KOALA SPATIAL DATASET AUDIT

TO SUPPORT THE SPATIAL PRIORITISATION OF LANDS FOR
INVESTMENT ACROSS NSW

A REPORT PREPARED FOR THE OFFICE OF ENVIRONMENT AND HERITAGE
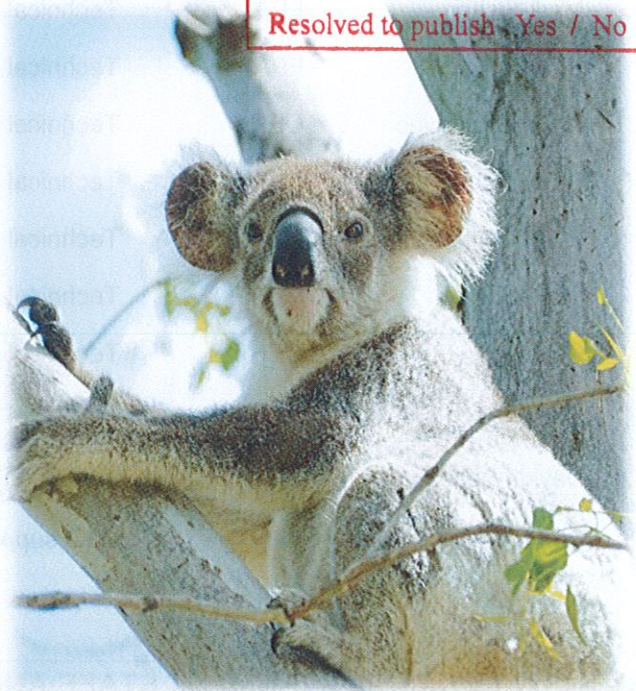
BRENDAN RENNISON

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DOCUMENT CONTROL

DRAFT 1	Prepared by: Brendan Rennison	14/02/2017
	Reviewed by Mark Fisher	25/10/2017
FINAL	Prepared by: Brendan Rennison	1/11/2017

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NSW AGENCY STAFF

John Turbill	OEH	Project Management
Mark Fisher	EPA	Technical advice
Bill Faulkner	EPA	Technical advice
Martin Predavec	OEH	Technical advice
David Scotts	OEH	Technical advice
Kylie Madden	OEH	Technical advice
Jill Smith	OEH	Technical advice
Chris Allen	OEH	Technical advice
Rod Pietsch	OEH	Technical advice
David Fuchs	OEH	NARCLiM modelling – Adapt NSW
Brad Law	DPI	Data supply and technical advice

NSW LOCAL GOVERNMENT STAFF AND PRIVATE CONSULTANTS

Appendix 3 contains a full list of local government staff and private consultants contacted during the course of the compilation of information for this audit.

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INTRODUCTION

This project has been funded under the Saving our Species Iconic Koala project to provide support and strategic direction to future priorities in conservation actions for the koala. The project is one of a number of projects designed to data driven (evidence based) decision making for koala conservation in NSW.

The project was designed to be completed over a 6 month period (to June 2017) and run over 2 stages. Stage 1 addressed 3 objectives:

Audit of State-wide Spatial Datasets

Assessment of the current Reservation Systems and Protection of Koalas within the Bioregional Areas of NSW

Development and implementation of trial prioritisation analysis of occupied koala habitat for acquisition in pilot areas (one or two areas).

This report addresses the objective of stage 1 of the project. Stage 2 will further develop the framework trialed in stage 1` with the objective of implementing a framework for the prioritisation of Saving our Species Iconic Koala projects.

OVERALL PROJECT OBJECTIVES

To provide an assessment of data sources regarding koala populations and koala habitat. Potential data sources are to be assessed and ranked for relevance, adequacy, practicality and recommended scale of use.

To identify the following features for consideration in the prioritisation for koala recovery actions and lands for investment.

- important regional koala populations
- koala observations
- local koala hubs
- areas of generational persistence of resident koala occupancy
- areas of preferred habitat
- refuge areas
- wildlife corridors.
- threats and threatening processes.

PROJECT TASKS

1. Collate spatial datasets at a range of scales relevant to koalas including, suitable habitat, koala occupancy, corridors, refugia and other variable such as soil fertility and moisture together with landscape scale threats such as heat stress, land clearing, fire and forestry.
2. Assess and rank each dataset for suitability for analysis and inclusion in a koala population prioritisation process.
3. Collate and present summary information for these datasets.

CATEGORIES OF DATA ASSESSED

Datasets for this study have been assessed and reported on within a number of categories. These categories reflect the types of data referred to in the project charter and also those that are anticipated to be useful for inclusion in the threat assessment and prioritisation process.

Table 1   Categories of datasets presenting in the spatial data audit

Data Category	Data Description
Occurrence (site based observations)	Records of koala observations primarily kept in the ATLAS of NSW Wildlife
Existing conservation priority mapping	Existing studies which present conservation prioritisation for koalas
Habitat Mapping	Mapping of preferred and Core koala habitat, mainly from CKPoMs and habitat studies
Habitat Suitability Modelling	Statistical modelling of koala habitat suitability from various sources including agency programs (Comprehensive Regional Assessments and other).
Occurrence modelling	Mapping of areas of likely koala occupancy based on past records. Includes Modelling of the likelihood of occurrence of koalas based on community based survey information.
Identified Populations and barriers to movement	Mapping which identifies known populations of koalas. This includes local populations identified in CKPoMs and regional populations identified in broader regional studies. Mapped barriers to koala movement in the landscape, both natural (e.g. rivers) and man-made (e.g. motor-ways).
Koala Care Information	Collated data from koala care groups across NSW
Habitat Connectivity	Data relating to connectivity of habitat. Data may be koala specific (from CKPoMs) or general (from regional studies).
Koala Management Boundaries	Boundaries of koala management areas, primarily relating to CKPoMs.
Refugia	Mapping of areas of real or predicted future refugia for koalas
Threats/Risks	Mapping of threating processes and surrogates for known koala threats

Each dataset reviewed in the audit has been assessed against a number of criteria, summarized in table 2 below. The criteria relate to the nature of each dataset, it's geographic range, whether it is likely to be available for use in analyses and at what scale of analysis it might be best applied.

Table 2   Criteria for review of datasets in the spatial data audit

Information collated for each dataset	Description
Title	Title of Dataset (As published)
Description	Short description of dataset
Category	Category of dataset (as described in table 1 above)
Data type	Polygon feature, point feature or raster
Custodianship	Owner or manager of dataset
Attributes collected	Description of attribute data held within dataset.
Availability	Held by OEH or can be obtained
Currency of data	Date of capture (or date of underlying information)
Scale of capture and usefulness for analysis	Rank of appropriate scale for analysis State Scale (Geographic e.g. IBRA), Regional Scale, Local scale and Property scale.
Extent of data	A description of the geographic extent of each dataset
Category of data	Category of attributes collected by data. Categories include habitat classes, activity, planning areas, population boundaries, corridors.
Availability	Availability of data. Held by OEH, availability for acquisition or not available.
Licence constraints	Information on whether a data licence agreement is likely to be required.
Citation	Citation for report if available or link to metadata statement

REVIEW OF DATASETS AVAILABLE FROM PUBLISHED LITERATURE

A wide range of literature has been published relating to koala behavior and koala habitat and other data. Many of the available studies have been published by councils (KPoMs and habitat studies) or NSW government agencies (habitat modelling, habitat mapping, threats analysis and other research.

A number of other prominent non-government organisations such as The National Parks Association and the Australian Koala Foundation have published literature concerning the distribution and status of koala populations and habitat across NSW.

Academic institutions including the University of Sydney, Western Sydney University, University of Melbourne and the University of Queensland have undertaken a number of studies and also habitat modelling projects in NSW which have proven to be useful for inclusion in this audit.

Consultancy firms including Biolink, Eco-Logical Australia and Greenloaning Biostudies Pty Ltd have made substantial contributions to the literature and overall knowledge base of koala science in NSW.

REVIEW OF OEH AND OTHER PUBLISHED NSW AGENCY DATASETS

A number of datasets produced by NSW public agencies remain unpublished and documented only through metadata statements available on the NSW Spatial Data Catalogue or on agency corporate data systems (NSW OEH, DPI and RMS). These datasets can best be understood and obtained through liaison with relevant data managers and data searches.

CONSULTATION WITH LOCAL GOVERNMENT STAFF AND KOALA ECOLOGY CONSULTANTS

Much of the fine-scale habitat data useful for property level assessments of koala occupancy and koala habitat have been undertaken for local councils either by local council staff or by consultants to engaged by these local councils.

Extensive consultation with consultants and local council planners and environmental staff has been undertaken to ensure that, as far as possible, the most recent published data has been included.

Appendix 3 contains a list of councils, private consultants and government staff consulted in the preparation of material for this report.

A total of 154 datasets were reviewed as part of this audit. The majority of datasets related to either koala habitat mapping, habitat modelling or threat surrogates. Land ownership and management data have been included in the audit, although not reviewed thoroughly in the following chapters, as they were thought important for viability analysis.

Table 3 below summarises the datasets reviewed in the audit. The full results data has been included as appendix 2 of this report.

Table 3   *Summary of dataset types reviewed in the spatial data audit*

Dataset Category	Number of datasets
Occurrence (observations)	15
Existing Conservation Priority Mapping	6
Habitat Mapping	25
Habitat Modelling	16
Occurrence modelling	2
Identified Populations and barriers to movement	10
Koala Care information	3
Habitat Connectivity	11
Koala Management Boundaries	14
Land ownership and management	15
Refugia	1
Threats and surrogates	36
Grand Total	**154**

Datasets relating to koala management boundaries and conservation priority mapping have not been presented in detail in this report. Datasets relating to land ownership and management have been presented (in part) as they relate to threat and risk mapping.

OCCURRENCE (SITE BASED OBSERVATIONS)

A map of likelihood of koala occurrence was developed by OEH in 2015 (OEH 2015). As part of this project, a koala sites database was compiled and filtered, removing obvious duplicates and other spurious records. The Predavec report compiled records up to March 2015. Several other databases with koala sighting information were identified which had the potential to add significantly to the recorded distribution of koalas in NSW.

To gain a further understanding of the overall survey effort underpinning the distribution of koala records, a second database of other arboreal mammals was compiled. The comparison of koala observation density with the overall arboreal mammal observation density can be used to give an indication of confidence to any measure of likelihood of occurrence, especially in instances where koalas observations are absent from an area (Predavec et al. 2015).

Six separate datasets were compiled and filtered to form the koala sightings information presented in this report.

Table 4   Source datasets for NSW compiled koala observations

Source	Description	Records
OEH (2015)	ATLAS records filtered for duplicates and spurious information. Dates from 1/1/1990 – 26/03/2015.	20,343
OEH (2016) – Bionet	Interim collation of Bionet ATLAS of NSW Wildlife data using methods of Predavec (2016) from 26/3/2015 – 17/2/2016.	666
Bionet – ATLAS of NSW Wildlife	Export of Koala records from 17/2/2016 – 12/12/2016. Filtered using methods of Predavec (2016).	308
Phillips SAT (Phillips 2016)	SAT data collected by Dr. Stephen Phillips. Includes data compiled as part of a number of Comprehensive Koala Plans of Management. These data are not included in Bionet.	616
OEH 2016 – SAT	SAT data supplied by Chris Allen (OEH), December 2016. These data are not included in Bionet.	406
RAPID SAT (Phillips and Wallis 2016)	Rapid SAT surveys undertaken by Dr. Stephen Phillips and OEH between April – June 2016.	85
Koala Count 2015 (NPA 2016)	Community surveys undertaken by NSW NPA in Western Woodlands (2015)	29
All Sources	Total of all compiled source data	22,453

The Atlas of Living Australia (ALA 2017) also contains a number of koala observations across NSW including important community based projects. Although not included in table 4, ALA data are becoming increasingly relevant for inclusion in any collation of koala observation information.

The 'Other Arboreals' dataset was compiled using primarily the Bionet ATLAS of NSW Wildlife data. For this purpose, a total of 117,116 observations were compiled across NSW. Methods of filtering were identical to those described below. SAT sites with a negative result for koala activity were also included in the 'other arboreals' database to reflect survey effort.

The methods used for filtering of the site data were established by Predavec (OEH 2015). They have 6 basic steps which are outlined below.

1. Removal of observations outside of NSW
2. Removal of observations with a spatial accuracy greater than 10km

3. Remove data with spurious observation information (e.g. observation type 'beached')
4. Remove duplicate data. Observations with the same date, observer and location were filtered to a single observation.
5. Removal of observations prior to 1990.
6. SAT data was filtered only to include active sites in koala records database.

Figure 1 below shows all the koala observations collated for NSW after the filtering process was completed. The observations have been sorted into 6 year periods to reflect koala generations.

A list of koala observations has been included as Appendix 1. This details surveys which make up the dataset and the number of observations in each.

Figure 1 Koala observations in NSW by generation (1990 – 2016)
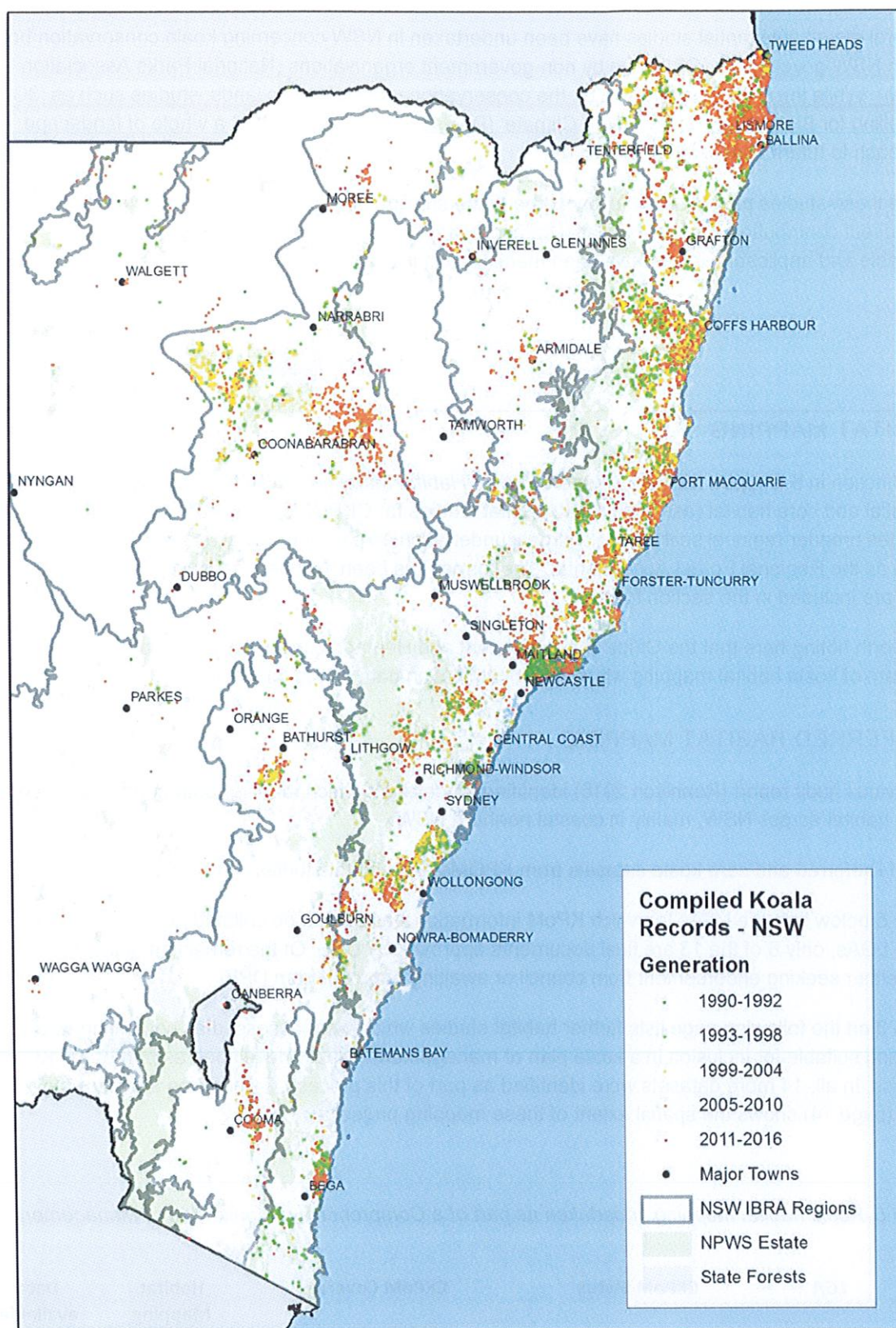
EXISTING CONSERVATION PRIORITY MAPPING

Several recent substantial studies have been undertaken in NSW concerning koala conservation both within NSW government (OEH) and by non-government organisations (National Parks Association (NPA)). While the NPA studies focus on the conservation value of public lands, studies such as '3C Modelling for Biodiversity under Future Climate' (Drielsma et al. 2015) adopt a whole of landscape approach to future conservation planning.

While these studies provide a useful backdrop to the current focus of Saving Our Species programs, their direct contribution in terms of spatial datasets for analysis is limited. Where datasets are available and applicable, these have been mentioned in the audit specifically.

HABITAT MAPPING

A distinction in this report has been made between *Habitat Mapping*, which focusses on mapping of potential and core habitat (associated with habitat studies for CKPOMs), and *Habitat Modelling*, which includes broader regional scale models largely undertaken as part of regional assessment processes (such as the Regional Forest Agreements). The former has been included in this section, whilst the latter are included in the section following.

It is worth noting here that the Office of Environment and Heritage currently have a state-wide program of koala habitat mapping which has a completion date aimed for 2019.

PREFERRED HABITAT MAPPING

A previous audit report (Rennison 2016) identified 27 datasets which mapped both potential and core koala habitat across NSW, mainly in coastal northern NSW.

List of Preferred and core koala datasets from KPOMs and habitat studies

Table 5 below lists the LGAs for which KPoM information was able to be collated and reported. Of these LGAs, only 6 of the 13 are final documents approved by DPE. Of the remaining plans, most are draft either seeking endorsement from council or awaiting approval from DPE.

Table 3 on the following page lists further habitat studies which were assessed as containing habitat mapping suitable for inclusion in a koala plan of management, usually developed as part of the KPoM process. In all, 14 more datasets were identified as part of this process. Figure 2 on the following page (page 14) shows the spatial extent of these mapping projects.

Table 5 Koala habitat mapping undertaken as part of a Comprehensive Koala Plan of Management

LGA	CKPoM Status	CKPoM Coverage	Habitat Mapping Status	Data available
Ballina	Approved by DPE.	Part shire (mainly western uplands)	Preferred and Core	Yes

Bellingen	Approved by DPE.	Coastal area	Preferred and Core	Yes
Byron	Draft. Currently being considered by council.	Byron coast only	Preferred and Core	No
Campbelltown	Adopted by Council.	Shire-wide	Preferred and Core	Yes
Clarence Valley	Draft. Currently being considered by council.	Ashby, Woombah and Iluka koala management areas	Preferred and Core	Yes
Coffs Harbour	Approved by DPE.	Shire wide excluding Corindi and Arrawarra.	Preferred and Core	Yes
Cooma - Monaro	Draft - public exhibition 2015	Part shire.	Preferred and Core	Yes
Greater Taree	Draft. Unlikely to be approved by council.	Shire-wide	Preferred only	Yes
Kempsey	Approved by DPE.	East of Pacific Highway only	Preferred and Core	Yes
Lismore	Approved by DPE.	South-east Lismore	Preferred only	Yes
Port Macquarie / Hastings	Currently being drafted.	East only	Preferred only	Yes
Port Stephens	Approved by DPE.	Shire wide	Preferred only	Yes
Tweed	Adopted by council. Currently being considered for approval by DPE	Tweed coast only	Preferred and Core	Yes

Table 6 Other koala habitat mapping datasets suitable for preferred koala habitat (SEPP 44) purposes.

LGA	Dataset name	Coverage	Habitat Mapping Status	Data available
Gunnedah	Gunnedah Koala Strategy	Part (central) LGA	Preferred only	No
Moree Plains	Moree Plains Shire Koala Habitat Mapping	Shire wide	Preferred only	Yes
Nambucca	Draft Koala Habitat Study	Coastal area	Preferred and Core	Yes

Richmond Valley	Koala Habitat and Population Assessment	Shire wide	Preferred only	No*
Tweed	Tweed Shire Council Koala Habitat Categories (2009 unpublished)	Shire-wide	Preferred only	Yes
Byron	Byron Shire Koala Habitat Mapping 2015 (Unpublished)	Coast and hinterland	Preferred only	No*
Byron	Byron Shire Koala Habitat Mapping 2007 (Unpublished)	Shire-wide	Preferred only	Yes
Coffs Harbour	Coffs Harbour Shire Koala Habitat Categories 2009	Shire-wide (including northern addition to LGA)	Preferred only	Yes
Kempsey	GHD 2007. Vegetation mapping and Koala Habitat Categories	Western portion of Kempsey Shire	Preferred only	Yes
Port Macquarie – Hastings	Biolink 2015 Koala Habitat Mapping Categories	Western portion of LGA	Preferred only	Yes
Port Macquarie – Hastings	Biolink 2015 koala activity contours	Shire-wide	Activity	Yes
Port Stephens	Port Stephens Koala Habitat Categories (2007 unpublished)	Shire-wide	Preferred only	Yes
Various	AKF Koala Habitat ATLAS	See figure 2 below	Preferred only	No
*Wingecarribee**	Southern Highlands Koala Conservation Project	Shire-wide	Preferred only	No

Figure 2 Preferred Habitat Mapping in NSW (CKPoMs and Koala Habitat Studies for Koala Strategies and Planning)

Legend:

• Major Towns

Koala Habitat Mapping in NSW
Mapping Status

No Suitable Mapping
Approved CKPoM
Draft CKPoM (or in progress)
Habitat Study Only
IBRA v7
NPWS Estate
State Forests

0 20 40   80 Kilometres
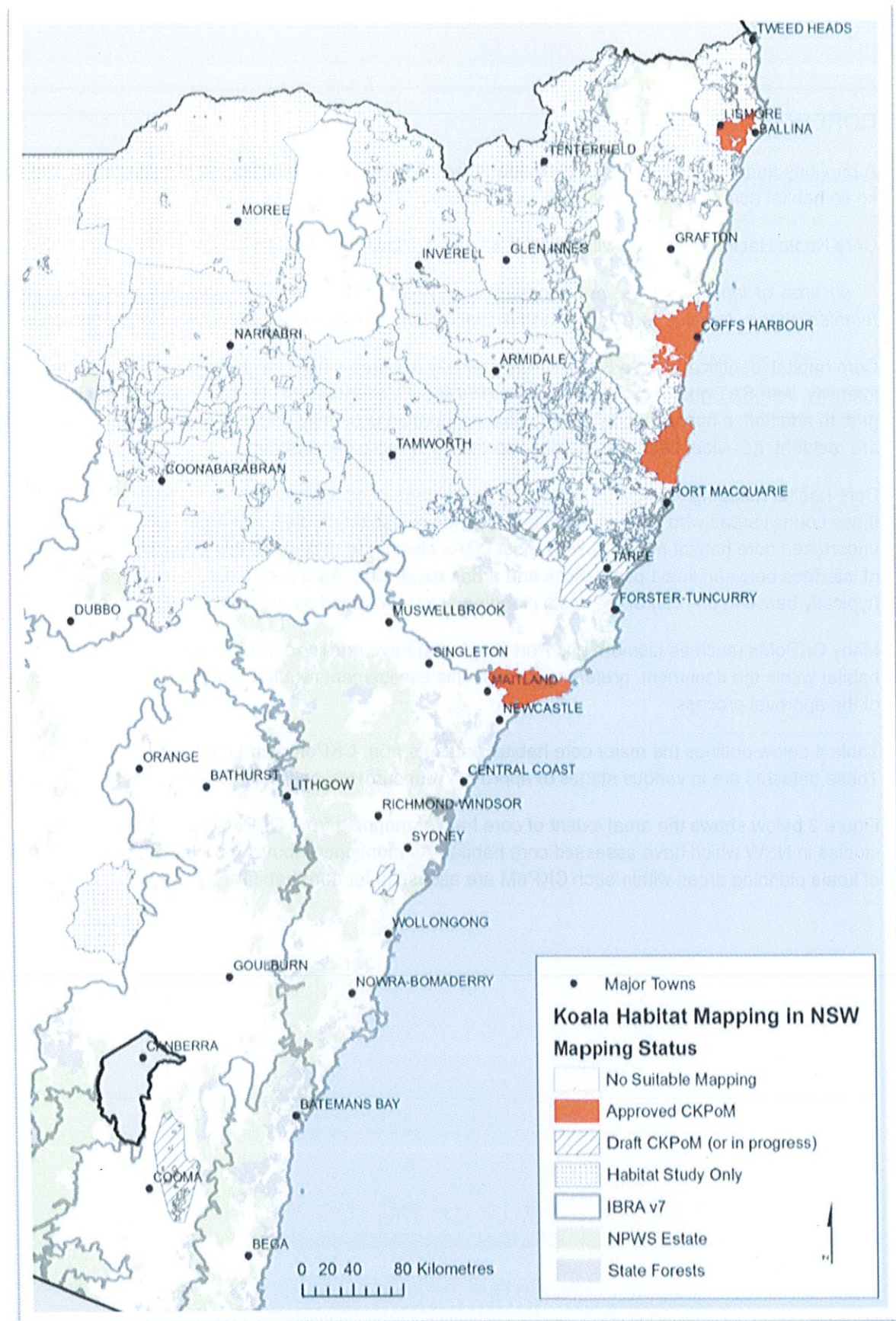
CORE HABITAT MAPPING

A previous audit report (Rennison 2016) identified 27 datasets which mapped both preferred and core koala habitat across NSW, mainly in coastal northern NSW.

Core Koala Habitat is defined within SEPP 44 (Dept. Planning 1995) as:

".. 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."

Core habitat identification in a Koala KPoM typically requires a high level of rigor with regard to survey intensity, with SAT grid based assessments (Phillips & Callaghan 2011) often undertaken on a 500m grid. In addition, a historical analysis of koala occupation is usually undertaken to establish that koalas are resident, as evidenced by continued use over 3 or more generations.

Core habitat mapping represents only a tiny percentage of occupied resident koala habitat in NSW. Of those council areas who have undertaken CKPoMs or habitat studies, less than half (10 of 22) have undertaken core habitat mapping, with most LGAs electing to undertake this mapping only over areas of interface between koala populations and urban expansion. As a result, only a minor percentage (typically between 3 – 7%) of the koala planning area is mapped as core habitat (Rennison 2016).

Many CKPoMs (such as Lismore and Port Stephens) have refrained from spatially defining core habitat within the document, preferring to defer this assessment requirement to be undertaken as part of the approval process.

Table 4 below outlines the major core habitat datasets from CKPoMs and habitat studies in NSW. These datasets are in various stages of approval, with currently only four CKPoMs approved by DPE.

Figure 3 below shows the areal extent of core habitat mapping from CKPoMs and other habitat studies in NSW which have assessed core habitat. As mentioned above, often only a small proportion of koala planning areas within each CKPoM are assessed for core habitat.

Figure 3   *Core Habitat Mapping in NSW (CKPoMs and Koala Habitat Studies)*

Table 7   Core and Potential Habitat datasets from Koala Plans of Management and Koala Habitat Studies in NSW

Dataset Name	Description of information	Extent	Scale of capture / precision	Attributes Collected	Custodian	Citation	Licencing Constraints	Notes
KPoM compilation and analysis (Rennison 2016)	Centralised register of spatial information relating to potential koala habitat as mapped across NSW by studies undertaken to an acceptable standard	LGA	Variable. Typically 1:25,000.	Preferred Koala Habitat classes	NSW Councils	EPA 2016	Licence agreements generally required by LGAs	Updates and additions to data required.
KPoM compilation and analysis (Rennison 2016)	Centralised register of spatial information relating to core koala habitat as mapped across NSW by studies undertaken to an acceptable standard	LGA	Variable. Typically 1:25,000.	Core koala habitat	NSW Councils	EPA 2016	Licence agreements generally required by LGAs	Updates and additions to data required.
Tweed CKPoM Preferred and Core Koala Habitat	Preferred and Core Koala Habitat Mapping undertaken within the Tweed Coast Comprehensive Koala Plan of Management	Tweed Shire KPA	Property scale	Preferred Koala Habitat classes; Core Koala Habitat	Tweed Shire Council	Phillips, S., Hopkins, M. and Shelton, M. 2011. Tweed Coast Koala Habitat Study. Unpublished report to Tweed Shire Council. Biolink Ecological Consultants, Uki.	Licence agreement with Tweed Shire Council	
Byron Koala habitat categories	Preferred Habitat Mapping	Byron Shire KPA	Property scale	Preferred Koala Habitat classes	Byron Shire Council	Byron Shire Council (2015) Byron Coast Comprehensive Koala Plan of Management. Byron Shire Council, Mullumbimby, NSW.	Licence agreement with Byron Shire Council	

Dataset Name	Description of information	Extent	Scale of capture / precision	Attributes Collected	Custodian	Citation	Licencing Constraints	Notes
Ballina Preferred Koala Habitat	Preferred Habitat Mapping	Ballina Shire KPA	Property scale	Preferred Koala Habitat classes	Ballina Shire Council	Biolink Ecological Consultants. November 2013. Koala Habitat and Population Assessment: Ballina Shire Council. Report to Ballina Shire Council.	Licence agreement with Ballina Shire Council	
Lismore Koala habitat categories	Preferred Habitat Mapping	Lismore City KPA	Regional	Preferred Koala Habitat classes	Lismore City Council	Lismore City Council (2013) Comprehensive Koala Plan of Management for south-east Lismore. Lismore City Council, Lismore, NSW.	Licence agreement with Lismore City Council	
Clarence Valley Koala habitat categories	Preferred Habitat Mapping	Woombah Iluka and Ashby localities	Property scale	Preferred Koala Habitat classes	Clarence Valley Council	Phillips S, Forsman H (2002) Assessment of Core Koala Habitat in the Woombah and Ashby areas of the Maclean LGA. Prepared for Maclean Shire Council by Biolink, Uki, NSW	Check with Rodney Wright, Clarence Valley Council	
Clarence Valley Core koala habitat	Core Koala Habitat	Woombah Iluka and Ashby localities	Property scale	Core koala habitat	Clarence Valley Council	Phillips S, Forsman H (2002) Assessment of Core Koala Habitat in the Woombah and Ashby areas of the Maclean LGA. Prepared for Maclean Shire Council by Biolink, Uki, NSW	Check with Rodney Wright, Clarence Valley Council	

Dataset Name	Description of information	Extent	Scale of capture / precision	Attributes Collected	Custodian	Citation	Licencing Constraints	Notes
Coffs Harbour Preferred Koala Habitat	Preferred Habitat Mapping	Coffs harbour LGA (not including Corindi and Red Rock)	Property scale	Core koala habitat	Coffs Harbour City Council	Lunney, D., Moon, C., Matthews, A., and Turbill, J. 1999. Coffs Harbour City Koala Plan of Management. Part A The Plan. NSW National Parks and Wildlife Service, Hurstville.	Not required	
Bellingen Preferred Koala Habitat	Preferred Habitat Mapping	Bellingen Coastal Area	Property scale	Preferred Koala Habitat classes	Bellingen Shire Council and OEH	Office of Environment and Heritage, 2014. Koala Habitat Study, Bellingen Shire Council Coastal Area. Report to Bellingen Shire Council. June 2014.	Not required	
Bellingen Core koala habitat	Core Koala Habitat	Bellingen Coastal Area	Property scale	Core koala habitat	Bellingen Shire Council and OEH	Office of Environment and Heritage, 2014. Koala Habitat Study, Bellingen Shire Council Coastal Area. Report to Bellingen Shire Council. June 2014.	Not required	
Nambucca Preferred Koala Habitat	Preferred Habitat Mapping	Nambucca Coastal Area	Property scale	Preferred Koala Habitat classes	Nambucca Shire Council and OEH	Office of Environment and Heritage, 2015. Koala Habitat Study for the Nambucca Shire Council Coastal Area. Report to Nambucca Shire Council. December 2015.	Not required	
Nambucca Koala planning area	Core Koala Habitat	Nambucca Coastal Area	Property scale	Core koala habitat	Nambucca Shire Council and OEH	Office of Environment and Heritage, 2015. Koala Habitat Study for the Nambucca Shire Council Coastal Area. Report to Nambucca Shire Council. December 2015.	Not required	

Dataset Name	Description of information	Extent	Scale of capture / precision	Attributes Collected	Custodian	Citation	Licencing Constraints	Notes
Kempsey Preferred Koala Habitat (East)	Preferred Habitat Mapping	Kempsey Shire Council (Eastern portion)	Property scale	Preferred Koala Habitat classes	Kempsey Shire Council	Telfer, D. and Kendall, P. 2006. Native Vegetation and Candidate Endangered Ecological Community Mapping Report. Kempsey LGA	Licence agreement required with Kempsey Shire Council	
Kempsey Preferred Koala Habitat (West)	Preferred Habitat Mapping	Kempsey Shire Council (Western portion)	Regional	Preferred Koala Habitat classes	Kempsey Shire Council	GHD. 2007. Report for Vegetation Mapping for Western Portion Kempsey LGA. Background Report. Report to Kempsey Shire Council.	Licence agreement required with Kempsey Shire Council	
Kempsey Core koala habitat	Core Koala Habitat	Kempsey East and Kempsey South study areas	Property scale	Core koala habitat	Kempsey Shire Council	Biolink (2011). Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA. A report for the Kempsey Shire Council. April 2011.	Licence agreement required with Kempsey Shire Council	
Port Macquarie Preferred Koala Habitat	Preferred Habitat Mapping	Port Macquarie - Hastings LGA freehold only	Property scale	Preferred Koala Habitat classes	Port Macquarie - Hastings council	Port Macquarie Hastings Koala Habitat & Population Assessment. Final Report to Port Macquarie - Hastings Council. February 2013.	Licence agreement required with Port Macquarie - Hastings Council	
Port Macquarie - Hastings Core Koala Habitat	Core Koala Habitat	Port Macquarie - Hastings LGA	Property scale	Core koala habitat	Port Macquarie - Hastings council	Port Macquarie Hastings Koala Habitat & Population Assessment. Final Report to Port Macquarie - Hastings Council. February 2013.	Licence agreement required with Port Macquarie - Hastings Council	

Dataset Name	Description of information	Extent	Scale of capture / precision	Attributes Collected	Custodian	Citation	Licencing Constraints	Notes
Greater Taree Koala habitat categories	Preferred Habitat Mapping	Greater Taree City Council	Regional	Preferred Koala Habitat classes	MidCoast Council	Australian Koala Foundation (2002). Greater Taree City Council draft Comprehensive Koala Plan of Management. Prepared for Greater Taree City Council under State Environmental Planning Policy no.44 - Koala Habitat Protection.	Licence agreement required with MidCoast Council	
Port Stephens Preferred Koala Habitat	Preferred Habitat Mapping	Port Stephens Council	Regional	Preferred Koala Habitat classes	Port Stephens Council	Port Stephens Council (2002). Port Stephens Council Comprehensive Koala Plan of Management (CKPoM) – June 2002. Prepared by Port Stephens Council with the Australian Koala Foundation.	Licence agreement required with Port Stephens Council	
Cooma - Monaro Preferred Koala Habitat	Preferred Habitat Mapping	Cooma - Monaro Koala Planning Area	Regional	Preferred Koala Habitat classes	Cooma Monaro Shire Council	Greenloaning Biostudies 2015. Cooma - Monaro Shire LGA Comprehensive Koala Plan of Management 2015 (Draft). Prepared by Greenloaning Biostudies Pty. Ltd. In conjunction with Dr. Stephen Phillips, June 2015.	Licence agreement required with Cooma Monaro Council	
Gunnedah Preferred Koala Habitat	Preferred Habitat Mapping	Gunnedah Shire Council Strategy Planning Area	Regional	Preferred Koala Habitat classes	Gunnedah Shire Council	Greenloaning Biostudies Pty Ltd (2015). Gunnedah Koala Strategy.		

Dataset Name	Description of information	Extent	Scale of capture / precision	Attributes Collected	Custodian	Citation	Licencing Constraints	Notes
Campbelltown Preferred Koala Habitat	Preferred Habitat Mapping	Campbelltown Koala Planning Area	Regional	Preferred Koala Habitat classes	Campbelltown City Council	Phillips, S (2016) Campbelltown Comprehensive Koala Plan of Management. Prepared by Biolink for Campbelltown City Council.	Licence agreement required with Campbelltown City Council	
Campbelltown Core koala habitat	Core Koala Habitat	Campbelltown Koala Planning Area	Regional	Core koala habitat	Campbelltown City Council	Phillips, S (2016) Campbelltown Comprehensive Koala Plan of Management. Prepared by Biolink for Campbelltown City Council.	Licence agreement required with Campbelltown City Council	Data presented as 2 km grids. Based on generational persistence data.
Moree Plains Preferred Koala Habitat	Preferred Habitat Mapping	Moree Plains Shire Council	Regional	Preferred Koala Habitat classes	Moree Plains Shire Council	Parsons Brinckerhoff, 2008. Moree Plains Shire Koala Habitat Mapping. A report to Moree Shire Council, June 2008.	Licence agreement required with Moree Plains Shire Council	
Cooma - Monaro Core Koala Habitat	Core Koala Habitat	Koala Precincts within the Koala Planning Area	Property scale	Lot and DP	OEH and Cooma Monaro Shire Council	Martin A. and Phillips S., 2015. Cooma - Monaro Shire LGA Comprehensive Koala Plan of Management 2015 (Draft). Prepared for Cooma - Monaro Shire Council.	Not required	Data derived from lots within the 4 management precincts also within activity contours of 10% or greater.

HABITAT MODELLING

Habitat Modelling available in some form for the bulk of the east coast of NSW.

Most habitat mapping now very dated, originating from the RFA process, extending from the late 1990s through to the mid 2000s. However, a recent project by DPI have undertaken modelling for the north coast of NSW, which extends across the Upper North East and Lower North East CRA regions (as shown on figure 4).
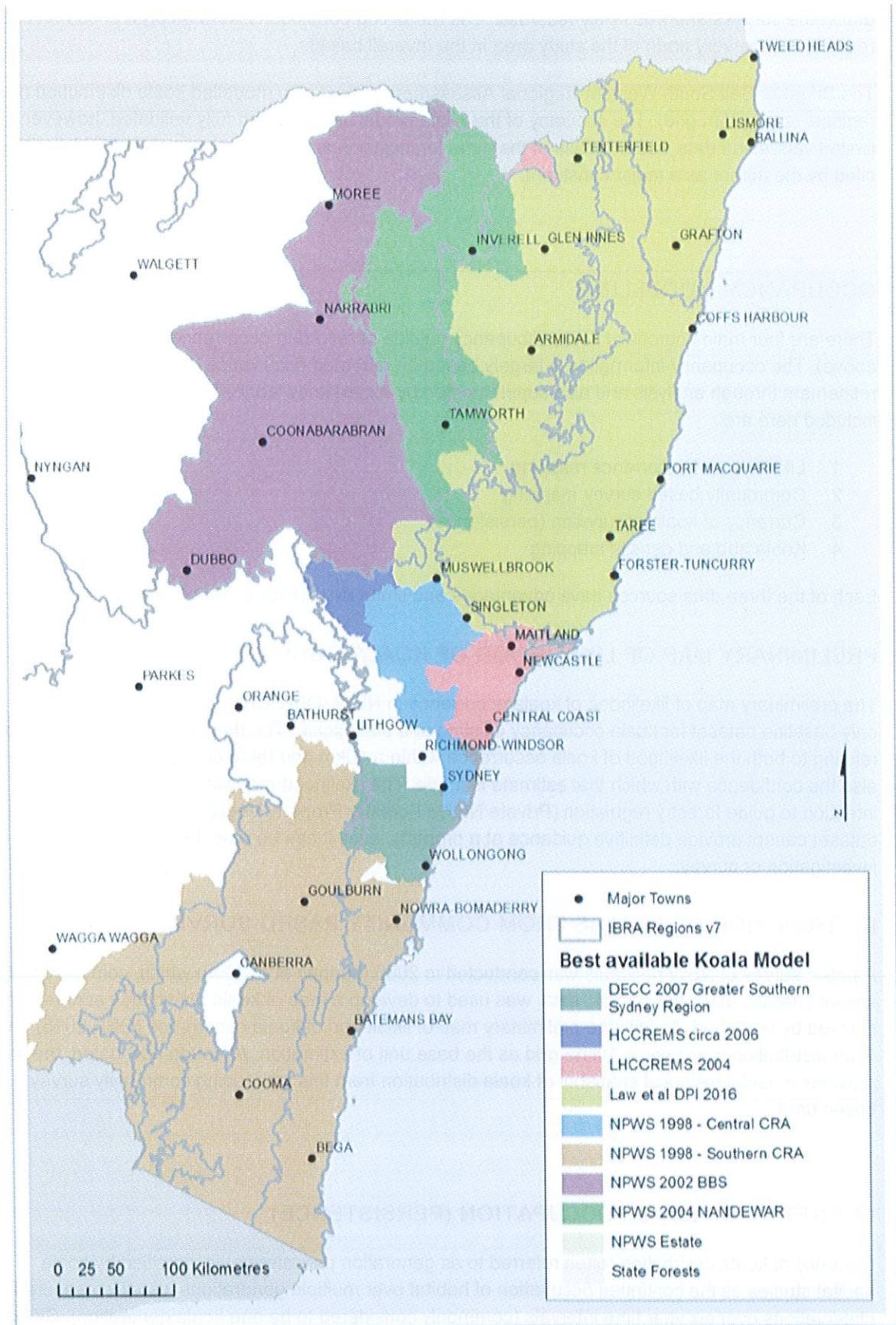
Current project to revise DPI model and continue for the balance of the state. This project is expected to start producing results within the next 6 months with priority given to refining the DPI model for the north coast of NSW.

Table 5 below outlines the individual datasets making up the coverage for the east coast of NSW. The bulk of datasets are considered to be regional scale, with grid cell size ranging from 25m at finest to 250m.

Table 8   Koala Habitat Suitability Modelling in NSW

Dataset Name	Scale of Capture	Year published
Spatially Explicit Predictive Model of the Distribution of Koalas in North-east NSW (Law et al.)	Regional	2016
CRA Northern	Regional	1999
Lower Hunter Fauna Habitat Modelling and Mapping	Regional	2004
Bermagui/Murrah Koala Habitat Model	Regional	1999
Greater Southern Sydney Region Koala Habitat Model	Regional	2007
Lower Hunter Koala Study Modelled habitat	Regional	2013
Canopy Nitrogen Habitat Quality Mapping	Property	Not yet published
SEWPAC Koala Distribution	Geographic	Unknown
Predictive Surfaces of Phascolarctos cinereus (Koala - 1162) - South Coast Subregion, Southern CRA	Regional	1998
Koala Habitat Model for North East NSW (CRAFTI)	Regional	Circa 2004
Koala habitat model for Hunter Catchment Area	Regional	Circa 2006
Nandewar WRA Key Habitat for Fauna groups	Regional	2004
Brigalow Belt South WRA Koala Distribution	Regional	2002

Figure 4   Koala Habitat Suitability Modelling in NSW

Legend:

Best available Koala Model

- Major Towns
- IBRA Regions v7
- DECC 2007 Greater Southern Sydney Region
- HCCREMS circa 2006
- LHCCREMS 2004
- Law et al DPI 2016
- NPWS 1998 - Central CRA
- NPWS 1998 - Southern CRA
- NPWS 2002 BBS
- NPWS 2004 NANDEWAR
- NPWS Estate
- State Forests

0 25 50   100 Kilometres

The Nandewar Western Regional Assessment Vertebrate Fauna study derived key habitats which considered the Koala, however the report notes that little evidence of koala occupation was noted during the surveys and was rarely recorded. The remaining populations were thought to be mainly restricted to the very north of the study area in the Inverell basalts.

The Brigalow Belt South Western Regional Assessment project also modelled koala distribution at regional scale (25m grid). The accuracy of the koala model has not been fully validated, however limited vegetation data was available at that time for inclusion in the modelling process, which was cited by the author as a major constraint.

OCCUPANCY MODELLING

There are four main sources of koala occupancy outside of recorded occurrences (listed in table 1 above). The occupancy information is largely based on recorded occurrence data with some refinement through analysis and also supplemented by expert knowledge. The three categories included here are:

1. Likelihood of occurrence mapping
2. Community based survey mapping
3. Currency of koala occupation (persistence)
4. Koala hub and density mapping

Each of the three data sources have advantages and limitations which are described below.

PRELIMINARY MAP OF LIKELIHOOD OF KOALA OCCURRENCE IN NSW

The preliminary map of likelihood of koala occurrence in NSW (OEH 2015), although broad, is the only baseline dataset for koala occupancy existing at a state scale. The dataset contains information relating to both the likelihood of koala occurrence within a 10km grid (5km on NSW North Coast) and also the confidence with which that estimate is made. The likelihood map was undertaken with the intention to guide forestry regulation (Private Native Forestry Property Vegetation Plans). While the dataset cannot provide definitive guidance at a property level, it can be a useful flag for further investigation or survey.

DISTRIBUTION OF KOALAS FROM COMMUNITY BASED SURVEY (2006)

A public survey of NSW residents was conducted in 2006 (Lunney et al 2009) which, combined with spatial analysis using bio-climatic data, was used to develop a map of koala distribution across NSW, indexed by likelihood. As with the preliminary map of likelihood of koala occurrence (OEH 2015), the 2006 distribution map uses a 10km² grid as the base unit of estimation. Although now dated, the study provides a useful historical snapshot of koala distribution from this time, using community survey based data.

CURRENCY OF KOALA OCCUPATION (PERSISTENCE)

Currency of koala occupation (often referred to as generation persistence) is identified by koala habitat studies as the continued occupation of habitat over multiple generations, usually measured by observations over six year time intervals (commonly considered to be one koala generation). CKPoMs for many LGAs include an analysis of generational persistence over the koala planning area. This

analysis is considered to form part of the core habitat assessment under SEPP 44 needed to demonstrate that a resident breeding population is present in an area.

The modelling of koala occupation included below has been based on site data collated for this project and analysed on a 1km grid to account for inherent uncertainty of site data accuracy and home range influences. That is, many community data records have a stated accuracy of 1km. Koalas also have a home range which typically varies between 10 hectares in high site quality areas and 30 hectares in low site quality areas, although higher densities (as much as 0.63/ha) are known in coastal fertile areas (Niche 2016). Any analysis at finer grid cell resolutions may provide a false impression of data precision.

The data have been grouped into two classes to represent the respective levels of confidence that an area has koala occupation.

Table 9   Koala Occupation Classes

Occupation Class	Description
Current	Koalas observed within the most recent mapped generation (2011 – 2016)
Prior continued occupation	Koalas observed in any two prior generations since 1990

Figure 5 below shows grids across NSW which have been defined using the classes in table 9. Grids which have both current and prior continued occupation are recognised as a separate category.

Figure 5 Generational Persistence of Koalas in NSW

Legend:

- Major Towns

Generational Persitence

Absent

Current and previous generations

Current generation only

Previous generations only

NSW IBRA Regions

RESIDENT POPULATIONS (KOALA HUBS) AND DENSITY MAPPING

An increasing focus on mapped areas of occupied koala habitat as a regulatory tool have led to the development of ever refining methods for delineating these areas for planning applications. While mapped understanding of resident populations of koalas is dynamic, property level understanding of long term resident koala populations can be very useful in anticipating planning dilemmas and directing investment at a more refined scale.

Hubs, or clusters of koala activity are currently being developed for koala populations in NSW, and represent a significant refinement of the scale of koala activity information. The identification of resident koala populations has been recognised by the SoS Iconic Koala Project (OEH 2017b) as one of a number of tools to guide conservation actions.

Koala hubs are defined as being regions of known, currently occupied habitat for koalas with a minimum threshold of distance and density of recorded occurrences. Typically, hubs will consist of multiple zones of activity within close proximity (less than 2 km).

Hubs have been developed with the assistance of a records density analysis, which uses established knowledge of koala movement and home range behavior to predict local activity.

An example of koala hub mapping from Port Stephens is presented in figure 6 below.

Figure 6 Example area of Koala Hub Mapping. Port Stephens
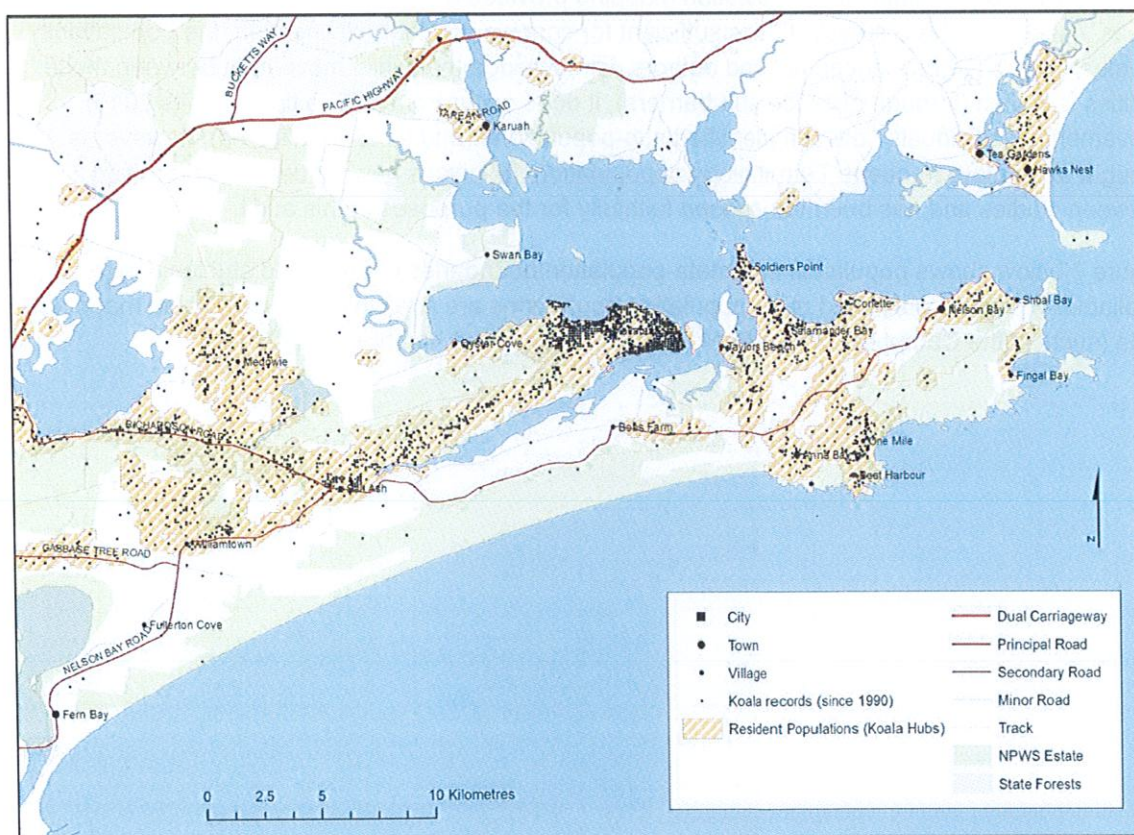
META POPULATION AND POPULATION MAPPING

A number of major studies have now plotted regional and sub-regional scale boundaries for the bulk of known koala populations in NSW. Two recent studies, the 'Western Woodlands Koala Park' proposal by the Western Woodlands Alliance (Paull and Hughes 2016) and the Preliminary Mapping of Populations as a basis for Further Study, Research and Planning (Scotts 2013), between them, map broadly the regional populations of the north-east and west of NSW. Further isolated studies have captured the populations in the south-east.
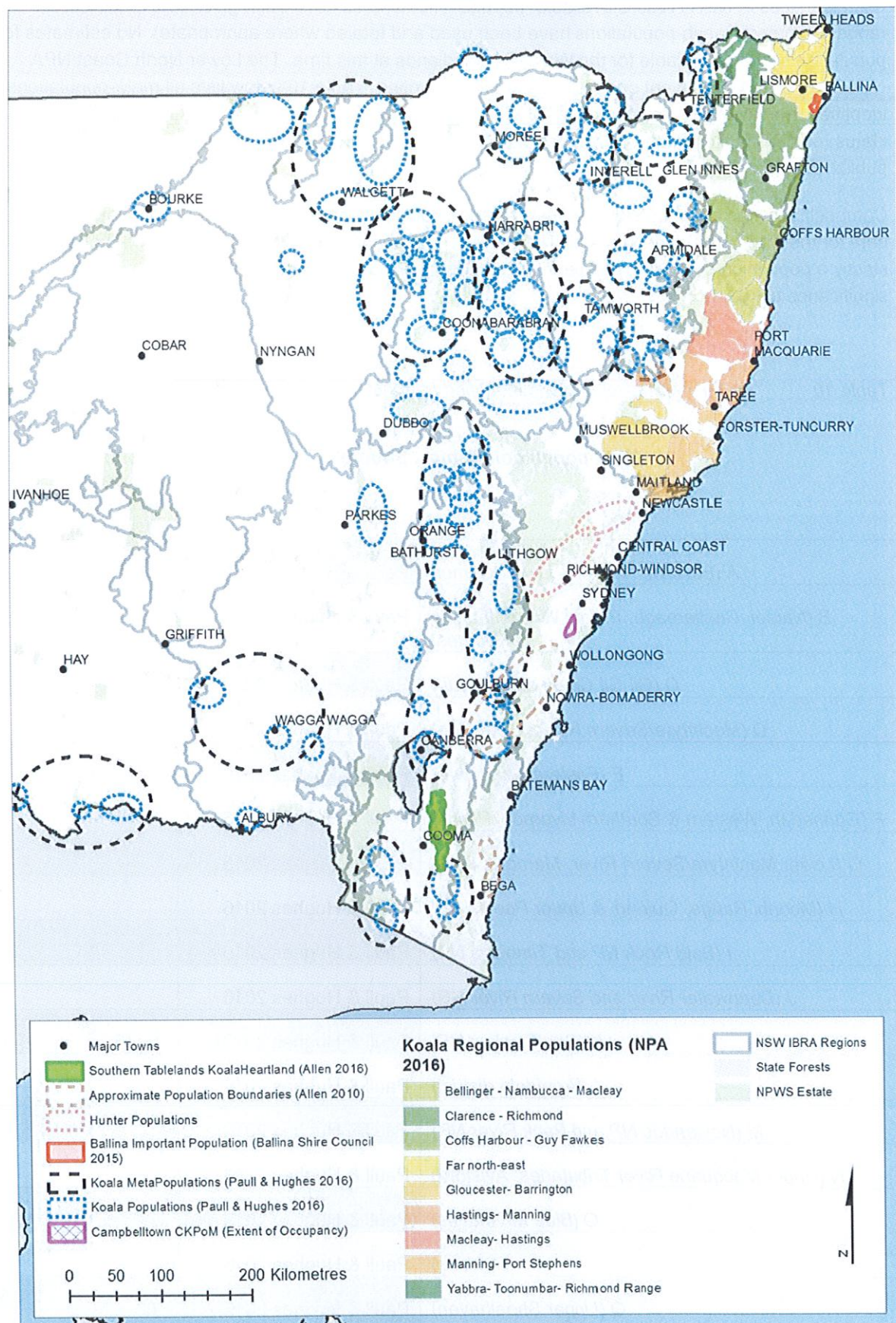
Populations in the Hunter catchment, though not well studied, have been documented in both Yengo National Park (Curtin, Lunney and Matthews 2002) and the Watagan Ranges to the north. Indicative population boundaries have been delineated as part of this report based on the Yengo study results, collated site data and generational persistence data in these areas.

Koala populations in South East NSW are broadly grouped into three areas, the Southern Highlands, North-East Monaro and Far South Coast. Mapping of populations for these areas has kindly been provided by Chris Allen (OEH) from two separate studies. Population mapping for the Southern Tablelands overlaps with the Western Woodlands mapping (Paull and Hughes 2016) and where this has occurred, both are shown.

Whilst the meta-population and population mapping provides a more definitive view of occupied areas, especially where survey data is sufficient for concise boundary delineation, the populations themselves are largely conceptual and authors acknowledge that while movement between these entities is limited (through distance and barriers), it does occur from time to time (Scotts 2013). Movement of individuals between identified sub-populations (and local populations), however is thought to be more frequent. Terminology of population definitions has not been standardised between studies and has been transposed faithfully for the purposes of this audit.

Figure 7 below shows population and meta-population boundaries of published studies where available. Where no published meta-population boundaries are available, other available mapping data (such as the Campbelltown CKPoM extent of occupancy) has been substituted.

Figure 7 Identified Regional Koala Populations in NSW (Regional Studies)

Legend:

- Major Towns
- Southern Tablelands KoalaHeartland (Allen 2016)
- Approximate Population Boundaries (Allen 2010)
- Hunter Populations
- Ballina Important Population (Ballina Shire Council 2015)
- Koala MetaPopulations (Paull & Hughes 2016)
- Koala Populations (Paull & Hughes 2016)
- Campbelltown CKPoM (Extent of Occupancy)

0 50 100 200 Kilometres

Koala Regional Populations (NPA 2016)

- Bellinger - Nambucca - Macleay
- Clarence - Richmond
- Coffs Harbour - Guy Fawkes
- Far north-east
- Gloucester - Barrington
- Hastings - Manning
- Macleay - Hastings
- Manning - Port Stephens
- Yabbra - Toonumbar - Richmond Range

- NSW IBRA Regions
- State Forests
- NPWS Estate

Largely from the studies mentioned above, a total of 35 populations of Regional Significance have been identified in NSW. Where available, population estimates have been given (the mid-point of range estimates for sub-populations have been used and totaled where appropriate). No estimates for population size are available for the Western Woodlands at this time. The Lower North Coast NPA reporting is ongoing, but not complete at the time of writing. Table 10 below lists all meta-populations identified from available literature in NSW. These populations are recognised as having a different status (or classification) according to the interpretation and understanding of the authors of the published works.

Campbelltown has been identified as being of regional significance in lieu of more complete regional data for the Southern Sydney region. The extent of occupancy mapping (Phillips 2016), though not strictly a population boundary, has been included on the map in recognition of the likely regional significance of koalas in this area.

Table 10   *Koala Meta-Populations Identified In NSW*

Meta-population Name	**Source**	**Population Estimate (Midpoint of range where available)**
A (Barwon, Narran & Lower Namoi)	Paull & Hughes 2016	
B (Namoi, Castlereagh, Pilliga, Warrumbungle Ranges)	Paull & Hughes 2016	
C (Gil Gil Creek and Gwydir)	Paull & Hughes 2016	
D (MacIntyre/Severn Rivers, Warialda)	Paull & Hughes 2016	
E (Eastern Nandewar)	Paull & Hughes 2016	
F (Gunnedah, Western & Southern Liverpool Plains)	Paull & Hughes 2016	
G (Lower MacIntyre/Severn River, Marooba SCA)	Paull & Hughes 2016	
H (Moonbi Range, Quirindi & Upper Peel River)	Paull & Hughes 2016	
I (Bald Rock NP and Timbarra NP)	Paull & Hughes 2016	
J (Deepwater River and Severn River NR)	Paull & Hughes 2016	
K (Guy Fawkes NP)	Paull & Hughes 2016	
L (Armidale district)	Paull & Hughes 2016	
M (Nowendoc NP and Back River NR)	Paull & Hughes 2016	
N (Upper Macquarie River Tributaries, Avisford)	Paull & Hughes 2016	
O (Blue Mountains)	Paull & Hughes 2016	
P (Yass)	Paull & Hughes 2016	
Q (Upper Shoalhaven) *Southern Highlands*	Paull & Hughes 2016, Allen 2010	400

Meta-population Name	Source	Population Estimate (Midpoint of range where available)
R (Upper Queanbeyan River, Numeralla, Kybean SCA) – Southern Tablelands Koala Heartland.	Allen 2016, Paull & Hughes 2016	200
S (Bemboka River and Towamba River)	Paull & Hughes 2016	
T (Snowy River and Corrowong Creek)	Paull & Hughes 2016	
U (Murrumbidgee River)	Paull & Hughes 2016	
V (Murray River)	Paull & Hughes 2016	
Far South Coast (Bermagui and Mumbulla)	Allen 2010	32
Campbelltown	Biolink 2016	177
Yengo NP	Curtin, Lunney and Matthews 2002	
Watagan Ranges	No reference. Site data only.	
Far North East	NPA 2017	2200
Yabbra – Toonumbar – Richmond Range	NPA 2017	200 +
Clarence – Richmond	NPA 2017	650
Coffs Harbour – Guy Fawkes	NPA 2017	2650
Bellinger – Nambucca – MacLeay	NPA 2017	600
MacLeay – Hastings	NPA 2017	975
Hastings – Manning	NPA 2017	
South Manning – Port Stephens	NPA 2017	
Gloucester – Barrington	NPA 2017	

A number of LGAs with Comprehensive Koala Plans of management have also identified meta-population boundaries. These include the LGAs of Tweed, Byron and Ballina.

KOALA CARE INFORMATION

Koalas in care and rescue data are collected under licence by care groups across NSW. Data collection is somewhat variable, with limited resources available for maintenance of data systems. Data are collated, standardised and analysed by OEH staff. Although coordinate information is collected by some care groups, collated data has been standardised to postcode, which all care groups were able to collect reliably.

A total of 7239 encounter records have been collected from 20 different groups and individuals across 5 years (2012 – 2016) throughout NSW. As shown on table 11 below, a large number of encounters have an unknown outcome recorded. These records cover a broad range of situations where a call out has not resulted in an encounter, or the encounter has been unresolved (pers. Com. Ron Haering, OEH 2017).

Table 11   Koala care information by postcode and observation type

Encounters/fates	Dead/Died/Euthanised/PC		Fate Unknown		Released		Totals
Attack	220	47.72%	88	19.09%	153	33.19%	461
Vehicle collision	650	**65.86%**	187	18.95%	150	15.20%	987
Disease	786	**48.85%**	509	31.63%	314	19.52%	1609
Electrocution	2	100.00%	0	0.00%	0	0.00%	2
Entanglement	4	36.36%	4	36.36%	3	27.27%	11
Entrapment	4	57.14%	1	14.29%	2	28.57%	7
Habitat Loss	12	10.00%	48	40.00%	60	50.00%	120
Fouled by Substance	0	0.00%	1	50.00%	1	50.00%	2
Unsuitable Environment	30	3.56%	399	47.39%	423	**50.24%**	842
Nuisance/Problem Fauna	1	1.69%	3	5.08%	55	**93.22%**	59
Weather	10	33.33%	15	50.00%	5	16.67%	30
Unknown	340	15.19%	1772	**79.18%**	126	5.63%	2238
Unclassified/Other	83	9.53%	710	81.52%	78	8.96%	871
	2142		3737		1370		7239

Figure 8 below shows an example of the data, vehicle collisions, which has been displayed by postcode. Clusters of activity are noted in populations which are known to have a large urban interface (Lismore, Port Macquarie, Taree and Port Stephens).

Figure 8   Care data example: Vehicle Collisions reported 2001 - 2006
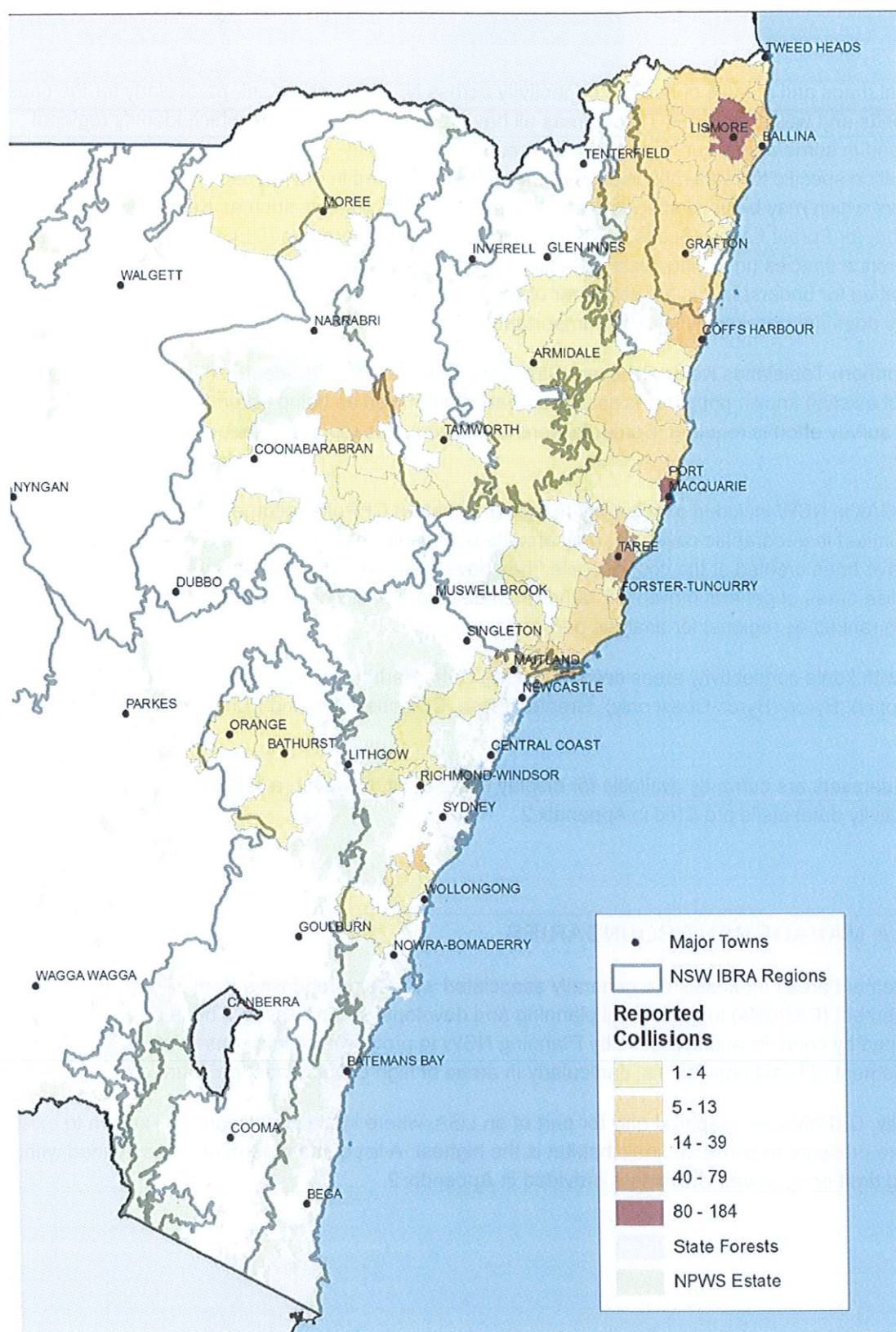
HABITAT CONNECTIVITY

General maps and models of habitat connectivity across NSW are abundant, particularly for the coast, tablelands and western slopes. These areas all have regional scale models which identify regional scale and in some areas, sub-regional scale areas of connectivity. These models do not provide information specific to koala movement and therefore are limited in their capacity for predicting corridors which may be used specifically by koalas. However, projects such as Key Habitats and Corridors for Forest Fauna (Scotts 2003) and Climate Change Corridors (DECC 2007) nominate focal, or reference species (including koala) for each corridor. Whilst the focal species can provide useful information for understanding the character of each corridor, the absence of the koala as a nominated species does not necessarily lessen its importance as such.

The Northern Tablelands Koala Recovery Strategy (Hawes et al 2016) identified koala corridors which connect existing known populations as well as habitat identified as being potentially suitable where further survey effort is required. Corridors were identified in this report with a focus on revegetation priority.

Four LGAs in NSW included connectivity mapping as part of CKPoM document. These datasets, whilst limited in geographic coverage, may provide useful information for these areas. Whilst these data have been created at the council scale, they have often been created as linear (line) features to symbolise areas of general movement rather than defined areas. For this reason, these datasets have all been ranked as regional for analysis purposes.

LGAs with koala connectivity areas defined include Coffs Harbour (1999 boundary), Tweed (Tweed Coast only), Byron (Byron Coast only), Greater Taree, Campbelltown and Port Macquarie (coast only).

Not all datasets are currently available for display in the audit, however, a list of habitat corridor and connectivity datasets is provided in Appendix 2.

KOALA MANAGEMENT BOUNDARIES

Management areas for koalas are generally associated with Comprehensive Koala Plans of Management (CKPoMs) to guide local planning and development processes. These plans are developed by councils and approved by Planning NSW to provide strategic conservation management of koala populations, particularly in areas of high development pressure.

Typically, CKPoMs are prepared only for part of an LGA, where koala populations are known to exist, or where pressure to conserve koala habitat is the highest. A list of management areas defined within existing draft or approved CKPoMs is provided in Appendix 2.

LAND OWNERSHIP AND MANAGEMENT

Spatial data associated with the ownership and management of land are often useful in assessing the security of conservation values and risk of management change into the future. Tenure categories are also regularly used to assess adequacy of the reserve network on a regional basis and also to drive priorities for conservation effort including land acquisition for reservation.

Datasets containing major categories of tenure and management are maintained by NSW government. These categories include:

- National Parks Estate
- State Forests Estate
- Crown Lands
- Cadastral boundaries
- LGA Zoning
- Conservation Agreements
- Wildlife Refuges
- Biobanking agreements
- Registered Property Agreements
- Council Owned and Managed Land

In addition, private land conservation groups such as Australian Wildlife Conservancy and Bush Heritage Australia maintain databases of properties with conservation trusts and agreements.

Indigenous Protected Areas are managed by the Australian Government, Department of Prime Minister and Cabinet. Spatial data for these areas has been made available to OEH.

REFUGIA

Assessment of koala refugia at a bioregional scale is difficult. A recent study by OEH (Drielsma 2015) maps priorities for conservation and rehabilitation across NSW under future climate scenarios. The study evaluates the impact of climate change on the persistence of biodiversity across south-eastern Australia. Taking into account predictions of future climate change (from multiple climate change scenarios), the study models predictions of range shifts of ecological envelopes and analyses future ecological landscapes for areas of greatest benefits for conservation investment and rehabilitation works. Whilst the information is generic in terms of habitat value (not species specific), predicted trends in shifting investment priorities are useful for future conservation planning.

The manage benefits analysis undertaken as part of the 3C Modelling for Biodiversity under Future Climate highlights areas of the NSW landscape that will, under future climate scenarios, become more important for conservation action in the future. Figure 9 below (from OEH 2015) depicts changing conservation priorities from past vegetation community distributions to those predicted in 2050.

While these analyses represent only a generalised habitat model of predicted management benefits, in the absence of a more detailed study of its type specifically relating to koala management, this adaption model can provide over-arching guidance on future investment direction.

Key observations for the Manage Benefits 1990 versus 2050:

- Southern Tablelands, Northern Tablelands, Northern Hinterland and parts of the Western Slopes including the Pilliga show the highest overall potential for future conservation investment.
- Many parts of the north and south coast, while important for conservation now, may become less so into the future.
- Much of the western slopes and plains (from Moree south to the Riverina) remain a low priority for investment now and into the future.

Bio-climatic Difference Model 1990 – 2050. This model represents a measure of the ecological difference between the landscape ecology in 1990 versus that modelled through bio-climatic variables in 2050. This is an indication of how much the ecology of different regions will change over the modelled period. The model, whilst indicating a shift in the bio-climatic landscapes, does not provide any indication of specific changes in suitability of habitat for koalas.
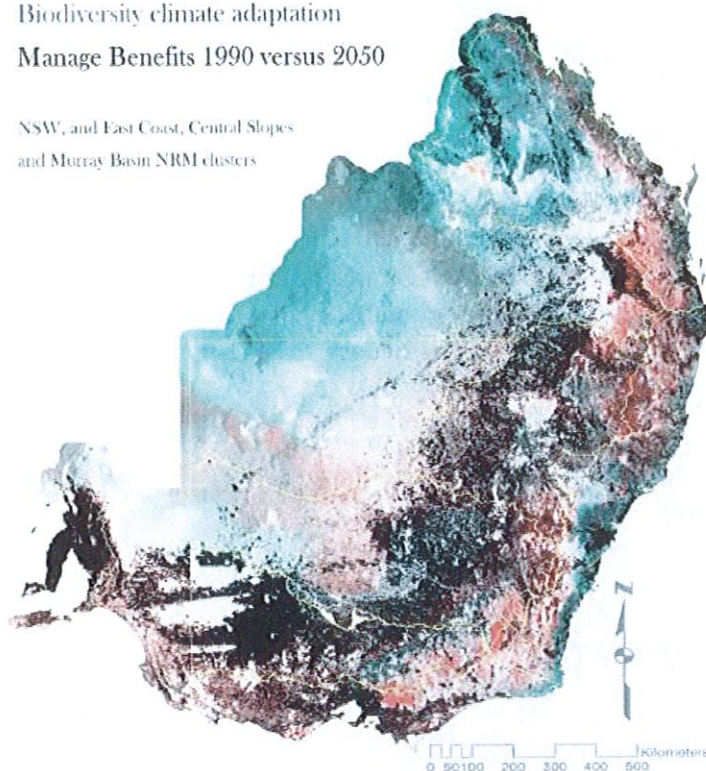
Key observations of the Bio-climatic Difference Model

- Relative Stability of the Southern Tablelands, far south coast and northern coast of NSW
- High degree of change prediction for western slopes, western plains, south-west slopes and Sydney-Illawarra regions.

Figure 9 Biodiversity Climate Adaptation: Manage Benefits 1990 versus 2050 (from OEH 2015)
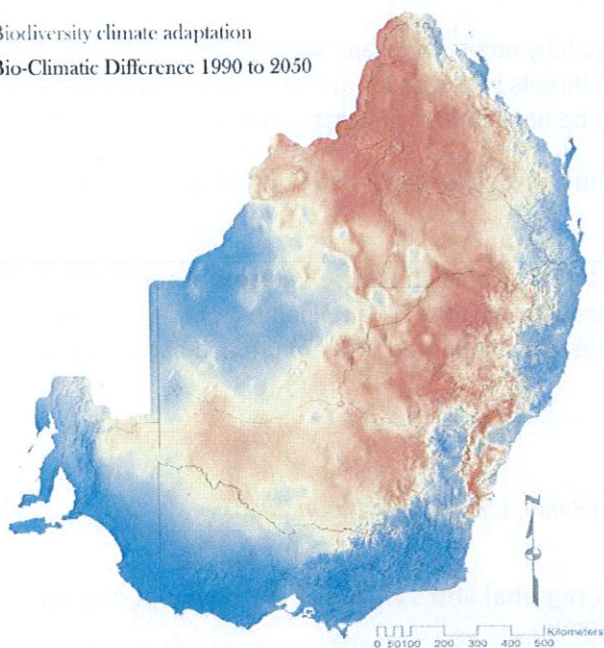

Figure 18: Manage benefits 1990 versus 2050
Blue indicates areas with high manage benefit in 1990 (averaged across all climate futures); red indicates high manage benefit in 2050; and white indicates high manage benefit across the timeframe

Figure 10   Bio-climatic Difference 1990 to 2050 (from OEH 2015)

Figure 10: Average bio-climatic difference between 1990 and 2050

3C Modelling for Biodiversity under Future Climate   22

Further recent modelling of climate refugia examined the koala as an example of a species likely to experience range contraction in the coming decades as a result of changing climate conditions and shifts in habitat suitability. The University of Melbourne (Briscoe et al. 2016) recently published work which has used predictions of bioenergetic envelopes and climate change scenarios to study the likely change in range limits of koalas across eastern Australia.

The key outcomes of this study included:

- Likely range contraction across all modelled predictions to 2070
- Refugia for koala populations are likely to reside in southern areas of Victoria, South Australia, Southern NSW, NSW North Coast and New England Tablelands.
- There is a predicted loss of populations from the northern inland of NSW and Queensland by 2070.

There is also some evidence that riparian areas (citation required) act as refugia for koala populations in times of stress (e.g. drought and fire).

THREATS AND THREAT SURROGATES

Koala threat mapping for conservation management was undertaken for OEH by Andrew Smith, Dan Lunney and Chris Moon in 2016 for OEH. The project was undertaken in consultation with ACEAS (Australian Centre for Ecological Analysis and Synthesis).

This threat mapping project defines and ranks threat categories across eastern Australia, using bioregions as a base unit for comparison. In this way, 14 threat groups were defined and assessed, using an ad-hoc elicitation process involving 15 experts to score threats across each bioregion.

Although the report acknowledges highly patchy nature of threat occurrences across the landscape and difficulty in transferring information on threats which occur at fine scales to a region scale, the report does create a framework which can be applied at a finer scale with appropriate data.

All bio-regions were reported to be experiencing high levels of threat, which are predicted to increase in the future from a variety of sources.

Table 12 below lists each of the identified threat groups and those datasets assessed in the audit which have potential to be analysed as spatial surrogates. The refinement of each dataset for use as a threat surrogate will require detailed assessment informed by literature and carer data where available.

Table 12   Threat groups assessed (Smith, Lunney and Moon 2016)

Threat Group	Appropriate regional and sub-regional data which may	Scale of capture
Habitat Loss, fragmentation and degradation	Land use (ALUM classes)	Property
	LEP SI zones	Property

	Future urban and employment lands	Property
	Tenure	Property
Urbanisation	Built up areas	Property
	LEP zones	Property
	Buildings	Property
Mining, Oil and Gas	Coal, mineral and petroleum titles and exploration licences	Property
Collisions with Motor Vehicles	Carer data. Vehicle strikes.	Regional
	NSW Roads database	Property
Predation by dogs	Carer data. Dog attack	Regional
	Built up areas	Property
	Buildings	Property
Fire	Fire history mapping	Regional
	RFS Fire Prone Lands	Regional
Drought	Bioclimatic data	Regional
Heatwave	Bioclimatic data	Regional
Cyclone	N/A	N/A
Disease	TBA	TBA
Leaf Chemistry Changes	TBA	TBA
Overbrowsing	N/A	N/A
Overabundant populations	N/A	N/A
Natural Resource Management	Forests NSW Forest Management Zones	Regional
	Private Native Forestry Approvals	Property

In terms of providing a useful guide to the potential utility of datasets for koala management, consideration of data scale is critical. Many of the datasets identified in this report, while potentially useful at the local scale (e.g. many of the CKPoM datasets), are difficult to apply in a regional or state level planning framework. Similarly, datasets which have been designed for regional or state level application (for example the Koala Likelihood map), have limited usefulness at the local scale. Figure 11 illustrates this concept using 3 example datasets of koala occupancy which are mapped at different scales over different geographic ranges using a range of techniques.

Therefore, when assessing the level of adequacy of koala data across categories, it is also useful to incorporate scale. The inclusion of scale in this assessment framework allows for a much clearer articulation of data adequacy across the categories represented in this report.

For the purposes of this analysis, three categories of data adequacy are considered, as outlined in table 13 below.

Table 13   Data adequacy categories for analysis

Data Category	Description
Adequate	The currency and completeness of data are suitable for analysis at this scale.
Partially adequate	Partial coverage or inconsistent coverage of data which allows for limited analytical scope
Inadequate	Data for this category and scale are absent or substantially lacking in currency or quality

Using the categories in Table 13 above, each data category included in the report was considered in the 3 scale groups to give an overall ranking of adequacy. Major useful datasets in each category are also listed. The results are shown below in Table 14.

The results of this analysis indicate either a partial or complete inadequacy of data coverage and currency across both scale and category. While the audit has captured some information across all the categories represented in the audit, no data category is considered adequate across all scales. Some categories (for example barriers to movement) are considered overall inadequate with very few datasets in existence.

Koala management datasets and existing conservation priority mapping have not been included in this analysis as they are considered less useful in terms of analytical processes for prioritisation and habitat assessment.

Figure 11   *Scale and utility of datasets. Example: Koala likelihood of Occurrence*

State Scale

- State-wide prioritisation of programs
- Consistency of data quality and completeness of coverage
- Typically coarse spatial scale
- Difficult to relate to site scale features

Preliminary Map of Koala Likelihood

- 10km grid (5km for NE NSW)
- Likelihood and confidence measure
- Suitable for identifying survey opportunities and state scale stats

Regional Scale

- Regional assessments of Priority (e.g. targeted prioritisation for acquisition)
- Sensitive to regional variations
- Intrmediate scale, often raster
- Interpretable at local scale with limited accuracy

Predictive Model of Koala Distribution (Law 2016)

- 250m raster
- Predicted distribution
- Proportional representation (e.g. tenure analysis)
- Trigger for property level assessment

Local Scale

- LGA programs (CKPoMs and habitat studies)
- Localised datasets may vary in methodology across the landscape
- Accuracy is property scale with high level of reliability
- Suitable for local planning applications

Core Koala Habitat, Bellingen Coastal Area (OEH 2014)

- Fine scale 3D Vegetation Classes
- Field Validated Polygons
- Informs Local Planning and Programs

Table 14   Data adequacy. Categories versus scale

SCALE OF ASSESSMENT

DATA CATEGORY	STATE	REGIONAL	LOCAL
Barriers to movement	NO SUITABLE DATA	SCOTTS 2013. *Regional study of barriers to koala movement for NSW North Coast* *Northern Tablelands Koala Recovery Strategy*	NO SUITABLE DATA
Habitat Connectivity and Consolidation	NO SUITABLE DATA	LIMITED KOALA CENTRIC CORRIDORS • *GSSR koala linkages* • *Northern Tablelands Koala Recovery Strategy Corridors* *Broader array of generalised fauna corridors.*	SPORADIC COVERAGE OF CKPOM BASED KOALA LINKAGES: • Tweed Coast • Byron Shire • Coffs Harbour • Port Macquarie • Greater Taree • Campbelltown
Koala Habitat Mapping (Preferred and Core Habitat)	NO SUITABLE DATA	9 DATASETS FROM CKPOMS AND HABITAT STUDIES (TABLE 7) SPORADIC NORTH COAST CENTRIC COVERAGE	15 DATASETS FROM CKPOMS AND HABITAT STUDIES (TABLE 7) SPORADIC NORTH COAST CENTRIC COVERAGE
Habitat Modelling	NO SUITABLE CURRENT DATA *Lunney et al (2009) provides 2006 snapshot* *SEWPAC (2015) provides a predicted occurrence range on sprat website.*	2 CONTEMPORARY USEFUL STUDIES 1. LAW ET AL (2014) FOR NSW NORTH COAST 2. ELA (2013) FOR LOWER HUNTER *A range of historic (1998 – 2007) models cover the NSW coast and escarpment ranges*	NO SUITABLE DATA *University of Queensland are currently undertaking a project investigating the use of hyperspectral imagery to map available nitrogen in the Numeralla district.*
Identified Populations	BIOREGIONAL ESTIMATES OF POPULATION TRENDS AND THREATS ADAMS HOSKING ET AL (2016)	THREE MAJOR STUDIES IDENTIFYING REGIONAL SCALE POPULATIONS 1. Western Woodlands Koala Park Proposal (Paul & Hughes 2016) 2. Conserving Koala	A NUMBER OF CKPOMS CONTAIN IDENTIFIED META-POPULATION BOUNDARIES. THESE INCLUDE: • Tweed Coast

		Populations of The NSW Upper Mid-North Coast (Scotts 2013) 3. Estimating Koala Numbers and Assessing Population Trends in South Eastern NSW (Allen 2010) *Sydney catchment and Hunter valley remain gaps in terms of regional population assessments.*	• Byron Shire • Ballina
Koala Occurrence	OEH 2014 *A Preliminary Map of the Likelihood of Koala Occurrence in NSW*	CURRENCY OF KOALA OCCUPATION *NSW wide coarse mapping of occupancy (current and prior). Limited by survey effort.*	GENERATIONAL PERSISTENCE MAPPING (CKPOMS) *Sporadic coverage of generational persistence across CKPoMs* *Areas of Local Koala Significance (Koala Hubs)*
THREAT AND RISK	SMITH LUNNEY AND MOON 2016 *Past and future trends in the impact of threats on koala populations, assessed at a bioregional level.*	KOALA CARE DATA (COMPILED BY OEH) *Community group data recorded across NSW. Records data on mortality and injury from a range of causes. Accurate to postcode only.* BIOCLIMATIC DATA ON DROUGHT AND HEATWAVE *OEH NARCLIM projections on heatwave (days over 35 degrees) and drought.* FIRE HISTORY AND FIRE PRONE LANDS MAPPING *RFS data for fire history and bushfire prone lands.*	LAND USE ASSOCIATED THREAT MAPPING • Areas identified for urban, commercial and industrial expansion (LEP zoning) • Land Tenure • Native Vegetation Regulation Maps (LLS Amendment Act 2016) • LEP SI zoning • Mining leases and Exploration Licences • PNF approvals • State Forest Management Zones

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APPENDIX 1   KOALA RECORDS BY SURVEY

Dataset Name	Count of Sites
Atlas Incidental Records	16
Avisford NR Fauna Survey	3
Bees Nest NR fauna survey	1
Bird lists and historical bird	7
Casino SF EIS Survey	4
Central CRA Fauna Survey	13
Chris Allen SAT	406
CRA Winter Survey 1998	1
CSIRO Australian National Wildlife Collection	3
Cudgera Creek NR Fauna Survey	2
Culgoa Fauna Survey	1
Dan Lunney's Community Wildlife Survey	3059
Data Priorities Fauna Survey	106
Dave Milledge priority (NEFBS)	2
Dave Scotts Fame Cove Survey	2
Dave Scotts non-system fauna	2
Dennis Gosper non-systematic	6
Dharawal SCA & NR Fauna Survey	4
Dorrigo SF EIS Survey	6
Fauna of Lower Hunter NP	1
Fauna trends in Western NSW	1
Georges River Biodiversity Sur	5
Glen Innes District Fauna Survey	1
Gloucester/Chichester SF EIS S	1
Harry Hines misc. fauna data	9
Illawarra ETS Surveys	8
Iluka Community Survey	95
Koala Count 2015	29
LNE Summer Survey 1997/98	56
Lower North East CRA Survey	51
Maryland NP Fauna Survey	1
Misc. Manobolai NR Surveys	3
Mt Royal Fauna Survey 1998	1
Murwillumbah SF EIS Survey	14
Nandewar Bio-region Assessment	10
Narran River Fauna Survey	1

NEFBS Vertebrate Fauna Surveys	56
North Coast Region Fauna Survey	4
NPA Community Camera Survey	1
NPA Great Koala Count	1443
NRAC Upper North East Fauna	59
NZCRA Collated data	33
OEH Data from Scientific Licences dataset	4754
OEH Default Sightings	7672
Phillips SAT	616
REMS Fauna Survey	4
SAT RAPID	85
SCA Special Area Fauna Survey	17
SEF Koala Research Project	17
SF Miscellaneous data	79
Southern Fauna Survey 1998	1
Southern Highlands Koala Conservation Project	126
Spring Faunal Survey	2
State Forest - Wauchope	2
State Forests 2002 Supply	847
State Forests Biodata	2274
State Forests pre-2001 Supply	119
Steve Debus syst owl surveys	13
Sydney Metro CMA Rapid Fauna	2
Tubbenhauer & Siliakus Birds	74
UNE Summer Survey 97/98	2
Upper Nepean SCA Fauna Surveys	1
Upper North East CRA Survey	14
Urban Bushland Biodiversity 2	1
Urbenville SF EIS Survey	8
Urunga/Coffs Harbour SF EIS S.	1
Walcha/Nundle Styx River EIS	2
Walgett Survey 1	1
Walgett Survey 2	5
Western Sydney Fauna Surveys	2
Wiarborough NR	2
Wild Count Fauna	48
Wollondilly Koala Conservation Project	16
Woronora Plateau Offset Project	51
Woronora Post Fire Survey	12
WRA Brigalow Belt Survey	56