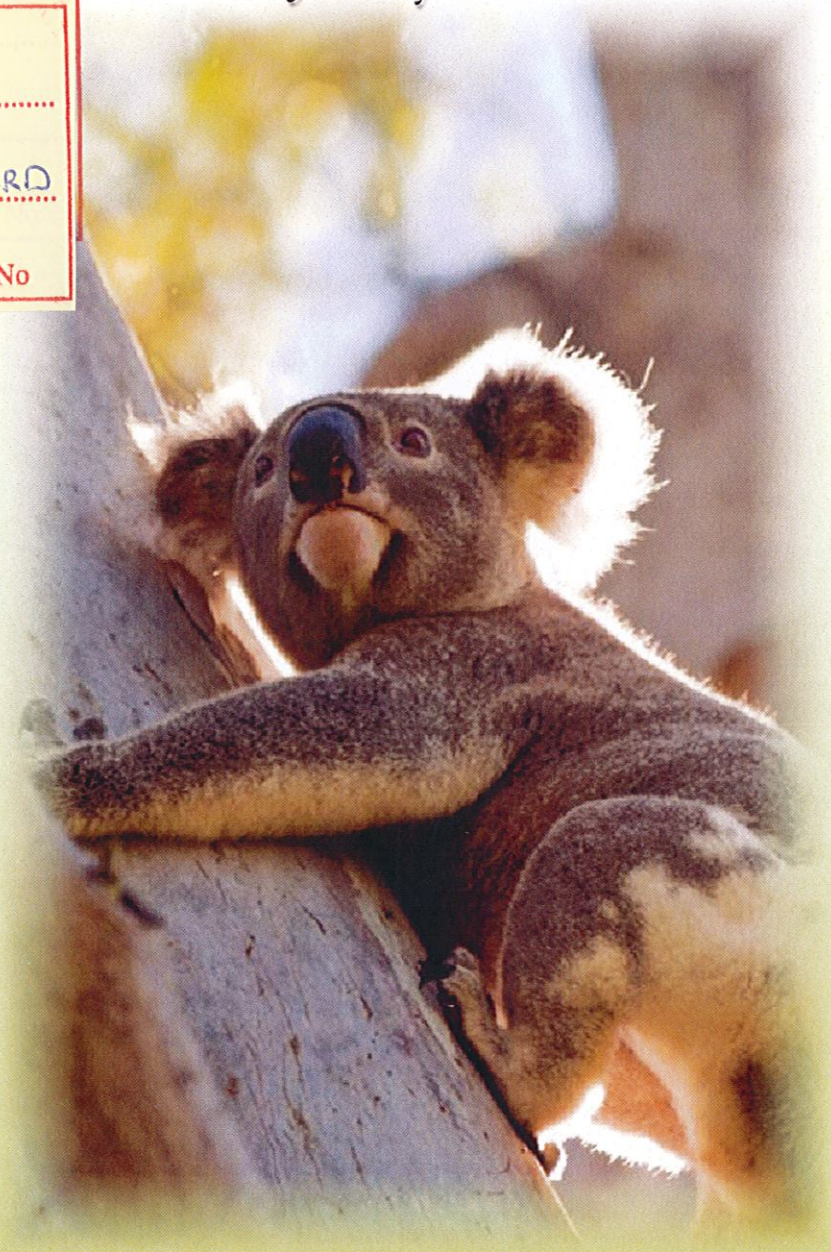
Conserving Koala Populations of the NSW Upper Mid-North Coast

Preliminary mapping of populations as a basis for further survey, research and planning

January 2013



Report by David Scotts for the North Coast Environment Council, Bellingen Environment Centre, Clarence Environment Centre, Nambucca Valley Conservation Association and NSW National Parks Association

Bellingen Environment Centre
www.bellingenenvironmentcentre.org.au

Nambucca Valley Conservation Association Inc.

Clarence Environment Centre

North Coast Environment Council Inc.

NPA
NATIONAL PARKS ASSOCIATION OF NSW
protecting nature through community action

Acknowledgements

This project was initiated largely through the efforts of Ashley Love, President of the NSW National Parks Association, Coffs Harbour – Bellingen Branch.

The North Coast Environment Council, Bellingen Environment Centre, Clarence Environment Centre, Nambucca Valley Conservation Association and NSW National Parks Association each contributed funds to the project. Key individuals within those groups helped to facilitate the project: Ashley Love, Caroline Joseph, Leif Nielsen Lemke, John Edwards, Paula Flack and Lynn Orrego. Leonie Blain from the Clarence Valley Conservation Coalition also helped initiate the project.

The Office of Environment and Heritage (NSW) staff, John Turbill and Jill Smith provided invaluable help in refining the project methods, broad habitat mapping, identifying potential population boundaries and mapping the project outputs. Their knowledge of local Koala occurrence and habitats and production of maps and tables was vital to the development of project outputs. A number of community representatives attended a meeting at each of Bellingen, Grafton and Nambucca Valley to discuss and refine initial project mapping outputs. Thanks go to Greg Clancy, Tricia Edwards, John Edwards, Gary Eggins, Warren Thompson and Lorraine Vass (South Grafton meeting); Peter Hanson, Brian Hawkins, Catherine Jones, Caroline Joseph, Ashley Love, John Pyle and Tim Thorncraft (Bellingen meeting); Paula Flack, Ashley Love, Lyn Orrego and Tim Thorncraft (Nambucca Valley meeting). Mark Graham helped with his impressions regarding Koala habitat in the Bellingen and Coffs Harbour areas. Tricia Edwards also provided access to maps she had generated reflecting her knowledge of Koala habitat in the lower Clarence Valley. This information confirmed and informed initial project outputs for that area. The willingness of people to make themselves available to participate in conservation exercises such as this is an on-going source of inspiration.

Ashley Love, Leif Nielsen Lemke, Lyn Orrego and Lorraine Vass provided helpful and constructive feedback concerning an earlier draft of the report.

Cover photo: Koala in Forest Red Gum; (John Turbill, 2012).

Table of Contents

Figures

Tables

Summary

The New South Wales (NSW) upper mid-north coast and hinterland supports Koala populations of national importance.

This project trialed Koala habitat mapping centred on six Local Government Areas (Kempsey (northern part), Nambucca, Bellingen, Coffs Harbour, Clarence Valley and Richmond Valley) and combined this with collated Koala locality records and local knowledge of Koala ecology and habitat to derive a number of mapped outputs relevant to Koala conservation assessment and planning in this region:

- potential Koala geographic barriers (e.g. cleared river valleys, dissected river gorges, rainforest or sandstone landscapes and cleared plateaus);
- seven likely Koala regional populations deemed appropriate as interim Koala Management Units;
- twenty five (25) likely Koala sub-populations as focus areas for further targeted survey, monitoring and research.

Important project outcomes include:

- the delineation and mapping of coastal and hinterland regional populations and sub-populations across the study area;
- confirmation that private lands support the vast majority of coastal and floodplain Koala populations in this region, with the outstanding exception of Bongil Bongil National Park in Coffs Harbour and Bellingen LGAs which remains a crucial focus area for Koala conservation;
- illustration that private lands and state forests currently support the majority of known foothill and hinterland Koala populations in this region; formal reserves may support important, *albeit* apparently low density Koala populations in the region (e.g. Chaelundi and Nymboi-Binderay national parks in southern Clarence Valley LGA, Bindarri and Ulidarra national parks in Coffs Harbour LGA) but targeted surveys are needed to formally assess populations within reserves of the region;
- A broad Koala population estimate for the study area ranging from 1,850 – 6,750 individuals.

The project concluded that three separate Koala meta-populations may exist in this region; each is considered important in its own right and deserving of targeted survey, monitoring and research to ascertain current Koala conservation status. The first, nominally called the Coffs Harbour – Guy Fawkes meta-population, is centred on the Coffs Harbour, Northern Bellingen and south-western Clarence Valley LGAs and extends from the coastal plains at Coffs Harbour / Bongil Bongil National Park west through hinterland and escarpment forests to Guy Fawkes River National Park. This meta-population is considered to be of national significance as a Koala core area. This same forest gradient has also been identified as significant in other conservation assessment and planning programs. It is clear that long term management programs need to be explored and promoted to ensure the long term welfare of this critical forest area where the Great Escarpment approaches the coast. The Coffs Harbour – Guy Fawkes meta-

population appears to be geographically separated from two additional potential Koala meta-populations. One is nominally called the Clarence – Richmond meta-population and is centred on the central and northern Clarence Valley LGA and extends further north to the Richmond River valley, encompassing the Richmond Valley LGA. The third is nominally called the Bellinger – Nambucca - Macleay meta-population, extending south and possibly west from the southern Bellingen LGA to encompass the Nambucca LGA and the northern part of the Kempsey LGA to the Macleay River valley.

Recommendations are provided concerning the need for future targeted and systematic Koala survey, monitoring and research in this region. Further tenure-blind habitat mapping and clarification of geographic Koala populations, including genetic relatedness, is considered an important aspect to be addressed.

1. **Project inception**

This project was generated and initiated by motivated individuals within local conservation groups (see acknowledgements above). It specifically concerns Koala (*Phascolarctos cinereus*) habitat and populations within the Kempsey (northern part), Nambucca, Bellingen, Coffs Harbour, Clarence Valley and Richmond Valley Local Government Areas (Figure 1). These LGAs include nationally important Koala populations and habitats (DECC 2008, Atlas of NSW Wildlife). As the state's primary conservation agency the Office of Environment and Heritage (NSW) (OEH) continues to co-ordinate and undertake Koala survey and recovery planning within the broader area but habitat mapping (particularly cross-tenure mapping) and population characterization has not been attempted at this six-LGA landscape scale, a scale that may prove to be appropriate for work of this kind.

The project evolved amid growing community, government and academic concerns for the long term conservation of the Koala at all scales of consideration: nationally, state level (Queensland, New South Wales, Australian Capital Territory) and locally on the mid-north and north coast of New South Wales. The project gained local support and impetus on the back of a number of factors:

- National listing of combined Koala populations of Queensland, New South Wales and the Australian Capital Territory as Vulnerable at the national level (Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999);
- Previous recognition of the Coffs Harbour – Bellingen Koala population as nationally significant but overall little knowledge of population character;
- Growing recognition of the importance of Koala populations in the Richmond, Clarence and Nambucca valleys but again little knowledge of population character;
- Overall lack of Koala habitat and population mapping across the NSW upper mid-north coast and hinterland, outside of mapping over Coffs Harbour private lands (Lunney *et al*. 1999);
- Clear need for preliminary work to chart a direction for further targeted Koala survey, research and conservation planning, across the upper mid-north coast and elsewhere.

The agenda for this project was ambitious in planning but restricted in resourcing so outputs should be viewed in that context (see project caveats below)

Figure 1. The upper mid-north coast Koala population mapping study area was centred on six Local Government Areas.

Note: Only the northern part of Kempsey LGA, south to the Macleay River valley, was included in the Koala population mapping project. The mapping also extended slightly north from the Richmond Valley LGA to include a small part of the Kyogle LGA

2. The Koala: aspects of ecology relevant to this project

The Koala is probably Australia's most recognizable and iconic wildlife species but its long term conservation remains clouded in uncertainty (Threatened Species Scientific Committee 2012) and key populations continue to decline in the face of on-going and escalating threats (e.g. Reed and Lunney 1999; Lunney *et al*. 2002, 2007; McAlpine *et al.* 2006 Phillips *et al*. 2011). In recognition of its significant overall population decline a Northern Designatable Unit of the Koala, comprising combined populations in Queensland, New South Wales and the Australian Capital Territory, has been listed as *vulnerable* under the national *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The species has been listed as *vulnerable* for some time under Queensland and New South Wales legislation.

The Koala inhabits forests and woodlands of eastern Australia, where it is the largest arboreal mammal, but its occurrence within that broad distribution is patchy (e.g. Melzer *et al*. 2000). Koalas are solitary animals but occupy home-ranges that may overlap extensively with those of other individuals (e.g. AMBS 2012). Koalas are herbivores that feed almost exclusively on the foliage of *Eucalyptus* species and their home range areas are determined largely by the availability of preferred food trees (Lee and Martin 1988).

Local Koala populations face a number of threats, including loss and fragmentation of habitat (Melzer *et al*. 2000, McAlpine *et al*. 2006), car strikes and dog attacks (Dique *et al*. 2003, Lunney et al. 2007), and disease, which can lead to death or infertility (Gordon *et al.* 1990). Wildfire can also be a major threat to koalas particularly where their habitat is fragmented and isolated. Koalas are also susceptible to climatic extremes (e.g. Seabrook *et al*. 2011) which may impact the quality of nutrients and moisture levels in their diet (Cork and Braithewaite 1996, Moore and Foley 2000). In Victoria and South Australia over-browsing, by "over-abundant" Koala populations, is also considered a threat in some locations.

Much has been written and reviewed about Koala ecology, habitat mapping and the threats that continue to plague and diminish populations (e.g. DECC 2008) and readers are referred to the provided references, and many others, for further background and more specific information. What follows initially below is a brief outline of some aspects of Koala ecology and habitat use considered directly relevant in the context of this project which is concerned not only with Koala habitat (at the landscape scale) but also the character of geographic populations.

2.1 Habitat

As for all wildlife species, Koala habitat quality is related to the availability of combinations of certain resources which if they can be mapped or spatially predicted across landscapes can be used in turn to map Koala habitat. Key among these, for koalas, are preferred food tree abundance and diversity (e.g. Hindell and Lee 1987, Lunney *et al.* 2000, Phillips and Callaghan 2000, Smith 2004, Callaghan 2011), forest structure (Smith 2004), soil type and soil moisture (e.g. Clifton *et al*. 2007), foliar chemistry (e.g. Cork and Sanson 1990, Moore *et al.* 2004), landscape configuration (e.g. McAlpine *et al.* 2006) and disturbance history (e.g. Smith 2004, Rhodes *et al*. 2006).

Koala habitat mapping has been undertaken at various locations across the species' range utilizing a variety of techniques. Examples include relatively local scale mapping through the application of "preferred feed tree" approaches (Callaghan *et al.* 2011, Phillips and Callaghan 2011). Another example is the approach adopted in south-east Queensland (Dique *et al.* (2004), Department of Environment and Resource Management 2009) utilizing land cover mapping derived from remote sensing and GIS in combination with habitat value ranking. At a broader scale, attempts have been made to predict the occurrence and extent of Koala habitat across larger geographic regions through broad-scale multi-attribute modeling approaches entailing analysis of locality records against multiple mapped environmental attributes within a GIS framework (e.g. NSW NPWS 1994, 1999; Wintle *et al.* 2004; Rhodes *et al.* 2006). The latter have been only moderately successful with the Koala's inherently variable occurrence and habitat use patterns making associations and correlations difficult to adequately quantify and characterize across broad regions (Department of Environment and Resource Management 2009).

With regard to the characterization of Koala habitat and populations AMBS (2012) make an important observation about our perceptions of relative habitat value. Some areas support more koalas than others but it does not necessarily follow that such areas are inherently more important (from a long term conservation viewpoint) Koala habitats, nor are they necessarily more viable in the long term. Koalas with established home-ranges in low density populations (particularly those remote from coastal human population) may live longer, suffer less from (stress-induced) disease and produce more surviving offspring over their lifetimes than those in high density populations (AMBS 2012). But conversely, it may be more difficult and dangerous for dispersing animals in low density populations to establish home-ranges and they may have to travel further to maintain their territory and access its resources, which might expose them to greater risks. It might be most appropriate to recognise lower quality habitats as those where prevailing conditions lead more often to localised, temporary extinction of the population (AMBS 2012). This may be a consideration in determining priorities for the allocation of limited Koala conservation resources.

It is generally considered that the best Koala habitats are poorly represented in NSW's formal reserve system (e.g. the National Park and Nature Reserve network, Flora Reserves within state forests) (e.g. DECC 2008). Many important Koala habitats are known to occur as remnants on private lands, where the impacts of previous, and sometimes on-going, vegetation clearance and fragmentation are most severe (Reed and Lunney 1990). The extent to which public lands (state forests, crown lands, national parks, nature reserves etc) support and foster on-going viable Koala populations remains to be investigated and quantified. As outlined above the lower density Koala populations of the hinterland forests in the NSW upper mid-north coast have not received the attention and planning emphasis of the higher quality, but more threatened, coastal Koala habitats but such landscapes may be critical to the species' long term viability and persistence in the region and nationally.

2.2 Movement, potential barriers and "Management Units"

Habitat fragmentation is a threat to mammal populations around the world. Fragmentation can result from habitat loss or the imposition of anthropogenic barriers (Lee *et al.* 2010). If barriers impede animal movement then gene flow can be impacted

and ultimately populations that were once contiguous can become isolated with many negative flow-on effects (Banks and Taylor 2004).

In the context of species conservation, the identification of population boundaries and dispersal patterns is important in designing optimal management strategies and management units, which are generally recognised as demographically independent populations (Lee *et al.* 2010). The identification of *management units* is a crucial step in the management and conservation of natural populations (Palsbol *et al.* 2007, Banks and Taylor 2004) and is considered a critical path for Koala conservation planning and management.

Landscape features, both natural (e.g. rivers, mountains) and artificial (e.g. roads, urban areas) can be barriers, or at least filters, to gene flow for certain species, depending on their movement potential (Lee *et al.* 2010). Potential barriers or filters to Koala movement include urban areas and non-preferred habitats (e.g. dense rainforest, very low fertility forests and woodlands) (Lee et al. 2010). It is also possible that clearings, large and busy roads (AMBS 2012) and agricultural lands associated with large river valleys may also serve as barriers to some extent.

Recent advances in genetic analyses have much to offer in terms of characterizing Koala populations (Banks and Taylor 2004). Lee *et al*. (2010) collected and analyzed genetic information to define management units for Koala conservation in the Sydney region. They provide information relating to natural and anthropogenic barriers and their impact on gene flow. Lee *et al*. (2010) recommend the development of tailored management plans for individual Koala management units. Recent studies in the north coast of NSW have started to identify the low genetic robustness of many of the small and isolated populations of koalas and the urgent need for identification and re-establishment of landscape level linkages (e.g. Hopkins and Phillips 2010, Phillips *et al*. 2011).

In this project multiple levels of Koala habitat are envisaged for conservation assessment, survey, research and management (after Hanski 1997, Lindenmayer and Franklin (2002), Lindenmayer and Fischer (2006). Three spatial levels of population character area have been derived and mapped as possible management and conservation units pending verification, or otherwise, upon further targeted Koala population research:

Koala sub-population- A local population of koalas that is assumed to undergo regular interchange of genetic material throughout an interconnected patch of preferred habitat. Adjacent sub-populations can move through non-preferred matrix habitats to interbreed and exchange genetic material with adjacent sub-populations. Groups of irregularly interbreeding sub-populations are termed regional populations.

Koala regional population- One or more Koala sub-populations deemed likely to interchange genetic material, but only on an irregular basis, through the dispersal or breeding movement of individuals between sub-populations. Regional populations are defined by mapped “barriers” that act as impediments to Koala movement. Regional populations are suspected to be largely isolated from adjacent regional populations but rare events of genetic interchange may occur across barriers.

A further scale of population character is also apparent and is often referred to in conservation ecology and landscape ecology: the *meta-population* (Hanski 1997).

Koala meta-population- One or more Koala regional populations deemed likely to interchange genetic material, but only rarely. Meta-populations are assumed to be functionally isolated from adjacent meta-populations by inhospitable barriers to Koala movement.

Koala sub-populations, regional populations and meta-populations are delineated and mapped across the thee-LGA study area in this project as potential units of Koala management and also to promote a potential structure for future targeted Koala survey, monitoring, habitat mapping and population characterization.

3. National, State and local Koala Information

3.1 Australia

Koala populations have declined across Queensland, New South Wales and the Australian Capital Territory as well as parts of Victoria (Threatened Species Scientific Committee 2012). Paradoxically, some Victorian and South Australian Koala populations are considered to be "over-abundant".

Key populations at the national level, in the context of the vulnerable Northern Designatable Unit, are located:

- Wet Tropics, Central Mackay Coast (Qld);
- Desert Upland, Mitchell Grass Downs, Einasleigh Uplands (Qld);
- Brigalow Belt (Qld);
- Mulga Lands (Qld);
- Southeast Queensland;
- North-east New South Wales;
- Central Coast, Sydney Bioregion (NSW);
- North-west New South Wales;
- Southern New South wales

3.2 New South Wales north coast

The NSW North Coast is regarded as a nationally important area for koalas (Minister for Sustainability, Environment, Water, Population and Communities (April 2012))

Although difficult to quantify due to a lack of targeted, systematic survey, indications are that Koala populations on the NSW North Coast have declined, in some cases to drastic degrees. Documented declines include discrete, well studied populations like Iluka Peninsula (Lunney *et al*. 2002) and broader populations like Tomago sand beds at Port Stephens (Lunney *et al.* 2007) and parts of coastal Tweed and Byron LGAs (Phillips *et al*, 2011, Biolink 2012).

3.3 Kempsey, Nambucca, Bellingen, Coffs Harbour, Clarence Valley and Richmond Valley LGAs

These six LGAs are known to support important Koala populations but the geographic character and inter-connectedness of those populations has not been previously addressed.

3.3.1 Kempsey (northern part) LGA – Nambucca LGA

Systematic survey for koalas has been limited across the northern part of the Kempsey LGA and the Nambucca LGA but important habitats are known to occur. State forests and private forests in the upper Nambucca Valley support important populations (Paula Flack, Lynn Orego personal communication) but face an uncertain future in the face of on-going threats.

Coastal forests in the vicinity of Valla – Nambucca – Bellwood, once supporting relatively high Koala numbers, have been impacted by development pressures and appear to have declined drastically.

Extensive hinterland forests protected within formal reserves (e.g. New England, Dungirr, Yarriabini national parks, Ngambaa Nature Reserve) are known to support koalas but formal survey and habitat mapping is required to establish population status across most forest landscapes in these LGAs.

3.3.2 Bellingen LGA – Coffs Harbour LGA

The Bellingen and Coffs Harbour areas have been identified as supporting important Koala populations (DECC 2008). Bongil Bongil National Park and Pine Creek State Forest in particularly have been noted as key areas of Koala habitat (Smith and Andrews 1997, Smith 2004). However even in this nationally important sub-population declines are apparent. Koala research and monitoring for the Bonville Pacific Highway upgrade was undertaken in this location over the period 2000 – 2009 and reported a decline in Koala numbers over that period. High levels of disease (Chlamydia), a low breeding rate and vehicle strike were implicated (AMBS 2012).

There are also anecdotal indications (declined reporting rates) that Koala populations have declined along the Coffs Harbour coast including Moonee, Korora Basin – Coffs Harbour – Toormina – North Boambee – Bonville districts (John Turbill, John Pyle, Tim Thorncraft, Brian Hawkins, Mark Graham personal communication).

Widespread records from the hinterland forests to the west and north-west of Coffs Harbour (Atlas of NSW Wildlife) provide indications of important public land-based Koala populations in this area. The majority of these occur on state forests but some important Koala populations occur within reserves like Chaelundi, Nymboi-Binderay, Ulidarra and Bindarri national parks. The lack of systematic survey data restricts the available information regarding the true distribution and population densities of koalas in these areas.

3.3.3 Clarence Valley LGA

Koalas appear to be patchy in occurrence but widely distributed, *albeit* at overall low densities across this large LGA (Atlas of NSW Wildlife, Greg Clancy, John Edwards, Tricia Edwards personal communication). Private lands of the lower Clarence Valley are known to support locally important populations, although only limited information is available on their status (e.g. Waterview Heights (west of Grafton), Ashby Peninsula, Upper Copmanhurst). In other areas Koalas are reported to have declined significantly. For example, a historically well known and renowned Koala population at Iluka – Woombah appears to have declined to the extent that it is considered functionally extinct.

Another Koala population near the Shannon Creek Dam has also apparently declined drastically (John and Tricia Edwards personal communication).

Low density Koala populations also persist within some Clarence Valley state forests and national parks where conditions are suitable (e.g. food tree species growing on amenable soils). Key examples include Gibberagee, Mount Marsh, Grange, Mount Belmore and Washpool state forests.

Based on current knowledge formal reserves within the Clarence Valley LGA support only very low Koala densities, the better habitats remaining on other tenures.

3.3.4 Richmond Valley LGA

Koalas occur across the Richmond Valley LGA with local densities ranging from sparse to high dependant upon habitat quality and prevailing threat levels. Coastal populations in the Rileys Hill – Broadwater district, once well known, appear to have declined drastically. Some state forests in this area are known to support important populations within Forest Red Gum – Grey Box – Grey Gum habitats. Key examples include Royal Camp, Carwong and Bungawalbin state forests.

Formal reserves within this LGA do not appear to support significant Koala populations overall. Sandstone based reserves such as Mount Neville and Hogarth Range nature reserves appear to be too infertile to provide for Koala habitat needs. The coastal sand-based Broadwater and northern Bundjalung national parks also offer little in the way of Koala habitat.

4. National Koala research priorities

An underlying driver for this project was the desire to document and highlight the importance of the NSW upper mid-north coast for Koala conservation and generate impetus for further targeted work in the general region. To that end the project has striven to address aspects of habitat and population mapping directly relevant to Koala research priorities identified elsewhere and as espoused in the document issued in the name of the Minister for Sustainability, Environment, Water, Population and Communities (April 2012) – Conservation Advice (combined populations of Qld, NSW, ACT). Specifically, the project addresses three key priorities:

1. Develop landscape-scale population models;
2. Develop understanding of gene flow and landscape connectivity;
3. Identify and delineate key populations

Note: This project was very limited in time and resources. In addressing the three stated priorities it is not claimed that they have been adequately addressed. Rather the project has made a preliminary attempt to address these three aspects and aims to chart a course for further targeted, well resourced, peer-reviewed work.

5. Project aim, objectives and caveats

This project was originally envisaged as a preliminary Koala habitat mapping effort but upon initiation and closer examination it became apparent very quickly that such a project was not possible within the limited resource and time constraints. It was also apparent that Koala habitat mapping at a local council scale has occurred (primarily in Coffs Harbour and small parts of Clarence areas), and continues to occur subject to available funding, across the species range, including the current study area, through tailored, targeted and resourced programs such as those undertaken to underpin Comprehensive Koala Plans of Management under State Environmental Planning Policy (SEPP) 44..

5.1 Project aim

It became apparent that this particular project might provide influence to on-going and future programs of Koala survey, research, habitat mapping and conservation management planning by aiming to delineate and map potential population units across the NSW upper mid-north coast and hinterland, previously identified as a location of national importance to the Koala, as a baseline for further targeted work. To that end the project's overall aim was defined in line with the Approved NSW Koala Recovery Plan (DECC (2008) and the recent national vulnerable listing for a "Northern Designatable Unit" :

- To increase knowledge of nationally significant geographical Koala populations centred upon the NSW upper mid-north coast and hinterland including Kempsey (northern part), Nambucca, Bellingen, Coffs Harbour, Clarence Valley and Richmond Valley Local Government Areas.

5.2 Project objectives

Within the context of this broad aim the project had the following objectives:

- Develop a tenure-blind, baseline and qualitative depiction of potential Koala habitat and collated locality records extending across the NSW upper mid-north coast and hinterland;
- Delineate and map potential Koala regional populations and constituent sub-populations across the three LGAs;
- Qualitatively assess and characterize the mapped regional populations and sub-populations in terms of perceived status and viability;
- Make recommendations concerning further targeted Koala survey, research and planning to address the priorities identified around the EPBC Act listing of a Northern Designatable (Koala) Unit.

The stated objectives are intentionally broad enough to allow flexibility in terms of the level to which they are met within the limited resources available to this project. They can be addressed and adapted for future well resourced projects concerning Koala habitats and population characterization.

5.3 Project caveats:

- Very limited time and budget – the project adopts a preliminary and qualitative approach to chart direction towards future targeted and systematic work;
- The mapped outputs are not based on statistically-derived modeling but represent expert-derived associations. The derived baseline representation of Koala habitat across the NSW upper mid-north coast and hinterland is not promoted, and should not be considered, as a Koala habitat model. It was developed as an aid to the delineation and mapping of potential Koala regional populations and sub-populations which are considered the most useful project outputs.

6. Project approach

As outlined above the project was not a Koala habitat mapping exercise *per se* but more a landscape approach to the derivation and mapping of likely regional populations and sub-populations across the study area.

The project made use of established GIS data layers and Koala locality records from the Atlas of NSW Wildlife or held by the local community. Data layers were overlayed, manipulated and assessed within a GIS framework to derive mapped project outputs.

6.1 Derivation of a baseline Koala habitat depiction

Two steps of GIS layer overlay and association were used:

(i) The best available vegetation mapping extending across the study area (the Northern River CMA Forest Ecosystems mapping) was assessed and compared with collated Koala locality records. In a purely qualitative process expert knowledge of local Koala habitat and feed tree preferences was used to place mapped vegetation ecosystem classes into perceived Koala habitat quality classes.

(ii) The derived baseline Koala habitat depiction was further refined by masking with habitat map overlays for a small number of fauna to exclude areas of vegetation considered unlikely to support koalas (e.g. treeless heaths mapped as Coastal Emu, Black-necked Stork and Wallum Froglet habitats, pure hinterland and littoral rainforests mapped as rainforest bird habitat). These data are held within OEH's fauna modeling GIS database;

(iii) The derived Koala habitat depiction was finalized as a GIS layer and mapped.

6.2 Delineation / mapping / characterization of potential Koala regional populations and sub-populations

Four steps of expert assessment were applied to the baseline Koala habitat depiction together with collated Koala locality records:

(i) Broad potential Koala geographic "barriers" (see above) were derived and mapped.

(ii) Likely Koala regional populations were derived based on association of Koala records, spatial extent of likely habitat extent and accounting for perceived barriers. Regional populations were deemed likely to be largely isolated from each other;

(iii) Likely Koala sub-populations were derived based on association of Koala records and the spatial extent of likely habitat within each regional population and accounting for perceived barriers and habitat variations at a finer scale of perception;

(iv) Regional populations and constituent sub-populations were qualitatively assigned relative population size ranges. Sub-populations were also assigned a qualitative rank reflecting overall perceived status, density, threat and extent of knowledge. A brief descriptive narrative was then developed for each sub-population;

(v) The derived Koala regional populations and sub-populations were mapped

7. Results

Project results and outputs are as follows:

7.1 Baseline Koala habitat depiction

Forest ecosystem classes provided in the Northern Rivers CMA Vegetation Ecosystems GIS data layer were associated with collated Koala locality records to derive four classes of Koala habitat: Class 1 (higher quality), Class 2 (intermediate quality), Class 3 (lower quality), and a Forestry Plantation class (see Figure 2). Hardwood plantations, primarily where they are close to or adjoin native forests, provide habitat for koalas but densities are typically low due to a simplified structure and low tree diversity (Smith 2004). Vegetation categories considered to be non-Koala habitat were excluded from the mapped habitat representation.

Figure 2 also includes the Koala habitat mapping developed for the Coffs Harbour Koala Plan of Management (Lunney *et al.* 1999). Figure 2 also includes likely Koala geographic barriers, derived regional populations and constituent sub-populations which were mapped as part of subsequent project components (see 7.2) and will be referred to again below.

It is not considered directly relevant to the aims of this project as to which of the specific vegetation ecosystem categories were assigned to each Koala habitat class as the resultant map is purely a qualitative baseline habitat depiction to aid local Koala population mapping (see 7.2). Suffice to say that vegetation classes were assigned in accordance with locally known preferred Koala habitats and previous local habitat mapping exercises (e.g. Fisher *et al.* 1996, Lunney *et al*. 1999, J. Turbill personal communication).

This process, further refined by the exclusion of other non-Koala habitat (see (ii) in 6.1 above) has allowed the development of a reasonable tenure-blind representation of Koala habitat across the study area. The representation appears to be quite sound in many areas but it clearly over-predicts Koala habitat in other areas. It a useful output for the initial purposes of this project, and maybe a useful starting point for further work at this scale of consideration however, as stated previously, this map should not be considered as a Koala habitat layer for any other purposes.

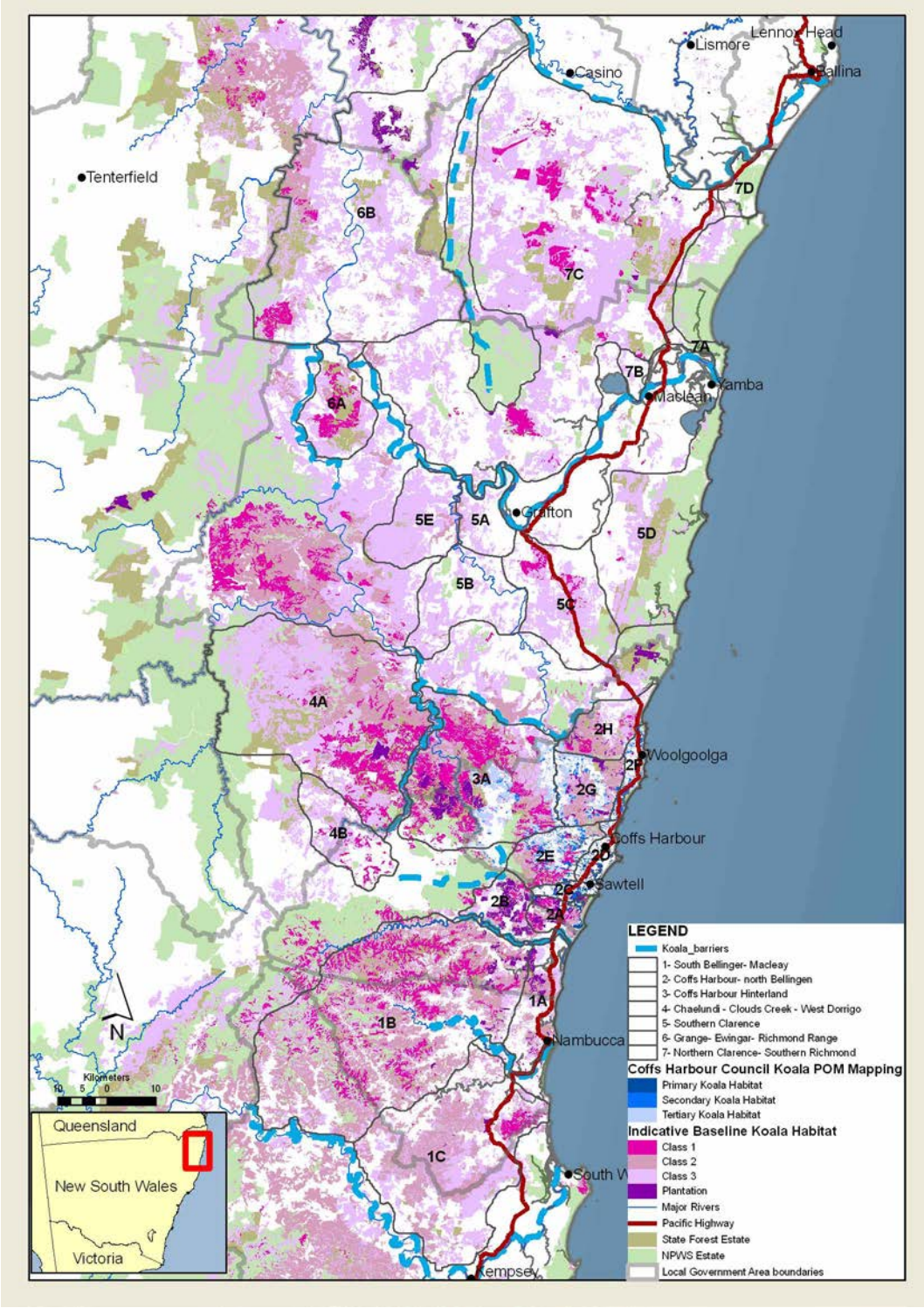


Figure 2. Baseline depiction of Koala habitat across the NSW upper mid-north coast study area.

The map also shows: likely Koala geographic barriers, derived regional populations and constituent sub-populations.

7.2 Potential Koala geographic barriers

Ten (10) potential Koala geographic barriers were derived and mapped within the study area:

These included:

1. The extensively cleared northern side of the Macleay River valley;
2. The extensively cleared lower Nambucca River valley
3. The extensively cleared lower Bellinger River valley
4. The extensively cleared lower Clarence River valley
5. The extensively cleared lower Mann River valley;
6. The extensively cleared southern side of the Richmond River valley
7. The steep and dissected gorge habitats associated with the Nymboida River within Nymboi-Binderay National Park;
8. The sandstone-based habitats of the southern Clarence Valley / northern Coffs Harbour LGAs;
9. The sandstone-based habitats extending from Banyabba Nature Reserve to the area west of Casino
10. The extensive rainforest vegetation within Dorrigo National Park together with adjacent cleared lands of the southern Dorrigo Plateau.

An eleventh barrier was contemplated namely the reasonably extensively cleared Orara River Valley but the clearing and barrier effects here were considered to be at a scale below the others named above. Never the less it is considered that this valley does comprise at least a filter impact on Koala movement leading to some level of barrier impacts. This valley and clearing was used to map a boundary between Koala regional populations 2 and 3 (see 7.3 and figures 2 and 3).

The potential Koala geographic barriers were used and applied in developing boundaries for derived Regional Populations (see 7.3) and are mapped as part of figures 2 and 3.

7.3 Regional populations and sub-populations

Potential Koala regional populations and constituent sub-populations were mapped relative to proposed Koala geographic barriers, collated Koala records and expert opinion of landscape units.

7.3.1 Koala regional populations

Seven Regional Populations were mapped across the study area (see figures 2, 3; Tables 1, 2).

A population size range was applied to each regional population ranging from 50 – 100 individuals to >1000 individuals (Table1).

Although the digitized boundaries are only broadly indicative, area calculations within each regional population showed private land and state forest to be the predominant tenures within mapped regional populations across the study area. NPWS estate figured prominently in only one of the seven regional populations (Table 1). Overall figures showed private land to support 57% of the mapped Koala regional populations, state forest 25% and NPWS estate 17% (Table 2).

Each regional population is considered separately in section 7.3.3 below.

For the purposes of this project, and perhaps until further targeted work indicates otherwise, regional populations are considered appropriate as Koala Management Units (as described above in section 2.2) where tailored management approaches should be directed.(e.g. Lee *et al.* 2010).

7.3.2 Koala sub-populations

Koala sub-populations were mapped as constituents of each Koala regional population (see figures 2, 3; Tables 1, 3). Twenty five (25) sub-populations were identified within the seven regional populations ranging from the coastal plains to the hinterland and beyond (Figure 3).

A population size range was applied to each sub-population ranging from <50 individuals to 500 - 1000 individuals (Table1). Manipulation of these figures, assuming 30 to be an arbitrary minimum for those sub-populations designated a <50 rank, allowed the development of a broad estimated population size range for the NSW upper mid-north coast and hinterland study area of 1,850 – 6,750 individuals.

Fifteen (15) of the 25 sub-populations were judged to support <50 individuals and are considered to be unviable in the long term without interchange of individuals with adjoining sub-populations (based upon figures and discussion in DECC (2008)).

Twenty one (21) of the 25 sub-populations were judged to be "declined" in status and four (4) were judged to be "stable" in terms of Koala population numbers and likely long term persistence potential (Table 1, section 7.4).

One (1) sub-population, 2A Bongil Bongil – Pine Creek, was considered to support a relatively high Koala density. Seven (7) were assigned a medium density and 17 were considered to support low density Koala populations (Table 1).

One (1) sub-population, 2A Bongil Bongil – Pine Creek, was considered to be at a low – medium threat level. 14 were assigned a medium threat level, 10 were considered to subject to high level of threat (Table 1).

Nine (9) sub-populations were considered to be relatively well known. These were all located on the coastal plain or lower Clarence Valley nearby to human population centres. Eleven (12) sub-populations were considered to be largely unknown and four (4) were considered unknown (Table 1, Figure 3).

The digitized boundaries are only broadly indicative, but area calculations within each Koala sub-population show private land and state forest to be the predominant tenures within mapped sub-populations across the study area. Private land was prominent (accounting for ≥25% of mapped indicative habitat) in all 25 sub-populations, state forest was prominent in eight (8) sub-populations and NPWS estate was prominent in six (6) sub-populations (Table 3, Figures 5-11, section 7.3.3). Of the latter six sub-populations only three (3), 1B Southern Hinterland, 2A Bongil – Bongil – Pine Creek and 3B Chaelundi – Clouds Creek, are considered likely to support viable Koala populations (see Table 4).

Disturbance mapping, as indicated by satellite imagery collected over the period 1988 - 2009 (collated by Greg Hall personal communication) is overlayed on Koala sub-

populations and tenure in Figure 4. This illustrates the extent to which disturbance has impacted Koala populations over that period; disturbance post-2009 cannot be accounted for until equivalent images are collated. Mapped disturbance over that period, in the form of logging, is concentrated in state forests and national parks that were previously state forest. However evidence of private native forestry and private land clearing (not distinguishable on this map) is also obvious within all Koala sub-populations.

Each Sub-population is considered separately in section 7.3.3 below.

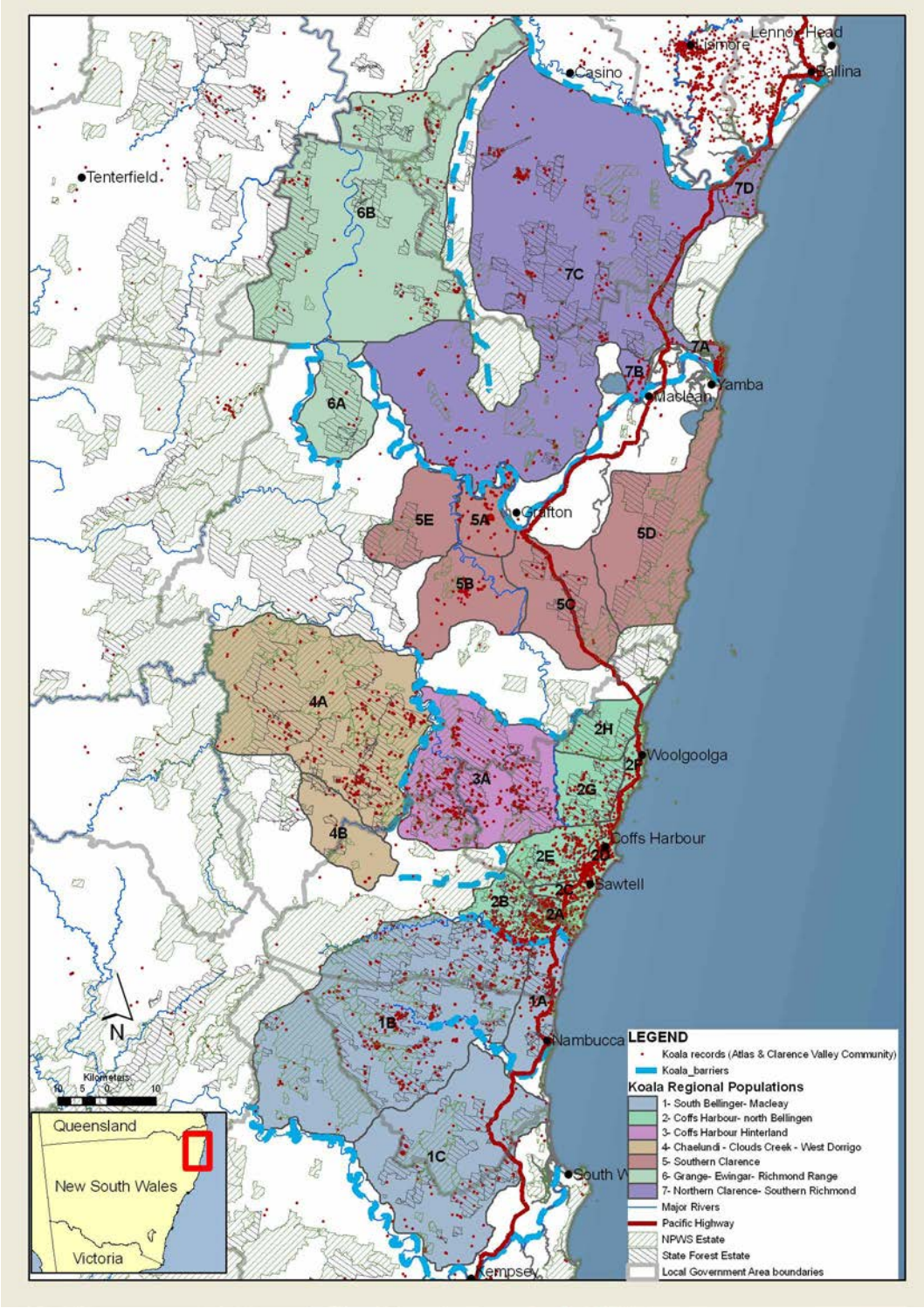


Figure 3. Derived Koala regional populations & constituent sub-populations across the NSW upper mid-north coast study area. The map also shows: Koala records as red dots, likely Koala geographic barriers.

Table 1. Summary information assigned to derived Koala populations of the NSW upper mid-north coast study area (November 2012 – January 2013). Shaded cells indicate likely "stable" Sub-populations.

Reg Pop no.	Regional Population name	Reg Pop size	Sub-population name	Sub-pop no.	Sub-pop size	Status	Density	Threat	Confidence	Comments
1	South Bellinger – Nambucca – North Macleay	500-1000	Southern Coastal	1A	<50	D	L	H	Largely unknown	Urban and rural-residential development, dogs, road strike
			Southern Hinterland	1B	50-500	S	L	M	Unknown	Stable but sparse; logging & fire
			Scotts Head – Ngambaa - Willawarrin	1C	50-500	D	L	M	Largely unknown	Overall declined particularly on private lands; state forests are potential strongholds but also declined; fire, logging
2	Coffs Harbour-north Bellingen	>1000	Bongil Bongil - Pine Creek	2A	500-1000	S	H	L-M	Well known	Includes Bongil Bongil - Pine Creek core; logging, fire, vehicle strike
			North Bellingen - Gleniffer	2B	50-500	D	M	M	Largely unknown	State Forest logging
			Bonville	2C	50-500	D	M	H	Well known	Targeted and increasing urban and rural-residential development
			Coffs Harbour - Toormina - Korora	2D	<50	D	M	H	Well known	Fragmented habitats; dogs, vehicle strike
			Orara West - Boambee	2E	50-500	D	M	M	Well known	State Forest logging, fire
			Coffs northern beaches	2F	<50	D	L	H	Well known	Highway upgrade, urban and rural-residential development, dogs
			Lower Bucca - Orara East	2G	<50	D	L	H	Well known	State Forest logging, fire
			Red Rock - Wedding Bells - Conglomerate	2H	<50	D	L	M	Unknown	State Forest logging, fire
3	Coffs Harbour Hinterland	500-1000	Coffs Harbour Hinterland	3A	500-1000	S	M	M	Largely unknown	Predominantly State Forest. Can't distinguish sub-populations

- continued over page -

Table 1 (continued)

Reg Pop no.	Regional Population name	Reg Pop size	Sub-population name	Sub-pop no.	Sub-pop size	Status	Density	Threat	Confidence	Comments
4	Chaelundi - Clouds Creek - West Dorrigo	50-500	Chaelundi - Clouds Creek	4A	50-500	S	M	M	Largely unknown	Predominantly State Forest & National Park
			West Dorrigo	4B	<50	D	L	M	Largely unknown	Fragmented and sparse population
5	Southern Clarence	50-500	Waterview Heights	5A	<50	D	M	H	Well known	Forest Red Gum-based population; rural residential development
			Shannon-Coutts	5B	<50	D	L	H	Unknown	Sparse Forest Red Gum-based habitats
			Bom Bom - Glenugie	5C	<50	D	L	H	Largely unknown	State Forest logging, fire; Highway upgrade
			Yuraygir	5D	<50	D	L	M	Largely unknown	Very low density population; high risk of fire
			Ramornie	5E	<50	D	L	M	Unknown	Low density population; logging, fire
6	Grange- Ewingar – Richmond Range	50-500	Grange	6A	<50	D	L	M	Largely unknown	State Forest logging, fire
			Ewingar – Washpool – Richmond Range	6B	<50	D	L	M	Largely unknown	Suspected sparse population; State Forest logging, fire
7	Northern Clarence – Southern Richmond	50-500	Illuka - Woombah	7A	<50	D	L	H	Well known	Former high quality habitat; recent sightings but very low numbers now
			Ashby	7B	<50	D	L	H	Well known	Mainly low quality habitat
			Northern Clarence – Southern Richmond	7C	50-500	D	L	M	Largely unknown	Forest Rd Gum / Grey Box habitats; suspected sparse numbers
			Broadwater – Evans Head	7D	<50	D	L	H	Largely unknown	Red Gum – Swamp Mahogany _Tallowwood; Highway impacts, fire, coastal development

Table 2. Summary area and tenure statistics for mapped Koala regional populations of the NSW upper mid-north coast study area (November 2012 – January 2013). Shaded cells indicate predominant tenure within a regional population.

Reg Pop no.	Regional Population name	Grand Total (ha)	State Forest (ha)	NPWS (ha)	Other (ha)	State Forest %	NPWS %	Other %
1	South Bellinger – Nambucca – North Macleay	286973	67120	59883	159970	23	21	56
2	Coffs Harbour- north Bellingen	88492	28517	10806	49169	32	12	56
3	Coffs Harbour Hinterland	77609	34266	16054	27290	44	21	35
4	Chaelundi - Clouds Creek - West Dorrigo	149476	54795	55164	39517	37	37	26
5	Southern Clarence	179599	26980	36298	116321	15	20	65
6	Grange- Ewingar – Richmond Range	211432	51805	9162	150465	25	4	71
7	Northern Clarence Southern Richmond	325607	47694	32218	245695	15	10	75
Grand Total		1319188	311175	219584	788427	24	17	60

Predominant tenure (>25%)

Table 3. Summary area and tenure statistics for mapped Koala sub-populations of the NSW upper mid-north coast study area (November 2012 January 2013). Shaded cells indicate predominant tenure within a sub-population.

Reg Pop no.	Regional Population name	Sub-population name	Sub-pop no.	Sub-pop area (ha)	SF (ha)	NPWS (ha)	Other (ha)	SF %	NPWS %	Other %
1	South Bellinger – Nambucca – North Macleay	Southern Coastal	1A	20534	4808	266	15460	23	1	75
		Southern Hinterland	1B	168224	42109	46054	80061	25	27	48
		Scoots Head – Ngambaa - Willawarrin	1C	98215	20203	13563	64448	21	14	66
2	Coffs Harbour- north Bellingen	Bongil Bongil - Pine Creek	2A	8617	1512	3869	3235	18	45	38
		North Bellingen - Gleniffer	2B	13061	5138	1517	6406	39	12	49
		Bonville	2C	3953	36	323	3594	1	8	91
		Coffs Harbour - Toormina - Korora	2D	6707	21	108	6577	0	2	98
		Orara West - Boambee	2E	16318	4658	2892	8768	29	18	54
		Coffs northern beaches	2F	6389	163	751	5475	3	12	86
		Lower Bucca - Orara East	2G	17684	8550	214	8919	48	1	50
		Red Rock - Wedding Bells - Conglomerate	2H	15763	8438	1131	6194	54	7	39
3	Coffs Harbour Hinterland	Coffs Harbour Hinterland	3A	77609	34266	16054	27290	44	21	35
4	Chaelundi - Clouds Creek - West Dorrigo	Chaelundi - Clouds Creek	4A	125972	52318	54206	19448	42	43	15
		West Dorrigo	4B	23504	2477	958	20069	11	4	85

- continued over page -

Table 3 continued

Reg Pop no.	Regional Population name	Sub-population name	Sub-pop no.	Sub-pop area (ha)	SF (ha)	NPWS (ha)	Other (ha)	SF %	NPWS %	Other %
5	Southern Clarence	Waterview Heights	5A	13634	0	0	13634	0	0	100
		Shannon-Coutts	5B	32968	0	1545	31423	0	5	95
		Bom Bom - Glenugie	5C	41808	8349	3487	29973	20	8	72
		Yuraygir	5D	64029	13476	28178	22374	21	44	35
		Ramornie	5E	27160	5155	3088	18917	19	11	70
6	Grange - Ewingar – Richmond Range	Grange	6A	25719	10572	0	15147	41	0	59
		Ewingar – Washpool – Richmond Range	6B	185713	41233	9162	135318	22	5	73
7	Northern Clarence Southern Richmond	Illuka - Woombah	7A	3806	0	1969	1837	0	52	48
		Ashby	7B	4199	0	0	4199	0	0	100
		Northern Clarence – Southern Richmond	7C	308655	47694	25923	235037	15	8	76
		Broadwater – Evans Head	7D	8948	0	4326	4622	0	48	52

Predominant tenure (>25%)

Table 4. Koala sub-populations with prominent representation of NPWS reserves.

Koala Sub-population	NPWS %	Status	Notes
1B Southern Hinterland	27	Stable	New England, Dungirr and Gumbayngirr national parks and Gumbayngirr State Conservation Area support a relatively large area of potential habitat for this sub-population but overall densities appear to be low; populations here remain largely unknown.
2A Bongil Bongil - Pine Creek	45	Stable	Bongil Bongil National Park is a known Koala core habitat of National importance.
3B Chaelundi - Clouds Creek	43	Stable	Chaelundi, (part) Nymboi-Binderay, (part) western Guy Fawkes River national parks may be critical Koala reserves but survey is required to verify occurrence and population densities which are likely to be low.
5D Yuraygir	44	Declined	Yuraygir National Park is not likely to support a long term viable Koala population without immigration from adjoining sub-population. Densities and overall population very low.
7A Iluka - Woombah	52	Declined	Bundjalung National Park is not likely to support a long term viable Koala population. Numbers have declined drastically and population appears functionally extinct.
7D Broadwater – Evans Head	48	Declined	Broadwater and (northern) Bundjalung national parks are not likely to support long term viable Koala populations. Populations are sparse on non-preferred coastal sand-based habitats

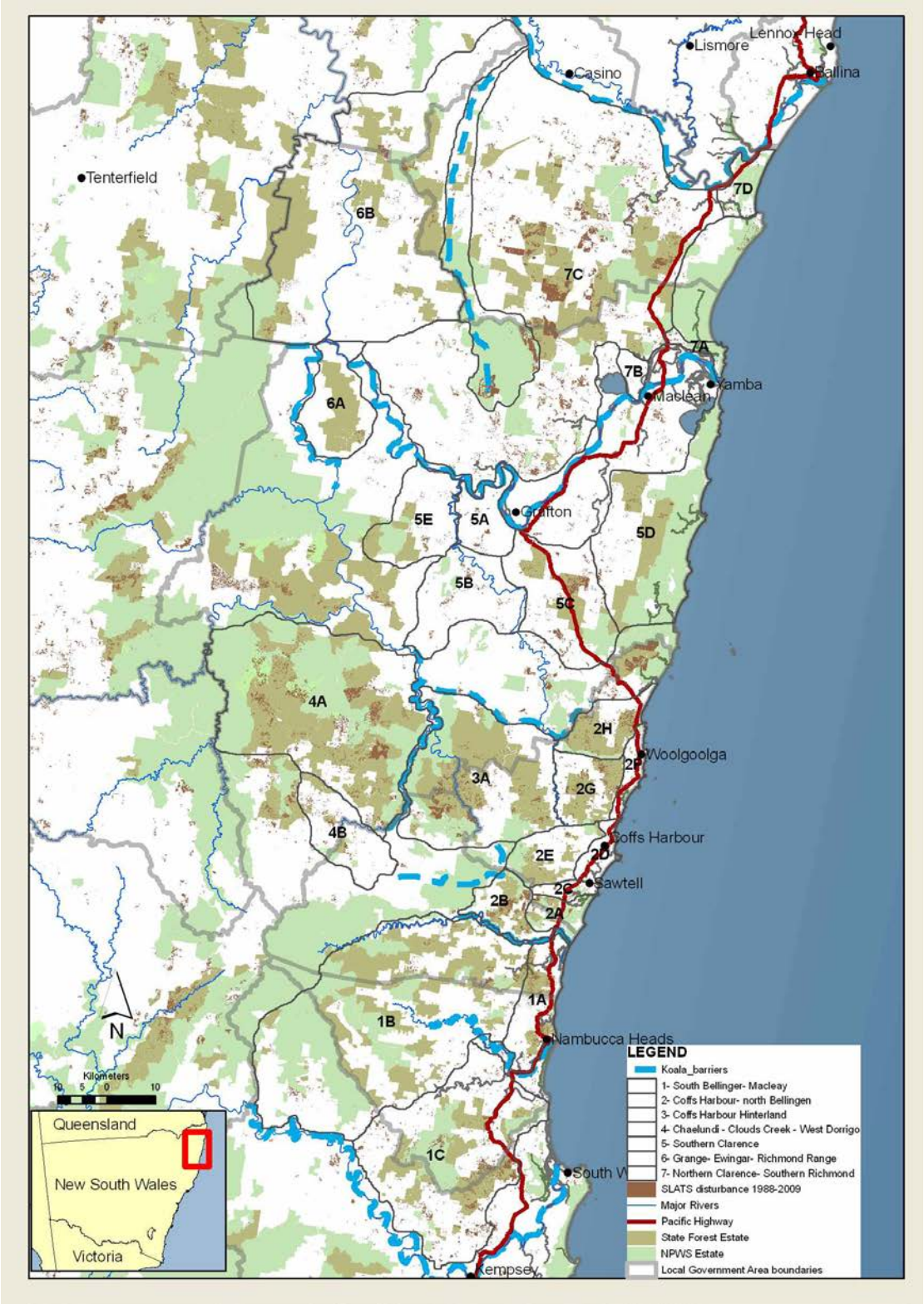


Figure 4. Mapped disturbance (vegetation clearance, logging) across the NSW upper mid-north coast study area as indicated by satellite imagery over the period 1988 – 2009.

7.3.3 Koala population summaries: Bellingen, Coffs Harbour, Clarence Valley LGAs

The following summarized point-form text describing aspects of relevance to each Koala regional population and constituent sub-population should be considered in conjunction with Tables 1 -4; Figures 2, 3, 4 and the relevant regional population map illustrating tenure, potential movement barriers and mapped population boundaries (Figures 5 -11).

1. SOUTH BELLINGER – NAMBUCCA – NORTH MACLEAY REGIONAL POPULATION

Northern and southern boundaries formed by geographic barriers associated with the lower reaches of the Bellinger River (north) and Macleay River (south) including extensive clearing and urban and agricultural development. The north-western boundary is mapped but remains ill-defined with little knowledge relating to Koala occurrence.

This regional population covers Nambucca LGA and the northern part of Kempsey LGA and is considered to comprise a Koala meta-population in its own right, nominally named the Bellinger – Nambucca meta-population (see section 7.4 below). This meta-population requires a targeted program of Koala habitat mapping and population characterization in order to clarify its character and Koala conservation status.

Overall South Bellinger – Macleay regional Koala population remains largely unknown but may support and extensive but most likely sparse population. A rough estimate of 130 – 1,550 individuals results from the projections generated in this project.

Three Koala sub-populations have been identified within this regional population (Figure 2, 3, 5).

1A. Southern Coastal Sub-population

Location / landform / habitat

Bellingen, Nambucca LGAs, south of Bellinger River and north of Nambucca River; coastal plain and coastal foothills; fragmented and degraded open forests.

Threats

Intensive development pressures (urban & rural-residential) on private lands (e.g. Valla, Valla Beach, Bellwood); intensive state forest logging; frequent fire, dogs and road strike.

Tenure

Mostly private lands; some intensively managed state forest; no formal reserves.

Prognosis

Low to sparse population (<50); functionally isolated; functional viability appears uncertain without drastic changes in land management and reduction of threats.

Recommendations

Severely impacted but restoration of functional corridors to the west, including across Pacific Highway, together with application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

1B. Southern Hinterland Sub-population

Location / landform / habitat

Bellingen, Nambucca LGAs, south of Bellinger River and north of Taylors Arm Valley; coastal foothills; largely intact forest landscapes; *Threats*

Extensive private and state forest logging; frequent fire; proposals for coal seam gas exploration are current and pose another significant threat in the upper Nambucca Valley.

Tenure

Extensive private forests and state forests; also extensive Koala habitat within reserves (e.g. New England, Dungirr, Gumbayngirr national parks; Jaaninga Nature Reserve) but the quality of reserved habitats remains largely unknown.

Prognosis

A stable but low density Koala population (50 – 500 individuals); likely a viable component of the Bellinger – Nambucca – Macleay Koala meta-population.

Recommendations

Targeted survey, monitoring, research leading to habitat and population characterization. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

1C Scotts Head – Ngambaa – Willawarrin Sub-population

Location / landform / habitat

Nambucca, northern Kempsey LGAs, south of Taylors Arm Valley and north of Macleay Valley; coastal foothills; some intact forest landscapes;

Threats

Extensive private and state forest logging; frequent fire.

Tenure

Extensive private forests and state forests; also significant areas of Koala habitat within reserves (e.g. Ngambaa Nature Reserve, Yarriabini National Park) but the quality of reserved habitats remains largely unknown.

Prognosis

This sub-population remains largely unknown but apparent declines in privately owned areas as well as Tamban State Forest suggest serious concerns; populations broadly estimated at 50 – 500 individuals but the upper limit may well be a drastic over-estimate.

Recommendations

Targeted survey, monitoring, research leading to habitat and population characterization. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

Figure 5. Mapped Koala regional population 1 (South Bellinger – Macleay) and three mapped sub-populations showing tenure, Koala records and potential barriers

2. COFFS HARBOUR – NORTH BELLINGEN REGIONAL POPULATION

The most critically important Koala regional population in this region and perhaps one of the most important in the nation. The coastal plains and foothills forests of the Coffs Harbour and north-east Bellingen LGAs are incorporated. Regional population boundaries are formed by sandstone-based habitats (north), rainforest habitats (east) and cleared river valleys (west and south) that act as likely barriers or filters to Koala movement.

There may be occasional interchange of dispersing koalas between this regional population and regional populations 2 and then 4 making them a potential large single Koala meta-population, nominally named the Coffs Harbour – Guy Fawkes meta-population.

This regional population supports the greatest Koala numbers (>1000 individuals) and highest densities in the region however significant threats associated with a close proximity to human centres and infrastructure prevail.

Eight Koala sub-populations have been identified within this regional population (Figure 2, 3, 6).

2A. Bongil Bongil – Pine Creek Sub-population

Location / landform / habitat

South-east corner of Coffs Harbour LGA / north-east corner of Bellingen LGA; north of the Bellinger River to Sawtell area; Tallowwood, Grey Gum, Flooded Gum habitats growing on relatively fertile soils.

Threats

Majority of extant habitat protected and threats managed within Bongil Bongil National Park; logging impacts severe including intensive plantation management in Pine Creek State Forest; the Pacific Highway bisects the area and road strike is an on-going threat; also dogs, fire and stress-related disease

Tenure

Formally reserved lands are prominent- Bongil Bongil National Park is a nationally important reserve for the Koala; some private lands are also extremely important habitats; some important state forest habitats (Pine Creek State Forest)

Prognosis

A nationally important Koala sub-population (500 – 1000 individuals estimated to occur; seemingly stable, although private land populations may decline in future; currently a potential source area for dispersers to adjoining sub-populations.

Recommendations

This critical population requires on-going targeted survey, monitoring and research, particularly within Bongil Bongil National Park and Pine Creek State Forest; prevailing threats require on-going monitoring and management; links to adjoining sub-populations require protection and enhancement, particularly western corridors to the hinterland through state forest and some private lands.

2B. North Bellingen – Gleniffer Sub-population

Location / landform / habitat

North-east corner of Bellingen LGA; north of Bellinger River; coastal foothills.

Threats

Private logging, state forest logging including extensive and intensive hardwood plantation logging; fire, dogs, stress-induced disease.

Tenure

Mixture of private forests and large areas of state forests; little formally reserved land but southern part of Bindarri National Park may provide habitat.

Prognosis

Broadly estimated at 50 – 500 individuals but population declines are apparent, based on low recent reporting rates, particularly on private lands; anecdotal evidence of decline in state forest areas.

Recommendations

Address threats; maintain forest connectivity within plantation areas and elsewhere.

2C. Bonville Sub-population

Location / landform / habitat

Southern Coffs Harbour LGA in Bonville district- east and west of Pacific Highway; coastal foothills; habitats as fragmented remnants.

Threats

Area of on-going and planned intensive urban and rural-residential development- habitat loss, fragmentation and degradation;; dogs, vehicle strike, stress-induced diseases.

Tenure

Predominantly private land;

Prognosis

This sub-population is thought to have shrunken significantly. A broad estimate of 50 – 500 individuals is estimated but the upper limit may well be a drastic over-estimate. The functional viability of this sub-population is uncertain in the face of on-going and escalating threats; essentially a sink area for dispersing individuals from sub-population 2A.

Recommendations

Severely impacted but retention and enhancement of habitat and corridor links wherever possible, along with koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

2D. Coffs Harbour - Toormina – Korora Sub-population

Location / landform / habitat

Central Coffs Harbour LGA; remnant habitat patches on coastal plain and foothills.

Threats

High level of threat associated with intense human presence and development; habitat loss, fragmentation, degradation, dogs, vehicle strike, stress-related diseases

Tenure

Almost entirely private lands, including commercial and industrial lands.

Prognosis

With a declined status and an estimated sub-population size of less than 50 individuals the functional viability of this sub-population is questionable in the face of on-going and escalating threats; essentially a sink area for dispersing individuals from sub-population 2A and possibly 2E.

Recommendations

Severely impacted but retention and enhancement of habitat and corridor links wherever possible, along with koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

2E. Orara West – Boambee Sub-population

Location / landform / habitat

Western-central Coffs Harbour LGA; coastal plains and foothills; fragmented remnant habitats but some more extensive habitat on public lands.

Threats

Habitat loss and degradation on private lands continues; private logging; state forest logging; dogs.

Tenure

Largely private forests but also tracts of state forest (Boambee and Orara West state forests); the foothills of Bindarri National Park and parts of Ulidarra National Park may provide habitat but surveys are needed to verify.

Prognosis

This formerly large Koala sub-population appears to have declined substantially and is now estimated at 50 – 500 individuals; previously known habitats in Boambee and Orara West state forests do not appear to currently support many koalas.

Recommendations

Targeted surveys and monitoring are required to establish current Koala status; Habitats need protection and enhancement and threats require targeted management. The Koala

conservation status of public forests including Boambee and Orara West state forest, Bindarri and Ulidarra national parks requires targeted updating.

2F. Coffs northern beaches Sub-population

Location / landform / habitat

North-east Coffs Harbour LGA; coastal plains; patchy, remnant and fragmented habitats

Threats

Significant threat levels associated with intense, and burgeoning, human presence and development; habitat loss, fragmentation and degradation; dogs, vehicle strike, stress-related diseases.

Tenure

Predominantly private lands with small amounts of habitat on state forest tenure.

Prognosis

This population may now be functionally extinct; always a low density population and estimated at less than 50 individuals currently.

Recommendations

Targeted survey is planned as part of Coffs Harbour Koala Plan of Management revision. The results of this survey may clarify current population status.

2G. Lower Bucca - Orara East Sub-population

Location / landform / habitat

North-east Coffs Harbour LGA; coastal foothills; relatively intact lower quality habitats.

Threats

Private logging; state forest logging including intensive plantation management; habitat clearance and fragmentation also continues on private lands; dogs.

Tenure

Mixture of private forest and state forest; no formally reserved habitat.

Prognosis

Historically low population density and estimated at less than 50 individuals currently; uncertain long term viability in face of on-going threats and lack of colonizing individuals from adjacent sub-populations.

Recommendations

Severely impacted but retention and enhancement of habitat and corridor links wherever possible, along with koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

2H. Red Rock - Wedding Bells – Conglomerate Sub-population

Location / landform / habitat

Northern end of Coffs Harbour LGA; coastal foothills; relatively intact but seemingly very low quality habitats.

Threats

Private logging; state forest logging including intensive plantation management; habitat clearance and fragmentation also continues on private lands; fire and dogs.

Tenure

Mixture of private forest and state forest; no formally reserved habitat.

Prognosis

Historically low to sparse population density and estimated at less than 50 individuals currently; uncertain long term viability in face of on-going threats and lack of colonizing individuals from adjacent sub-populations.

Recommendations

Severely impacted but retention and enhancement of habitat and corridor links wherever possible, along with koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

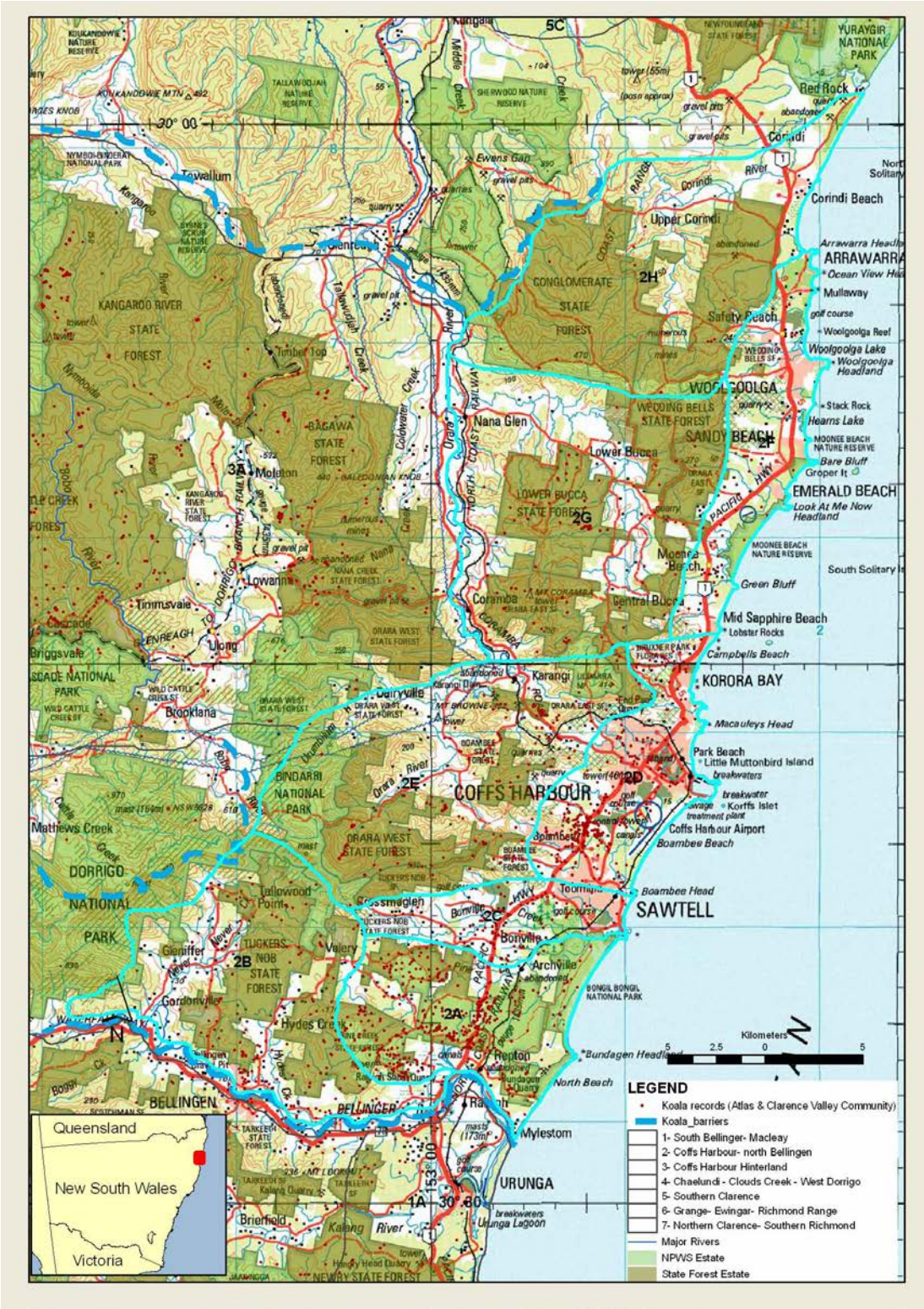


Figure 6. Mapped Koala regional population 2 (Coffs Harbour – north Bellingen) and eight mapped sub-populations showing tenure, Koala records and potential barriers

3. COFFS HARBOUR HINTERLAND REGIONAL POPULATION

This regional population is bounded to the north by non-preferred sandstone-based forests and woodlands, to the south by clearing associated with the eastern Dorrigo Plateau and also non-preferred rainforest habitats, to the west by the rugged, steep gorges associated with the Nymboida River and to the east by clearing associated with the Orara Valley.

This is appears to be a critical Koala regional population supporting in the order of 500 – 100 individuals centred upon hinterland public forests, particularly state forests, but also including important private forests on the eastern Dorrigo Plateau. Some reserved Koala habitat is found on NPWS estate.

Past surveys have been largely on state forest estate so targeted surveys and monitoring are needed across tenures to verify the status of Koala populations.

There may be occasional interchange of dispersing koalas between this regional population and regional populations 2 and then 4 making them a potential large single Koala meta-population, nominally named the Coffs Harbour – Guy Fawkes meta-population.

Only one sub-population has been identified for this regional population (Figure 2, 7).

3A. Coffs Harbour Hinterland Sub-population

Location / landform / habitat

Western Coffs Harbour LGA, Northern Bellingen LGA, southern Clarence Valley LGA; foothill, escarpment and plateau tall open forests.

Threats

State forest logging and private land logging; dogs may be a localised threat, particularly on and near private lands; fire.

Tenure

Mostly private land and state forest but Nymboi-Binderay, northern Bindarri and Cascade national parks may support low density populations; Koala records are most widespread on state forests (e.g. Wild Cattle Creek, Bagawa, Kangaroo River state forests) due to previous survey effort.

Prognosis

Suggested as an important stable Koala sub-population (broadly estimated at 500 – 100 individuals) with extensive Koala records across the state forest estate; targeted survey and characterization is needed.

Recommendations

Targeted survey and monitoring, habitat mapping and research aimed at population characterization are needed across this sub-population area to establish its Koala conservation status and set appropriate land management directions.

Figure 7. Mapped Koala regional population 3 (Coffs Harbour hinterland) and one mapped sub-population showing tenure, Koala records and potential barriers

4. CHAELUNDI – CLOUDS CREEK – WEST DORRIGO REGIONAL POPULATION

This regional population is bounded to south by clearing associated with the eastern Dorrigo Plateau and also non-preferred rainforest habitats, to the east by the rugged, steep gorges associated with the Nymboida River and to the west by rugged and lower fertility forests and woodlands of the Guy Fawkes River National Park. To the north of the mapped regional population Koala records become scarce (e.g. Marara, Dalmorton state forests) and habitats may be less suitable. The Boyd River may also present a barrier or at least a filter to Koala movement.

This appears to be a critical Koala regional population supporting in the order of 500 – 1000 individuals. The mapped area includes hinterland, escarpment and gorge public forests and some tracts of private forest west of Dorrigo. Some reasonably extensive potential Koala habitats occur on NPWS estate. State forests in this area (e.g. Marengo, Ellis, Clouds Creek, Sheas Nob and Moonpar state forests) are known to support important populations of additional high profile forest fauna species including nationally threatened species (Hastings River Mouse, Spotted-tailed Quoll, Long-nosed Potoroo) and many others listed at state level. This is a national epicentre for forest fauna conservation and management and koalas are an important species in what should be an integrated cross-tenure management regime.

Past surveys for koalas in this area have been largely on state forest estate and Koala records are widespread on that tenure; targeted surveys and monitoring are needed across tenures to verify the status of Koala populations.

There may be occasional interchange of dispersing koalas between this regional population and regional population 3 and then 2 making them a potential large, and nationally significant single Koala meta-population, nominally named the Coffs Harbour – Guy Fawkes meta-population.

Two sub-populations have been identified but 4A is considered the critically important one in the context of long term Koala conservation (Figure 2, 8).

4A. Chaelundi - Clouds Creek Sub-population

Location / landform / habitat

Southern end of Clarence Valley LGA, west of Nymboida River and extending to Guy Fawkes River National Park. Escarpment and gorge tall open forests.

Threats

State forest logging and private land logging; dogs may be a localised threat, particularly on and near private lands; fire is a threat across all tenures.

Tenure

Potential Koala habitat is on forests of all tenures but most records are on state forests (e.g. Clouds Creek, Ellis, Moonpar, Sheas Nob, Marengo state forests) due to previous survey effort; Chaelundi, western Nymboi-Bideray and eastern Guy Fawkes River national parks may support low density but extensive populations. There may also be some higher density populations on NPWS estate but targeted survey is required.

Prognosis

Suggested as a nationally important stable Koala sub-population (estimated at 500 – 100 individuals) with extensive Koala records across the state forest estate; targeted survey and characterization is needed; a number of Koala records have come from private and state forests in the Billys Creek area in recent times where local residents are concerned about state forest logging within Koala habitats (Glen Little personal communication).

Recommendations

Targeted survey and monitoring, habitat mapping and research aimed at population characterization are needed across this sub-population area to establish its Koala conservation status and set appropriate land management directions.

4B. West Dorrigo Sub-population

Location / landform / habitat

Northern Bellingen and southern Clarence valley LGAs; Remnant and patchy escarpment and plateau tall open forests

Threats

State forest and private logging; dogs; fire.

Tenure

Predominantly private lands but small areas of potential habitat within southern Marengo, eastern Hyland and Muldiva state forests and also Bagul Waajarr Nature Reserve which supports stands of tall moist open forest.

Prognosis

The Koala population is broadly estimated at <50 individuals but the area is largely unknown in terms of current conservation status for koalas; likely a low density population overall but local densities may be higher in patchy higher quality habitats (e.g. upper Nymboida and Little Murray rivers).

Recommendations

Targeted survey is needed to clarify knowledge regarding this sub-population and to provide information on habitat and population character. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

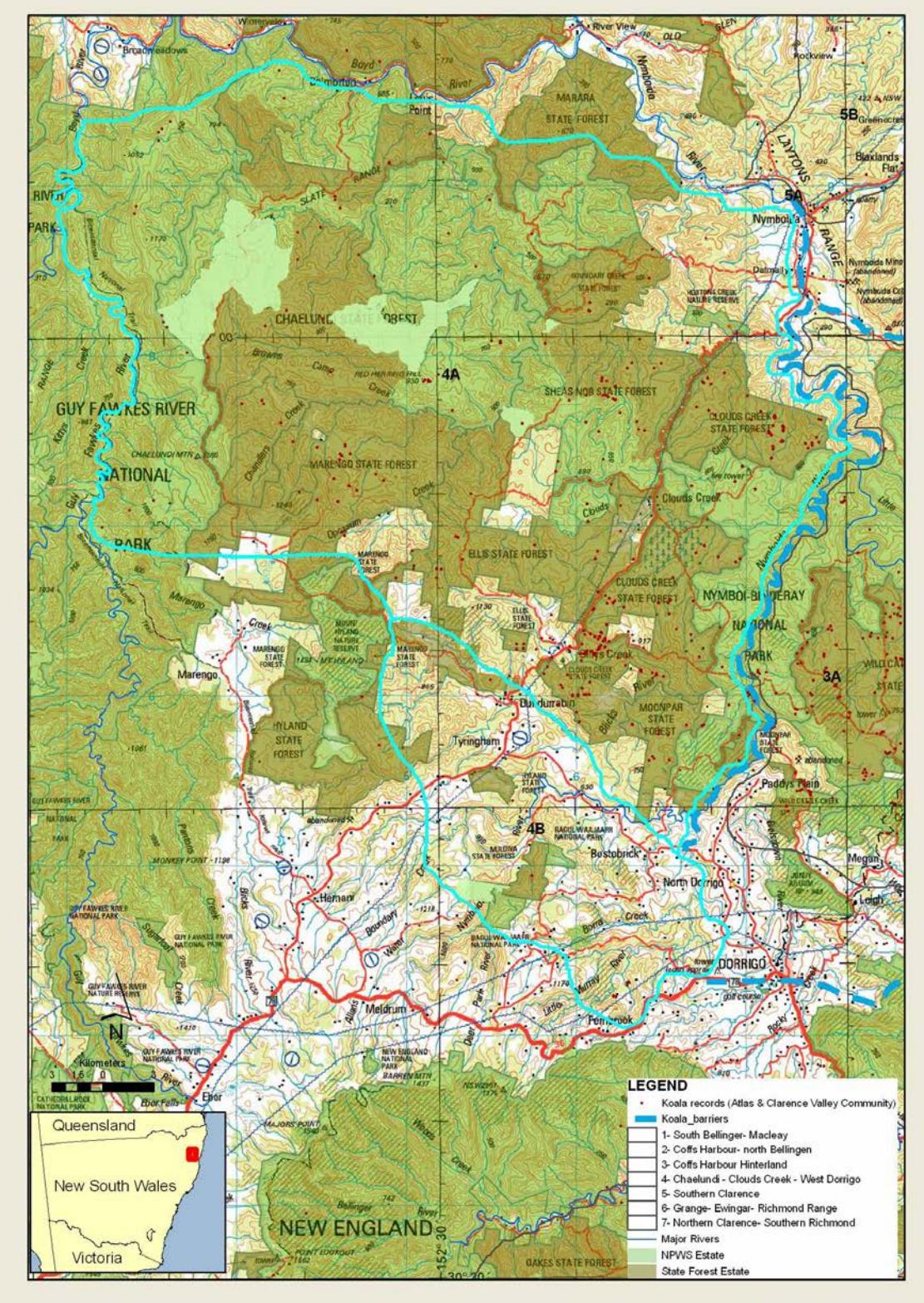


Figure 8. Mapped Koala regional population 4 (Chaelundi – Clouds Creek _ Wets Dorrigo) and two mapped sub-populations showing tenure, Koala records and potential barriers.

5. SOUTHERN CLARENCE REGIONAL POPULATION

This Koala regional population extends south of the Clarence River from the Yuraygir coast in the east to the Nymboida River in the west; sandstone-based habitats in the south separate it from regional populations 2, 3 and 4. Koalas here predominantly occur on private lands west of Grafton and Coutts Crossing with very low densities extending to state forests and Yuraygir National Park.

There may be occasional interchange of dispersing koalas between this regional population and regional populations 6 and 7 making them a potential large single Koala meta-population, nominally named the Clarence – Richmond meta-population.

Five sub-populations have been identified within this regional population (Figure 2, 9).

5A. Waterview Heights Sub-population

Location / landform / habitat

Immediately west of Grafton and south of the Clarence River; floodplain and associated foothill remnant forests; Forest Red Gum (*Eucalyptus teretecornis*) is the preferred Koala feed tree here.

Threats

This area is subject of landuse intensification for rural-residential development leading to on-going habitat loss, degradation and fragmentation; dogs, vehicle strike and stress-related disease

Tenure

One hundred percent private lands

Prognosis

Numbers may be low overall (<50 individuals estimated); although koalas continue to persist in this area and breeding is reported locally the long term prognosis is for a continued decline in numbers in the face of ongoing and intensifying threats.

Recommendations

Address threats- habitat protection and restoration is critical here; substantial corridor links are also required to maintain and restore habitat connectivity. The application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

5B. Shannon-Coutts Sub-population

Location / landform / habitat

Remnant and patchy generally low quality habitat (three red gum species, Grey Box, Swamp Mahogany and Small-fruited Grey Gum) on alluvial and foothill landforms.

Threats

Habitat loss, degradation and fragmentation; fires; dogs; possibly stress-related disease.

Tenure

Almost entirely private lands with some Koala habitat extending to lands reserved as part of the Shannon Creek Dam.

Prognosis

Numbers may be very low overall (< 50 individuals estimated); the Koala population here has been subject of some monitoring as part of development approval requirements for the Shannon Creek dam. Numbers appear to have declined drastically in recent times (John and Tricia Edwards, personal communication).

Recommendations

Further targeted survey and monitoring is needed to establish the status of koalas in this sub-population. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

5C. Bom Bom – Glenugie Sub-population

Location / landform / habitat

Central-east Clarence Valley LGA; small remnant patches of alluvial forest and larger expanses of foothill forest (e.g. spotted gum), generally low quality habitat.

Threats

Private and state forest logging; vehicle strike; dogs; fire.

Tenure

Predominantly private forest but also very low density populations in Bom Bom and Glenugie state forests.

Prognosis

Populations occur at very low densities here and long term persistence seems unlikely with a very low potential for any influx of individuals from adjoining sub-populations; Koala sub-population broadly estimated at <50 individuals.

Recommendations

Koala conservation priorities probably lie elsewhere in this regional population but targeted survey and enhancement of landscape connectivity should be promoted.

5D. Yuraygir Sub-population

Location / landform / habitat

Centred on Yuraygir National Park and adjoining state forests in the east of the Clarence Valley LGA; sparse populations on coastal plains and foothills forests growing on quaternary sands and alluviums and adjacent lithic sandstones and mudrocks.

Threats

High fire frequency; logging on private and state forests.

Tenure

Mixture of tenures including a large area within Yuraygir National Park although likely very few koalas within the reserve; Pine Creek and Candole state forests may support very low density local populations.

Prognosis

Populations occur at very low densities and long term persistence seems unlikely with a very low potential for any influx of individuals from adjoining sub-population; Koala sub-population broadly estimated at <50 individuals.

Recommendations

Koala conservation priorities probably lie elsewhere in this regional population but targeted survey and enhancement of landscape connectivity should be promoted. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

5E. Ramornie Sub-population

Location / landform / habitat

Central Clarence Valley LGA; foothills open forest growing on lower fertility soils of quartz sandstone origin.

Threats

Private and state forest logging; frequent fire.

Tenure

Predominantly private lands with some lower quality Koala habitat Ramornie State Forest and Ramornie National Park

Prognosis

Populations occur at very low densities in low quality habitat and long term persistence seems uncertain with a very low potential for any influx of individuals from adjoining sub-populations; sub-population broadly estimated at <50 individuals.

Recommendations

Koala conservation priorities probably lie elsewhere in this regional population but targeted survey and enhancement of landscape connectivity should be promoted. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

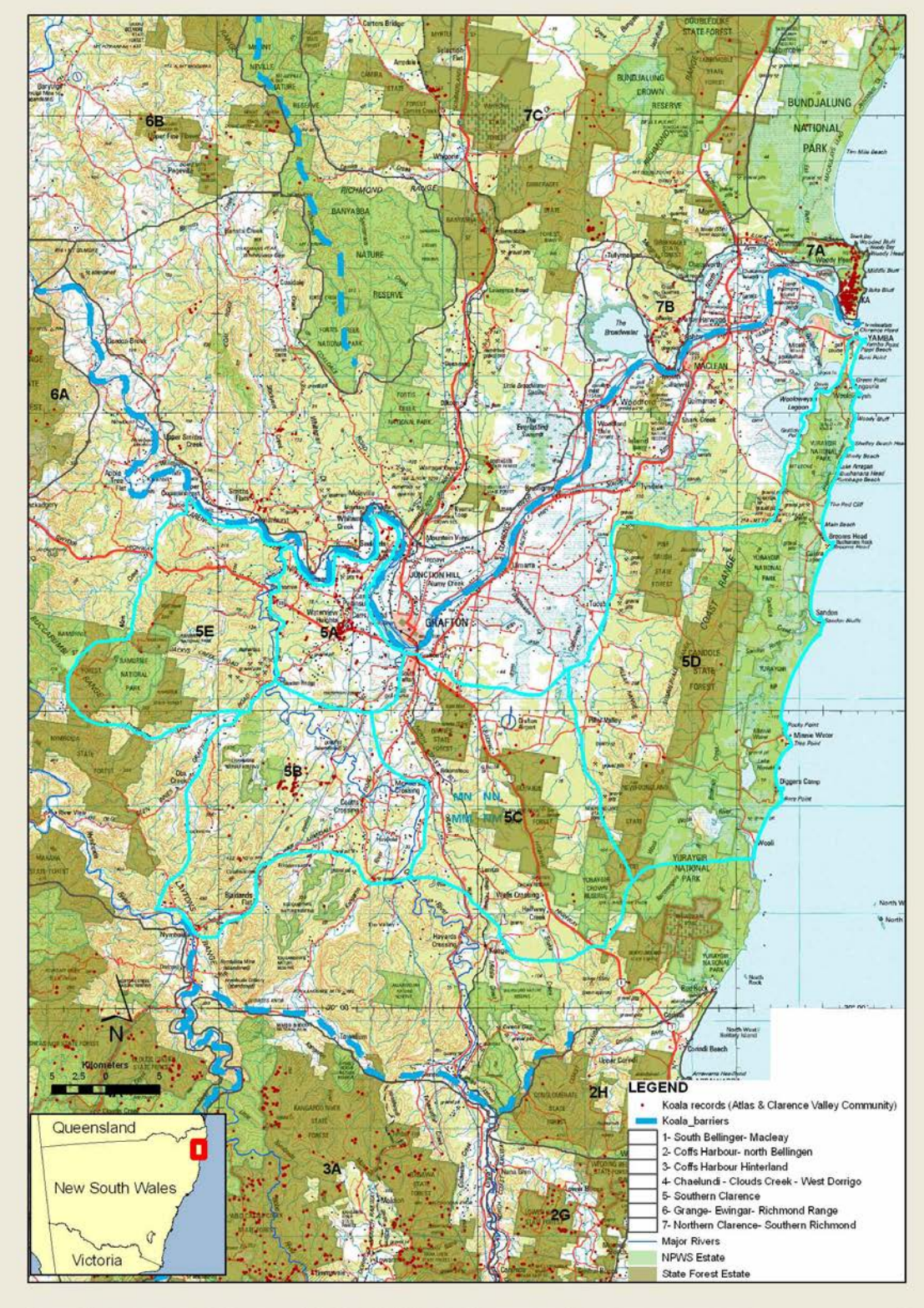


Figure 9. Mapped Koala regional population 5 (Southern Clarence) and five mapped sub-populations showing tenure, Koala records and potential barriers.

6. GRANGE – EWINGAR – RICHMOND RANGE REGIONAL POPULATION

A seemingly low density Koala Regional Population mostly occurring on private and state forests. This regional population is separated from regional population 7 by clearing associated with the Clarence Valley but occasional dispersing koalas may cross this perceived barrier. Koalas here are likely to be part of a potential large single Koala meta-population incorporating regional populations 5, 6 and 7 and nominally named the Clarence – Richmond meta-population.

Two sub-populations have been identified within this regional population (Figure 2).

6A. Grange Sub-population

Location / landform / habitat

Western Clarence Valley LGA; foothills forests growing on relatively low fertility soils of lithic sandstone origin; the Mann Valley is suggested as a western boundary for this sub-population.

Threats

Private and state forest logging has been intensive in this area in the past.

Tenure

Extensive private forest lands plus Grange State Forest.

Prognosis

This sub-population is largely isolated and largely unknown; Koalas occur at seemingly low density and long term persistence seems dubious in the face of ongoing threats.

Recommendations

Targeted survey, habitat mapping and population characterization is needed to establish the status of koalas here; habitat enhancement, sympathetic approaches to logging and promotion of landscape connectivity should be interim land management directions.

6B. Ewingar – Washpool Sub-population

Location / landform / habitat

An extensive area within the north-western sector of Clarence Valley LGA and extending into the far southern part of Kyogle LGA; the sub-population may in fact extend further north up the Richmond Range; largely Spotted Gum – Tallowwood – Grey Gum forests form the basis of mapped potential habitats in this area.

Threats

Private and state forest logging; fires.

Tenure

Predominantly private lands but also includes tracts of state forest with focused records of koalas (e.g. Mount Marsh, Mount Belmore, Cherry Tree, Ewingar and Washpool state forests); a part of Washpool National Park is included but habitat quality there is not known; similarly sands-stone and dry-rainforest based reserves in this area are generally

low quality or non-preferred habitats (e.g. western Banyabba and Mount Neville nature reserves, Mount Pikapene National Park.

Prognosis

Overall a low density Koala sub-population but potentially self-contained; habitat in many directions is overall extensive but often based on less preferred habitat types.

Recommendations

Targeted survey, habitat mapping and population characterization is needed to establish this population's status; habitat enhancement, including protection and promotion of landscape connectivity should be interim land management directions. It would be instructive to investigate the functionality of habitat connectivity to the north, through the Richmond Range, by targeted genetic sampling and analysis.

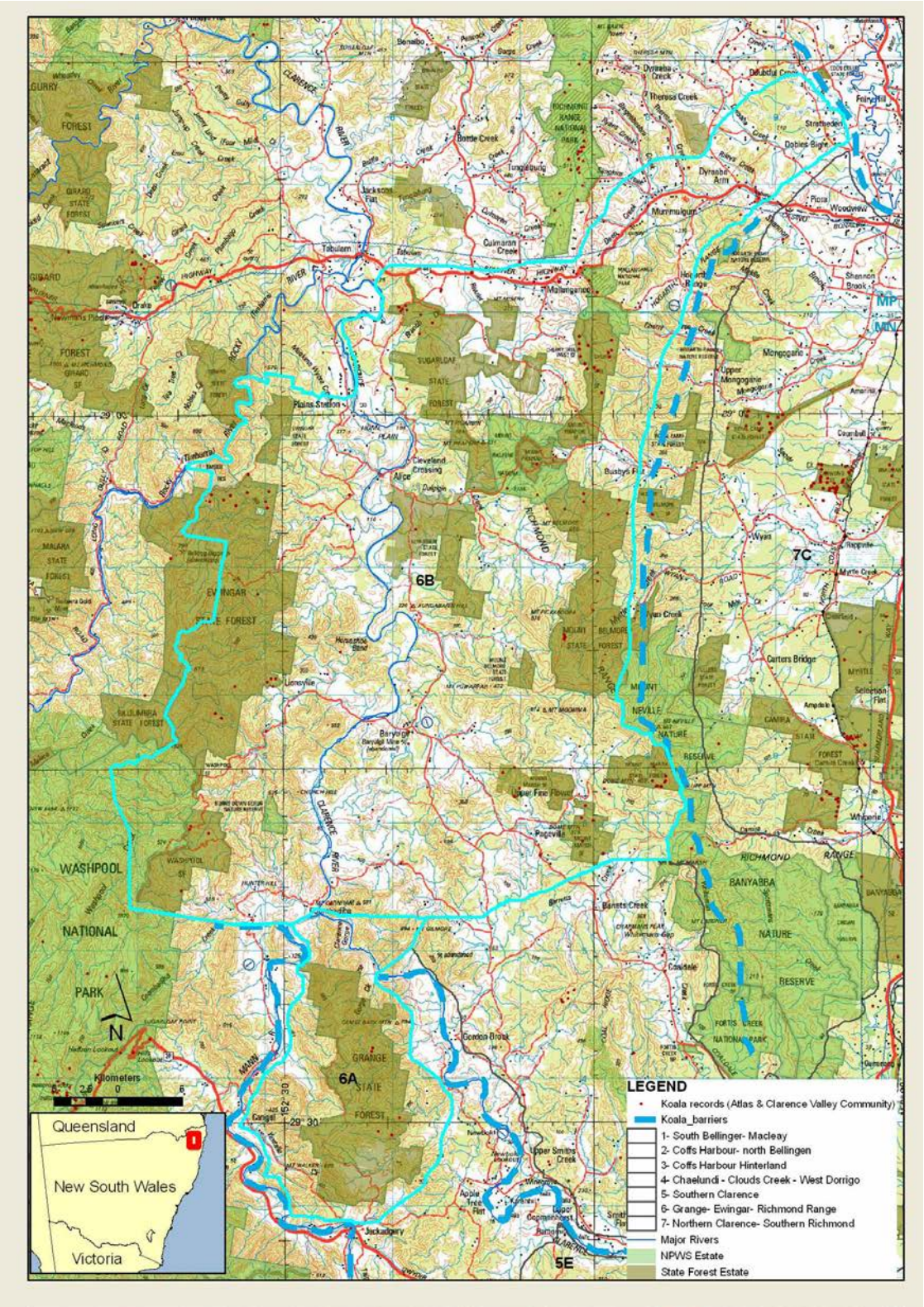


Figure 10. Mapped Koala regional population 6 (Grange – Ewingar – Richmond range) and two mapped sub-populations showing tenure, Koala records and potential barriers

7. NORTHERN CLARENCE – SOUTHERN RICHMOND REGIONAL POPULATION

Located at the northern end of the Clarence Valley LGA and extending north of the Clarence River from the Iluka in the east to the Richmond Valley LGA in the north. An extensive sandstone-based belt separates this regional population from regional population 6 although limited dispersal across the barrier may occur. Private lands support important habitats in the Copmanhurst, Gibberagee and Ashby locations. The former coastal Koala hub at Iluka Peninsula has declined drastically and maybe functionally extinct. State forests are important habitat focus areas in the north and north-west of the area.

There may be occasional interchange of dispersing koalas between this regional population and regional populations 5 and 6 making them a potential large single Koala meta-population, nominally named the Clarence – Richmond meta-population.

Four sub-populations have been identified within this regional population (Figure 2, 11).

7A. Iluka – Woombah Sub-population

Location / landform / habitat

North-eastern end of Clarence Valley LGA; west of Pacific Highway at southern end of Bundjalung National Park; in Iluka area predominately Forest Red Gum on sand substrate with a mixture of red gums, swamp mahogany, Tallowwood and paperbark feed trees elsewhere on clay based soils.

Threats

Urban and small rural lot development and associated habitat clearance, degradation and fragmentation; road strike; high intensity fire;

Tenure

Mix of private lands and NPWS lands (Bundjalung National Park and Iluka Nature Reserve).

Prognosis

Until relatively recently Iluka Peninsula supported a renowned high density Koala population; a recent drastic decline over the last 10 years or so has left this sub-population functionally extinct.

Recommendations

Habitat restoration is currently in progress with many areas now treated for weeds such as lantana. Further threat abatement particularly reducing road strike may enhance chances for sub-population recovery but recolonization opportunities from the west appear limited; human-aided translocations could be considered. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

7B. Ashby Sub-population

Location / landform / habitat

Ashby Peninsula north of the Clarence River and east of The Broadwater; Koala habitats here are a mixture of Forest Red Gum, Tallowwood, and Grey Gum on floodplain alluviums and adjacent foothills on sandstone-based soils.

Threats

Rural-residential development is occurring rapidly in this area with ever increasing incursions into forest areas leading to increased habitat degradation and edge effects such as weeds, elevated dog predation, fire, road strike.

Tenure

One hundred percent private lands.

Prognosis

Given the decline of Koala populations on the coast in the Woombah – Iluka area the importance of the Ashby Koala sub-population is high but ongoing and increasing threat levels make long term persistence uncertain. Clarence council presently completing a CKPoM for this area, Woombah and Iluka under SEPP 44.

Recommendations

This sub-population has had recent field surveys undertaken by Biolink for council but requires further monitoring; forest habitat should be retained and enhanced wherever possible to maintain refuge areas and corridor links. Landscape links to sub-population 7C (e.g. Gibberagee State Forest) are probably critical to the long term viability of the Ashby sub-population. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

7C. Northern Clarence – Southern Richmond

Location / landform / habitat

An extensive area extending from Northern Clarence Valley LGA and incorporating a large part of the Richmond Valley LGA; mixtures of habitats (e.g. Forest Red Gum, Grey Box, Spotted Gum, Grey Gum) in remnant patches on coastal plain alluviums and more extensive forests on adjacent foothills, often underlain by sandstone-based soils.

Threats

Private and state forest logging; on-going vegetation clearing in some foothill and coastal plains habitats of the Richmond Valley; fire;

Tenure

Predominantly private (Copmanhurst area and remnants along the lower Richmond Valley appear to be important focus areas); State forests support important habitats and populations (e.g. Royal Camp, Carwong, Gibberagee, Banyabba, Southgate, Fortis Creek state forests) where a number of Koala records are clustered; Fortis Creek and Bungawalbin national parks, along with Bungawalbyn Nature Reserve may support low

density Koala populations. Royal Camp and Carwong state forests appear to be important areas for regional Koala conservation (D. Milledge personal communication).

Prognosis

This extensive and ill-defined sub-population is the focus area for regional population 7. The extent to which koalas cross cleared lands associated with the Richmond Valley in the north of the sub-population area, and indeed the Richmond River itself, remains unclear. Landscape links persist to the west but these are based on less preferred sandstone-based habitats.

Recommendations

This appears to be an important Koala sub-population and the focus for Koala conservation in the Northern Clarence – Southern Richmond regional population; a sub-population size of 5 - 500 individuals is broadly estimated; targeted Koala survey, habitat mapping and population characterization is needed to establish this population's status and importance in long term Koala conservation; the relative importance of private, state forest and NPWS tenures in this area requires investigation. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

7D. Broadwater – Evans Head

Location / landform / habitat

A small mapped sub-population at the far north-east end of Richmond Valley LGA; mixtures of habitats including red gum, swamp mahogany and Tallowwood stands in remnant patches on coastal plain alluviums.

Threats

Habitat loss, fragmentation and isolation; fire also poses a threat to localized and isolated population units.

Tenure

The mapped area includes private lands and NPWS estate but the latter is generally sand-based and of low quality for koalas (e.g. Bundjalung National Park). Previously well known populations at Rileys Hill and near Evans Head appear to have declined drastically and maybe functionally extinct.

Prognosis

A very small sub-population (<50 individuals); long term viability appears dubious and uncertain.

Recommendations

Koala conservation priorities probably lie elsewhere in this regional population but targeted survey and enhancement of landscape connectivity should be promoted. Application of koala-supportive management strategies as are possible over time will be of benefit; on-going public education regarding Koala conservation, impacts of road collision and management of domestic dogs is required.

Figure 11. Mapped Koala regional population 7 (Northern Clarence – Southern Richmond) and four mapped sub-populations showing tenure, Koala records and potential barriers.

7.4 Koala meta-populations

Seven Koala Regional Populations were identified across the NSW upper mid-north coast study area. Based as they are on qualitative representations of likely habitat, movement barriers and filters the potential population boundaries must be viewed as speculative until targeted research and survey demonstrates otherwise. Similarly, the extent to which populations extend into, and link with, populations to the north, south and west of the study area also remains unknown pending further information and data. As a final representation of potential Koala population character in the study area the regional populations identified in this project have been tentatively assigned to three broad "Koala meta-populations" (Figure 12).

1. Bellinger – Nambucca – Macleay meta-population: Comprising mapped regional population 1 and extending from the southern Bellingen LGA through the Nambucca LGA to the northern part of the Kempsey LGA. Based upon the information assessed in this project this meta-population should be considered nationally important but a targeted program of Koala habitat mapping and population characterization is needed to establish its relative conservation status.

2. Coffs Harbour – Guy Fawkes meta-population: Comprising Regional Populations 2, 3 and 4, with a potential further extension into the Guy Fawkes Wilderness area. Based on currently available information this Koala meta-population is considered to be the most important locally and perhaps one of the most important nationally;

3. Clarence – Richmond meta-population: Comprising Regional Populations 5, 6 and 7, but with a potential extension west of 6 (e.g. Washpool National Park and State Forest), north of 6 (Richmond Range) and north of 7 (across the Richmond Valley and even the Richmond River). This meta-population appears to be clearly separate from meta-population 2. Although much of it supports lower Koala densities overall there are patches of higher quality habitat where Koala densities are high. This Koala meta-population is also considered important from a national context.

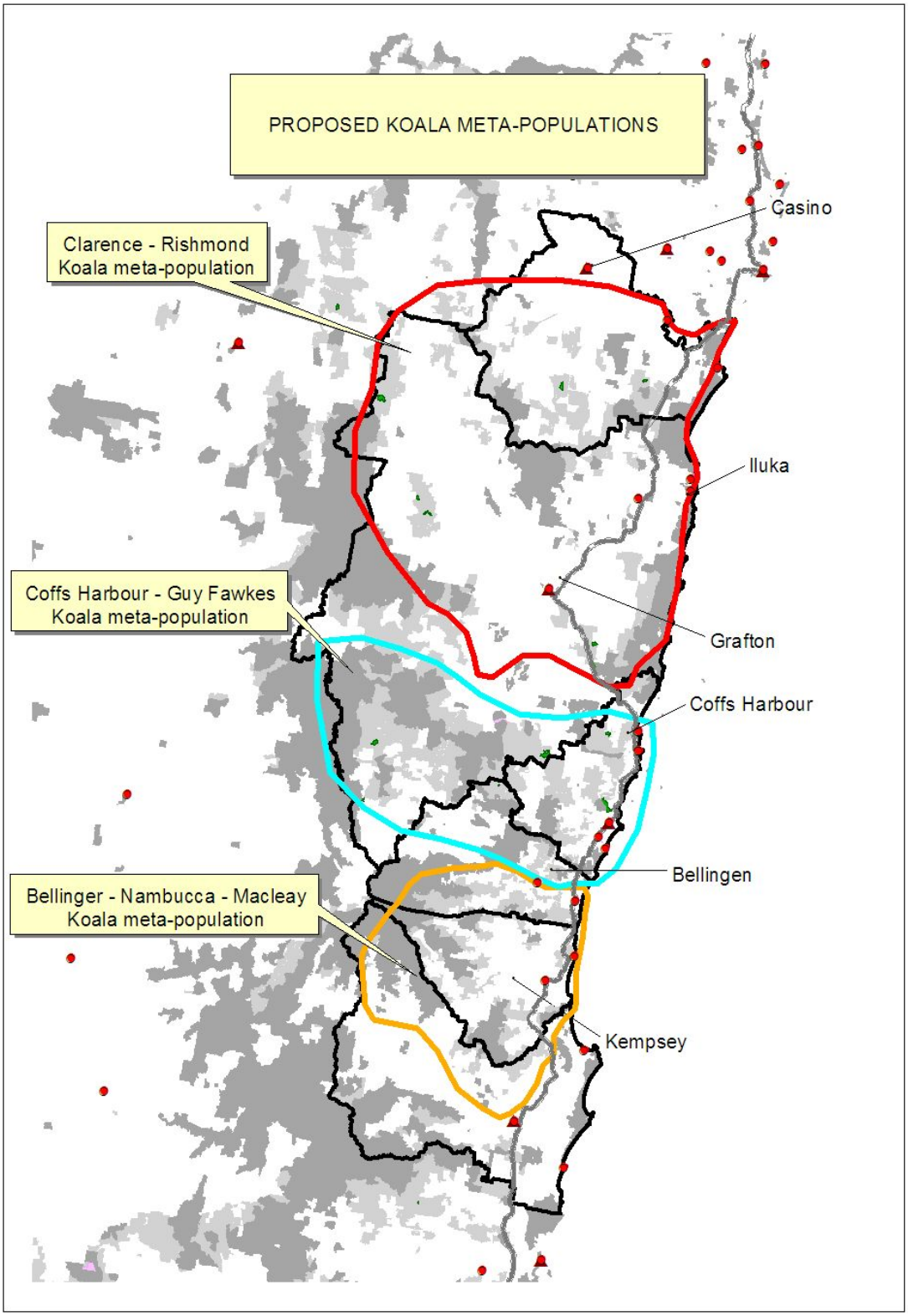


Figure 12. Proposed Koala meta-populations extending across the NSW upper mid-north coast study area.

8. Discussion and project recommendations

This project has provided the opportunity for the application of some novel, qualitative, approaches to the consideration of Koala habitat, populations and conservation across the NSW upper mid-north coast study area. The following discussion draws together some of the points and ideas generated through the work. Recommendations are then provided outlining a direction towards further work that is needed to address the conservation planning and management needs of these nationally important Koala populations.

8.1 Viability

Based upon the information collated in this project, the viability of many of the mapped Koala sub-populations, particularly many coastal and floodplain sub-populations, appears to be tenuous. For example, within the Coffs Harbour – Bellingen regional population, a national core area for the Koala, only one of eight sub-populations is judged to be stable, 2A Bongil Bongil – Pine Creek sub-population. The other seven sub-populations are considered to have declined substantially in the face of medium to high level threats and their persistence appears dependent upon immigration from adjoining sub-populations. This may be feasible in the short term for sub-populations 2B and 2C, as they adjoin the source 2A sub-population. However, in the face of on-going and escalating threats the viability of all seven of these "sink" populations (after Pulliam 1988) appears low. A similar scenario can be predicted for a number of sub-populations in the South Bellinger Macleay, Southern Clarence and Northern Clarence – Southern Richmond regional populations. Coastal and floodplain sub-populations are all subject to on-going and escalating threats placing them at great risk of local extinction. Declining potential for recolonization means that the long term viability of these sub-populations appears very low.

Hinterland Koala populations in this region persist at apparently low densities overall but they are also subject to lower levels of threat. While logging continues to threaten sub-populations dominated by state forest tenure other key threats such as road strike, dog attack and stress-induced disease appear to be lower in these areas. In that context, 1B Southern Hinterland sub-population, 3A Coffs Harbour Hinterland sub-population, 4A Chaelundi – Clouds Creek sub-population, 6B Ewingar – Washpool – Richmond Range and 7C Northern Clarence – Southern Richmond sub-populations may be critically important focus areas for Koala conservation in this region. This highlights an urgent need for targeted survey, monitoring, research and management in the sub-population areas aimed at securing knowledge to drive the long term welfare and viability of the Koala in this region.

8.2 Tenure considerations

Threats are on-going and likely to be escalating in many Koala habitats on private lands, the tenure that predominantly supports Koala habitat in this study area. Vegetation clearance, fragmentation and degradation is on-going, private native forestry is extensive and often also intensive locally, dogs, road strike and stress-induced disease are prevalent threats along the coastal plains, foothills and floodplains landscapes.

Significant proportions of hinterland regional populations are predominantly state forest. Logging continues in these areas, and in many areas has intensified following formal reservation of former state forests following the upper and lower north-east Regional Forestry Agreements. Fire is also an on-going major threat.

NPWS reserves are critical refugia for koalas where they occur but most reserves support only low density Koala populations and seemingly the best of any local habitats remain on private or state forest tenures. The reserves that do support Koala habitat require targeted survey and monitoring in the short term as few have been subject of systematic survey. Their status as Koala refugia amid landscapes that are subject of on-going and escalating threats needs to be clarified. In the longer term it seems highly desirable that higher quality habitats within any particular mapped Koala sub-population or regional population should be added to the formal reserve system and managed accordingly.

8.3 Project outcomes

Overall important project outcomes include:

- The delineation and mapping of important coastal and hinterland Koala regional populations and sub-populations across the three LGAs;
- Confirmation that private lands support the vast majority of coastal Koala populations in this study area, with the outstanding exception of Bongil Bongil National Park which remains a crucial focus area for Koala conservation;
- Illustration that private lands and state forests currently support the majority of hinterland Koala populations in this location, with the exception of Chaelundi and Nymboi-Binderay national park which may support important, *albeit* low density reserved Koala populations (surveys are needed to confirm).
- Proposal that three separate Koala meta-populations may exist in this study area; each considered important in its own right and deserving of targeted survey, monitoring and research to ascertain current Koala conservation status.
- The project emphasizes the general lack of knowledge and data concerning regional koala populations across the broader landscape, particularly hinterland populations, remote from human populated areas. This lack of knowledge means that planning for koala management and long-term persistence in these areas is difficult and often ill informed with smaller, or at least less extensive and possibly less viable, coastal populations receiving relatively greater survey, research and management focus. Perhaps resource re-direction is appropriate to address this imbalance.
- The project has highlighted the significance, and overall importance to Koala conservation, of the forest gradient extending from the coastal plains and foothills at Coffs Harbour / Bongil Bongil National Park to the rugged forest landscapes of Guy Fawkes National Park. The Koala may be considered a conservation umbrella species across this forest gradient placing emphasis on sympathetic and appropriate management of its habitat across all land tenures. This forest gradient includes coastal, hinterland, escarpment and gorge public forests as well as important tracts of private forest west of Dorrigo. Some renowned and reasonably extensive formal reserves (NPWS estate) occur but state forests in the hinterland area (e.g. Marengo,

Ellis, Clouds Creek and Moonpar state forests) are known to support critical populations of additional high profile forest fauna species including nationally threatened species (Hastings River Mouse, Spotted-tailed Quoll, Long-nosed Potoroo) and many others listed at state level. This is a national epicentre for forest fauna conservation and management and koalas are an important species in what should be an integrated cross-tenure management regime.

- The fact that this forest gradient has been identified as significant in other conservation assessment and planning programs is important. These include the Great Eastern Ranges initiative, the Jaaligirr Project, and a preliminary World Heritage assessment (Cerese 2012). It is clear that synergies between these projects need to be explored and promoted to promote and ensure the long term welfare of this critical forest area where the Great Escarpment approaches the coast.
- Targeted studies of genetic relatedness are needed to determine the status, efficacy and applicability of subpopulations, regional populations and even meta-populations proposed and mapped in this project and to set a direction for Koala population characterization and management in this region. Applicable techniques such as mitochondrial DNA analyses have been successfully trialed using Koala scats as source material (AMBS 2012).

8.4 Recommendations

It is not immediately clear to whom recommendations emanating from this project should be directed. Never the less the following are put forward as a possible direction for future Koala conservation assessment and planning and to help facilitate the on-going development of practical, site-based Koala conservation efforts in this region.

- That the Koala populations of the NSW upper mid-north coast be recognized for their national conservation significance;
- That targeted programs of systematic Koala habitat mapping be extended across all tenures to place all land tenures within an appropriate planning and assessment context;
- That targeted, systematic and on-going programs of Koala survey and monitoring be established and extended across all land tenures to establish the status and character of populations throughout the mapped sub-populations, regional populations and meta-populations;
- That hinterland Koala populations receive elevated survey, research and management resource allocation in light of their potential long term importance to overall species viability;
- That targeted genetics-based research be funded to help characterize Koala populations and to help determine appropriate Koala management units in this region;
- That interim and long term guidelines be generated detailing how the information generated from the Koala research and survey promoted in this report can be applied to direct practical Koala conservation efforts across all land tenures (e.g. carbon credits schemes, property management plans, ……., ……., …….)

ASHLEY? …… landholder incentives schemes, biodiversity offsetting, local government biodiversity management plans, plans of management for reserves, timber harvesting plans, fire management plans, etc

- That "nationally important Koala habitats" be added to the list of conservation values assigned to the renowned forest gradient extending from the coastal plains and foothills at Coffs Harbour / Bongil Bongil National Park to the rugged forest landscapes of Guy Fawkes River National Park.

9. References

AMBS 2011. *Investigation of the Impact of Roads on Koalas*. Report prepared for the NSW Roads and Traffic Authority by Australian Museum Business Services, Sydney.

Banks, S.C. and Taylor, A.C. 2004. Genetic analyses in fauna conservation: issues and applications to Australian forests. Pp. 576-590 in D. Lunney, editor. Conservation of Australia's forest fauna. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.

Biolink (2012). *Byron Coast Koala Habitat Study*. Report to Byron Shire Council. Biolink, Ecological Consultants, Uki, NSW.

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

Cerese, B., 2012. *The Eucalypt Forests of Northeast New South Wales. A preliminary Assessment and Documentation of their World Heritage Values.* Report prepared for NSW National Parks Association, Sydney.

Clifton, I. D., Ellis, W. A. H., and Melzer, A. 2007. Water turnover and the northern range of the Koala (*Phascolarctos cinereus*). *Australian Mammalogy*, 29: 85-88.

Cork, S.J. and Sanson, G.D. 1990. Digestion and nutrition in the koala: a review. Pp. 129–144 in *Biology of the Koala*. Lee, A.K., Handasyde, K.A. and Sanson, G.D. (Eds). Surrey Beatty & Sons, Sydney.

Cork, S.J. and Braithewaite, L.W. 1996. Resource availability, eucalypt chemical defences, and habitat quality for leaf-eating marsupials. Pp. 9-16 in *Koalas, Research for Management* edited by G. Gordon. World Koala research Inc, Brisbane.

Department of Environment and Climate Change 2008. *Recovery plan for the koala (*Phascolarctos cinereus*).* Department of Environment and Climate Change NSW, Sydney.

Department of Environment and Resource Management (2009). *South East Queensland Koala Habitat Assessment and Mapping Project*. Brisbane.

Dique, D.S., Thompson, J., Preece, H.J., Penfold, G.C., de Villiers, D.L. and Leslie, R.S. 2003. Koala mortality on roads in south-east Queensland: the Koala speed-zone trial. *Wildlife Research*, 30: 419-426.

Dique, D., Preece, H., Thompson, J., and de Villiers, D. (2004). Determining the distribution and abundance of a regional koala population in South-East Queensland for conservation management. *Wildlife Research* **31**, 109-117.

Fisher, M., Body & Gill, J. 1996. The Vegetation of Coffs Harbour City Council LGA. A report to Coffs Harbour City Council, June 1996.

Gordon, G., McGeevy, D.G. and Lawrie, B. 1990. Koala populations in Queensland: major limiting factors. Pp. 85-95 in *Biology of the Koala*, edited by A.K. Lee, K.A. Handasyde and G.D. Sanson. Surrey Beatty and Sons, Sydney.

Hanski, I. 1999. Habitat connectivity, habitat continuity and metapopulations in dynamic landscapes. *Oikos* **87:** 209-219.

Hindell, M.A. and Lee, A.K. **1987**. Habitat use and tree preferences of Koalas in a mixed eucalypt forest. *Australian Wildlife Research* **14:** 349–60.

Hopkins, M. and Phillips, S. 2010. *Koala Habitat Assessment and Monitoring Program 2010.* Final report to Bluesfest Pty Ltd. Bioloink Ecological Consultants.

Lee, A. and Martin, R. 1988. *The Koala: A Natural History*. New South Wales University Press, Kensington.

Lee, T., Zenger, K.R., Close, R.L., Jones, M. and Phalen, D.N. 2010. Defining spatial genetic structure and management units for vulnerable koala (*Phascolarctos cinereus*) populations in the Sydney region, Australia. *Wildlife Research* **37:** 156-165.

Lindenmayer, D.B. and Franklin, J.F. 2002. *Conserving Forest Biodiversity: a comprehensive multi-scaled approach.* Island Press, Washington, USA.

Lindenmayer, D.B. and Fischer, J. 2006. *Habitat Fragmentation and Landscape Change; an Ecological and Conservation Synthesis*. CSIRO Publishing, Collingwood, Victoria.

Lunney, D., Moon, C., Matthews, A. and Turbill, J. 1999. *Coffs Harbour City Koala Plan of Management*. *Part A: The Plan*. NSW National Parks & Wildlife Service, Hurstville.

Lunney, D., Matthews, A., Moon, C. and Ferrier, S. 2000. Incorporating habitat mapping into practical koala conservation on private lands. *Conservation Biology* 14(3): 669–680

Lunney, D., Gresser, S., O'Neill, L.E., Matthews, A. and Rhodes, J. 2007. 'The impact of fire and dogs on koalas at Port Stephens, New South Wales, using population viability analysis'. *Pacific Conservation Biology* 13: 189-201.

McAlpine, C.A., Rhodes, J.R., Callaghan, J.G., Bowen, M.E, Lunney, D., Mitchell, D.L., Pullar, D.V. and Possingham, H.P. 2006. The importance of forest area and

configuration relative to local factors for conserving forest mammals: A case study of koalas in Queensland, Australia. *Biological Conservation*,132: 153-165.

Melzer, A., Carrick, F., Menkhorst, P., Lunney, D. and St. John, B. 2000. 'Overview, critical assessment, and conservation implications of koala distribution and abundance'. *Conservation Biology* 14(3): 619–628.

Moore, B.D. and Foley, W.J. 2000. A review of feeding and diet selection in koalas (*Phascolarctos cinereus*). *Australian Journal of Zoology* **48:** 317-333.

Moore, B. D., I. R. Wallis, K. J. Marsh, and W. J. Foley. 2004. The role of nutrition in the conservation of the marsupial folivores of eucalypt forests. Pages 549–575 in D. Lunney, editor. Conservation of Australia's forest fauna. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.

Minister for Sustainability, Environment, Water, Population and Communities (April 2012). *Approved Conservation Advice for* Phascolarctos cinereus *(combined populations of Queensland, New South Wales and the Australian Capital Territory) (koala Northern Designatable Unit)*. Canberra

NSW NPWS 1994. *Fauna of North-east NSW Forests.* North East Forests Biodiversity Study Report No. 3a. Unpublished Report, NSW National Parks and Wildlife Service, Hurstville, NSW.

NSW NPWS 1999. *Modeling areas of habitat significance for fauna and vascular flora in north east NSW*. Unpublished Report, NSW National Parks and Wildlife Service, Hurstville, NSW.

Palsbol, P.J., Berube, M. and Allendorf, F.W. 2007. Identification of management units using population genetic data. *Trends in Ecology and Evolution* **22:** 11-16.

Phillips S and Callaghan J. 2000. Tree species preferences of Koalas (*Phascolarctos cinereus*) in the Campbelltown area south-west of Sydney, New South Wales. *Wildlife Research*, 27(5): 509 – 516.

Phillips, S. and Callaghan, J. 2011. The Spot Assessment Technique: a tool for determining levels of localised habitat use by Koalas *Phascolarctos cinereus*. *Australian Zoologist.* 35(3): 774-780.

Phillips, S., Hopkins, M. and Shelton, M. 2011. Tweed Coast Koala Habitat Study. Unpublished report to Tweed Shire Council. Biolink Pty Ltd.

Reed, P.C. and Lunney, D. 1990. 'Habitat loss: the key problem for the long-term survival of koalas in New South Wales'. Pp. 9–31 in *Koala Summit: Managing Koalas in New South Wales*. Lunney, D., Urquhart, C.A. and Reed, P. (eds). NSW National Parks & Wildlife Service, Hurstville.

Rhodes, J.R., Wiegand, T., McAlpine, C.A., Callaghan, J., Lunney, D., Bowen, M. and Possingham, H.P. 2006. Modelling species' distributions to improve conservation in semiurban landscapes: Koala case study. *Conservation Biology*, 20: 449-459.

Seabrook, L., McAlpine, C., Baxter, G., Rhodes, J., Bradley, A. and Lunney, D., 2011. Drought-driven change in wildlife distribution and numbers: a case study of koalas in south west Queensland. *Wildlife Research* **38:** 509-524.

Sherwin, W.B., Timms, P., Wilcken, J. and Houlden, B. 2000. 'Analysis and conservation implications of koala genetics'. *Conservation Biology* 14(3): 639–649.

Smith, A.P and Andrews, S. 1997. *Koala Habitat, Abundance and Distribution in the Pine Creek Study Area. A Report to State Forests of NSW.* Austeco Environmental Consultants, Armidale.

Smith A.P. 2004. 'Koala conservation and habitat requirements in a timber production forest in north-east New South Wales'. Pp. 591–611 in *Conservation of Australia's Forest Fauna* (second ed.). Lunney, D. (ed). Royal Zoological Society of New South Wales, Mosman, NSW.

Threatened Species Scientific Committee 2012. *Advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee (the Committee) on Amendment to the list of Threatened Species under the* Environment Protection and Biodiversity Conservation Act 1999 *(EPBC Act).*

Ward, S.J and Close, R.L. 2004. Southern Sydney's urban Koalas: community research and education at Campbelltown. In Lunney, D. and Burgin, S. (Eds).*Urban Wildlife: More Than Meets the Eye,* pp. 44– 54. Royal Zoological Society of NSW, Mosman, NSW.

Wintle, B.A., Elith, R.J., Yamada, K. and Burgman, M.A. 2004. *Lower Hunter & Central Coast regional Biodiversity Conservation Strategy, Technical Report, LHCCREMS, fauna survey and mapping project, Module 2: Habitat modelling and conservation requirements.* Lower Hunter & Central Coast Regional Environmental Strategy, Callaghan, NSW.