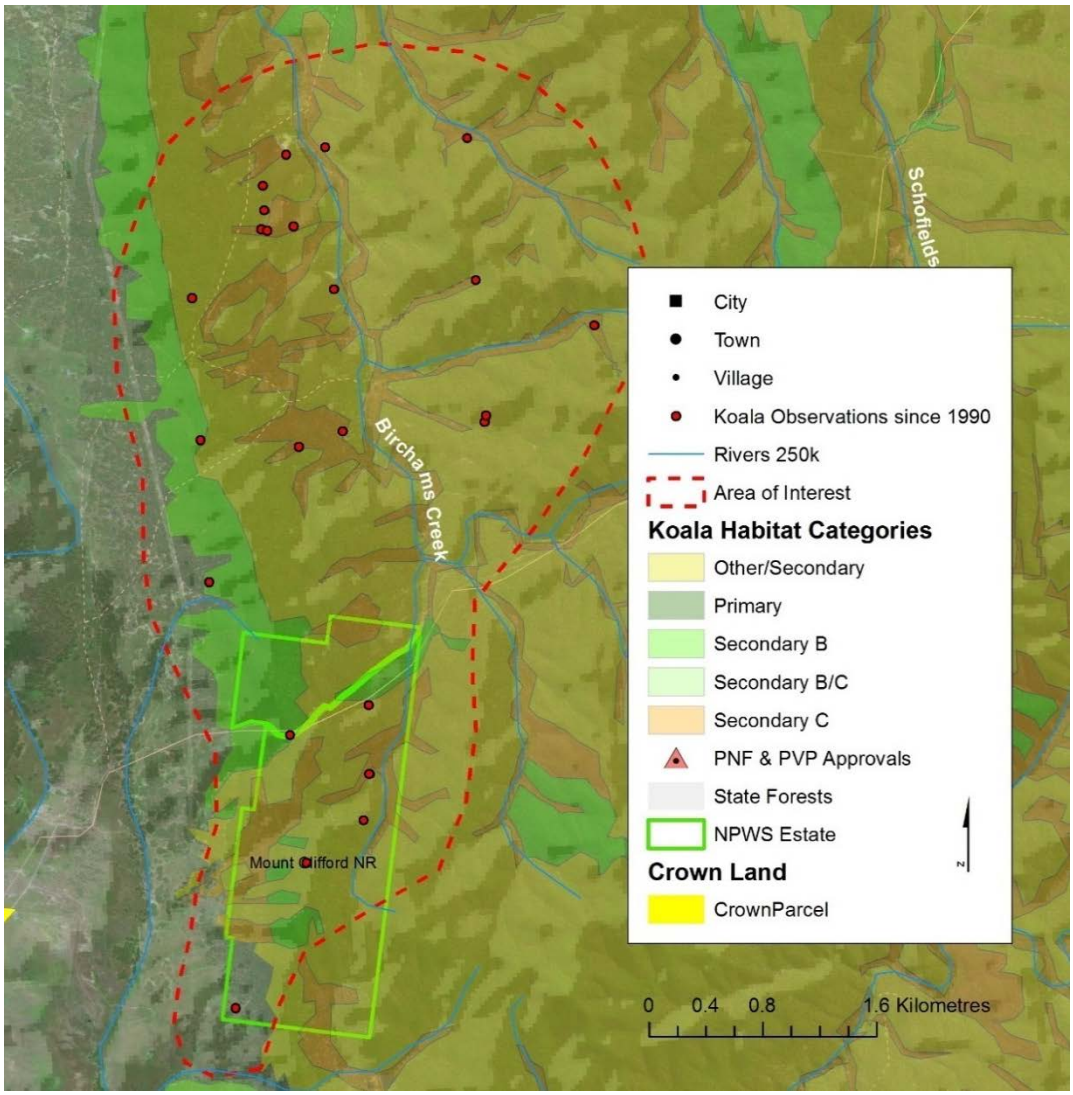
BIOREGIONAL ASSESSMENT OF KOALA POPULATIONS IN NSW



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CONTENTS

FIGURES

TABLES

PROJECT OUTLINE

PROJECT CHARTER OBJECTIVES

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.

In 2016, the NSW Government announced an initiative to assist in the long to protection of priority koala habitat. It has allocated $10 million over 5 years to purchase and conserve land (in the National Parks reserve system) which protects priority koala habitat (OEH 2017). These purchases are to be made in line with NPWS acquisition criteria with a focus on koala habitat and occupancy. It is intended that this project help guide, at a bioregional and sub-regional level, further investigation of properties to be assessed for acquisition under this initiative.

STAGE 1 AUDIT OF STATEWIDE SPATIAL DATASETS

Collation and assessment of a range of datasets relevant to koalas. Scope of data to include habitat, occupancy, population status, threats, refugia, connectivity and suitability for conservation investment. The results of the Spatial Data Audit are presented in a separate report.

STAGE 1 ASSESSMENT OF THE CURRENT RESERVATION SYSTEMS AND PROTECTION OF KOALAS WITHIN THE BIOREGIONAL AREAS OF NSW

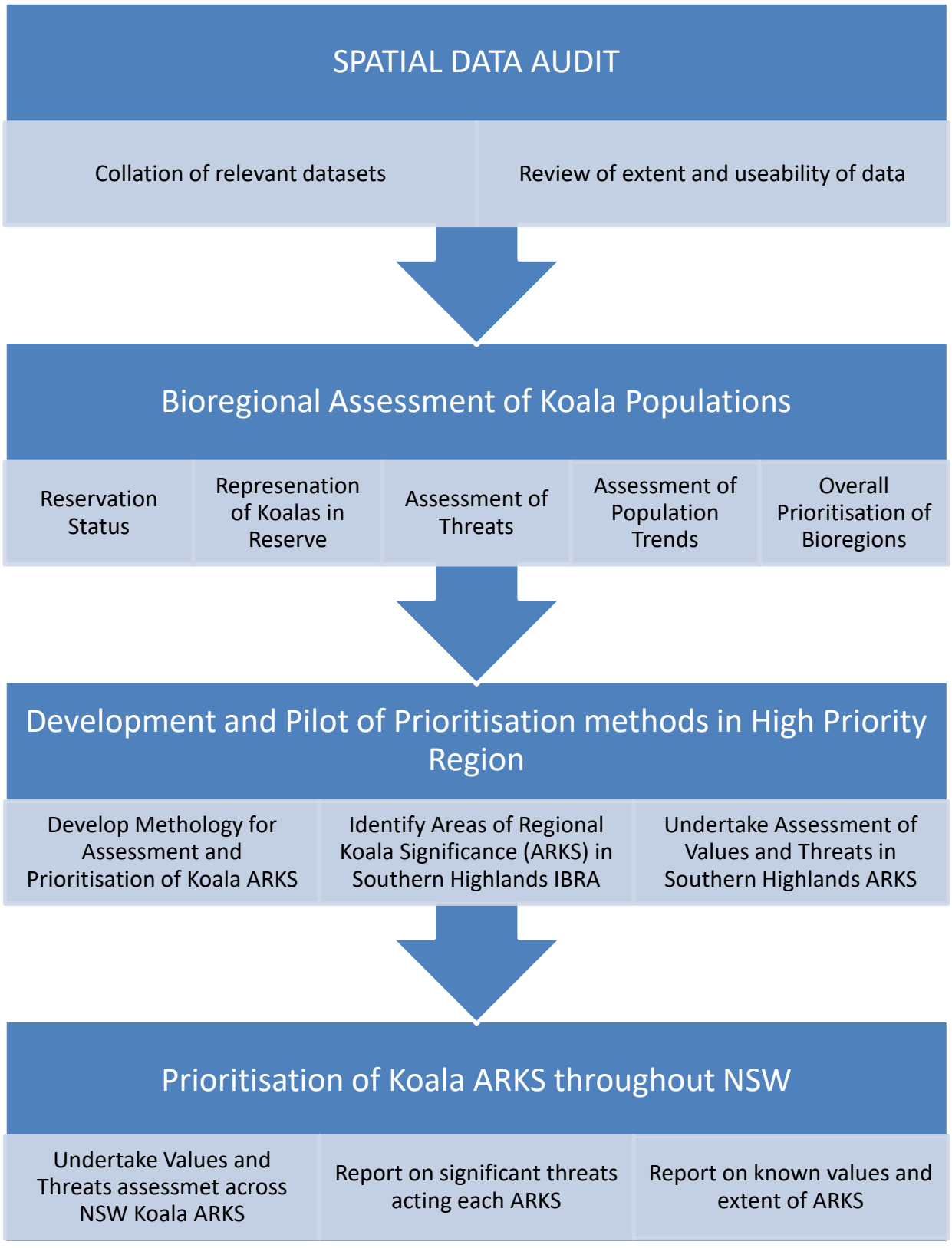
Assessment of the overall reservation status of Bioregions in NSW as it relates to the conservation status of koala populations. Identification of threats that are currently acting on these populations. Selection of trial bioregion for prioritisation analysis.

STAGE 1 ASSESSMENT OF PRIORITY AREAS FOR ACQUISITION IN SOUTHERN HIGHLANDS BIOREGION

Identify and present areas of potential for further investigation for acquisition in Southern Highlands Bioregion. Analysis of occupied koala areas, threats and tenure using available data.

Stage 2 of this project will fully implement the methodology of the prioritisation of Areas of Regional Koala Significance analysis across NSW.

Figure 1 Koala Prioritisation Project Process diagram



Bio-Regional Assessment

The Bioregion (Interim Biogeographic Regionalisation for Australia) is recognised by the NSW Office of Environment and Heritage (DECC 2008) as being the regional scale guiding framework for assessing and guiding investment in the reserve system. Together with the principles of a Comprehensive, adequate and representative (CAR) reserve system, they have formed the basis of reserve establishment and priority setting in NSW for the last 20 years.

CRITERIA FOR ASSESSMENT

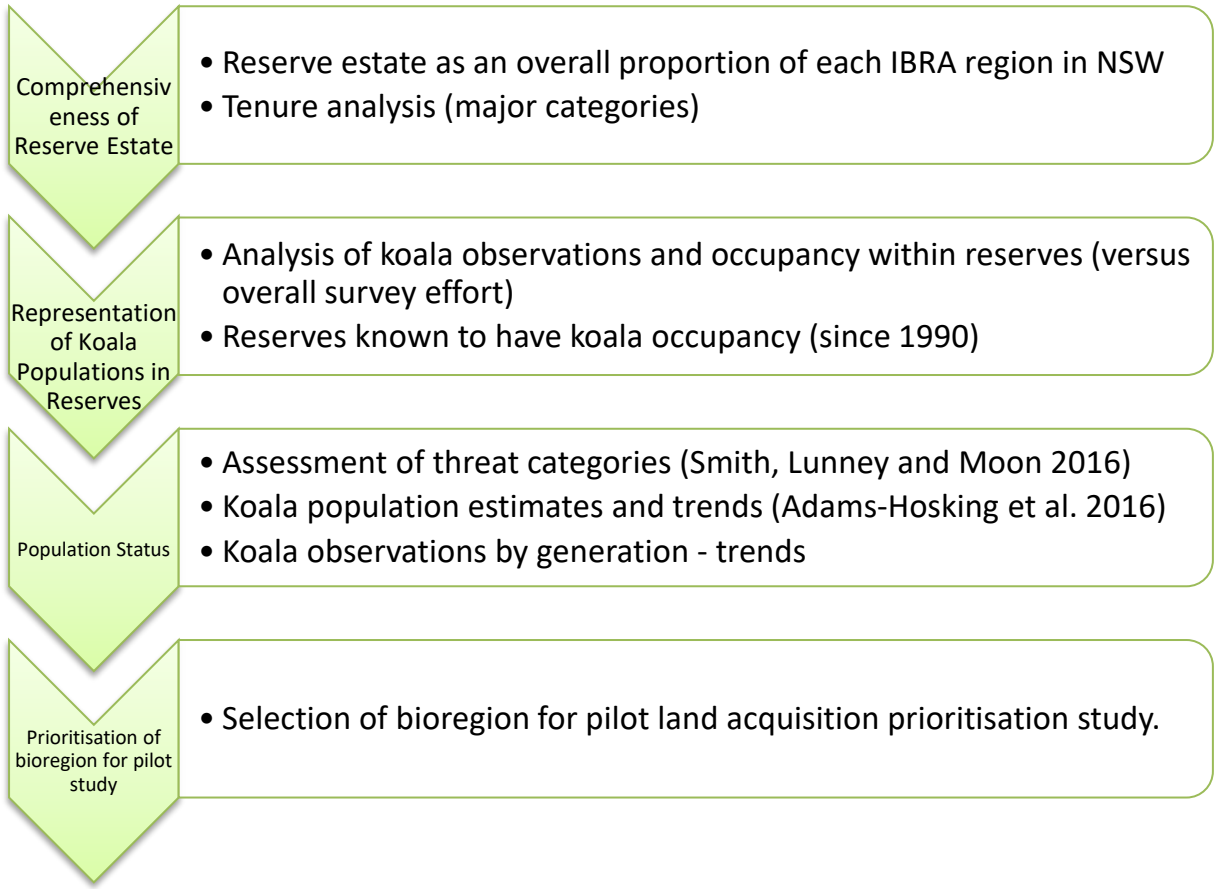
The criteria for the bioregional assessment are, as far as possible, based around the principles of a comprehensive, adequate and representative (CAR) reserve system which were established as part of the development of the National Forest Policy Statement (JANIS 1997). These criteria established both criteria and benchmarks for the reservation of forest systems and are therefore appropriate as a starting point for assessing reservation requirements of the koala.

Applying CAR principles to koala conservation, while not straightforward, is broadly possible. Three broad criteria for assessment were developed for assessment of koala conservation priorities at the bioregional scale and applying in the following sections. These criteria include assessments of the adequacy of current reservation systems and representation of koalas within reserve estate in NSW. Assessment of population size and trends across bioregions in NSW were also undertaken. Assessments of threats which act on populations at the regional scale were also examined.

As well as the CAR principles, the bioregional analysis also examines population trend and threat information available at this scale

Figure 2 below broadly describes the process of assessment, with three broad categories being undertaken. As a result of the bioregional assessment and prioritisation, one area (South East Highlands) was selected for a sub-regional land acquisition study.

Figure 2 *Bio-regional assessment*



Following the pilot study, stage 2 of the prioritisation study will focus on a NSW prioritisation, which will further develop the framework for assessment across all regional populations in NSW. The framework will incorporate assessments and koala values and threats to develop a prioritisation of areas of regional significance for koalas incorporating their future resilience.

ADEQUACY OF RESERVE ESTATE

Adequacy of reserve estate measures the area and proportion of land protected or managed for conservation both in public estate (National Park Estate) or through other mechanisms (mainly on private land). Ten categories of land management and ownership have been recognised by the analysis, for which the primary dataset is the Digital Cadastre Database (DCDB), managed by NSW LPI.

The Office of Environment and Heritage currently consider reservation adequacy at a bioregional level to be 17% of all lands. While this figure is indicative, the results presented below should be viewed with this benchmark in mind.

A number of other conservation mechanisms were collated and figures presented here. Because of the mixed tenure for the other conservation mechanisms, the 'other conservation' category areas are exclusive of the total. These lands are typically private land in coastal bioregions and crown lands for many western bioregions.

Table 1 Tenure categories for reserve estate adequacy analysis

Tenure Category	**Data Source**	**Notes**
AUSTRALIAN GOV.	Cadastre DCDB	Category of Controlling Authority within DCDB database.
CROWN	Cadastre DCDB	Category of Controlling Authority within DCDB database. Includes NSW Crown not within other crown categories (NPWS Reserves, State Forests etc.)
FREEHOLD	Cadastre DCDB	Category of Controlling Authority within DCDB database. Some freehold land may also be contained within UNKNOWN category in some regions.
LOCAL GOV. AUTHORITY	Cadastre DCDB	Category of Controlling Authority within DCDB database.
NPWS RESERVES	Corporate NPWS Estate	Extracted November 2016.
Other Conservation	Compiled Data	Refer to conservation lands categories outlined below. Figures in table are exclusive of total, as conservation agreements occur across multiple tenures.
STATE FOREST	Corporate State Forest Estate	Provided courtesy DPI NSW. Extracted November 2016.
NSW GOVERNMENT (Other)	Cadastre DCDB	Category of Controlling Authority within DCDB database
SHARED CROWN / COUNCIL	Cadastre DCDB	Category of Controlling Authority within DCDB database
UNKNOWN	Cadastre DCDB	Category of Controlling Authority within DCDB database.

OTHER CONSERVATION CATEGORYS

Other conservation lands have been compiled from multiple datasets held by Office of Environment and Heritage. Agreements are generally across private land, but also include crown lands, so figures provided in

table 2 are exclusive of the total. All figures were extracted in from OEH databases in November 2016. Categories of *Other Conservation* include those listed below.

CATEGORIES OF OTHER CONSERVATION LANDS

- Conservation Agreements (VCAs)
- Wildlife Refuges
- Indigenous Protected Areas
- Registered Property Agreements (In perpetuity)
- Nature Conservation Trust – Conservation Covenants
- Biobanking Agreements
- Other private conservation agreements include Bush Heritage Australia and Australian Wildlife Conservancy.

RELEVANCE AND APPLICATION OF RESERVE COMPREHENSIVENESS DATA FOR KOALA RESERVE PLANNING

How this data can be applied in selecting priority koala acquisitions

Achieving a comprehensive sample of biodiversity is a primary goal of the national park establishment program at the national and state level. There is an opportunity to maximise the benefit of acquisitions by targeting those areas that are a priority for koalas and which capture other biodiversity which is under represented in the reserve system. As an iconic species with a broad range of habitats, the koala can provide opportunities to capture a variety of ecosystems and biodiversity elements, many of which occur in threatened landscapes.

How is this data informing the acquisition program?

The table provides a figure for the percent reserved in each bioregion. There is no single percentage target for reservation quoted at the national or state level. (Instead, these programs aim to sample a proportion (80%) of regional ecosystems in each bioregion and subregion, with the priority given to bioregions with less than 10% of the total area (ha) conserved.) As a signatory to the International Convention of Biological Diversity, Australia aims to conserve at least 17 % of terrestrial and inland water areas by 2020.

Broad guidelines for interpreting reservation priorities from table 2

- Bioregions with under 17% reserved can be considered priority for reservation
- Bioregions with a low proportion of freehold and high proportion of State Forest present less opportunities for acquisitions and transfers.
- Bioregions with off-park reserves present opportunities for multi-tenure conservation networks.

TABLE 2 COMPREHENSIVENESS OF RESERVE ESTATE ACROSS BIO-REGIONS IN NSW

Bioregion Name	**AUSTRALIAN GOV.**		**CROWN**		**FREEHOLD**		**LOCAL GOV. AUTH**		**NPWS RESERVES**		**Other Conservation**		**STATE FOREST**		**NSW GOV (Other)**		**CROWN /COUNCIL**		**UNKNOWN**		**All Tenure**
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	
Australian Alps	0	0%	1924	0%	47619	10%		0%	377307	81%	479	0%	35697	8%	142	0%	0	0%	1609	0%	464298
Brigalow Belt South	0	0%	518762	9%	4211295	75%	1695	0%	487079	9%	56825	1%	261294	5%	4271	0%	18	0%	140323	2%	5624738
Broken Hill Complex	0	0%	3636737	97%	20047	1%	350	0%	75617	2%	331930	9%	0	0%	29	0%	0	0%	30538	1%	3763318
Channel Country	0	0%	2101213	90%	11868	1%		0%	218779	9%	141131	6%	0	0%	0	0%	0	0%	8801	0%	2340662
Cobar Peneplain	0	0%	4507214	61%	2517852	34%	1062	0%	193922	3%	187514	3%	64052	1%	13140	0%	11	0%	79968	1%	7377221
Darling Riverine Plains	0	0%	3945129	42%	4775926	51%	765	0%	249791	3%	626808	7%	11271	0%	13611	0%	9	0%	422757	4%	9419258
Mulga Lands	0	0%	6240021	95%	22375	0%	16	0%	290075	4%	437877	7%	0	0%	765	0%	17	0%	38015	1%	6591283
Murray Darling Depression	0	0%	7050650	89%	375329	5%	103	0%	462437	6%	547735	7%	0	0%	1643	0%	0	0%	45718	1%	7935880
Nandewar	0	0%	74107	4%	1817734	88%	955	0%	85950	4%	8142	0%	16254	1%	2507	0%	0	0%	77375	4%	2074882

Bioregion Name	AUSTRALIAN GOV.		CROWN		FREEHOLD		LOCAL GOV. AUTH		NPWS RESERVES		Other Conservation		STATE FOREST		NSW GOV (Other)		CROWN /COUNCIL		UNKNOWN		All Tenure
New England Tablelands	4	0%	94678	3%	2288162	80%	224	0%	275059	10%	28558	1%	119110	4%	2507	0%	468	0%	80087	3%	2860298
NSW North Coast	650	0%	59478	1%	2228076	56%	7360	0%	994637	25%	61728	2%	564654	14%	7181	0%	0	0%	133546	3%	3995583
NSW SW Slopes	21	0%	223809	3%	7261188	90%	5907	0%	194983	2%	146795	2%	102635	1%	11270	0%	50	0%	303510	4%	8103373
Riverina	951	0.00%	1923228	27%	4482355	64%	15131	0%	236728	3%	286893	4%	40075	1%	24998	0%	0	0%	299225	4%	7022691
South East Corner	19	0.00%	15672	1%	356710	30%	1624	0%	498014	41%	7854	1%	301720	25%	989	0%	0	0%	33282	3%	1208028
South East Highlands	236	0.00%	143613	3%	3558397	72%	7924	0%	730135	15%	125397	3%	336430	7%	9772	0%	4	0%	155506	3%	4942018
South East Queensland	0	0.00%	23432	1%	1170334	70%	1714	0%	227795	14%	26884	2%	152121	9%	2937	0%	0	0%	82937	5%	1661270
Simpson Strzelecki Dunefields	0	0.00%	973900	89%	36	0%		0%	119146	11%		0%	0	0%	0	0%	0	0%	2714	0%	1095797
Sydney Basin	20350	0.60%	206348	6%	1600902	44%	5619	0%	1443744	40%	30935	1%	159036	4%	11405	0%	257	0%	169274	5%	3616933
All Bioregions	22231	0.60%	3173991 6	40%	3674620 4	46%	50449	0%	716119 5	9%	305348 5	4%	216435 0	3%	10716 9	0%	833	0%	210518 6	3%	80097533

REPRESENTATION OF KOALAS WITHIN RESERVE ESTATE

In the context of this bioregional assessment, the purpose of this component of the analysis is to gain an appreciation of the level of occupation of the reserve system within each bioregion by koala populations. Given the historical bias of land reservation in NSW toward less productive land, it cannot be assumed that a higher reservation adequacy at a bioregional scale translates to protection of koala populations.

The lack of systematic survey across geographic regions and tenure types for koalas is a confounding influence on any analysis of koala occurrence and distribution. It is commonly accepted that observations of koalas have a bias toward areas which are more populated, particular rural and regional centres (such as Lismore), and also toward lands which are the subject of survey. These latter lands include councils which have conducted a Comprehensive Koala Plan of Management (CKPoM) and also State Forests (pre-logging surveys). While many National Park areas were surveyed intensively during the Regional Forest Agreement process in the late 1990's, this survey effort has been inconsistent. It can be a presumption of this analysis that generally, representation in National Park Estate will be underestimated.

The recent declaration of the Murrah flora reserves (near Bermagui) has significantly increased the security of koala populations for the South East Corner Bioregion. While Flora Reserves are considered secure in terms of conservation (IUCN I, II, III or IV) (Forests NSW 2010), they are included in State Forest estate for reporting purposes.

Observations of koalas considered for the analysis and presented in table 3 include filtered records from 1990 through to present (January 2017).

Observations are represented in terms of both the raw number recorded per tenure type and also as a percentage of the total for that Bioregion. Readers should be aware that results for bioregions with a low overall count of observations are subject to large stochastic variability and therefore have a low overall confidence. This caution is in addition to the observations on sampling bias given in the paragraph above.

The results are however, expected to give a good account of the trends in representation of koalas in reserves across bioregions and therefore useful in a relative sense. Bioregions with a lower overall representation of koalas in reserves are expected to broadly indicate a reserve system less well suited for koala conservation, relative to a bioregion with a higher representation, particularly in bioregions with a higher overall observation count.

Table 3 Representation of koalas within reserve estate across bio-regions in NSW

Bioregion Name	AUST. GOV.		CROWN		FREEHOLD		LOCAL GOV. AUTHORIT		NATIONAL PARK		NSW GOV.		STATE FOREST		UNKNOWN		All tenure
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	
Brigalow Belt South (NSW)	0	0%	88	6%	707	48%	9	1%	271	18%	12	1%	305	21%	75	5%	1467
Cobar Penneplain	0	0%	1	50%	1	50%	0	0%	0	0%	0	0%	0	0%	0	0%	2
Darling Riverine Plains	0	0%	36	60%	13	22%	0	0%	6	10%	0	0%	2	3%	3	5%	60
Mulga Lands	0	0%	3	100%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	3
Nandewar	0	0%	18	13%	91	66%	0	0%	22	16%	0	0%	1	1%	5	4%	137
New England Tablelands	0	0%	25	8%	176	58%	0	0%	44	15%	2	1%	56	18%	0	0%	303
NSW North Coast	0	0%	716	7%	5812	54%	33	0%	1332	12%	50	0%	2311	22%	446	4%	10700
NSW South West Slopes	0	0%	78	38%	58	28%	0	0%	54	26%	1	0%	1	0%	13	6%	205
Riverina	0	0%	1	2%	13	23%	0	0%	34	61%	0	0%	2	4%	6	11%	56
South East Corner	0	0%	8	1%	77	11%	0	0%	265	38%	4	1%	336	49%	1	0%	691
South East Highlands	0	0%	82	5%	1297	81%	0	0%	173	11%	0	0%	9	1%	34	2%	1595
South East Queensland (NSW)	0	0%	715	16%	2646	60%	35	1%	452	10%	14	0%	487	11%	27	1%	4376
Sydney Basin	214	8%	149	5%	1658	58%	7	0%	596	21%	15	1%	70	2%	129	5%	2838
All Bioregions	214	1%	1920	9%	12549	56%	84	0%	3249	14%	98	0%	3580	16%	739	3%	22433

RELEVANCE AND APPLICATION OF KOALA REPRESENTATION DATA FOR KOALA RESERVE PLANNING

Applying the representation of koalas within reserve estate analysis

This analysis identifies what proportion of the known populations occur in reserve estate in each bioregion. While records will have a tendency overall to be skewed towards off-park tenure, this trend will be survey dependant and influenced by the management history of each reserve and its accessibility to survey. As a general comment, areas with a history of active management (forestry, mining and clearing), where surveys are required, will be more likely to be highly represented in this analysis.

This analysis can be used to support decisions for determining:

- Where there are potentially high conservation benefits in acquiring private land (or conserving private land via conservation agreements).
- Where known populations are well represented across multiple tenures. These bioregions might be priorities for collaborative best practice between land managers across tenures.
- Which bioregions show reasonable representation of known populations in reserves.

This analysis is limited by data available and cannot be used to determine whether the reserve system is adequate for koalas as it does not take into account survey effort or population viability analysis. Finer scale analyses (sub-regional or reserve specific) may reveal variations in survey effort that will give a more meaningful indication of the confidence of koala occupation and persistence. The Koala Likelihood of Occurrence map for NSW (OEH 2016) reveals a wide variation of confidence for koala survey across NSW, with most of western NSW (and many parts of the coast) having a low overall confidence.

POPULATION STATUS

Resilience and viability of koala populations have been the subject of recent studies and reports including the Independent Review into the Decline of Koala Populations in Key Areas of NSW (NSW Chief Scientist and Engineer 2016).

While detailed studies of population viability are usually undertaken at the local scale (e.g. Niche 2016 – Pacific High way upgrade near Wardell), studies of population trends, threats and estimates of population size are more regularly undertaken at the regional or sub-regional scale. A key study involving expert elicitation of population trends and threats was undertaken in 2012 and forms the basis of much of the analysis results presented in this section.

Three criteria have been applied for assessment of population status and trends at the bioregional scale.

1. Population estimates and trends at a bioregional scale, based on expert knowledge (Adams-Hosking et al. 2016)
2. Analysis of sites records by generation to estimate trends in koala activity (as a surrogate of population size) at a bioregional scale.
3. Threat mapping undertaken at a bioregional scale by Adams-Hosking et al. 2016.

With wild populations of koalas known to be declining throughout NSW, the viability of existing populations into the future is an important consideration when directing investment in conservation for the species. Although no quantitative analysis of koala population viability has been undertaken in NSW, related studies give some guidance for future conservation direction.

Scotts (2013) comments that the viability of many of the sub-populations on the Upper Mid-North Coast of NSW (particularly coastal and floodplain sub-populations) now appears to be tenuous. Only 1 of 8 sub-populations in the Coffs-Bellingen regional population is considered to be stable. The other seven populations are now in decline and dependent on immigration from adjoining sub-populations. Scotts predicts a similar situation for the other regional populations of South Bellinger, Macleay, Southern Clarence and Northern Clarence.

While hinterland sub-populations are not subject to the same degree of habitat loss associated with coastal development, timber harvesting presents an ongoing threat to habitat condition where it occurs. A recent study identified a preference for larger diameter feed trees present in structurally mature dominated forests of northern NSW forests (EPA 2016).

Given the variance in threats across the landscape, even within the Upper Mid-North Coast, assessment of threat levels at a bioregional scale can only be indicative. Predicting trends in the status of populations from factors such as the availability and quality of habitat and exposure to threatening processes such as vehicle strike and urbanisation is feasible (McAlpine et al. 2015).

POPULATION ESTIMATES AND TRENDS ACROSS BIOREGIONS IN NSW

Workshop conducted in 2012 (Adams-Hosking 2016) to elicit population size and trends for bioregions in Queensland, NSW, Victoria and South Australia. A panel of 15 experts provided estimations of populations size and predicted trends across bioregions. Both estimates of population size and trends in decline (or increment) were qualified by generally high levels of uncertainty, often over 50% for a bioregion.

Coupled with the 2012 expert elicitation study is a recent records analysis of the trends in koala observations relative to the total arboreal observations for that period (using 6 year periods). The trend in relative observations of koalas across generation periods has then been used to observe increasing or decreasing trends in predicted koala populations. Previous comments regarding bias in observations toward more populated and more intensively surveyed areas also apply to this analysis.

Table 4 below integrates both the results of the 2012 expert elicitation for population trends and also the numerical records analysis. Both analyses show a clear trend to declining populations across almost all bioregions in NSW. Some of the western bioregions were considered too data poor to present results for the numerical analysis.

A recognised anomaly of the numerical records analysis shows an increase in observations of koalas over the analysis period in the South East Queensland Bioregion. This result has been attributed to a large increase in koala specific survey effort in this region, with several Comprehensive Koala Plans of Management being prepared over this period.

Table 4 Koala populations across NSW IBRA regions

IBRA NAME	**Population Estimate (Adams – Hosking et al. 2016)**	**Status (Stable, Declining, sharply declining) from Adams-Hosking et al.**	**Observations since 2011 (current generation)**	**Koala Observations as a proportion of all arboreal observations (as a measure of survey effort)**	**Records analysis** **Stable or declining (since previous generation/s)**	**Overall Trend**
Brigalow Belt South and Nandewar	11,133	Declining (-35%)	292	11%	Overall decline over analysis period.	Declining
Cobar Peneplain and Riverina	2354	Declining – Stable (-9%)	2	15%	Insufficient data	Declining – Stable
Darling Riverine Plains	964	Declining (-34%)	2	25%	Insufficient data	Declining
Mulga Lands	711	Declining (-31%)	0	N/A	Insufficient data	Declining
Murray Darling Depression	55	Declining – Stable (-12%)	0	N/A	Insufficient data	Declining – Stable
New England Tablelands	2771	Stable – increasing (6%)	79	1%	Slight decline over analysis period.	Stable
NSW North Coast	8367	Declining (-50%)	2010	21%	Overall decline over analysis period.	Declining
NSW South Western Slopes	2310	Declining (-23%)	3	0%	Overall decline over analysis period.	Declining
South East Corner	2768	Declining (-46%)	213	4%	Declining over last generation, but stable overall.	Declining - stable
South Eastern Highlands	1363	Declining (-19%)	323	5%	Overall decline over analysis period.	Declining
South Eastern Queensland (QLD figures)	15,821	Declining (-51%)	1801	51%	Increase over recorded period*	Declining
Sydney Basin	5667	Declining – Stable (-4%)	406	5%	Moderate decline over survey period.	Declining - Stable

* Increase in recorded occurrence of koalas in South East Queensland over past 3 generations associated with increased focus on koala management and accompanying survey effort including CKPoM SAT data and Dan Lunney's Community Wildlife Survey.

Table 5 **Trend in recorded occurrence of koalas across generation (6 year period) as a proportion of overall survey effort.**

Bioregion Name	Koalas 1990-1992	% total Arboreals	Koalas 1993-1998	% total Arboreals	Koalas 1999-2004	% total Arboreals	Koalas 2005-2010	% total Arboreals	Koalas 2011-2016	% total Arboreals	Trend
Brigalow Belt South	12	75%	203	22%	331	39%	670	72%	251	11%	Declining over last generation
Cobar Peneplain	1	50%	0	0%	1	5%	0	0%	0	0%	Insufficient data
Darling Riverine Plains	8	62%	16	31%	4	3%	30	42%	2	25%	Declining over last generation
Mulga Lands	0	0%	3	60%	0	0%	0	0%	0	0%	Insufficient data
Murray Darling Depression	0	0%	0	0%	0	0%	1	25%	0	0%	Insufficient data
Nandewar	8	73%	11	7%	30	6%	47	22%	41	4%	Declining over last generation
New England Tablelands	20	1%	83	5%	38	3%	90	7%	79	1%	Declining over last generation
NSW North Coast	2096	30%	1776	24%	1378	26%	3440	43%	2010	21%	Declining over last generation
NSW South Western Slopes	6	22%	136	22%	8	2%	52	3%	3	0%	Declining over last generation
Riverina	0	0%	5	1%	4	2%	45	20%	2	15%	Declining over last generation

South East Corner	129	7%	171	3%	20	1%	158	8%	213	4%	Declining over last generation
South Eastern Highlands	23	12%	428	20%	673	28%	148	10%	323	5%	Declining over last 2 generations
South Eastern Queensland	201	15%	582	23%	368	26%	1424	42%	1801	51%	Increase over recorded period*
Sydney Basin	575	70%	542	12%	861	11%	454	5%	406	5%	Decline over survey period
Grand Total	3079	23%	3956	15%	3716	16%	6559	23%	5131	11%	Declining over last generation

* Increase in recorded occurrence of koalas in South East Queensland over past 3 generations associated with increased focus on koala management and accompanying survey effort including CKPoM SAT data and Dan Lunney's Community Wildlife Survey.

USING POPULATION STATUS AND TREND DATA TO ASSIST IN SELECTING PRIORITY KOALA LAND ACQUISITIONS

Koala trend and population estimate data presented above in table 4 and table 5 provide a useful, but broad overview of the status of koalas at a bioregional level across NSW. Information in table 5 is a summary table of data drawn from an expert elicitation process (Adams Hosking et al. 2016) and data drawn from a quantitative analysis of filtered generational data (detailed in table 5). While the respective analyses provide results which are largely consistent, many of the western bioregions exhibit data deficiency issues, making comparison of the expert elicitation and quantitative analysis difficult.

Two bioregions exhibited conflicting trends between expert elicitation and site analysis data. New England Tablelands has been assessed by Adams – Hosking et al. as having a koala population which is stable to increasing (6% increase), while site analysis records a slight decline in koala observations over the most recent period. Given the relatively small koala site dataset (79 records from 2011 – 2016) and the fact that the expert elicitation estimate has a wide margin of error (-19% to +28%), this discrepancy can be viewed as inconclusive.

The increase in koala site records for the South East Queensland bioregion is a more interesting result. Study of the sites database for this area has revealed an increased focus on koala management over the last 3 generations (several Comprehensive Koala Plans of Management and Dan Lunney's Community Wildlife Survey). This increased focus on survey is thought to have resulted in elevated recorded occurrences of koalas.

When considering population trend data with regard to reservation priorities, relevant factors should include:

- Whether reservation has the capacity to reverse the trend in bioregions with declines. For example, reservation can protect against changes in land-use and can address threats such as fire and wild dogs but offers limited direct protection against extreme heat events. Boundary additions to reserves that buffer koala populations maybe beneficial in some circumstances, for example by improving the ability to better manage fire by providing fire zones away from a population.
- Whether reservation has the capacity to improve the resilience of populations in those bioregions which are currently stable or with smaller declines. A more detailed analysis of koala occupation within reserves may be appropriate at a sub-regional scale to further understand the potential for improving resilience of regional koala populations.

THREATENING PROCESSES

Processes and activities which are recognised as threatening to koalas are well recognised by the literature, both at a state and federal level. The documented decline in populations in NSW has brought a focus onto the understanding and mapping of these processes. At a bioregional scale, the 2012 expert elicitation report (Adams-Hosking et al.) provides the most useful guide to the intensity and trends in recognised threatening processes.

As with the population trend data, there is significant variation in the spatial distribution of processes at the sub-regional scale which are generalised to the bioregional scale. The difficulty in translating finer scale processes to a bioregional scale has led to some inconsistencies. More detailed data on threatening processes has been captured for some areas in documents such as Comprehensive Koala Plans of Management.

For both past and future, experts were asked to estimate the level of threat associated with each threat criteria. Threats of ranking 4 and 5 are considered to be of the highest importance.

Table 6 Classes of past and future threat impact mapping

Threat Ranking	**Threat Description**
1	Present, but with no likely measurable impact on koala populations
2	Having a minor impact on koala populations
3	Having a moderate impact on koala populations
4	Having a major impact on koala populations
5	Having a key impact on koala populations

Table 7 **Threat mapping by bio-region and threat category across NSW (Adams-Hosking et al. 2016).**

Bioregion	Fire		Drought		Disease		Dogs		Habitat Loss		Heatwave		NRM		Vehicle Collision		Leaf Chemistry Change		Mining		Urbanisation		All Past	All Future	Change
Past/Future (P/F)	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F			
Australian Alps	3	3	2	3	1	1	1	1	1	1	1	2	1	1	1	1	0	1	0	0	0	0	11	14	3
Brigalow Belt Sth	3	4	5	5	1	3	1	1	3	3	4	5	2	3	2	2	0	1	1	5	1	1	23	33	10
Cobar Peneplain	1	2	3	4	1	1	1	1	2	2	2	3	1	1	1	1	0	1	1	1	1	1	14	18	4
Combined Western Bioregion	1	1	3	4	1	1	1	1	2	2	2	3	1	1	1	1	0	1	1	1	1	1	14	17	3
Darling Riverine Plains	1	2	3	4	1	1	1	1	3	3	2	4	2	4	1	2	0	1	0	1	1	1	15	24	9
Nandewar	3	4	5	5	1	3	1	1	3	3	4	5	2	3	2	2	0	1	1	5	1	1	23	33	10
New England Tablelands	2	3	3	4	2	2	2	2	3	3	2	4	2	2	2	2	0	1	1	1	1	2	20	26	6

Bioregion	Fire		Drought		Disease		Dogs		Habitat Loss		Heatwave		NRM		Vehicle Collision		Leaf Chemistry Change		Mining		Urbanisation		All Past	All Future	Change
NSW North Coast	2	3	2	3	2	3	3	4	5	5	1	2	1	2	4	5	0	1	0	0	5	5	25	33	8
South East Queensland	1	2	2	3	3	4	3	4	5	5	1	2	1	2	3	4	0	1	1	2	5	5	25	34	9
NSW South Western Slopes	2	3	3	4	1	1	1	1	3	3	1	2	1	2	1	1	0	1	1	1	1	1	15	20	5
Riverina	1	1	3	4	1	1	1	1	3	3	2	4	2	4	1	2	0	1	0	1	1	1	15	23	8
South East Corner	1	3	2	3	1	1	2	2	3	2	1	2	2	2	2	1	0	1	0	0	1	1	15	18	3
South East Highlands	3	3	2	4	1	1	3	3	2	2	2	3	1	2	1	1	0	1	0	0	1	1	16	21	5
Sydney Basin	2	4	2	2	2	3	2	2	2	3	1	2	1	2	2	3	0	1	1	2	3	4	18	28	10

USE OF BIOREGIONAL THREAT DATA IN SELECTING PRIORITY KOALA ACQUISITIONS

CAN THE THREAT BE MITIGATED BY PROVIDING SECURITY OF TENURE?

When considering priorities for reservation, the mitigation potential of threatening processes at the site level needs to be considered. These known threats provide a checklist of considerations that can be used at the site and population level. Some of these threats can be addressed through acquisition (e.g. habitat loss), others cannot be (leaf chemistry change).

Not all threats operating at the bioregional level will be operating at the site level, but should provide a flag for assessment at the local and site level. Whether on balance a particular acquisition will benefit a koala population can only be considered case by case in the context of surrounding land use.

The threat information can also be used to indicate where acquisition is best considered in association with other conservation programs, particularly where adjacent land management is important to the ongoing persistence of koala populations and habitat in the area.

KEY OBSERVATIONS FROM THE BIOREGIONAL THREAT ANALYSIS

Threat groups which cannot be mitigated by reservation (such as drought and heatwave) are generally higher in the west. Brigalow Belt South and Nandewar also include high predicted threats which can be mitigated by reservation, such as Mining and NRM.

Coastal bioregions, particularly in the north, are dominated by threats associated with urban and rural development (such as road strike, urbanisation and habitat loss). Whilst these threats are notionally able to be mitigated at the site scale where they occur through reservation, the overall resilience of populations at the regional scale needs to be considered, especially in bioregions which are thought to be in sever decline (refer to *Population Status* assessment above).

All bioregions report increased threat in the future from a variety of sources. Future threat levels of 4 and 5 are considered to be the highest priority for mitigation through reservation or mitigation actions.

RESILIENCE MAPPING

Climate change is a potential threat to the Koala, as it is expected to lead to increased frequency of high temperatures, changes to rainfall, increasing frequency and intensity of droughts, and increased fire risk over much of the Koala's range (NRMMC 2010). Increased temperatures inland are expected to cause the Koala's range to contract eastward (Adams-Hosking 2011; Adams-Hosking et al. 2011; Dunlop & Brown 2008; Queensland Office of Climate Change 2008). This effect would be compounded by extended drought that may be expected under climate change scenarios (Queensland Office of Climate Change 2008). Access to permanent water in times of drought and heat stress are considered important landscape features for koala populations during these high stress

There is also some evidence that riparian areas act as refugia for koala populations in times of stress characterised by climate change, heat stress, drought and fire events (Gordon et al. 1990).

3C MODELLING FOR BIODIVERSITY UNDER FUTURE CLIMATE

Assessment of koala habitat values as a surrogate to assess resilience to threats at a bioregional scale is difficult. A recent study by OEH evaluated the impacts of climate change on biodiversity up to 2050 and mapped where conservation actions will provide the greatest benefits maps priorities for conservation and rehabilitation across NSW under future climate scenarios (Drielsma et al. 2015). The models provided by this study, although described as big picture, are detailed and best applied at a sub-regional level or local level.

Two analyses from the 3C study have been included in this report which are thought to be useful for application to koala conservation and future resilience planning. A summary of the *Manage Benefits* and *Bioclimatic Difference* analyses are provided below with a short interpretation of their applicability to koala conservation and future reservation implications.

MANAGE BENEFITS ANALYSIS

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 3 below (from Drielsma et al. 2015) depicts changing conservation priorities from past vegetation community distributions to those predicted in 2050. The model has been designed for generalised biodiversity and is not specific to koala, however it does give general guidance on the ability of reserve managers to protect depleted biodiversity both now and under a future climate change scenario.

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.

Figure 3 Biodiversity climate adaptation: Manage Benefits 1990 versus 2050 (Drielsma et al. 2015)

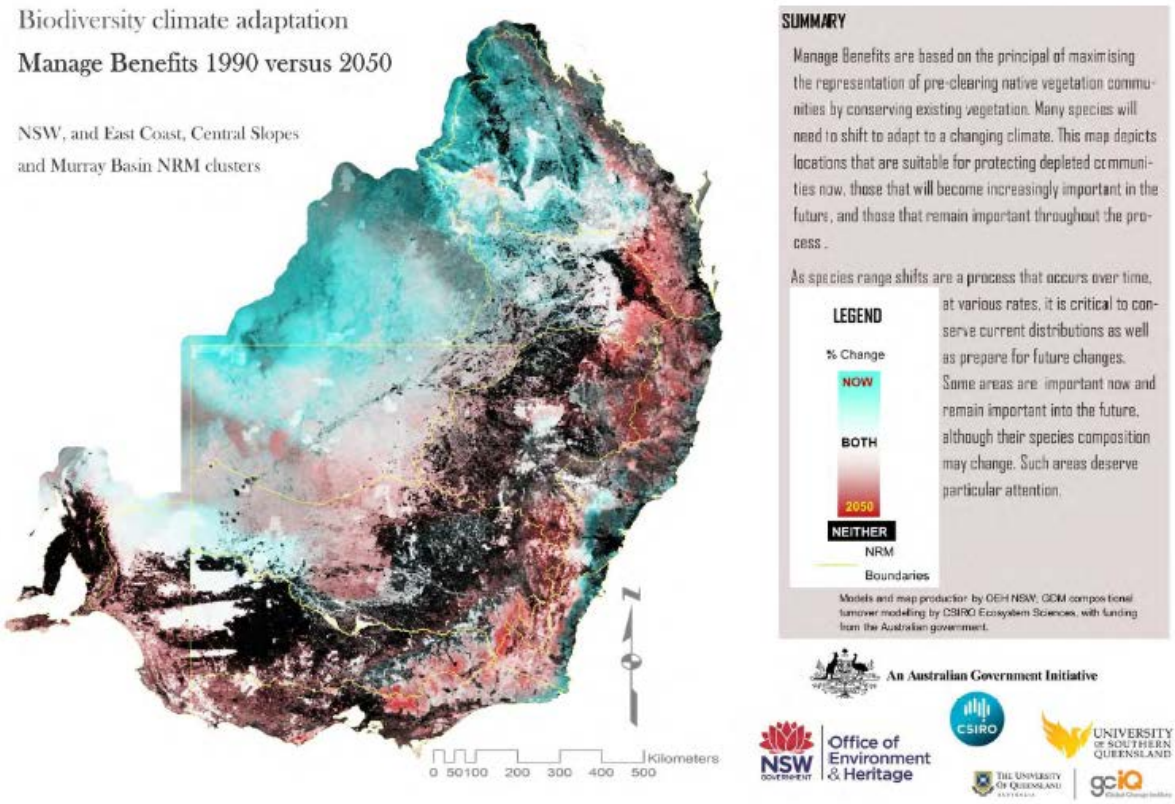


Figure 18: Manage benefits 1990 versus 2050

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

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. Figure 4 below, an excerpt from the 3C Modelling report (Drielsma 2016), shows the Bioclimatic difference model at a geographic scale.

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 4 Bio-Climatic Difference 1990 to 2050 (Drielsma et al. 2015)

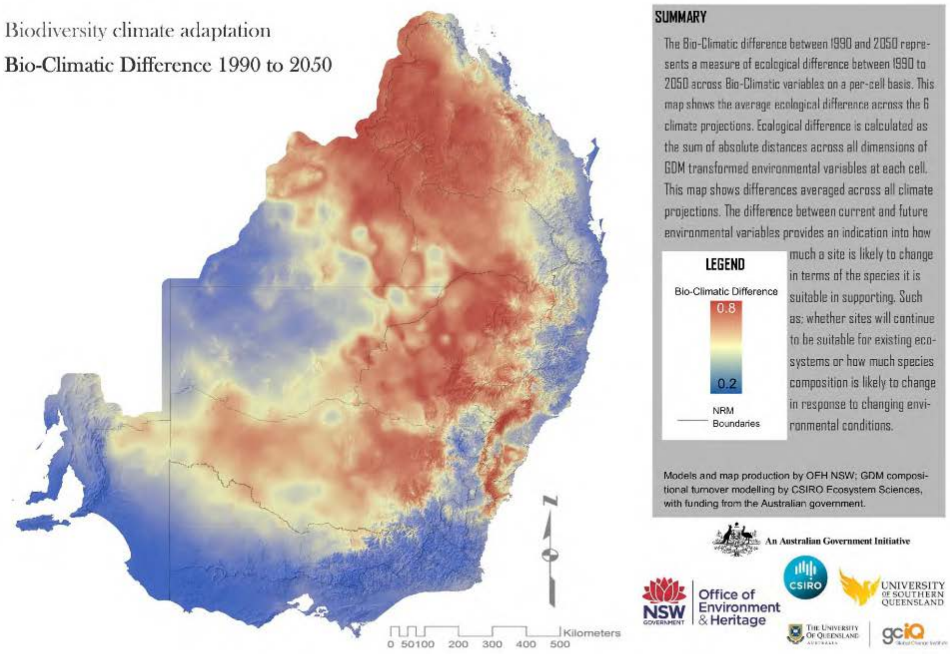


Figure 10: Average bio-climatic difference between 1990 and 2050

OVERALL PRIORITY FOR CONSERVATION AND RESERVATION

Achieving a conservation priority for koala conservation across NSW, even at a bioregional scale, is difficult and subjective at best, with criteria for assessment being drawn from datasets, which themselves are interpreted, or based on expert elicitation. Nevertheless, such a prioritisation can help to flag the need for further, finer scale studies which can address opportunities and issues at the sub-regional and local level.

Table 9 presents a set of linguistic classified criteria which are outlined and described in table 8. The criteria are a summary of the material presenting in the previous sections and together contribute to an overall priority class for koala conservation at the bioregional scale.

As has been stressed in previous sections, this analysis generalises to the extent that individual koala populations cannot adequately be represented and the trends and priorities at the sub-regional level may be obscured by this assessment.

The final ranking of the bioregion has been assigned manually in consideration of all criteria, with most weight given to criteria most affecting the long-term benefits from acquisition of koala lands. Details of crucial factors in ranking the three highest ranked bioregions (South East highlands, Nandewar and Brigalow Belt South) are provided below.

Table 8 Criteria for bioregional prioritisation of koala conservation and reservation

Criteria	**Description**
Population Size	From Adams-Hosking (2016). Categories are: Very Large: Over 10,000 individuals Large: 5,000 – 10,000 individuals Moderate: 1,000 – 5,000 individuals Small: 500 – 1,000 individuals Very Small: Less than 500 individuals
Trend	From Adams-Hosking (2016) as interpreted in Table 4 (*Populations Status*).
Representation in reserves	From table 3, *Representation of Koalas within Reserve Estate*. Categories are: Very High: Over 50% High: 20% - 50% Moderate: 15% – 20% Low: 10% - 15% Unknown: Insufficient data
Exposure to land use change	From table 3. Proportion of koala observations on private land. Categories are: Very High: Over 80% High: 60% – 80% Moderate: 40% - 60% Low: Less than 40% Unknown: Insufficient data

Criteria	**Description**
Ability to mitigate dominant threats	Manual assessment of the mitigation potential for the most dominant threats for each bioregion presented in table 7. Threats considered to have the most potential for mitigation include habitat loss, vehicle strike, urbanisation and fire. Climatic threats are considered to have a low potential for mitigation.
Reservation Status	From table 2. Proportion of bioregion in formal reserve. Very Adequate: Over 30% Adequate: 17% - 30% Inadequate: 10% - 17% Low: 5% - 10% Very Low: Less than 5%
Future Resilience	Desktop manual interpretation of the overall future resilience of bioregions in terms of future potential for conservation management (Management Benefits Analysis - Figure 3).

Table 9 Overall bio-regional priority for conservation investment and reservation for NSW

Bio-region	Pop. size	Population Trend	Representation in Reserves	Exposure to Landuse change	Ability to mitigate dominant threats	Status of Reserve Estate	Future Resilience	Conservation and Reservation Priority
South East Highlands	Moderate	Declining	Low	Very High	Moderate	Inadequate	High	Very High
Brigalow Belt South	Very Large	Declining	Moderate	Moderate	Low	Low	Low	High
Nandewar	Moderate	Declining	Moderate	High	Low	Very Low	Moderate	High
South East Queensland	Very Large (moderate in NSW)	Declining	Low	High	Moderate	Inadequate	Low	Moderate-High
NSW North Coast	Large	Declining (some stable)	Low – Moderate	Moderate	Moderate	Adequate	Moderate	Moderate – High
Darling Riverine Plains	Small	Declining	Unknown	Unknown	Low	Very Low	Low	Moderate – High
New England Tablelands	Moderate	Declining – Stable	Moderate	Moderate – High	Low	Inadequate	High	Moderate – High
Sydney Basin	Large	Declining – Stable	High	Moderate – High	High	Very Adequate	Moderate - High	Moderate
Cobar Peneplain	Moderate	Declining – Stable	Unknown	Unknown	Low	Very Low	Low	Moderate
Mulga Lands	Small	Declining	Unknown	Unknown	Low	Very Low	Low	Moderate
NSW South West Slopes	Moderate	Declining	High	Low	Moderate	Very Low	Low	Moderate – Low

Bio-region	Pop. size	Population Trend	Representation in Reserves	Exposure to Landuse change	Ability to mitigate dominant threats	Status of Reserve Estate	Future Resilience	Conservation and Reservation Priority
Murray Darling Depression	Very Small	Declining – Stable	Unknown	Unknown	Low	Low	Low	Moderate – Low
Riverina	Moderate	Declining – Stable	Very High	Low	Low	Very Low	Low	Low
South East Corner	Moderate	Declining –stable	High	Low	High	Very Adequate	Moderate	Low

INTERPRETATION OF OVERALL BIOREGIONAL PRIORITY FOR RESERVATION OF KOALA LANDS

Most bioregions present a moderate to high priority for conservation of koala lands. The two bioregions with low overall priority (South East Corner and Riverina) have been ranked as such primarily because the majority of known koala populations occur in lands which have been reserved.

The highest ranked bioregions, South East Highlands, Nandewar and Brigalow Belt South have a combination of moderate to large koala populations which are poorly reserved and under moderate to high levels of threat. South East Highlands has been found to provide the highest benefit for future conservation investment, having a high predicted resilience to climate change and relatively stable (but declining populations) with threats that are able to be mitigated at the site level.

A summary of the key criteria for assignment of priority for South East Highlands, Nandewar and Brigalow Belt South Bioregions is shown below in tables 10 and 11 respectively.

Table 10 Key criteria for South East Highlands Very High Reservation Priority

SOUTH EAST HIGHLANDS BIOREGION	VERY HIGH RESERVATION PRIORITY

- Significant but declining koala populations
- Increasing threats to viability
- Low overall estimated representation within reserve estate (11%)
- Very high exposure to future changes in land use (81% occurrence on freehold land).
- Below target overall reservation within bioregion
- High resilience to bio-climatic differences resulting from climate change (Drielsma et al. 2015). Refer figure 5.

Table 11 Key criteria for Nandewar and Brigalow Belt South High Reservation Priority

NANDEWAR AND BRIGALOW BELT SOUTH BIOREGIONS	HIGH RESERVATION PRIORITY

- Large but declining koala populations
- Increasing threats to viability (particularly mining related and climate change related threats)
- Low overall representation within the reserve estate (16-18%)
- Moderate exposure to changing land-use (48-66% occurrence on private land)

- Below target overall reservation within bioregions (4-9%)

SOUTH EAST HIGHLANDS BIOREGION PRIORITISATION OF OCCUPIED KOALA HABITAT

OBJECTIVE AND SUMMARY OF METHODOLOGY

The purpose of this analysis is to provide a summary of potential areas of investigation in the South East Highlands Bioregion for land acquisition by NSW National Park and Wildlife Service, as part of their initiative to protect koalas under the Saving Our Species Iconic Koala Project.

Five areas of interest for koala investment have been identified for the Southern Highlands Bioregion (Southern Tablelands Koala Management Area). The areas of interest have been derived from interpretation of koala occupancy information, then refined by koala habitat information and expert advice (where available). While a quantitative threat assessment and viability analysis has not yet been undertaken, available advice and mapping has been used in desktop assessment to profile each area for major influencing risk factors.

THE AREAS OF INTEREST

The five areas of interest are listed below in table 12. All identified areas of occupied are predominantly on private land with the exception of the Bungonia population (within Bungonia NP).

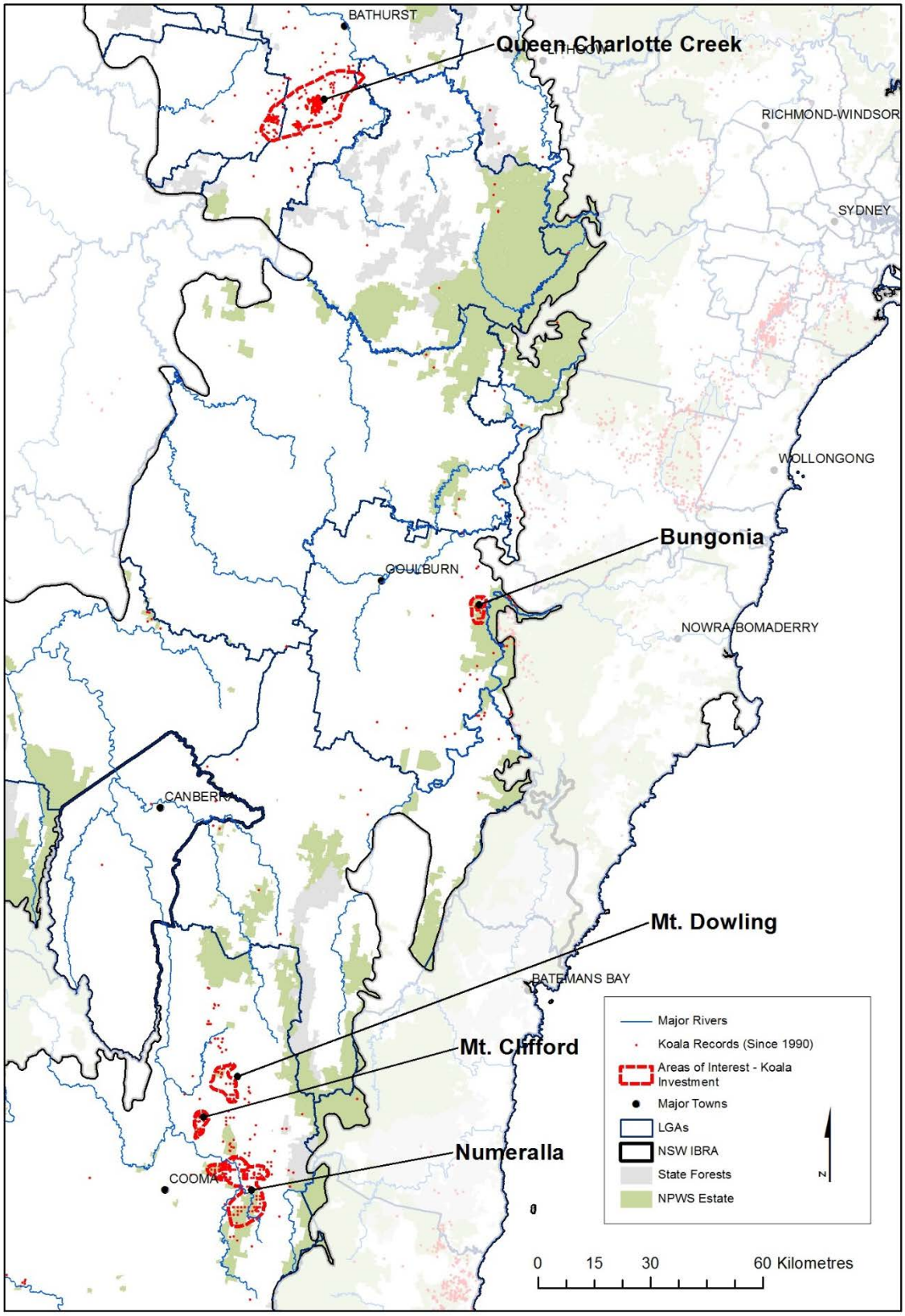
The best available information on koala population size for the region is 1363 individuals (Adams-Hosking et al.) with this number projecting to decline moderately in the medium term. Figures on number of individuals for sub-populations (within each area of interest) are sporadic and expert-based.

Table 12 Five Areas of Interest for Koala Conservation in South East Highlands Bioregion

Area of Interest	Description
Numeralla.	From Macanally NR in the north, south to Kybeyan SCA including lands surrounding Numeralla township.
Mt. Clifford	From Mt. Clifford NR in the south, extending north along ranges weset of Buchans Creek.
Mt. Dowling.	Extending from Mt. Dowling NR south to Bredbo River and Cowra Creek in the south.
Queen Charlottes Creek.	Extends from *The Lagoon* in the east to Wimbledon Road in the west.
Bungonia	Centred on the western edge of Bungonia NP, roughly 8km NE of Bungonia township.

The population of koalas within the combined five areas of interest are considered to be small. Allen (2010 unpublished) estimates the NE Monaro population (including Numeralla, Mt. Clifford and Mt. Dowling) to be somewhere between 80 and 320 individuals. Steven Cox (pers. Com.) estimates that the Queen Charlottes Creek population, south-west of Bathurst, is between 200 and 500. No information on the population in Bungonia has yet been discovered.

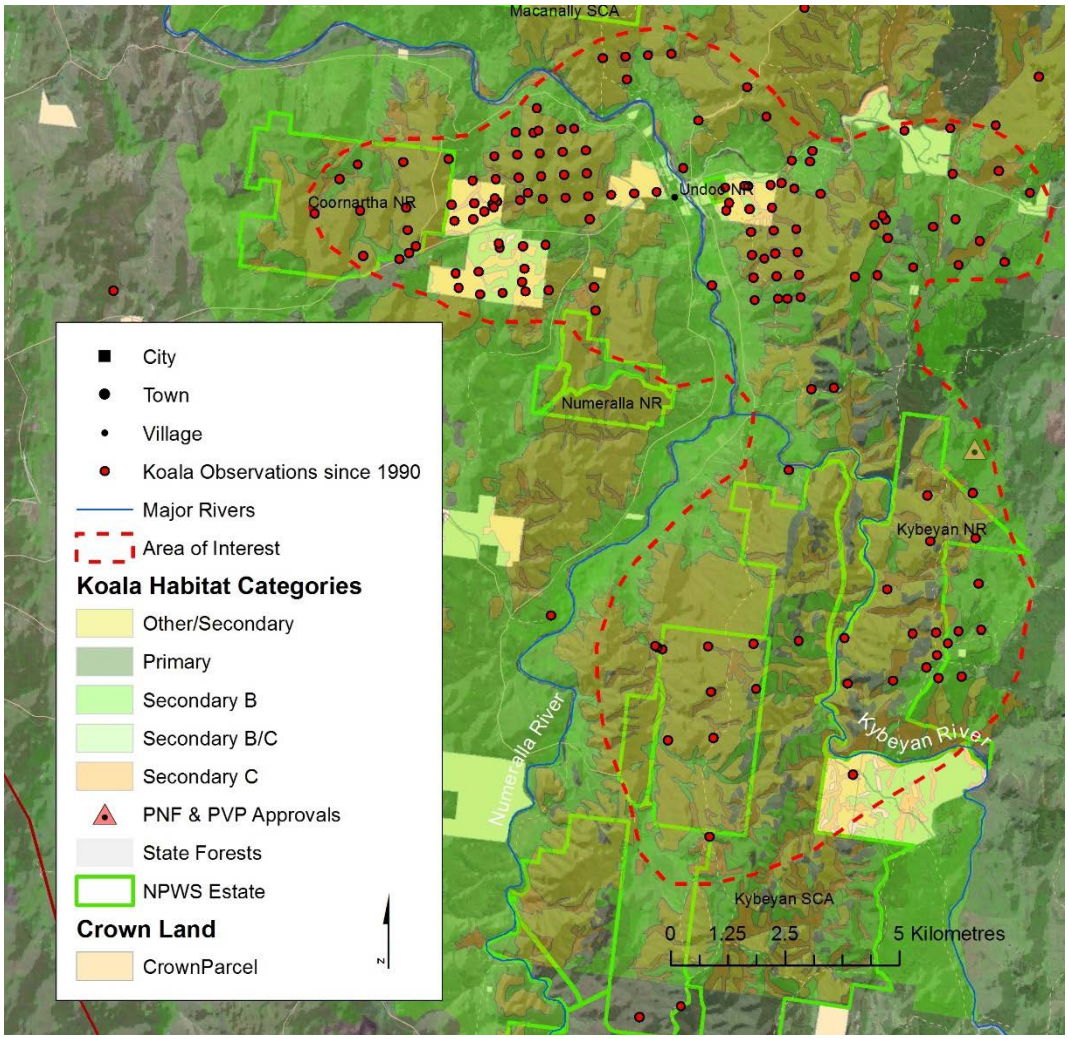
Figure 5 Areas of Interest for South East Highlands Bioregion



KEY ASSESSMENT CRITERIA

CRITERIA	DESCRIPTION
Population size	Low density koala population. estimated to be around 200 individuals (DECCW 2010) for the NE Monaro area. Generational data shows evidence of long term occupation by koalas.
Habitat Quality	Koala habitat (as mapped by Biolink 2015) across the AOI is predominantly Secondary B)
Landscape Features	Perennial streams including the Numeralla River and the Kybeyan River. Habitat is consolidated.
Threats and Pressures	Currently under pressures which include urban / rural residential expansion from Numeralla town centre and mining interest (gold). There is some recorded history of wildfire and prescribed burning (Macanally NR) in the area and the majority of the study area is considered to be fire prone. Some private native forestry activity in the area.
Conservation Opportunities	Dominant land use outside of reserve estate is passive, with livestock grazing largely restricted to valley flats. Crown land parcels west of Numeralla have significant conservation value, however the potential for conversion of these lands to reserve is unknown. Overall high potential for koala conservation through reserve acquisition.

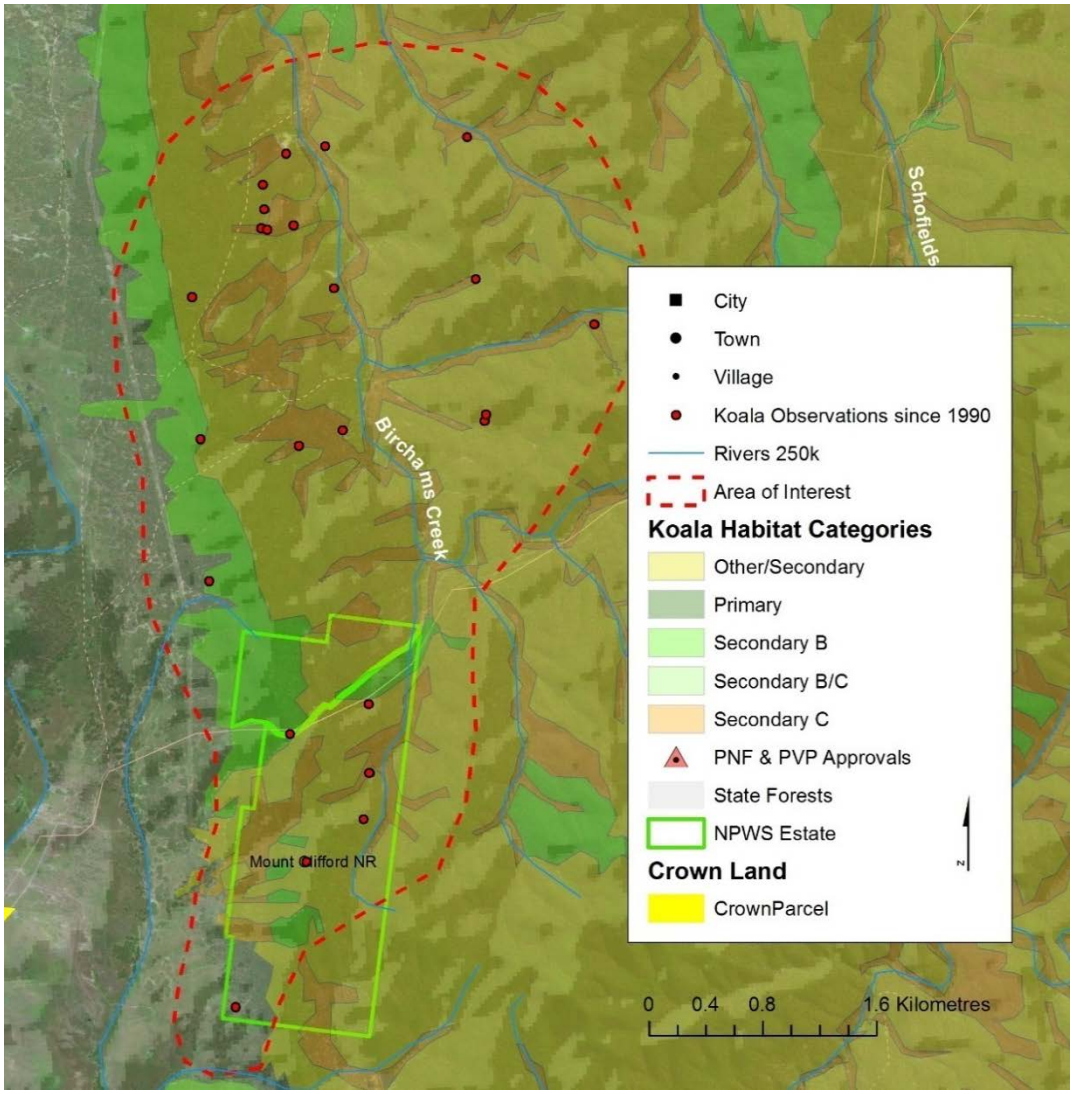
Figure 6 Numeralla Area of Interest



KEY ASSESSMENT CRITERIA

CRITERIA	DESCRIPTION
Population size	Low density koala population. estimated to be around 200 individuals (DECCW 2010) for the NE Monaro area. Generational data shows evidence of long term occupation by koalas.
Habitat Quality	Koala habitat (as mapped by Biolink 2015) across the AOI is predominantly Secondary B)
Landscape Features	Perennial streams including Birchmans Creek which flows through the centre of the area. Habitat is consolidated.
Threats and Pressures	There is an exploration licence for minerals to the west (Peel Pty Ltd.), but this does not extend significantly into the area of interest. While there is no recorded history of wildfire in the immediate vicinity the majority of the study area is considered to be fire prone.
Conservation Opportunities	Northern section of area of interest is covered by a Voluntary Conservation Agreement (Black Ridge). Dominant land use outside of reserve estate is passive, with livestock grazing largely restricted to valley flats. There is negligible crown land outside reserve in the area. Overall low - moderate potential for koala conservation through reserve acquisition.

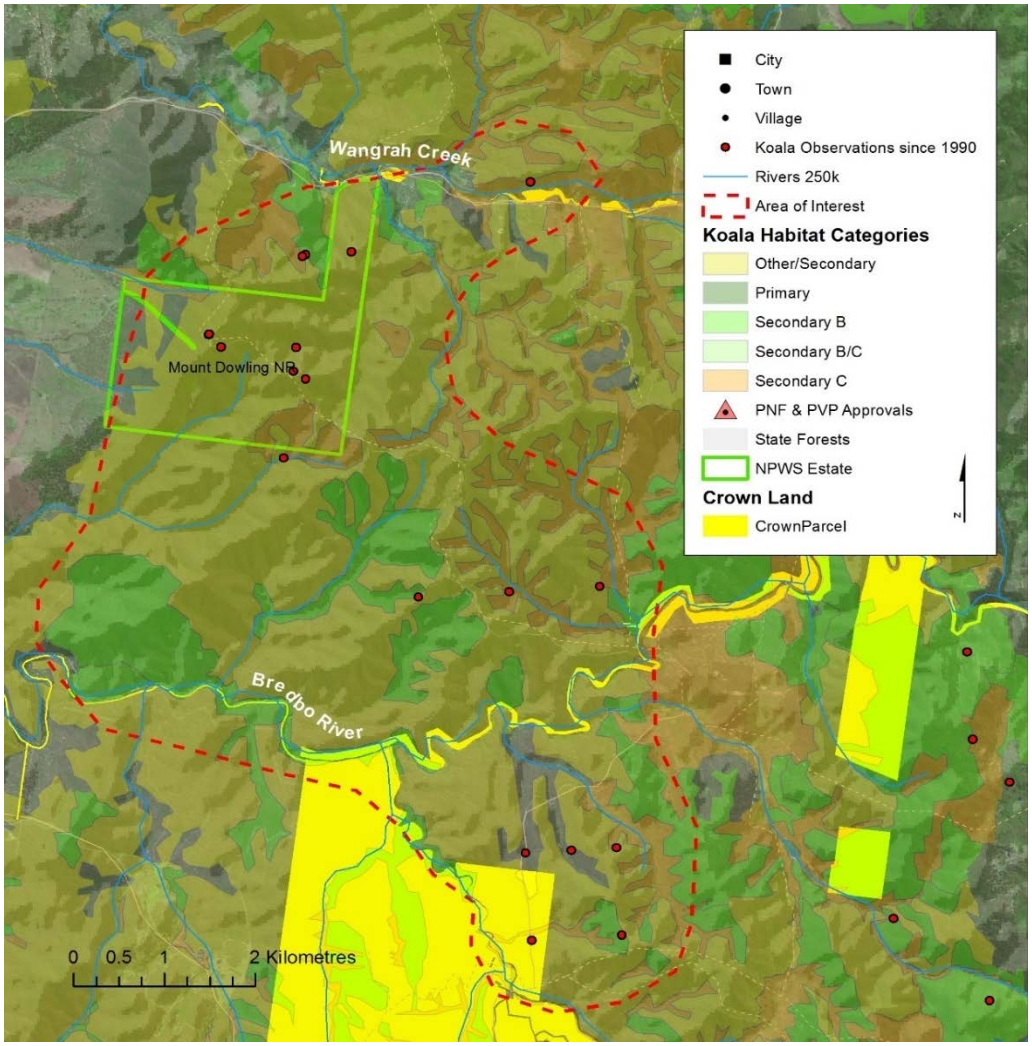
Figure 7 Mount Clifford Area of Interest



KEY ASSESSMENT CRITERIA

CRITERIA	DESCRIPTION
Population size	Low density koala population. estimated to be around 200 individuals (DECCW 2010) for the NE Monaro area. Generational data shows evidence of long term occupation by koalas.
Habitat Quality	Koala habitat (as mapped by Biolink 2015) across the AOI is predominantly Secondary B with areas of Secondary C.
Landscape Features	Perennial streams including the Bredbo River and Wangrah Creek. Habitat is consolidated.
Threats and Pressures	There are exploration licences across much of the south and east for minerals (Capital Mining and Ironbark Zinc Limited). While there is no recorded history of wildfire in the immediate vicinity the majority of the study area is considered to be fire prone.
Conservation Opportunities	No private conservation within the area of interest, however Black Ridge VCA lies to the south and Whinstone Valley Wildlife Refuge lies to the north east (mainly east of Frogs Hole Creek). Dominant land use outside of reserve estate is passive, with livestock grazing largely restricted to valley flats. There is a large area of crown land to the south of the Bredbo River. Overall high potential for koala conservation through reserve acquisition.

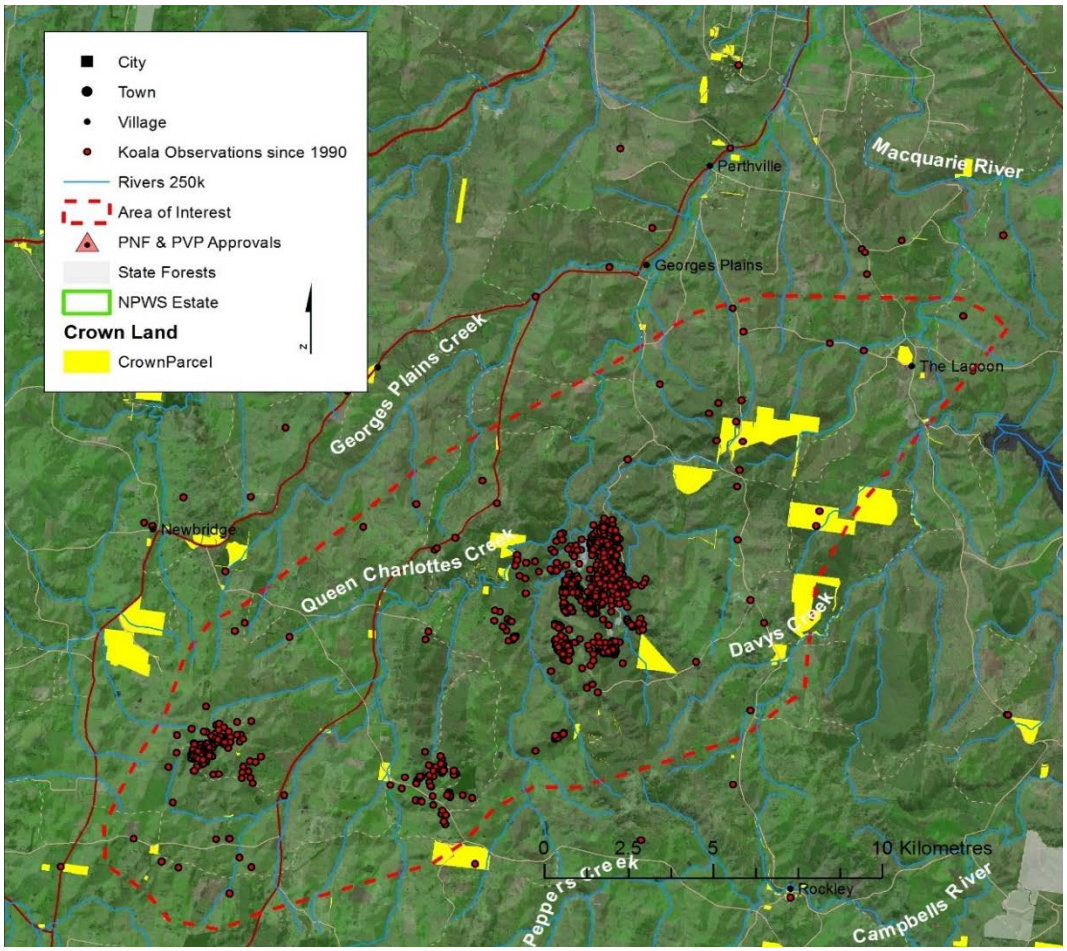
Figure 8 Mount Dowling Area of Interest



KEY ASSESSMENT CRITERIA

CRITERIA	DESCRIPTION
Population size	Moderate density koala population. estimated to be between 200 - 500 individuals (Steve Cox pers. Comm.). Generational data shows evidence of long term occupation by koalas.
Habitat Quality	No Koala habitat mapping available. Koalas known to be feeding on all species within occupied areas including Red Stringybark (*Eucalyptus macrorhyncha*) and Brittle Gum (*E. mannifera*).
Landscape Features	Perennial streams including the Queen Charlottes Creek. Habitat is fragmented.
Threats and Pressures	Despite a dominant land-use of grazing for agriculture, the population appears to be under low pressure (Steven Cox pers. Comm.). While there is no recorded history of wildfire in the immediate vicinity the majority of the vegetation in the study area is considered to be fire prone.
Conservation Opportunities	Two Voluntary Conservation Areas adjacent to Crown Land (Bundari and Cow Flat). Tarthra Park Wildlife Refuge on Queen Charlotte's Creek in the South-west of the Area of Interest. Isolated by surrounding cleared landscape with very low connectivity to adjacent populations. No adjacent reserve estate. Significant areas of crown land. Overall low potential for koala conservation through reserve acquisition.

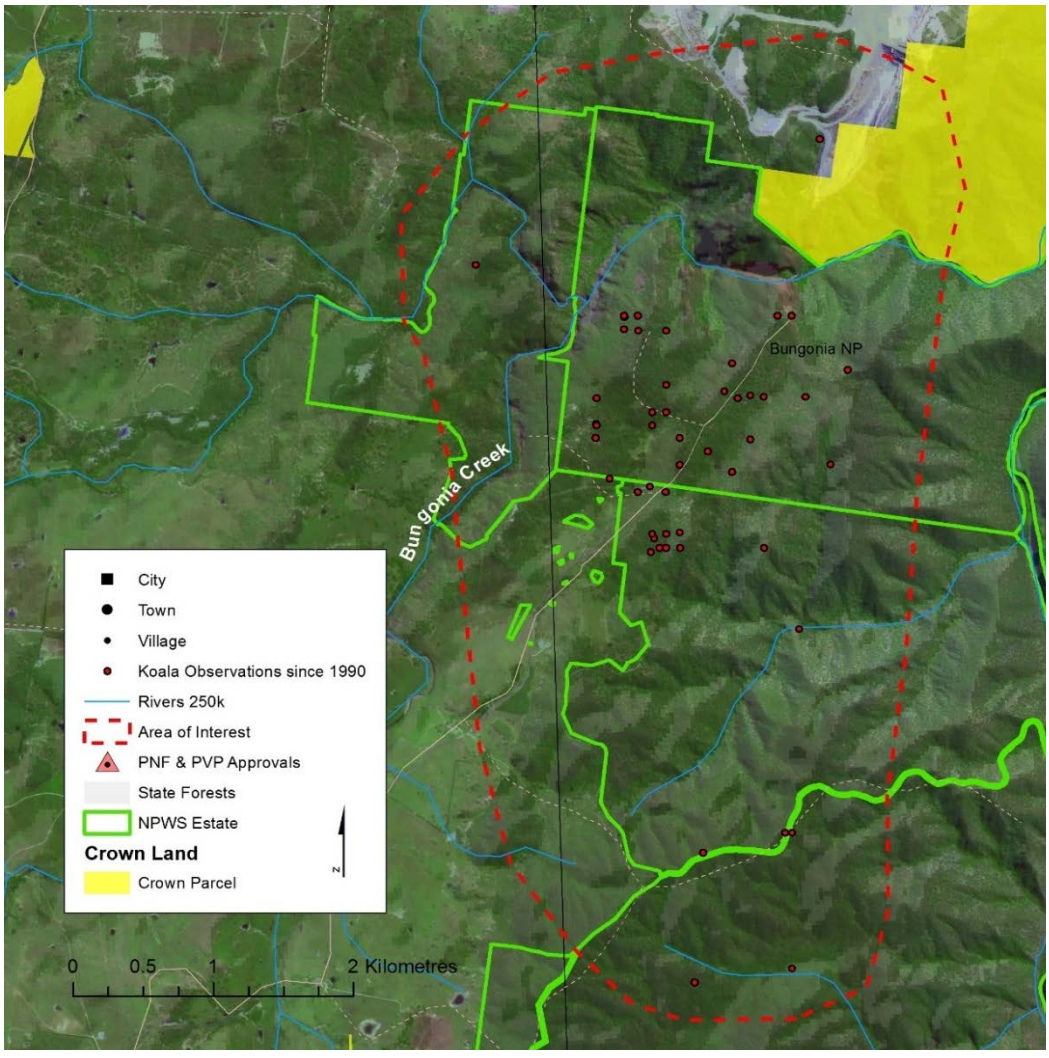
Figure 9 *Queen Charlotte Area of Interest*



KEY ASSESSMENT CRITERIA

CRITERIA	DESCRIPTION
Population size	Moderate density koala population. Size of population unknown.
Habitat Quality	No Koala habitat mapping available. Only modelled koala suitability available (CRA model), which estimates the majority of off-park habitat to be intermediate.
Landscape Features	Perennial streams including Bungonia Creek. Habitat is fragmented.
Threats and Pressures	The majority of the known occupied areas are within Bungonia National Park. Adjacent private tenure to the north and west is well connected and has generally passive land use. Boral limestone quarry to the north of Bungonia National Park. The area has a history of wildfire, with fires recorded in 1964-665, 1977-78, 1982-83 and most recently in 2012-13.
Conservation Opportunities	Isolated by surrounding cleared landscape with very low connectivity to adjacent populations. Most of area of interest within reserve estate. Large area of crown land to the north. Overall low potential for koala conservation through reserve acquisition.

Figure 10 *Bungonia Area of Interest*



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