COMPREHENSIVE

KOALA PLAN OF MANAGEMENT

Prepared by Biolink for Campbelltown City Council

campbelltown city council

NSW GOVERNMENT Office of Environment & Heritage

biolink

Prepared by

Dr Steve Phillips of Biolink and Campbelltown City Council staff, with supplementary funding from the NSW Office of Environment and Heritage

Published by

Campbelltown City Council

91 Queen St

CAMPBELLTOWN NSW 2560

PO Box 57

CAMPBELLTOWN NSW 2560

Tel: (02) 4645 4000

Website: www.campbelltown.nsw.gov.au/koalas

For further information, contact

Council's Natural Areas Team

Email: koalas@campbelltown.nsw.gov.au

Phone: 02 4645 4601

Citation

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

Frontcover

"Valentine" the koala at Winbourne Place, Airds.

Photo courtesy of Alana Keane

Backcover

Female koala with joey at St Helens Park.

Photo courtesy of Carla-Maree Simmons

Authors

This Comprehensive Koala Plan of Management (CKPoM) has been prepared by Dr Stephen Phillips (Biolink) with support from Alexandra Cave (Campbelltown City Council).

Dr Stephen Phillips is the Managing Director of Biolink ecological consultancy. He is a professional wildlife ecologist and former university lecturer with over 35 years of experience in all facets of natural area management, from the investigation and planning of new conservation areas to the design of specialised survey programs for threatened plants and animals.

Stephen is an internationally acknowledged authority on the ecology, conservation and management of koalas, has spoken at national and international conferences and written popular articles, book chapters and scientific papers, the latter published in various conference proceedings and journals such as Pacific Conservation Biology, Australian Mammology, Biological Conservation, Australian Journal of Botany, Australian Zoologist, Wildlife Research and Conservation Biology.

Other contributors

Preparation of this document has benefited from input and discussions with the Koala Management Project Reference Group (PRG), and internal workshops with Campbelltown City Council (Council) Environment and Planning staff. A series of formal PRG meetings that included relevant stakeholder groups were held during the course of the development of this Plan. Key members of the PRG included: Andrew Spooner, Renee Winsor, Angela Taylor, Alexandra Cave, Jeff Burton, Graham Pascoe and Troy Lessels (Campbelltown City Council), Associate Professor Robert Close (Western Sydney University), Pat Durman (Macarthur Branch of the National Parks Association), Lou Ewins and Deborah Ashworth (NSW Office of Environment and Heritage), Kate Carter (NSW Rural Fire Service), Michelle Dellagiacoma (NSW Department of Planning and Environment) and Vickii Lett (NSW National Parks and Wildlife Service and WIRES).

Others who have assisted during the course of the project include Dr David Phalen and Dr Hamish Baron (University of Sydney), Mike Roache and Kylie Madden (Office of Environment and Heritage), Martin Smith (NSW National Parks and Wildlife Service), Scott Hetherington (Tweed Shire Council), Dr John Callaghan (Biolink) and a number of individuals associated with local wildlife rescue groups, including WIRES and Sydney Wildlife.

This document considers an underlying koala habitat study undertaken by Eco Logical Australia (Ward, 2014) with funding provided by the NSW Office of Environment and Heritage.

This CKPoM also acknowledges the following contributions including koala records from the Western Sydney University research database as collected by Associate Professor Robert Close, and wildlife history spatial data provided by the NSW Rural Fire Service (RFS).

Contents

Definitions and acronyms

AoS	Assessment of Significance under the NSW TSC Act
APZ	Asset Protection Zone
CLEP	Campbelltown Local Environmental Plan 2015
CKPoM	Comprehensive Koala Plan of Management prepared under SEPP 44
Core koala habitat	is any parcel of land that is either wholly or partly identified under SEPP44 to contain a resident population of koalas, evidenced by attributes such as breeding females (that is females with young) and recent sightings of and historical records of a population; a) as identified in Figure 5.1 of this Plan, or b) any other land identified as such by other processes arising from the Plan (such as a KAAR).
Council	Campbelltown City Council
DBH	the diameter at breast height of a tree (when measured at a trunk height of 1.3 m off the ground)
DA	Development Application
DCP	Development Control Plan
DoD	Commonwealth Department of Defence
DotE	Commonwealth Department of the Environment
DoPE	NSW Department of Planning & Environment
ECA	Ecological Consultants Association of NSW
EIANZ	Environment Institute of Australia and New Zealand
EP&A Act	NSW *Environmental Planning and Assessment Act, 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999*
IKPoM	Individual Koala Plan of Management prepared under SEPP 44
IUCN	International Union for Conservation of Nature
KAAR	Koala Activity Assessment Report
KMA	Koala Management Area
KMC	Koala Management Committee
KMPRG	Koala Management Project Reference Group
KFT	Koala Food Tree; which for the purpose of this Plan is required by the DoPE to be consistent with Schedule 2 of SEPP44* (for the purposes of identifying potential koala habitat), and includes: • Forest Red Gum *Eucalyptus tereticornis* • Grey Gum *E.punctata* • Broad-leaved Scribbly Gum *E. haemastoma* • Manna Gum *E. viminalis* *Refer to Appendix E for more information regarding the classification of KFTs and PKFTs.
KTP	Key Threatening Process under the NSW TSC Act

LEP	Local Environmental Plan
LCAMP	Local Companion Animals Management Plan under the *Companion Animals Act, 1998*
LGA	Local Government Area
Major development	a DA that relates to the subdivision of a single lot of land into ≥ three lots and/or requires the removal of three or more (P)KFTs for each hectare of assessable land to which the DA relates.
Minor development	a DA that relates to the construction of a single residential dwelling and/or the subdivision of land into ≤ two lots and/ or requires the removal of no more than two (P)KFTs for each hectare of assessable land to which the DA relates
MNES	Matters of National Environmental Significance under the EPBC Act
MOU	Memorandum of Understanding
Native vegetation	any species of tree or shrub endemic to NSW
NPW Act	NSW National Parks and Wildlife Act, 1974
NPWS	NSW National Parks and Wildlife Service
OEH	NSW Office of Environment & Heritage
PKFT	Preferred Koala Food Tree; which for the purpose of this Plan includes the following species (in addition to listed KFTs) that are recognised as important food trees for the Campbelltown LGA*: • Blue-leaved Stringybark *E. agglomerata* • Woolybutt *E. longifolia* • Grey Box *E. molucanna* *Refer to Appendix E for more information regarding the classification of KFTs and PKFTs.
Potential koala habitat	is any area of native vegetation where the trees of the types listed in Schedule 2 of SEPP44 (KFTs) consitute at least 15% of the total number of trees in the upper or lower strata of the tree component; a) as identified in Figure 5.1 of this Plan, or b) any other land identified as such by other processes arising from the Plan (such as a VAR).
RFS	NSW Rural Fire Service
RMS	NSW Roads & Maritime Services
SAT	Spot Assessment Technique
SEE	Statement of Environmental Effects
SEPP44	State Environmental Planning Policy No. 44 (Koala Habitat Protection)
Shelter tree	Tree species known to be preferentially utilised by koalas in the Campbelltown LGA for roosting or thermoregulatory purposes: • Turpentine *Syncarpia glomulifera* • Brush Box *Lophostemon confertus*
Significant koala activity	a SAT-derived koala activity level of 10% or greater as identified through a KAAR
SIS	Species Impact Statement under the NSW TSC Act
SLA	Strategic Linkage Areas; being important areas of core (and potential) koala habitat that support major movement corridors for koalas across the Campbelltown LGA as illustrated by Figure 5.3 of this plan
Stadia-metric survey	a survey showing the precise location of an object, in this case a (P)KFT or a shelter tree
Suitably qualified	an individual with post-graduate qualifications in koala ecology and/or demonstrable work experience that includes publication of works on koala ecology in peer-reviewed scientific literature and/or accreditation as a koala specialist by Council and/or a professional body such as the EIANZ
Sydney Wildlife	Sydney Metropolitan Wildlife Services Inc
TSC Act	NSW *Threatened Species Conservation Act, 1995*
VAR	Vegetation Assessment Report
WIRES	NSW Wildlife Information, Rescue and Education Services
WSU	Western Sydney University

Koala at Cowra Place, Leumeah . Photo courtesy of Barbara Swainston

PREAMBLE

EXECUTIVE SUMMARY

The koala (*Phascolarctos cinereus*) has suffered a dramatic decline in numbers and distribution since the arrival of Europeans, aspects of which have included hunting for the fur trade in the late 19th and early 20th centuries. Even though the fur trade ceased in the late 1930s, millions of koala pelts were exported over a 50 year period preceding this date (Fowler, 1993).

Many koala populations in NSW now survive in fragmented and isolated habitat, while some areas in which koalas remain more common are increasingly subject to ongoing pressures, in particular clearing for agriculture, logging and urban expansion.

The koala is listed as 'Vulnerable' to extinction under the NSW *Threatened Species Conservation Act, 1995* (TSC Act) because of declining numbers and habitat. In 2008, the State Government approved the NSW Recovery Plan for the koala under Part 4 of the TSC Act, which identifies actions to be taken to ensure the long-term viability of the koala in nature, and the parties who are responsible for undertaking these actions. These actions include:

- habitat management
- community education
- monitoring, research and mapping.

Campbelltown has one of the last known koala populations in the Sydney region and was identified in the approved recovery plan as a priority area for preparation of a Comprehensive Koala Plan of Management (CKPoM). The conservation of koalas and their habitat within parts of the Campbelltown Local Government Area (LGA) has long been of interest to the local community. This interest has resulted in a number of scientific studies focused on koala habitat use, distribution and abundance, movement patterns, planning and welfare issues. The historical clearing of fertile plateau land for agricultural and then urban development, resulted in remnants of the Campbelltown LGA's koala population persisting on lower carrying capacity habitat on the plateau/gorge-land interface. A series of major fires in the latter part of the 20th century and in particular from 1955 to 1975 are considered to have further diminished the local population. While a detailed population estimate remains to be determined, and in the light of evidence indicating that koala numbers have increased in recent decades, the total population size is likely in the order of no more than 170 individuals as at the time this CKPoM was being prepared.

State Environmental Planning Policy No.44 – Koala Habitat Protection (SEPP44) came into effect in 1995 with the aim of reversing trends in koala population decline by encouraging better management of habitat that supports the species. The principal aim of SEPP44 is to 'encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline.' SEPP44 is a prescribed consideration under the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) for all development applications (DA) that may impact on koalas or their habitat.

One of the proposed ways of achieving the stated aim of SEPP44 is for a CKPoM to be prepared for part or all of an LGA so as to enable a consistent, landscape-based approach to matters relating to how koalas and their habitat are managed. The Campbelltown CKPoM has been prepared in accordance with the provisions of SEPP44, and provides a strategic approach to the protection, management and restoration of koala habitat for the entire LGA. Compliance with the CKPoM will constitute compliance with the provisions of SEPP44. The documentation that follows is intended to function as a CKPoM for the whole of the Campbelltown LGA and is comprised of two key parts:

1. Part A (Background Information) initiates the CKPoM process by placing koalas, humans and the habitat they share into an appropriate Commonwealth, State and Local Government planning context. This section explains how the different levels of governance work and how the balance between a growing human population and that of the natural environment ideally remains balanced through frameworks such as Local Environmental Plans (LEPs). Also detailed are the legislative interactions intended to afford protection to biodiversity elements of the Campbelltown LGA, with particular emphasis on koalas and their habitat. The recent listing of koalas as a threatened species for purposes of the Commonwealth Government's *Environmental Protection and Biodiversity Conservation Act, 1999* (EPBC Act) is particularly relevant given its capacity in the context of 'important' koala populations to potentially over-ride State legislation.

2. Part B (Working Provisions) establishes the statutory framework for future koala management by recognising important areas of core koala habitat, where management actions can be focussed to assist implementation of a long-term, sustainable management regime. A voluntary mechanism to create a network of Strategic Linkage Areas (SLAs) is also put forward with a view to enhancing connectivity both within areas of potential and core koala habitat, and across the broader Campbelltown LGA over time.

Several new mechanisms to assist control of development outcomes within areas of potential and core koala habitat are also established in Part B. One important part is the way in which areas of native vegetation in the LGA are assessed for potential koala habitat through the requirement for a Vegetation Assessment Report (VAR). In areas of potential koala habitat, koala population assessment procedures are standardised to ensure that best practice measures are applied to identify core koala habitat through the requirement for a Koala Activity Assessment Report (KAAR). Through this process, Council's Planners are supplied with information in a standardised way that enables interaction with other elements of the CKPoM's assessment and determination process. Also detailed in the document, are compensation and offsetting mechanisms arising from the loss of Preferred/ Koala Food Trees ((P)KFTs) and shelter trees, to assist the undertaking of koala habitat rehabilitation works on private and public lands which are being managed for conservation purposes. In terms of the decision making process, the CKPoM also defines Council's discretionary capacity in terms of dealing with non-conforming development proposals. Subject to considerations relating to the numbers of (P)KFTs that may need to be removed, the Plan also makes a distinction between 'major' and 'minor' development, with the intent to streamline the planning and approval process for single residential dwellings and small subdivision applications.

Part B also establishes procedures by which the Campbelltown koala population will be monitored over time, and how the efficacy of the CKPoM will be regularly reviewed and updated. Also identified, are mechanisms to assist broader community engagement with the conservation of koalas and their habitat, matters requiring further research and the need for better networking and engagement between Council and relevant stakeholders.

Memorandums of Understanding (MoU) relating to the need for greater collaboration between Council and agencies such as the Commonwealth Department of Defence (DoD), NSW Office of Environment & Heritage (OEH), NSW National Parks and Wildlife Service (NPWS), NSW Rural Fire Service (RFS) and NSW Roads and Maritime Services (RMS) are also envisaged; as these bodies are recognised as having key roles to play in terms of collectively working towards the CKPoM's stated objective of assisting in the long-term maintenance and sustainable management of a permanent, free living koala population in the Campbelltown LGA.

PART A

BACKGROUND INFORMATION

Koala at Peter Meadows Creek, Minto Heights. Photo courtesy of Andy Attewell

PART ONE

INTRODUCTION

The aim of SEPP44 is to encourage the conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over the species' present range, and reverse a state-wide trend of population decline. Among measures required to assist this aim is the preparation of Koala Plans of Management.

In addition to conservation measures enacted by SEPP44, the NSW Government's TSC Act additionally lists koalas as a Vulnerable species and in December 2008, a Recovery Plan for the koala was approved by the NSW Government (DECC, 2008). Objectives of the approved Recovery Plan include:

- the integration of koala habitat conservation into Local and State Government planning processes
- development of appropriate road risk management in areas of koala habitat
- implementation of strategies which minimise the impacts of domestic dogs on free ranging koalas
- development and implementation of strategies to reduce the impact of fires on koala populations
- the rehabilitation and restoration of koala habitat and populations.

In 2012, the koala (combined populations of QLD, NSW and ACT) was listed as Vulnerable under the Commonwealth Government's EPBC Act.

Given the recent Commonwealth listing and the preceding, long history of statutory protection in NSW, it is arguable that much has really been achieved in terms of sustainable management of free-ranging koala populations. Indeed, mitigating the processes that threaten the viability and survival of free-ranging koala populations is not a straightforward task. However, we do know what the problems are, and the knowledge is there to enable such matters to be managed more sustainably. In this context and with regard to background studies (outlined in Section 2.3) that inform this Plan, the following management issues will need to be addressed in order to ensure a sustainable future for koalas inhabiting the Campbelltown LGA:

1. ongoing loss of (P)KFTs along with fragmentation/ modification of important habitat areas supporting resident koala populations
2. increasing numbers of koala mortalities due to vehicle-strike and domestic dog attacks
3. bushfire management.

These issues are not unique to the Campbelltown LGA, although the potential extent and severity of the associated impacts of habitat loss/modification and vehicle-strike have become more apparent in recent years as koala numbers have slowly recovered to now reoccupy some of their former range in the east of the LGA. While a number of actions have been taken by Council and other stakeholders to address some issues, it is clear that further measures will be required if the potential for the population to be sustainably managed over the long-term is to be achievable. Indeed, such a goal will require actions that:

(i) facilitate and encourage coordinated action across all levels of governance
(ii) effectively resource Council to enable it to be the lead agency in terms of implementing required management actions on lands under its governance
(iii) ensure that best practice koala habitat and population assessment procedures are applied
(iv) adequately inform and engage all sectors of the community in the processes of sustainable koala management.

1.1 The planning area

This document functions as a CKPoM for koalas and their habitat in the Campbelltown LGA south-west of Sydney, NSW. Including areas of the National Parks and Wildlife Services (NPWS) estate that are otherwise exempt from SEPP44, the Campbelltown LGA covers a total area of 311.66 square kilometres (31,166ha), approximately half of which has been mostly cleared and is bounded to the southwest by the Nepean River and by the Georges River to the northeast. The M5 South-West Motorway passes through the north western section of the Campbelltown LGA.

The following information is primarily derived from the work of (Callaghan et al 2005).

1.1.1 The human environment

The Campbelltown LGA has grown from a country locality supporting a small population of less than 1,000 people in the latter part of the 19th century, to an urban centre now supporting more than 150,000 residents. Until the 1950s, the LGA comprised of small farms located around the urban landscape of Campbelltown with emerging urban villages expanding out from railway platforms at Glenfield, Macquarie Fields, Ingleburn, Minto, Leumeah and Menangle Park. During the 1960s, all of the villages except Menangle Park were expanding and a planned satellite city concept guided urban development which joined Leumeah to Campbelltown and developed the suburbs of Bradbury and Ruse.

In the 1970s, Campbelltown became a growth corridor in the planned urban expansion of Metropolitan Sydney under the Sydney Region Outline Plan 1970 – 2000 and the New Cities of Campbelltown – Camden – Appin Structure Plan. The New Cities Structure Plan identified sensitive environmental land adjacent to the Georges River, together with vegetated corridors joining the river and its tributaries. The identified land, which is adjacent to the Campbelltown urban area from Glenfield south to St Helens Park, was identified as Regional Open Space. A majority of the Regional Open Space has been acquired by the NSW Government for conservation purposes and further management options are being considered.

Today, the Council LGA is home to more than 150,000 people who occupy diverse housing from low density to medium density and limited high rise residential apartments, in the suburbs and centres. Dispersed lifestyle housing opportunities occur in the rural-residential areas fringing the suburbs and centres, while a small number of people reside on rural holdings (CLEP, 2015). The current landuse zonings that apply across the LGA are illustrated in Figure 1.1.

Embedded in the matrix of sensitive environmental lands are the plateau landscapes of Wedderburn, Kentlyn and Minto Heights. These plateau areas have a long history of agricultural use which has been followed in more recent years by subdivision for rural residential purposes, so the sustainable management of koalas, agriculture and rural-residential lifestyles is a key focus of this plan. Elsewhere arguably less sensitive land from Macquarie Fields south to St Helens Park has been zoned Scenic Protection with a two ha standard for subdivision and erection of houses, as have other largely forested areas to the west and south of Campbelltown City. In contrast, the greater proportion of forested lands to the east is under the control of the DoD's Australian Army's Holsworthy Barracks.

Overall, this pattern of land tenure and use means that controls on koala habitat vary throughout the LGA in response to differing legislative requirements that inter alia affect such things as planning, bushfire management and the clearing of native vegetation; most importantly however it also means that meaningful koala conservation and management is a responsibility shared across the entire community and relevant stakeholders.

Campbelltown is a developing regional centre, and significant future projected growth pressure is anticipated for the region. Forward projections by the Department of Planning and

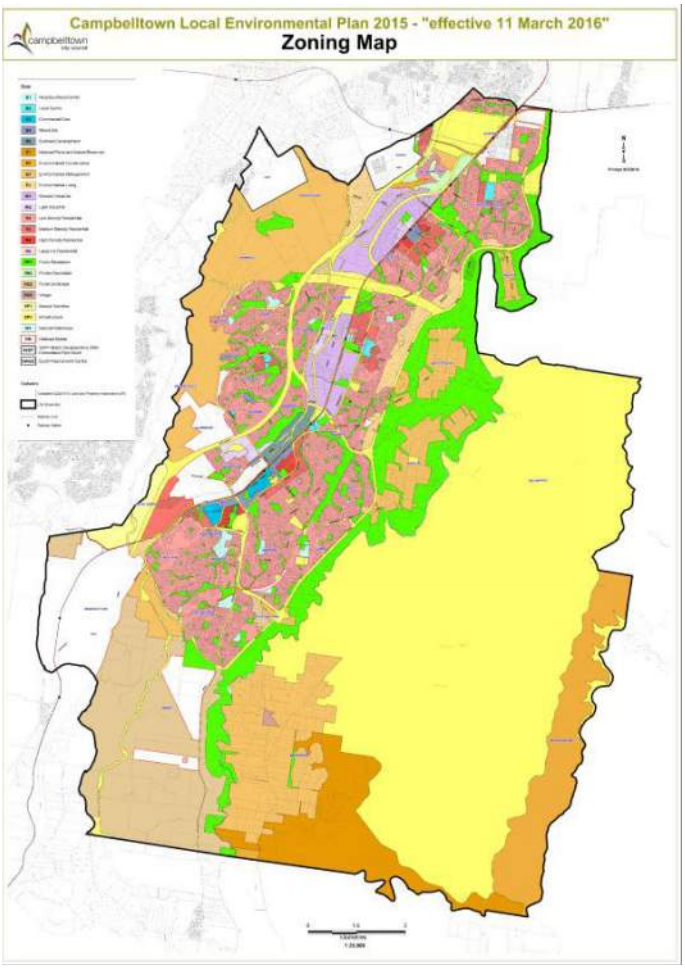


Figure 1.1: Campbelltown City Couuncil LGA land-use zoning map (CLEP, 2015)

Environment (DoPE) indicate that Campbelltown's population is set to increase by close to 50% in the next 15 years (DoPE, 2014). Therefore, in addition to the fundamental need to provide quality assets and infrastructure to ensure that the city can cope with a range of future challenges, the identification and protection of important biodiversity conservation values in the LGA (such as core koala habitat) is imperative to ensure long-term, sustainable planning outcomes.

1.1.2 The natural environment

a) Topography and geomorphology

The Campbelltown LGA consists predominately of sandstone and plateau landscapes, the eastern and southern parts deeply dissected by gorges associated with O'Hare's, Williams, Stokes and Pheasants Creeks and the Nepean, Woronora and Georges Rivers. Elevations within the Campbelltown LGA range from approximately 100m above sea level in the gorges to 240m above sea level on the plateau.

The east and south of the Campbelltown LGA are characterised by Hawkesbury Sandstone geology and geomorphology with steep, cliffed benches along the Georges River, and stepped platforms exposing prominent interbedded shale layers associated with O'Hare's and Pheasants Creeks. On the plateau tops, transitional beds of shale and sandstone are common and are exposed in some areas to produce an impervious layer with associated 'hanging swamps'. In the western and northern sections of the LGA, the landscape is dominated by gentle undulating rises associated with Wianamatta Shale formations. Floodplain landscapes, including the southern section of the Cumberland Plain, occur in the north and west.

Soil types within the LGA range from yellow earths, sandy skeletal podzols and red podzols associated with plateau formations to brown, red and yellow podzols and prairie soils on the Wianamatta Shales. The yellow earth soils are generally confined to residual plateau tops where the underlying strata are composed of lightly cemented, quartz rich sandstone. The podzols have clay subsoil as a result of weathering of the underlying shale, claystone or siltstone with the red podzols developing from material with an iron rich component.

b) Climate

The climate of Campbelltown can be described as temperate with warm to hot summers (maximum temperatures in excess of 30 degrees) and cool to mild winters. The LGA typically experiences its wettest periods in January – February and June with average annual rainfall in the range of 700 to 900mm.

c) Flora and fauna

Land units in the western and north western parts of the LGA include scattered trees and remnant stands of eucalypt forest and woodland communities. In the southeast, the vegetation is predominantly woodland with Blue-leaved Stringybark (*Eucalyptus agglomerata*) and Red Bloodwood (*Corymbia gummifera*) the dominant canopy species. Grey Gum (*E. punctata*) becomes dominant where interbedded lenses of shale occur, but is replaced as the dominant canopy species by Blackbutt (*E. pilularis*) where sandstone outcrops occur.

To the south, the vegetation changes to one dominated by Scribbly Gum (*E. racemosa*), Red Bloodwood (*C. gummifera*) and Blue-leaved Stringybark (*E. agglomerata*). Narrow-leaved Apple (*Angophora bakeri*) occurs as a dominant lower-stratum tree on some easterly aspects. Other land units support wet heathlands under a woodland canopy of Sydney Peppermint (*E. piperita*), Smooth-barked Apple (*A. costata*) and Red Bloodwood (*C. gummifera*), interspersed with pockets of Whip-stick Mallee Ash (*E. multicaulis*).

Historical accounts indicate that the Campbelltown area once supported a rich and diverse fauna assemblage. Despite the loss of some species over time since settlement, more than 330 fauna species have been recorded within the LGA. Forty-four of these species are listed as threatened under the TSC Act, 16 of which are also listed under the EPBC Act. Many of these species also have global significance, and are listed on the IUCN Red List for Threatened Species. Iconic threatened species found in the LGA range from the tiny Red-crowned Toadlet (*Pseudophryne australis*) to the Giant Burrowing Frog (*Helioporus australiacus*) and Broad-headed Snake (*Hoplocephalus bungaroides*), Glossy Black Cockatoo

Core koala habitat at Frere's Crossing, Kentlyn. Photo courtesy of Renee Winsor.

(*Calyptorhynchus lathami*), several species of micro-bat and of course, the koala (*P. cinereus*).

1.2 Statutory context

Interest in the management of koalas is reflected by a range of Commonwealth and State-based statutory measures that are intended to minimise impacts on koalas and their habitat. A brief overview of the legislation at work within the Campbelltown LGA is provided below.

1.2.1 Commonwealth legislation

a) Environment Protection and Biodiversity Conservation Act 1999

The koala is listed as a Vulnerable species throughout NSW for purposes of this legislation. In order to assist the conservation of important populations, the EPBC Act has the ability to over-ride the majority of State legislation. For EPBC Act purposes, the Campbelltown koala population readily meets two criteria required for identification as an important population, these being:

- it is a key source population either for breeding or dispersal
- it is a population necessary for maintaining genetic diversity.

Some large-scale DA/re-zonings that have the potential to impact on koalas and/or their habitat within the LGA may require referral to the Commonwealth Government as a consequence of the EPBC Act listing; Significant Impact Guidelines (DotE, 2013) are available to assist this process, as are referral guidelines for the vulnerable koala (DotE, 2014).

b) Defence Act 1903

This legislation governs the management of Commonwealth lands comprising those areas of the Holsworthy Barracks that fall within the Council LGA. Unless otherwise exempted from compliance by discretionary powers of the Minister, all infrastructure and capability projects, operations, training exercises, research trials, other projects and even maintenance activities potentially constitute 'actions' for the purposes of the aforementiod EPBC Act. Defence must not undertake actions that cause a significant impact on Commonwealth Matters of National Environmental Significance (MNES) without obtaining approval from the Federal Minister for the Environment.

1.2.2 State legislation

a) Threatened Species Conservation Act 1995

The koala is listed as Vulnerable to extinction throughout NSW for purposes of this legislation.

As a consequence of TSC Act links to other legislation such as the EP&A Act (see below), the potential for negative impact up koalas must be assessed by way of what is generally known as a 7 – part test or Assessment of Significance (AoS). A Species Impact Statement (SIS) will be required for any DA and/or rezoning that the AoS determines as having the potential for a significant impact on a local population of koalas.

The NSW Recovery Plan for the Koala (DECC, 2008) has been prepared under the TSC Act, and outlines conservation actions being undertaken in NSW to support the koala.

The Commonwealth government considers the protection of threatened species and it's habitat to be primarily each State's responsibilty. A draft approval bilateral agreement provides for accreditation of NSW processes for approval of proposed actions that would otherwise be assessed by the Australian Government for approval under the EPBC Act. Only one decision including conditions on approval is made by NSW, accounting for State matters and Commonwealth MNES.

b) Environmental Planning & Assessment Act 1979

The EP&A Act sets out the laws under which planning in NSW takes place. The main parts of the EP&A Act that relate to development assessment and approval are Part 4 (Development Assessment) and Part 5 (Environmental Assessment).

The EP&A Act also makes provision for the creation of environmental planning instruments which provide for the protection of koala habitat, including State Environmental Planning Policies (SEPPs), Local Environmental Plans (LEPs) and Development Control Plans (DCPs).

Within the Campbelltown LGA, those planning instruments of particular relevance to koalas include:

• State Environmental Planning Policy No. 44 (Koala Habitat Protection)

SEPP44 "aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline:

(a) by requiring the preparation of plans of management before development consent can be granted in relation to areas of core koala habitat, and
(b) by encouraging the identification of areas of core koala habitat
(c) by encouraging the inclusion of areas of core koala habitat in environment protection zones".

Under SEPP44:

"Core koala habitat" means an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.

"Potential koala habitat" means areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component.

Clause 6 only applies to land in relation to which a DA has been made that has an area (or together with any adjoining land in the same ownership) of more than 1 ha. Clause 5 excludes land dedicated or reserved under the *National Parks and Wildlife Act, 1974* (NPW Act), such as Dharawal National Park. In order to give effect to the aims of the SEPP44, Clause 15 provides that LGAs listed in Schedule 1 of the SEPP (which includes Campbelltown) should:

(a) survey the land within its area so as to identify areas of potential and core koala habitat
(b) make or amend a local environmental plan:
(i) to include land identified as a core koala habitat within an environmental protection zone
(ii) to identify land that is a core koala habitat and apply special provisions to control the development of that land
(c) give consideration to preparing an appropriate development control plan for land that is or adjoins an area of core koala habitat.

Under Clause 6 of SEPP44, Local councils cannot approve development on lands greater than 1ha without an investigation of potential and where warranted, core koala habitat as described in Clause 7 and 8. The Department of Planning Circular No. B35 guides councils through the process of addressing koala conservation through either Individual Koala Plans of Management (IKPoM) for small, localised developments, or CKPoM that apply to part or the whole of a LGA. A site-specific IKPoM must accompany any DA where core koala habitat is found to occur. However, if a CKPoM has been approved for the area, then individual DAs no longer need to include an IKPoM – as long as the DA is not inconsistent with the requirements of the CKPoM. In this way, the adoption of a CKPoM effectively streamlines the process for proponents applying to undertake development in areas of core koala habitat. However, an applicant may still prepare an IKPoM if they so choose.

Clause 10 states that a council must take into consideration the guidelines made by the Director-General, DPE. Appendix B sets out how this Plan has addressed these guidelines.

• State Environmental Planning Policy (Exempt and Complying Development Codes), 2008

This CKPoM identifies areas of core koala habitat within the Campbelltown LGA. Areas of core koala habitat are considered to constitute both 'environmentally sensitive areas' and 'ecologically sensitive areas' (Clause 1.17A, 1.19 of the Codes SEPP) due to the high biodiversity significance associated with important threatened species breeding habitat pertaining to the local koala population. Subsequently, these Clauses prevent complying development from being carried out on land identified as being located within an area of core koala habitat.

Furthermore, Section 6.4.5 of this Plan specifies fencing requirements, and applies to fences subject to the Exempt Development Codes (Clause 2.34, 2.36 and 2.38 of the Codes SEPP); which requires fencing:

"if it is located in a core koala habitat or potential koala habitat within the meaning of SEPP44 or in a movement corridor used by koalas - be constructed or installed in accordance with any relevant council policy or guideline under that Policy."

• Draft Campbelltown Local Environmental Plan 2015

In response to the State Government's requirement for all NSW councils to adopt new planning controls based on state-wide standards, Council has prepared a Campbelltown Local Environmental Plan 2015 (CLEP 2015). Formerly known as the Draft Campbelltown Local Environmental Plan, 2014, the CLEP 2015 has now been finalised with its publication on the NSW Legislation website in December 2015, and gazetted in March 2016.

The CLEP 2015 is a legal document that aims to control land use and development across the Campbelltown LGA and guides planning decisions, largely through the application of land use zones and development controls.

The plan applies to most land in the Council area. It consolidates and updates a wide range of existing planning controls and introduces some new policy positions that describe what development may be permissible in specific locations. It sets out future growth, as well as environmental and infrastructure goals for the city, and identifies what landowners can do on their properties.

• Campbelltown (Sustainable City) Development Control Plan 2014

The Sustainable City DCP is Council's primary DCP; its specific purpose is to provide more detailed provisions to supplement the CLEP 2015 by promoting high quality development and encouraging safe and livable environments.

Part 11 of the DCP sets out controls relating to the management of native vegetation and wildlife habitat (flora and fauna), including the requirement for koala habitat assessments.

c) Rural Fires Act 1997

The Rural Fires Act 1997 effectively created the NSW Rural Fire Service (RFS) and its associated command structure. Among other things, the objects of this legislation provide for the protection of the environment by requiring its key management focus (ie fire prevention, mitigation and suppression) to be carried out having regard to the principles of ecologically sustainable development as defined by Section 6 (2) of the Protection of the Environment Administration Act 1991.

Because of the nature of bush fires and the danger they pose to life and property, both managed and emergency bushfire hazard reduction have legal priority. Environmental Planning Instruments such as those referred to above cannot prohibit, require development consent for or otherwise restrict activities associated with bushfire planning and management. Similarly, Part 5 of the EP&A Act does not apply to managed bushfire hazard reduction work carried out on land other than excluded land if:

(a) the work is carried out in accordance with a bushfire risk management plan that applies to the land

(b) there is a bushfire hazard reduction certificate in force in respect of the work and the work is carried out in accordance with any conditions specified in the certificate

(c) the work is carried out in accordance with the provisions of a bushfire code applying to the land specified in the certificate."

Similar legal over-ridings are in place in respect of the TSC Act and the NPW Act.

• Bush Fire Environmental Assessment Code for NSW

The purpose of this Code is to provide a streamlined environmental assessment process for use by issuing authorities and certifying authorities in determining bushfire hazard reduction certificates. The Code has been prepared pursuant to sections 100J to 100N of the *Rural Fires Act, 1997.* Section 4.5 of the Code sets out standards for the protection of biodiversity, including determining the presence of threatened species and management conditions set out in the Threatened Species Hazard Reduction List. Under this list, the species specific conditions outlined for koalas relate to the:

- Use of fire: Low intensity fire only in areas formally identified as koala core habitat or koala high use habitat
- Mechanical forms of hazard reduction: No tree removal.
- 10/50 Vegetation Clearing Code of Practice 2014.

This Code of Practice under Section 100Q of the *Rural Fires Act, 1997* permits landowners within a 10/50 Vegetation Clearing Entitlement Area to clear certain vegetation near their homes, and enable residents to guard their homes against bushfire with a minimum amount of red tape. In August 2015, a review of the 10/50 scheme was conducted by the NSW RFS, DoPE and OEH, and the Code of Practice was amended in September 2015 to incorporate the 30 recommendations made

in the final report.

- The Rural Fires Amendment (Bush Fire Prevention) Bill 2015

This Bill amends the *Rural Fires Act 1997* to make provision with respect to bushfire hazard reduction work and vegetation clearing work associated with the 10/50 Vegetation Clearing Code of Practice. Under the Code, land parcels (lots) which are wholly or partly mapped within core koala habitat as identified in CKPoMs, are now excluded from the operation of the 10/50 scheme meaning tree clearing measures associated with the Code of Practice cannot be applied . However, it should be noted that core koala habitat as identified in approved IKPoMS are not excluded from the operation of the Code of Practice.

d) Companion Animals Act 1998

The *Companion Animals Act 1998* requires dogs to be under the control of a competent person when in public places they should not be permitted to roam and/or attack other animals including native wildlife, such as koalas. In practice, enforcement of these key aspects of the Act can be problematic.

The Act provides for the preparation of a Local Companion Animals Management Plan (LCAMP), to enable a council to fulfil its responsibilities under the Act by determining relevant objectives and priorities along with a clear program of implementation.

e) Local Government Act 1993

The *Local Government Act, 1993* requires Council to have in place an Integrated Planning and Reporting Framework to ensure that Council operations and strategic planning are meeting the needs of the community. Among other things, budgetary items such as those arising from nominated actions in the Plan must be sanctioned within this framework before they can be actioned. Within this framework, Strategy 1.2 under Council's Delivery Program 2012-2016 and Operational Plan 2015-2016 (Strategy 1.2.1) commits to the development and completion of a CKPoM.

f) Roads Act 1993

Among other things, the *Roads Act 1993* regulates the carrying out of activities on public roads, including those managed by Local Government authorities. Section 88 in Division 3 of this Act enables Council to lop or remove any tree (including a (P) KFT) that is growing in or overhanging a road reserve, and exempts them from the need to consider any other State Act or law to the contrary.

g) National Parks and Wildlife Act 1974

Under the NPW Act, the Director-General of NPWS is responsible for the care, control and management of all national parks, historic sites, nature reserves, reserves, Aboriginal areas and state game reserves.

The Director-General is also responsible under this legislation for the protection and care of native fauna and flora (including koalas) and Aboriginal places and objects throughout NSW.

1.2.3 Legislative overview

A review of relevant legislation confirms an extensive framework of legal protection afforded to koalas and their habitat on which long-term sustainable management of the Campbelltowns koalas can be based. However, current land use zonings (other than environmental protection areas) do not accurately reflect their value as koala habitat. Hence, there is a need for consistency and coordination of actions at all levels of governance, planning and management if a long-term sustainable future for the koalas in the Campbelltown LGA is to be realised. The Plan that follows is intended to provide the basis for this, but it needs to be well coordinated. While Council is arguably best placed to co-ordinate orderly implementation, it also needs both resources and cooperation to achieve this outcome.

Koala at Peter Meadows Creek, Minto Heights. Photo courtesy of Andy Attewell

PART B

WORKING PROVISIONS

"Keren" the koala. Photo courtesy of Richard Lonza

PART TWO

PRELIMINARIES

2.1. Name of plan

(i) This document is called the Campbelltown Comprehensive Koala Plan of Management, 2018 (CKPoM), hereafter referred to as "the Plan".

2.2. Area to which the plan applies

(i) Excluding the National Park estate, the Plan applies to those lands identified by Figure 2.1.

2.3. Supporting documentation

(i) Documents and literature relevant to the development of this Plan include:

- J. Callaghan, T. Curran, J. Thompson and A. Taylor (2005) Campbelltown City Council Draft Comprehensive Koala Plan of Management. Part 2: Resource Document. Australian Koala Foundation
- S. Ward, B. Failes and S. Woodgate (2013) Resource Document: Koala Habitat Study in Draft Campbelltown Comprehensive Koala Plan of Management. EcoLogical Pty Ltd

2.4. Commencement date

(i) The Plan was adopted by resolution of Council at its Ordinary Meeting held on 13 December 2016, and approved by the Secretary of the DPIE (previously DoPE) on 30 July 2020.

(ii) Council shall incorporate a clause that activates the approved provisions of the Plan for purposes of any LEP that covers all or part of the area to which the Plan applies.

2.5. Relationship to other koala plans of management

(i) The Plan does not supersede any other approved IKPoM that has been prepared in accordance with SEPP44 and which is currently in force on lands to which the Plan applies, unless there is provision within that IKPoM for ongoing amendment and/or revision, in which case relevant provisions of the Plan must be applied and incorporated.

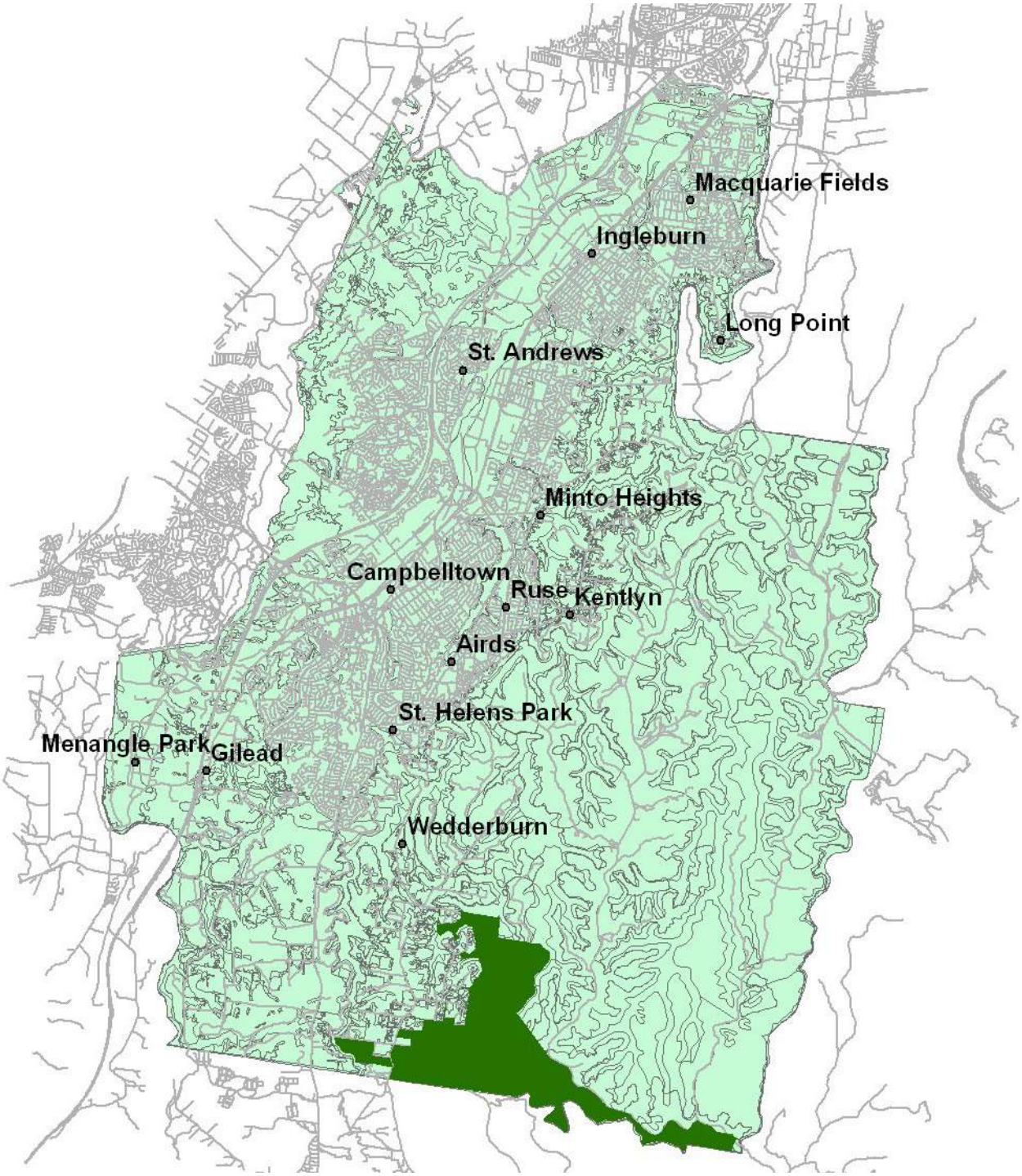


Figure 2.1: The Campbelltown City Council LGA - the land to which the Plan applies.
Note: the NPWS estate (Dharawal National Park) is otherwise excluded from the provisions of SEPP44.

PART THREE

VISIONS, AIMS and OBJECTIVES

3.1 Visions and aims

(I) In accordance with the aims and objectives of SEPP44 and the approved NSW Koala Recovery Plan, the overall vision of this Plan is to:

"provide for the long-term maintenance of a viable, free-ranging koala population in the Campbelltown LGA."

This vision is to be realised by way of the following aims:

a) To the maximum extent possible, enable persistence of a koala population of at least 300 koalas over the life of the Plan

b) To support the harmonious co-existence of the community with koalas

c) To provide regulatory and non-regulatory mechanisms to safeguard the future of the Campbelltown koala population.

3.2. Objectives

(i) The aims of the Plan will be realised by way of the following objectives:

a) Seeking support and engagement from all relevant stakeholders with a view to increasing the extent of koala friendly habitat and associated connectivity options

b) Incorporating best-practice habitat assessment procedures to ensure that adequate detail is provided with all development and/or rezoning applications, along with an accompanying set of development standards and controls

c) Developing appropriate fire management regimes to minimise bushfire risk

d) Minimising koala mortalities due to vehicle-strike and domestic dog attacks

Mum and bub at St Helens Park. Photo courtesy of Carla-Maree Simmons

Hazard reduction burn at Freres Crossing Reserve, Kentlyn. Photo courtesy of Troy Lessels

e) Formulating a strategic program of koala habitat regeneration and/or rehabilitation projects

f) Increasing community and public awareness through education programs promoting koala conservation and management

g) Securing financial compensation through DAs for the removal of (P)KFTs, and shelter trees; and utilising funds to provide resources for koala habitat restoration and rehabilitation initiatives

h) Establishing procedures for long-term monitoring of the conservation status of the Campbelltown koalas, so as to assess the efficacy of the Plan and enable regular review

i) Identifying koala welfare and research needs intended to improve and inform long-term management of the Campbelltown LGA's resident koala population

j) Procuring MOU's related to issues such as fire management that are intended to encourage better networking and cooperative management between other agencies whose activities can have a significant influence on koala conservation in the planning area.

Do you want to keep up to date on koalas in the Campbelltown LGA?

Head to - www.campbelltown.nsw.gov.au/koalatown

PART FOUR

ROLES and RESPONSIBILITIES

Context: responsibilities for the management of koalas and their habitat are spread widely across the community. While some land tenures (such as National Park estate) and activities (such as fire hazard reduction) are excluded from the provisions of SEPP44, it is important that all stakeholders strive to manage remaining areas of habitat in the Campbelltown LGA without detriment to koalas. To facilitate/coordinate this commitment, a lead agency is essential.

Overall objective: to create the framework for coordination and integration of the actions of all agencies responsible for land management across the lands to which the Plan applies, and ensure broad community representation and inter-agency involvement in the processes of koala management.

4.1 Lead authority

(i) Council will be the lead authority to champion sustainable koala management within the Campbelltown LGA by:

- developing, implementing and enforcing planning controls that relate to the management of koala habitat
- undertaking and supervising habitat rehabilitation works;
- supporting koala welfare groups
- preparing and implementing education programs
- monitoring koala populations and the effectiveness of the Plan
- integrating the provisions of the Plan into all other plans and policies associated with governance of the area to which the Plan will apply.

Council will seek the support of government agencies in managing the Campbelltown LGA's koala population, particularly in respect of those elements of the Plan such as fire control, vehicle-strike on State-owned roads and the management of Commonwealth land and National Park estate which fall outside Council's responsibility.

"Alexis" the koala and bub at Smiths Creek Reserve, Ruse. Photo courtesy of Carla-Maree Simmons

Council will advise and work with landowners who will be encouraged to review their land management practices in light of the Plan, and examine the potential of their holdings to assist with koala management and/or habitat rehabilitation measures.

Council will advise and work with developers to ensure adoption of best practice measures to accommodate and/or assist koala management in the context of development proposals.

Council will assist the Campbelltown community to become more actively involved with the management effort through participation in habitat regeneration/rehabilitation programs and assisting licensed welfare activities, being better informed about koala management issues and increasing levels of vigilance and engagement with koalas.

4.2. Establishment of a koala management committee

(i) Council shall establish a Koala Management Committee (KMC) to assist with implementation of the Plan.

(ii) Within the first six months following commencement of the Plan, Council shall have drafted and adopted Terms of Reference for the KMC and arranged for the first meeting.

(iii) The Terms of Reference shall include the following:

- minimum representation by Council, State Government, RFS, Academia and a minimum of two persons from the local community
- a chairperson elected from the members who shall retain that position for a period of no greater than 12 months
- a minimum of three meetings a year for the first 5 years of the Plan, and therafter as required but no less than twice a year.

Keen to get involved? Become a Koalatown supporter!

Head to:

www.campbelltown.nsw.gov.au/CCC/BecomeAKoalatownSupporter

Mum and bub at Smiths Creek Reserve, Ruse. Photo courtesy of Carla-Maree Simmons

PART FIVE

KOALA MANAGEMENT FRAMEWORK

Context: achieving the vision of the Plan requires a consistent approach to matters of koala habitat and koala population management. This includes establishing a clearly enunciated framework by which key management components of the koala management strategy can be discussed.

Overall objective: to set out a strategic framework for koala management that will form the basis of all future actions, allow Council to respond to specific opportunities as they arise and to focus, prioritise and direct the management actions required to achieve the objectives of the Plan.

5.1 Classification of potential koala habitat

(i) For purposes of the Plan the term 'potential koala habitat' means any area of native vegetation where the trees of the types listed in Schedule 2 of SEPP44 (being KFTs) constitute at least 15% of the total number of trees in the upper or lower strata of the tree component;

a) as identified in Figure 5.1 of the Plan, or

b) any other land identified as such by other processes arising from the Plan (such as a VAR).

5.2 Identification of core koala habitat

(i) For purposes of the Plan, the term core koala habitat means any parcel of land that is either wholly or partly identified under SEPP44 to contain a resident population of koalas, evidenced by attributes such as breeding females (that is females with young) and recent sightings of and historical records of a population;

a) as identified in Figure 5.1 of this Plan, or

b) any other land identified as such by other processes arising from the Plan (such as a VAR)[1].

5.3 Review of koala habitat mapping

(i) Council will give consideration to the need to update the mapping of areas of potential and core koala habitat with each major review of the Plan.

1 Based on an assessment undertaken in accord with methodology specified in Appendix B.

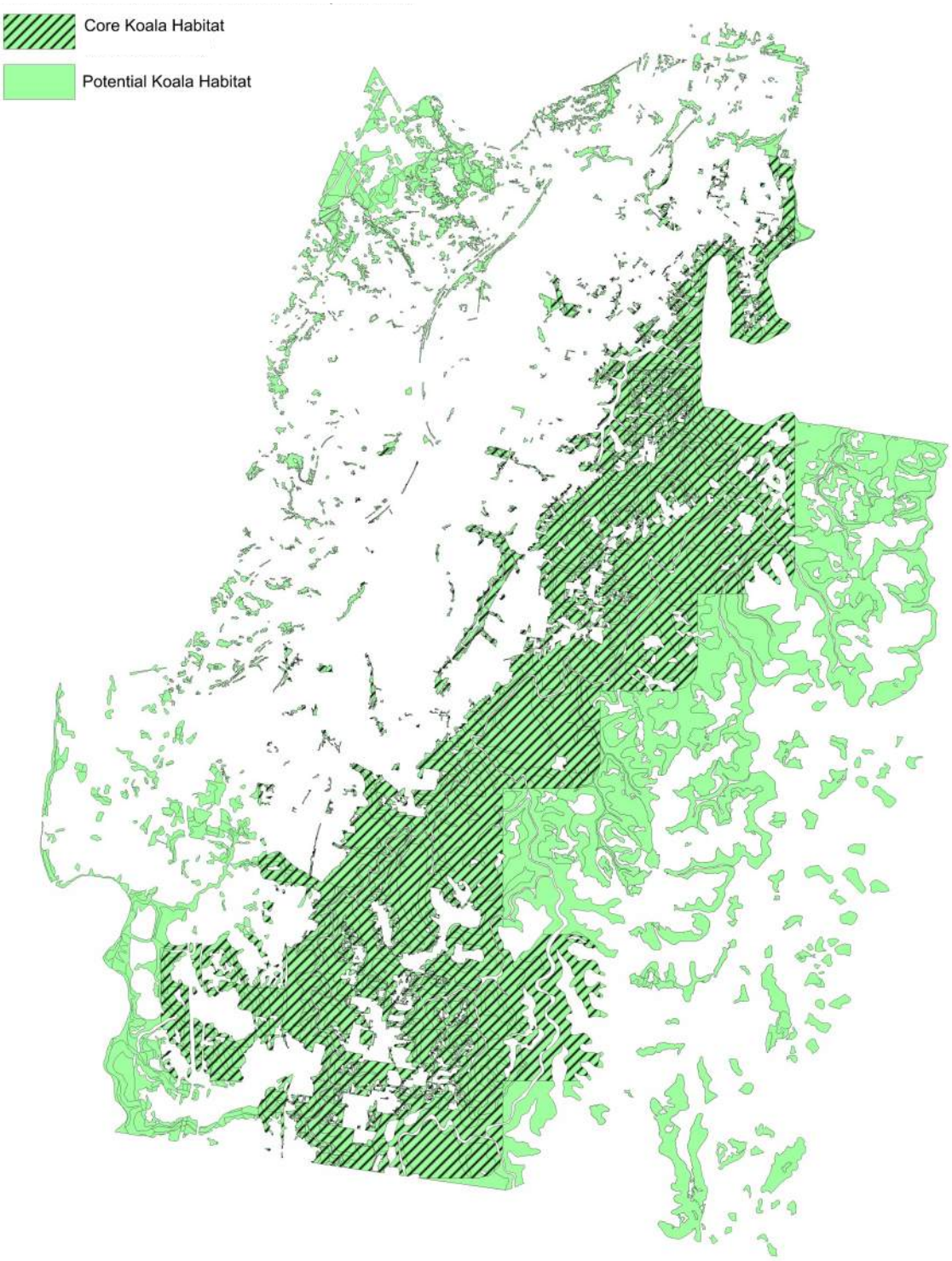


Figure 5.1: Extent of potential and core koala habitat across the Campbelltown LGA.

Note: The approximate extent of core koala habitat as evidenced by the presence of one or more koala records for each of the three most recent koala generations 1994 - 2017 (Appendix F)

5.4 Strategic linkage areas

At the landscape scale, local koala populations are maintained by processes of recruitment and dispersal from other populations in the general area. Koalas are at their most vulnerable when on the ground travelling between trees, hence safe movement of koalas across the landscape can be facilitated by the presence of vegetation.

(i) A schematic illustration showing key koala Strategic Linkage Areas (SLA) within the Campbelltown LGA is provided in Figure 5.3 of this Plan.

(i) Within the first three months of the Plan, Council and the KMC will establish an ongoing process soliciting expressions of interest from landholders with areas of core koala habitat to have their land identified as part of a SLA that assists in affording safe passage and movement corridors for koalas in the LGA.

(ii) Subject to landholder permission and funding, where SLAs occur across cleared land, revegetation of koala habitat, to at least a Woodland standard (ie scattered trees/discontinuous canopy cover) will be facilitated by Council.

(iii) Works associated with the establishment of additional vegetation cover in SLAs may be funded from grant monies obtained by landholders and/or Council.

(iv) The provision of grant monies referred to in (iii) will be contingent on the landholder entering into a conservation agreement or other restriction that functions to protect the habitat on the land containing the SLA. Council will investigate a range of financial and non-financial incentives to promote conservation to encourage private landholders to actively manage their lands for conservation purposes.

5.5 Section 149 Certificates

(i) Pursuant to Section 149(5) of the EP&A Act, Council may include advice on such other relevant matters affecting the land of which it may be aware. This could include information on the presence of mapped areas of potential and core koala habitat, and SLAs.

Maintaining koala habitat corridors and connectivity

SLA's are broadly identified as being important areas of koala habitat (comprising both core and potential) that support major movement corridors for koalas across the Campbelltown LGA as identified in Figure 5.3 of this Plan.

The optimal average corridor width for koalas in Campbelltown has been calculated to be 425m, based on the home range size requirements for female koalas in low carrying capacity landscapes (Biolink, 2017).

In early 2018, a strategic koala habitat corridor study was undertaken across the Campbelltown LGA, exploring specific connectivity requirements for koalas in order to calculate the least-cost dispersal pathways for the population. The results further informed local corridor planning for the Campbelltown LGA (Biolink 2018; Appendix G). These pathways are illustrated in Figure 5.3 of this Plan.

Koala at Airds. Photo courtesy of Newspix

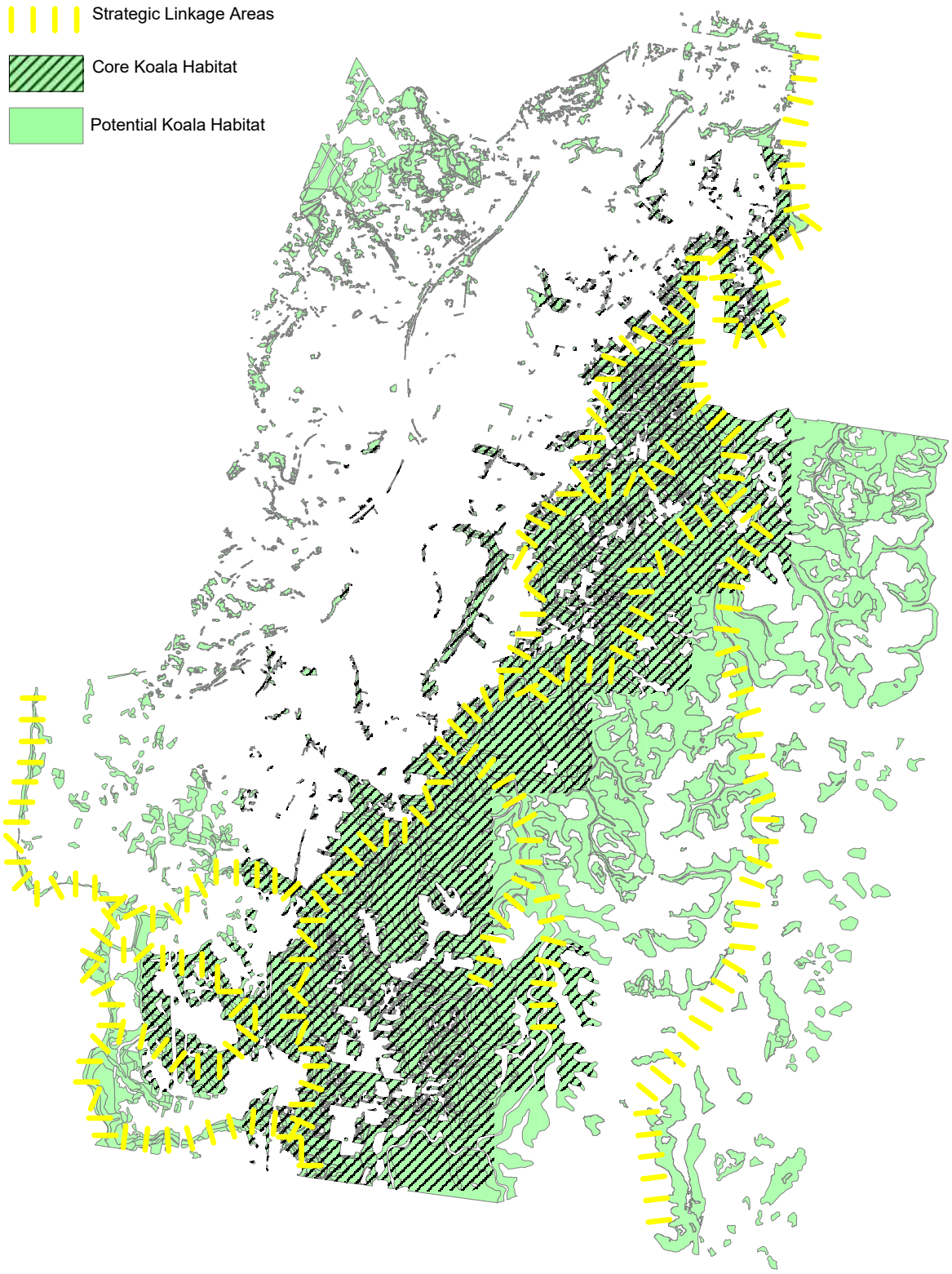


Figure 5.3: Key koala SLAs identified for the LGA

Note: The approximate extent of SLA's have been independently validated through a GAP CLoSR analysis identifying the least-cost dispersal pathways for koalas within the Campbelltown City Local Government Area (Appendix G)

Are you interested in restoring koala habitat on your property?

For more information, get in touch with Council's Natural Areas Team on 4645 4601 or email koalas@campbelltown.nsw.gov.au

"Mr Nymboida" the koala at Smiths Creek Reserve, Ruse. Photo courtesty of Carla-Maree Simmons

PART SIX

DEVELOPMENT ASSESSMENT and CONTROL

Context: to assist future assessments and associated planning decisions, it will be essential for Council to have unambiguous data on koala habitat use to ensure that potential impacts are effectively minimised in areas of core koala habitat.

Overall objective: to ensure that koala habitat is correctly assessed for purposes of development and/or rezoning applications so any potential for negative impact can be identified, and to protect and effectively manage remaining koala habitat through application of best practice measures.

6.1 Application and exclusions

(i) Subject to the exclusions specified in (ii and iii) below and unless otherwise specified elsewhere, this Part applies to all lands to which the Plan applies.

(ii) This Part does not apply to a DA that does not require the removal of native vegetation and which otherwise relates to:

a) a boundary adjustment, alterations or additions to a lawfully erected building

b) lands that are wholly located outside of core koala habitat that either singley or together with any adjoining land in the same ownership have an area of less than 1ha, whether or not the DA applies to the whole or only part of the land.

(ii) Although the adoption of this plan replaces the requirement for the preparation of an IKPoM under SEPP 44, the applicant can opt to prepare an IKPoM instead.

6.2 General guidelines

6.2.1 Register of development

(i) Council shall establish and maintain a register of DA's and/or rezoning applications that arise from Section 6.1 above. The register must include a mechanism to ensure that any matters concerning koala habitat arising from the development can be tracked and mapped for monitoring and review purposes. This includes nominated actions in any Statement of Environmental Effects (SEE) and the policing of associated consent conditions.

(ii) The register must also include details of any lands with an associated program of habitat restoration and/or rehabilitation that is being undertaken as a consequence of Part 8 of the Plan.

(iii) A summary of items entered into the register must be provided to each meeting of the KMC.

(iv) The register shall be available for public inspection at any time during normal office hours.

6.2.2 Assessment and control standards

(i) A DA for any land the subject of Clause 6.1 above must include an assessment of the proposed development against the flowchart located in Figure 6.

(ii) Council cannot approve a DA that does not conform to the required controls and standards arising from this part unless:

a) there are proven to be extenuating circumstances

b) the overarching objectives of the Plan are not unduly compromised

c) any proposed deviation has the support of the KMC.

6.2.3 Strategic linkage areas

(i) Council cannot approve a DA to which this section applies unless it is satisfied that the proposal will not sever or otherwise interfere with the movement of koalas within an identified SLA.

6.2.4 Rezoning applications

(i) A planning proposal pursuant to Section 55 of the EPA Act should demonstrate consistency with this Plan so as to identify the likely impact on koala habitat and populations of the type of development to be facilitated by the rezoning.

6.3 Assessment of koala habitat

6.3.1 Vegetation Assessment Report

(i) A rezoning or DA must establish if the land being the subject of the application contains any potential koala habitat by way of a Vegetation Assessment Report (VAR).

(ii) As a minimum, the VAR shall include:

- a description of the tallest stratum cover as well as details of the species composition of each vegetation community
- a checklist of native vegetation species occurring in each vegetation patch, including any isolated paddock trees on partially cleared lands
- a stadia-metric survey that identifies the precise location, identity and dbh of all native vegetation proposed to be removed and/or within 20m of the proposed development footprint, including any proposed infrastructure, easements and APZs
- a map of where (P)KFTs and shelter trees were recorded.

6.3.2 Koala Activity Assessment Report

(i) Subject to 6.3.2 (v) below, this section only applies to land that is located outside the boundaries of mapped core koala habitat as identified in Figure 5.1; and on which potential koala habitat has been identified as a consequence of a VAR.

(ii) A DA for any land the subject of 6.3.2(i) must include a Koala Activity Assessment Report (KAAR) for that land.

(iii) The KAAR must employ the methodology outlined in Appendix B of the Plan.

(iv) The KAAR must be undertaken by a suitably qualified person with relevant accreditations; being an individual with post-graduate qualifications in koala ecology, and/or demonstrable work experience that includes publication of works on koala ecology in peer-reviewed scientific literature and/or supported by membership with a professional body such as the EIANZ or ECA.

(v) Council may also require a KAAR to be prepared for any development within mapped core koala habitat identified in Figure 5.1 - where detailed information on the distribution of koala activity and movement is required to assist evaluation of development design, and also reserves the right to have any KAAR prepared pursuant to this section peer-reviewed.

Koala faecal pellets identified through KAAR

Koala scratchings identified through KAAR at Minerva Road, Wedderburn. Photo courtesy of Alexandra Cave

6.4 Development controls

6.4.1 Planning controls in 'core' koala habitat

(i) This section applies to all planning proposals, rezonings, and DA's that relate to areas of core koala habitat.

6.4.2 Retention of (P)KFTs and shelter trees

For the purposes of this Plan, development has been classified into 'minor' and 'major' development (see caption below).

(i) There shall be no removal of (P)KFTs or shelter trees as a consequence of any new DA, beyond what is permissable under the definitions for minor and major development.

(ii) The applicant must demonstrate to the satisfaction of Council that the protection of all (P)KFTs and shelter trees are consistent with the requirements of AS 4970-2009 (Protection of Trees on Development Sites).

(iii) Retained (P)KFTs and shelter trees that occur within residential allotments arising from the subdivision of land must be protected by a covenant or other effective restriction on the user on title of the land where appropriate.

6.4.3 Swimming pools

(i) All new swimming pools must incorporate a design component such as a shallow ramp or other feature that will enable egress by koalas; and/or a stout rope (> 50 mm diameter), one end of which must be secured to a stable poolside fixture, the other end of which must trail in the pool.

(ii) Without contravening provisions of the *Swimming Pools Act 1992*, fencing must also be of a type that prevents access to the pool area by koalas (eg not be of timber or have timber posts or have shrubs and trees within 1m of either side of the fence that would allow koalas to climb over).

6.4.4 Domestic dogs[1]

(i) On any new residential lots arising from the subdivision of land, the keeping of domestic dogs will be either:

a) prohibited by an effective restriction as to user on the title of the land, or other suitable planning measure.

b) subject to a covenant; imposing a legal requirement to install a dog-proof yard, whether the prospective owner has the immediate intention of owning a dog or not. The yard must not contain (P)KFTs or shelter trees, with a minimum area of approximately 300m^2 around a residential dwelling or part thereof. Yard-fencing must be a minimum of 1.8 m high and either be partially buried or have an associated buried component to a minimum depth of 0.3m. All gates into the enclosed area must be of the same height and general structure as the yard-fence and must have minimum clearance above ground to allow for swinging of the gate, below which must be a solid barrier (eg concrete) to deter digging.

(ii) The options referred to in 6.4.4(i) above must be either registered and/or in place prior to the issuing of a CC.

6.4.5 Fencing

(i) Fencing of residential lots must not impede the movement of koalas. Fences that are not supported by this Plan, include (but are not limited to):

- colourbond panel fencing
- barbed wire fencing
- solid brick fencing (>1m high)
- steel fencing (>30cm gaps between rails)

1 Excludes an "assistance animal" as defined for purposes of Part 6 of the Companion Animals Act 1998

Is my DA classified as 'minor' or 'major' development?

Minor development means a DA that relates to construction of a single residential dwelling, and/or the subdivision of land into ≤ two lots, and/or requires the removal of no more than two (P)KFTs for each hectare of assessable land to which the DA relates.

Major development means a DA that relates to the subdivision of a single lot of land into ≥ three lots, and/or requires the removal of > three (P)KFTs for each assessable land to which the DA relates.

Did you know...

Significant koala activity levels for the Campbelltown population are those ≥ 10%.

Ongoing evaluation of the significant use activity level threshold in east-coast low density koala populations has been assisted by the large data sets collected by the NSW OEH from the south-east forests of NSW. These data have unequivocally established that activity levels below 10% are associated with transient use (ie tree species / faecal pellet associations appear random), whereas those above 10% are not (ie pattern non-random and associated with preferential utilisation of food tree species typical of habitat use by individual koalas with established home range patterns clearly indicative of resident koala populations).

6.4.6 Road design

(i) Road design standards and/or approved vehicle calming devices (eg speed humps, roundabouts, chicanes and wildlife activated signage) must be incorporated on any new roads created through residential subdivision with a maximum speed of 40km/hr.

(ii) Outside of residential subdivisions, where new roads or road upgrades are proposed that traverse areas of koala habitat and are predicted to accommodate in excess of 1,500 vehicle movements/day, the following standards apply:

a) approved wildlife exclusion fencing must be installed along both sides of the road, the lower half of which must be clad with galvansied tin sheeting on the outside face.

b) round pipe koala-grids or other approved devices must be installed at fence-ends and driveways and other access points to prevent koala access to the road corridor.

c) connectivity structures such as overpasses or underpasses (comprising a minimum of 1.2m X 1.2m reinforced concrete box culverts) must be installed at regular intervals that approximate one structure per 250m of exclusion fencing.

(d) in areas where significant topographical or engineering constraints exist, solutions are to be sought that do not compromise the long-term viability of the koala population.

(e) detailed design in accordance with (i) and (ii) above must be prepared in consultation with a suitably qualified person.

6.4.7 Protection of koalas from disturbance

(i) Clearing of native vegetation and/or earthworks as part of any consent from Council must be temporarily suspended within a range of 25m from any tree which is concurrently occupied by a koala and must not resume until the koala has moved from the tree of its own volition.

(ii) Any clearing of land must not commence until the area proposed for clearing has been inspected for the presence of koalas by a suitably qualified person, and approval given in writing.

(iii) Approval to proceed with the clearing of vegetation in accordance with this section is only valid for the day on which the inspection has been undertaken.

(iv) The individual referred to in (ii) above, or a nominated representative, must remain on site during any approved clearing of vegetation. If clearing operations are being undertaken concurrently in different sections of a property, a suitably qualified person must be present in each section.

6.4.8 Planning controls in 'potential' koala habitat

In areas of potential koala habitat, consideration has been given to relaxing development standards of the Plan as they apply to areas of core koala habitat.

(i) This section applies to all planning proposals, rezonings, and DA's that relate to areas of potential koala habitat.

(ii) for the purposes of Section 6.4.2 of the Plan, Council may exercise discretion subject to the application demonstrating to the satisfaction of Council that that retention of (P)KFTs > 200mm DBH has been maximised and that the proposed tree removal will not prejudice the overall vision, aims and objectives of the Plan.

(iii) for the purposes of Sections 6.4.3 – 6.4.6 of the Plan, Council may exercise discretion in terms of requiring the development to conform.

(iv) Part 7 of the Plan applies to any DA being considered for the purposes of this section.

Mum and bub at Heritage Heights Crescent in St Helens Park. Photo courtesy of Newspix

6.5 Non-conforming developments

In the event that extenuating circumstances beyond the capacity of the Plan to resolve can be demonstrated, some basis may exist for Council to consider modifying a development proposal in such a way as to not compromise long-term koala management objectives.

(i) This section applies to a DA relating to land to which this Part applies and contains potential koala habitat.

(ii) Notwithstanding the requirements of Section 6.4 and at the discretion of Council, a DA for the subdivision of land for the creation of three or more lots may be approved for enclaving in such a way as to permanently exclude koalas by way of fencing, koala-grids and gateways of a type that do not allow koalas to enter the area.

(iii) Any DA to be considered for enclaving must be accompanied by a KAAR.

(iv) Areas of land where core koala habitat has been established to be present by way of a KAAR; cannot be included in any land that is proposed for enclaving.

(v) In considering any application for the purposes of this section and only after consultation with the KMC, Council must be satisfied that all options relating to conformity with Section 6.4 of the Plan have been explored and exhausted.

(vi) For the purposes of (v) above, the KMC must provide a written response which must be considered by Council as part of the assessment process.

(vii) Council may consequently consider approval of the application subject to:

a) All roads and pedestrian access ways entering the enclaved area including suitable approved devices such as specially constructed koala-grids[1] and gates to prevent koalas from entering the area.

b) The design and specifications of the fencing, koala-grids and/or gates referred to in (ii) above being designed in consultation with a suitably qualified and/or accredited individual. Where the use of fencing is not considered necessary, sufficient justification in writing must be provided within the documentation supporting the DA.

c) Lands on which the fencing is to be installed must be managed in perpetuity by the proponent with access to Council afforded by way of formal easement.

d) The original DA for development of land to be enclaved providing the following plans to the satisfaction of Council:

- the precise location of the fencing
- details of conformity with (a) to (c) above.

e) The costs of providing and installing fencing, and maintenance thereof must be met by the proponent. No development works pursuant to a CC being provided, are to be undertaken on the land to be enclaved, other than fencing approved as a consequence of (vii) above until the fencing referred to in (b) above is installed and operational.

(viii) Part 7 of the Plan applies to all lands that are within any area to be enclaved.

(ix) The balance of lands relating the DA and which are not to be enclaved, will be subject to the requirements of Part 6.4 of the Plan.

1 Specifications to require use of 60mm tubular steel pipes at 200mm centres

When submitting my DA, what information do I need to provide to Council?

Use the Development Assessment Flowchart in Figure 6.1 to determine what information you are required to provide to Council to support your DA.

Mum and bub at Heritage Heights Crescent in St Helens Park. Photo courtesy of Newspix

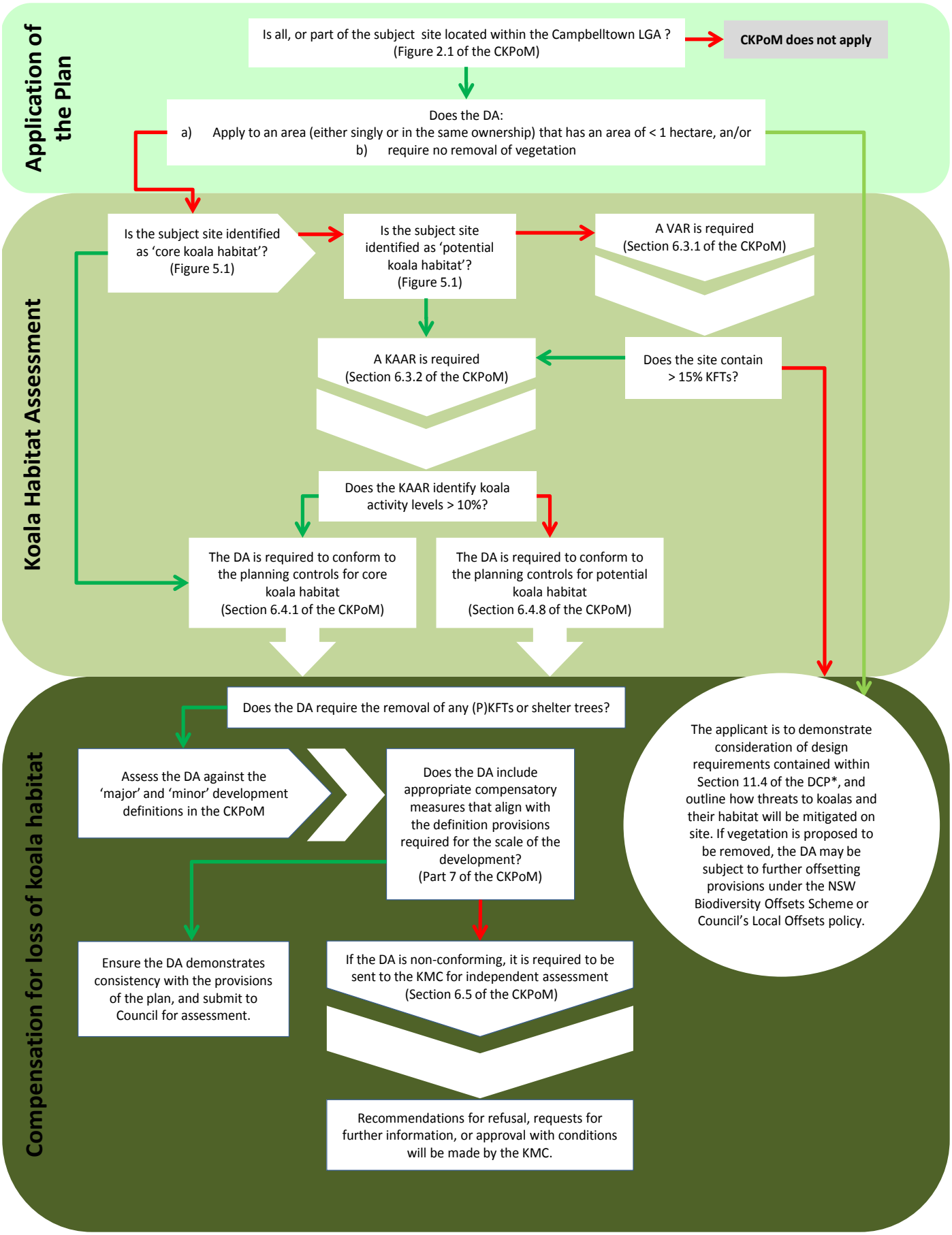


Figure 6.1: Development Assessment framework flowchart

"Mr Nymboida" the koala at Smiths Creek Reserve, Ruse.
Photo courtesy of Carla-Maree Simmons

PART SEVEN

COMPENSATION FOR LOSS OF KOALA HABITAT

Context: the loss of native vegetation is listed as a Key Threatening Process (KTP) and can be a contributing factor to koala population decline. For koalas, a number of issues arise with regard to compensating for habitat losses arising from development:

1. compensatory plantings take time before they can provide the equivalent food resource that the removed trees provided
2. proposals for compensatory plantings may not necessarily be in the most appropriate location in terms of longer-term koala management objectives
3. compensatory plantings cannot be guaranteed in perpetuity, particularly if undertaken on lands that do not have a secure conservation tenure
4. there is no supervision of planting to ensure that the planting succeeds over time
5. there are no standards by which compensation can be determined for the loss of habitat.

While controls can be put into place to attempt to address these issues, none will provide an efficient management regime to ensure the compensatory planting will be effective. If compensatory planting has to be accommodated as a last resort, then overall responsibility should be borne by a responsible authority, such as Council, to supervise such planting in the most appropriate location having regard to the requirements for koala management as set out in the Plan.

Overall objective: to provide a standardised approach to the compensation and offsetting of koala habitat loss with a transparent assessment process that enables loss to be quantified; and to belatedly provide a mechanism for effectively resourcing koala habitat rehabilitation and regeneration programs.

7.1 Major development

(i) This section applies to any DA that relates to the subdivision of land into ≥ three lots, and/or requires the removal of three or more (P)KFTs for each hectare of assessable land.

(ii) Where a proponent chooses to seek the removal of (P)KFTs or shelter trees in accordance with a DA, provision must be made to compensate for the loss of the associated habitat.

(iii) To ensure that the provision of compensation is:

- equivalent to the importance of habitat being removed
- geographically appropriate so as to contribute to the long-term conservation and viability of Campbelltown's koalas

the proponent shall agree to either, at the applicants expense:

a) to enter into a legally binding agreement with Council to make a monetary contribution towards the Koala Habitat Rehabilitation Program detailed in Part 8 of the Plan, or

(b) to enter into a legally binding agreement with Council to undertake rehabilitation works in areas identified by the Koala Rehabilitation Program detailed in Part 8 of the Plan. This will include payment of a Compensation Guarantee in the form of a Bank Bond which will be released once the required works have been implemented in accord with the agreement. The purpose of a Compensatory Guarantee is to allow Council to implement the required works in the event that the proponent is unable or unwilling to comply.

(iv) The amount of the monies referred to in 7.1(iii)(a-b) above will be based on the value of the required 'compensation units' (CU) (for every cm of DBH or part thereof) arising from the total number and size of (P)KFTs and shelter trees that will be removed, as follows:

(a) Small (DBH < 100mm)	8 CU/mm of DBH
(b) Medium (DBH >100<300mm)	15 CU/mm of DBH
(c) Large (DBH > 300mm)	25 CU/mm of DBH

(v) The value of a CU as at the date of commencement of the Plan is $1.00, this value to be adjusted annually using the CPI increase for the 12 months prior to the review date.

(vi) Council must establish a special trust fund into which the monetary amount determined as compensation for the purposes of 7.1(iii)(a) above can be placed, and from which only habitat rehabilitation or regeneration works identified through the provisions of Part 8 of the Plan can be funded.

7.2 Minor development

(i) This section applies to any DA that relates to the construction of a single residential dwelling, and/or subdivision of land into ≤ two lots, and/ or requires the removal of no more than two (P)KFTs for each hectare of assessable land.

(ii) Where a proponent chooses to seek the removal of (P)KFTs or shelter trees in accordance with a DA, provision must be made to compensate for the loss of the associated habitat.

(iii) To ensure that the provision of compensation is:

- equivalent to the importance of habitat to be removed
- geographically appropriate so as to contribute to the long-term conservation and viability of Campbelltown's koalas

the proponent shall be required to compensate for the loss of any (P)KFTs or shelter trees at the following ratio of replacement trees (or the monetary equivalent[1]) for every individual tree that is removed:

(a) Small (DBH<100 mm)	1:10
(b) Medium (DBH>100<300 mm)	1:15
(c) Large (DBH>300 mm)	1:20

(iv) the location of the compensatory plantings shall be at the discretion of Council in the context of Part 8 of the Plan.

Note: Compensation case studies that explore hypothetical offsetting scenarios can be found on the following pages.

7.3 Compensatory planting locations

(i) Nothing in this Part prohibits the proponent from undertaking compensatory plantings and/or habitat rehabilitation measures on lands being the subject of the DA. However, such an action cannot otherwise be used to discount the obligations of the proponent for the purposes of this Part unless both:

a) an agreement as outlined in 7.1(iii)(b) above is in place, requiring both a caveat being placed on the property and payment of a Conservation Guarantee

(b) the proponent develops a Vegetation Management Plan (VMP) that meets the requirements set out in Council's VMP Guidelines, 2016; adequately addresses 8.1(v); and is formally approved by Council

(ii) Development consent shall be conditional upon the agreement referred to in 7.3(i) above being registered and in place prior to issuing of a CC; and be subject to random audits.

Did you know?

Campbelltown occurs on low nutrient soil substrates, which means that the growth rate of Eucalypts are considerably slower when compared to high nutrient substrates, such as those found on the NSW north coast. This means that PKFTs take a much longer time to grow to a size that is palatable for koalas.

Koala food tree planting day, Smiths Creek Reserve, 26 July 2015. Photo courtesy of Angela Taylor.

1 Monetary equivalent proposed as $35 per replacement tree

Compensation case study A

A landowner in Wedderburn is seeking DA approval to build a house on their 2ha property. The property is located in an area identified as 'potential koala habitat', and the applicant is required to submit a KAAR to support their DA.

There are found to be 37 (P)KFTs and shelter trees on the property. The applicant proposes to remove eight of these in order to build their house. However, the proposed removal of this number of trees means that the DA is classified as non-complying development under the CKPoM – and the applicant would be required to submit their DA to the KMC for special consideration.

The applicant decides to review their application, and in doing so to re-design their development to reduce the impacts to (P)KFTs and shelter trees. The applicant manages to reduce the proposed number of trees to be removed down to four trees, comprising three PKFTs, and one shelter tree. The proposed development now meets the definition requirements of 'Minor development'.

The applicant is required to compensate for the loss of (P) KFTS and shelter trees under the plan, and has the option of either:

1. Offsetting the loss of the four trees at the offset ratio outlined in 7.2(iii) and planting the required number of replacement trees on site:
   - 2 x Medium (DBH: 153, 275mm) @ 1:15
   - 1 x Large (DBH: 560mm) @ 1:20
   - 1 x Small (DBH: 93mm) @ 1:10

   Requiring the planting of 60 replacement trees on site, comprising a combination of (P)KFTs and shelter trees.
2. Paying Council $35 per replacement tree, in this instance being (60 x $35), totalling $2,100.

Koala sitting on fence. Photo courtesy of istock

Case study A - Example Wedderburn site

Compensation case study B

A property developer in Ingleburn is seeking development approval to subdivide a 5 ha land parcel adjacent to the Georges River into three allotments.

The proposed development is classified as 'Major development' under the Plan. The subject land is located in core koala habitat, however due to the size of the development - Council requests a KAAR be prepared to further inform the development (Section 6.3.2v).

The subdivision is conditionally approved with Council requiring the retention of a number of the largest PKFTs, but permitting removal of a total of nine (P)KFTs and shelter trees across the site; subject to the developer meeting the applicable offsetting provisions.

The amount of compensation payable to Council's koala habitat rehabilitation fund is calculated at $53, 334 (see below for breakdown of per tree amount).

Koala in Kentlyn. Photo courtesy of Carla-Maree Simmons

	Common name	Scientific name	DBH (mm)	CU	Amount
1	Grey Gum	*Eucalyptus punctata*	151	15 (M)	$2 265
2	Grey Gum	*Eucalyptus punctata*	270	15 (M)	$4 050
3	Grey Gum	*Eucalyptus punctata*	88	8 (S)	$704
4	Grey Gum	*Eucalyptus punctata*	290	15 (M)	$4 350
5	Blue-leaved Stringybark	*Eucalyptus agglomerata*	185	15 (M)	$2 775
6	Blue-leaved Stringybark	*Eucalyptus agglomerata*	210	8 (S)	$1 680
7	Forest Red Gum	*Eucalyptus tereticornis*	800	25 (L)	$20 000
8	Manna Gum	*Eucalyptus viminalis*	95	8 (S)	$760
9	Turpentine	*Syncarpia glomulifera*	670	25 (L)	$16 750
	TOTAL				$53 334

*The amount for each tree is calculated by multiplying the DBH by the compensation units at a cost of $1 each.

PKFTs at Ingleburn. Photo courtesy of Council

Case study B - Example Ingelburn site

Campbelltown koala. Photo courtesy of Richard Lonza.

PART EIGHT

HABITAT REHABILITATION & RESTORATION

Context: additional koala habitat areas will assist in sustaining a free-ranging koala population in perpetuity. This habitat is ideally perceived to include the in-filling of gaps within and adjoining existing areas of potential and core koala habitat, in addition to SLAs. It is important that resources are used effectively to gain this additional koala habitat and that it is available in perpetuity for the koala population. The best means of achieving this is for Council to take an overseeing role for all rehabilitation and/or revegetation works.

Overall objective: to provide a coordinated program of habitat rehabilitation and linkage creation.

8.1 Habitat rehabilitation

(i) Where necessary, Council shall coordinate the rehabilitation of koala habitat across all lands to which the Plan applies. Council will seek partners and funding to secure the rehabilitation.

(ii) Within the first 18 months of the Plan and in consultation with the KMC, Council shall prepare a Koala Habitat Rehabilitation Program (the Program) for lands to which the Plan applies. The Program must identify and prioritise largely un-vegetated areas with a secure conservation tenure and/or conservation agreement for habitat restoration and/or rehabilitation purposes.

(iii) As a component of (ii) above, Council will actively seek interest from government agencies and private landholders within core koala habitat and SLAs to have their land considered for rehabilitation purposes.

(iv) Council will use the funds obtained by the habitat compensation measures detailed in Part 7 of the Plan to resource the Program, together with other such funding sources as may be available from time to time.

(v) Habitat rehabilitation plans must be prepared for each rehabilitation project. Habitat rehabilitation plan's and VMPs that are prepared by a proponent in accordance with 7.3 (i) (b) must be approved by Council prior to works commencing, and must include the following information:

- the total area proposed for rehabilitation
- description and condition of current vegetation cover
- the number of trees to be planted, location of plantings and planting densities
- details of the sourcing of all seedlings (demonstrating local seed stock will be used)
- a schedule of management, monitoring and maintenance activities to ensure establishment and ongoing protection and management of plantings
- the length of the proposed monitoring and management periods, the timing of key milestones and reporting requirements
- provisions for planting mortality replacements
- nominate responsible parties for the undertaking of all works and activities included in the Plan
- if the revegetation is to take place on other than public land, how the revegetation will be maintained in perpetuity for the benefit of koalas.

(vi) As a general rule, (P)KFTs must comprise no less than 25% of the tree species used for rehabilitation purposes.

(vii) A Council officer will be made responsible for overall planning, supervision, resourcing and coordination of revegetation works; and will liaise with the KMC regarding the Program.

(viii) Where priority areas for koala habitat restoration are identified on land managed by Council, provision should be made in the relevant Plan of Management for this work.

Did you know that Council has a number of Bushcare groups operating in various locations throughout the Campbelltown LGA.

Interested in joining? For more information, contact Council's Bushcare Coordinator on 4645 4194 or email bushcare@campbelltown.nsw.gov.au

Koala food tree planting day, Smiths Creek Reserve, 26 July 2015. Photo courtesy of Angela Taylor

PART NINE

COMMUNITY EDUCATION

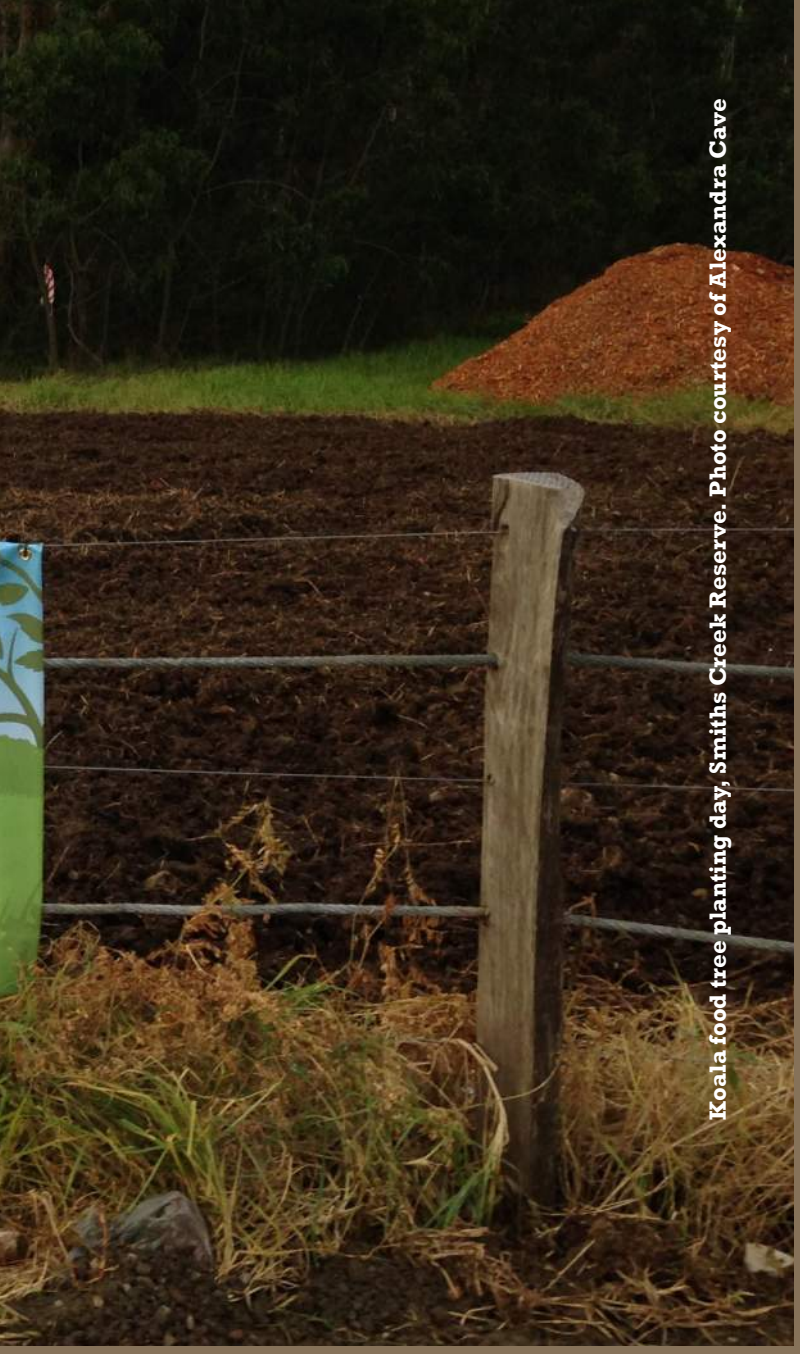
Context: while there is generally community support for koalas, there is limited appreciation of the threats they face and the measures required to ensure longer-term sustainable management of existing populations.

Overall objective: to increase the wider community's awareness of threats to koala habitat and populations, together with measures required to better manage the species and to facilitate active engagement of the community with koala management.

9.1 Education strategy

(i) In conjunction with the KMC, within the first 18 months of the Plan Council shall prepare a Koala Education Strategy aimed at raising awareness about the need for the involvement of the broader community in the management of the Campbelltown koalas. Measures may include, but are not limited to:

- a brochure aimed at visitors to the Campbelltown LGA
- a program targeted at providing information sessions at schools



Koala food tree planting day, Smiths Creek Reserve. Photo courtesy of Alexandra Cave

Koala crossing warning signs on Appin Road, Gilead. Photo courtesy of Council

- signage on roads through areas known to be occupied by koalas
- regular workshops for the community on measures necessary to assist the koala management effort
- a web-based mechanism allowing or advising residents to record koala sightings and other incidents of interest to koala management
- a koala management page or pages on the Council website that provides access to the Plan, along with details of koala management measures and actions that residents, landowners etc. can take to assist longer-term koala management efforts.

(ii) In addition to the measures to encourage habitat regeneration on private lands, Council will promote discussions with private landholders about options for conservation of koala habitat on their lands, including offering incentive instruments such as voluntary Conservation Agreements to assist in conservation of koala habitat.

Have you seen a koala?

Report your sighting to Council's Natural Areas Team on 4645 4601 or email koalas@campbelltown.nsw.gov.au

Dr Rob Close and Angela Taylor at Riverside Drive, Airds. Photo courtesy of Andy Attewell

PART TEN

MONITORING, REPORTING and REVIEW

Context: appropriate measures are required to inform stakeholder interests in the distribution, abundance and conservation status of Campbelltowns resident koala population(s), assess the effectiveness of the Plan's working provisions and if necessary, identify if and how they should be amended.

Overall objective: To ensure that the Plan remains relevant and that planning controls are regularly reviewed so as to achieve the vision and aims of the Plan.

10.1 Population monitoring

(i) Within and immediately adjoining areas of core koala habitat recognised for purposes of the Plan, Council will monitor the amount of habitat being utilised by koalas by reassessing the occupancy rate and/or levels of koala activity, ideally within the first year following commencement of the Plan, and thereafter at intervals of every two years.

(ii) For purposes of the monitoring program, a series of approximately 50 field sites at 500m intervals will be established as permanent monitoring points, the locations of which are known to Council.

(iii) Each monitoring event must involve an assessment of koala habitat use at each of the 50 sites that arise from those created by 10.1(ii) above.

(v) The minimum data set to be collected from each field site that is sampled for purposes of (iii) above must include either:

a) a full measure of koala activity (ie application of SAT methodology applied in accord with Appendix D) from a central point located at the site coordinates, along with the number of koalas sighted in a 250m x 40m (1ha) transect, or

b) a determination as to whether koalas are using the site based on 10 minute searches for koala faecal pellets around the base of and/or beneath the canopies of any (P)KFTs that are located within a 25m radius of the site coordinates (or other tree species if no (P)KFTs are present).

(vi) A determination as to which of the two preceding options will be utilised will be made on the basis of resources available to Council at each monitoring event.

(vii) For the first monitoring event, coordinates for the centre of the site must be documented and the precise location permanently identified so as to enable it to be found for the purpose of subsequent monitoring events.

(viii) Monitoring and any associated data analysis must be undertaken by suitably qualified and/or accredited Council officers or other individuals who must also gather data from organisations such as the Macarthur Veterinary Group, WIRES and Sydney Wildlife on any koala incidents that may have occurred in the time period that has elapsed since the previous monitoring event.

(ix) As a component of every third monitoring event, Council will undertake a view of historical koala records using the methods described in Appendix D and F.

10.2 Performance indicators

(i) For monitoring purposes, the benchmark habitat occupancy rate to be achieved for koala populations inhabiting areas of core koala habitat and adjoining lands should ideally average 45 - 50% of sampled field sites.

(ii) Notwithstanding the influence of events beyond the control of Council, the Plan can only be deemed successful if the occupancy rate estimated by the historical records analysis referred to in 10.1(ix) above is not significantly less than the estimate established by the monitoring program.

(iii) Generally, conclusions relating to changes in the occupancy rate within areas of core koala habitat should only be undertaken at every third monitoring event (ie every six years) by examining both the occupancy trend over the intervening six year period and by a direct comparison to the occupancy estimate of the six years previous.

(iv) Any statistically significant reduction in either the occupancy rate or the number of field sites returning evidence of koala activity when compared to that estimated by the previous monitoring period, will warrant further investigation as to cause and so trigger a formal review of the Plan.

10.3 Reporting

(i) A report detailing the results of the field survey must be prepared by the person or organisation referred to above and forwarded to Council and the KMC within one month following completion of the field assessment.

(ii) Among other things, the report must include the following:

(a) a comparison of the extent of koala activity using baseline data from the initial monitoring event and that of any other surveys undertaken in accord with this Part, including consideration of the performance indicators

(b) a review of koala incidents obtained as a result of 10.1(v) above

(c) in relation to koalas and their habitat, a breakdown of the number and outcomes of development and/or rezoning applications that have been approved in accordance with Part 6 of the Plan

(d) the area of koala habitat rehabilitation achieved in areas identified for restoration according to the criteria outlined in Part 8

(e) any other observations and data of relevance to koala management

(f) recommendations for any amendment of the Plan by Council.

10.4 Review

(i) At every third reporting event, the KMC must undertake a major review of the Plan by considering the reports referred to in 10.3 above, along with any associated recommendations for amendment of the working provisions.

(ii) At every major review, the KMC will consider and evaluate the need to incorporate additional survey techniques such as use of specialised telephone applications, phone-in surveys and/or annual koala census days to augment the field survey component.

Frere's Crossing. Photo courtesy of Renee Winsor

Koala at Briar Road, Airds.
Photo courtesy of Richard Lonza

Sick koala in care. Photo courtesy of Richard Lonza

PART ELEVEN

KOALA WELFARE and ONGOING RESEARCH

Context: an important aspect of koala management within the Campbelltown LGA is the care and rehabilitation of koalas. This is undertaken in a voluntary capacity by organisations such as the Macarthur Veterinary Group, WIRES and Sydney Wildlife. There is a need for stronger ties and liaison with Council in the context of koala welfare and the management and rehabilitation of wild koalas. There is also a need to address the matter of the rescue, care and rehabilitation of the LGA's koalas.

Overall objective: identification of koala welfare and research needs intended to improve and inform long-term management of the Campbelltown koalas.

11.1 Koala care and welfare

(i) To assist with the rapid rescue of koalas in the Campbelltown LGA, a direct link to the emergency contact details of WIRES/ Sydney Wildlife/Macarthur Veterinary Group website will be provided through Council's website.

(ii) Within the first three months of the Plan, Council must seek a formal submission from WIRES/Sydney Wildlife/Macarthur Veterinary Group as to how Council may best materially assist with the rescue, care treatment and rehabilitation of koalas across the Campbelltown LGA.

(iii) Council will investigate the merit of designating public parks, reserves and recreational areas within areas of core koala habitat and SLAs as dog-free zones.

Core koala habitat at Smiths Creek Reserve, Ruse. Photo courtesy of Andy Attewell

11.2 Koala research

(i) Council will encourage further research, investigations and assessments into habitat use by the Campbelltown koalas, including further and ongoing refinement of the vegetation mapping layer which otherwise informs the Plan.

(ii) In collaboration with stakeholders, Council will encourage further and ongoing research into how best to reduce the potential for koala vehicle-strike and attacks on koalas by domestic dogs.

(iii) In collaboration with OEH, WSU and other stakeholders, Council will encourage further and ongoing research into various aspects of koala disease and the genetic composition of the Campbelltown koalas.

(v) Council will establish permanent vegetation growth and koala use monitoring plots within any area replanted and/or rehabilitated for the purposes of improving habitat connectivity within the lands to which the Plan applies.

(vi) Council will continue to work closely with RFS on issues associated with fire management specifically in and around areas of core koala habitat.

Did you know: The University of Sydney's Koala Health Hub at the Faculty of Veterinary Science in Camden provides diagnostic services for koalas, to wildlife rehabilitation groups - free of charge.

Koala at Winbourne Place, Airds. Photo courtesy of Andy Attawell

PART TWELVE

OTHER THREATS

Context: the most significant threats to long-term koala population viability in the Campbelltown LGA are wildfire, incidental mortalities due to vehicle-strike and domestic dog attack, and habitat loss. While management of fire is outside of the control of Council, it is hoped that through the workings of the Plan, Council will be able to influence the management of fire to reduce the potential for negative impact, and effectivey reduce habitat loss. The numbers of koalas being killed by vehicle-strike is also increasing commensurate with recovery of the Campbelltown koala population generally.

Overall objective: highlight the risks associated with fire and vehicle-strike through provisions intended to result in engagement with key agencies involved.

12.1 Fire management

(i) Council will encourage all relevant authorities and landowners to adopt a 'minimal use of fire' policy within areas of core koala habitat identified by the Plan by way of:

(a) undertaking bush fire hazard reduction using mechanical means

(b) extinguishing any bushfire at the first practical opportunity.

(ii) Council will ensure that maps indicating the location of core koala habitat areas within the Council LGA are made available to all RFS stations.

(iii) Council will instigate appropriate koala awareness training for RFS members, Council staff and others involved with the management of fire, assessment of DAs and provision of hazard reduction certificates.

(iv) Council will assist the RFS in conducting community education in respect to the management of bushfires and hazard reduction burns in areas of core koala habitat.

(v) Council will assist in the preparation of protocols for land management agencies and the RFS to cooperate with the local

Hazard reduction burn at Frere's Crossing, Kentlyn. Photo courtesy of Troy Lessels

Koala crossing warning sign at Junction Road, Ruse. Photo courtesy of Alexandra Cave

wildlife carer/rehabilitation groups and OEH concerning fauna welfare issues following bushfires.

12.2 Vehicle-strike

(i) Within the first six months of the Plan and in consultation with RMS, Council shall prepare a koala road-kill mitigation strategy for those roads within areas of core koala habitat and where koala road-kills are historically known to occur.

(ii) The strategy referred to in (i) above must identify best-practice solutions and prioritise a five year program of works intended to reduce the risk of koala road mortalities.

If you find an injured koala, call the WIRES koala hotline on 0466 318 688 or Sydney Wildlife on 02 9413 4300

References

Callaghan, J., Curran, T, Thompson, J. and Taylor, A. (2005) Campbelltown City Council Draft Comprehensive Koala Plan of Management. Australian Koala Foundation, Brisbane.

CLEP (2015) Campbelltown Local Environmental Plan. Campbelltown City Council. Accessible online - http://www.campbelltown.nsw.gov.au/RBD/BuildAndDevelop/PlanningPoliciesandControls/CampbelltownLocalEnvironmentalPlan2015CLEP2015

DECC (2008) Approved Recovery Plan for the Koala (Phascolarctos cinereus). NSW Department of Environment and Climate Change. Accessed online - http://www.environment.nsw.gov.au/threatenedspecies/RecoveryPlans.htm

DotE (2013) Matters of National Environmental Significance - Significant impact guidelines 1.1. Commonwealth Department of the Environment. Accessed online - http://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance

DotE (2014) EPBC Act Referral guidelines for the Vulnerable Koala (combined populations of Queensland, NSW and the ACT. Department of the Environment. Accessed online - http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala

DPE (2014) NSW population, household and dwelling projections: Projection Data by LGA. Department of Planning and Environment. Accessed online - http://www.planning.nsw.gov.au/en/Research-and-Demography/Demography/Population-Projections

Fowler, G (1993) Black August – Queensland's Open season on koalas in 1927. Unpub. B. A. (Hons) Thesis. Australian National University.

Phillips S and Callaghan J (2000) Tree species preferences of koalas (*Phascolarctos cinereus*) in the Campbelltown area south-west of Sydney, New South Wales. *Wildlife Research* 27:509-16

Phillips S (2017) South Campbelltown Koala Habitat Connectivity Study. Report to Campbelltown City Council (Ordinary Council Meeting 13 March 2018). Biolink Ecological Consultants, Uki

Phillips S (2018) Identifying Least-cost Dispersal Pathways for Koalas within the Campbelltown Council Local Government Area (LGA). Report to Campbelltown City Council. Biolink Ecological Consultants, Uki

Reed, P. C., Lunney, D., and Walker, P. (1990) A 1986-1987 survey of the Koala Phascolarctos cinereus (Goldfuss) in New South Wales and an ecological interpretation of its distribution. In: Biology of the Koala, (eds A. K. Lee, K. A. Handasyde and G. D. Sanson) pp 55-74. Surrey Beatty and Sons: Sydney.

Ward, S (2013) Campbelltown City Council Resource Document: Vegetation Analysis. Draft Campbelltown Comprehensive Koala Plan of Management. Prepared by EcoLogical Australia.

Appendices

Appendix A - **Schedule of management actions**

Appendix B - **Undertaking koala habitat assessments using Regularised Grid-based SAT (RG-bSAT) Sampling**

Appendix C - **Development Control Plan provisions**

Supporting Information

Appendix D - **Analysis of historical koala records in the Campbelltown LGA (Generational persistence modelling), 2016**

Appendix E(i) - **Preferred koala food tree identification and koala habitat classification for the Campbelltown LGA, 2016**

Appendix E(ii) - **Re-classification of potential koala habitat based on SEPP44 criteria, 2018**

Appendix F - **Review of koala generational persistence across the Campbelltown LGA, 2018**

Appendix G - **Identifying Least-cost Dispersal Pathways for Koalas within the Campbelltown LGA, 2018**

Appendix A: Schedule of management actions

Action ID	Description of Action	Priority	Target Start Date	Action Duration	Indicative Budget	Funding Source
Part Four: Roles and responsibilities						
1	Establishment of a KMC to assist the implementation of the Plan	H	< Six months	Quarterly	Internal	Council
2	Preparation of a koala habitat clause for inclusion in the CLEP, 2015 to activate planning provisions of the Plan	H	When plan adopted	3 months	Internal	Council
3	Council to update Section 149 Planning Certificates under the EP&A Act to include information on the presence of koala habitat	H	< Six months	6 months	Internal	Council
4	Council to amend the Tree Removal Application under Section 78A of the EP&A Act in regards to PKFTs and shelter trees that triggers the requirements of the Plan	H	< One month	3 months	Internal	Council
Part Five: Koala Management framework						
5	Creation of an interactive koala habitat planning layer to support the koala habitat provisions	H	< Two years	6 months	Internal	Council
Part Six: Development assessment and control						
6	Development of an interactive DA register to enable access and review of past conditions of consent in areas of core koala habitat	M	< Two years	6 months	Internal	Council
7	Development of a monitoring program to randomly audit the compliance of conditions of consent for DA's subject to this plan (and under approved IKPoMs)	H	< Six months	Ongoing	Internal	Council
Part Seven: Compensation for loss of koala habitat						
8	Preparation of compensatory provisions for inclusion in the DCP for offsetting the loss of PKFTs and shelter trees	H	When plan adopted	3 months	Internal	Council
Part Eight: Habitat rehabilitation and restoration						
9	Develop a Council-owned land register listing properties suitable for offsetting and compensatory PKFT plantings	M	< Six months	6 months	Internal	Council
10	Maintain a register of landholders who are interested in rehabilitating koala habitat and developing the conservation value of their property	L	< Two years	Ongoing	$10,000	External grants
11	Identify priority restoration sites for core koala habitat in order to target revegetation of strategic koala habitat corridor linkages	M	< One year	6 months	$40,000	External grants
12	Letterbox drop property owners providing information on koala conservation agreements, targeting landowners in key koala HLAs as shown in Figure 5.3	L	< Two years	Ongoing	$5,000	External grants
13	Provide and support habitat restoration measures within koala habitat, through direct delivery and conservation partnerships	M	< One year	Annually	$15,000	External grants
14	Investigate opportunities for the rezoning of core koala habitat on Council owned lands for environmental protection purposes	L	< Two years	3 months	Internal	Council

15	Undertake koala community planting projects to develop environmental stewardship in urban parks and local reserves	M	< One year	Annually	$10,000	Council
Part Nine: Community education						
16	Develop a koala-specific webpage on the Council website providing information on koalas relevant to the LGA	H	< One month	Ongoing updates	Internal	Council
17	Provision of effective mechanisms for community reporting of koala sightings (including telephone, email and website)	H	< One month	Ongoing	Internal	Council
18	Development of a 'Koala education & awareness strategy' to raise awareness and facilitate increased community involvement	M	< Six months	3 months	Internal	Council
19	Develop a koala field ID guide/ booklet for the community to encourage education and promote koala conservation	L	< Two years	Annually	$5,000	External grants
20	Provide community seminars and workshops to actively engage residents and stakeholder groups on koala related issues	M	< One year	Annually	Internal	Council
21	Develop koala education programs for primary schools, particularly for those areas in close proximity to core koala habitat	L	< Two years	Annually	Internal	Council
22	Install educational koala signage and plaques in local schools to encourage younger generations to actively engage on koala related issues	L	< Two years	Ongoing	$5,000	External grants
Part Ten: Monitoring, reporting and review						
23	Develop a koala population monitoring program involving the establishment of a series of monitoring sites within the LGA	H	< One year	Triennial	$35,000	External grants
24	Coordinate annual community citizen science transect-based koala searches of designated monitoring sites[1]	H	< One year	Annual	$15,000	External grants
25	Annual report to Council on the implementation of management actions and performance indicators identified in the Plan	H	< One year	Annually	Internal	Council
26	Explore funding opportunities through various external grant programs for the implementation of management actions identified in this plan	H	When plan adopted	Ongoing	Internal	Council
Part Eleven: Koala welfare and research						
27	Keep informed of recent developments and news regarding koala health through regular liason with key research stakeholders	L	< Six months	Ongoing	Internal	Council
28	Explore opportunities with local utility contractors to provide cut PKFT branches to the Koala Health Hub at the University of Sydney's Faculty of Veterinary Science	M	< One year	Ongoing	Internal	Council
Part Twelve: Other threats						
29	Identify koala threat mortality hot spots through an up to date sightings, injury and fatality recording framework	M	< One year	6 months	Internal	Council

[1] (based on the scientifically rigorous methodology as per NPWS Community Koala Surveys Bongil Bongil National Park program)

30	Install koala crossing warning road signage to improve road safety in key areas subject to high koala mortality	H	When plan adopted	3 months	Internal	Council
31	Contact NSW RMS to upgrade road signage to reflect reduced speeds (60km/ hour), and enforce speed limits on state roads in koala habitat	L	< Two years	1 month	Internal	Council
32	Lobby NSW RMS to incorporate koala-friendly crossings (such as fauna overpasses and culverts) into state road designs in koala habitat (ie Appin Road upgrade)	H	< Six months	3 months	Internal	Council
33	Install signage in high-risk dog attack areas in koala habitat outlining leashed area restrictions to notify and educate dog owners	M	< Two years	3 months	Internal	Council
34	Letterbox drop property owners in high-risk dog attack areas to educate residents and promote responsible dog ownership	M	< Six months	3 months	$5,000	External grants
35	Implement appropriate regulatory tools and compliance measures in Council Reserves subject to leashed area restrictions	L	< Two years	Ongoing	Internal	Council
36	Develop an interactive internal mapping system to query history and extent of hazard reduction burns across the LGA to inform future burns in koala habitat	M	< One year	Ongoing	Internal	Council
37	Provide RFS with core koala habitat planning mapping the subject of this Plan, to ensure exclusion from the operation of the 10/50 scheme	H	< Three months	3 months	Internal	Council

Appendix B

Undertaking koala habitat assessments using Regularised Grid-based SAT (RG-bSAT) Sampling

PREAMBLE

The ecology of koalas in the Campbelltown LGA is, among other things, influenced by the availability of, and access to preferentially utilised food tree species. The purpose of this appendix is to assist landholders and proponents of development to identify important habitat areas that are currently being utilised as part of normal koala ranging, socialising and feeding patterns. The overall approach is as follows:

STEP 1

Determine appropriate sampling intensities for the site to be assessed using the following table:

Table C.1 Sampling Intensity per Unit Area

Area of land being subject of DA or rezoning application	Initial SAT sampling intensity	High SAT sampling intensity
< 15ha	250m intervals	125m intervals
15 - 50ha	500m intervals	250m intervals
> 50ha	700m intervals	350m intervals

STEP 2

Overlay the proposed development site with a square grid the dimensions of which correspond to the "high SAT sampling intensity" specifications in the table above, then use the resulting grid-cell intersections to identify those points that fall on areas of land where 30 trees of any species that have a DBH ≥ 100mm could theoretically be sampled within a radius approximately equal to that of 50% of the sampling intensity being utilised (eg 150m = 75m radius, 250m = 125m etc). Note that this approach requires areas of cleared land with scattered trees to be included for assessment purposes.

When overlaying the grid, ensure that adjoining areas of land are included to the extent that an overlap consistent with the relevant "initial SAT sampling intensity" interval has been achieved (ie provision is made to sample adjoining areas of habitat and so place the site into a broader koala management context).

STEP 3

a) Preliminary sampling of the site should be undertaken at intervals commensurate with the "initial SAT sampling intensity" specified in Step 1.

b) Sampling is to be undertaken at each sampling point using the Spot Assessment Technique (SAT) of Phillips and Callaghan (2011).

c) In the event that koala activity is recorded at any of the initial sampling sites, then the surrounding "high SAT sampling intensity" sites within the boundary of the land under assessment (or immediately adjoining areas) must also to be sampled where there is an activity level transition from high or medium use to that of low use.

STEP 4

In the absence of a suitable spatial modelling technique such as splining, all SAT sites where significant koala activity has been recorded must become the central point of a grid cell, the size of which must be commensurate with sampling intensity as follows.

- For 125m sampling intersections, the grid cell size will be 125m x 125m (1.56 ha)
- For 250m sampling intersections, the grid cell size will be 250m x 250m (6.25 ha)
- For 350m sampling intersections, the grid cell size will be 350m x 350m (12.25ha)

All areas within a grid cell identified in Step 4 and that have an activity level of 10% or greater must be regarded as supporting a resident koala population for the purposes of this plan.

The overall process is illustrated in Figures 1 – 3, below.

Figure 1: Nominal study area – in this example, 300ha - comprising some cleared areas and a heterogeneous mix of vegetation communities.

Figure 2: Study area overlain with a point-based, regularized grid at 350m intervals for sampling purposes, each grid cell intersection point that falls within an area of forest subsequently sampled for koala activity using the Spot Assessment Technique of Phillips and Callaghan (2011).

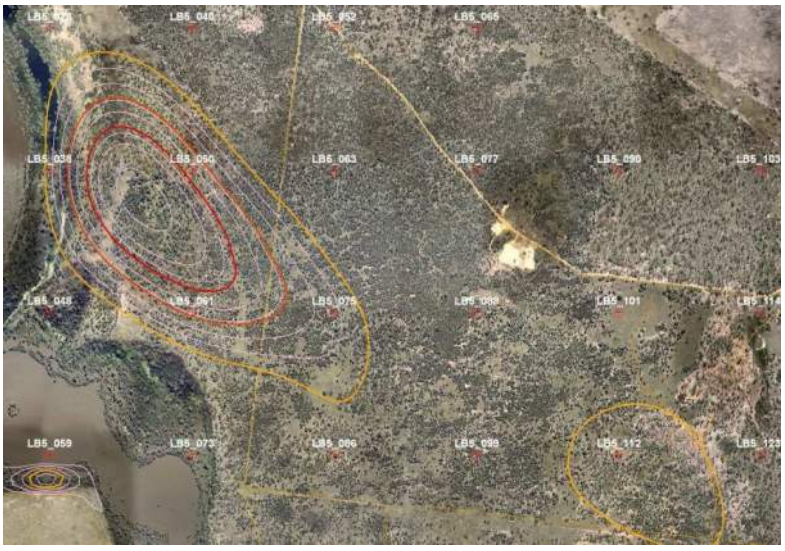


Figure 3: Once field survey has been completed, areas supporting significant koala activity (ie in this example, habitat areas surrounding LB5_038, 050,061,075 and 112) can be interpolated using thin-plate splining techniques and associated contouring to provide a more refined outcome. A coarser outcome producing the same result would be to make each of the aforementioned sites the centre of 12.25ha grid cells. In this image, the extent of significant koala activity is indicated by the outer orange line.

11.4 Design requirements for developments in core koala habitat

11.4 Design requirements for developments in core koala habitat

Objectives:

- To assist in the effective implementation of the Campbelltown Comprehensive Koala Plan of Management (CKPoM) for development within core koala habitat
- To facilitate development sympathetic to the local koala population, in order to minimize the impacts of development on koala habitat.

11.4.1 Management of core koala habitat

a) Development applications for properties located in core koala habitat, and relating to a boundary adjustment, alterations, or additions to a lawfully erected building; and where no removal of native vegetation is proposed, are required to:

i) be designed and located in such a way as to avoid any adverse indirect impacts to preferred koala food trees (PKFTs).

ii) incorporate fences in a way that allows for the movement of koalas through the property, either through:

- the installation of koala-friendly fencing (that allows the movement of koalas)
- incorporating structures that enables koalas to climb over fencing
- retaining mature vegetation on either side of fences.

iii) confine domestic dogs to a dog run, or koala-proof fenced enclosure during peak koala activity levels, being between 6pm and 6am.

iv) design swimming pools with a graduated shallow edge, or fitted with a permanent flotation device to prevent koalas drowning.

Plate 11.4.1 - The protection of koala habitat is essential to provide for the long-term maintenance of a viable, free-ranging koala population in the Campbelltown LGA (Koala "Mr Nymboida" in Ruse. Photo courtesy of Carla-Maree Simmons).

Note:

Many koala populations in NSW now survive in fragmented and isolated habitat, while some areas in which koalas remain more common are increasingly subject to ongoing pressures, in particular clearing for agriculture, logging and urban expansion.

Campbelltown has one of the last, disease-free koala populations in the Sydney region. Therefore it is essential to put in place design measures that support the harmonious co-existence of the community with koalas.

Appendix D

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

March 2016

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

Background

Analysis of historical fauna records can inform management and conservation decisions. The koala is an iconic Australian mammal and has been the focus of one national survey (Phillips 1990). While in NSW, at least three statewide surveys have also occurred (Gall 1978; Reed and Lunney 1990; Lunney *et al.* 2009). Analyses of historical koala records are increasingly being used to inform planning outcomes at the Local Government Area (LGA) level (Lunney *et al*. 1998; Phillips *et al*. 2007; Phillips and Hopkins 2010). The range parameters Extent of Occurrence (EoO) and Area of Occupancy (AoO) are two key measures pertaining to the spatial distribution of a species, the EoO being that area encapsulating the outermost limits of the area in which the species can be found, while the AoO is that area within the EoO in which the species actually occurs (Gaston 1997). The AoO is typically estimated by enumerating the number of occupied grid cells and is thus sensitive to sampling parameters such as study area and grid cell size.

As a consequence of databases in the public domain which invite contribution, coupled with a mandatory requirement in some instances to report species records, relatively large data sets are now available for use. However, the adhoc nature of data collection and associated reporting indirectly results in a suite of statistical issues which can make objective interpretation of such data problematical.

The boundaries of the Campbelltown LGA encompass an area of approximately 31, 200ha. This report is part of a process initiated by Campbelltown City Council to progress towards the adoption of a Comprehensive Koala Plan of Management (CKPoM) for the LGA. Herein an analysis of historical koala records for the LGA is undertaken, with a view to examining the following issues:

(i) identifying any changes/trends in the geographic distribution of koalas within the Campbelltown LGA over time

(ii) determining the extent to which the historical records may be capable of assisting/informing decisions relating to koala conservation by way of identifying important historical and contemporaneous source populations, the latter additionally qualifying as core koala habitat for the purposes of SEPP 44.

Knowledge gained from the preceding process in conjunction with data derived from habitat mapping and radio-tracking studies, has also been used to derive an indicative koala population estimate for the entire LGA.

Methods

An inherent problem associated with survey data such as historical koala records, is that they are typically observer-biased and do not reflect the results of a systematic survey effort. Hence, quantitative range parameters such as the Area of Occupancy (AoO) and concepts such as generational persistence could potentially miscalculate the full extent of any indicative change (positive or negative) and/or the locations of such things as source populations respectively, if existing bias cannot be accommodated; it is with such considerations and limitations in mind that the following methodological approach was developed.

Historical koala records were provided by Council, these being those previously collated by Ward *et al*. (2013) from Western Sydney University (WSU), and the NSW Office of Environment and Heritage (OEH) Wildlife Atlas databases for the time period 1900 - 2012. Once collated, records were sorted chronologically by koala generation (determined to approximate six years (Phillips 2000)) dating backwards from 2012. The resulting data set was then further partitioned in order to enable comparisons pre 1995 and post 1994 (the timeframes 1995 - 2000, 2001 - 2006 and 2007- 2012 approximating the time intervals for the three most recent koala generations respectively). This approach enables results to be considered in the context of International Union for Conservation of Nature (IUCN), Commonwealth and State-based conservation criteria which place weight on the concept of population change over a time period of three consecutive (taxon- specific) generations (WCUSSC 1994).

Extent of occurrence

The *EoO* was determined as the total area enclosed by a Minimum Convex Polygon (MCP) derived by connecting the outer-most koala records over time for each koala generation for which sufficient data was available. Three *EoO*s for the Campbelltown LGA were determined as follows:

a) that encapsulating all known koala records over time (the historical EoO)
b) that for the time period 1900 – 1994
c) that for the three most recent koala generations 1995 - 2012.

Area of occupancy

Although the more useful of the two range parameters, changes in the *AoO* over time are harder to quantify because there is an increase in available records over the last

two decades. The following procedures were applied in order to minimise the influence of chronological bias.

A 2km x 2km (400ha) fixed-grid overlay constrained by the boundaries of the historical EoO was used to create a series of cells for sampling purposes. The 400ha grid cell size was considered the minimum necessary to accommodate spatial uncertainty in the data (use of different mapping datums, observer error, etc), while the actual number of records themselves became academic, the primary scoring mechanism being whether a koala record was either present or absent. Fifty percent of the grid cells were then randomly selected through each of 10 iterations for each time period examined, the number of cells within which koala records were present enumerated and converted to a proportion of the total area occupied. Differences between time periods were analysed using two sample *t*-tests. In order to deal with the disproportionately greater number of koala records in recent years, sampling iterations for the three most recent koala generations was based on a single suite of randomly selected records, the number being equal to that for all preceding generations.

Generational persistence

The records were also examined for re-occurrence over timeframes that were beyond the life spans of individual koalas. The term Generational Persistence Assessment (GPA) is used to describe this process; examining the data for repeated records of koalas within a localised area over overlapping generational time spans, and so identifying the presence of long-standing (20 years+) historical resident and/or source populations (ie core koala habitat as defined by SEPP 44). For the purpose of this report, “localised” was considered to include that area defined by the 2km grid cell around each koala record, with generational persistence inferred by the presence of records for each of the three most recent koala generations.

The proximity of some records to grid cell edges invariably warrants the need to include an appropriate buffer to areas of generational persistence, the size of which necessitates considerations of the koala home range size as follows:

- Buffer width (m) = square root of average adult female home range size (m^2), modified to accommodate spatial overlap.

Estimating population size

Population size was estimated by intersecting the 1995 – 2012 EoO with underlying vegetation mapping in order to estimate the amount of preferred koala habitat. This result was then modified by the AoO (including bounds) to indicate the likely number of hectares currently occupied by resident koala populations. This value was then divided by a koala density estimate determined by reducing the average home size of an adult female koala by 50% to accommodate some spatial overlap (35%) with other females and breeding males (15%) respectively. An indicative population estimate can then be derived as follows:

N = [PKH x *AoO* (± 95% CL)] x *D/2*

where:

N = population estimate

PKH = amount of available habitat (in ha) contained within the 1995 – 2012 EoO

AoO = record-derived occupancy estimate expressed as a proportion

D = mid-point of range of female koala home range size determined by Ward (2002).

Results

Koala records

A total of 1,600 koala records were contained in the dataset of Ward *et al.* (2014), of which 1,588 had a date reliably attributed to them; hereafter the results of analyses utilising only dated records are presented. The chronological distribution of these koala records is presented in **Figure 1**.

The earliest records of koalas in the Campbelltown LGA (*ca* 1900) occur at Campbelltown and in the area now known as Minto Heights. Through the 1960s to the 1980s, sporadic records appear in the Wedderburn area, Minto Heights – Kentlyn and between St Andrews and Ingleburn. The frequency of reporting of koala records gathers momentum from the late 1980s through to 2006, this time period coinciding with the first statewide survey (Gall 1978), thereafter the National Koala Survey (Phillips 1990; Reed and Lunney 1990) and most recently Dan Lunney's 2006 community-based koala survey for NSW (Lunney *et al*. 2009).

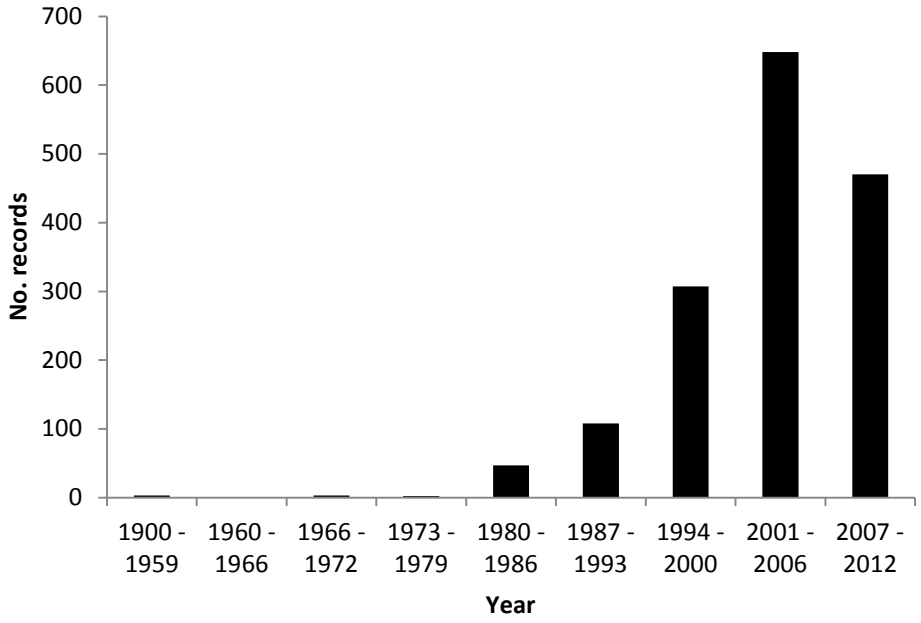


Figure 1: Chronological distribution of 1,588 koala records for the Campbelltown LGA over the period 1900 - 2012.

Extent of Occurrence

Available koala records reveal an historical *EoO* of approximately 15,225ha, this being the area captured by a MCP with vertices that intersect the outer-most koala records in the dataset for the time period 1900 - 2012 (Figure 2).

The records further imply that an *EoO* of this size has not always been the case, the time period 1900 -1994 being substantively smaller at approximately 63% (9,509ha) of this area (**Figure 3**). As might be deduced from this difference, the trend over the last three consecutive koala generations (1995 - 2012) appears to have been one of overall range expansion / recovery, the associated EoO estimated at 14,863ha (**Figure 4**).

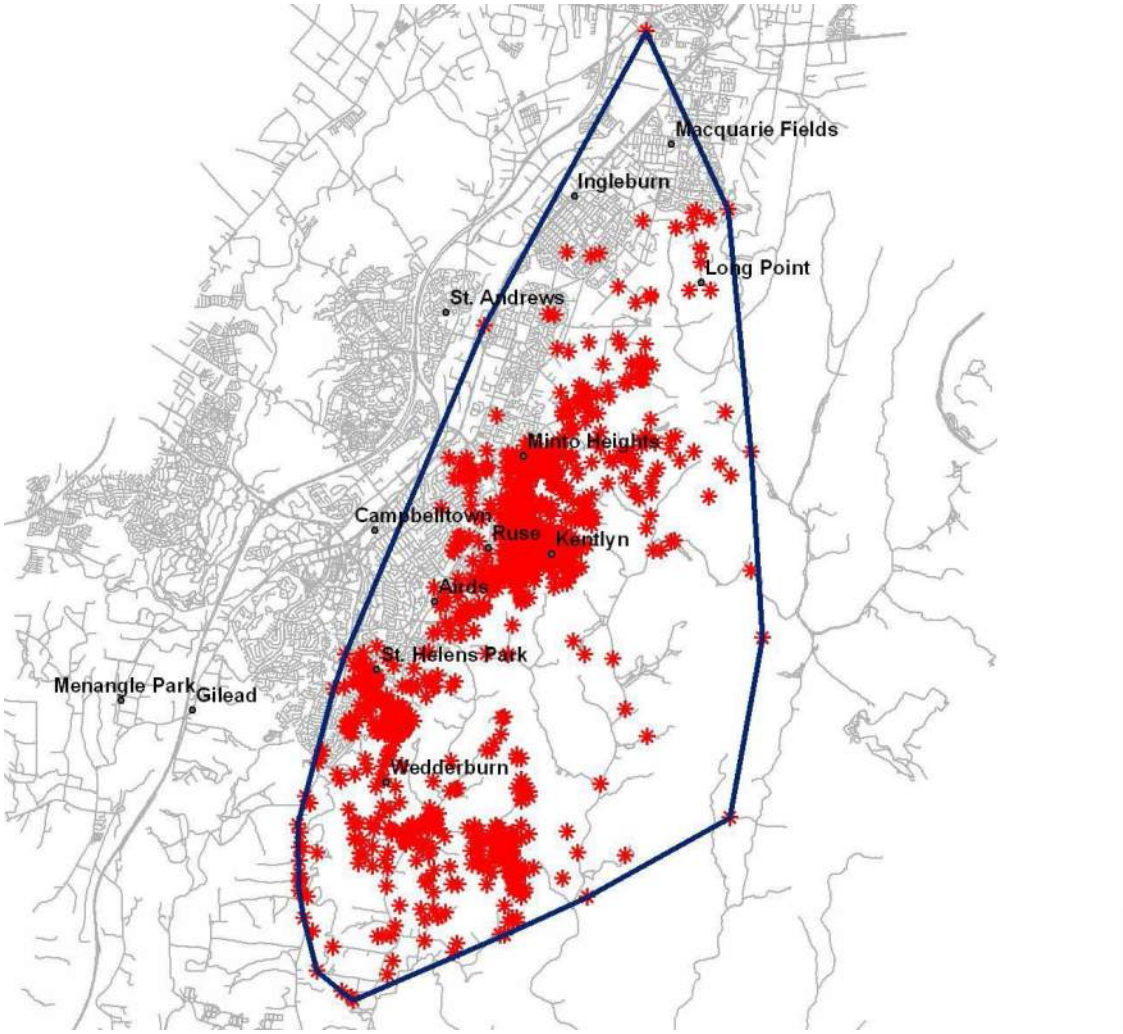


Figure 2: Historical EoO of koalas (red asterisks) in the Campbelltown LGA over the period 1900 - 2012.

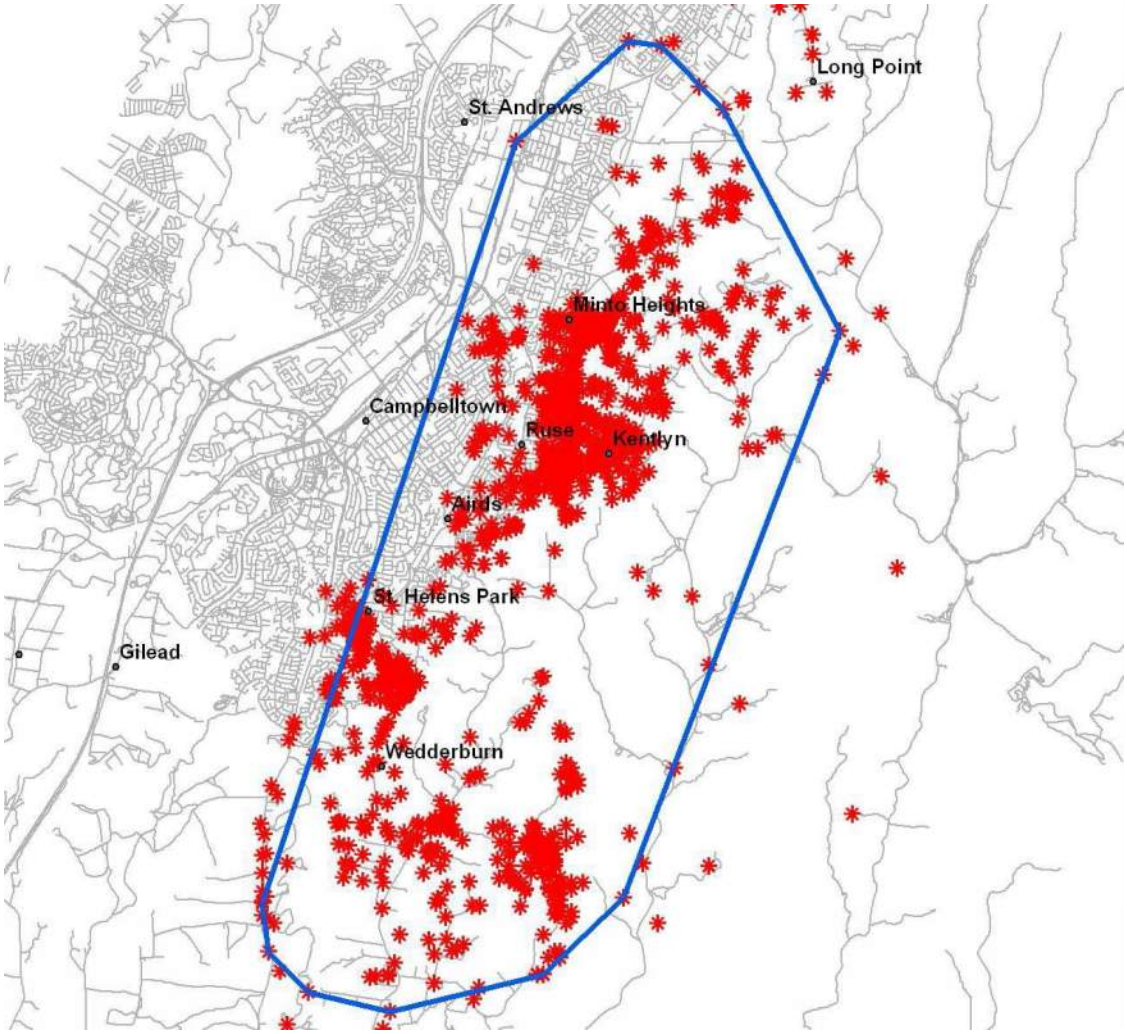


Figure 3: Historical EoO of koalas (red asterisks) in the Campbelltown LGA over the period 1900 - 1994 (Note: red asterisks outside of blue MCP indicate post 1994 records).

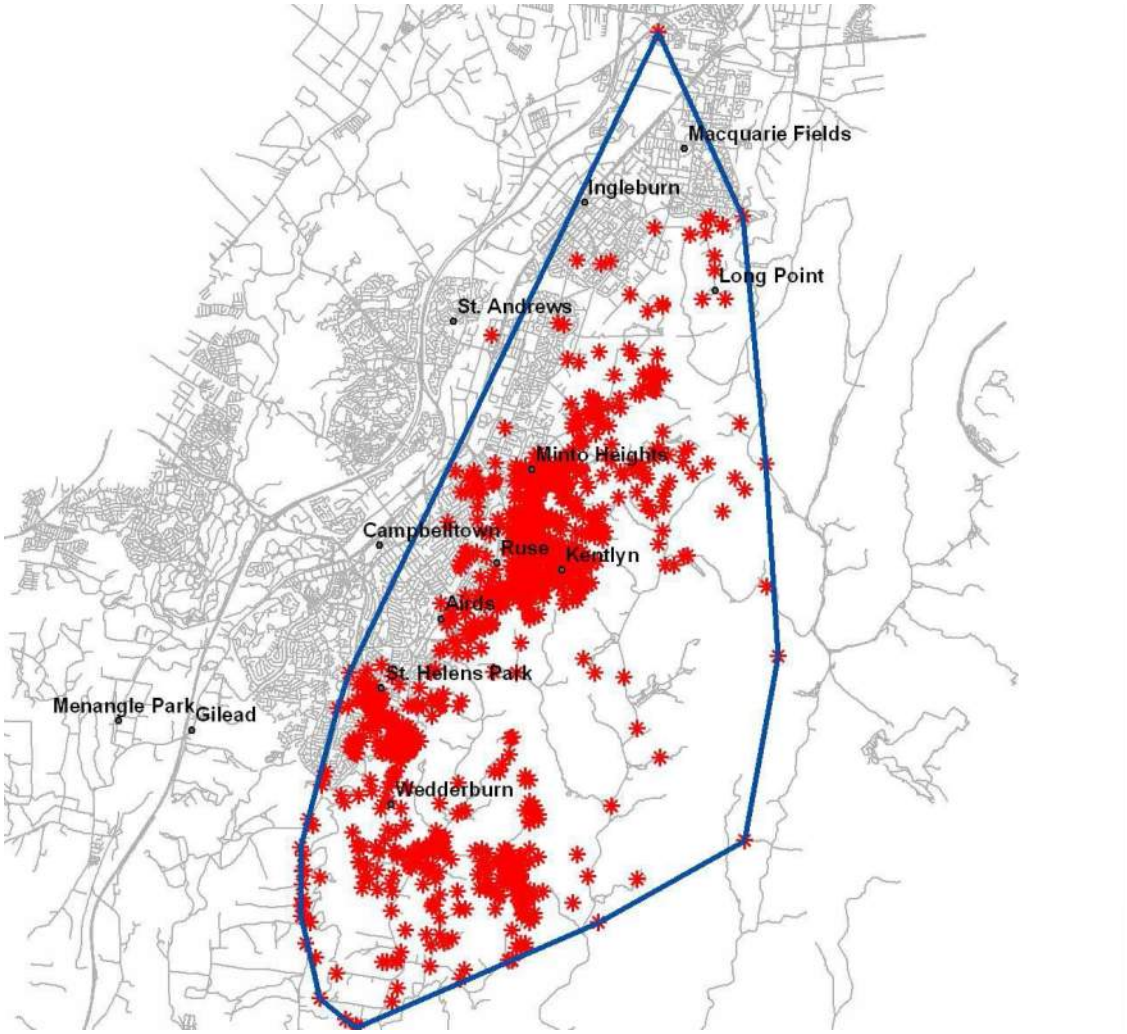


Figure 4: Historical EoO of koalas (red asterisks) in the Campbelltown LGA over the period 1995 – 2012 (Note single pre 1995 record in St Andrews).

Area of Occupancy

The occupancy rate estimated from the 163 records that comprise the entire subset of data for the time period 1900 - 1994 was compared to that of a single suite of 163 randomly selected records for the time period 1995 - 2012. Randomly sampling 50% of the grid cells within the historical EoO over 10 iterations returned the following results:

1900 – 1994

Mean AoO estimated at 41.23 ± 7.39% (SD) of available habitat.

1995 – 2012

Mean AoO estimated at 46.42 ± 5.58% (SD) of available habitat.

Analysis of the data associated with these two outcomes confirms that there has been a statistically significant increase in the extent of the study area being occupied by koalas over the last three koala generations [1900 - 1994 *vs* 1995 - 2012: t = -2.16984, 28_{df}, $P < 0.05$ (two-tailed test)].

Generational persistence

During the three koala generations from 1977 to 1994, the records indicate two areas of generational persistence, coinciding with the Wedderburn Plateau and Kentlyn – Minto Heights localities. This result (**Figure 5**) implies the presence of small and localised population cells over that time period.

The subsequent three generation subset (years 1995 - 2012) indicates a substantive increase in the area of generational persistence, with records from the aforementioned locations persisting through to 2012 (**Figure 6**). The most evident change when contrasted to that in Figure 6 is the increased number of grid cells along the interface of the Campbelltown urban environment where it abuts adjoining bushland areas.

Ward (2002) determined the size of female koala home range areas to vary between 11 – 61ha. Making allowance for estimated home range overlap of 50%, the midpoint of these estimates is 0.5 x 36ha or 180,000m^2, the square root of which is 424m.

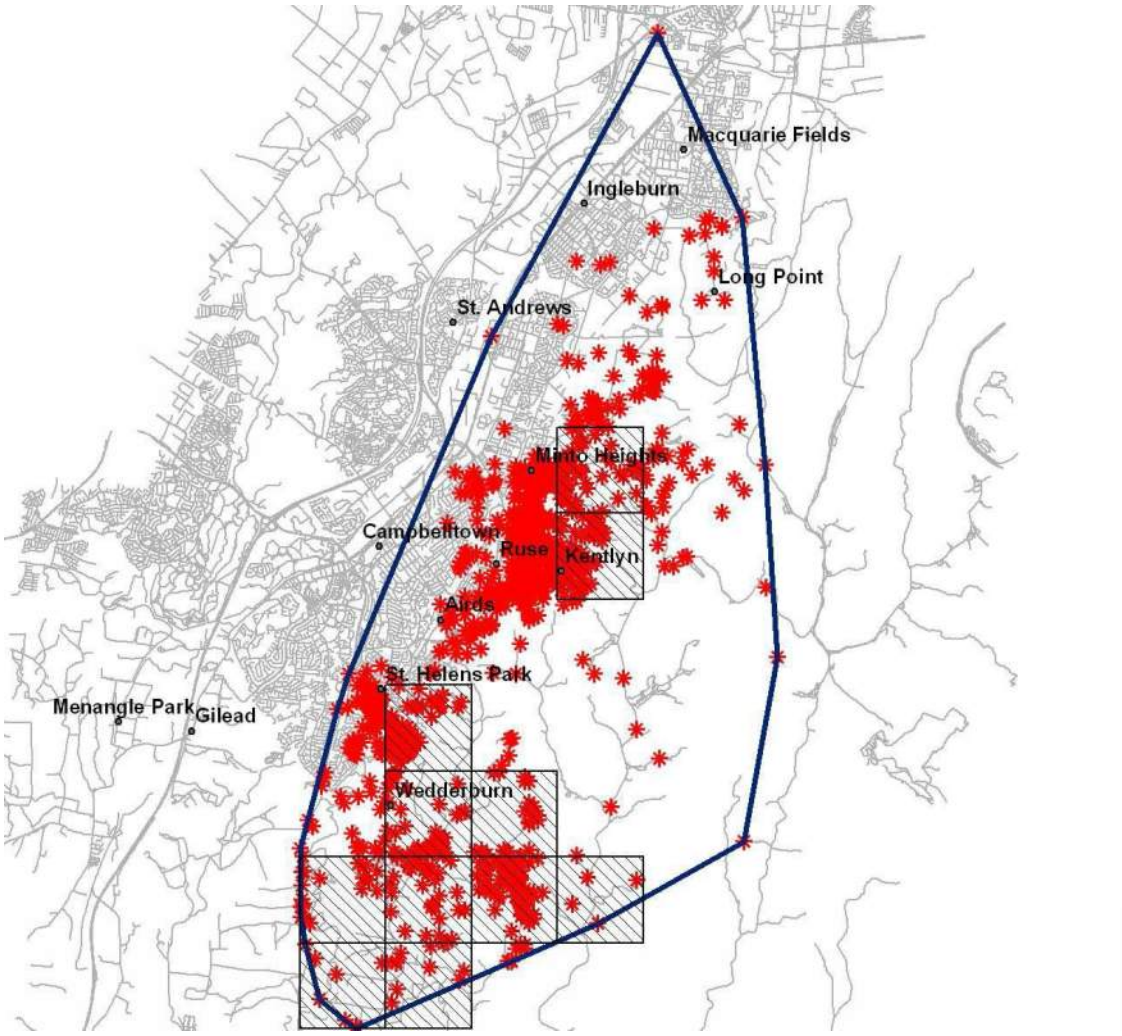


Figure 5: Areas of generational persistence (diagonally crossed grid cells): 1977 – 1994.

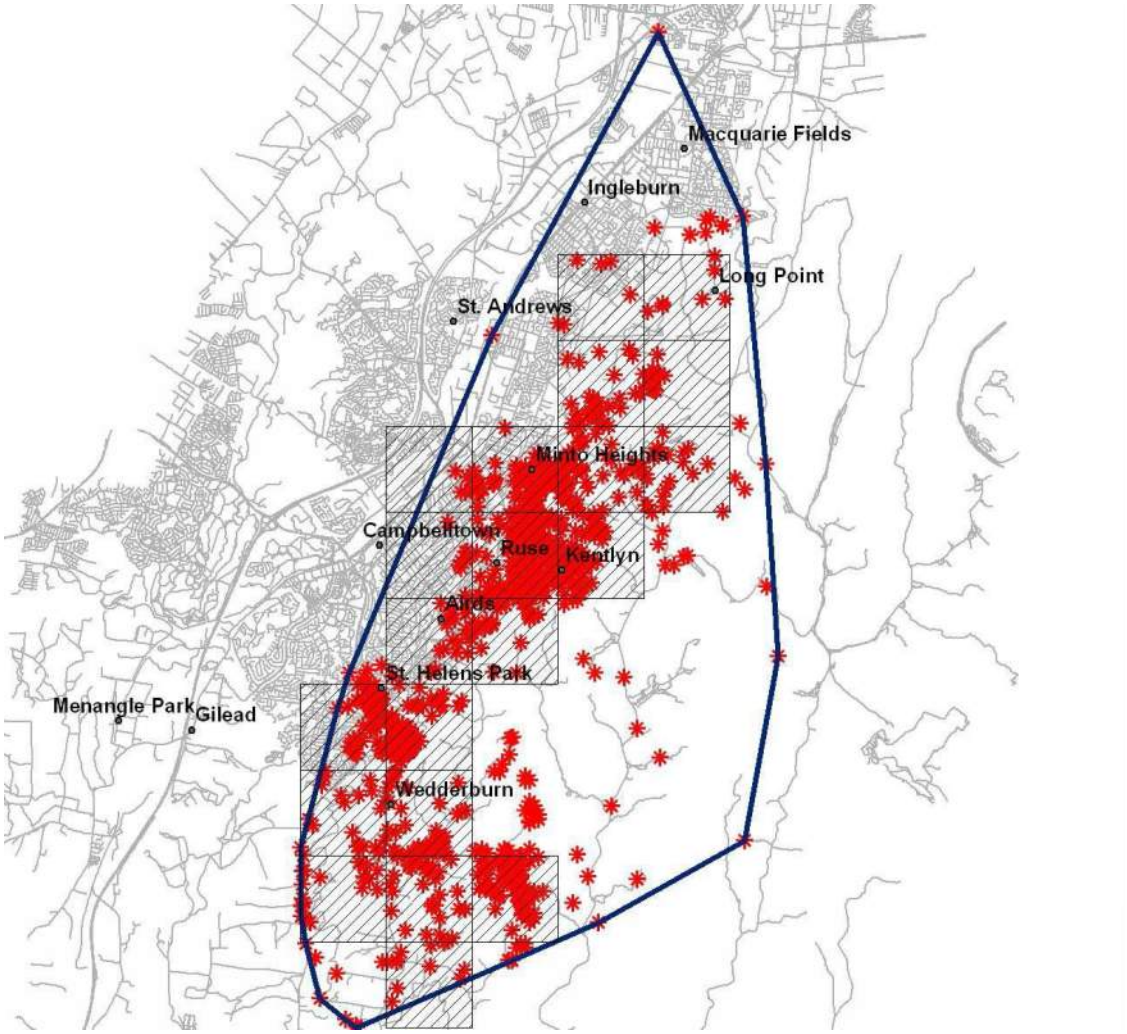


Figure 6: Areas of generational persistence (diagonally crossed grid cells): 1995 – 2012.

Estimating population size

The 1995 – 2012 EoO contains approximately 6,857ha of preferred koala habitat, 46.42% ± 3.09% (95% CI) of which has been estimated as currently occupied by koalas. Using the modified home range size of 18ha, allows a population estimate for the Campbelltown LGA of 177 ± 12 (95% CI) koalas to be derived.

Key Outcomes

- The historical records indicate that koalas have a long history of occupation in the Campbelltown LGA. The population appears to have been on a recovery trajectory over at least the last three koala generations.

- The recovery trend is well supported by analysis of changes in the key range parameters EoO and AoO. There have been progressive increases in the EoO leading up to the mid 1990s, with that for the, three last koala generations exceeding that of all generations before it. The current EoO for koalas in the Campbelltown LGA approximates an area of 14,000ha.

- Commensurate with the increase in the *EoO*, there has also been a statistically significant increase in the *AoO*. Optimal occupancy rates for free ranging koala populations are estimated to be approximately 50% of available habitat, a measure which already appears be the case within the Campbelltown LGA.

- GPA implies the presence of two source populations in the Wedderburn and Minto Heights – Kentlyn areas up until the mid 1990s. Thereafter, the 1995 - 2012 GPA data alludes to both an expansion of these areas into adjoining bushland areas abutting localities of St Helens Park, Airds, Ruse and Long Point.

- A minimum buffer width of 425m is deemed necessary to effectively accommodate likely koala ranging patterns on peripheral GPA cells.

- Recovery and range expansion described herein accommodates neither complacency nor apathy in its outcomes. The estimated numbers of koalas comprising the Campbelltown koala population remain low such that a recovery, long-term sustainable management-themed CKPoM will be necessary.

References

Gall, B. 1978. Koala Distribution in New South Wales. p115 in Bergin, T. (Ed.) *The Koala – Proceedings of the Taronga Symposium*. Zoological Parks Board of New South Wales, Sydney.

Gaston, K. J. 1997. *The biology of rarity: causes and consequences for rare-common differences*. Chapman and Hall, London.

Lunney, D., Phillips, S., Callaghan, J., and Coburn, D. 1998. A new approach to determining the distribution of koalas and conserving their habitat: a case study from Port Stephens Shire on the central coast of New South Wales. *Pacific Conservation Biology* **4**:186-196.

Lunney, D., Crowther, M. S., Shannon, I., and Bryant, J. V. 2009. Combining a map-based public survey with an estimation of site occupancy to determine the recent and changing distribution of the koala in New South Wales. *Wildlife Research* **36**: 262 – 273.

Phillips, B. 1990. *Koalas, the Little Australians We'd All Hate to Lose*. Australian Government Publishing Service, Canberra.

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

Phillips, S. and Hopkins, M. 2010. *Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA.* Prepared for Kempsey Shire Council. Biolink Ecological Consultants

Phillips, S., Hopkins, M. and Callaghan, J. 2007. *Koala habitat and population assessment for Gold Coast City LGA*. Report to Gold Coast City Council. Biolink Ecological Consultants.

Reed, P. and Lunney, D. 1990. Habitat loss: the key problem for the long-term survival of koalas in New South Wales. pp9-31in Lunney, D., Urquhart, C. A. and Reed, P. (Eds). *Koala Summit – Managing koalas in New South Wales*. NSW National Parks & Wildlife Service, Hurstville NSW.

Ward, S. J. 2002. *Koalas and the Community: A Study of Low Density Populations in Southern Sydney. Ph.D. Thesis.* University of Western Sydney.

Ward, S., Failes, B., and Woodgate, S. 2013. *Draft Campbelltown Comprehensive Koala Plan of Management.* Prepared for Campbelltown City Council by Eco logical Australia.

World Conservation Union Species Survival Commission. 1994. *IUCN red list categories*. Gland, Switzerland.

Appendix E(i)

Preferred food tree species in the CCC LGA and the koala habitat classification process

Preferred Koala Food Tree Species (PKFTs)

A CKPoM is not necessarily bound by either the 15% rule or Schedule 2 of SEPP 44 in terms of how it deals with the issue of PKFTs and the identification of koala habitat. To this end knowledge from resource documents, published studies and other documents enables a list of PKFTs for the CCC LGA to be identified; these are listed below in terms of categories consistent with that used by the approved Koala Recovery Plan (DECC 2008).

Species Name	Common Name
Primary food tree species	
Eucalyptus tereticornis	Forest red gum
Eucalyptus viminalis	Ribbon gum
Secondary food tree species	
Eucalyptus longifolia	Woollybutt
Eucalyptus moluccana	Grey box
Eucalyptus punctata	Grey Gum
Stringybark/supplementary food tree species	
Eucalyptus agglomerata	Blue-leaved stringybark
Eucalyptus consideniana	Yertchuk
Eucalyptus globoidea	White stringybark

Koala Habitat Classification

Floristic information relating to the tallest-stratum of vegetation communities known to occur across the CCC LGA were reviewed in terms of the presence/absence and abundance of PKFTS so as to enable the following habitat classifications:

- Primary Koala Habitat: forest and/or woodland communities, groups or types occurring on soils of medium to high nutrient value whereupon primary[1] koala food tree species are dominant or co-dominant components of the tallest stratum species.

- Secondary (Class A or 2A) Koala Habitat: forest and/or woodland communities, groups or types occurring on soils of medium to high nutrient value whereupon primary food tree species are sub-dominant components of the tallest stratum species.

[1] A preferentially utilized tree species expressing levels of utilization by koalas that are independent of density and/or size class.

- Secondary (Class B or 2B) Koala Habitat – forest and/or woodland communities, groups or types occurring on soils of low to medium nutrient value whereupon primary food tree species are absent, the tallest stratum instead dominated or co-dominated by secondary[2] food tree species only.

- Secondary (Class C or 2C) Koala Habitat – forest and/or woodland communities, groups or types occurring on soils of low to medium nutrient value whereupon primary food tree species are absent and secondary food tree species are sub-dominant or only occasional components of the tallest stratum species.

Each of the preceding classifications reflects 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 Koala Habitat can only sustain low density populations (i.e. < 0.1 koalas ha^{-1}). Collectively, these four major habitat classifications function to identify areas of *Preferred Koala Habitat* for CKPoM purposes. The application of this classification process to mapped vegetation communities of the CCC LGA results in the following classification outcomes for CKPoM purposes:

Vegetation	**Koala Habitat Classification**
Dry Rainforest	2A
Eastern Gully Forest on Hawkesbury Sandstone	2C
Western Gully Forest on Hawkesbury Sandstone	2C
Woodland on Hawkesbury Sandstone	2C
Woodland on river flats	2A
Woodland on Wianamatta Shale (slopes and plateau)	2B
Ironstone Heath	2C
Mallee Heath	Other
Sedgeland on Hawkesbury Sandstone	Other
Woodland on smaller creeks	2A
Predominately cleared	Other/2A-C

[2] A preferentially utilised tree species expressing levels of utilisation by koalas that are density and/or size-class dependent.

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

Appendix E(ii)

The General Manager
Attn: Alexandra Cave
Senior Environmental Officer
Campbelltown City Council

e-mail: Alexandra.Cave@campbelltown.nsw.gov.au

10th February 2018

Dear Alex,

This letter highlights the differences in the koala habitat classification process in Campbelltown as required by the strict application of Schedule 2 of SEPP 44, in comparison to that typically employed by our organisation. Using *The Native Vegetation of the Sydney Metropolitan Area Volume 2: Vegetation Community Profiles version 2.0*'s PCT Codes, SEPP 44 identifies 11,435 hectares of *Potential Koala Habitat* and 7,176 hectares of '*Other*' Habitat. Using Biolink's koala habitat classification process (BKHCP) there are 343 hectares of 'Primary' Koala Habitat, 10,317 hectares of 'Secondary (Class 2B)' habitat and 7,950 hectares of 'Other' habitat.

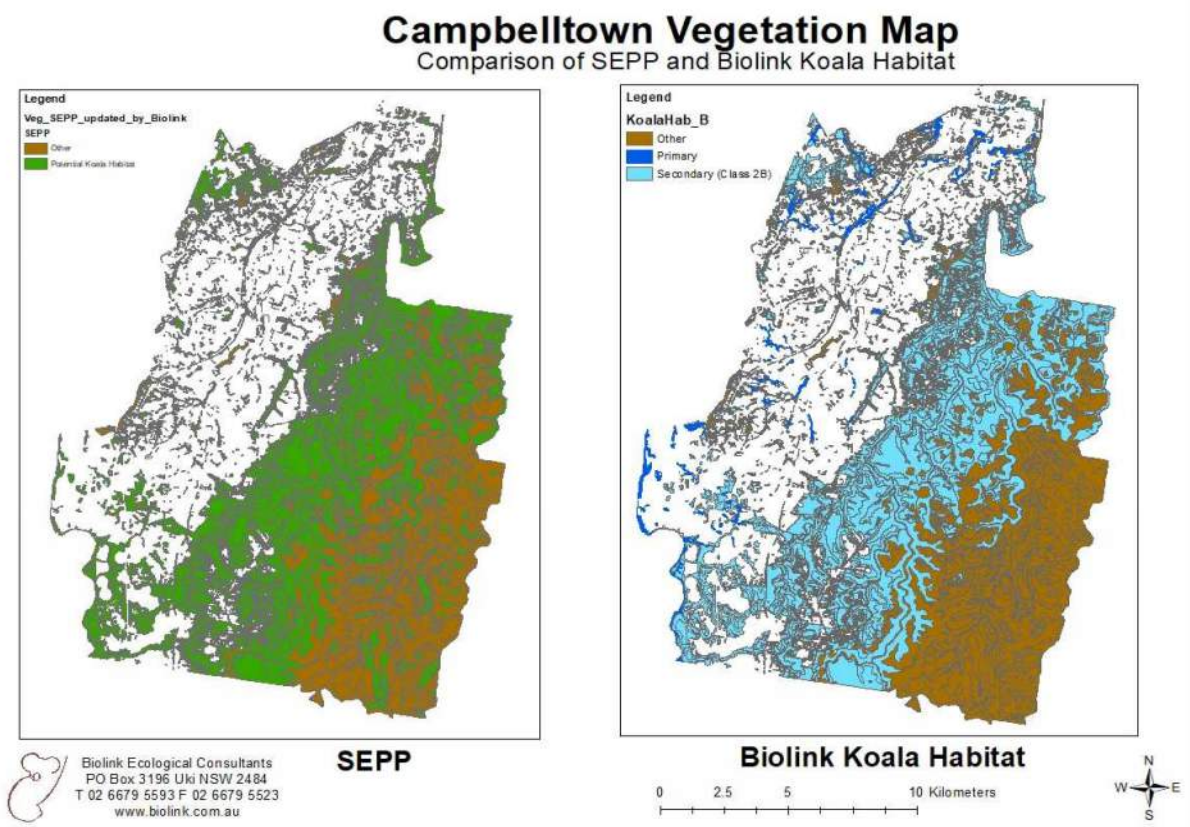
We classified twenty three PCTs based on their floristics. For the SEPP classification if a Schedule 2 Feed tree species was found in the Typical Species tree list and the Average Cover & Cover Range (%) was greater than or equal to fifteen percent we classified it as *Potential Koala Habitat*. For Biolink's koala habitat classification we determined which Preferred Koala Food Trees were present and considered their dominance in the canopy as detailed in our 2016 report to Council.

Table 1 provides a summary of results obtained by the two approaches. While providing broadly similar outcomes in terms of the amount of vegetation classified as koala habitat, there were two profile codes that the SEPP and BKHCP classifications differed on: S_GW01 Cumberland Moist Shale Woodland that comprises 28 hectares of the Campbelltown area. A SEPP-informed approach classifies this PCT as 'Other' habitat despite the fact that *Eucalyptus moluccana* (a preferred koala food tree species not listed on SEPP 44) comprises on average fourteen percent of the canopy cover. The second PCT was S_HL08 Coastal Sandstone Heath_Mallee that comprised 802 hectares was classified by the SEPP system as *Potential Koala Habitat* due to the presence of *E. haemastoma* at an average of seventeen percent of the canopy cover. However, we are not aware of any data supportive of consideration of *E. haemastoma* as a Preferred Koala Food Tree, hence this species is not considered in our classification hierarchy.

Of note is that there are two PCTs that Biolink considers to be Primary Koala habitat due to the presence of *E. tereticornis* on good quality soils, these being S_F0W06 Cumberland Riverflat Forest and S_F0W07 Cumberland Swamp Oak Riparian Forest. These areas add up to a total of 316 hectares and can be seen in the attached Koala Habitat Maps.

Table 1: Comparison of Classification of Vegetation Profile Codes as koala habitat based on SEPP 44 criteria and that of Biolink (2016).

Map Unit Code	Map Unit Name	SEPP		Biolink	
		Classification	**Reason**	**Classification**	**Reason**
S_DSF05	Sydney South Exposed Sandstone Woodland	Other	presence of *E. haemastoma* at 12%	Other	sandstone, no PKFTs
S_DSF08	Coastal Sandstone Riparian Forest	Other	no PKFTs	Other	no PKFTs
S_DSF09	Coastal Sandstone Gully Forest	Other	no PKFTs	Other	no PKFTs
S_DSF15	Sydney Hinterland Exposed Sandstone Woodland	Potential Koala Habitat	presence of *E. punctata* 19%, *E. haemostoma* in description	Secondary (Class 2B)	*E. punctata* as a dominant on exposed sandstone
S_DSF17	Sydney Hinterland Apple-Blackbutt Gully Forest	Potential Koala Habitat	presence of *E.punctata* at 20%	Secondary (Class 2B)	*E. punctata* as a dominant on exposed sandstone
S_DSF18	Sydney Hinterland Grey Gum Ridgetop Forest	Potential Koala Habitat	presence of *E.punctata* at 21%	Secondary (Class 2B)	*E. punctata* as a dominant on exposed sandstone
S_DSF19	Castlereagh Scribbly Gum Woodland	Potential Koala Habitat	presence of *E.punctata* at 20%	Secondary (Class 2B)	*E. punctata* as a dominant on exposed sandstone
S_FoW06	Cumberland Riverflat Forest	Potential Koala Habitat	Presence of *E.tereticornis* at 28%	Primary	Presence of *E. tereticornis*
S_FoW07	Cumberland Swamp Oak Riparian Forest	Potential Koala Habitat	Presence of *E.tereticornis* at 33%	Primary	Presence of *E. tereticornis*
S_FoW09	Hinterland Riverflat Eucalypt Forest	Other	no PKFTs	Other	no PKFTs
S_FoW20	Coastal Sandstone Riparian Scrub	Other	no PKFTs	Other	no PKFTs
S_FRW01	Coastal Upland Damp Heath Swamp	Other	no PKFTs	Other	no PKFTs
S_FRW02	Coastal Upland Wet Heath Swamp	Other	no PKFTs	Other	no PKFTs
S_FRW03	Coastal Freshwater Wetland	Other	no PKFTs	Other	no PKFTs
S_Gw01	Cumberland Moist Shale Woodland	Other	only 14% *E. moluccana* and *E. tereticornis*	Secondary (Class 2B)	*E.tereticornis* as dominant
S_Gw02	Cumberland Shale Hills Woodland	Potential Koala Habitat	*E.tereticornis and E. moluccana* at 17%	Secondary (Class 2B)	*E.tereticornis* as dominant
S_Gw03	Cumberland Shale Plains Woodland	Potential Koala Habitat	*E.tereticornis* and *E. moluccana* at 19%	Secondary (Class 2B)	*E.tereticornis* as dominant
S_Gw04	Cumberland Shale_Sandstone Ironbark Forest	Potential Koala Habitat	*E. punctata* at 21%	Secondary (Class 2B)	*E. punctata* as a dominant on clay-rich shale soil
S_HL08	Coastal Sandstone Heath-Mallee	Potential Koala Habitat	*E. haemastoma* at 17%	Other	no PKFTs
S_HL09	Coastal Sandstone Rock Plate Heath	Other	*E. haemastoma* at 17%	Other	no PKFTs
S_HL10	Sydney Hinterland Dwarf Apple Heath-Woodland	Other	*E. haemastoma* at 12%	Other	no PKFTs
S_WSF02	Coastal Enriched Sandstone Moist Forest	Other	no PKFTs	Other	no PKFTs
S_WSF09	Sydney Turpentine-Ironbark Forest	Other	no PKFTs	Other	no PKFTs



A shapefile containing attribute columns enabling the two approaches to be identified has been forwarded separately. Please don't hesitate to contact the undersigned or our GIS/Conservation Analyst Kirsty Wallis if you require any further information.

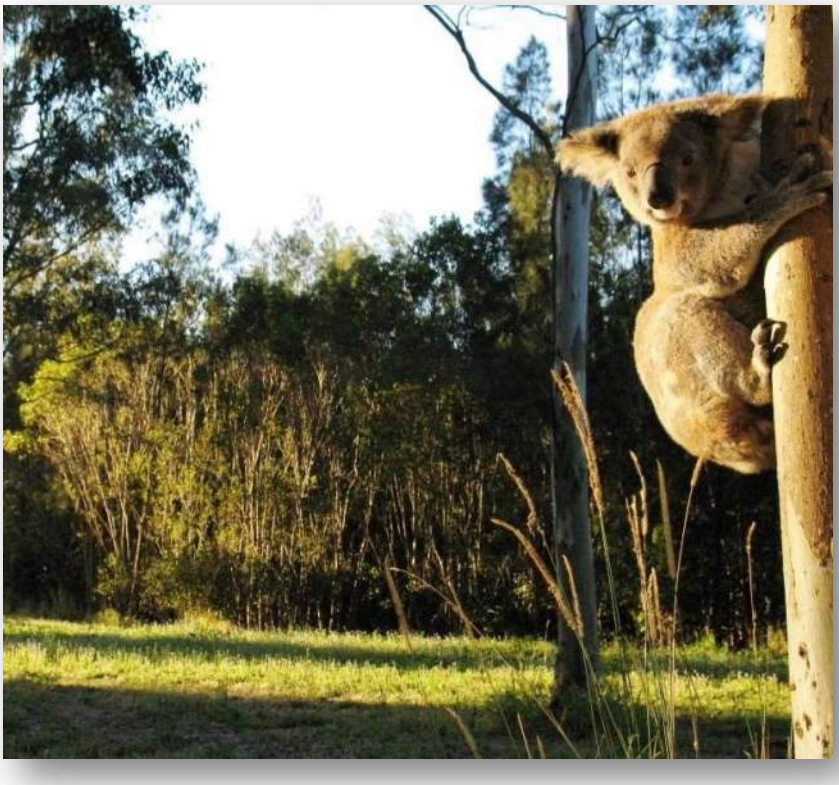
Yours Sincerely,

Dr Stephen Phillips

M/Director – Principal Research Scientist

Appendix F

Review of koala generational persistence across the Campbelltown City Council Local Government Area 2012 - 2017



Report to Campbelltown City Council

June 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

CoLS

Principal Consultant	Steve Phillips
Senior Ecologist	Grant Brearley
Conservation Analyst	Kirsty Wallis
Ecologist	Jade Krause

How to cite this report:

Biolink. 2018. *Review of koala Generational Persistence across Campbelltown City Council Local Government Area: 2012 - 2017*. Biolink Ecological Consultants, Uki, NSW.

Summary

Koalas inhabiting the Campbelltown City Local Government Area (CCCLGA) have been the focus of scientific and community interest for many years. While current estimates of population size are less than 200 individuals, available data indicates that the population has experienced a measure of recovery over recent decades.

Analyses of historical koala records are increasingly being used to understand changes/trends in distribution and abundance and to inform long-term conservation planning outcomes at the LGA level. One aspect of records analyses - Generational Persistence Assessment (GPA) - is used to examine the data for re-occurring records within a localised area over overlapping generational time spans. This process can assist in identifying the presence of long-standing historical resident and/or source populations.

This report is part of an ongoing monitoring program for the Campbelltown koala population and so reviews and examines changes in areas of generational persistence by incorporating data for the most recent koala generation (2012 – 2017) into the 1900 to 2012 dataset that was considered by earlier studies.

The GPA review supports the ongoing recovery trend of the population, with increases in generational persistence during 2000 - 2017 when compared with 1994 – 2012 outcomes. GPA has identified population expansion to the north past Long Point, to the west into the localities of Ambarvale and St. Helens Park and in areas to the southwest. Whilst there appears to be some contraction along the eastern edges of the Wedderburn Plateau and Kentlyn, overall there is a net gain. This is a positive outcome that reinforces a notion that long-term conservation planning for the Campbelltown koala population requires a strategic approach to manage the issue of range expansions as the koala population continues to expand into formerly occupied areas of suitable habitat.

1. Introduction

The Campbelltown City Council Local Government Area (CCCLGA) is located in the Macarthur region of south-western Sydney, New South Wales. Koalas inhabiting the CCCLGA are the focus of ongoing scientific and community interest. Currently estimated to have a population size of less than 200 koalas, available data based on analysis of historical records supported by recent field assessments indicate that the population has demonstrated a measure of recovery over recent decades (Biolink 2016; 2017).

Historical koala records are increasingly being used to understand changes/trends in distribution and abundance and to inform long-term conservation planning outcomes at the LGA level (Lunney *et al*. 1998; Phillips *et al*. 2007; Predavec *et al* 2016). One particular aspect of records analyses, Generational Persistence Assessment (*GPA*), examines for re-occurring records of a species within a localised area over overlapping generational time spans and so identifies the presence of long-standing historical resident and/or source populations.

This report is part of an ongoing monitoring program for the Campbelltown koala population, initiated by CCC, to examine changes in areas of Generational Persistence using records for the most recent koala generation 2012 – 2017. This follows the Biolink (2016) report: "*Analysing the historical record: aspects of the distribution and abundance of koalas in the Campbelltown City Council Local Government Area 1900 - 2012*", which involved analyses of 1,588 historical koala records for the time period 1900 to 2012. The results of this study indicated the presence of two smaller areas of generational persistence *pre*-1995 (*i.e*. Wedderburn Plateau and Kentlyn - Minto Heights) expanding into adjoining bushland areas abutting localities of St. Helens Park, Airds, Ruse and Long Point over more recent generations.

1.1. Objective

The purpose of this report is to review the GPA outcomes described by Biolink (2016) by incorporating records for the most recent koala generation (2012 – 2017) so as to inform Council about ongoing trends in the distribution of koalas throughout the CCCLGA.

2. Methodology

2.1. Records analyses

2.1.1. Koala records

Koala records sourced from OEH Wildlife Atlas database (BioNet) for the time period 2012-2017 were added to the dataset originally analysed by Biolink (2016). This larger dataset was then manually checked for duplications and sorted chronologically by koala generation (determined to be six years

(Phillips, 2000)), dating backwards from 2017. The resulting data set was then partitioned in order to enable comparisons *post*-1999 (the time frames 2000 - 2005, 2006 - 2011, 2012 - 2017 approximating the time intervals for the most recent three koala generations). Records dating *pre*-2000 were thereafter categorised as *historic*.

2.1.2. Generational persistence

The resulting records were examined for re-occurrence within a localised area predefined by the same 2 km x 2 km grid-cell overlay utilised in the original Biolink (2016) assessment, with generational persistence again determined by the presence of records within single grid-cells for each of the three most recent koala generations.

3. Results

3.1. Koala records

Two thousand, three hundred and twenty (2,320) koala records were contained in the updated dataset. These were comprised of:

- The 1,588 records initially reported on by Biolink (2016),
- 492 'new' koala records for the period leading up to 2012 which had not been present in the BioNet database when originally accessed for the Biolink (2016) analyses, and
- 240 recent BioNet records for the time-period 2012-2017.

3.2. Generational persistence

Comparison between the three koala generations 1994 - 2012 reported by Biolink (2016) to that of the updated three generational data set for the period 2000 – 2017 indicates an increase in the extent of generational persistence in the north, west and southern areas of the CCCLGA. Increases in extent of areas of generational persistence were most apparent in the area to the north of Long Point near Ingleburn and northeast of Minto respectively, in the Ambervale area to the southwest of Campbelltown City and to the west of Appin Road in the south. In contrast, there were implied losses in areas of generational persistence from embedded plateau landscapes to the east of Minto and southeast of Wedderburn. Figure 2 illustrates differences to the original grid-cell configuration that result from these changes.

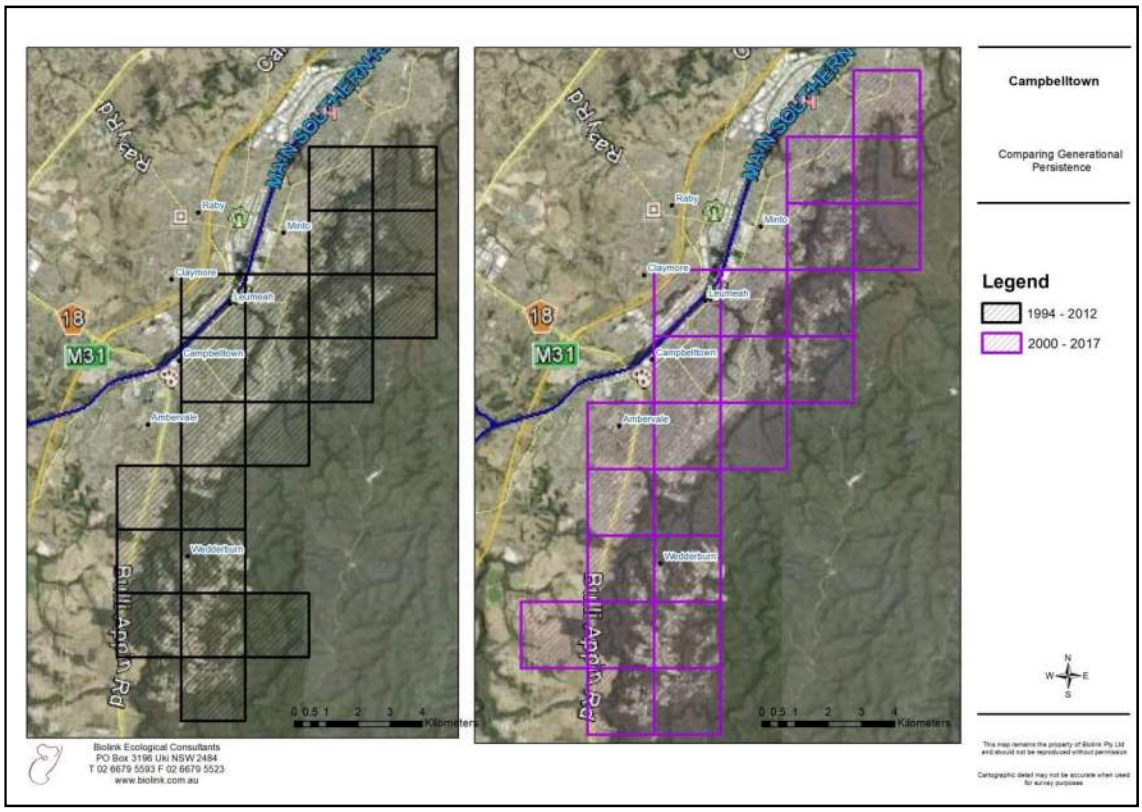


Figure 2. Areas of Generational Persistence (diagonally crossed grid cells) comparing the three most recent koala generations (1994-2012) considered by the Biolink (2016) report, to that now apparent for the three most recent koala generations (2000 – 2017).

4. Key outcomes

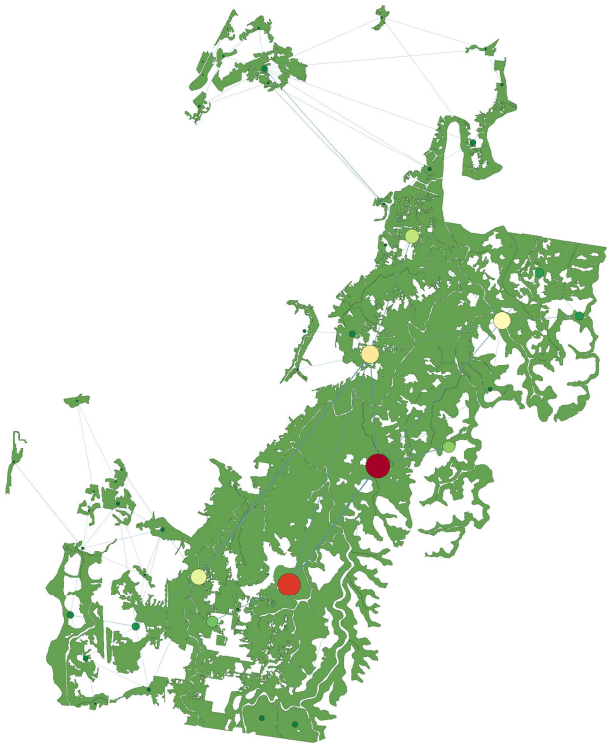
- GPA indicates that the Campbelltown koalas are maintaining high occupancy levels in eastern areas of the CCCLGA and further support a hypothesis of ongoing recovery and associated range expansion. This recovery trend is supported by changes in the extent of areas of Generational Persistence for the 3 most recent koala generations 2000 - 2017 compared with that of 1994 - 2012.

- GPA analyses evidences population expansion to the north past Long Point, to the west into the localities of Ambervale and St. Helens Park and in areas to the southwest between South Campbelltown and Appin. Whilst there appears to be some contraction of areas of generational persistence along the eastern edges of the embedded plateau landscapes to the east of Minto and Wedderburn Plateau respectively, the overall trend across the LGA is one of gain, not loss.

- With recent survey work confirming connectivity between koala populations inhabiting the Nepean and George's River catchments (Biolink 2017), ongoing long-term conservation planning for the Campbelltown koala population requires an increasingly strategic approach to managing the issue of population recovery and associated range expansions to the west.

Appendix G

Identifying Least-Cost Dispersal Pathways for Koalas within the Campbelltown City Council Local Government Area



Final Report to Campbelltown City Council

September 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
CCC	Campbelltown City Council
BEC	Biolink Ecological Consultants
CKPoM	Comprehensive Koala Plan of Management
DIIC	Delta Integral Index of Connectivity
GAP CLoSR	General Approach to Planning Connectivity from Local Scales to Regional
LGA	Local Government Area
PCT	Plant Community Type
PKFT	Preferred Koala Food Tree
PKH	Preferred Koala Habitat
PRV	Percentage Resistance Value
RMS	Roads and Maritime Services
SC	Statewide Class

CoLS

Principal Consultant	Dr. Stephen Phillips
GAP CLoSR Analysts	Dr. Amanda Lane / Kirsty Wallis

How to cite this report:

Biolink. 2018. *Identifying Least Cost Dispersal Pathways for Koalas within the Campbelltown City Council Local Government Area*. Biolink Ecological Consultants, Uki, NSW.

Summary

Koalas inhabiting the Campbelltown City Council (CCC) Local Government Area (LGA) have long been the focus of scientific and community interest. While available data indicates that the population has experienced a measure of recovery over the last 20 years, current population size estimates for the CCC LGA imply a koala population estimate of less than 200 individuals, the majority of which occur in the area between Minto Heights and Wedderburn. This relatively low number warns of little ground for complacency given the vulnerability of the greater part of the recovering population to a fire event, the impacts of which could impede the recovery process.

This report is part of an ongoing series intended to inform longer-term management of the Campbelltown koala population, and more specifically aims to identify locations for connecting areas of Preferred Koala Habitat (PKH) at a fine scale across the CCC LGA. To achieve this, previously classified Primary and Secondary (2B) PKH patches > 10 ha as well as all other vegetated areas and/or land uses within the CCC LGA were mapped according to the resistance they presented to koala movement. In this way the entire surface of the LGA was coded for costs to koala dispersal. Areas of highest cost to koala movement include fenced train lines, highways, aqueducts and heavy industrial and commercial development. Examples of lower-cost land uses are non-PKH vegetation and areas of low density development. Examination of the PKH habitat matrix and the associated connectivity issues were thereafter conducted in accordance with the analytical and spatial framework offered by the *General Approach to Planning Connectivity from Local Scales to Regional* (GAP CLoSR) package, in concert with the supporting *Graphab* software package.

Output identified that the greater proportion of the CCC LGA (31,052 ha) currently functions as a single, interconnected landscape component comprised of 44 habitat patches linked by 82 least-cost pathways. A second, much smaller (171 ha) landscape component in the far north-west of the LGA comprises three habitat patches linked *via* three least-cost pathways disconnected from the rest of the LGA by the Lachlan Way aqueduct. Considering the larger of the two landscape components, no least-cost pathways occur in the central, heavily urbanised portion of the LGA; rather, they are concentrated in the north near Macquarie Fields and Denham Court and in the south-west in the vicinity of Gilead respectively. Connectivity in this latter area is additionally reliant upon crossing Appin Road and the Lachlan Way aqueduct in order to link the Nepean and Georges Rivers catchments and their associated koala populations *via* areas of PKH on the Wedderburn Plateau in the east, to smaller areas of higher carrying capacity PKH in the west.

Long-term conservation planning for the Campbelltown koala population requires a strategic and considered approach to managing the issue of koala population recovery and associated range expansion as koalas continue to move across the landscape and occupy areas of formerly unoccupied habitat. Independently of knowledge about the current conservation / population status of koalas in the CCC LGA, *Graphab* output identified the habitat matrix between Kentlyn and Wedderburn as supporting the most important patch attributes in terms of size and capacity to offer

linkage support to associated patches. Given this background, the future upgrading of Appin Road and increasing development pressure in the south-western area of Campbelltown mandate the need for informed connectivity analyses as a pre-requisite to finalising road design and other development outcomes.

Recommendations arising from the outcomes of the GAP CLoSR analyses include the need to consider how best to consolidate effective integration of connectivity needs at three locations along the Lachlan Way aqueduct as a part of landscape-themed connectivity outcomes in the southwest of the CCC LGA. With a view to maintaining newly established connectivity between koala populations of the Georges and Nepean Rivers, design concepts / solutions for consideration are also recommended for three locations associated with the Appin Road upgrade at Rosemeadow South, Beulah and Mallaty's Creek which have additionally been identified by the GAP CLoSR process as offering the most suitable dispersal pathway opportunities.

1. Introduction

The Campbelltown City Council (CCC) Local Government Area (LGA) is located in the Macarthur region to the south-west of Sydney, New South Wales and encompasses an area of 31,200 ha. Koalas inhabiting the CCC LGA have been the focus of scientific and community interest since the 1980's (Cork *et al*. 1988; Sheppard, 1990; Phillips and Callaghan 2000; Ward 2002; Lunney *et al*., 2010). Currently estimated to have a widely dispersed[1] population of less than 200 animals (Biolink Ecological Consultants (BEC) 2016), data derived from analyses of historical koala records and ongoing field assessments indicates that the CCC LGA koala population – contrary to many others in eastern New South Wales and Queensland - has experienced a measure of recovery over the last 20 years (BEC 2017; 2018).

This report is part of an ongoing series of management related studies intended to assist CCC in enabling the potential for a long-term sustainable management framework for the Campbelltown koalas to be achieved. At the time of drafting this report, the ongoing recovery trend referred to in the preceding paragraph is manifesting itself and amongst other things in greater numbers of koalas being struck by motor vehicles along Appin Road between Campbelltown & Appin. There is also evidence of occupancy in habitat areas to the west of Appin Road in areas where koalas have not previously been reported, amongst the implications of which is that koala populations in the Nepean and Georges Rivers catchments, previously regarded as separate populations for management purposes, are now in direct contact (BEC 2017).

The key to long-term sustainable management of free-ranging koala populations is knowledge. Building on available knowledge indicating and ongoing recovery trend, there is merit in knowing how best to build resilience into the population so that the potential for longer-term population viability can be maximised such that the population is better placed to withstand the impacts of stochastic impacts from catastrophic fire events which have likely played a significant historical role in terms of influencing population distribution and conservation status, the threat now elevated given the future uncertainties associated with climate change. The best way to achieve such resilience will be to have viable population cells widely distributed and occupying habitat outliers that are effectively insulated from large-scale fire events, so enabling recolonization to occur. In order to do this, linkages need to be secured across the landscape.

As its name implies, the *Generalised Approach to Planning Connectivity at Local and Regional Scales* (GAP CLoSR) developed by Lechner and Lefroy (2014) offers a GIS-based approach with a supporting

[1] This a reflection of the large home range areas required to sustain individual koalas

analytical and spatial framework that enables objective examination of issues associated with processes of historical habitat fragmentation and landscape-scale connectivity. Amongst other things GAP CLoSR does this by considering the ecological needs and movement characteristics of a given target species and the extent to which the planning landscape functions to impede and/or facilitate movement, including considerations such as patch size and the location of areas of preferred habitat, the greatest distance of open ground that can be crossed and the distances that can be moved in a connected landscape. Output from the GAP CLoSR process thus enables identification of key landscape 'components' and associated habitat 'patches' linked *via* a system of 'least-cost pathways', these being the shortest pathway between two habitat patches within a given area as a function of land cover resistance (*i.e*. barriers to movement) as well as knowledge about ranging patterns and dispersal behaviour.

It is the exploration of connectivity across the landscape and specifically the identification of least-cost dispersal pathways for koalas that is the primary focus of this report. A series of conceptualised linkages were identified for the purpose of the draft Comprehensive Koala Plan of Management (CKPoM) endorsed by Council (CCC 2017). While these linkages were intuitively informed, the Greater Sydney area and the CCC LGA in particular is also about to undergo a period of further expansion and development in the south-west. Analyses such as that offered by the GAP CLoSR process thus have the capacity to inform future planning decisions by offering objective analyses of connectivity across the planning landscape at a key point in ecological time. Knowledge of the locations of least-cost pathways also has the potential to inform future planning decisions by way of identifying key locations for linkage consolidation and/or future rehabilitation / restoration.

The purpose of this project was to take a more informed and scientifically-driven approach to the issue of connectivity considerations for koalas across the CCC LGA and in so doing enable a comparative examination of connectivity options by way of:

- Identifying key landscape components and habitat patches of PKH associated with koala conservation across the CCC LGA,
- Prioritising the habitat patch network in terms of size and intra-component connectivity,
- Identifying and prioritising least-cost pathways between the patches within each component for long-term koala conservation benefit,
- Examining issues of conservation relevance to the continued functionality of these least-cost pathways in light of potential future development.

2. Methodology

i) Study area and koala records

The CCC LGA is located along on the eastern edge of the Cumberland Plain to the southwest of Sydney, NSW and covers an area of 31, 200 ha. (Figure 1). Koala records from the most recent koala generation (2011 - 2017) were obtained from Bionet.

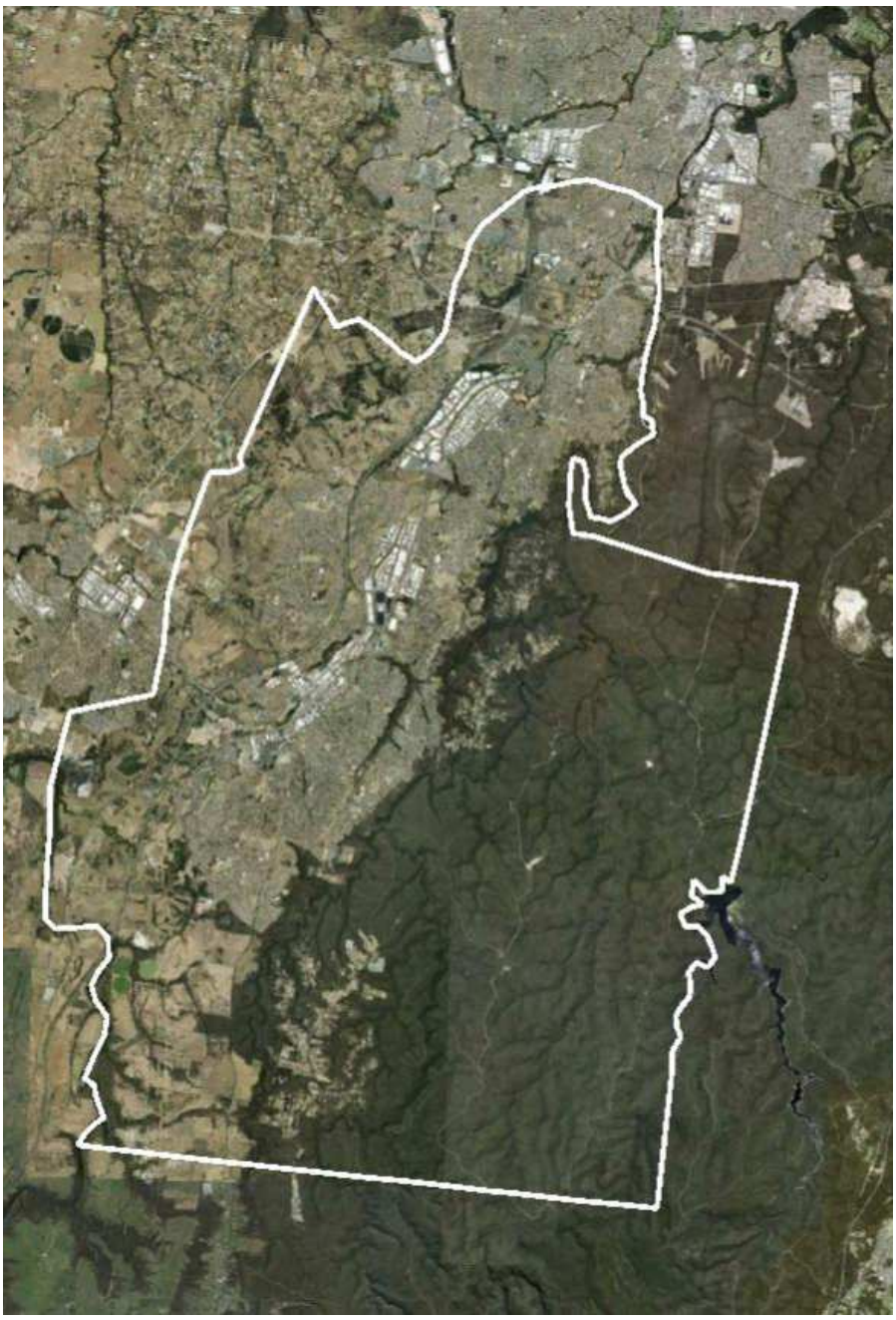


Figure 1: Location of the CCC LGA (white polygon) along the eastern periphery of the Cumberland Plain to the south-west of Sydney, NSW.

ii) Allocating resistance to land-use for koala movement

For low-density koala populations such as that which naturally occur in the CCC LGA, the costs of moving across the vegetated landscape are higher than for those occupying higher carrying capacity landscapes elsewhere; this is because the distances between individual Preferred Koala Food Trees (PKFTs) are invariably greater.

The percentage resistance value (PRV) refers to the effort or cost that it takes a koala to cross a particular land-use class. A PRV of 100% is the baseline cost indicating that it takes a koala 50 m of effort to cross a distance 50 m, 200% equates to an effort equivalent to 100 m to cross 50 m and so on. These PRVs are based on Lechner and Lefroy's (2014) initial recommendations for each land-use category, refined herein according to species-specific knowledge.

iii) Determination of a gap-crossing threshold

In order to determine the maximum distance that a koala was likely to travel from a vegetated area (the gap-crossing threshold), we calculated the Euclidian distance of all CCC LGA koala records that were located in non-vegetated areas from that of the nearest patch of mapped vegetation (including both PKH and other non-PKH mapped vegetation).

Of the 240 koala records for the study area, 89 were located outside mapped vegetation polygons. The largest distance a koala record was located from mapped vegetation was ~ 220 m and the average distance was ~ 44 m. Only 2.2% of koala records were located > 200m from vegetation and 14.6% were located between 100 - 200 m from mapped vegetation. The remaining 83.2% of records were within 100 m of mapped vegetation (indeed, 40.4% were within 10 m of mapped vegetation). On the basis of this knowledge we applied a buffer of 220 m around all mapped vegetation in order to best delineate the gap-crossing threshold. For areas beyond this buffer zone we applied a complete barrier to movement (*i.e.* ∞ dispersal cost) (Appendix 1, Section E refers).

iv) Creation of a dispersal cost surface

The various land-use layers that make up the CCC LGA landscape were used to create a *dispersal cost surface*; this is a rasterised[2] surface where each pixel's value represents a dispersal cost for koalas that is derived from the land cover type, reflecting the potential ecological costs of traversing this area. This approach requires evaluation of individual land cover resistance levels, based on a practical consideration of both the likelihood of koala movement and the hazards that are likely to be encountered, herein defined as the extent of localised resistance.

The dispersal cost surface incorporates considerations of localised resistance related to the following land-use attributes:

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

1. Transport infrastructure *(i.e*. roads and railway lines),
2. Hydrology (drainage lines, canals, artificial waterbodies, aqueduct),
3. Vegetation cover (including, but not limited to Preferred Koala Habitat),
4. Mining and quarrying,
5. Agricultural activities (grazing & horticulture) and
6. Urban, Commercial and Industrial Areas.

Each of the preceding land-use layers (*e.g*. cadastre, roads, Strahler stream orders, vegetation mapping) were available as a consequence of ongoing work with CCC. Where appropriate, digital data relating to linear landscape elements such as watercourses and infrastructure such as railway lines and roads were underlain with available satellite imagery in order to identify potential connectivity opportunities for koalas, whereupon dispersal costs were lowered accordingly (see below - Appendix 1 refers).

v) Coding of Statewide Class (SC) / Plant Community Types (PCTs)

For the purpose of this project all SC/PCTs recognised by the vegetation mapping layer were categorised in accord with criteria of BEC (2016) used to identify areas of PKH based on considerations of presence / absence / dominance relating to the following PKFT species: Grey Box *Eucalytpus. moluccana*, Grey Gum *E. punctata*, Manna Gum *E. viminalis* and Forest Red Gum *E. tereticornis*. Based on this knowledge, SCs/PCTs could be classified hierarchically in terms of their inherent koala carrying capacity as follows:

- **Primary Koala Habitat** – SC/PCT wherein 'primary' PKFTs comprise the dominant or co-dominant overstorey species.
- **Secondary Koala Habitat (Class A)** – SC/PCT wherein 'primary' PKFTs are a sub-dominant component of the overstorey species (typically alluvial deposits).
- **Secondary Koala Habitat (Class B)** – Primary PKFTs absent, SC/PCT dominated by one or more 'secondary' PKFTs.
- **Secondary Koala Habitat (Class C)** - Primary PKFTs absent, one or more 'secondary' PKFTs present within SC/PCT as a sub-dominant component of overstorey species.

Collectively, SC/PCTs coded in accord with the preceding classification system qualify as PKH for koala conservation and management purposes. SC/PCTs that did not contain PKFTs were classified as '**Other**' vegetation for analysis purposes.

As already alluded to in ii) above, the allocation of cost must be determined in a different way for PKH compared to all other categories. In areas of PKH categorised as 'Primary', the smaller home range sizes needed to sustain an individual koala require less daily movement, notwithstanding that such movement in itself carries costs associated with exposure and misadventure. In the subsequent series of Secondary habitat types (*i.e*. A, B and C), home ranges are by necessity larger, due to the

increasingly sparser distribution of PKFTs. This requires larger daily movements to be undertaken, with associated higher costs. Because the physical movement through Secondary habitats is costlier for koalas, this requires a higher cost metric to be applied. 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. At the other end of this spectrum, SC/PCTs that did not contain PKFTs were classified as '**Other**' vegetation for analysis purposes and incurred a higher cost again, as did areas of cleared land or cleared land with scattered trees.

For the purpose of GAP CLoSR analyses we have continued to develop and refine a standardised set of resistance parameters for koalas which are supported by ecological correlates that can be applied 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. The current detail of this standardisation process in terms of the relationship between a given cost parameter and their associated ecological correlate is provided in Appendix 1.

vi) Layering for rasterization purposes

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

1. Gap-crossing threshold layer,
2. Connectivity structures spanning roads, train lines and aqueducts,
3. Train lines and aqueduct,
4. Roads,
5. Hydrology,
6. Vegetation, including PKH, and
7. 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.

vii) Identifying landscape components, habitat patches and least-cost dispersal pathways

Graphic approaches can be used to represent ecological landscapes in terms of 'nodes' and 'edges', where the former exist as key 'patches' of interconnected habitat within a larger (regional) network

of 'landscape components', while the edges of landscape components, in theory at least, represent the interface between separate / disconnected matrices of habitat. In this framework, 'edges' may also refer to the least-cost pathways between interconnected habitat patches. To this end we determined to use a minimum patch size of 10 ha and the supporting *Graphab* software functions developed by Foltête *et al*. (2012) to identify key landscape components and associated patch networks therein. We also used the *Graphab* functions to identify least-cost dispersal pathways across the study area using a threshold method. To this end and rather than relying on Euclidian distance, cost considerations were used to incorporate information from the landuse layer whereby a cumulative cost threshold of 300,000% was deemed to be that beyond which a pathway could not be formed. The calculation of this value is informed by ancillary koala ecology considerations / metrics (Appendix 1 Section E refers).

viii) Graphab settings and metrics

Analyses were run using minimum patch sizes of 10 ha, 20 ha and 50 ha respectively. Patch connexity 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 from the landscape map using the maximum cumulative cost threshold as defined in the preceding section.

The primary graph metric utilized for analysis 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 is presented at a local level (that of habitat patch or pathway) but also by reference to the global level (*i.e*. the entire study area).

3. Results

i) Land use layer and associated dispersal cost surface

Rasterisation of the input landuse layers resulted in a large series of pixels which were checked and coded manually for resistance in accord with values detailed in Appendix 1. Figure 2 illustrates the fine scale complexities of the dispersal cost surface, including the gap crossing layer, for a section of the CCC LGA in comparison to available satellite imagery and Figure 3 demonstrates this cost dispersal surface more broadly for the entire LGA.

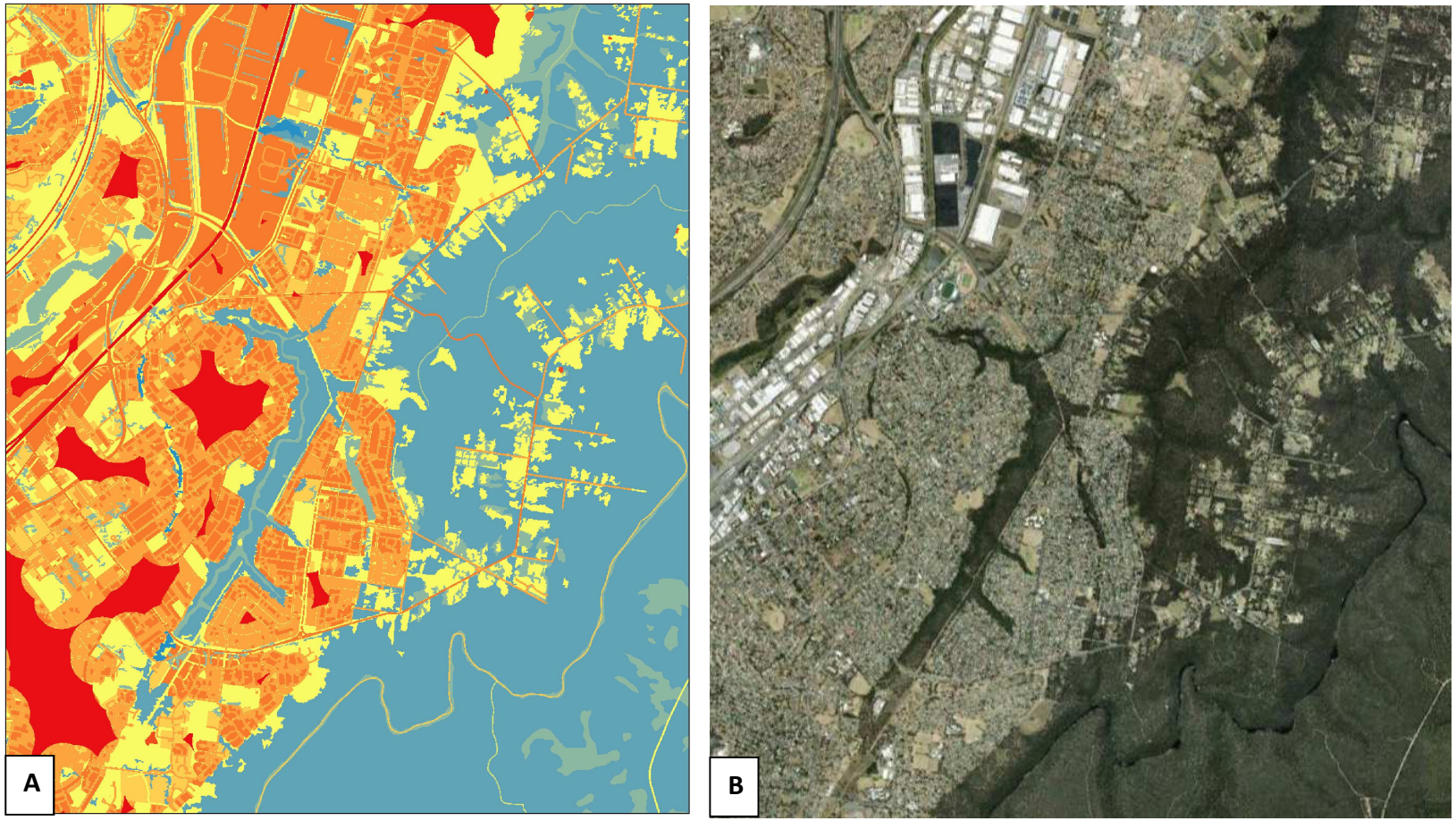


Figure 2: An example of the dispersal cost surface for a section of the CCC LGA in the vicinity of Leumeah, Ruse and Minto Heights (A), compared to satellite imagery (B) for the same area. High cost (red) represents a land type that is either difficult for koalas to traverse, lower costs (blue) are easy to traverse. Note that the area is costed for a range of land uses including vegetation type, agriculture, urban and commercial development, industry, transportation infrastructure and hydrology. The large patches of red represent the gap-crossing threshold, meaning that these areas are > 220m from any mapped vegetation and therefore not likely to be crossable by koalas.

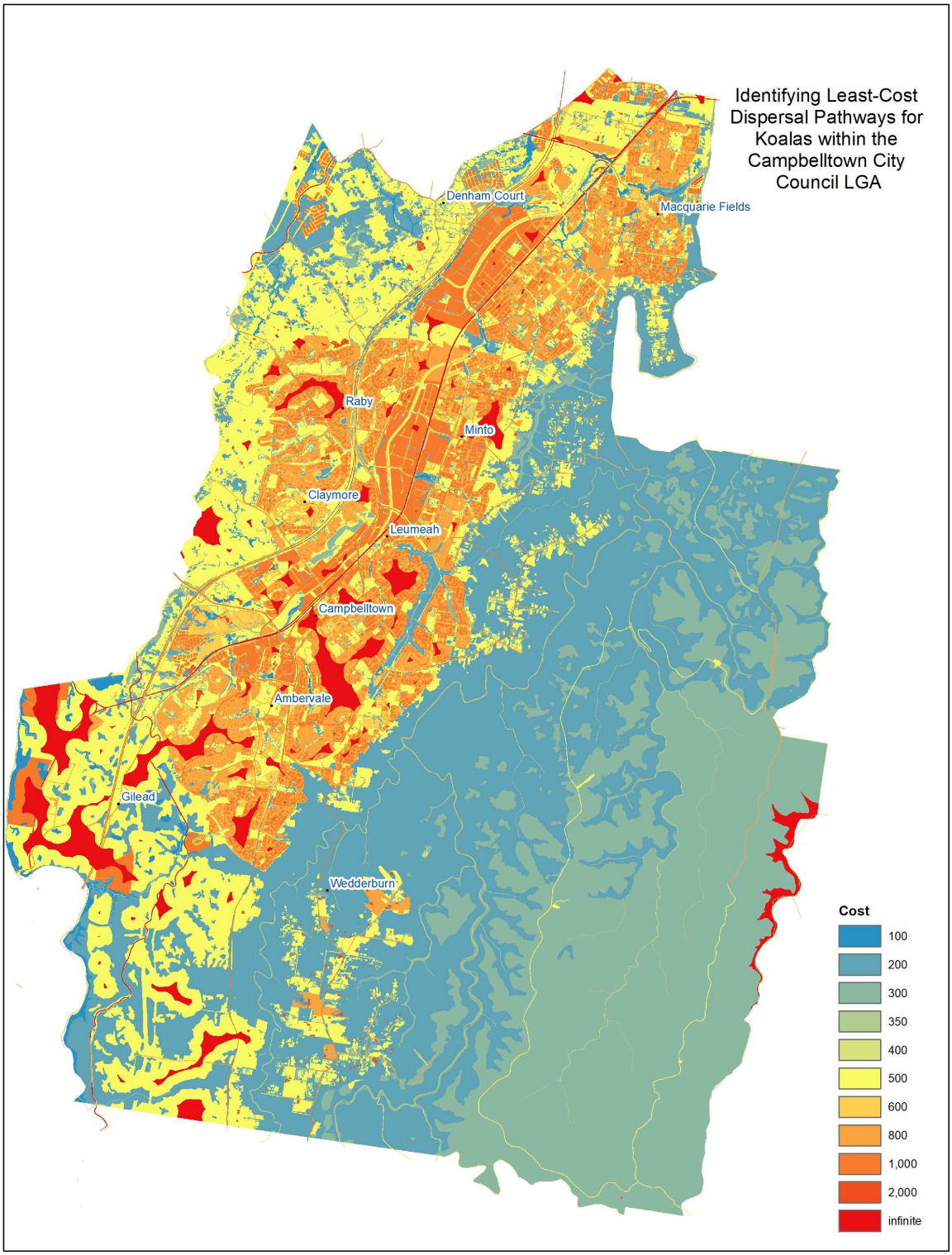


Figure 3: Dispersal cost surface for the CCC LGA.

ii) Graphab / GAP CLoSR output

Table 1 summarises the baseline GAP CLoSR output metrics for the study area in terms of increases in the minimum PKH patch size from 10 ha, to 20 ha and 50 ha. The highest numbers of potential least-cost dispersal pathways are identified by considering all areas of PKH to a minimum size of 10 ha and given that our objective is to characterise linkage areas across gaps in the habitat, there is greater ecological benefit to consider the highest number of practicable pathways; further analysis and figures are thus based on this minimum patch size. If a 20 ha or 50 ha minimum patch size is used, the loss of smaller, unidentified patches and pathways could lead to a failure to consider important linkage areas in planning or management.

Table 1. Baseline connectivity elements identified on the basis of required access to 10 ha, 20 ha and 50 ha minimum PKH patch sizes.

Landscape Element / Patch size	**10 ha**	**20 ha**	**50 ha**
Landscape components	2	2	1
Habitat patches	47	30	22
Least-cost pathways	85	49	39

Graphab output for the study area is illustrated in terms of landscape components and associated habitat patch networks connected by least-cost pathways (Figure 4). At the 10 ha habitat patch scale, this output implies that the CCC LGA consists of two landscape components, the smaller of the two comprising just three habitat patches connected by three least-cost pathways located at the very north-western edge of the CCC LGA where it adjoins the Camden and Liverpool LGAs. Thereafter, the remainder of the LGA (31,052 ha) is determined to function as a separate landscape component comprised of 44 habitat patches connected by 82 least-cost pathways. Areas of potential connectivity between the east and west of the study area occur in the north of the CCC LGA, around Macquarie Fields and Denham Court, and to the south of Gilead around Wedderburn and Menangle. Figures 5 and 6 display this output at a higher resolution for both the north-western edge of the LGA and the south-west of Campbelltown respectively.

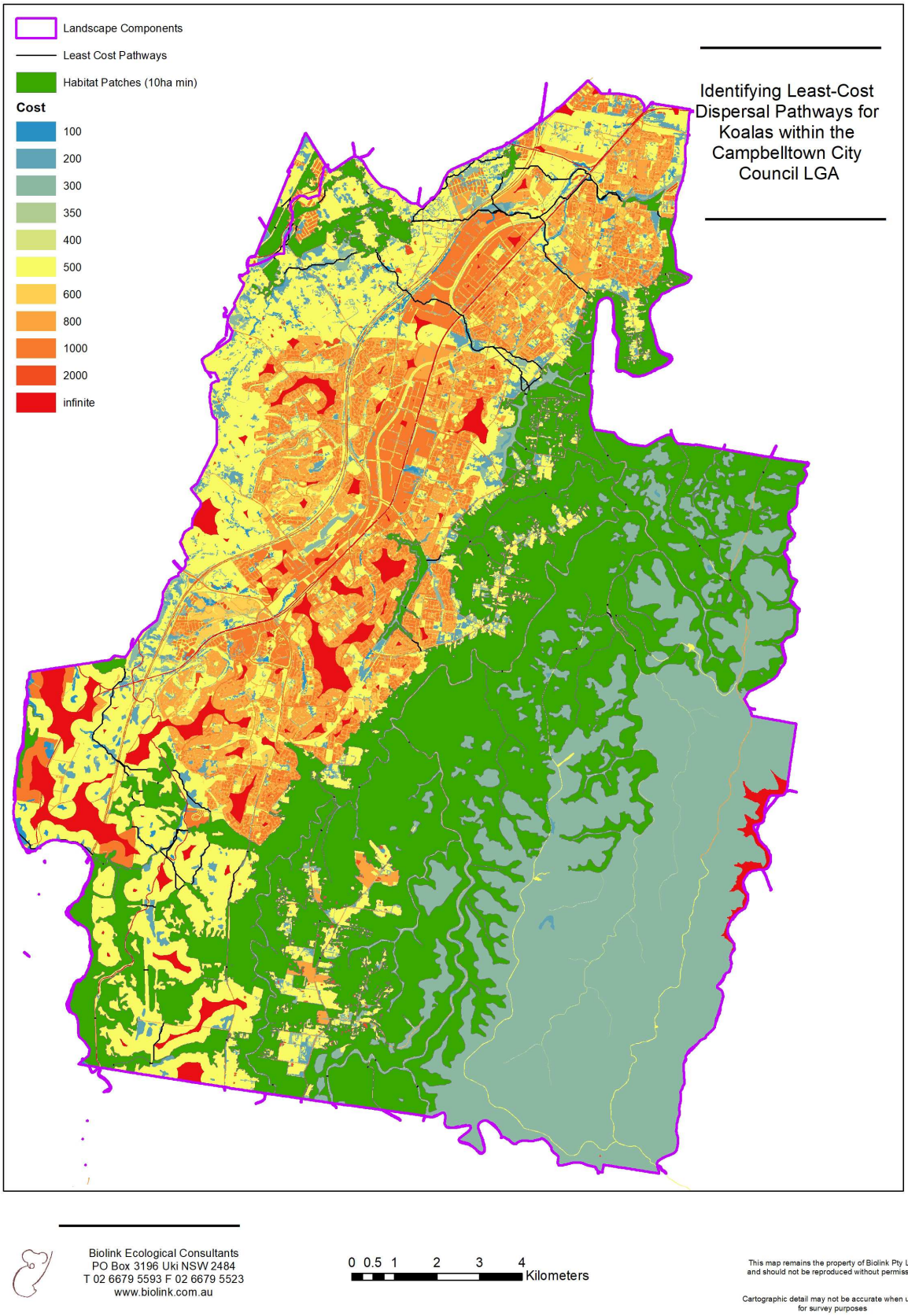


Figure 4: Dispersal cost surface for the CCC LGA which comprises two landscape components (purple outlines) consisting of 47 habitat patches (10 ha minimum size) connected by 85 least-cost pathways, the locations of which are illustrated by black lines.

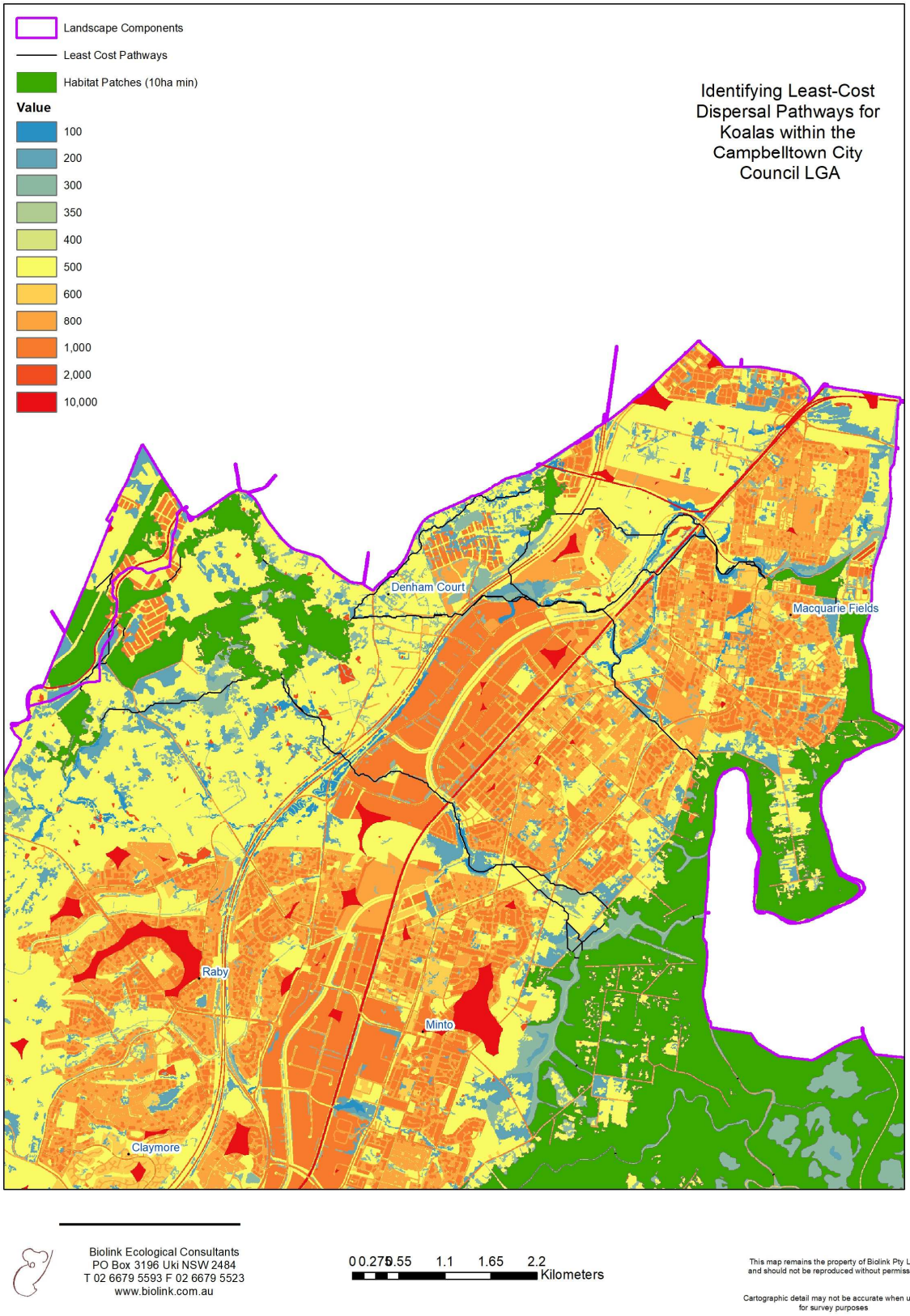


Figure 5: Higher resolution of potential least-cost pathways (black lines) in the northern part of the CCC LGA. Potential for connectivity is dependent upon ribbons of PKH, generally following watercourses, winding through otherwise urban areas; four railways crossings are also incorporated.

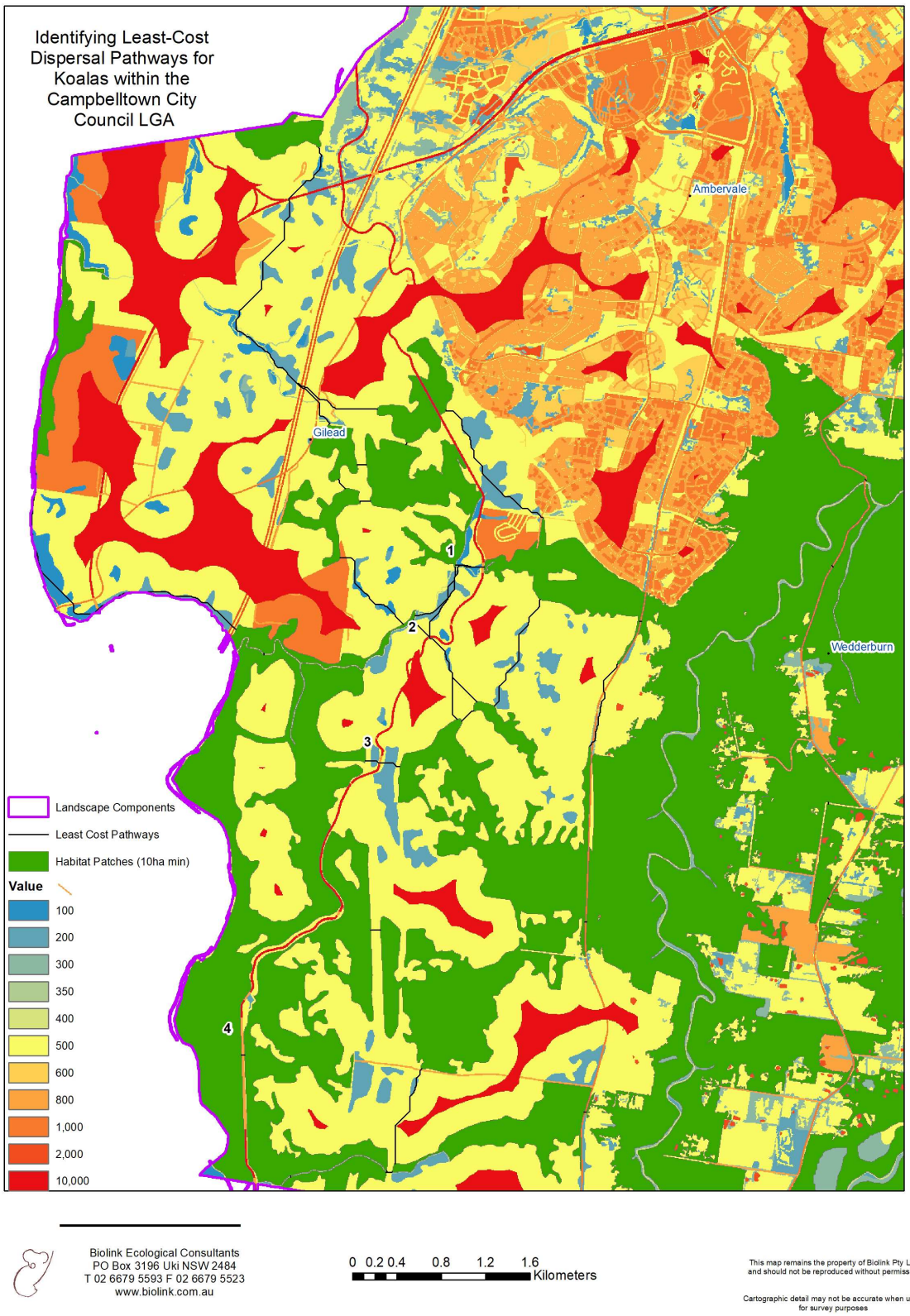


Figure 6: Higher resolution of least-cost pathways (black lines) in the south-western portion of the CCC LGA. East-west movement out of the large habitat patches of the Wedderburn Plateau is dependent upon crossing both Appin Road and the Lachlan Way aqueduct. Areas where aqueduct crossings are theoretically possible are numbered 1 – 4.

East-west connectivity in the north of the LGA from Macquarie Fields towards Denham Court is not discussed in further detail in this report, given the lack of evidence for current koala occupancy in the habitat patches to the north-west (Figure 7). Occupancy in the south is documented for both the east and west of the LGA, with recent movement of koalas from habitat on the Wedderburn Plateau, across Appin Road, through the Beulah biobanking site and as far as the Nepean River near Menangle (Figure 7).

The relative importance of PKH patches across the CCC LGA, as defined by the graph-metrics generated by Graphab, identifies the habitat area along the Georges River between Kentlyn and Wedderburn as the largest and most consolidated for long-term management purposes (Figure 8). Outside of this area, the habitat patch network between the Georges and Nepean Rivers in the vicinity of the Beulah biobanking site is also identified as important. Linkages connecting elements within the large Kentlyn-to-Wedderburn habitat matrix are identified as being the most important to the overall connectivity of study area, while linkages following the Beulah biobanking site and Noorumba Reserve are also identified as substantially contributing to overall connectivity (Figure 8).

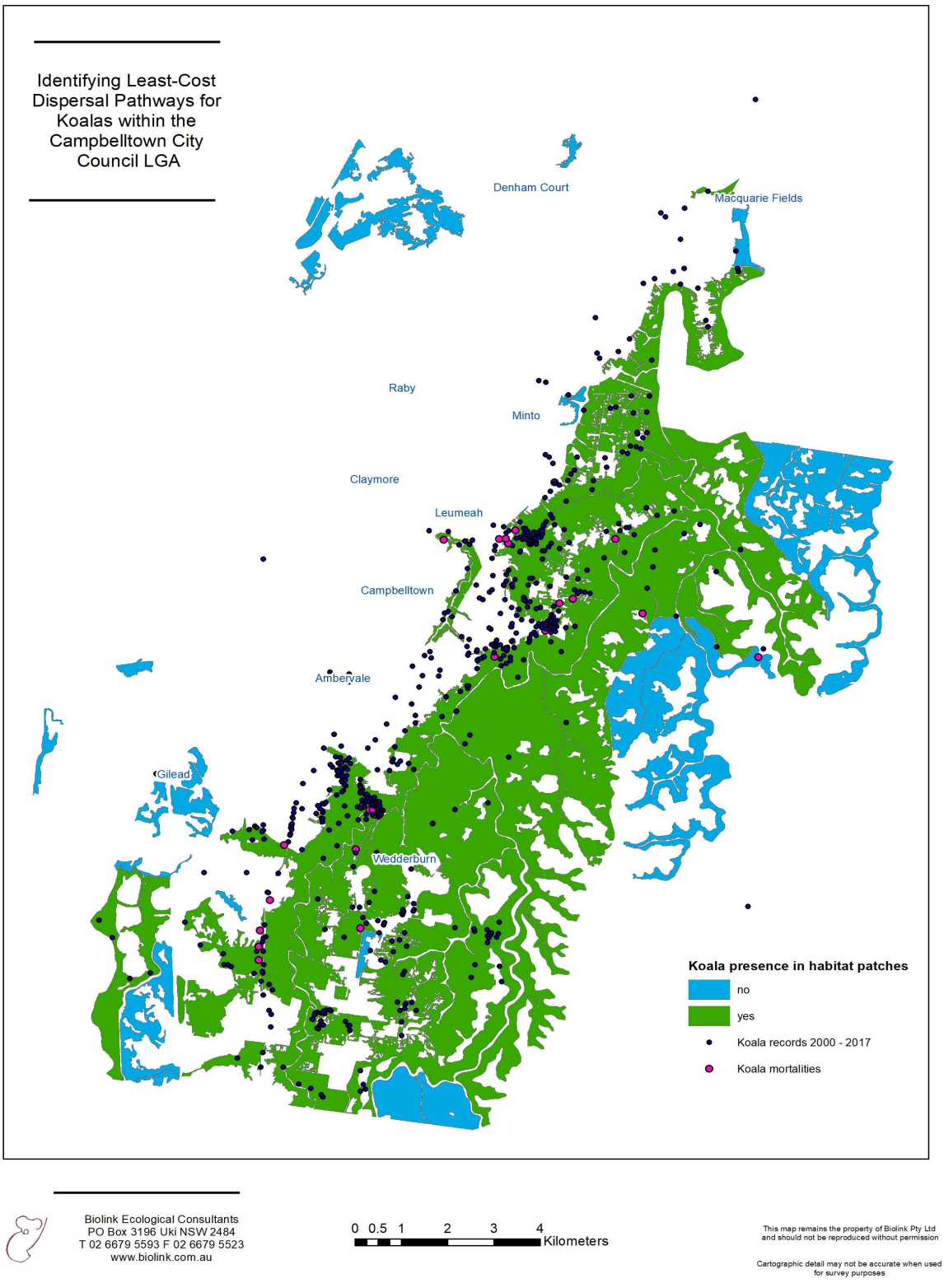


Figure 7: Habitat patches identified by Graphab, here intersected with koala records (shown as black circles) from the most recent koala generation (2011-2017), are coloured green. Habitat patches with no/unknown koala occupancy are coloured blue. The locations of known koala mortalities are shown as pink circles.

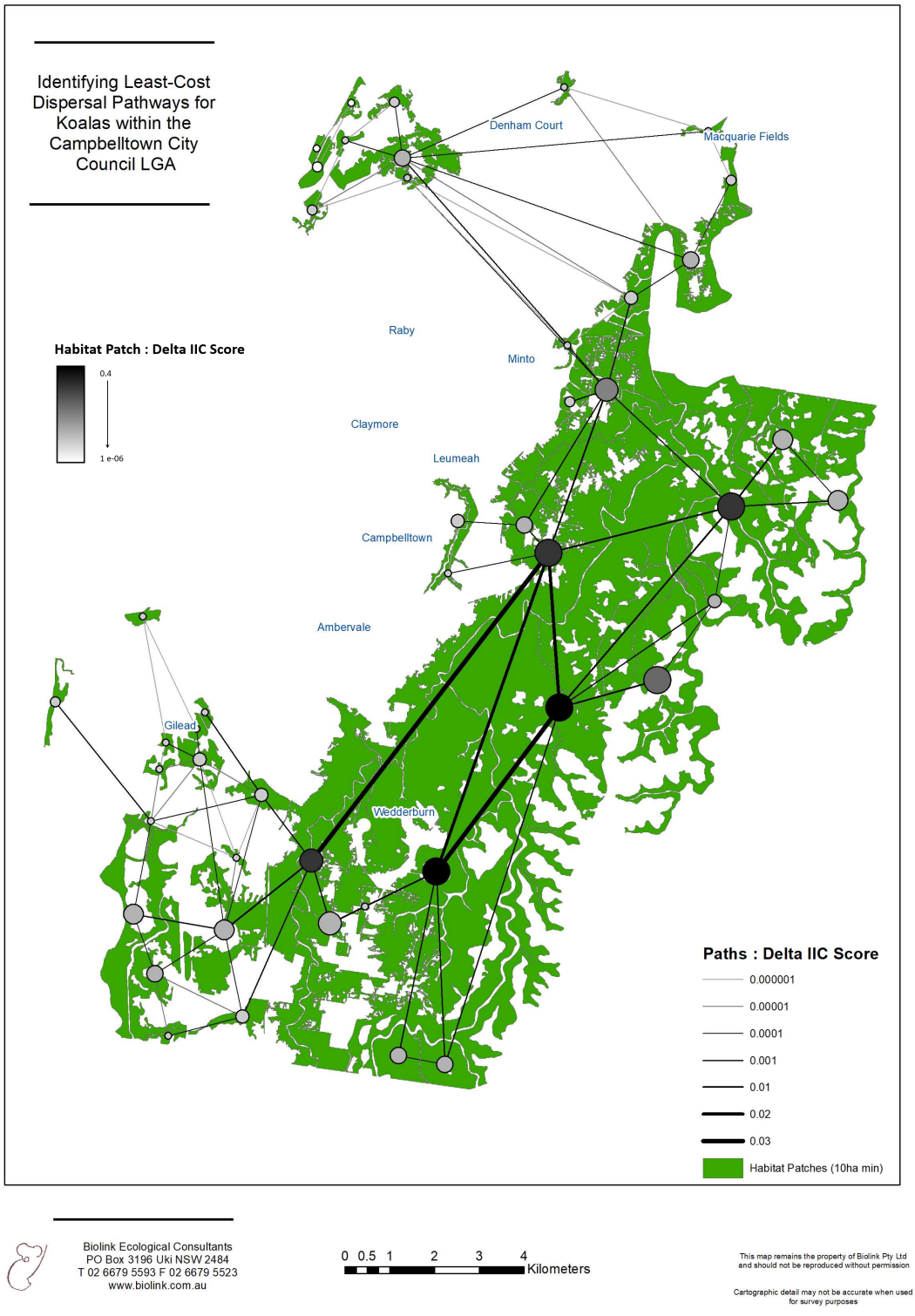


Figure 8: Delta Integral Interconnectivity (DIIC) scores for habitat patches and associated linkages. This metric characterises the importance of patches and linkages to the network and is computed by measuring the effects of patch / linkage removal to overall connectivity. Habitat patches are represented by circles - colour represents their importance (DIIC score) with the most important patches, in terms of their contribution to overall connectivity, shown in the darkest colour (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.

4. Discussion

This project is the first to undertake an informed and objective examination of existing connectivity pathways and linkage opportunities for koalas across the CCC LGA.

Of the 47 habitat patches > 10 ha utilised identified by GAP CLoSR framework, sixteen contain koala records from the most recent three koala generations (2000 - 2017). There are 28 least-cost pathways connecting these currently occupied habitat patches, all of which are located in the east and south-west of the LGA. It is noteworthy that connections between the east and west of the study area are reliant entirely upon successful crossings by koalas of both the Lachlan Way aqueduct and Appin Road between Rosemeadow South and Appin Village. Potential linkages in north of the CCC LGA have also been identified. These are questionable in terms of indicative conservation investments in restoration / rehabilitation because of a lack of evidence for koala occupancy in the very north-west of the LGA (Figure 7) and an absence of connectivity and/or habitat patches to the north in the adjoining Camden Council and Liverpool City Council LGAs.

For the greater part of its route the Lachlan Way aqueduct offers little opportunity for successful crossings by koalas and other non-volant mammals. Fine-scale inspection of satellite imagery however, revealed four areas that offered potential crossing opportunities (locations numbered 1 – 4 respectively in Figure 6 of this report). Of these, crossing 4 is the most substantive (a navigable interface ~ 800 m in width) and thus offers the greatest opportunity through a known area of PKH. From the south, this area connects to a linear strip of riparian habitat associated with Mallaty's Creek which is independently identified as a key east-west linkage across Appin Road between the Georges and Nepean River catchments. Connectivity opportunities to the north are more complex to unravel and/or consolidate but are clearly anchored to the Beulah biobanking site which has also been identified by the GAP CLoSR analysis as fundamental to maintaining east-west linkage. The Beulah site is also associated with access to crossing 3 along The Lachlan Way; this is a 72 m section where the aqueduct is suspended above a gully with PKH on both sides. Elsewhere, crossing 1 is a 100 m section of the aqueduct which is enclosed within piping, with some potential for koala movement under the concrete footings of the pipe. Preferred Koala Habitat abuts this crossing on either side, offering a medium level of potential utility. Crossing 2 is a 4 m wide vehicle bridge with surrounding agricultural land including scattered trees. The nearest PKH is 230 m away on the east and 138 m away to the west, these distances implying a low potential utility in the absence of strategic replanting to consolidate the linkage.

The importance of establishing and maintaining strategic linkages at Rosemeadow, Beulah and Mallaty's Creek as initially identified by the Campbelltown CKPoM is strongly reinforced by the GAP CLoSR analyses, least-cost dispersal pathways across Appin Road being independently identified in all three locations previously identified by BEC (2017). The general area between South Campbelltown and Appin village is also identified as an important patch matrix by the *Graphab* output.

One of the underlying assumptions of the GAP CLoSR approach is the notion of 100% occupancy. 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 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, BEC (2017) promoted an optimal 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 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.

In terms of the south-western LGA, graph metrics independently identified the overall importance of the linkage matrix that currently exists between the Nepean and Georges River catchments in in the area between South Campbelltown and Appin village. Three main pathways are identified by the analyses, the more important of which stems from large habitat area to the east of Appin Road across the Beulah biobanking site and thereafter across the Gilead area to the Nepean River. It follows that this area should notionally become the focus of connectivity planning, the intent to optimise functionality of the existing connectivity network in this area. Other important dispersal pathways in the area between South Campbelltown and Appin village are located at Mallaty's Creek and the Noorumbah Reserve at Rosemeadow respectively. Overriding considerations in this regard are opportunities to traverse the barrier otherwise represented by the Lachlan Way aqueduct. As we have alluded to in terms of the current landscape, crossing areas 1, 3 & 4 in Figure 6 of this report thus become focal points for connectivity planning, the intent of which should be to ensure that potential east-west connectivity outcomes at these locations are not compromised by poor planning decisions/design.

It is clear that future upgrading of Appin Road will need to consider the matter of maintaining connectivity in the broader context of encouraging a final design by government to also reduce the potential for vehicle-strike along the road alignment in this location (mapped in Figure 7). 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 bio-

banking 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.

Recommendations

1. Council engage with NSW Roads & Maritime Services regarding the need for connectivity measures to be provided in the vicinity of Noorumbah Reserve, the Beulah biobanking site and Mallaty's Creek as part of an integrated connectivity outcome for the southwestern corner of the CCC LGA, and
2. Pursuant to 1 above and with a view to effectively connecting the Nepean and Georges River populations, Council strive to consolidate and deliver an east-west corridor design for koalas focussed on least-cost dispersal pathway locations at the Noorumbah Reserve, the Beulah biobanking site and Mallaty's Creek, all of which are to be collectively linked to the Lachlan Way Crossing Points 1, 3 and 4.

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*. Final 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*. Final Report to Campbelltown City Council.

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

Phillips, S. and Callaghan, J. (2000). Tree species preferences of a koala (*Phascolarctos cinereus*) population in the Campbelltown area south-west of Sydney, New South Wales. *Wildlife Research* **27**, 569 - 575.

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.

APPENDIX 1

Standardised resistance surface parameters & associated ecological definitions: Koala (*Phascolarctos cinereus*)

A. Linear Infrastructure

Road Hierarchy (class subtype – function)	**Cost Category**	**Cost Metric**	**Cost defined**
Pathway - Path (unsealed)	n/a	As per surroundings	One lane, pedestrian use; negligible interference with normal movement pattern.
Pathway / Continuity Line - Path (sealed)	n/a	As per surroundings	One lane, pedestrian use; negligible interference with normal movement pattern.
Vehicular Track - Access Way / Track Vehicular (unsealed)	n/a	As per surroundings	Low volume (ADTC < 100), average speed ≤ 25 km hour. Negligible interference with normal movement pattern.
Continuity Line / Standard Road - Urban Service Lane	Medium	500%	Low volume (ADTC < 1000), average speed ≤ 40 km hr.
Continuity Line / Standard Road – Local Road (one lane)	Medium	750%	Low volume (ADTC < 5000), speed < 60 km hr.
Roundabout – any context	High	800%	Cars at decreased speed, 60 – 80 km hr^{-1} even on Distributor/Arterial roads, 10% risk of mortality if crossing attempted.

On-Off ramp – any context	High	800%	Cars at decreased speed, 60 – 80 km hr^{-1} even on Distributor/Arterial Roads, 10% risk of mortality if crossing attempted.
Continuity Line / Dual Carriageway / Standard road - Local Road (two or more lanes)	High	800%	Medium volume (ADTC < 10000), speed limit 60 km hr^{-1}, 20% risk of mortality if crossing attempted.
Standard Road / Dual Carriageway - Primary Road	High	800%	Medium volumes (ADTC < 10000), speed limit 60 km hr^{-1}, 20% risk of mortality if crossing attempted.
Continuity Road / Dual Carriageway / Standard Road - Distributor Road	Very high	1000%	High volume (ADTC > 10000), speed limit 60km – 80 km hr^{-1}, 30% risk of mortality if crossing attempted.
Continuity Line / Dual Carriageway / Standard Road - Arterial Road	Very high	2000%	High volume (ADTC > 15000), speed ≥100 km hour, two or more lanes, 30% risk of mortality if crossing attempted.
Motorway	Extremely high	5000%	Hume Highway, two or more lanes in each direction, high volume (ADTC > 15000), speed ≥ 100 km hour, 75% risk of mortality if crossing attempted.
Railway / Fenced Motorway	Infinite	∞ cost	No access (exclusion fencing present).
Railway under/over passes	High	800%	Exposure and access difficulties
Lachlan Way Aqueduct	Infinite	∞ cost	Vertical walls, no egress (typically exclusion fenced).
Aqueduct bridges	High	800%	Exposure and access difficulties

B. Watercourses

Strahler Stream Order	Cost Category	Cost Metric	Cost defined
1st	n/a	As per surroundings	Ephemeral drainage line. Negligible interference with normal movement pattern.
2nd	n/a	As per surroundings	Ephemeral drainage line. Negligible interference with normal movement pattern.
3rd	Low	350%	Perennial stream, shallow (< 1 m on average), increased vulnerability/exposure, 15% turn back.
4th	Medium	400%	In some cases permanent water / stream flow, deep (> 1 m on average), increased vulnerability/exposure, 25% turn back.
5th	High	600%	Permanently flowing creek or river > 5m wide, > 1m deep on average), 50% turn back.
6th and 7th	High	800%	Permanently flowing river >10 m wide, > 2 m deep; 75% turn back. Includes sections of Bunbury Curran Creek south of Kennett Park, though these are ~2m wide, the surrounding substrate is difficult for koalas to traverse.
6th	Infinite	∞ cost	Steep walled concrete bound section of Bunbury Creek near Kennett Park.
Artificial Wetlands and Lakes	Very high	2000%	Drowning risk in dams and lakes

Woronora Dam	Infinite	∞ cost	Uncrossable

C. Vegetation Cover

Vegetation Type	Cost Category	Cost Metric	Cost Defined
Preferred Koala Habitat			
Primary	No	100%	Enables small home range areas (< 5ha) to be maintained; little mobility cost
Secondary (Class A)	Low	150%	Intermediate home range size (5 – 10 ha); mobility cost increases
Secondary (Class 2B)	Low	200%	Larger home range size (10 – 30 ha); daily movements typically greater than 100 m.
Secondary (Class C)	Low	250%	Requires large home ranges (> 30 ha) to be maintained; daily movements typically greater than 200 m)
Other Vegetation			
Other	Low	300%	No PKFTs, shelter available but large movements required to traverse
Unclassified / Unknown vegetation	Low	300%	As above

Grassland (scattered trees)	Medium	500%	Some refuge opportunities, large movements required to traverse.
Grassland (no trees)	High	800%	No refuge opportunities, large movements required to traverse.

D. Land Use

Land use Type	Cost Category	Cost Metric	Cost Defined
Intensive cropping / grazing	High	800%	As for Grassland (no trees)
Mining and Quarrying	Very High	1000%	Habitat limiting
Industrial / shopping centres / carparks	Very High	1000%	Habitat limiting
Low-Medium density urban (Lot sizes >2,400m^2)	Medium	500%	Habitat ± PKFTs, as per Grasslands – scattered trees (Table C)
Medium density urban (Lot sizes 1,200 – 2,400 m^2)	Very High	1000%	Habitat ± PKFTs, high risk of domestic dog attack
High-Medium density urban (Lot sizes 600 – 1,200 m^2)	Very High	1500%	Habitat ± PKFTs, high risk of domestic dog attack
High density urban (Lot sizes < 600m^2)	Very High	2000%	Habitat limiting, at high risk of domestic dog attack

E. Ancillary Koala Ecology Considerations / Metrics

1. Minimum patch size: some research suggests 50 ha as minimum habitat requirement (McAlpine *et al*., 2007), however available data suggests that the minimum patch size is considerably smaller. In order to optimise outcomes in terms of the numbers of least-cost dispersal pathways, we run analyses utilising a minimum patch sizes of 10 ha.
2. Gap-crossing threshold: Maximum distance an individual koala will move between two structural connectivity elements / stepping stones: 220 m
3. Inter-patch gap crossing distance: The maximum distance that individuals will move between patches, providing there is some kind of structural connectivity element such as stepping stones *(e.g.* scattered paddock trees) or non-PKH vegetated corridors: 6km (Dique *et al*., 2003; Norman *et al*., in press), the latter dispersal measure based on genetic data.

References

Dique, D., Thompson, J., Preece, H.J., de Villiers, D and Carrick, F.N. 2003. Dispersal patterns in a regional koala population in south-east Queensland. *Wildlife Research* **30**: 281 – 290.

McAlpine, C., Rhodes, J., Peterson, A., Possingham, H. Callaghan, H. Curran, J. Mitchell, D. and Lunney, D. 2007. *Planning guidelines for koala conservation and recovery: A guide to best planning practice.* Australian Koala Foundation and the University of Queensland. Brisbane, Australia.

Norman, J. A., Phillips, S., Blackmore, C., Goldingay, R., and Christidis, L. in press. Parallel inference improves estimation of recent migration when sampling is sub-optimal: an empirical evaluation of source-sink dynamics in the koala *Phascolarctos cinereus*. *Methods in Ecology and Evolution*.