Forest	2B	2,660
3330	South Coast Lowland Woollybutt Grassy Forest	2B	732
3336	Hunter Range Basalt Peaks Red Gum-Velvet Wattle Forest	2B	85
3348	Southern Tableland Granites Ribbon Gum Grassy Forest	2B	25
3354	Liverpool Range Box-Silvertop Stringybark Forest	2B	7,604
3367	Central Tableland Granites Grassy Box Woodland	2B	498
3388	Central West Valleys White Box Forest	2B	13,754
3395	Northwest Elevated White Box Woodland	2B	979
3402	Western Blue Mountains White Box Forest	2B	7,266
3404	Central West Flats Grassy Box Woodland	2B	904
3405	Central West Flats Inland Grey Box Grassy Forest	2B	1,701
3439	Hunter Escarpment Grey Gum Sheltered Forest	2B	3,298
3456	Clarence Gorges Grey Gum-Ironbark Grassy Forest	2B	88
3466	Northern Gorges Red Gum-Stringybark Forest	2B	95
3473	Bungonia Slates Shrubby Open Forest	2B	515
3474	Burragorang Escarpment Grey Gum Sheltered Forest	2B	19,755
3475	Burragorang Escarpment Ironbark Forest	2B	21,752
3478	Burragorang Gorges Quartzite Grey Gum Forest	2B	1,061
3479	Burragorang Gorges Grey Gum-Stringybark Dry Forest	2B	2,095
3480	Capertee-Wolgan Escarpment Dry Forest	2B	349
3481	Burragorang Gorges Felsic Stringybark Forest	2B	1,108
3482	Burragorang Gorges Ironbark Grassy Forest	2B	2,151
3484	Burragorang Gorges Red Gum-Ironbark Sheltered Forest	2B	1,043
3488	Ettrema Gorge Ironbark-Grey Gum Shrub Forest	2B	8
3489	Hunter Escarpment Grey Box Forest	2B	6,271
3494	Western Blue Mountains Gorges Box Forest	2B	2,428
3495	Western Blue Mountains Monkey Gum Gully Forest	2B	1,732
3496	Western Hunter Colluvial Grey Gum Forest	2B	21,927
3498	Wingecarribee Gorges Stringybark-Grey Gum Forest	2B	9,473
3509	Capertee Escarpment Slaty Gum-Ironbark Forest	2B	2,068
3510	Capertee Slopes Stringybark-Box Forest	2B	7,337
3512	Western Hunter Basalt Cap Woodland	2B	407
3521	Northwest White Box Woodland	2B	3,355
3529	Western Hunter Sandy Colluvial Gully Forest	2B	2,608
3532	Western Hunter Ironbark-Box Forest	2B	13,108
3597	Watagan Escarpment Rocky Shrub Forest	2B	70
3602	Burragorang Permian Sandstone Grey Gum-Peppermint Forest	2B	1,483
3603	Hawkesbury Escarpment Bloodwood Forest	2B	917
3604	Hunter Range Grey Gum-Stringybark Forest	2B	67,100
3605	Hunter Range Ironbark Forest	2B	71,970
3608	Hunter Range Yellow Bloodwood Forest	2B	15,883
3616	Sydney Hinterland Grey Gum Transition Forest	2B	18,268
3623	Western Blue Mountains Grey Gum-Stringybark Forest	2B	34,055
3626	Wollemi Plateau Stringybark-Grey Gum Forest	2B	22,788
3634	Quorrobolong Sand Flats Forest	2B	2,477

PCT ID	PCT Name	Koala Habitat	Area (ha)
3635	Thirlmere Sand Swamp Woodland	2B	5
3657	South Coast Foothills Monkey Gum Sheltered Forest	2B	299
3664	Southeast Foothills Woollybutt Dry Shrub Forest	2B	384
3686	Mount Airly Sandstone Forest	2B	203
3731	Capertee Conglomerate Grey Gum-Stringybark Forest	2B	497
3760	Munghorn Sandstone Grey Gum-Stringybark Forest	2B	3,320
3762	Northern Wollemi Rocky Stringybark Forest	2B	12,623
3763	Northwest Wollemi Colluvial Apple Forest	2B	17,452
3767	Upper Hunter Escarpment Colluvial Ironbark Forest	2B	31,159
3777	Western Hunter Grey Gum Sheltered Forest	2B	22,262
3778	Western Hunter Grey Gum-Stringybark Forest	2B	6,699
3786	Western Hunter Scribbly Gum-Pine Woodland	2B	23,114
4051	South Coast Lowland Red Gum-Swamp Oak Forest	2B	235
4068	Ettrema Plateau Riparian Scrub	2B	38
3074	Hunter Coast Lowland Grey Myrtle Wet Forest	2C	1,215
3077	Illawarra Complex Dry Rainforest	2C	6,458
3082	Western Sydney Complex Dry Rainforest	2C	142
3084	Lower North Choricarpia Wet Forest	2C	31
3089	Lower North Waterhousea Riparian Rainforest	2C	1
3110	Greater Sydney Enriched Grey Myrtle Dry Rainforest	2C	2,770
3111	Sydney Hinterland Grey Myrtle Riparian Forest	2C	3,300
3114	Upper Hunter Ranges Moist Gully Forest	2C	1,072
3136	Blue Gum High Forest	2C	1,500
3137	Blue Mountains Enriched Blue Gum Moist Forest	2C	4,420
3138	Blue Mountains Wet Gully Forest	2C	1,066
3153	Illawarra Escarpment Bangalay x Blue Gum Wet Forest	2C	11,049
3183	Far South Hinterland Stringybark Sheltered Forest	2C	23,089
3201	Mid North Escarpment Blue Gum Moist Forest	2C	2
3209	Blue Mountains Basalt Cap Forest	2C	4,803
3213	Illawarra Southern Escarpment Wet Forest	2C	10,919
3222	Southern Highlands Shale Margins Moist Forest	2C	3,451
3226	Western Blue Mountains Montane Wet Fern Forest	2C	1,511
3230	Central Coast Escarpment Moist Forest	2C	7,396
3236	Hunter Valley Hills Wet Vine Forest	2C	204
3237	Hunter Range Blue Gum Gully Forest	2C	7,771
3238	Hunter Range Colluvial Apple-Gum Forest	2C	41,870
3241	Lower North White Mahogany-Spotted Gum Moist Forest	2C	2,884
3244	Lower North Spotted Gum-Mahogany-Ironbark Sheltered Forest	2C	14,810
3262	Sydney Turpentine Ironbark Forest	2C	2,792
3263	Watagan Range Turpentine-Mahogany Grassy Forest	2C	12,190
3266	Nattai-Morton Sandstone Peppermint Gully Forest	2C	5,506
3269	Shoalhaven Lowland Spotted Gum-Paperbark Forest	2C	1,694
3272	South Coast Lowland Creekflat Forest	2C	81
3273	South Coast Lowland Shrub-Grass Forest	2C	12,357
3276	South Coast Stringybark Cycad Exposed Forest	2C	54

PCT ID	PCT Name	Koala Habitat	Area (ha)
3282	Liverpool Range Apple Gully Forest	2C	1,094
3284	Liverpool Range Ribbon Gum-Stringybark Forest	2C	44
3285	Lower North Escarpment Blue Gum Grassy Forest	2C	8
3299	Nullo Mountain Basalt Stringybark Forest	2C	3,432
3302	Southern Highlands Shale-Basalt Dry Forest	2C	2,890
3315	Central Hunter Ironbark-Spotted Gum Forest	2C	17,547
3321	Cumberland Shale-Sandstone Ironbark Forest	2C	25,208
3401	Upper Hunter Sheltered Viney Shrub Forest	2C	732
3431	Central Hunter Ironbark Grassy Woodland	2C	30,675
3435	Hunter Coast Lowland Flats Damp Forest	2C	346
3436	Hunter Coast Sandy Creekflat Low Paperbark Scrub	2C	1,634
3437	Hunter Coast Lowland Spotted Gum Dry Forest	2C	962
3438	Hunter Escarpment Footslopes Ironbark Forest	2C	6,412
3443	Lower Hunter Spotted Gum Scrubby Transition Forest	2C	2,278
3444	Lower Hunter Spotted Gum-Ironbark Forest	2C	7,593
3446	Lower North Foothills Ironbark-Box-Gum Grassy Forest	2C	3,695
3447	Shoalhaven Foothills Spotted Gum Forest	2C	8,140
3476	Burragorang Escarpment Rocky Woodland	2C	853
3477	Burragorang Gorges Moist Fern Forest	2C	1,688
3485	Central Hunter Slaty Gum Grassy Forest	2C	3,043
3486	Wollondilly-Shoalhaven Slopes Grassy Open Forest	2C	153
3487	Douglas Scarp Woodland	2C	1
3490	Hunter Valley Footslopes Slaty Gum Forest	2C	7,425
3492	Wollondilly-Shoalhaven Quartz Hills Forest	2C	477
3497	Western Hunter Escarpment Slaty Gum-Pine Forest	2C	51,546
3599	Blue Mountains Peppermint Shrub Forest	2C	53,087
3601	Burragorang Footslopes Scribbly Gum Forest	2C	7,869
3606	Hunter Range Peppermint Moist Gully Forest	2C	1,450
3607	Hunter Range Rockplate Scrub	2C	3
3610	Lower Hunter Yellow Bloodwood Forest	2C	1,356
3612	Nattai Plateau Peppermint Gully Forest	2C	1,288
3613	Shoalhaven Sandstone Cliffline Woodland	2C	11
3615	Sydney Hinterland Apple-Blackbutt Gully Forest	2C	8,338
3619	Sydney Hinterland Enriched Sandstone Bloodwood Forest	2C	18,535
3620	Sydney Hinterland Turpentine Sheltered Forest	2C	7,305
3622	Sydney Hinterland Yellow Bloodwood Woodland	2C	127,835
3625	Wingecarribee Sandstone Shrub Forest	2C	15,816
3636	Warkworth Sands Woodland	2C	1,910
3654	Shoalhaven Lowland Bloodwood Shrub Forest	2C	16,491
3660	South Coast Hinterland Yellow Stringybark Forest	2C	159
3667	Southern Highlands Enriched Sandstone Forest	2C	16,585
3687	Newnes Plateau Peppermint-Ash Tall Forest	2C	11,311
3690	Southern Highlands Sandstone Rockplate Heath	2C	308
3692	Upper Blue Mountains Moist Forest	2C	15,749
3693	Upper Blue Mountains Peppermint Dry Forest	2C	3,620

PCT ID	PCT Name	Koala Habitat	Area (ha)
3695	Western Blue Mountains Peppermint Sheltered Forest	2C	42,869
3734	Central Tableland Dry Slopes Stringybark-Box Forest	2C	14
3756	Gulgong Ranges Stringybark-Ironbark Forest	2C	1,629
3758	Hunter Escarpment Ironbark Wattle Scrub	2C	74
3768	Upper Hunter Ranges Enriched Ironbark Forest	2C	10,865
3769	Upper Hunter Sandstone Stringybark-Ironbark Forest	2C	875
3772	Western Hunter Caleys Ironbark Low Forest	2C	3,899
3775	Western Hunter Escarpment Ironbark Forest	2C	21,304
3780	Goulburn River Ironbark-Bloodwood Heathy Forest	2C	26,646
3783	Western Hunter Rocky Sandstone Ironbark Forest	2C	984
3872	Illawarra Basalt Melaleuca Scrub	2C	586
3895	Budawang Damp Swamp Heath	2C	1,399
3904	Hunter Coast Grasstree Graminoid Swamp Scrub	2C	15
4049	South Coast Floodplain Grassy Swamp Forest	2C	1,348
4059	Sydney Hinterland Sandy Creekflat Shrub Forest	2C	23
4085	Southwest Tableland Gorges Riparian Shrubland	2C	2
4106	Illawarra Escarpment Cool Temperate Rainforest	2C	4
4111	Lower North Grey Myrtle Riparian Dry Rainforest	2C	25
4121	Mount Dangar Wattle Scrub	2C	59
4125	New England Youmans Stringybark-Box Forest	2C	4
3013	Illawarra Lowland Subtropical Rainforest	Other	4,743
3024	Blue Mountains Gorge Warm Temperate Rainforest	Other	419
3025	Central Coast Gallery Rainforest	Other	799
3028	Illawarra Escarpment Warm Temperate Rainforest	Other	6,865
3029	Lower North Wet Gully Palm Rainforest	Other	3,345
3030	Nattai Plateau Callicoma Gully Rainforest	Other	9
3032	Northern Escarpment Sassafras-Booyong-Corkwood Rainforest	Other	29
3036	South Coast Warm Temperate-Subtropical Rainforest	Other	5,579
3037	Sydney Basin Warm Temperate Rainforest	Other	13,369
3038	Sydney Coastal Coachwood Gallery Rainforest	Other	3,530
3039	Sydney Coastal Lilly Pilly-Palm Gallery Rainforest	Other	261
3040	Sydney Coastal Foreshores Gully Rainforest	Other	25
3041	Sydney Sandstone Coachwood-Grey Myrtle Rainforest	Other	3,939
3043	Upper Blue Mountains Gully Rainforest	Other	102
3045	South Coast Temperate Gully Rainforest	Other	3,494
3047	Sydney Montane Basalt Rainforest	Other	2,017
3054	Southeast Cool Temperate Rainforest	Other	4
3056	Central Eastern Ranges Riparian Dry Rainforest	Other	1,071
3075	Hunter Valley Rusty Fig Dry Rainforest	Other	59
3076	Hunter Valley Whalebone Dry Rainforest	Other	526
3079	Kandos Riparian Rainforest	Other	13
3083	Lower Hunter Tuckeroo Riparian Rainforest	Other	1,472
3086	Lower North Hinterland Riparian Dry Rainforest	Other	1,223
3087	Lower North Ranges Riparian Turpentine Forest	Other	1,288
3095	Mount Warrawolong Screeslope Rainforest	Other	11

PCT ID	PCT Name	Koala Habitat	Area (ha)
3096	Mount Yengo Subtropical Dry Rainforest	Other	4
3097	Northern Escarpment Dry Rainforest	Other	1
3100	Northern Hinterland Baloghia-Dendrocnide Subtropical Rainforest	Other	127
3101	Northern Hinterland Shatterwood Dry Rainforest	Other	35
3106	South Coast Grey Myrtle Dry Rainforest	Other	220
3120	Hunter-Peel Ranges Dry Rainforest	Other	708
3125	Illawarra Seacliff Banksia-Bangalay Forest	Other	299
3133	Sydney Coast Tuckeroo Littoral Rainforest	Other	147
3134	Illawarra Seacliffs Littoral Rainforest	Other	178
3140	Blue Mountains Sandstone Turpentine Moist Forest	Other	17,618
3145	Cumberland Bangalay x Blue Gum Riverflat Forest	Other	1,277
3150	Hunter Coast Ranges Turpentine Wet Forest	Other	28,442
3151	Northwest Sydney Sandstone Grey Myrtle Dry Rainforest	Other	8,552
3152	Hunter Range Turpentine-Grey Myrtle Gully Forest	Other	8,164
3154	Illawarra Blackbutt Moist Forest	Other	4,563
3155	Illawarra North-Pittwater Bangalay Moist Forest	Other	806
3156	Jervis Bay Sands Littoral Moist Forest	Other	15
3164	Mountain Lagoon Basalt Wet Forest	Other	5
3176	Sydney Enriched Sandstone Moist Forest	Other	1,925
3182	Far South Coastal Apple Gully Forest	Other	1,576
3187	Shoalhaven Hinterland Peppermint Wet Gully Forest	Other	3,414
3188	South Coast Riverflat Peppermint Forest	Other	1,537
3191	South Coast Ranges Moist Gully Forest	Other	11,085
3211	Central Tableland Montane Wet Forest	Other	565
3215	Mount Jellore Trachyte Forest	Other	197
3216	Mount Warrawolong Basalt Wet Forest	Other	53
3231	Cordeaux Crinanite Moist Grassy Forest	Other	2
3234	Hunter Coast Lowland Spotted Gum Moist Forest	Other	8,096
3242	Lower North Ranges Turpentine Moist Forest	Other	16,269
3257	Sun Valley Diatreme Cabbage Gum Forest	Other	6
3258	Sydney Basin Creekflat Blue Gum-Apple Forest	Other	7,261
3259	Sydney Coastal Shale-Sandstone Forest	Other	653
3261	Sydney Sandstone Plateau Shale Forest	Other	3,269
3267	Shoalhaven Foothills Turpentine Forest	Other	34,659
3268	Shoalhaven Foothills Turpentine-Ironbark Moist Forest	Other	14,141
3270	Shoalhaven Lowland Wet Gully Forest	Other	5,984
3271	Shoalhaven Spotted Gum-Blackbutt Moist Forest	Other	3,616
3274	South Coast Spotted Gum Moist Forest	Other	87
3275	South Coast Spotted Gum Cycad Dry Forest	Other	54
3283	Liverpool Range Montane Stringybark Forest	Other	166
3286	Northern Escarpment Blackbutt Cool Moist Forest	Other	5
3287	Northern Escarpment Messmate Cool Wet Forest	Other	7
3288	Northern Escarpment Messmate Moist Grassy Forest	Other	21
3292	Bondo Slopes Peppermint Moist Grassy Forest	Other	5
3294	Central Tableland Peppermint-Gum Montane Forest	Other	159

PCT ID	PCT Name	Koala Habitat	Area (ha)
3307	Kosciuszko-Namadgi Alpine Ash Moist Grassy Forest	Other	17
3311	Southeast Escarpment Ash Forest	Other	7
3338	Goulburn Tableland Frost Hollow Grassy Woodland	Other	1,315
3369	Central Tableland Ranges Peppermint-Gum Grassy Forest	Other	774
3385	Southern Tableland Creekflat Swamp Woodland	Other	321
3391	Munghorn Seepage Wet Herbfield	Other	0
3407	Central Headland Grassland	Other	193
3409	Southern Headland Grassland	Other	21
3410	Spinifex Strandline Grassland	Other	183
3411	Tollgate Island Littoral Scrub	Other	57
3416	Southern Tableland Valley Flats Damp Grassland	Other	59
3432	Hunter Coast Foothills Apple-Ironbark Grassy Forest	Other	3,352
3433	Hunter Coast Foothills Spotted Gum-Ironbark Grassy Forest	Other	20,465
3434	Hunter Coast White Mahogany Low Forest	Other	164
3441	Lower Hunter Clay Heath	Other	3
3442	Lower Hunter Lowland Ironbark-Paperbark Forest	Other	2,433
3448	Castlereagh Ironbark Forest	Other	5,364
3500	Cathedral Rock Granite Peppermint-Gum Forest	Other	53
3526	Warrumbungle Rockplate Scrub	Other	7
3527	Western Hunter Broombush Grassy Scrub	Other	13
3544	Coastal Sands Apple-Blackbutt Forest	Other	793
3545	Coastal Sands Bloodwood Low Forest	Other	798
3546	Coastal Sands Littoral Scrub-Forest	Other	689
3549	Lower North Sandplain Heathy Forest	Other	16
3556	Umina Coastal Sand Woodland	Other	67
3578	Blue Mountains Low Heathy Woodland	Other	19,540
3580	Burralow Swamp Woodland	Other	0
3581	Hunter Coast Foothills Apple Forest	Other	5,032
3582	Hunter Coast Lowland Apple-Bloodwood Forest	Other	6,981
3583	Hunter Coast Lowland Scribbly Gum Forest	Other	10,488
3584	Illawarra Escarpment Cliffline Scrub	Other	236
3585	Morton Plateau Shrub Forest	Other	12,689
3586	Northern Sydney Scribbly Gum Woodland	Other	7,139
3587	Pearl Beach Sand Forest	Other	28
3588	Shoalhaven Foothills Bloodwood Heathy Forest	Other	22,390
3589	Southern Highlands Escarpment Peppermint Gully Forest	Other	1,454
3590	Southern Sydney Scribbly Gum Woodland	Other	7,581
3591	Southern Sydney Sheltered Forest	Other	1,915
3592	Sydney Coastal Enriched Sandstone Forest	Other	3,693
3593	Sydney Coastal Sandstone Bloodwood Shrub Forest	Other	44,723
3594	Sydney Coastal Sandstone Foreshores Forest	Other	769
3595	Sydney Coastal Sandstone Gully Forest	Other	38,564
3596	Sydney Coastal Sandstone Riparian Forest	Other	1,598
3598	Woronora Plateau Scribbly Gum Woodland	Other	51,663
3600	Burragorang Escarpment Heath	Other	0

PCT ID	PCT Name	Koala Habitat	Area (ha)
3609	Kangaroo Valley Colluvial Scribbly Gum-Stringybark Forest	Other	644
3611	Nattai Plateau Bloodwood-Peppermint Forest	Other	32,537
3614	Southern Highlands Sandstone Peppermint Forest	Other	28,039
3617	Sydney Hinterland Peppermint-Apple Forest	Other	87,517
3618	Sydney Hinterland Sandflat Peppermint Forest	Other	944
3621	Sydney Hinterland Turpentine-Apple Gully Forest	Other	46,969
3627	Wollemi Plateau Yertchuk-Stringybark Woodland	Other	42,914
3638	South Coast Sands Bangalay Forest	Other	2,380
3639	South Coast Sands Bangalay Littoral Forest	Other	121
3640	South Coast Sands Littoral Scrub	Other	17
3643	Bungonia Tableland Silvertop Ash-Stringybark Forest	Other	9,529
3646	Far South Coastal Ranges Silvertop Ash Forest	Other	1
3650	Goulburn-Lithgow Ranges Silvertop Ash Forest	Other	1,234
3653	Kanangra Peaks Silvertop Ash Forest	Other	648
3659	South Coast Hinterland Silvertop Ash Forest	Other	534
3661	South Coast Hinterland Yertchuk Forest	Other	555
3662	South Coast Lowland Blackbutt Forest	Other	10,794
3663	Southeast Foothills Stringybark Shrub Forest	Other	359
3665	Southeast Hinterland Silvertop Ash-Stringybark Forest	Other	211
3668	Southern Highlands Scribbly Gum Forest	Other	7,929
3685	Budawang Sandstone Silvertop Ash Forest	Other	5,030
3688	Newnes Plateau Silvertop Ash Woodland	Other	10,034
3689	Shoalhaven Escarpment Peppermint-Silvertop Ash Forest	Other	22,190
3691	Upper Blue Mountains Fringing Swamp Woodland	Other	1,689
3694	Upper Blue Mountains Ridgetop Woodland	Other	38,249
3696	Western Blue Mountains Rocky Scribbly Gum Woodland	Other	6,379
3735	Central Tableland Peppermint Shrub-Grass Forest	Other	1,021
3736	Cudgegong Sandslope Scribbly Gum Woodland	Other	3,860
3737	Bungonia Tableland Scribbly Gum Shrub Forest	Other	2,906
3738	Goulburn-Lithgow Tableland Hills Grassy Forest	Other	1,581
3747	Southern Tableland Western Hills Scribbly Gum Forest	Other	1,626
3749	Western Blue Mountains Scribbly Gum Forest	Other	998
3753	Dunedoo Sandstone Ironbark-Pine Forest	Other	73
3754	Durridgere Sandstone Ironbark Forest	Other	114
3757	Hunter Escarpment Ironbark Scrubby Low Forest	Other	1,144
3759	Hunter Escarpment Wattle Scrub	Other	124
3770	Western Blue Mountains Escarpment Ironbark Forest	Other	395
3771	Western Hunter Broombush Mallee Shrubland	Other	2,156
3776	Goulburn River Grassy Mallee Scrub	Other	138
3785	Goulburn River Ironbark Shrub Forest	Other	9,691
3788	Coastal Foredune Wattle Scrub	Other	1,020
3789	Coastal Headland Clay Heath	Other	230
3793	Hunter Coast Headland Clay Heath	Other	95
3794	Lower North Coast Headland Clay Heath	Other	360
3795	Mid North Swamp Oak Headland Scrub	Other	3

PCT ID	PCT Name	Koala Habitat	Area (ha)
3799	Agnes Banks Woodland	Other	193
3800	Bouddi Headland Wallum Heath	Other	290
3802	Lower North Sandplain Wallum Heath	Other	346
3803	Northern Sandplain Damp Wallum Heath	Other	3
3805	Southern Sandplain Heath	Other	997
3806	Sydney Coastal Sand Mantle Heath	Other	23
3807	Northern Sydney Heath-Mallee	Other	246
3808	Northern Sydney Sandstone Rockplate Shrubland	Other	517
3809	Shoalhaven Rockplate Heath	Other	8,050
3810	Southern Sydney Rockplate Heath	Other	5,024
3811	Sydney Coastal Headland Cliff Scrub	Other	129
3812	Sydney Coastal Sandstone Headland Heath	Other	378
3813	Sydney Hinterland Dwarf Apple Low Woodland	Other	5,339
3814	Woronora Plateau Heath-Mallee	Other	10,201
3854	New England Rockplate Shrubland	Other	0
3857	Blue Mountains Rocky Mallee Heath	Other	5,132
3859	Genowlan Point Heath	Other	53
3861	Morton Plateau Rocky Heath-Woodland	Other	35,044
3862	Newnes Plateau Rockplate Heath	Other	3,513
3863	Upper Blue Mountains Mallee Heath	Other	6,379
3865	Western Blue Mountains Pagoda Scrub	Other	4,102
3869	Southern Escarpment Montane Heath	Other	232
3870	Far Southeast Mountain Rock Scrub	Other	0
3873	Milton Volcanics Tick Bush Rocky Scrub	Other	18
3875	Southern Highlands Conglomerate Mallee Scrub	Other	5
3883	Alpine Short Herbfield	Other	12
3894	Blue Mountains Creekline Shrub Swamp	Other	251
3896	Budderoo-Morton Damp Swamp Heath	Other	2,072
3905	Jervis Bay Headland Dune Wet Heath	Other	33
3916	Sandstone Cliff Soak	Other	0
3917	Shoalhaven Lowland Heath	Other	1,987
3919	Southern Highlands Wet Swamp Heath	Other	233
3920	Coastal Clifftop Shrubby Marsh	Other	0
3923	Sydney Coastal Sandstone Creekline Swamp Heath	Other	913
3924	Sydney Coastal Upland Swamp Heath	Other	5,916
3925	Sydney Sandstone Button Grass Sedgeland	Other	4,321
3928	Blue Mountains Damp Coral Fern Swamp	Other	7
3929	Blue Mountains Swamp Heath	Other	5,304
3932	Central and Southern Tableland Swamp Meadow Complex	Other	1,001
3941	Megalong Valley Fringing Swamp Scrub	Other	11
3945	Newnes Plateau Shrub Swamp	Other	730
3946	Newnes Plateau Swamp Woodland	Other	806
3948	Southeast Subalpine Bog	Other	1
3949	Southern Highlands Sand Swamp Sedgeland	Other	621
3950	Southern Highlands Sand Swamp Woodland	Other	51

PCT ID	PCT Name	Koala Habitat	Area (ha)
3953	Western Blue Mountains Swamp Gum Low Forest	Other	10
3962	Coastal Floodplain Phragmites Reedland	Other	1,500
3963	Estuarine Reedland	Other	204
3967	Northern Lower Floodplain Eleocharis Wetland	Other	852
3975	Southern Lower Floodplain Freshwater Wetland	Other	2,037
3976	Southern Sands Freshwater Lagoon Wetland	Other	369
3977	Sydney Coastal Headland Lagoon Sedgeland	Other	1
3978	Morass Margin Shallow Wetlands	Other	33
3981	Tableland Semi-permanent Shallow Wetlands	Other	113
4007	Northern Sands Paperbark Sedge Low Forest	Other	1
4010	Sydney Hinterland Creekflat Paperbark Scrub	Other	32
4015	Central Hunter Swamp Oak Riparian Forest	Other	5,366
4026	Estuarine Sea Rush Swamp Oak Forest	Other	1,046
4027	Estuarine Swamp Oak-Mangrove Forest	Other	1,213
4028	Estuarine Swamp Oak Twig-rush Forest	Other	2,771
4037	Hunter Coast Swamp Oak Rainforest	Other	11
4040	South Coast Selliera-Sea Rush Swamp Oak Saltmarsh	Other	470
4056	Southern Estuarine Swamp Paperbark Creekflat Scrub	Other	680
4060	Yengo Creekflat Sedgeland	Other	7
4063	Central and Southern Tableland River Oak Forest	Other	878
4064	Central Eastern Ranges River Oak Forest	Other	2,627
4073	Lower North Hinterland River Oak Forest	Other	2,063
4084	Southern Escarpment River Oak Forest	Other	2,523
4086	Sydney Coastal Sandstone Riparian Scrub	Other	4,180
4091	Grey Mangrove-River Mangrove Forest	Other	3,837
4092	Coastal Headland Sea Spray Grassland	Other	0
4094	Estuarine Club Rush-Arrowgrass Wetland	Other	13
4095	Paspalum vaginatum-Samphire Saltmarsh	Other	228
4096	Prickly Couch-Sea Rush Saltmarsh	Other	1
4097	Samphire Saltmarsh	Other	881
4103	Sporobolus virginicus Saltmarsh	Other	265
4104	Central Hunter Weeping Myall Forest	Other	106
4105	Border Ranges Red Carabeen Rainforest	Other	8
4114	Lower North Sands Littoral Rainforest	Other	3
4122	Cockle Creek Sandflat Scribbly Gum Forest	Other	26
4127	Colo Plateau Dwarf Apple Heath-Woodland	Other	3,447
4137	Coastal Sand Couch Wetland	Other	1
4155	Kedumba Valley Alluvial Flats Forest	Other	47
3750	Binnaway Sandstone Ironbark-Pine Shrubby Woodland	Unknown	12
32767	Unattributed	Unknown	5

Appendix 3 – Vegetation mapping across LGAs, National Parks and State Forest

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
Bayside Council	4,724			Primary	1 (0.02 %)		
				2A	19 (0.4 %)		
				2C	1 (0.03 %)		
				Other	4702 (99.55 %)		
				Unknown	0 (0 %)		
Blacktown City Council	24,019	672 (2.80%)		Primary	1156 (4.81 %)	93 (13.84% / 8.04%)	
				2A	107 (0.45 %)	4 (0.6% / 3.73%)	
				2B	2304 (9.59 %)	354 (52.68% / 15.36%)	
				2C	0 (0 %)		
				Other	20456 (85.16 %)	133 (19.79% / 0.65%)	
Blue Mountains City Council	132,456	100,469 (75.85%)		Primary	53 (0.04 %)	23 (0.02% / 43.2%)	
				2A	1447 (1.09 %)	1335 (1.33% / 92.25%)	
				2B	9483 (7.16 %)	8823 (8.78% / 93.04%)	
				2C	37578 (28.37 %)	26364 (26.24% / 70.16%)	
				Other	83975 (63.4 %)	63784 (63.49% / 75.96%)	
				Unknown	0 (0 %)		
Burwood Council	714			Other	714 (100 %)		
Camden Council	20,090	43 (0.21%)		Primary	893 (4.45 %)		
				2A	15 (0.08 %)		
				2B	3815 (18.99 %)	21 (48.84% / 0.55%)	
				2C	28 (0.14 %)		
				Other	15345 (76.38 %)		
				Unknown	0 (0 %)		

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
Campbelltown City Council	31,121	1,187 (3.81%)		Primary	127 (0.41 %)		
				2A	117 (0.38 %)		
				2B	3014 (9.69 %)	7 (0.59% / 0.02%)	
				2C	6688 (21.49 %)	392 (33.02% / 0.49%)	
				Other	21179 (68.05 %)	777 (65.46% / 0.31%)	
				Unknown	0 (0 %)		
Canterbury-Bankstown Council	11,104	239 (2.15%)		Primary	6 (0.05 %)	3 (1.26% / 50.00%)	
				2A	87 (0.79 %)	6 (2.51% / 6.90%)	
				2B	82 (0.74 %)		
				2C	167 (1.5 %)	101 (42.26% / 60.48%)	
				Other	10762 (96.92 %)	83 (34.73% / 0.77%)	
				Unknown	0 (0 %)		
Central Coast Council	180,392	46,696 (25.89%)	21,804 (12.09%)	Primary	3075 (1.7 %)		2 (0.01% / 0.07%)
				2A	1668 (0.92 %)	213 (0.46% / 12.77%)	28 (0.13% / 1.68%)
				2B	3736 (2.07 %)	405 (0.87% / 10.84%)	668 (3.06% / 17.88%)
				2C	30870 (17.11 %)	11752 (25.17% / 38.07%)	5277 (24.2% / 17.09%)
				Other	141010 (78.17 %)	33367 (71.46% / 23.66%)	14548 (66.72% / 10.32%)
				Unknown	0 (0 %)		
Cessnock City Council	196,492	53,098 (27.02%)	24,946 (12.70%)	Primary	5296 (2.7 %)	965 (1.82% / 18.22%)	60 (0.24% / 1.13%)
				2A	5185 (2.64 %)	60 (0.11% / 1.16%)	22 (0.09% / 0.42%)
				2B	43070 (21.92 %)	14408 (27.13% / 33.45%)	7848 (31.46% / 18.22%)
				2C	54816 (27.9 %)	22142 (41.7% / 40.39%)	6951 (27.86% / 12.68%)
				Other	88103 (44.84 %)	15220 (28.66% / 17.28%)	9272 (37.17% / 10.52%)
				Unknown	0 (0 %)		

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
City of Canada Bay Council	1,980			2C	18 (0.91 %)		
				Other	1962 (99.09 %)		
City of Parramatta Council	8,380	48 (0.57%)		Primary	12 (0.14 %)		
				2A	44 (0.52 %)		
				2B	19 (0.22 %)		
				2C	224 (2.68 %)	10 (20.83% / 4.46%)	
				Other	8082 (96.44 %)	30 (62.5% / 0.37%)	
				Unknown	0 (0 %)		
Council of the City of Sydney	2,640			Other	2640 (99.99 %)		
Cumberland Council	7,163			2A	48 (0.67 %)		
				2B	59 (0.82 %)		
				2C	0 (0.01 %)		
				Other	7056 (98.51 %)		
				Unknown	0 (0 %)		
Dungog Shire Council	1,827			2A	32 (1.77 %)		
				2C	191 (10.46 %)		
				Other	1603 (87.73 %)		
Eurobodalla Shire Council	498	194 (38.98%)		Primary	8 (1.59 %)	3 (1.55% / 37.92%)	
				2A	0 (0 %)		
				2C	121 (24.37 %)	45 (23.2% / 37.09%)	
				Other	369 (74.1 %)	139 (71.65% / 37.69%)	
Fairfield City Council	10,156	562 (5.53%)		Primary	90 (0.88 %)	7 (3.61% / 7.82%)	
				2A	216 (2.13 %)		
				2B	711 (7 %)	159 (28.29% / 22.36%)	
				Other	9141 (90 %)		
Georges River Council	4,408	19 (0.43%)		Primary	3 (0.06 %)		
				2A	2 (0.04 %)		

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
				2C	82 (1.87 %)	2 (10.53% / 2.43%)	
				Other	4321 (98.03 %)	15 (78.95% / 0.35%)	
				Unknown	0 (0 %)		
Goulburn Mulwaree Council	20,016	4,831 (24.14%)	1,356 (6.77%)	Primary	295 (1.47 %)	44 (0.91% / 14.91%)	1 (0.07% / 0.34%)
				2A	1143 (5.71 %)	149 (3.08% / 13.03%)	98 (7.23% / 8.57%)
				2B	113 (0.56 %)	82 (1.7% / 72.89%)	1 (0.07% / 0.89%)
				2C	3228 (16.13 %)	979 (20.26% / 30.32%)	314 (23.16% / 9.73%)
				Other	15254 (76.21 %)	3561 (73.71% / 23.34%)	287 (21.17% / 1.88%)
				Unknown	0 (0 %)		
Hawkesbury City Council	277,508	200,788 (72.35%)	2,910 (1.05%)	Primary	7707 (2.78 %)	3655 (1.82% / 47.43%)	1 (0.03% / 0.01%)
				2A	407 (0.15 %)	202 (0.1% / 49.64%)	
				2B	45997 (16.57 %)	33124 (16.5% / 72.01%)	96 (3.3% / 0.21%)
				2C	104324 (37.59 %)	84385 (42.03% / 80.89%)	2036 (69.97% / 1.95%)
				Other	119147 (42.93 %)	79037 (39.36% / 66.34%)	773 (26.56% / 0.65%)
				Unknown	0 (0 %)		
Inner West Council	3,517			Other	3517 (99.99 %)		
Ku-ring-gai Council	8,540	1,714 (20.07%)		Primary	0 (0 %)		
				2B	0 (0 %)		
				2C	699 (8.18 %)	145 (8.46% / 20.75%)	
				Other	7841 (91.81 %)	1489 (86.87% / 18.99%)	
Lake Macquarie City Council	75,553	8,780 (11.62%)	5,075 (6.72%)	Primary	2547 (3.37 %)	349 (3.97% / 13.7%)	120 (2.36% / 4.71%)
				2A	3079 (4.07 %)	119 (1.36% / 3.87%)	
				2B	3626 (4.8 %)	499 (5.68% / 13.76%)	1125 (22.17% / 31.02%)
				2C	2153 (2.85 %)	631 (7.19% / 29.31%)	269 (5.3% / 12.5%)

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
				Other	64122 (84.87 %)	6775 (77.16% / 10.57%)	3283 (64.69% / 5.12%)
				Unknown	0 (0 %)		0 (0% / 0%)
Lane Cove Municipal Council	1,044			2C	11 (1.09 %)		(0% / 0%)
				Other	1032 (98.9 %)		(0% / 0%)
Lithgow City Council	223,937	165,680 (73.99%)	1,950 (0.87%)	Primary	1436 (0.64 %)	1249 (0.75% / 86.95%)	6 (0.31% / 0.42%)
				2A	6952 (3.1 %)	6260 (3.78% / 90.04%)	71 (3.64% / 1.02%)
				2B	49302 (22.02 %)	42283 (25.52% / 85.76%)	518 (26.56% / 1.05%)
				2C	76544 (34.18 %)	67357 (40.65% / 88%)	390 (20% / 0.51%)
				Other	89866 (40.13 %)	48570 (29.32% / 54.05%)	917 (47.03% / 1.02%)
				Unknown	0 (0 %)		
Liverpool City Council	30,607	554 (1.81%)		Primary	1028 (3.36 %)	70 (12.64% / 6.81%)	
				2A	719 (2.35 %)	9 (1.62% / 1.25%)	
				2B	4366 (14.26 %)	129 (23.29% / 2.95%)	
				2C	2345 (7.66 %)	192 (34.66% / 8.19%)	
				Other	22154 (72.38 %)	104 (18.77% / 0.47%)	
				Unknown	0 (0 %)		
Liverpool Plains Shire Council	642			2A	6 (0.89 %)		
				2B	249 (38.81 %)		
				2C	106 (16.46 %)		
				Other	282 (43.87 %)		
Maitland City Council	35,432			Primary	261 (0.74 %)		
				2A	457 (1.29 %)		
				2C	1609 (4.54 %)		
				Other	33093 (93.4 %)		
				Unknown	0 (0 %)		

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
Mid-Coast Council	228	22 (0.10%)		2A	60 (26.39 %)		
				2C	68 (29.99 %)	4 (18.18% / 5.84%)	
				Other	99 (43.56 %)	16 (72.73% / 16.09%)	
Mid-Western Regional Council	290,655	90,474 (31.13%)	11,640 (4.01%)	Primary	8373 (2.88 %)	3059 (3.38% / 36.53%)	522 (4.48% / 0.05%)
				2A	42277 (14.55 %)	16990 (18.78% / 40.19%)	1369 (11.76% / 0.03%)
				2B	107232 (36.89 %)	36584 (40.44% / 34.12%)	2536 (21.79% / 0.02%)
				2C	70287 (24.18 %)	28578 (31.59% / 40.66%)	4414 (37.92% / 0.05%)
				Other	62806 (21.61 %)	5011 (5.54% / 7.98%)	2753 (23.65% / 0.04%)
				Unknown	12 (0 %)		
Mosman Municipal Council	835	83 (9.94%)		2C	3 (0.38 %)	1 (1.2% / 31.42%)	
				Other	832 (99.6 %)	68 (81.93% / 8.18%)	
Muswellbrook Shire Council	311,278	144,598 (46.45%)	939 (0.30%)	Primary	10551 (3.39 %)	6366 (4.4% / 60.34%)	284 (30.24% / 2.69%)
				2A	12916 (4.15 %)	7825 (5.41% / 60.59%)	20 (2.13% / 0.15%)
				2B	95550 (30.7 %)	67120 (46.42% / 70.25%)	
				2C	74213 (23.84 %)	42857 (29.64% / 57.75%)	381 (40.58% / 0.51%)
				Other	118194 (37.97 %)	20215 (13.98% / 17.1%)	254 (27.05% / 0.21%)
				Unknown	0 (0 %)		
Newcastle City Council	19,799	3,304 (16.69%)		Primary	77 (0.39 %)		
				2A	177 (0.9 %)		
				2C	957 (4.83 %)	190 (5.75% / 19.85%)	
				Other	18579 (93.84 %)	1713 (51.85% / 9.22%)	
North Sydney Council	1,044			2C	0 (0.04 %)		
				Other	1044 (99.95 %)		
Northern Beaches Council	25,594	11,296 (44.14%)		Primary	58 (0.23 %)	1 (0.01% / 1.72%)	

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
				2A	106 (0.41 %)	32 (0.28% / 30.2%)	
				2B	21 (0.08 %)	19 (0.17% / 91.75%)	
				2C	2375 (9.28 %)	2127 (18.83% / 89.55%)	
				Other	23030 (89.98 %)	8662 (76.68% / 37.61%)	
Oberon Council	190	190 (100.00%)		2A	3 (1.68 %)	3 (1.58% / 93.98%)	
				2B	43 (22.5 %)	43 (22.63% / 100.33%)	
				2C	1 (0.44 %)	1 (0.53% / 118.07%)	
				Other	144 (75.47 %)	144 (75.79% / 100.16%)	
Penrith City Council	40,387	1,884 (2.93%)		Primary	2388 (5.91 %)	30 (1.59% / 1.26%)	
				2A	4339 (10.74 %)	408 (21.66% / 9.4%)	
				2B	4454 (11.03 %)	188 (9.98% / 4.22%)	
				2C	1576 (3.9 %)	719 (38.16% / 45.61%)	
				Other	27641 (68.44 %)	487 (25.85% / 1.76%)	
Port Stephens Council	24,726	2,384 (9.64%)	1,155 (4.67%)	Primary	1094 (4.43 %)	297 (12.46% / 27.14%)	92 (7.97% / 8.41%)
				2A	1074 (4.34 %)	185 (7.76% / 17.22%)	81 (7.01% / 7.54%)
				2B	163 (0.66 %)	64 (2.68% / 39.31%)	3 (0.26% / 1.84%)
				2C	1932 (7.81 %)	419 (17.58% / 21.69%)	328 (28.4% / 16.98%)
				Other	20451 (82.71 %)	1386 (58.14% / 6.78%)	640 (55.41% / 3.13%)
Queanbeyan-Palerang Regional Council	5,866	5,806 (98.98%)		Primary	1 (0.01 %)	1 (0.02% / 100%)	
				2A	256 (4.36 %)	250 (4.31% / 97.66%)	
				2B	318 (5.41 %)	318 (5.48% / 100%)	
				2C	927 (15.81 %)	920 (15.85% / 99.22%)	
				Other	4369 (74.49 %)	4321 (74.42% / 98.9%)	
Randwick City Council	3,580	164 (4.58%)		Primary	2 (0.05 %)		
				2A	7 (0.21 %)	5 (3.05% / 67.93%)	

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
				Other	3570 (99.72 %)	115 (70.12% / 3.22%)	
				Unknown	0 (0 %)		
Ryde City Council	4,051	276 (6.81%)		Primary	0 (0.01 %)		
				2C	93 (2.3 %)	11 (3.99% / 11.83%)	
				Other	3957 (97.69 %)	217 (78.62% / 5.48%)	
Shellharbour City Council	15,397	984 (6.39%)		Primary	103 (0.67 %)		
				2A	464 (3.01 %)		
				2B	1301 (8.45 %)	20 (2.03% / 1.54%)	
				2C	2360 (15.33 %)	517 (52.54% / 21.91%)	
				Other	11173 (72.56 %)	407 (41.36% / 3.64%)	
Shoalhaven City Council	356,645	176,711 (49.55%)	14,978	Primary	7103 (1.99 %)	2772 (1.57% / 39.02%)	395 (2.64% / 5.56%)
				2A	9831 (2.76 %)	5457 (3.09% / 55.51%)	101 (0.67% / 1.03%)
				2B	3004 (0.84 %)	1116 (0.63% / 37.16%)	
				2C	64842 (18.18 %)	30329 (17.16% / 46.77%)	3939 (26.3% / 6.07%)
				Other	272044 (76.28 %)	135340 (76.59% / 49.75%)	10452 (69.78% / 3.84%)
				Unknown	1 (0 %)		0 (0% / 0%)
Singleton Council	388,503	159,681 (41.10%)	28,806 (7.41%)	Primary	2821 (0.73 %)	873 (0.55% / 30.94%)	30 (0.1% / 1.06%)
				2A	9681 (2.49 %)	1256 (0.79% / 12.97%)	171 (0.59% / 1.77%)
				2B	120956 (31.13 %)	78875 (49.4% / 65.21%)	14948 (51.89% / 12.36%)
				2C	114747 (29.54 %)	48230 (30.2% / 42.03%)	9667 (33.56% / 8.42%)
				Other	140370 (36.13 %)	30376 (19.02% / 21.64%)	3726 (12.93% / 2.65%)
				Unknown	1 (0 %)		
Strathfield Municipal Council	1,386			2C	1 (0.11 %)		
				Other	1385 (99.89 %)		

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
Sutherland Shire Council	35,086	17,280 (49.25%)		Primary	13 (0.04 %)	8 (0.05% / 63.87%)	
				2A	80 (0.23 %)	41 (0.24% / 51.32%)	
				2B	110 (0.31 %)	60 (0.35% / 54.62%)	
				2C	2092 (5.96 %)	314 (1.82% / 15.01%)	
				Other	32791 (93.46 %)	16340 (94.56% / 49.83%)	
				Unknown	0 (0 %)		
The Council of the Municipality of Hunters Hill	562	5 (0.89%)		Primary	0 (0.06 %)		
				2C	3 (0.54 %)		
				Other	559 (99.39 %)		
The Council of the Municipality of Kiama	25,740	5,370 (20.86%)		Primary	77 (0.3 %)		
				2A	22 (0.09 %)		
				2B	1084 (4.21 %)	167 (3.11% / 15.41%)	
				2C	6577 (25.55 %)	783 (14.58% / 11.9%)	
				Other	17986 (69.88 %)	4411 (82.14% / 24.52%)	
The Council of the Shire of Hornsby	47,461	22,946 (48.33%)		Primary	131 (0.28 %)	93 (0.41% / 70.87%)	
				2A	29 (0.06 %)	28 (0.12% / 98.17%)	
				2B	2006 (4.23 %)	588 (2.56% / 29.3%)	
				2C	5202 (10.96 %)	3860 (16.82% / 74.2%)	
				Other	40091 (84.47 %)	17746 (77.34% / 44.26%)	
				Unknown	0 (0 %)		
The Hills Shire Council	38,620	566 (1.47%)	40 (0.10%)	Primary	2100 (5.44 %)		
				2A	3 (0.01 %)		
				2B	5175 (13.4 %)	51 (9.01% / 0.99%)	
				2C	12787 (33.11 %)	363 (64.13% / 2.84%)	33 (82.5% / 0.26%)
				Other	18558 (48.05 %)	49 (8.66% / 0.26%)	

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
				Unknown	0 (0 %)		
Unincorporated - Sydney Harbour Area	2,568	9 (0.35%)		Primary	0 (0 %)		
				2C	1 (0.03 %)		
				Other	2567 (99.96 %)		
Upper Hunter Shire Council	141,963	35,582 (25.06%)	270 (0.19%)	Primary	3359 (2.37 %)	1126 (3.16% / 33.52%)	22 (8.15% / 0.65%)
				2A	4796 (3.38 %)	1497 (4.21% / 31.21%)	8 (2.96% / 0.17%)
				2B	42214 (29.74 %)	11893 (33.42% / 28.17%)	89 (32.96% / 0.21%)
				2C	31276 (22.03 %)	16978 (47.72% / 54.28%)	151 (55.93% / 0.48%)
				Other	60386 (42.54 %)	3990 (11.21% / 6.61%)	
				Unknown	0 (0 %)		
Warrumbungle Shire Council	19,424			Primary	462 (2.38 %)		
				2A	6942 (35.74 %)		
				2B	2182 (11.24 %)		
				2C	742 (3.82 %)		
				Other	9127 (46.99 %)		
				Unknown	0 (0 %)		
Waverley Council	893			Other	893 (99.98 %)		
Willoughby City Council	2,218	5 (0.23%)		Primary	0 (0.01 %)		
				2C	44 (1.96 %)		
				Other	2174 (98.02 %)	1 (20% / 0.05%)	
Wingecarribee Shire Council	232,984	68,027 (29.20%)	14,448 (6.20%)	Primary	3724 (1.6 %)	1179 (1.73% / 31.66%)	200 (1.38% / 5.37%)
				2A	5064 (2.17 %)	1096 (1.61% / 21.64%)	588 (4.07% / 11.61%)
				2B	20649 (8.86 %)	5808 (8.54% / 28.13%)	1366 (9.45% / 6.62%)
				2C	37428 (16.06 %)	15635 (22.98% / 41.77%)	2428 (16.81% / 6.49%)
				Other	166262 (71.36 %)	43983 (64.66% / 26.45%)	6227 (43.1% / 3.75%)

LGA	LGA Area (ha) in the Sydney Basin	National Parks (ha), % in LGA	State Forest LGA (ha), % in LGA	PKH	area of LGA in hectares) (% in LGA)	Area in National Park (% of National Park / % Koala Habitat Category	Area in State Forest(% of State / % Koala Habitat Category
				Unknown	1 (0 %)		0 (0% / 0%)
Wollondilly Shire Council	197,748	106,646 (53.93%)		Primary	2179 (1.1 %)	838 (0.79% / 38.46%)	
				2A	678 (0.34 %)	494 (0.46% / 72.87%)	
				2B	51980 (26.29 %)	35857 (33.62% / 68.98%)	
				2C	26675 (13.49 %)	10951 (10.27% / 41.05%)	
				Other	116336 (58.83 %)	57948 (54.34% / 49.81%)	
				Unknown	0 (0 %)		
Wollongong City Council	71,154	7,430 (10.44%)		Primary	466 (0.66 %)	33 (0.44% / 7.08%)	
				2A	520 (0.73 %)	5 (0.07% / 0.96%)	
				2B	1033 (1.45 %)	23 (0.31% / 2.23%)	
				2C	6921 (9.73 %)	1111 (14.95% / 16.05%)	
				Other	62224 (87.45 %)	5927 (79.77% / 9.53%)	
				Unknown	0 (0 %)		
Woollahra Municipal Council	1,193	37 (3.10%)		Primary	1 (0.05 %)		
				Other	1192 (99.94 %)	18 (48.65% / 1.51%)	

Appendix 4 – Vegetation mapping accuracy

Floristic data (30-tree sample *per* 349 field sites) used to ground truth the accuracy of the "NSW Version cCM11m1" vegetation mapping layer. A score of '1' indicating correctly typed (agreement between the tallest stratum tree species recorded at field sites and PCT descriptions for the mapped polygons); score of '0.5' indicating partial agreeance (incorrectly typed but a corresponding PCT appeared within 100m); and score of '0' indicating incorrectly typed (no conformity was apparent). Please note that canopy floristics column consists of the first letter of the genus and first three letters of the species, with the number of individual trees of that species followed in brackets *eg*. Alit = *Allocasuarina littoralis.*

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_006	Ar_cun (14), Alit (3), Esee (3), Ecre (2), Egra (2), Wmah (2), Esid (1), Eter (1), Mqui (1), Sbark (1)	0	3172	0
NR_014	Eter (15), Mqui (4), Cgla (2), Erob (2), Esid (2), Exo (2), Call (1), Lsua (1), Melsp (1)	0	3002	0
NR_018	Eter (26), Ccam (2), Lsua (2)	0	4034	0.5
NR_021	Cint (6), Emic (6), Rfsp (4), Allo (2), Emel (2), Grob (2), Jmim (2), Mtan (2), Aexc (1), Eter (1), Jpsu (1), Sbark (1)	0	3322	0.5
NR_027	Ibark (9), Ccam (6), Cint (5), Lcon (3), Emic (2), Cbar (1), Egra (1), Eter (1), Ficus (1), Jpsu (1)	0	3021	0
NR_0281	Epro (28), Ccam (1), Emic (1)	0	3427	0
NR_032	Emic (13), Ctor (6), Rfsp (5), Gsem (3), Aexc (1), Jmim (1), Sact (1)	0	3139	0.5
NR_035	Rfsp (21), Dreg (2), Ar_cun (1), Ccam (1), El_gra (1), Emic (1), Epil (1), Epro (1), Ficus (1)	0	3011	0.5
NR_036	Rfsp (10), Lcon (9), Cint (5), Epro (5), Esid (1)	0	3148	0.5
NR_040	Ccam (16), Emic (12), Mphi (1), Pund (1)	0		1
NR_042	Rfsp (12), Lcon (6), Ccam (5), Cint (3), Emic (2), Ac_spp (1), Exo (1)	0	3148	0.5
NR_047	Egra (30)	0	3001	0.5
NR_050	Emic (27), Rfsp (2), Ccam (1)	0	3002	0
NR_051	Emic (29), Mtet (1)	0	3002	0
NR_054	Ccam (23), Gsem (6), Isin (1)	0		1
NR_075	Pell (29), Eeug (1)	0		1
NR_081	Epil (26), Cint (3), Lsua (1)	0	3420	0

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_097	Eter (20), Esid (4), Ac_dis (3), Aexc (2), Al_con (1)	0	3428	0.5
NR_099	Pell (12), Cint (11), Eter (6), Lsua (1)	0	4045	0.5
NR_108	Prad (30)	0		1
NR_139	Eter (21), Awoo (3)	0	4001	0.5
NR_143	Ccit (30)	0	3329	0
NR_154	Cgla (10), Rfsp (5), Exo (4), Mphi (4), Ac_spp (2), Ccam (2), Pgua (2), Eter (1)	0	3066	0.5
NR_157	Ccit (30)	0	3329	0
NR_165	Eter (28), Emol (2)	0	3420	0
NR_174	Emic (8), Ccam (7), Al_con (6), Aflo (2), Rfsp (2), Ac_mai (1), Aexc (1), Cint (1), Epil (1), Fcor (1)	0	3427	0
NR_180	Eter (27), Lsua (3)	0	3428	0.5
NR_186	Cgla (21), Eter (4), Cana (3), Av_mar (1), Cint (1)	0	3987	0.5
NR_188	Ccit (30)	0	3427	0
NR_196	Call (9), Cint (4), Eter (4), G_spp (4), Ctor (2), Epil (2), Ccit (1), Chen (1), Dreg (1), Exo (1), Mqui (1)	0	3427	0
NR_206	Epro (29), Ccit (1)	0	4070	0
NR_209	Emic (26), Ccit (1), Cgla (1), Eter (1), Mlin (1)	0	3427	0
NR_213	Ccam (18), Rfsp (12)	0		1
NR_214	Egra (28), Lcon (1), Rfsp (1)	0	3002	0.5
NR_217	Ccit (30)	0	3427	0
NR_223	Lsua (17), Cint (12), Ccam (1)	0	3427	0
NR_225	Eter (23), Ecar (3), Emic (3), Cana (1)	0	3323	0.5
NR_227	Eter (15), Lcon (4), Wmah (4), Ecre (3), Cgla (1), Cint (1), Grob (1), Melsp (1)	0	3021	0
NR_229	Mphi (8), Cgla (5), Eter (5), Cvim (3), Lsua (3), Rfsp (2), Ac_spp (1), Mtan (1)	0	3001	0
NR_230	Ccam (24), Rfsp (5), Lcon (1)	0		1
NR_231	upar (17), Grey gum (5), Grob (2), Br_pop (1), Epil (1), Eter (1), exo (1), Melsp (1), Sbark (1)	0	3002	0
NR_243	Eter (28), Cas_sp (2)	0	4046	0.5
NR_248	Esal (8), Eter (7), Esee (4), Ccam (3), Epil (3), Emic (1), Epun (1), exo (1), Rfsp (1), Unknown (1)	0	3001	0
NR_249	Ccam (18), Rfsp (8), Wmah (2), Ar_bid (1), Ar_cun (1)	0		1
NR_250	Ccam (20), Eter (6), Egra (2), Rfsp (1), Sbark (1)	0		1
NR_252	Rfsp (30)	0	3002	0.5
NR_284	Ccam (16), Egra (9), Cint (1), Emic (1), epro (1), Gsem (1), Lcon (1)	0		1

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_285	Ccam (19), Rfsp (9), Pund (1), Wmah (1)	0		1
NR_291	Eter (22), Ac_spp (3), Eacm (3), Aflo (1), Esid (1)	0	3427	0.5
NR_292	Aflo (23), Rfsp (4), Eter (3)	0	4033	0.5
NR_299	Egra (29), Ac_spp (1)	0	3003	0.5
NR_309	Eter (30)	0	3251	0
NR_310	Prad (25), Ac_spp (5)	0		1
NR_317	Eter (16), Cint (12), Jmim (2)	0	3322	0.5
NR_320	Ccam (12), Cint (6), Eter (5), Lsua (5), Cas_sp (1), Rfsp (1)	0	3251	0
NR_329	Edun (8), Aflo (7), Ecar (6), Cint (5), Eter (3), Ac_spp (1)	0	3465	0
NR_336	Ar_cun (17), Rfsp (6), Egra (4), Epro (2), Mphi (1)	0	3003	0.5
NR_346	Rfsp (8), Cgla (5), El_gra (3), Sglo (3), Ar_cun (1), Call (1), Cana (1), Cmac (1), Fcor (1), Ficus (1), Grob (1), kpan (1), Mphi (1), Sing (1), Wmah (1)	0	3009	0.5
NR_348	Edun (26), Ac_spp (4)	0	3139	0
NR_363	Ccam (30)	0		1
NR_378	Ccam (20), Rfsp (5), Egra (4), Lcon (1)	0		1
NR_391	Rfsp (8), Cgla (7), Lcon (7), Sy_sp (2), Ac_spp (1), Ar_cun (1), Ccam (1), Epro (1), Fcor (1), Prad (1)	0	3011	0.5
NR_392	Lcon (9), Eacm (5), Prad (4), Ctor (3), Rfsp (3), Cint (2), Esid (2), Ctes (1), Unknown (1)	0	4070	0
NR_397	Rfsp (28), Ccam (1), Pund (1)	0	3011	0.5
NR_403	Eter (15), Mqui (6), Rfsp (4), Ac_spp (2), Cint (2), Cgla (1)	0	4034	0.5
NR_406	Epil (19), Ca_col (5), Bint (2), Cana (2), Cgum (2)	0	3551	0.5
NR_407		0		0
NR_A_02	Alei (6), Esid (5), Ecre (4), Sglo (4), Cint (3), Lsua (3), Awoo (2), Ccit (2), Epil (1)	0	3420	0
NR_A_10	Eter (29), Lsua (1)	0	4046	0.5
NR_A_12	Esid (11), Emol (8), Eter (5), Chen (3), Cint (2), Ccit (1)	0	3420	0.5
NR_A_13	Eter (12), Cint (9), Lsua (6), Ecre (2), Ficus (1)	0	4046	0.5
NR_A_14	Eter (13), Emic (10), Wmah (3), Egra (2), Aexc (1), Grob (1)	0	4046	0.5
NR_A_19	Lsua (16), Eter (9), Cint (3), Al_con (1), di_aus (1)	0	3420	0
NR_A_21	Rgum (15), Lsua (7), Cgla (6), Eter (1), Mqui (1)	0	4001	0.5
NR_A_27	Emol (21), Mnod (4), Aflo (2), Cgla (2), Eter (1)	0	3428	0
NR_A_32	Cas_sp (13), Eter (11), Ccit (4), Lcon (1), Lsua (1)	0	4070	0.5
NR_A_37	Edun (30)	0	3427	0

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_A_44	Wmah (18), Cint (6), Eter (6)	0	3427	0
NR_A_47	Emol (19), Eter (6), Ibark (3), Ac_spp (1), Grob (1)	0	3427	0.5
NR_A_48	Prad (12), Cana (10), Bank (4), Cint (3), Ccin (1)	0		1
NR_A_52	Cint (16), Eter (11), Esid (2), Aexc (1)	0	3322	0.5
NR_A_60	Eter (5)	0	4070	0
NR_184	Rfsp (29), Ar_tri (1)	3001		1
NR_199	Rfsp (30)	3001		1
NR_200	Rfsp (12), Ccam (7), Fsch (3), En_pub (1), Ffra (1), Gsem (1), Jpsu (1), Mphi (1), Pund (1), Rrub (1), Unknown (1)	3001		1
NR_268	Rfsp (30)	3001		1
NR_302	Rfsp (22), Cana (7), Ccam (1)	3001		1
23		3001		1
NR_232	Rfsp (27), Cas_sp (1), Cint (1), Sglo (1)	3002		1
NR_251	Rfsp (30)	3002		1
NR_347	Ccam (15), Emic (14), El_ret (1)	3002		1
NR_005	Ecre (13), Lcon (8), Ccam (6), Esid (2), Ecar (1)	3003	3251	0.5
NR_300	Egra (7), Eter (6), Ccam (5), Ecre (3), Erob (3), Rfsp (3), Ac_spp (2), Ccit (2)	3003	3251	0
NR_316	Eter (19), Ac_spp (3), Emic (3), Cint (2), Aflo (1), Cas_sp (1), Ibark (1)	3003	3322	0.5
NR_331	Rfsp (20), Dexc (4), Saus (4), pele (2)	3003		1
NR_333	Rfsp (26), Dexc (4)	3003		1
NR_351	Rfsp (28), Egra (1), pele (1)	3003		1
NR_386	Egra (8), Dexc (7), Rfsp (6), Cas_sp (3), Grob (2), sfra (2), Fcor (1), Unknown (1)	3003		1
NR_389	Rfsp (30)	3003		1
NR_064	Rfsp (14), Cgla (10), Mphi (4), Ffra (1), Ficus (1)	3004		1
NR_233	Ccam (15), Cgla (6), Rfsp (6), Mqui (3)	3004	0	0.5
NR_400	Ccit (8), Ccam (5), Rfsp (5), Exo (3), Ctor (2), Unknown (2), Acer_sp (1), Ar_cun (1), Av_mar (1), Prad (1), Pund (1)	3004	3993 or 0	0
NR_037	Rfsp (18), Lcon (5), Alit (4), Epil (2), Cint (1)	3011		1
NR_326	Lcon (21), Rfsp (7), Ccam (2)	3011		1
NR_374	Rfsp (30)	3011		1
NR_380	Lcon (16), Emic (7), Eacm (6), Ac_spp (1)	3011		1
NR_399	Ccam (10), Emic (5), Epro (5), Cint (4), Ator (3), Esid (2), Ccit (1)	3011	0/3148	0

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_185	Ccam (12), Pund (8), Mind (4), Ac_spp (3), Rfsp (2), Cint (1)	3021		1
NR_267	Egra (19), Ecre (6), Ar_cun (4), Sy_sp (1)	3021		1
NR_301	Aflo (10), Rfsp (9), Cint (5), Ecre (3), Ac_spp (2), Aexc (1)	3021	3065	0
NR_304	Rfsp (30)	3021		1
NR_334	Rfsp (30)	3021		1
NR_358	Rfsp (30)	3035		1
NR_390	Rfsp (18), Ac_spp (12)	3048		1
NR_020	Rfsp (17), Lcon (11), Ar_bid (1), Sbark (1)	3064		1
NR_323	Rfsp (18), Ccam (6), Ac_spp (2), Lfer (1), Nlon (1), Sy_sp (1), Unknown (1)	3064		1
NR_228	Aflo (7), Ccam (5), Cgla (4), Gsem (4), Esid (2), Mtan (2), Eter (1), Lluc (1), Lsua (1), Mphi (1), Rfsp (1), Wmah (1)	3065	0/3322	0.5
NR_137	Rfsp (28), Lsua (2)	3066		1
NR_173	Ccit (24), Eter (3), Rfsp (2), Ar_cun (1)	3069		1
NR_A_39	Emol (15), Eter (9), Ccit (4), Ibark (2)	3069		1
NR_258	Emic (11), Lcon (10), Ecar (6), Ccit (1), Cint (1), Rfsp (1)	3070	3251	0.5
NR_084	Esid (30)	3092	0/3420	0.5
NR_161	Eter (12), Aflo (10), Ccam (3), Bint (2), Lsua (2), Cint (1), Eres (1)	3102		1
NR_A_04	Pell (15), Lsua (4), Epil (3), Cint (2), Esid (2), Eter (2), Ccit (1), Rfsp (1)	3102	0	0.5
NR_A_06	Eter (17), Aexc (8), Lcon (4), Emol (1)	3102		1
NR_293	Emic (10), Cint (5), Ecar (4), Lluc (4), Cas_sp (3), Epro (2), Lcon (1), Rfsp (1)	3139		1
NR_314	Lcon (23), Rfsp (6), Egra (1)	3139		1
NR_315	Rfsp (12), Egra (4), Emic (4), Gfer (2), Gsem (2), Ibark (2), Lcon (2), Aexc (1), Dexc (1)	3139		1
NR_321	Lcon (16), Rfsp (5), Sbark (3), Egra (2), Ficus (2), Cint (1), cr_gla (1)	3139		1
NR_335	Rfsp (12), Emic (7), Lcon (4), Eter (3), Epro (2), Cint (1), Ecre (1)	3139		1
NR_350	Emic (7), pele (7), Rfsp (5), Fcor (3), Aflo (2), Egra (2), Gsem (1), Lcon (1), Ndea (1), Tlau (1)	3139		1
NR_353	Eter (13), Cas_sp (6), Cint (5), Aflo (2), Esid (1), Lcon (1), Rfsp (1), Wmah (1)	3139		1
NR_382	Ecre (6), Emic (5), Lcon (5), Cint (4), Epro (3), Wmah (3), Esid (2), Cgla (1), Eter (1)	3139		1
NR_387	Emic (15), Eter (7), Lcon (3), Melsp (2), Aflo (1), Ar_cun (1), Cint (1)	3139		1
NR_394	Epro (8), Ecar (7), Eter (6), Epun (3), Ac_spp (2), Cint (2), Esal (2)	3139	3249	0.5
NR_500	Rfsp (15), Emic (8), Cint (5), Lcon (1), pele (1)	3139		1
NR_A_53	Epil (28), Ac_spp (2)	3139	3252	0.5

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_A_62	Rfsp (13), Eter (9), Mphi (3), Ccin (2), Aflo (1), Ang_sp (1), Ar_cun (1)	3139	3233	0.5
NR_286	Rfsp (12), Ar_cun (4), Ficus (4), El_gra (2), Mell (2), Unknown (2), Ccam (1), Egra (1), Epil (1), Exo (1)	3147	3002	0.5
NR_024	Lcon (14), Rfsp (9), Emic (6), Allo (1)	3148		1
NR_026	Ccam (15), Lcon (14), Rfsp (1)	3148		1
NR_033	Rfsp (14), Emic (6), Lcon (6), Cint (1), Ecar (1), Ibark (1), Mtan (1)	3148		1
NR_043	Lcon (14), Emic (8), Cint (4), Epro (2), Ficus (1), Rfsp (1)	3148		1
NR_046	Eacm (13), Cint (6), Ecre (5), Lcon (2), Ac_spp (1), Ccam (1), Emic (1), Esid (1)	3148		1
NR_058	Lcon (13), Rfsp (11), Emic (3), Ccam (1), Ecre (1), Epro (1)	3148		1
NR_395	Rfsp (20), El_gra (4), Lcon (3), Ficus (1), Mphi (1), pele (1)	3148	3011	0.5
NR_398	Lcon (25), Aflo (2), Rfsp (2), Ccam (1)	3148		1
NR_008	Rfsp (11), Lcon (5), Eter (4), Ar_cun (2), Sglo (2), Emic (1), Emol (1), Esal (1), Grob (1), Melsp (1), Wmah (1)	3149		1
NR_305	Rfsp (18), Lcon (4), Cal_ser (3), Ator (2), Egra (2), Sglo (1)	3165		1
NR_306	Cgla (8), Ccit (6), Eter (5), Ecar (3), Rfsp (3), Call (1), Gsem (1), Ibark (1), Melsp (1), Mqui (1)	3165	3002	0
NR_044	Emic (10), Rfsp (7), Eter (3), Lcon (3), Cint (2), Epil (2), Esal (1), Sbark (1), Unknown (1)	3167		1
NR_104	Epil (12), Emic (9), Cas_sp (5), Cint (2), Wmah (2)	3169		1
NR_009	Ecar (14), Cint (10), Lsua (5), Ator (1)	3172		1
NR_017	Sglo (10), Cint (6), Rfsp (5), Emic (4), Lcon (2), Wmah (2), Ator (1)	3172		1
NR_130	Aflo (24), Eter (6)	3172	3427	0.5
NR_239	Wmah (9), Cas_sp (7), Rfsp (5), pele (3), Tlau (3), Sbark (2), Cint (1)	3172	3251	0.5
NR_255	Eter (9), Egra (5), Rfsp (5), Emic (3), Ndea (3), Lcon (2), naus (2), Epro (1)	3172		1
NR_260	Rfsp (11), Ecar (9), Lcon (6), Ccit (2), Emic (2)	3172		1
NR_289	Aflo (5), Cas_sp (5), Cint (4), Eter (4), Ibark (4), Emic (3), Ac_spp (2), Pell (2), Lcon (1)	3172	3251	0.5
NR_330	Epro (16), Rfsp (8), Melsp (6)	3172	3251	0.5
NR_339	Ccit (9), Ccam (7), Prad (5), Grob (3), Ac_spp (2), Mtet (2), Dreg (1), Lcon (1)	3172	3251	0
NR_341	Emic (10), Lcon (8), Pund (4), Rfsp (3), Ac_spp (1), Cint (1), Egra (1), Eter (1), pele (1)	3172		1
NR_343	Emic (16), Epro (5), Cint (3), Ar_cun (2), Ccam (2), Rfsp (2)	3172		1
NR_344	Ar_cun (6), Emic (6), Rfsp (6), Lcon (3), Mqui (3), Ctor (2), Egra (2), Msty (2)	3172		1
NR_345	Lcon (9), Egra (7), Rfsp (6), Emic (4), Cint (3), Etin (1)	3172		1
NR_376	Egra (18), Emic (4), Lcon (4), Rfsp (4)	3172		1
NR_235	Eres (16), Egra (12), Emic (2)	3173	3003	0

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_275	Emic (15), Lcon (6), Egra (5), pele (2), Ac_mai (1), Jpsu (1)	3173	3172	0.5
NR_369	Eter (18), Cint (3), El_gra (3), Mphi (3), Epro (1), pele (1), Unknown (1)	3173	3322	0.5
NR_A_50	Rfsp (9), Lcon (8), Eres (4), Emic (2), Cint (1), Egra (1), Eter (1), Gsem (1), Ndea (1), pele (1), Sy_sp (1)	3173		1
NR_A_58	Esid (8), Eres (7), Cint (3), Eter (3), Rfsp (3), Ecre (2), Sglo (2), Ecar (1), Mphi (1)	3174	3251	0.5
NR_013	Ccam (22), Cint (5), Eacm (1), Emic (1), Sglo (1)	3177	0	0.5
NR_038	Rfsp (11), Ibark (7), Ccam (5), Cint (5), Lcon (1), Wmah (1)	3232		1
NR_052	Ccam (9), Epil (5), Acer_sp (3), Ac_spp (2), Ecre (2), Emic (2), Rfsp (2), Ccit (1), Cint (1), Ctor (1), Ibark (1), Jmim (1)	3232	0	0
NR_053	Lcon (18), Ac_spp (6), Ecre (6)	3232		1
NR_055	Lcon (12), Epro (8), Rfsp (7), Cgla (2), Cint (1)	3232		1
NR_362	Etin (12), Sglo (7), Cint (4), Epil (4), Cgla (1), Emic (1), Lsua (1)	3232	3166	0
NR_364	Lcon (10), Epil (9), Ccam (8), Cgla (1), Ecre (1), Sact (1)	3232		1
NR_379	Rfsp (8), Emic (7), Egra (5), Epil (4), Lcon (3), Cint (2), Ac_spp (1)	3232		1
NR_393	Lcon (23), Ar_cun (3), Rfsp (3), Faus (1)	3232		1
NR_219	Emic (20), Egra (7), Lcon (2), pele (1)	3233		1
NR_061	Ac_spp (6), Ang_sp (4), Sbark (4), Cint (3), Epro (3), Eter (3), Emic (2), Gfer (2), Rfsp (2), Ibark (1)	3248	3251	0
NR_367	Emol (17), Eter (8), Ecre (4), Ac_spp (1)	3249		1
NR_004	Aflo (23), Cgla (2), Mphi (2), Cint (1), Epun (1), Ficus (1)	3251	3322	0.5
NR_159	Ccit (10), Emol (10), Wmah (5), Epro (3), Eter (2)	3251		1
NR_203	Emic (28), Ibark (2)	3251		1
NR_240	Ccit (14), Emic (9), Emel (3), Lcon (2), Epro (1), Faus (1)	3251		1
NR_254	Epro (12), Emol (9), Alit (2), Cgla (2), Ecre (2), Wmah (2), Cint (1)	3251		1
NR_256	Eter (26), Cint (2), Aflo (1), Wmah (1)	3251	3427	0.5
NR_259	Eter (7), Ac_spp (5), Gsem (5), Epro (4), Rfsp (3), Unknown (2), Ar_cun (1), Ecre (1), Ibark (1), pele (1)	3251	3233	0.5
NR_276	Cas_sp (8), Ccit (8), Ecar (8), Epro (3), Emol (2), Ibark (1)	3251		1
NR_283	Eter (18), Aflo (8), Mtan (2), Mphi (1), Rfsp (1)	3251	3139	0
NR_294	Ccit (15), Emic (9), Epro (6)	3251		1
NR_319	Lcon (8), Jmim (5), Eter (4), Ac_spp (3), bvar (2), Egra (2), Kpan (2), Esid (1), Mtan (1), Prad (1), Unknown (1)	3251	4046	0
NR_349	Emic (11), Wmah (6), Cint (5), Epro (5), Esid (3)	3251		1
NR_371	Lcon (9), Emic (8), Aflo (4), Sbark (4), Esid (3), Cas_sp (1), Eter (1)	3251	3322	0.5
NR_A_56	Cint (12), Esid (11), Ac_spp (2), Eter (2), Cas_sp (1), Ccam (1), Emol (1)	3251		1

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_155	Epil (10), Cint (8), Ac_spp (4), Lsua (4), Rfsp (3), Mqui (1)	3252	4001	0
NR_311	Rfsp (13), Cint (8), Epro (4), Wmah (3), Ecre (1), Lcon (1)	3252		1
NR_340	Cas_sp (12), Ecar (9), Cint (6), Pund (2), Unknown (1)	3252		1
NR_003	Cas_sp (6), Ecre (6), Emic (5), Sbark (5), Cint (4), Epro (2), Lcon (2)	3253		1
NR_007	Cas_sp (8), Esid (7), Cint (5), Emic (5), Epro (2), Unknown (2), Ecar (1)	3253		1
NR_023	Cas_sp (9), Lsua (9), Sbark (4), Cint (3), Ac_spp (2), Eacm (2), Emic (1)	3253		1
NR_071	Sglo (19), Cint (4), Eacm (2), Ccit (1), Chen (1), Ecre (1), Esid (1)	3253		1
NR_342	Emic (10), Sglo (7), Cint (5), Sbark (4), Efib (2), Lsua (2)	3253		1
NR_359	Emic (13), Egra (8), Rfsp (5), Cint (2), Eter (2)	3253		1
NR_360	Lcon (16), Egra (7), Cint (3), Br_pop (1), Esid (1), mspp (1), Rfsp (1)	3253	3248	0.5
NR_361	Lcon (16), Rfsp (9), Egra (4), Cint (1)	3253	3232	0.5
NR_375	Lcon (9), Rfsp (6), Emic (5), Ccam (4), Cint (4), Sglo (1), Unknown (1)	3253	3248	0.5
NR_377	Lcon (13), Rfsp (6), Emic (5), Epro (4), Cint (1), Ibark (1)	3253	3148	0.5
NR_396	Ator (12), Awoo (8), Emic (3), Esid (2), Wmah (2), Ac_spp (1), Alit (1), Epro (1)	3253		1
NR_204	Emic (20), Epro (3), Ac_mai (2), Egra (2), Rfsp (2), Ator (1)	3322		1
NR_337	Eter (17), Cint (9), Rfsp (3), Epro (1)	3322		1
NR_352	Emol (13), Eter (9), Esid (6), Aexc (1), Wmah (1)	3322		1
NR_354	Eter (28), Ctor (1), Kpan (1)	3322		1
NR_385	Aflo (10), Gsem (7), Rfsp (7), ac_spp (2), Cint (1), Eter (1), hfla (1), Mphi (1)	3322	4070	0
NR_A_57	Ecre (16), Eter (10), Ibark (4)	3322		1
NR_A_63	Eter (11), Aflo (8), Lsua (5), Lcon (4), Eamp (2)	3322		1
NR_211	Ecar (13), Cint (5), Emic (4), Ac_spp (3), Lsua (3), Ccam (1), Mqui (1)	3323		1
NR_A_31	Esid (11), Lsua (5), Cgla (4), Emol (4), Eter (4), Cint (2)	3323	3427	0.5
NR_201	Lsua (13), Eter (9), Ac_spp (4), Cint (2), Ctor (1), Ecre (1)	3329		1
NR_074	Etin (8), Ecre (6), Ccit (5), Epro (4), Cint (3), Lsua (2), Aexc (1), Eter (1)	3420		1
NR_083	Ccit (14), Esid (12), Lsua (3), Eeug (1)	3420		1
NR_093	Aflo (10), Cint (9), Lsua (4), Eter (3), Ecar (2), Epro (2)	3420		1
NR_094	Emol (16), Ibark (9), Cint (3), Csal (2)	3420		1
NR_100	Ccit (14), Esid (8), Epro (4), Eres (4)	3420		1
NR_111	Ccit (24), Emol (5), Ecre (1)	3420		1

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_114	Ecre (14), Ac_spp (8), Lsua (8)	3420		1
NR_123	Emol (15), Ccit (6), Esid (4), Eter (2), Aexc (1), Cint (1), Epro (1)	3420		1
NR_133	Chen (6), Emol (6), Icon (6), Ccit (4), Eter (3), Esid (2), Ac_spp (1), Aexc (1), Alit (1)	3420		1
NR_135	Cint (10), Eacm (7), Emic (5), Eter (4), Esid (2), Erac (1), Lcon (1)	3420		1
NR_136	Cint (14), Emic (5), Rfsp (5), Lcon (2), Aexc (1), Emel (1), Epro (1), Erac (1)	3420		1
NR_148	Emol (26), Eter (2), Ca_spp (1), Chen (1)	3420		1
NR_163	Eter (26), Esid (2), Ccit (1), Emol (1)	3420		1
NR_166	Eter (14), Lsua (12), Cint (3), Aflo (1)	3420		1
NR_408	Ccit (18), Eter (8), Emol (3), Ecre (1)	3420		1
NR_410	Cmac (19), Emol (4), Cint (2), Efib (2), Aflo (1), Ecre (1), Emic (1)	3420		1
NR_411	Cmac (16), Ecre (7), Emol (7)	3420		1
NR_A_05	Ccit (15), Esid (12), Lsua (2), Eter (1)	3420		1
NR_A_18	Chen (8), Emol (8), Eter (7), Ccit (6), Esid (1)	3420		1
NR_A_20	Cint (17), Eter (10), Lsua (3)	3420		1
NR_A_30	Eter (14), Cint (5), Ccam (4), Ctor (3), Epro (2), Ar_cun (1), Ccit (1)	3420		1
NR_102	Cint (8), Wmah (8), Alit (7), Epil (7)	3421		1
NR_124	Epil (16), Cint (5), Eres (5), Lsua (2), Alit (1), Unknown (1)	3421		1
NR_001	Aflo (12), Eter (11), Ecre (3), Ccam (2), Cint (2)	3422		1
NR_002	Eacm (17), Ccit (8), Ecre (3), Awoo (1), Cint (1)	3422		1
NR_068	Ccit (16), Esid (9), Eeug (2), Cint (1), Eacm (1), Wmah (1)	3422		1
NR_077	Ccit (17), Epil (4), Aexc (2), Cint (2), Esid (2), Eter (2), Ecre (1)	3422		1
NR_080	Etin (13), Ccit (9), Cint (7), Ccin (1)	3422		1
NR_092	Efib (15), Sbark (8), Cmac (6), Ibark (1)	3422		1
NR_106	Cint (10), Aflo (7), Alit (3), Lsua (3), Ac_spp (2), Aexc (1), Alei (1), Ccit (1), Chen (1), Ecar (1)	3422		1
NR_120	Eter (17), Ccit (7), Esid (2), Lsua (2), Cint (1), Mqui (1)	3422		1
NR_170	Chen (13), Emol (10), Ibark (6), Wmah (1)	3422		1
NR_247	Esid (19), Emic (11), Epil (10), Ecar (7), Cint (6), Alit (2), Wmah (2), Aexc (1), Awoo (1), Sglo (1)	3422		1
NR_405	Cmac (11), Efib (9), Emol (5), Ibark (4), Sbark (1)	3422		1
NR_A_22	Esid (14), Eter (8), Cint (4), Lcon (4)	3422		1
NR_A_23	Ccit (19), Emol (9), Eter (2)	3422		1

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_A_46	Cint (17), Ecar (9), Ator (1), Bint (1), Eter (1), Lcon (1)	3422	3322	0.5
NR_141	Emol (13), Ccit (8), Aflo (3), Ecre (2), Eter (2), Epro (1), Wmah (1)	3427		1
NR_171	Ibark (11), Eter (7), Lsua (6), Emol (4), Aflo (1), Grob (1)	3427		1
NR_192	Ccit (13), Emol (10), Eter (3), Rfsp (2), Wmah (2)	3427	3465	0.5
NR_194	Cint (13), Ccit (11), Lsua (5), Ibark (1)	3427		1
NR_202	Cint (20), Epro (3), Eter (3), Ac_spp (2), Ecar (2)	3427		1
NR_205	Ccit (12), Eter (7), Emol (5), Aflo (4), Efib (2)	3427	3422	0.5
NR_207	Cint (25), Esid (3), Ecar (2)	3427		1
NR_208	Ccit (24), Ecre (4), Cint (1), Esid (1)	3427	3428	0
NR_237	Ccit (21), Epro (4), Ecre (3), Cint (2)	3427	351	0.5
NR_241	Aflo (10), Eter (7), Emol (5), Ccit (2), Cint (2), Esid (2), Ac_spp (1), Lcon (1)	3427		1
NR_261	Ccit (14), Epil (5), Emic (3), Epro (3), Esid (3), Ibark (1), Lcon (1)	3427	3070	0
NR_264	Epro (17), Cint (7), Ac_spp (4), Eter (2)	3427	3322	0
NR_266	Ctor (15), Eter (7), Grob (3), Rfsp (2), Aflo (1), Csal (1), Ecar (1)	3427	0	0.5
NR_273	Ccit (21), Epro (4), Wmah (3), Emol (1), Rfsp (1)	3427		0
NR_277	Ecar (25), Cint (2), Ecre (1), Epro (1), Esid (1)	3427		1
NR_279	Aflo (8), Cint (7), Emic (7), Eter (7), Ecre (1)	3427		1
NR_295	Cas_sp (11), Ecar (6), Cint (5), Sglo (3), Ac_spp (2), Lcon (2), Emic (1)	3427		1
NR_313	Eamp (22), Aflo (4), Ac_spp (2), Eter (1), Ibark (1)	3427	3322	0
NR_366	Epro (16), Emic (5), Cas_sp (4), Esid (3), Emol (2)	3427	3251	0.5
NR_381	Wmah (12), Cgla (9), Epro (7), Cint (2)	3427		1
NR_A_17	Eter (21), Aexc (3), Cint (3), Aflo (2), Unknown (1)	3427		1
NR_A_25	Eter (10), Emic (7), Ctrac (4), Aflo (3), Er_ves (2), Ac_mai (1), Ator (1), Emel (1), pele (1)	3427		1
NR_A_29	Cint (13), Ccit (11), Eter (4), ac_lei (1), Alit (1)	3427		1
NR_A_33	Eter (9), Cint (8), Emic (6), Lsua (3), Jmim (2), Rfsp (2)	3427		1
NR_A_34	Lsua (15), Cint (9), Aflo (5), Aexc (1)	3427		1
NR_A_35	Emel (17), Ccit (12), Esid (1)	3427		1
NR_A_36	Cint (28), Eter (1), Lsua (1)	3427		1
NR_A_38	Emic (24), Cas_sp (6)	3427	3422	0
NR_A_40	Eter (14), Lsua (11), Cint (5)	3427	3102	0.5

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_A_41	Wmah (18), Eter (7), Ibark (3), Cint (2)	3427		1
NR_A_45	Ccit (26), Emol (3), Eter (1)	3427	3251	0.5
NR_A_51	Emol (12), Wmah (8), Eacm (6), Cas_sp (2), Epro (1), Eter (1)	3427		1
NR_A_54	Aflo (23), Eter (6), Ccam (1)	3427		1
NR_A_55	Ar_cun (8), Ca_col (3), Cgla (3), Cvim (3), Epro (3), Esal (3), Grob (2), Ccam (1), Ccit (1), Emic (1), Lsua (1), Rfsp (1)	3427	3003	0.5
NR_085	Sglo (20), Mdec (4), Cgla (3), Eter (2), Eres (1)	3428	4046	0
NR_112	Eter (25), Lsua (5)	3428		1
NR_150	Lsua (21), Eter (5), Ac_spp (3), eter hybrid (1)	3428		1
NR_167	Ac_spp (6), Ecre (6), Lsua (6), Eter (5), Cint (4), Cgla (2), Rfsp (1)	3428		1
NR_168	Eter (29), Rfsp (1)	3428		1
NR_178	Emol (30)	3428		0
NR_197	Eter (28), Mlin (2)	3428		1
NR_262	Ecar (13), Emic (8), Cint (5), Ibark (2), Aexc (1), Eter (1)	3428	3427	0.5
NR_A_07	Esid (11), Lsua (10), Eter (5), Alit (2), Cint (2)	3428	4046	0.5
NR_A_16	Cint (12), Lcon (7), Esid (6), Emic (4), Eter (1)	3428	3987	0
NR_A_24	Eter (27), Lsua (2), Emol (1)	3428		1
NR_A_28	Cgla (13), Eter (5), Rfsp (5), Lsua (4), Mphi (2), Unknown (1)	3428	3066	0.5
NR_066	Ccit (18), Eter (3), Ecre (2), Aexc (1), Ang_sp (1), Awoo (1), Eacm (1), Epil (1), Esid (1), Gfer (1)	3465	3427	0.5
NR_190	Eter (14), Ccit (6), Emol (5), Rfsp (2), Cint (1), Epro (1), Esid (1)	3465		1
NR_234	Epro (15), Wmah (7), Eter (4), Ibark (2), Cgla (1), Cint (1)	3465	3251	0.5
NR_365	Eamp (13), Epro (6), Emol (4), Aflo (3), Ac_spp (2), Esid (1), Wmah (1)	3465		1
NR_089	Erob (14), Epil (7), Alei (4), Bser (4), Ac_spp (1)	3548		1
NR_115	Lsua (17), Ac_spp (3), Grey gum (3), Cgla (2), Cint (2), Gfer (1), Ibark (1), Mqui (1)	3551	3420	0
NR_070	Ccit (8), Mnod (8), Esid (5), Alei (4), Cgla (3), Cint (1), Epro (1)	3561		0
NR_A_08	Cint (9), Cgla (8), Sglo (7), Wmah (4), Ecre (1), Eter (1)	3564		1
NR_A_15	Cint (13), Bint (6), Eter (5), Alei (3), Aexc (1), Epil (1), Mqui (1)	3564		1
NR_327	Alit (16), Epil (9), Rfsp (2), Cint (1), Erac (1), Lcon (1)	3572		1
NR_101	Cint (12), Erac (5), Sglo (5), Epil (3), Ccit (2), Ecar (1), Sbark (1), Wmah (1)	3573	3989	0
NR_087	Mirb (9), Eres (8), Ecar (4), Aflo (2), Cas_sp (2), Ccit (1), Cint (1), Erac (1), Lsua (1), Sglo (1)	3574		1
NR_169	Bint (12), Cgla (6), Fcor (4), Ficus (4), Mqui (3), Rfsp (1)	3788	3990	0.5

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_129	Mqui (17), Erob (5), Lept (3), Bint (2), psqu (2), Mnod (1)	3913		1
NR_065	Ccit (9), Mqui (9), Eter (3), Ficus (3), Cana (2), eter x erob (2), Lcon (2)	3989		1
NR_103	Cint (13), Erac (6), Cgla (5), Ac_spp (3), Ibark (2), Eres (1)	3989		1
NR_140	Mqui (28), Aexc (1), Rfsp (1)	3989		1
NR_088	Mqui (21), Eter (8), Lsua (1)	4001		1
NR_086	Sglo (15), Eacm (4), Emic (4), Cint (2), Epil (2), Lcon (1), Mbra (1), Melsp (1)	4003		1
NR_172	Eter (20), Cas_sp (5), Emol (2), Ar_cun (1), Grob (1), malb (1)	4033	3329	0.5
NR_A_43	Cas_sp (9), Rfsp (5), Emic (4), Mphi (4), Exo (2), Fcor (2), Aflo (1), Ar_cun (1), Ficus (1), Lcon (1)	4033	3322	0.5
NR_029	Rfsp (10), Eter (3), Lcon (3), Ccam (2), Ar_cun (1), atri (1), bcel (1), Caus (1), Ccit (1), Daus (1), Exo (1), Jmim (1), Mell (1), Mind (1), Unknown (1), Wmah (1)	4034		1
NR_039	Lsua (9), Ac_spp (8), Cint (5), Ccam (3), Cgla (2), Eter (2), Esid (1)	4034		1
NR_116	Egra (18), Cint (4), Eter (3), Sbark (3), Ecar (1), Sglo (1)	4045	3988	0.5
NR_117	Mqui (9), Cint (4), Ecre (4), Sglo (4), Ac_spp (3), Eter (2), Cgla (1), Er_arb (1), Ibark (1), Sole (1)	4045		1
NR_095	Ac_spp (18), Aflo (3), Emic (3), Eter (2), Unknown (2), Call (1), Cint (1)	4046		1
NR_113	Eter (11), Lsua (8), Erac (7), Mbra (2), Ccit (1), Cint (1)	4046		1
NR_245	Eter (28), Aflo (1), Ficus (1)	4046		1
NR_404	Erob (23), Eres (4), Ac_spp (3)	4046	3990	0.5
NR_A_11	Eter (19), Exo (5), Lsua (3), Ac_spp (1), Ccit (1), Msty (1)	4046		1
NR_A_26	Ccit (25), Rfsp (3), Cint (1), Lsua (1)	4046	3420	0.5
NR_A_49	Csal (5), Eter (5), Lcon (4), Cas_sp (3), Egra (3), Melsp (3), Mqui (2), Wmah (2), Ac_spp (1), ccit (1), Rfsp (1)	4046		1
NR_012	ap_phi (8), Rfsp (8), Ccam (7), Mphi (4), Ar_cun (1), Cgla (1), Lsin (1)	4070		1
NR_221	Lsua (18), Cint (9), Cas_sp (2), Eter (1)	4070	4046	0.5
NR_278	Aflo (13), Ecar (11), Rfsp (2), Ac_spp (1), Ccam (1), Eter (1), Jpsu (1)	4070	3070	0
NR_297	Rfsp (9), Lcon (6), Ccit (4), Emic (3), Eter (3), Ar_cun (2), Grob (2), Ac_spp (1)	4070	3322	0
NR_356	Rfsp (12), Eter (4), Ficus (4), Grob (4), Ccam (2), Tlau (2), smor (1), Unknown (1)	4070		1
NR_388	Rfsp (14), Egra (5), Lcon (4), Cgla (2), Epro (2), Ar_cun (1), Ccam (1), Unknown (1)	4070		1
NR_A_59	Emic (16), Ac_spp (4), Ccam (4), Unknown (3), Cgla (2), Ecar (1)	4070	3172	0.5
NR_090	Epil (13), Rfsp (5), Emic (4), Cint (3), Lcon (3), Sglo (1), Tlau (1)	4078	3251	0
NR_274	Aflo (10), Ac_spp (8), Eamp (7), Cas_sp (1), Eter (1), Ibark (1), Rfsp (1), Sy_sp (1)	4078	3172	0.5
NR_402	Mqui (10), Av_mar (8), Lcon (5), Cgla (4), Rfsp (3)	4091		1

Biolink site code	Canopy floristics - field data	PCT code	Nearby PCT code (within 100m)	Score
NR_373	Rfsp (30)	4105		1
NR_045	Sglo (17), Lcon (5), Rfsp (4), Cgla (3), Epil (1)	4115		1
NR_401	Cgla (15), Av_mar (14), Rfsp (1)	4140		1

Appendix 5 – Koala corridors in the Greater Macarthur Growth Area

Koala Corridor Project

Campbelltown City Council & Wollondilly Local Government Areas: Greater Macarthur Growth Area.

Report to NSW Office of Environment & Heritage

October 2018

biolink pty ltd
ecological consultants
PO Box 3196 Uki NSW 2484
T 02 6679 5593
F 02 6679 5523
www.biolink.com.au

Table of contents

Abbreviation	Description
BEC	Biolink Ecological Consultants
CCC	Campbelltown City Council
CKPoM	Comprehensive Koala Plan of Management
dIIC	delta-Integral Index of Connectivity
DoPE	Department of Planning and Environment
FPSP	Full Proposed Structure Plan
GAP CLoSR	General Approach to Planning Connectivity from Local Scales to Regional
GMGA	Greater Macarthur Growth Area
LGA	Local Government Area
PKFT	Preferred Koala Food Tree
PKH	Preferred Koala Habitat
PRV	Percentage Resistance Value
OEH	Office of Environment and Heritage
RMS	Roads and Maritime Services
SC	Statewide Class
VCT	Vegetation Community Types
WS	Wollondilly Shire

CoLS

Principal Consultant Dr. Stephen Phillips

Senior Ecologist /GAPCLoSR Analysts Dr. Amanda Lane / Kirsty Wallis

External consultation / liaison: A/Prof Alex Lechner, University of Nottingham.

Citation:

Biolink. 2018. Koala Corridor Project: Campbelltown & Wollondilly Local Government Areas. Biolink Ecological Consultants, Uki, NSW. Report to NSW Office of Environment & Heritage.

1. Summary

The Campbelltown City Council (CCC) and Wollondilly Shire (WS) Local Government Areas (LGAs) are located in the Macarthur region of south-western Sydney. While koalas inhabiting the CCC LGA have been the focus of scientific and community interest since the early 1980's, those in the adjoining WS LGA to the south have only recently become the focus of investigation. Available information based on consideration of historical koala records analyses and the aforementioned research imply that the two populations are in fact one and the same, with recent sightings along the eastern edge of the more southerly WS LGA commensurate with a known recovery trend in the north. Koalas in both areas share similar ecological traits such as preferred food tree species.

There is a need build resilience into these recovering koala populations so that they are capable of better withstanding the impacts of future development and stochastic impacts such as fire. One way to achieve such resilience will be to have population cells widely distributed and occupying habitat outliers that are arguably protected to varying degrees from catastrophic fire events. In order to do this, viable linkages and associated habitat patches need to be secured across the landscape. Parts of the Campbelltown and Wollondilly LGAs additionally form the Greater Macarthur Growth Area (GMGA) and are about to undergo a period of further expansion and development. Elements of such expansion in addition to an increased development footprint dedicated to urbanisation, include the upgrading of arterial roads, some of which have seen an increased rate of koala road-kill in recent years.

The Generalised Approach to Planning Connectivity at Local and Regional Scales (GAP CLoSR) offers a GIS-based spatial and analytical framework that enables examination of issues associated with landscape-scale habitat fragmentation and connectivity. Analyses such as that offered by the GAP CLoSR process have the capacity to inform future planning decisions by offering objective assessment of the landscape at a key point in ecological time. This report describes the application of GAP CLoSR to examine issues relating to the future impacts of land use change on koala movements in the GMGA and surrounding areas. Working from a baseline connectivity and patchmatrix assessment covering an area of 90,000 ha, analyses considered the fragmentation and connectivity issues arising from full implementation of an envisaged structure plan for the southern part of the GMGA between South Campbelltown and Appin in concert with two options relating to the future upgrading of Appin Road.

A baseline (status quo) GAP CLoSR analysis of the current vegetated landscape using a minimum Preferred Koala Habitat (PKH) patch size of 10 ha implied that the study area currently functioned as seven separate landscape components comprised of 218 PKH patches that were

notionally interconnected by 476 least-cost dispersal pathways. The associated delta-Integral Index of Connectivity (d-IIC) graph-metrics confirmed the importance of the consolidated linear linkages of PKH that skirts the eastern parts of the study area along the Georges River from Long Point through Kentlyn and Wedderburn and Appin down to the east of Wilton and Bargo in the south. In the area from Long Point in the CCC LGA to the east of Appin, analysis independently identified the habitat patch matrix that currently connects the Nepean and Georges Rivers catchments in the vicinity of the Beulah biobanking site as amongst the most important, with other east-west linkages also identified at Appin, Rosemeadow South / Noorumba Reserve and Ousedale-Mallaty.

Implementation of the full structure plan within the GMGA results in significant fragmentation of the associated landscape with implications for adjoining areas beyond the GMGA boundary. While the area within the development footprint remained as a single landscape component with no net loss of habitat patches (subject to provisions), at a locally-focussed 10 ha habitat patch level of resolution, implementation of the full structure plan resulted in a 36% reduction in the number of least-cost dispersal pathways. In terms of modelled scenarios, it was additionally determined that the upgrading of Appin Road with a fence along the eastern edge only would result in reduced connectivity options that will achieve little in terms of reducing vehicle-strike potential. Depending on final design, fencing of Appin Road so as to provide an impermeable barrier to koalas would result in the loss of either three or four locally significant least-cost pathways that were independently identified by the analysis as regionally important and currently facilitating the eastwest movement of koalas through this area. Consequently, a reliance on pathways that remained to service connectivity at either end of the fence were also deemed likely to result in increased mortality levels due to dispersing koalas having to navigate urban landscapes in south Campbelltown and Appin village.

Resolution of the preceding considerations should involve a fencing program along both sides of the Appin Road as a requirement of any upgrading, in addition to the integrated maintenance of connectivity in key locations. There are at least three opportunities to achieve this latter outcome, involving landscape / traffic managing solution at the northern end where Appin Road enters Rosemeadow South, one or more dedicated fauna overpasses in the vicinity of the Beulah biobanking site and an engineering solution sufficient to enable installation of an elevated road surface, bebo arch or similar structure towards the southern end near the head of Mallaty's Creek. Graphmetric output further implies that consideration should also be given to a re-evaluation of the scale of the final FPSP footprint so as to give some effect to the outcomes in terms of recognising the importance of the habitat linkage network through areas to the west of Appin Road between South Campbelltown and Appin village. Consolidation of the key linkages and effectively integrating associated dispersal pathways into the development footprint will be required to achieve this outcome.

2. Introduction

The Campbelltown City Council (CCC) and Wollondilly Shire (WS) Local Government Areas (LGA) are located in the Macarthur region of south-western Sydney. While koalas inhabiting the CCC LGA have been the focus of scientific and community interest since the early 1980's (Cork et al. 1988; Sheppard, 1990; Phillips and Callaghan 2000; Ward 2002; Lunney et al., 2010), it is only recently that those in the adjoining WS LGA have become the focus of research effort (NSW Office of Environment & Heritage (OEH), unpublished report). Available information based on consideration of historical koala records analyses in the CCC LGA, (Biolink Ecological Consultants (BEC) 2016) now indirectly supported by the aforementioned research effort and associated field assessments in the adjoining WS LGA to the south imply that the two populations are in fact one and the same, with recent increased sightings along the eastern edge of the more southerly WS LGA commensurate with the known recovery trend in the north.

At the time of preparing this report, the ongoing trend of koala population recovery referred to in the preceding paragraph is manifesting itself in increasingly greater numbers of koalas (including breeding females) being struck and killed by motor vehicles along the arterial road network between Campbelltown, Appin and Wilton. Correlated with this trend in the CCC LGA at least is an extension of areas of generational persistence (i.e. presence of resident koala populations) from the Wedderburn area to habitat areas to the west of Appin Road where koalas have not previously been reported. The implications of this knowledge, now supported by field assessments, imply that koala populations in the Nepean and Georges Rivers catchments that up until recently were considered to be separate populations for management purposes are now in direct contact (BEC 2017, 2018); not surprisingly, the two populations sharing similar, if not identical ecological traits such as preferred food tree species.

The key to long-term sustainable management of free-ranging koala populations is knowledge. Based on understandings of koala density, occupancy rate and the amount of habitat containing preferred koala food tree species, BEC (2016) estimated the entire CCC LGA koala population population to comprise approximately 200 koalas. Given this circumstance and amongst other things, there is now an arguable need to know how best to build resilience into the recovering population so that it is capable of better withstanding the impacts of future stochastic impacts such as fire, which have likely played a significant role in the past in influencing population distribution in the past. The best way to achieve such resilience will be to have population cells more widely distributed and occupying habitat outliers that are better protected from catastrophic fire events, so enabling recolonization to occur. In order to assist this process, viable linkages need to be secured across the landscape.

As it's name implies, the Generalised Approach to Planning Connectivity at Local and Regional Scales (GAP CLoSR) developed by Lechner and Lefroy (2014) is a GIS-based planning tool and supporting spatial / analytical framework that enables the examination and modelling of issues associated with connectivity. Amongst other things, GAP CLoSR does this by taking into account the ecological needs and movement characteristics of a given target species, and the extent to which the existing landscape impedes and/or influences movement. Importantly, the process is inclusive of key ecological considerations such as (i) the locations of areas of preferred habitat, (ii) the greatest distance of open ground that can be crossed, and (iii) the distances that can be moved across the landscape. Output from the GAP CLoSR process thus enables identification and compartmentalisation of habitat patches linked via a system of notional least-cost pathways, these being the shortest pathway between two vegetated patches within a given habitat compartment/component as a function of land cover resistance (i.e. barriers to movement). It is important to recognise that while the locations of least cost pathways are spatially explicit, the associated spatial dimensions such as width are not specified.

It is the exploration of connectivity across the current and envisaged future landscape that is the primary focus of this report. Parts of the CCC and WS LGAs form the Greater Macarthur Growth Area (GMGA) and are about to undergo a period of further expansion and development. Commensurate with an increased development footprint dedicated to urbanisation is the upgrading of arterial roads such as Appin Road, which has seen an increasing rate of koala road-kill in recent years. Analyses such as that offered by the GAP CLoSR process have the capacity to inform future planning decisions by offering informed analyses of the landscape at a key point in ecological time.

The purpose of this project was to take a strategic but analytical approach to connectivity issues by examining and better understanding the potential impacts arising from progressive development of the GMGA. This was firstly done by undertaking a landscape-scale baseline (status quo) analysis of habitat patches and connectivity, prior to investigating the potential impacts of two future planning scenarios[5] as follows:

1. a development (Structure Plan) footprint with Appin Road as a multi-lane dual carriage way, fenced on eastern side, and
2. a development (Structure Plan) footprint with Appin Road as a multi-lane dual carriage way, fenced on eastern side with a crossing at Ousedale-Mallaty corridor.

This report follows on from an earlier draft submitted in July 2018 which utilised a different vegetation mapping layer and considered other specified development scenarios. Pursuant to this report and a presentation of the results to a meeting in Sydney on the 3rd August 2018, a request was received for previously considered scenarios and some reporting requirements to

[5] Scenarios were explicitly specified by NSW OEH.

be changed. To this end we have endeavoured to incorporate changes to reporting requirements where possible, but were unable to accommodate others such as corridor / linkage widths which we considered to be peripheral and so distract from the specific objective of the initial project brief.

3. Methodology

3.1. Study area

The primary focal area for this project was the southern portion of the GMGA as identified by the NSW Department of Planning & Environment (DoPE). The GMGA traverses the southwestern portion of the CCC LGA extending into the north-eastern corner of the adjoining WS LGA. The southern part of the GMGA includes all activities related to the Full Proposed Structure Plan (FPSP) including changes to transportation infrastructure and urban development. To effectively capture this area and to place it into an appropriate landscape context, we identified a study area of approximately 90,000 ha, the eastern half of which captured the area which the majority of historical and more recent koala research work has been undertaken, where the associated areas of koala habitat are located and within which the GMGA occurs (Figure 1).

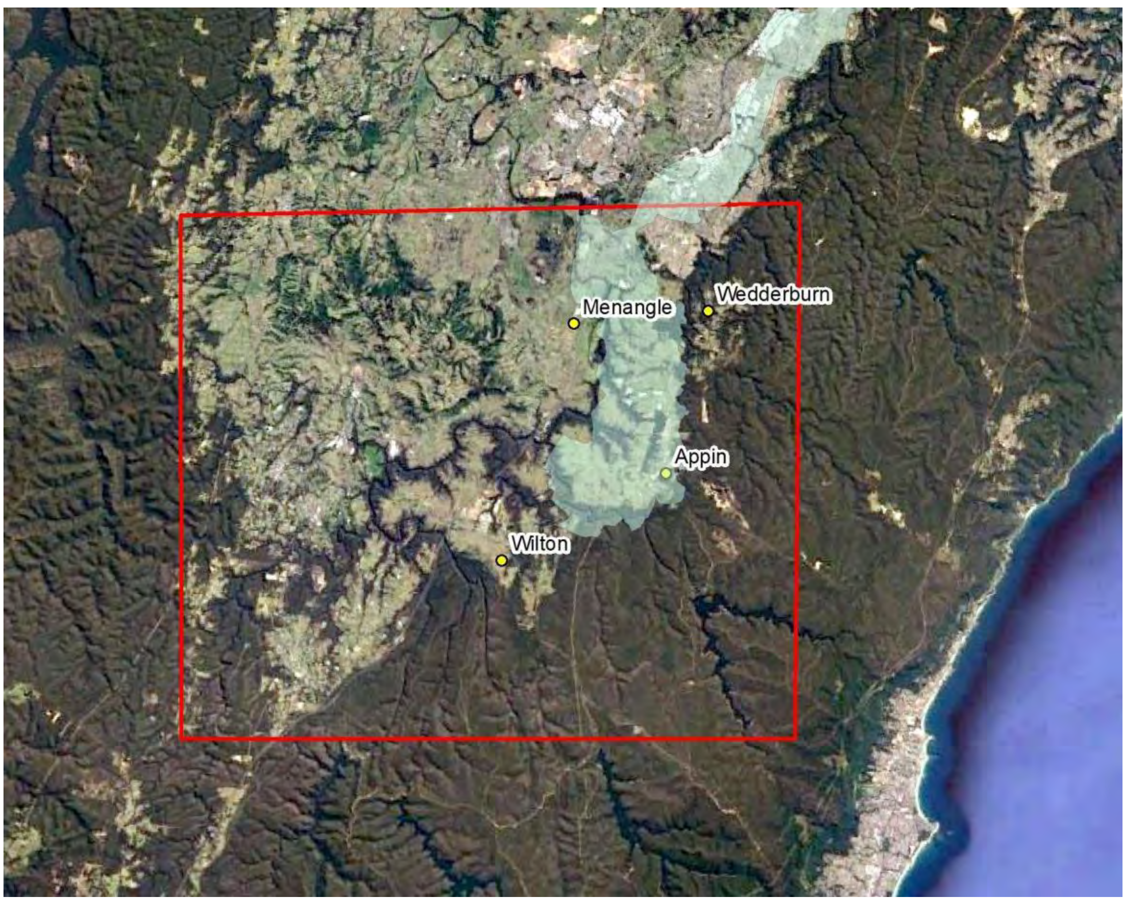

Figure 1: The study area boundaries, as defined by the red square, incorporate the southern portion of the Greater Macarthur Growth Area (GMGA), shown in pale green in the upper right-hand corner. This boundary includes all activities pertaining to infrastructure and urban development changes as outlined in the FPSP.

3.2. Allocating resistance to land use for koala movement

The Percentage Resistance Value (PRV) refers to the effort or cost that it takes a koala to cross a particular land-use type or class and is based on the notion that 100% resistance value takes 100 m of effort to cross a distance 100 m, 200% = takes an effort equivalent to 200 m to cross 100 m and so on. These resistance values are based on Lechner and Lefroy's (2014) initial recommendations for each land use category but have been refined herein according to species-specific expertise.

The Land use layer

Spatial data layers relating to both natural and human-influenced land uses were used to create a Dispersal Cost Surface – this is a rasterised[6] surface where each pixel's value represents a dispersal cost for koalas that is derived from the land cover type, reflecting the ecological costs for an individual to traverse the area. This requires evaluation of individual resistance levels, based on a practical assessment of both the likelihood of koala movement and the hazards that are likely to be encountered, herein defined as the extent of localised resistance.

For this project the Dispersal Cost Surface incorporated considerations of resistance related to the following landscape attributes:

i. Transport infrastructure (i.e. roads and railway lines),
ii. Hydrology (drainage lines, canals, aqueduct),
iii. Vegetation cover (including Preferred Koala Habitat [PKH]), iv. Mining and quarrying,
v. Agricultural activities (grazing & horticulture) and
vi. Urban, Commercial and Industrial Areas.

Spatial data layers relating to the preceding attributes were obtained from a variety of sources, including that already available to us as a consequence of our ongoing work with CCC (e.g. cadastre, roads, Strahler stream orders, vegetation mapping) and through licence / confidentiality agreements with NSW OEH data broker (Satellite imagery, GMGA and FPSP). Where appropriate, digital data layers detailing linear elements such as watercourses and infrastructure such as railway lines, roads etc. were underlain with satellite imagery in order to identify potential connectivity opportunities for koalas (e.g. underpasses and/or bridges), whereupon dispersal costs for that particular land use type were lowered accordingly. Other publicly available spatial data was accessed through the NSW Government Portal.

[6] A matrix of cells or pixels organized into rows and columns.

Gap-crossing layer

In order to determine the maximum distance that a koala was likely to travel from vegetation, BEC (2018b) calculated the Euclidian distance of all koala records to the nearest patch of mapped vegetation (including both PKH and other non-PKH mapped vegetation) in the CCC LGA. This analysis determined a maximum distance of 220 m that a koala had been recorded from a patch of vegetation. On the basis of this knowledge we applied a buffer of 220 m around all mapped vegetation. For areas outside this buffer zone we applied a complete barrier to movement (i.e. infinite dispersal cost).

3.3. Vegetation Cover

Vegetation mapping was provided by OEH ("SWSydneyVegStitched"). For portions of the far north and south-east of the study area that were not covered by this mapping layer we used publicly available spatial data, accessed through the NSW Government Portal as follows:

OEH. 2013. The Native Vegetation of the Sydney Metropolitan Area Volume 2. Vegetation Community Profiles Version 3. NSW Office of Environment & Heritage, Sydney.

Wollongong VIS map 2356.

In order to only capture those areas which are currently vegetated we deleted polygons classified as "cleared" in the "Broad Veg" column and polygons classified as "high disturbance" in the "Dist_Class" column. Some areas classified as "scattered trees" in the Dist_Class" column were also deleted. Further inspection of satellite imagery allowed the determination of polygons which did not accurately characterise vegetated areas, and these were also removed.

Classification of Statewide Class (SC) / Vegetation Community Types (VCTs)

For naturally occurring low-density koala populations such as those inhabiting the CCC and WS LGAs, the costs of moving across the vegetated landscape are higher than for those occupying higher carrying capacity landscapes; this is because the distances between individual Preferred Koala Food Trees (PKFTs) and/or for purposes of social contact between individuals are invariably greater.

For the purpose of this project all SC/VCTs recognised by the preceding mapping layers and represented within the study area were coded using the same hierarchical classification system previously used by BEC (2016) to identify areas of Preferred Koala Habitat (PKH) in the CCC LGA, expanded as necessary to include considerations of presence / absence / dominance relating to the following local PKFTs: grey box Eucalyptus moluccana, woolybutt E. longifolia, grey gum E.

punctata, manna gum E. viminalis and forest red gum E. tereticornis. Based on this knowledge, SCs/VCTs were classified in terms of their inherent koala carrying capacity as follows:

- Primary Koala Habitat – SC/VCT wherein 'primary' PKFTs comprise the dominant or codominant overstory species.
- Secondary Koala Habitat (Class A) – SC/VCT wherein 'primary' PKFTs are a sub-dominant component of the overstory species.
- Secondary Koala Habitat (Class B) – Primary PKFTs absent, SC/VCT dominated by one or more 'secondary' PKFTs.
- Secondary Koala Habitat (Class C) - Primary PKFTs absent, one or more 'secondary' PKFTs present within SC/VCT as a sub-dominant component of overstory species.

Collectively, SC/VCTs coded in accord with the preceding classification system qualify as PKH for koala conservation and management purposes. SC/VCTs that did not contain PKFTs were classified as 'Other' vegetation for analysis purposes. There is broad congruity of the preceding classification system with that of the High, Medium and Low quality habitat rankings designated by the OEH Wollondilly koala study (Appendix 1).

The allocation of cost metric is determined in a different way for PKH compared to all other categories. By example, in areas of SCs/VCTs categorised as Primary Koala Habitat, small home range sizes require less daily movement – that movement itself carrying costs associated with exposure and predation. In the subsequent series of Secondary habitat type (i.e. A, B and C), home ranges are by necessity larger, due to the commensurately sparser distribution of PKFTs. This requires greater daily movements to be undertaken, with associated higher costs. Because the physical movement through Secondary habitats is more costly to the koala, this leads us to recognise the need for a higher cost. All PKH (Primary and Secondary Classes) are considered 'no cost' when incorporated into a habitat patch in the GAP CLoSR framework. In order to qualify as a habitat patch per se, a minimum size threshold, defined by the user, must be exceeded. In cases where the amount of available habitat does not meet this threshold, Secondary PKH classes carry progressively higher costs to traverse than Primary PKH, which is the only land use that is 'no cost' in all contexts.

For the purpose of this project but also informed by other GAP CLoSR projects we have undertaken (BEC 2017, 2018b) we have continued to develop and refine a standardised set of resistance parameters for koalas that were ecologically defined and hence broadly applicable throughout the species range. Notwithstanding the need to acknowledge localised departures from a standardised set as particular circumstances arise (e.g. the Lachlan Way aqueduct and other channelled watercourses such as occur in the CCC LGA), the use of a standardised approach enables a consistent approach to be applied across the koala's range. Our current approach to this standardisation process is detailed in Appendix 2. In order to enable a fine-scale understanding and to optimise flexibility for planning purposes, we approached the majority of our analyses using a 10 ha minimum habitat patch size.

3.4. Layering for Rasterization Purposes

Multiple data layers are used to form the cost-dispersal surface and it is frequent that polygons from one data layer (e.g. roads) will intersect another data layer such as vegetation. In such instances it is important to define which data layer has the values that take precedence. Data layers were defined as having the following order of precedence, in terms of their cost value:

i. Connectivity structures spanning roads, train lines and aqueducts.
ii. Train lines and aqueduct
iii. Roads iv. Hydrology
v. Vegetation cover (including PKH and non-PKH vegetation)
vi. Urban / Commercial / Industrial / Agricultural land uses

Preliminary investigations of surface complexity resulted in a determination to utilise a pixel size of 6 m x 6 m for rasterization purposes.

3.5. Identifying Landscape Components, Linkage Networks and Least-cost Dispersal pathways

Graphic approaches can be used to represent ecological landscapes in terms of nodes and edges, whereby the former exist as interconnected habitat patches within a larger (regional) network of landscape components, while the edges, in theory at least, represent connectivity between such components. To this end, we used the supporting GraphHab software function developed by Foltête et al. (2012) to identify key components and associated patch networks/linkages. We also used the GraphHab function to identify least-cost dispersal pathways using a threshold method. To this end and as opposed to a reliance on Euclidian distance, cumulative costs paths were used to incorporate information from the PRVs of the dispersal cost surface, with a maximum cumulative cost threshold of 300,000 beyond which a pathway would not be formed.

3.6. Graphab Settings and Metrics

Principal settings stipulated in the GraphHab software package included patch connexity, which was set to 4, meaning that a habitat 'patch' consists of the central pixel with its four neighbors if they were of the same value. Patches were simplified for planar graphing purposes to streamline the creation of polygonal boundaries, thereby accelerating analysis. Topology was also complete, meaning that all links that did not otherwise cross habitat patches were considered. The cumulative cost was determined using the maximum cumulative cost threshold as defined in the preceding section.

The primary graph metric output required from analyses was the delta-Integral Index of Connectivity (dIIC) which is expressed as the product of patch capacities (which in this case was determined by habitat patch size) divided by the number of links between them, with the sum divided by the square of the study area using the calculations of Pascual-Hortal and Saura (2006). The dIIC, as opposed to either the global- or component-IIC, describes the relative importance of each graphic element by computing the rate of variation in the global metric induced by the removal of either patches or paths. The result of a delta metric can be presented both at a local level (that of habitat patch or pathway) but also by reference to the global level (i.e. the entire study area). The dIIC thus offers a useful overall measure of connectivity that takes into account the area of habitat and connectedness between patches. The dIIC index is also calculated between pairs of nodes (patches) and is a measure of the level of connectivity between patches.

3.7. Scenario modelling

The revised instructions required us to consider the following scenarios:

a) A development (FPSP) footprint including Appin Road as a multilane dual carriage way, fenced on eastern side.

A spatial data layer of detail regarding envisaged FDSP outcomes for the GMGA was provided by NSW OEH for incorporation into the dispersal cost surface. For GAP CLoSR purposes we subjugated affected polygons from the vegetation cover mapping layer to reflect the developed landscape that was envisaged and then parameterised the area with land-use metrics and dispersal costs associated with related Appendix 3 components that related to the GMGA FPSP infrastructure detail that was provided. This approach required changes from background dispersal cost metrics of 150% – 500% that were otherwise applicable to former habitat areas and cleared areas with trees respectively, to that of 2000% imposed by highest-density Urban Areas. Lands identified (but not confirmed) for Environmental Protection, were replaced with a blanket value of 250%, reflective of the fact that these areas either have the capacity to be regenerated to or otherwise predominantly comprise Secondary (Class B) koala habitat. Areas identified as urban footprint capable land that has been changed to conservation were replaced with a value of 200%, reflective of their value, or potential value as Secondary (Class A) koala habitat. The proposed Sydney Orbital was coded with a cost metric applicable to an unfenced motorway (5000%). Additional arterial roads (1000%) and a train line (infinite cost) were also costed according to the cost of similar existing infrastructure as detailed in Appendix 3).

The required fence along the eastern side of Appin Road was incorporated as a single line of 6 m x 6 m pixels each of which carried an infinite costing to reinforce the impermeability notion.

b) A development (FPSP) footprint with Appin Road as a multi-lane dual carriage way, fenced on eastern side with a crossing at Ousedale-Mallaty corridor.

In terms of the envisaged FPSP, this scenario was costed as described above. No specifications were provided as to what form a crossing at the Ousedale – Mallaty's corridor might look like. Subject to this qualification we determined to decrease over a distance of 100 m the cost metric otherwise applicable to the single line of pixels as we have described above, to that of non-PKH vegetation.

4. Results

Rasterisation of the input land use layer resulted in a large series of pixels that were checked and coded manually for resistance in accord with values detailed in Appendix 1. An example illustrating the fine-scale complexities of the resistance coded land use layer is provided in Figure 2.

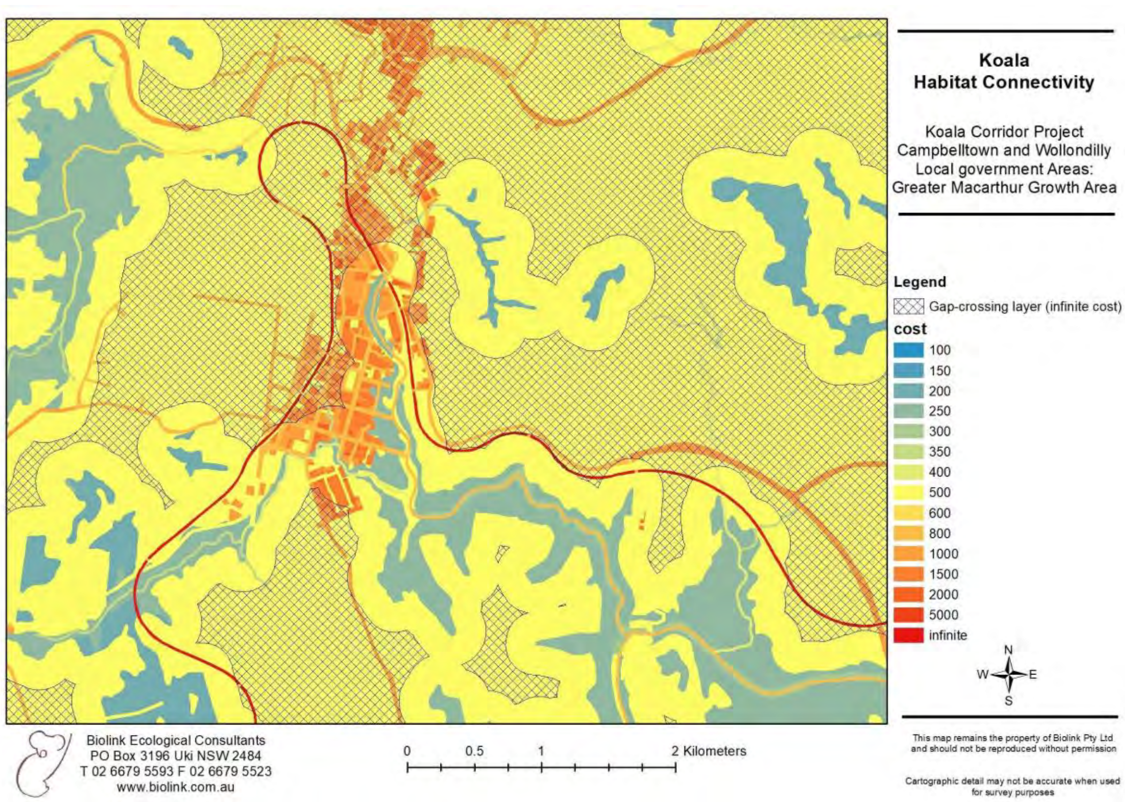

Figure 2: The area south of Picton coded to reflect a variety of cost metrics relating to koala movement/dispersal. The cross-hatched and orange/red areas represent infra-structure and/or land surfaces that are difficult for koalas to traverse whereas low cost (blue) offer relatively easier traverses. Note that the area is costed for a range of land uses including vegetation type, agriculture, urban development, industry, transportation infrastructure and hydrology, among others. The thin red line represents a fenced train line with various areas where crossings may occur in orange. The gap crossing layer (in cross hatch) represents all those areas which are greater than 220 m from any mapped vegetation.

4.1. Baseline (Status quo)

The baseline (status quo) cost-dispersal surface for the study area is presented in Figure 3, with GraphHab output for the same area illustrated in terms of landscape components, associated habitat patch networks and least-cost pathways in Figure 4. At the 10 ha habitat patch scale of analyses, output determined that the study area functioned as seven discrete landscape components collectively comprised of 218 identifiable habitat patches notionally connected by 476 least-cost pathways. The largest landscape component comprises the entire south and the northeast of the study area, incorporating the GMGA and the development footprint of the FPSP, with the exception of the very north-west of the FPSP, near Camden south, and western portions of the Great Sydney Orbital and the train line. Within those parts of the study area intersecting with the GMGA, there are 36 habitat patches and 69 least-cost dispersal pathways. Figure 5 displays this output at a higher resolution for the area surrounding Appin Road, which is crossed by four least-cost pathways as follows: (1) immediately south of Rosemeadow South in the vicinity of the Noorumbah Reserve, (2) at the Beluah Biobanking site, (3) at Ousedale – Mallaty and (4) directly north of Appin township. For comparison purposes, Table 1 summarises the baseline (status quo) output GAP CLoSR metrics for the study area based on three different minimum PKH patch sizes. The highest number of potential movement pathways, and thus greatest flexibility for planning purposes, are identified by considering all areas of PKH to a minimum patch size of 10 ha.

Table 1. Baseline (status quo) GAP CLoSR connectivity attributes and associated elements (components, patches and pathways) identified on the basis of 10-ha, 20-ha and 50-ha minimum patch sizes and required access to correspondingly sized patches of Preferred Koala Habitat throughout the study area.

Connectivity Attribute / PKH Patch size	(10 ha)	(20 ha)	(50 ha)
Landscape Components	7	6	4
Habitat patches	218	134	68
Least-cost dispersal pathways	476	273	129

The relative importance of PKH patches across the study area, as defined by the graph-metrics generated by GraphHab (d-IIC scores), identifies the PKH area between Kentlyn, Wedderburn and Appin as the largest and most consolidated in terms of the long-term management of the GMGA (Figure 6). The associated d-IIC scores express the value of each habitat patch as serving a linkage function with higher d-IIC scores expressing the incrementally greater importance of a habitat patch to overall connectivity. Within this habitat patch network, the Beulah biobanking site and adjoining habitat to the east along Appin Road is identified as the most important in a local context (patches along the east of Appin Road, d-IIC = 0.0934, d-IIC = 0.0658; patch at Beluah d-IIC = 0.0088). Eastwest connectivity also occurs through the Noorumba Reserve (d-IIC = 0.0037) and Mallaty's Creek (dIIC = 0.0026). Two habitat patches further to the west in the vicinity of Menangle, which the Beluah, Noorumba and Mallaty patches all connect with, also receive high scores (d-IIC = 0.0122, d-IIC = 0.0078). Further to the south, habitat to the west of Appin township provides additional east-west connectivity (d-IIC = 0.0166). All the aforementioned d-IIC scores illustrate the value of each habitat patch to overall connectivity. In addition to this, the linkages themselves are also scored, according to how their presence or absence impacts upon local and regional connectivity. The d-IIC scores for east-west linkages from the large habitat patches in the east, through Noorumba, Beluah, Mallaty and Appin are d-IIC = 0.0009; 0.0018; 0.0006; 0.0058 respectively. These linkage pathways are illustrated in Figure 6. Graph-metrics for the entire study area are illustrated in Appendix 4, where at a more regional scale beyond the GMGA and FPSP, large habitat networks to the south and southwest are identified as having both high patch capacity (based on habitat patch size, represented by circle size) and importance to the overall linkage of the region (represented by colour; Appendix 4).

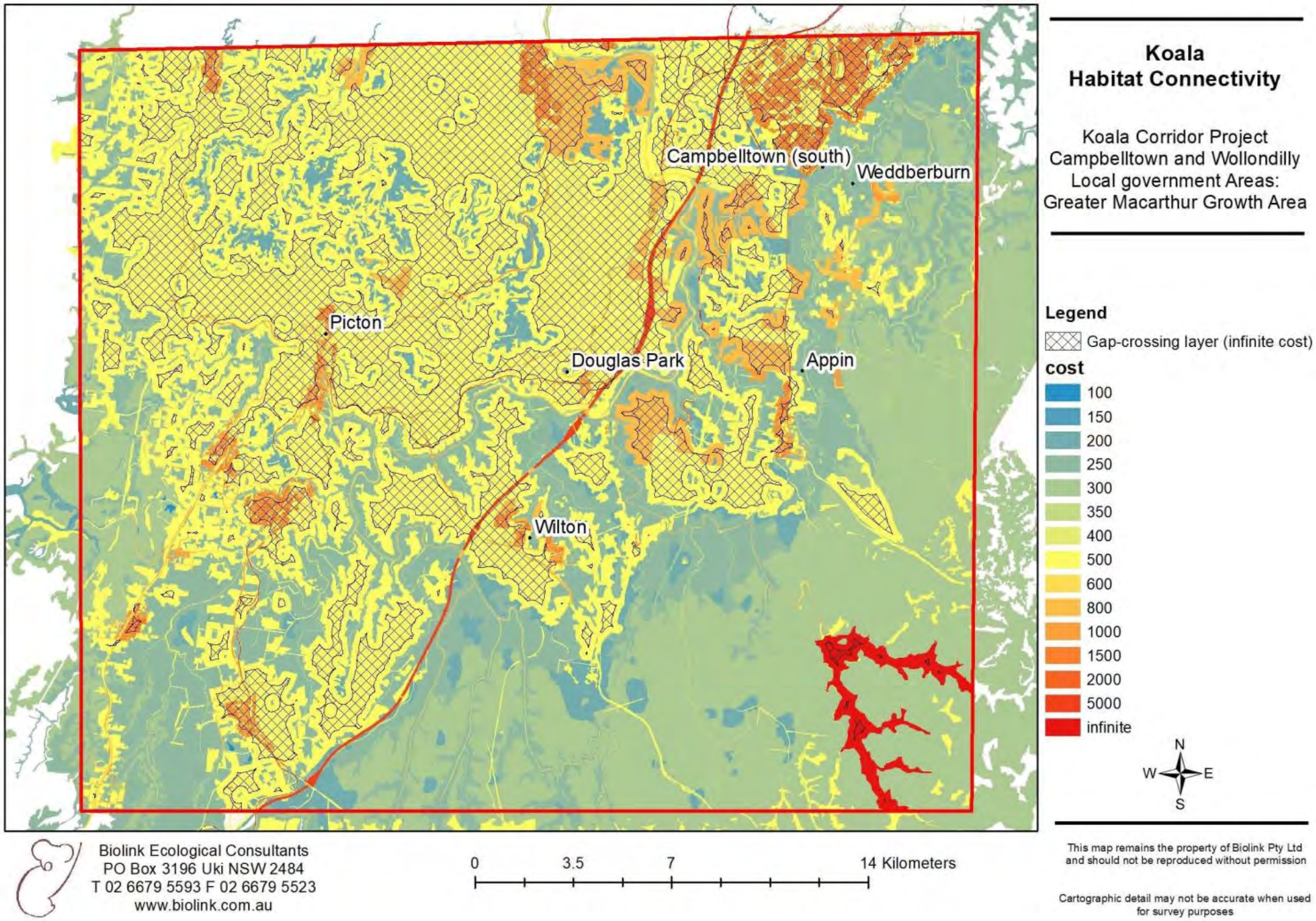

Figure 3: Cost dispersal surface for the Campbelltown – Wollondilly study area

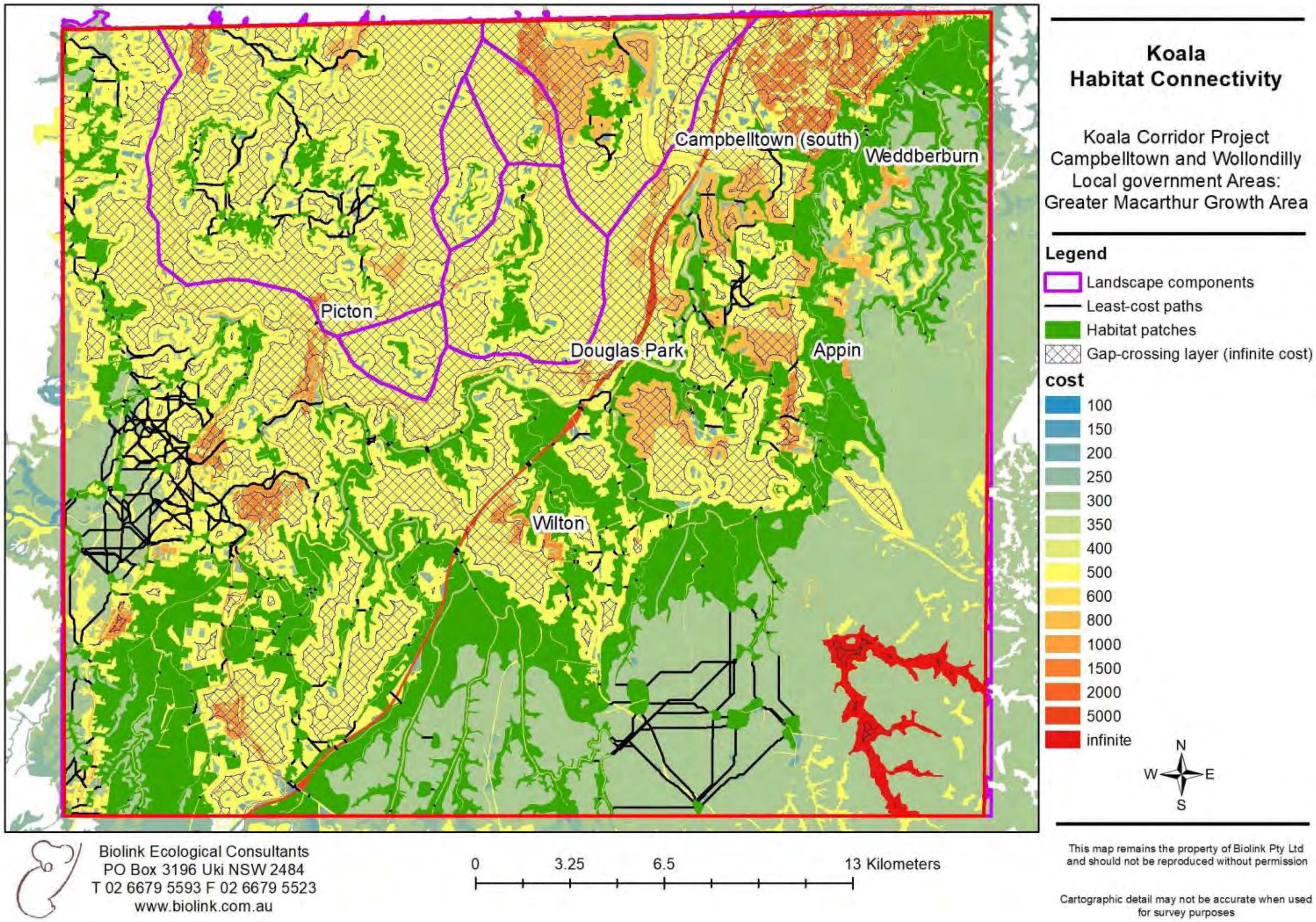

Figure 4: The study area comprises seven landscape components consisting of 218 habitat patches (10 ha minimum size) connected by 476 least-cost pathways.

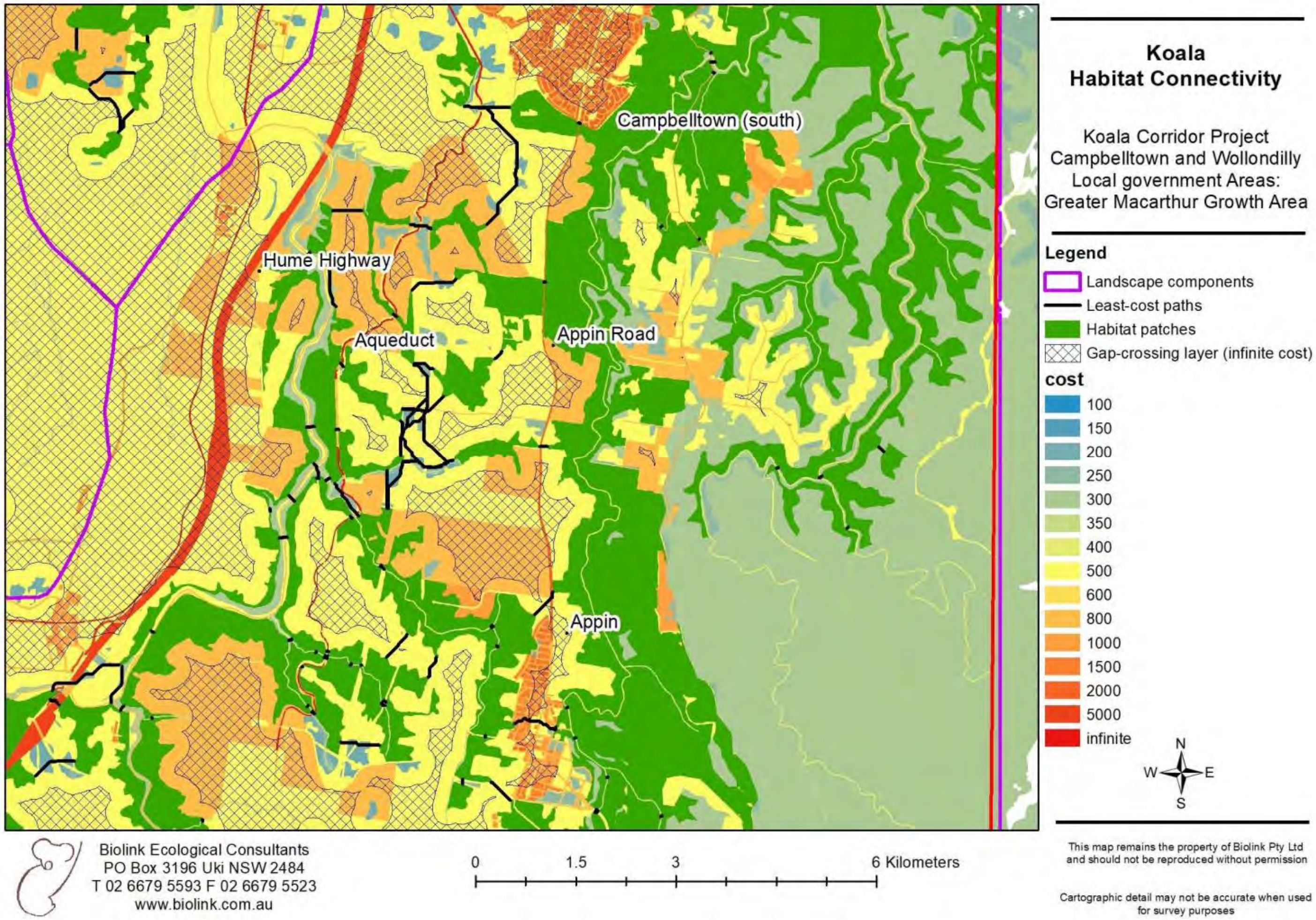

Figure 5: Higher resolution of habitat connectivity in the area surrounding Appin Road - seen as a dark orange line (2000 cost), running from South Campbelltown to Appin. It is crossed by four least-cost pathways; (1) directly south of Rosemeadow South, (2) the Beluah biobanking site, (3) Ousedale-Mallaty's Creek and (4) just north of Appin township.

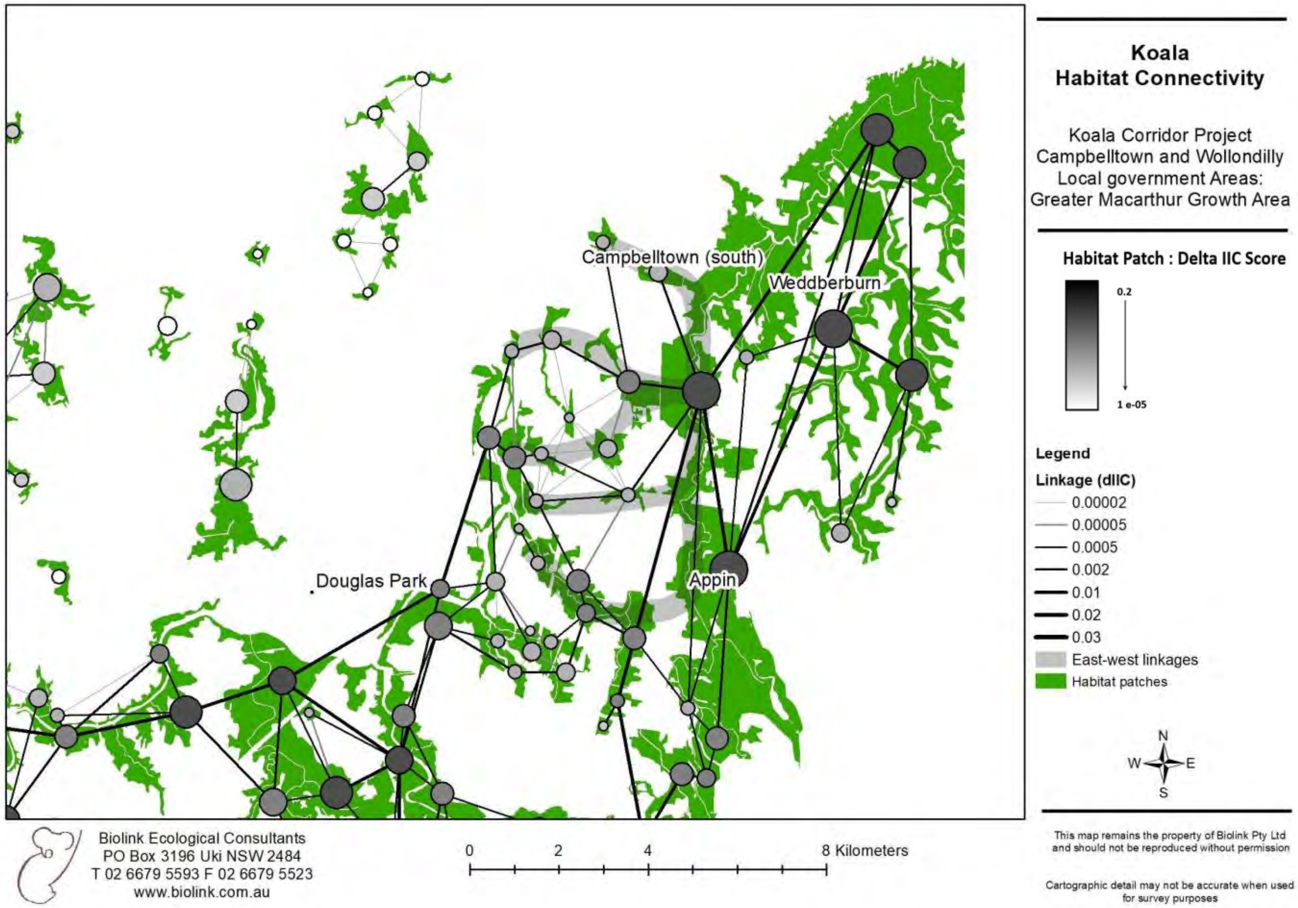

Figure 6: Baseline delta-Integral Interconnectivity (dIIC) graph-metrics and associated scores and weightings for habitat patches and linkages for the area to be impacted by the FPSP and associated upgrading of Appin Road. This metric characterises the importance of patches and linkages to the network and is computed by measuring the effects of patch / linkage removal to overall connectivity. Habitat patches are represented by circles with the most important patches, in terms of their contribution to overall connectivity, shown in the darkest shade (higher dIIC score). Circle size represents patch capacity (calculated from total area). The importance of each linkage to overall connectivity is represented by the thickness of the line, thicker lines being the most important (higher dIIC score). Note that linkages do not represent the 'real paths' as shown in previous figures, but are the Euclidian distance between two patches. Areas over-shaded in grey show indicative linkages of relevance to GMGA.

Scenario 1 – The FPSP footprint including Appin Road as a multi-lane dual carriage way, fenced on the eastern side.

The cost-dispersal surface for the study area inclusive of the FPSP and an Appin Road upgrade fenced only on the eastern side is presented in Figure 7, while GraphHab output for the same area is illustrated in terms of landscape components and associated habitat patch networks and notional least-cost pathways in Figure 8. At the 10 ha habitat patch scale of analyses, output determined that the study area continues to function as seven discrete landscape components collectively comprised of 208 identifiable habitat patches connected by 405 least-cost pathways. Compared to the baseline scenario, at the regional scale this scenario results in a 5% loss of patches and a 15% loss of pathways. The largest landscape component is similar to the baseline scenario, incorporating the development footprint of the FPSP and now extending slightly further to the north-west. Within the GMGA however, there are 38 habitat patches and 44 least-cost paths, with implementation of the FPSP and the Appin Road upgrade fenced only on the eastern side resulting in a 5.55% increase in the number of habitat patches but a 36.23% loss of pathways. The increased number of habitat patches directly pertains to the most north-westerly portion of the FPSP footprint, where areas mapped as "Environmental Conservation to be Confirmed" comprise lands that were not included in the baseline considerations. Pathways are lost throughout the development footprint, with the highest concentration lost from the area between Mallaty's Creek and Beluah. Figure 9 displays this output at a higher resolution for the area surrounding Appin Road, which has seen the loss of the three least-cost pathways at the Beluah Biobanking site, at Ousedale – Mallaty, and directly north of Appin township. Depending on exactly where the Appin Road upgraded commences in the north, a further crossing that currently enables access by koalas to the Noorumba Reserve may also be lost. Table 2 summarises the Scenario 1 output GAP CLoSR metrics for the study area.

Table 2. Full implementation of structure plan that includes Appin Road as a multilane dual carriageway fenced on the eastern side. Results are for 10 ha minimum patch sizes. Figures in brackets are initial baseline (status quo) values derived from Table 1.

Connectivity Attribute	No. Elements
Landscape Components	7 (7)
Habitat patches	208 (218)
Least-cost pathways	405 (476)

Scenario 2 - The FPSP footprint with Appin Road as a multilane dual carriage way, fenced on eastern side with a crossing at Ousedale-Mallaty corridor.

This scenario results in little change to that predicted above, the primary difference being the restoration of a single pre-FPSP least-cost pathway at Ousedale – Mallaty. Figure 10 displays the GraphHab output at high resolution for the GMGA inclusive of the FPSP and an Appin Road upgrade fenced only on the eastern side but with a crossing at Ouesdale – Mallaty. Table 3 summarises the Scenario 2 output GAP CLoSR metrics.

Table 3. Full implementation of structure plan that includes Appin Road as a multilane dual carriageway fenced on the eastern side, with a crossing at Ousedale-Mallaty. Results are for 10-ha minimum patch sizes. Figures in brackets are initial baseline (status quo) values derived from Table 1.

Connectivity Attributes	No. Elements
Landscape components	7 (7)
Habitat patches	208 (218)
Least-cost pathways	406 (476)

Figure 11 illustrates changes to the d-IIC graph-metric output arising from implementation of the FPSP with a crossing at Ousedale Mallaty, while Table 4 summarises associated changes in terms of d-IIC metric values. The most evident change following implementation of the FPSP is the isolation of the Beulah biobanking site and a redundancy of its current connectivity role which in turn, renders problematical the functioning of remaining linkages which will otherwise be required to be fed from the west, while the removal of crossing opportunity at the Beulah location additionally creates one or more pathway bottlenecks. This situation will become exacerbated if the crossing at Noorumba Reserve is also compromised.

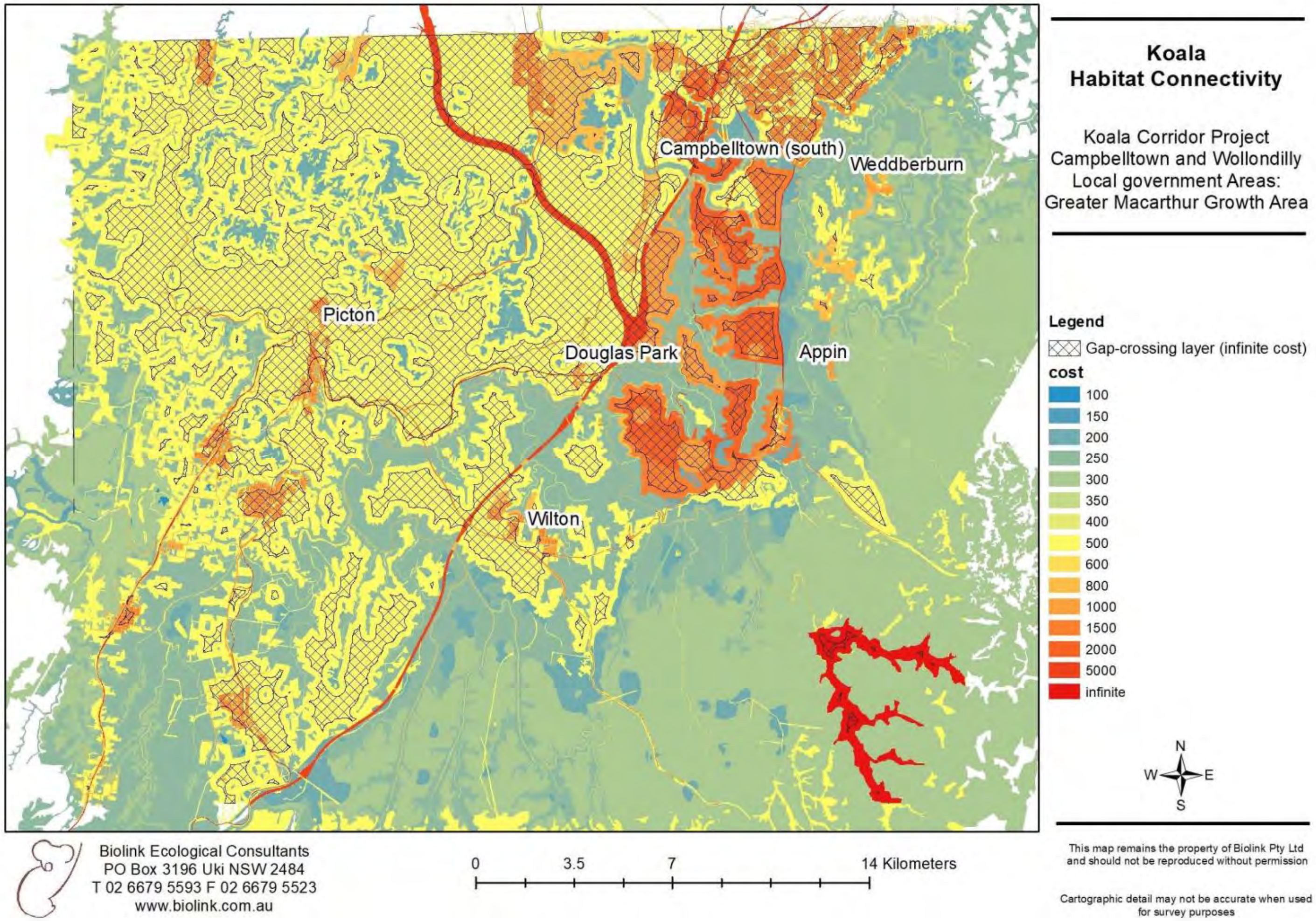

Figure 7: Cost dispersal surface for the Campbelltown – Wollondilly study area under Scenario 1 (FPSP plus Appin Road exclusion fenced).

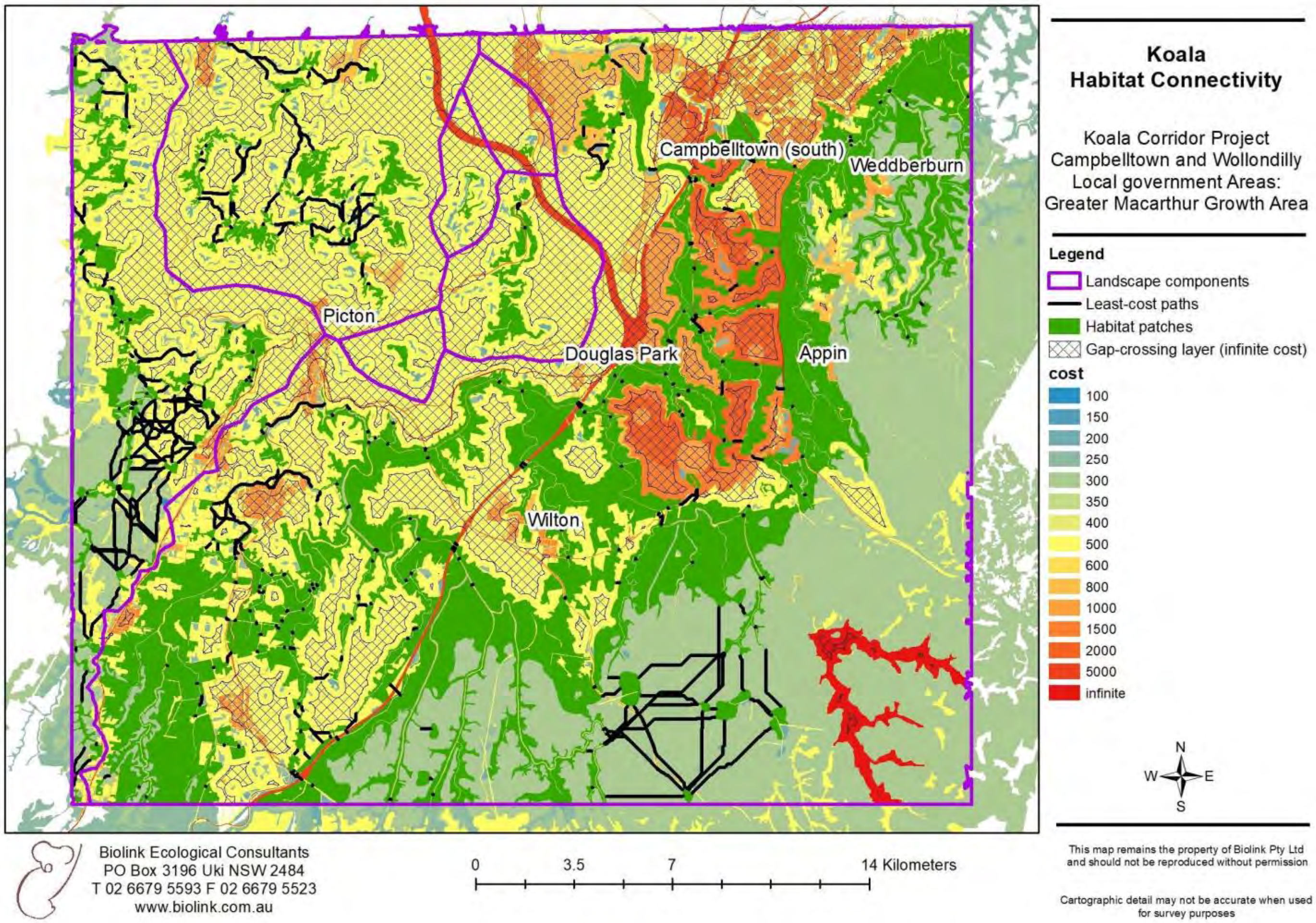
Koala
Habitat Connectivity
Koala Corridor Project
Campbelltown and Wollondilly
Local government Areas:
Greater Macarthur Growth Area
Legend
Landscape components
Least-cost paths
Habitat patches
Gap-crossing layer (infinite cost)
cost
100
150
200
250
300
350
400
500
600
800
1000
1500
2000
5000
infinite
Campbelltown (south)
Weddberburn
Picton
Douglas Park
Appin
Wilton
N
W
E
S
Biolink Ecological Consultants
PO Box 3196 Uki NSW 2484
T 02 6679 5593 F 02 6679 5523
www.biolink.com.au
0
3.5
7
14 Kilometers
This map remains the property of Biolink Pty Ltd and should not be reproduced without permission
Cartographic detail may not be accurate when used for survey purposes

Figure 8: Under Scenario 1, the study area comprises seven landscape components consisting of 208 habitat patches (10 ha minimum size) connected by 405 least-cost pathways. Habitat connectivity in the Appin Road alignment-and development footprint is impacted at the local and regional scale through the loss of 10 habitat patches > 10 ha and 71 leastcost pathways.

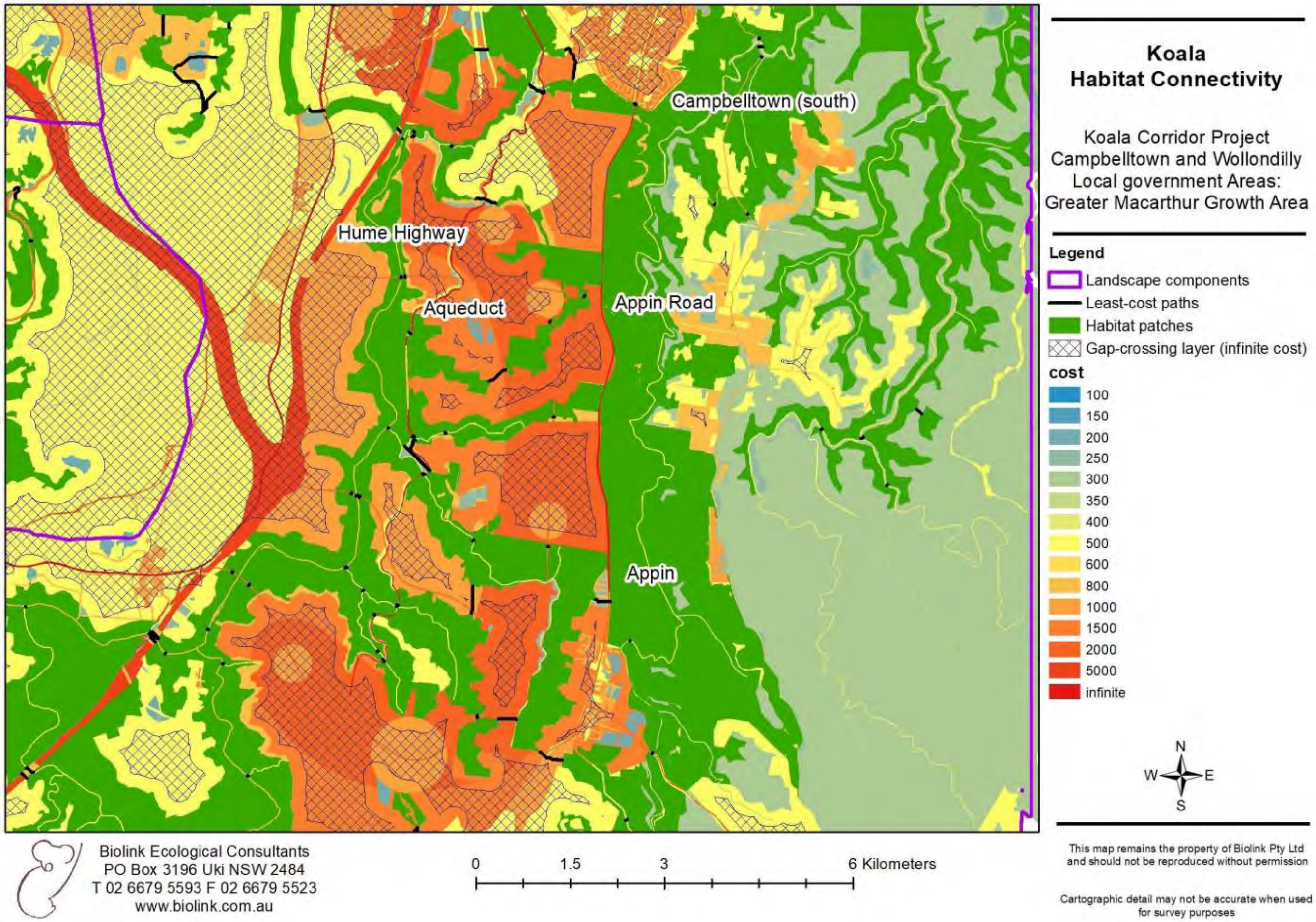

Figure 9: Higher resolution of habitat connectivity under Scenario 1 in the area surrounding Appin Road - seen as a red line (infinite cost), running from South Campbelltown to Appin. Habitat connectivity is impacted at the local scale through the loss of two key east-west linkages (Beleuah biobanking site and Ousedale-Mallaty's Creek) and the movement of one linkage further to the south, from north of Appin to moving through the township itself. Connectivity is maintained at regional scale.

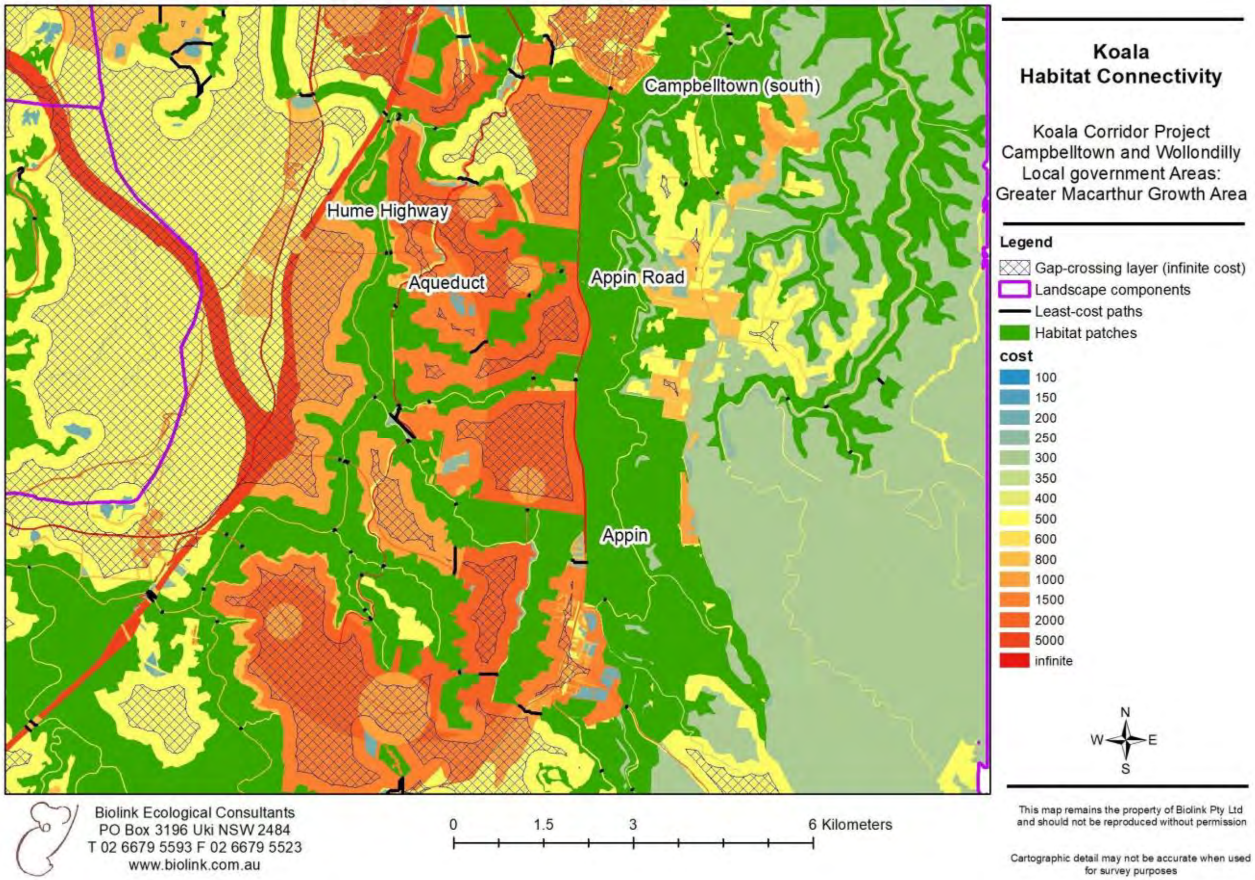

Figure 10: High resolution of habitat connectivity under Scenario 2 in the area surrounding Appin Road - seen as a red line (infinite cost), running from South Campbelltown to Appin, with a 100 m wide, vegetated crossing at Ousedale-Mallaty's Creek. A pathway is formed at this crossing, seen roughly half way between Campbelltown (south) and Appin, increasing the total number of pathways by one, to 406. All other factors remain unchanged from Scenario 1.

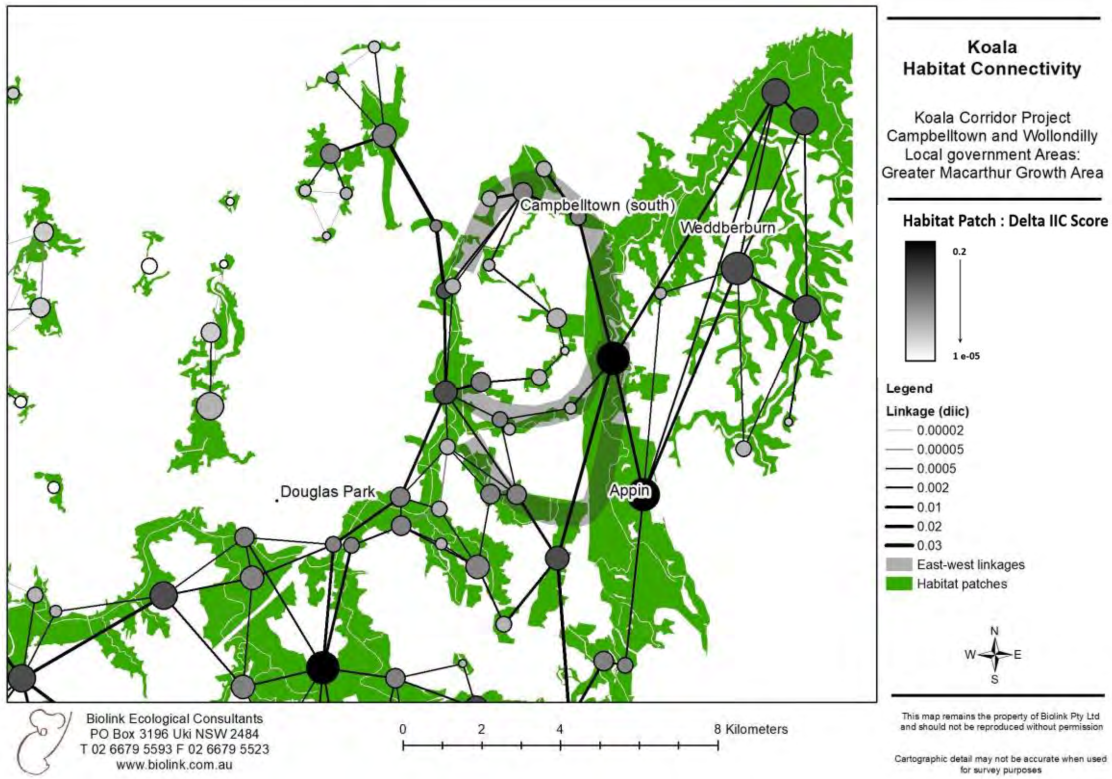

Figure 11: delta-Integral Interconnectivity (dIIC) outcomes for habitat patches and associated linkages for the area to be impacted by the FPSP and associated upgrading of Appin Road according to Scenario 2. This metric characterises the importance of patches and linkages to the network and is computed by measuring the effects of patch / linkage removal

to overall connectivity. Habitat patches are represented by circles with the most important patches, in terms of their contribution to overall connectivity, shown in the darkest shade (higher dIIC score). Circle size represents patch capacity (calculated from total area). The importance of each linkage to overall connectivity is represented by the thickness of the line, thicker lines being the most important (higher dIIC score). Note that linkages do not represent the 'real paths' as shown in previous figures, but are the straight-line, shortest Euclidian distance between two patches. Areas over-shaded grey show indicative linkages of relevance to GMGA.

Table 4. Changes in d-IIC metrics resulting from implementation of FPSP and the associated upgrading of Appin Road, with a crossing at Ousedale-Mallaty (Scenario 2). Higher scores represent a larger contribution to connectivity.

	d-IIC scores	Baseline (status quo)	Scenario 2
Habitat patches	Noorumba	0.0037	0.0106
	Beluah	0.0088	0.0048
	Mallaty	0.0026	0.0028
	Appin	0.0166	0.0386
East-west linkages	Noorumba	0.0009	0.0057
	Beluah	0.0018	n/a
	Mallaty	0.0006	0.0009
	Appin	0.0058	0.0179

5. Discussion

This project utilised a specialised spatial analysis and analytical framework GAP CLoSR to examine aspects of landscape connectivity related to the longer-term conservation and management of freeranging koala populations in key parts of the CCC and WS LGAs that will become the subject of increased development pressure arising from progressive urbanisation and associated road works within the southern portion of the GMGA. We foresee that the value of such an approach is that it provides an initial means of identifying habitat patches with high value for maintaining overall connectivity and associated non-habitat linkage areas in an otherwise fragmented habitat matrix. Through the process of identifying the locations of least-cost dispersal pathways, output identifies locations that represent best practice ecological and planning investment by characterizing the most appropriate areas for consolidation and/ or rehabilitation.

One of the underlying assumptions of the GAP CLoSR approach is the notion of 100% occupancy by the focal species, in this case the koala. Aside from considerations of patch size in the graph-metric output (the DIIC score), this means that all habitat patches are weighted equally in terms of their connectivity potential and the least-cost dispersal pathways that are subsequently identified, as opposed to an outcome that may be more biased by a reliance of a contemporaneous koala residency distribution pattern. In this regard it is important to recognise that the least-cost dispersal pathways are linear representations of linkages that are not spatially explicit. This means that while the location has been identified, precise dimensions and more specifically width has not been specified. This is also advantageous given that precise dimensions of linkages / corridors can then be adapted in response to local knowledge and the needs of a given target species and/or suite of species as required. For koalas, Biolink (2017) promoted an optimal buffer / corridor width of ~ 425 m based upon considerations of female home range size. While this is a useful and scalable metric that reflects the low koala carrying capacity of the landscape, it is also evident from available studies in the CCC LGA that koalas will use areas with a narrower width than this. Invariably, final corridor width in most instances will likely reflect other considerations; it goes without saying that wider is better in order to reduce the potential negative impacts associated with edge effects, more so in areas where related themes such as water quality must also be considered.

Following submission of our initial draft report it was suggested that we should not discount vegetation communities on sandstone as koala habitat. In considering this request we determined that vegetation communities on sandstone had not been discounted, but for the most part neither were they preferred koala habitat (PKH) for the following reasons:

a) In order for a vegetation community to qualify as PKH it must contain Preferred Koala Food Tree species (PKFTs). Based on our review of community descriptions and floristic attribute tables associated with each of the contributing mapping reports, the majority of communities on sandstone do not contain PKFTs and hence the correct classification for koala management purposes is as 'Other' vegetation (or Low Quality Habitat as the case may

be). The presence of 'Other' vegetation is however considered for the purpose of creating a cost-dispersal surface, the associated cost metric marginally higher than that of Secondary (C) Class habitat as defined in this report, and

b) Given the extent of Other / Low Quality Habitat and its lack of association with data relating to occupancy and/or habitat use by koalas within the study area, to include 'Other' vegetation as PKH would be to both disregard available data / knowledge and unduly force graph-metrics such as that associated with the d-IIC determinations into arguably erroneous output.

Based on a minimum patch size of 10 ha, baseline GAP CLoSR analyses indicated that the study area currently functioned as seven discrete landscape components comprised of 218 habitat patches that were connected via a notional network of 426 pathways, within which the GMGA was identified as functioning as a single landscape component. Graph-metrics identified a key linkage along both sides of the Georges River between Appin and Campbelltown South / Wedderburn, from which connectivity between the Georges River corridor and the Nepean River is centrally affected primarily through the Beulah biobanking site and Mallaty's Creek linkages. Predictably perhaps, implementation of the FPSP was determined by analyses to have a negative effect on connectivity outcomes at the local scale, most notably in the Beluah locality. Baseline (status quo) graph-metrics for the GMGA unambiguously identify this locality as important in terms of accommodating eastwest connectivity at the local and regional landscape level of resolution. We again reiterate our earlier advice that this knowledge mandates the need for a revised FPSP and associated planning approach that seeks to minimise the loss of connectivity within that area of the GMGA between Rosemeadow South and Appin village to the maximum extent possible. The final design solution for the Appin Road upgrade is thus of fundamental importance to future koala conservation outcomes.

In its current state Appin Road clearly bisects an area that is the focus of increasing numbers of east/west koala movements, the numbers of animals known to have already been killed along this road likely representing less than half of the real number. The fencing of Appin Road along the eastern side only so as to create a barrier to east-west koala movement reflects neither best practice nor makes ecological sense given that it will have no material effect in terms of reducing koala roadkill numbers. GraphHab output indicates the loss of three locally significant dispersal pathways under Scenario 1 and two pathways under Scenario 2. At the local scale this cost should be considered as ecologically significant given that fencing will create a barrier approximately 6 km in length immediately abutting a large patch of high-quality habitat, against which dispersing koalas from both directions will be required to navigate. In addition to an increased potential for vehiclestrike, the fence will result in high levels of agonistic interactions along the length of the fence as dispersing koalas encounter resident animals. There is also the chance of creating higher levels of domestic dog attack, disease and other misadventure issues at either end where dispersing koalas will be required to traverse urbanized areas in order for connectivity and genetic exchange to be maintained, or otherwise enter the road reserve where they will in all likelihood be killed by vehiclestrike.

The d-IIC scores associated with enforced pathways that remain at either end of the fence indicate that the loss of linkages through Beluah (and potentially Ousedale-Mallaty) creates a greater dependence on pathways to the north and south of the road upgrade. Consideration of a fence along the eastern side only warrants further discussion in terms of cost effectiveness and likely efficacy. Amongst other things, it assumes that all koala movement is unidirectional (i.e. from east to west) when, given the presence of populations in the west this is not the case. Again, it had been suggested to us that we might consider including in our discussion that such an outcome (i.e. a fence on the eastern side of the road only) might be better for koalas than no fence on the road. We do not support this assertion for the following reasons:

a) Studies have demonstrated that fences function to impede the movement of koalas but typically work best when installed in conjunction with crossing structures such as underpasses or overpasses, reinforced by the installation of koala-grids at fence ends and intersections to reinforce the exclusion principle,
b) Studies have demonstrated that Koalas encountering fences will travel along them until an opening is located, whereupon a crossing attempt will be attempted. This means that in the absence of measures to enforce the exclusion principle, vehicle-strike clusters will occur at the ends of the fencing,
c) Koalas also occur to the west of Appin road. If moving from west to east, they will become trapped in the road corridor where they will be susceptible to vehicle-strike.
d) A fence along one side of the road only will give no effect to a crossing at Ouesdale – Mallaty beyond providing another access point onto the road for koalas dispersing from the east.

Assuming that the FPSP incorporates lands identified (but not confirmed) for Environmental Protection and areas identified as urban footprint capable land that has been changed to conservation, there will be no net loss of habitat patches within the GMGA. Within the same boundary however, GAP CLoSR identifies a 36.23 % loss of pathways. These lost pathways occur through-out the GMGA but are most concentrated between the Beluah biobanking site and at Mallaty's Creek. Under both Scenarios 1 and 2, the direct east-west passage of koalas to Beluah is cut-off by the Appin Road upgrade and continued connectivity relies on pathways to the north via Noorumba (as discussed above) and to the south via Mallaty's Creek, where pathway loss is the most pronounced. This places the continued value of the Beluah biobanking site under some provision.

While not a specific requirement of this project brief, design solutions to assist in minimising the impacts of the road upgrade while still accommodating connectivity needs are available, ranging from a extended lead-in (to the upgrade) at Rosemeadow so as to enable a design solution (slower vehicle speed enforced by roundabout and koala-grids), an overpass in the general vicinity of the Beluah biobanking site and an engineering solution at Mallaty Creek so as to create either an elevated road section or excavated area beneath any upgraded road alignment through which koala movement can occur. Fencing along both sides of Appin Road along with other measures that reinforce the exclusion objective will be required to effectively manage connectivity and deal with the issue of vehicle-strike.

The results of this project imply that some consideration could be given to a re-evaluation of the scale of the final FPSP footprint so as to give some effect to the outcomes in terms of consolidating key linkage areas to the west of Appin Road. The preservation of key linkages and effectively integrating associated dispersal pathways into the development footprint is required to achieve this outcome.

……………………………………

References

Biolink. (2016). Analysing the historical record: aspects of the distribution and abundance of koalas in the Campbelltown City Council Local Government Area 1900 – 2012. Report to Campbelltown City Council.

Biolink. (2017). South Campbelltown Koala Connectivity Study. Final Report (Revised and updated 2018) to Campbelltown City Council.

Biolink. (2018a). Review of koala generational persistence across the Campbelltown City Council Local Government Area 2012 – 2017. Report to Campbelltown City Council.

Biolink. (2018b). Identification of Least-cost dispersal pathways for koalas within the Campbelltown City Council Local Government Area. Report to Campbelltown City Council.

Cork, S., Margules, C. R., and Braithwaite, L. W. (1988). A survey of koalas and their habitat near Wedderburn NSW, suggestions for management and an assessment of the potential effects of a proposed subdivision of four-hectare residential lots. Report to Campbelltown City Council.

Foltête, J.C., Clauzel, C. and Vuidel, G. 2012. A software tool dedicated to the modelling of landscape networks. Environmental Modelling and Software 38: 316-327.

Lechner, A.M. and Lefroy, E.C. (2014). General Approach to Planning Connectivity from Local Scales to Regional (GAP CLoSR): combining multi-criteria analysis and connectivity science to enhance conservation outcomes at a regional scale – Lower Hunter, University of Tasmania, Hobart, Tasmania

Lunney, D., Close, R., Bryant, J. V., Crowther, M. S., Shannon, I., Madden, K., and Ward, S. (2010). Campbelltown's koalas: their place in the natural history of Sydney. Pages 319-325 in D. Lunney, P. Hutchings and D. Hochuli (Eds.) The Natural History of Sydney.

Pascual-Hortal, L. and Saura, S. (2006). Comparison and development of new graph-based landscape connectivity indices: towards the prioritization of habitat patches and corridors for conservation. Landscape Ecology 21: 959-967.

Sheppard, J. 1990. The Wedderburn koala colony. Pages 70 – 73 in D. Lunney, C. A. Urquhart and P. Reed (Eds). Koala Summit – Managing Koalas in New South Wales. NSW National Parks & Wildlife Service, Hurstville NSW.

Ward, S., (2002) Koalas and the community: a study of low-density populations in Southern Sydney, Unpublished Ph.D. Thesis, University of Western Sydney.