



Office of
Environment
& Heritage

Document tendered by

MR JOHN TURBILL

Received by

ANDREW RATCHFORD

Date: 4 / 2 / 20

Resolved to publish Yes / No



Koala Habitat Study

Bellingen Shire Council Coastal Area

Report to Bellingen Shire Council

JUNE 2014

© Copyright State of NSW and Office of Environment and Heritage

The Office of Environment and Heritage (OEH) has compiled this report in good faith, exercising all due care and attention. No representation is made about the accuracy, completeness or suitability of the information in this publication for any particular purpose. OEH shall not be liable for any damage which may occur to any person or organisation taking action or not on the basis of this publication. Readers should seek appropriate advice when applying the information to their specific needs.

Published by:

Office of Environment and Heritage NSW

59 Goulburn Street, Sydney NSW 2000

PO Box A290, Sydney South NSW 1232

Phone: (02) 9995 5000 (switchboard)

Phone: 131 555 (environment information and publications requests)

Phone: 1300 361 967 (national parks, climate change and energy efficiency information, and publications requests)

Fax: (02) 9995 5999

TTY: (02) 9211 4723

Email: info@environment.nsw.gov.au

Website: www.environment.nsw.gov.au

Report pollution and environmental incidents

Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au

See also www.environment.nsw.gov.au

ISBN 978 1 XXXX XXX X

OEH 2014/XXXX

May 2014

Acknowledgements

This report was prepared by the NSW Office of Environment and Heritage for Bellingen Shire Council. Funding for this plan was provided by the NSW State Government 'Saving Our Species' Koala 'iconics':
<http://www.environment.nsw.gov.au/savingourspecies/iconic.htm>

NSW Office of Environment and Heritage contributors

Report, field surveys, data analysis and research	John Turbill
Field surveys and data management	Mark Fisher
GIS data analysis, habitat modelling and mapping specialist	Jill Smith
Bellingen Vegetation Mapping	Karen Caves
	Brendan Rennison
	Paul Sheringham
	Mark Cameron

Additional assistance during field surveys	Anni Blaxland Fuad, Shane Ruming, Dianne Brown, Adrian Deville and Mark Cameron
--	---

Additional assistance was provided during the field surveys by volunteers:

Erin Waller, Jack Nesbit and Sam Turbill

Dr. Stephen Phillips, Principle Ecologist, Biolink Ecological Consultants provided specialist assistance for the survey methodology, data and statistical analysis and mapping.

Table of Contents

Executive Summary	1
Part 1	2
1. Introduction	2
1.1 Description of the study area	2
1.2 History of the Study Area	3
1.3 Koala ecology	3
1.4 Statutory Context	5
Part 2	6
2. Historical koala records	6
2.1 Introduction	6
2.2 Records analysis	9
Extent of Occupancy	9
Area of Occupancy	9
Generational Persistence	10
2.3 Results	10
Extent of Occurrence	10
Area of Occupancy	10
Generational Persistence	11
2.4 Discussion	11
2.5 Koala records threats analysis	13
2.6 Key Findings	14
Part 3	16
3. Koala field surveys	16
3.1 Introduction	16
3.2 Survey Methods	16
3.3 Results	17
Koala site surveys	17

North of the Bellinger River	19
South of Bellinger River	19
Koala activity levels	21
Limitations during field surveys	21
3.4 Koala habitat mapping	22
Introduction	22
Preferred Koala Food Trees	23
Koala Habitat Mapping	25
3.5 <i>Discussion</i>	28
Koala habitat North and South of the Bellinger River	29
4. Threatening processes	30
Habitat loss, fragmentation and barriers to movement	30
Wild Fire	30
Summary of Wildfire in coastal Bellinger LGA	31
Road strike and mortalities	31
Dog harassment and attacks	32
Disease	32
Climate Change	33
5. Environment Protection and Biodiversity Conservation Act 1999	33
5.1 Important Population	33
5.2 Habitat critical for the survival of the species	34
6. Conclusion	35
7. Recommended Management Actions	36
8. References	37

FIGURES

Figure 1. Chronological distribution in ten year periods of koala records 1949 - 2013..... 7

Figure 2. Summary of strike rate result for tree species in active sites where P = strike rate and SE = standard error 24

TABLES

Table 1. Extent (ha) and Area of Occupancy (%) calculation for 1977 – 1994 and 1995 - 2013 10

Table 2. Number of koala reported to WIRES for Coffs Harbour region July 2005 – March 2013 13

Table 3. Number of koala reported to WIRES for Bellinger Area July 2005 – March 2013.. 14

Table 4. Categorisation of Koala activity into Low, Medium (normal) and High use. 17

Table 5. Summary of all tree species sampled, those with scats recorded, minimum and maximum tree diameter and average and trees that recorded individual koalas..... 18

Table 6. Summary of all sites north and south of the Bellinger River, activity levels, tree species with scats and their diameter at breast height and where koalas were observed 20

Table 7. Bellinger Rainfall Statistics for period 01/01/2013- 07/06/2013 22

Table 8. Summary of tree species recorded in active field sites where P = strike rate, n = number of trees, SE = standard error 23

Table 9. Rules for classification of vegetation communities into koala habitat ranking based partly on Appendix 3 of the NSW Koala Recovery Plan 2008 and Biolink (2012)..... 25

Table 10. Mapped koala habitat classes and % area of total mapped forest communities. 26

Table 11. Koala habitat mapping areas..... 27

MAPS

MAP 1 – Study Area

MAP 2 – Koala Records

MAP 3 – Extent of Occurrence

MAP 4 – Generational Persistence

MAP 5 – Field Survey Sites

MAP 6 – Koala Activity Levels

MAP 7 – Koala Habitat Map

MAP 8 – Wild Fire

MAP 9 – ‘Important’ Habitat

Executive Summary

The study area of this report comprises some 44,579ha generally east of Great Eastern Range out to the coastline. Within this area national parks and nature reserves comprise 3,730ha (8%), state forests 15,919ha (36%), Crown reserve or leasehold land 860ha (2%) and 24,071ha (54%) is privately owned lands. This study undertook an assessment of all available koala records across all land tenures, and undertook a systematic field-based assessment across all private lands.

This study aimed to examine the historic and recent koala distribution through an analysis of koala records in the NSW Wildlife Atlas and field based surveys. Some 878 koala records were used to analyse trends in distribution and persistence over time and 134 surveys sites were undertaken across the study area of which 38 sites recorded koala activity. An assessment of key threats on koalas in this area was also undertaken. The results, outcomes and recommendation of this study are intended to inform the preparation of a Comprehensive Koala Plan of Management for the coastal are of Bellingen Shire Council.

The Bellingen coastal area has had a long history of land clearing/ringbarking for agriculture and habitat disturbance through forestry, weed invasion and fire which has significantly altered the availability and quality of habitat available for koalas. This reduction and fragmentation of habitat likely peaked in the period from the late 1890's to the mid 1900's where koala abundance and distribution were probably at their lowest.

This study, however, found that koalas still persist in many forested areas and, in particular, the area north and north-east of Bellingen town and out to the coast. In this area there is recorded evidence of persistence over 6 koala generations or a period of 36 years. This finding is supported in both the analysis of koala records and the results of the field surveys.

Both the records analysis and the surveys, however, also showed a trend of decline in some areas both south and south-west of Bellingen township around Boggy Creek Road and Scotchman Range Road and in the coastal areas south of Urunga and in the Hungry Head and Wenonah Headland areas.

Records over the last three koala generations indicate a koala population persists in the Johnsens Road area west of Dorrigo.

South of the Bellinger and Kalang Rivers the koala records analysis and the surveys confirmed the presence of a widespread but low density koala population in what could be considered lower quality habitat.

In the south-east coastal part of the LGA, the analysis of koala records shows a historical and more recent small number of koalas persisting in the area of Ballards Road, Oyster Creek and North Valla, including the northern part of Jagun Nature Reserve and the eastern part of Little Newry State Forest. More research is required to determine the size and viability of the koala population in this area.

Observed occupancy rates calculated from the records analysis (30.65%) and the field surveys (28.36%) are below optimal level (50% per Phillips *et al* 2011) but are similar to those observed for other north coast studies (eg 28% in the Byron Coast Koala Habitat Study, Biolink 2011).

PART 1

1. Introduction

1.1 Description of the study area

The Bellingen Shire Council Local Government Area (LGA) is located on the mid-north coast region of NSW and encompasses a total area of 160,191ha of which 51,891ha (32%) comprises national parks and nature reserves, 34,163ha state forests (21%), 4,305ha Crown reserve or leasehold land (3%) and 69,832ha privately owned lands (44%). The LGA includes some 14kms of coast line and encompasses coastal floodplains, valley floors and coastal ranges in the east and the Great Eastern Range and Dorrigo Plateau in the west.

The study area of this report is shown in Map 1 and encompasses an area of 44,579ha generally east of Great Eastern Range out to the coastline. Within this area national parks and nature reserves comprise 3,730ha (8%), state forests 15,919ha (36%), Crown reserve or leasehold land 860ha (2%) and 24,071ha (54%) is privately owned lands. Whilst a number of earlier community-based studies (eg Lunney *et al* 2009 and a 1998 survey and data on the Atlas of NSW Wildlife) have been undertaken over private lands in the study area, this report details the results of the first systematic field-based assessment of koala distribution and numbers in the coastal part of the Bellingen LGA. Whilst this study undertook an assessment of all available koala records across all land tenures, the field-based assessment was limited to private lands.

Vegetation mapping undertaken by the Office of Environment and Heritage (OEH) Coffs Harbour (OEH 2013) for the study area shows that 13,388ha (30% of study area) of private lands remain vegetated. Cleared agricultural land within the study area comprises 10,683ha and primarily occurs along the Bellingen River valley and coastal floodplain and other associated valleys such as Hydes Creek, Never Never River, Kalang River and Thora River.

The study area (refer Map 1) adjoins significant areas of state forest and national park estate to the north and south. To the north Bongil Bongil National Park straddles the LGA boundary with Coffs Harbour City Council. The park, which originally when first dedicated in March 1995 comprised 1,447ha, was added to in 2003 by a transfer of some 2,786ha from Pine Creek State Forest bringing the total area to 4,233ha. This addition represented 81% of the mapped high quality koala habitat identified in the Pine Creek State Forest Koala Management Plan (Fisher & Murray 2000) and was added to the park to protect the significant koala population within this area. Pine Creek State Forest now comprises 3,104ha of which some 1,900ha is hardwood plantation comprising mainly flooded gum with some smaller areas of Blackbutt. To the north and west of Pine Creek is Tuckers Nob State Forest and Bindarri National Park.

To the south of the Bellinger River is Tarkeeth State Forest, Newry State Forest, Little Newry State Forest, Gladstone State Forest and Scotchman State Forest and Jaaningga and part of Jagun Nature Reserves. To the west of the study area is Dorrigo National Park and Bellinger River National Park.

Soils in the study area vary from alluvial floodplain soils of the Bellinger and Kalang River valleys to the less fertile soils on the mid-slopes, hills and ridges of the coastal range. Soils

are mudstone, shales and quartz gravels of the Permian age resulting in often shallow soils with quartz gravel occurring on or near the surface on upper-slopes and ridges. Valley floors and gullies generally have deeper more fertile soils as a result of alluvial deposits.

1.2 History of the Study Area

The Bellinger Valley was originally occupied by Kooris - the Gumbaynggir People - long before Europeans first arrived in 1840 looking for new valleys north of Kempsey to farm. Surveyor Clement Hodgkinson explored the valley and by 1842 there were cedar cutters at the mouth of the Bellinger River and sheep grazing in the valley. It is reported that the growth of cedar cutting in the valley was dramatic with 20 pit sawyers operating along the river by 1843 and, by 1849, the first timber vessel, the 'Minerva', being built by a shipwright named William Darbyshire. The cedar was hauled down to the river by teams of bullocks or horses. It was estimated that over 2 million feet of cedar was extracted each year from the valley.

The village of Bellingen was first designated in 1864 and by 1869 town allotments were being set aside and sold. At this time the Bellinger River was the main transport link for timber and trade between Bellingen and Sydney.

Cutting of red cedar and clearing of land for farming continued into the 1900's with dairying becoming a key landuse as red cedar became rare and harder to find. Whilst dairying still continues today, cattle grazing is the major landuse for most areas. Forestry has been a traditional industry in the valley both on private and public lands, although this has diminished in recent times.

Historically the impact on koala habitat in the Bellingen area can be directly linked to the clearing of the more fertile river flats, valley floors and coastal plains for agriculture. Additionally, logging was a widespread practice which was mostly unregulated and the removal of koala food trees would have had a significant impact. Over time this displaced koalas from many of their traditional key areas of habitat leaving the steeper and often less fertile mid slopes and hills as remaining refuge. Whilst in many areas of New South Wales (NSW) and Queensland (Qld) in the late 1890's and early 1900's widespread hunting of koalas for pelts was undertaken for export to England, anecdotal evidence suggests that this practice hunting koalas for export of pelts was not common in the Bellingen area.

Rural landuse in the study area is now a mix of traditional and non-traditional farming including many rural lifestyle allotments. Private Native Forestry remains a component of farm landuse and income for some landholders.

1.3 Koala ecology

The koala is considered an 'iconic' Australian species, a unique part of Australia's native wildlife with international significance. The koalas distribution originally ranged from the south-east corner of South Australia to the north coast of Qld and west into central Qld and NSW. However the distribution of koalas has now declined significantly and populations are now scattered, often at low densities across a greatly reduced range and in some areas,

particularly in Qld and NSW, population declines of up to 80% and even local extinctions have been documented (Senate Report 2011).

Koalas are known to feed mainly on a select number of eucalypt species in any one area. As the leaves of eucalypts are high in fibre but low in nutrients and protein (Ellis *et al* 1995) koala behaviour usually involves resting or sleeping for most of the day and part of the night with feeding often only occurring for periods of two to four hours. As koalas have a low metabolic rate their behaviour of resting and sleeping is an adaptation used to conserve energy (Cork *et al* 2000).

Females koalas start to breed at about two years of age and potentially can produce up to one joey a year. Births occur in spring and summer. Males do not become sexually mature until about three years of age (Gall 1980) and the ratio of males to females in a koala population is usually dominated by females. A dominant “alpha” male will mate with several females (Gall 1980) however, other roaming male koalas can also mate with a number of females in any population (Ellis *et al* 2002b). Koalas in the wild may live up to about 12 years of age but this may be shorter depending on the presence of disease and other threats.

Young koalas usually disperse from their mothers home ranges when they are between one and a half to three years of age (Dique *et al* 2003a). Dispersal of young animals occurs during the early part of the breeding season (McLean and Handasyde 2006) and young animals may travel many kilometres in search of suitable unoccupied habitat. These dispersing animals, spending longer periods on the ground, are often subject to increased threats from car strike and predation.

Adult koalas generally occupy a home range which can vary in size depending on habitat quality. In the Bonville area (now part of Bongil Bongil National Park) home range sizes for koalas within the locality of the Pacific Highway upgrade were found to vary in size from 15.7ha for females and 30.6ha for males with the largest home range for two individual animals being 53.6ha and 69.7ha (AMBS 2011). Smith and Andrews (1997) in a study of the former Pine Creek State Forest recorded an average koala density across all forest types including plantations of one koala per 15ha. This equated to one koala per 73ha in plantation habitat, one koala per 14ha in medium density habitat and one koala per 12ha in high density habitat.

Koalas rely primarily on the moisture within the leaves they eat for daily water intake, however there is some evidence (for example Ellis *et al* 1995) that koalas may move into areas of higher soil moisture and microclimate such as gullies and drainage lines in times of higher temperatures and drought, where trees with a higher leaf moisture can be accessed. The reliance by koalas on a select number of species and individual trees within their home range for foraging is not only linked to leaf moisture but also to the levels of formyl phloroglucinol and phenolic compounds within leaves making many trees unpalatable (DECC 2008). Tree usage by koalas is also compounded by the fact that koalas may use other non-feed trees (including non-eucalypts) for incidental browsing, resting or sheltering in during cold weather or hot days. They therefore require a range of both food and non-food (shelter) trees in their habitat to cater for different seasons and weather extremes and for thermoregulation (Crowther *et al* 2013)

Koala populations within NSW carry the pathogens *Chlamydia* spp. the clinical signs of which are wet bottom (urogenital tract infection) and conjunctivitis. These signs are not always apparent or obvious in animals sighted in the wild. Chlamydia infection is often exacerbated when animals are exposed to higher levels of stress associated with habitat disturbance, increased exposure to predators or extremes in environmental attributes such as heat waves and drought. Koalas suffering from chlamydia can become weakened and subject to increased levels of threats, and in severe cases, may have reduced fertility or become infertile (DECC 2008). Observation of animals in the Bellingen area indicate that chlamydia is present in the population with numbers of animals reported with wet bottom and conjunctivitis. Records for WIRES Bellingen koala rescues over the last eight years show that out of 66 rescues 16 were for chlamydia with eight euthanised.

1.4 Statutory Context

The koala is listed as a 'Vulnerable' species under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (listed as the combined populations of Queensland, New South Wales and the Australian Capital Territory).

Additionally, through the *Environmental Planning and Assessment Act 1979* (EPA Act) the koala is subject to the provisions of State Environmental Planning Policy No 44 – Koala Habitat Protection (SEPP 44). The aim of SEPP 44 is *'to encourage the proper conservation and management of naturally vegetated areas that provide habitat for koalas to ensure a permanent free-ranging population over their present range and reverse the present trend of koala population decline:*

- a. *by requiring the preparation of plans of management before development consent can be granted in relation to areas of core koala habitat; and*
- b. *by encouraging the identification of areas of core koala habitat; and*
- c. *by encouraging the inclusion of areas of core koala habitat in environmental protection zones.*

Core koala habitat is defined in SEPP 44 as:

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

Under the above legislation, there is a statutory responsibility on council's as the consent authority for development activities within the LGA to fully consider the likely impacts on koalas and their habitat from any proposed developments.

The *Native Vegetation Act 2003* (NV Act) regulates the clearing of native vegetation on private land. The Act permits minimal removal of native vegetation for the purposes of Routine Agricultural Management Activities (RAMAs). Clearing other than that permitted under a RAMA requires a Property Vegetation Plan (PVP) to be approved for that property. Private Native Forestry (PNF) is also regulated through the NV Act and requires the approval

of a PVP for the property. Where a PVP is approved, PNF can be undertaken in accordance with the PNF Code of Practice. PNF however is not permitted in any area identified as 'core koala habitat' within the meaning of SEPP 44.

The *Companion Animals Act 1998* (CA Act) requires for the proper management of dogs to ensure they are under the control of a competent person when in public places, and that dogs must not be allowed to roam or attack other people, animals and wildlife. The Act provides for the preparation of a Local Companion Animals Management Plan which enables council to fulfil its responsibilities by determining appropriate rules for dog ownership and areas for dog release, exercise and exclusion.

PART 2

2. Historical koala records

2.1 Introduction

The koala is an 'iconic' species and as a result of its higher public profile and its easier identification than for many other animals, reporting of koalas across the landscape in any area is usually much higher than for any other threatened species. Additionally, two community based surveys have been undertaken where Bellingen LGA was included as part of the study (Lunney *et al* 2009, Lunney *et al* 2011 unpublished; and a Bellingen survey in 1998, with the data on the NSW Wildlife Atlas). Records, while providing an important indication of where koalas occur across the landscape, tend to be biased towards areas of higher human population. Lunney *et al* (2009) found in the results of a NSW community-based study that most sightings (records) were within 2.5km of the reporter's home and that few records were more than 10km from a dwelling. This infers that in more rural agricultural areas, properties of 40ha or larger, that reporting rates for koalas is likely to be lower or scarce across these areas. Koalas in these areas of larger rural lots can therefore go unreported and infer a false negative (i.e. no animals reported when in fact they occur).

Historical koala records for the Bellingen LGA were collated primarily from OEH's NSW Wildlife Atlas. A total of 1216 koala records were collated for the LGA dating from the period 1949 to 2013. After removing duplicate and unreliable records a total of 878 records were used in the analysis. The chronological distribution in ten year periods for all 1216 records is shown in Figure 1 below.

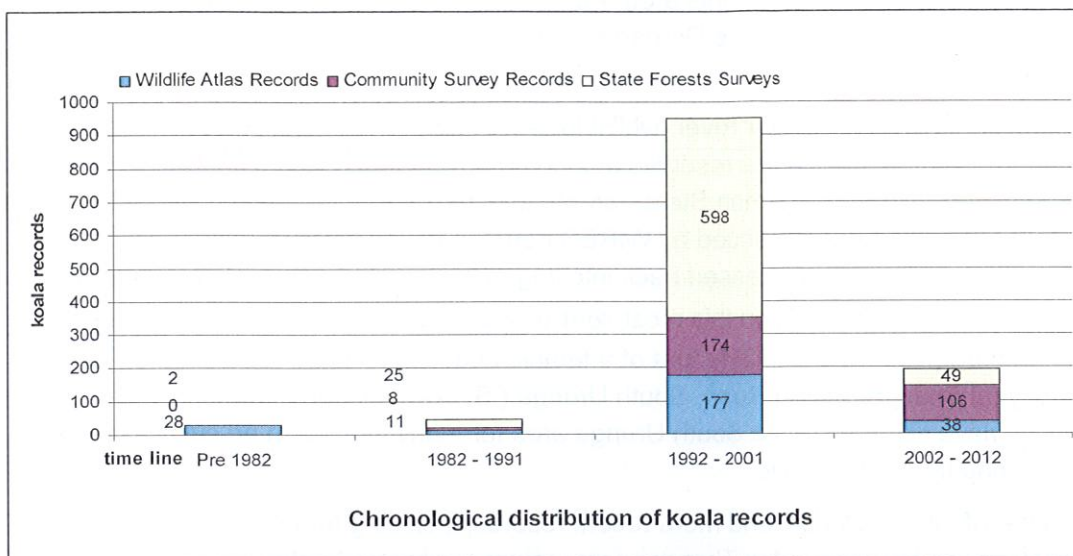


Figure 1. Chronological distribution in ten year periods of koala records 1949 - 2013

The chronological distribution shows that predominantly the bulk of records (949 records) occurs in the 1992 – 2001 time period as a result of the community based surveys and fauna surveys undertaken in state forest estate as part of the regional forestry agreements.

The spatial distribution across the LGA of all koala records is shown in Map 2. The majority of records occur in the eastern part of the LGA and in particular the north eastern area, north of the Bellinger River. A large percentage of these records as shown in Map 2 occur in Pine Creek State Forest or Bongil Bongil National Park (formerly Pine Creek State Forest). A number of records also occur on the plateau in the far north of the LGA, primarily in Cascade National Park and State Conservation Area and in Wild Cattle Creek State Forest.

Whilst koala records on the Dorrigo Plateau are lower than in other areas, given the more cleared agricultural landscape and larger rural properties, there are clusters of records in some forested areas such as in the Upper Murray River Valley. Sightings at the end of Johnsens Road in August this year and in previous years (Martin Smith OEH pers.comm.) indicates that there is likely an active and possibly expanding high altitude koala population associated with the Sydney Blue Gum / Dorrigo White Gum / Tallowwood forest community in this area west of Dorrigo.



Photo 1 – Koala Johnsens Road, West Dorrigo August 2013 (Photo: M. Smith)

Another recent record for the east Dorrigo area was located at the eastern end of Slingsby Road, just within the Dorrigo National Park (S. Ruming OEH pers.comm.). Together with a record of scats in this vicinity in 2012, and more historically in 1973 and 1994, is indicative of

a koala population persisting in this area. Additionally, a record of a koala crossing the Waterfall Way near the top of the Dorrigo mountain was recently reported by a community member.

Records south of the Bellinger River, whilst lower in number, are widespread across a number of state forests, nature reserves and some private lands including Gladstone, Tarkeeth, Newry and Scotchman State Forests and Jaanningga and Jagun Nature Reserves. A recent record of a koala rescued by WIRES from the beach north of Valla (Elizabeth Mulligan pers comm.) and released back into Jagun Nature Reserve, confirms that a small number of koalas still persist in this most southern part of the LGA. Another significant recent record (December 2013) is that of a female and joey in the area east of the Pacific Highway off Snapper Beach Road, South Urunga (S. Townley pers. comm.). No koala sightings have occurred in the South Urunga area for many years and no evidence was found during the field surveys.

A number of other historical and more recent records, including females with joeys, in the North Bellingen township (Max Thrower pers. comm.) indicates koalas regularly reside in and/or move through the urban area utilising street and backyard trees and/or council reserves. Two koalas were observed in the council reserve between Sunset Ridge Drive and Kenny Close at North Bellingen in late September 2012 (Daan Schiebaan pers. comm.) and another koala was sighted in a Swamp Mahogany tree during the field work in the reserve off Tamarind Drive on the 17 January 2013. Further more, a koala with a back young was reported in the North Bellingen area in a letter to the editor of the Bellingen Courier Sun newspaper on 21 August 2013 by local resident Trevor Pike. A further record was reported in July this year by local resident Max Thrower of a female koala in Lyon Street which paused at some recently disturbed clay and proceeded to eat some of the soil.



Photo 2 – Koala rescued from Valla Beach 3 June 2013 and Koala eating dirt Lyon Road, North Bellingen 24 July 2013 (Photo: Elizabeth Mulligan and Max Thrower)

Another recent record was noted by a local resident south of the Bellinger River, where two koalas, a female and male, were observed in a Tallowwood tree near the Trig Station at

Mount Lookout on Fernmount Range Trail. The male showed signs of chlamydia infection with severely infected eyes. Additionally, koala scats were found along the forested trail out to the Council water reservoir south-west of Short Cut Road at Raleigh in May 2013 (John Pile pers. comm.).

A koala was also recently observed on Boggy Creek Road near the turn off to the Boggy Creek Nursery (J. Muldoon pers. comm.) which is a significant record given the lack of sightings over the last decade or more in this areas and the nil activity recorded during this survey.

2.2 Records analysis

Using the koala records collated for the Bellingen LGA, an analysis to determine broad trends over time of the geographical distribution of koalas was undertaken. The aim of this analysis was to show both the historical and more recent population centres and distribution and to indicate any regional spatial and temporal population trends

After a vetting process to remove duplicate and unreliable records, 878 records were deemed appropriate for further analysis. These records were then sorted into chronological order and assigned to the last 6 koala generational periods from 1977 to 2013 (a koala generation being defined as a period of six years (Phillips 2000a). The six generational periods were then split to the two periods of three koala generations of 1977 – 1994 and 1995 – 2013. This is in line with the International Union for Conservation of Nature (IUCN) criteria for assessing perceived population declines over a time period of three generations (IUCN SPS, 2010). Records split for these two period were 286 for 1977 – 1994 and 592 for the later three generations 1995 – 2013.

Based on a GIS analysis methodology developed by Dr. Steve Phillips of Biolink Ecological Consultants Uki, two key measures of spatial distribution over time were determined to represent “*extent of occurrence*” (EoO) and “*area of occupancy*” (AoO) for koala distribution in the LGA. These measures provide an indication at the LGA scale of any broad changes in distribution between the historic distribution of records and the more recent last three koala generations.

Extent of Occupancy

The historical EoO represents the boundary extent of those koala records prior to 1995 enclosed by a Minimum Convex Polygon (MCP) which was mapped spatially by connecting the outer-most koala records for the LGA. This area was then compared to the EoO mapped for the records for the last three koala generations 1995 – 2013. This comparison allows any broad regional changes in the extent of koala distribution over these time periods to be compared spatially.

Area of Occupancy

The AoO was determined over the LGA for the two periods 1977 – 1994 and 1995 – 2013. This was determined by using a 2.5km by 2.5km grid overlay representing a sampling cell area of 625ha. For the historical period 1977 – 1994 all 286 records were used to determine each cell across the LGA where at least one koala record occurred.

To determine AoO for the last three koala generations the total available records for that period of 592 had to be firstly reduced to the same number as the previous pre 1994 period (ie 286). To ensure that an equitable area comparison could be made for these two periods 286 records were randomly selected from the 1995 – 2013 dataset by running ten random samples of fifty percent of the grid cells with records. The AoO was calculated based on the number of grid cells occupied by at least one koala record

Generational Persistence

Generational persistence uses the concept of determining grid cells based on the same grid size as used above where records for all three koala generations in that period are represented. Thus for the two time periods cells were identified where repeated koala records for all generational time spans between 1977 – 1994 and 1995 – 2013 were present. This allows comparison of likely key source koala population areas that have persisted over either historically three generations pre 1994 or, more recently, six generational periods 1977 – 2013 indicating long time persistence. Comparison of the cells for these periods indicates both key areas of continual occupation by koalas and as well provides a regional indication of distributional expansion and contraction.

2.3 Results

Koala records in the Bellingen LGA, whilst widely distributed, are concentrated in the far north in the areas of Cascade National Park and Wild Cattle Creek State Forest, the south east in the West Valla and Newry, Tarkeeth and Gladstone State Forests and Jaaningga Nature Reserve areas and in the area from Bellingen both north and east to the coast where the vast majority of records occur.

Extent of Occurrence

The EoO mapped within the Minimum Convex Polygon's for the pre 1995 period was 129,161ha and for 1995 – 2013 period was 147,940ha (refer to Table 1). For the majority of the LGA, with the exception of the far western boundary, the historical extent of occupancy and the more recent extent have not changed indicating that over the majority of the LGA koala distributional extent is unaltered over at least the last 6 koala generations (the western expansion of the post 1995 extent is based on three additional koala records in that area).

Area of Occupancy

The calculations for AoO shown in Table 1 below indicate a trend of decline in the period of the last three koala generations in comparison to that of the pre 1994 period ($t = ??$ $P > 0.05$). This trend is demonstrated in the absence of continuous koala records in the last three koala generations in the areas to the west and south of Bellingen and in the South Urunga – Hungry Head areas.

Period	EoO (ha)	AoO (%)
1977 - 1995	129,161ha	34.87 ± 2.18
1995 - 2013	147,940ha	30.65 ± 1.58

Table 1. Extent (ha) and Area of Occupancy (%) calculation for 1977 – 1994 and 1995 - 2013

Generational Persistence

In the historical time period 1977 – 1994, some 31 cells were identified where koala records over the three koala generations pre 1994 occurred, highlighting areas of recorded continual koala activity. Four of these cells occurred in the far northern section of the LGA in the areas of Cascade National Park and Wild Cattle Creek State Forest. One cell occurred in the far south-east of the LGA in the south Urunga – Hungry Head area with the majority of the cells occurring in the north east part of the LGA from just west of Bellingen township to the coast at North Beach – Mylestom (refer Map 4).

For the post 1995 period of three koala generations, 38 cells were identified comprising the same four cells in the far northern section of the LGA, two new cells in the far south-east West Valla and Newry State Forest area, two new cells in the Johnsens Road area of West Dorrigo and a majority of the same cells identified in the north east part of the LGA (refer Map 4).

2.4 Discussion

The historical assessment of koala records for Bellingen is intended to indicate spatially, at the LGA scale, koala distribution areas and source populations and suggest any overall trends in population patterns. As in other areas of the north coast, the number and locations of koala records for the LGA may be influenced by the location and concentration of the human population, with records often biased towards more populated areas where properties are smaller. Lunney *et al* 2009, in their study of community-based records found that reports of koalas more than 10km from a dwelling were relatively scarce. As a result false negatives may influence results particularly in less populated areas and this needs to be considered in interpreting the results of the spatial analysis of the available records.

The assessment of the records over the LGA into six historical generations for the period of 36 years from 1977 – 2013 supports the anecdotal evidence that koalas have a long history of occupation in many parts of the Bellingen area. However, the settlement, logging and clearing (ringbarking) of the most productive and fertile lands for agriculture including dairy farming from the mid to late 1800's to the 1940 and 50's is likely to have had a significant impact on what was the highest quality koala habitat. This may have lead to a 'bottleneck' for koalas in some areas during this extended period of clearing over a number of decades where the population suffered a marked decline. As a result of the areas of habitat that were removed over numbers of decades, the reestablishment of koalas in some areas of post 1940 and 50's regrowth forest is low or non existent. This is supported by the field surveys which recorded in many areas early mature to mature forests reportedly regrown from this earlier clearing event.

The assessment of the records over the LGA for the period of 36 years from 1977 – 2013 were categorised into six historical generations. This data supports the anecdotal evidence that koalas have a long history of occupation in many parts of the Bellingen area. However, settlement resulted in the logging and clearing (ringbarking) of the most productive and fertile lands from the mid to late 1800's to the 1940 and 50's. This intense period of landuse would have had a significant impact on what was the highest quality koala habitat and impacted on local koala populations and presented a significant barrier to movement over a number of decades. The reestablishment of koalas in post 1940 and 50's early mature to

mature forests has been low or non-existent in some areas. This is supported by the results of the records analysis and field surveys.

The Generational Persistence Analysis (GPA) undertaken for the LGA indicates areas where koalas have persisted over the last 36 years (refer Map 4). It is significant to note the major difference in historical records and koala occupation density between the areas north and south of the Bellinger River. Whilst numbers of records exist in the area south of the Bellinger River, the GPA indicates that, whilst widespread, reporting of koalas across this area is relatively low and inconsistent. This indicates the persistence of a widely dispersed and likely lower density population surviving on what is considered lower quality habitat. This finding is supported by the field surveys for the area south of the river (refer to section B).

The calculations for Area of Occupancy (AoO) over the LGA indicates a trend of decline in some areas over the period of the last three koala generations in comparison to that of the pre 1994 period. This trend is demonstrated in the absence of continuous koala records in the last three koala generations in the areas to the west and south of Bellingen and in the South Urunga – Hungry Head areas.

The contraction in range in the South Urunga – Hungry Head area confirms residents' comments during this survey and a previous survey of this area in 1992 where it was noted in the fauna and flora study of the South Urunga Development Area that *"many suitable koala food trees occur here, however no koalas were located during the fieldwork.....there absence is somewhat problematic as they have been reliably reported at the site in past years"* (Clancy and Turbill 1992). The observation at this time was that the frequency of fires, combined with the combination of cars and dogs, may have impacted on koalas in this area. The recent record of a female with joey in the area between the Pacific Highway and Osprey Drive, near Wenonah Head is significant and provides evidence that a small population may still be residing in this area. Further investigation of the area is required to determine the extent and viability of koalas in this south eastern area of the LGA.

Another area of contraction in the last three koala generations is in the area west and south-west of Bellingen around Boggy Creek Road and Scotchman Range Road. This supports landholder reports during the fieldwork in this area that koalas have not been heard or sighted for some 15 – 20 years. Although a recent reporting of koala on Boggy Creek Road near the driveway to the Boggy Creek Nursery is evidence that some individual animals may still persist or move through this area. The reasons for this absence or low number of koalas in these areas is not fully understood and requires further investigation.

A significant outcome of the records analysis is the confirmation of a significant and important koala population in the area both north and north-east of Bellingen out to the coast at Repton. This is demonstrated in the GPA which shows a large cluster of cells for this area where koalas have persisted for at least the last 36 years. This supports the findings of previous koala studies in the north-east part of the Bellingen LGA undertaken in the Pine Creek State Forest and Bongil Bongil National Park where a significant koala population has been identified. (Smith and Andrews 1997, AMBS 2011). In their study of the former 6010ha area of Pine Creek State Forest in 1997, Smith and Andrews estimated the koala population to be 350 – 450 animals (see also Andrews 2004 in *The Conservation of Australia's Forest Fauna* (2nd edition), edited by D. Lunney, Royal Zoological Society of NSW, Mosman NSW).

The GPA also highlights the persistence of an important koala population in the far north-west of the LGA, primarily in the public lands of Cascade National Park and State Conservation Area and in Wild Cattle Creek State Forest. Additionally, whilst only a few records occur in the general Dorriggo Plateau area, a cluster of records over the last three koala generation indicates an important population of animals in the forested valleys and foothills in the Johnsens Road area. Whilst records in the southern parts of the LGA south of the Kalang River are fewer, clusters of records across Gladstone and Tarkeeth state forests and some private lands south of the Bellinger River, indicate persistence of a population in this area over at least three koala generations.

2.5 Koala records threats analysis

An assessment of the threats to koalas within the study area was undertaken based on the records of koalas taken into care by WIRES and by assessing koala road kill records for the major roads.

Koalas can be subject to a number of threats including habitat loss and disturbance, disease such as *Chlamydia*, road strike by vehicles, fire and dog attack. Records for koala admittances into WIRES and other carer groups such as the Friends of the Koala, Lismore and the Koala Hospital at Port Macquarie show that in many areas these impacts can be significant on local koala populations. For example, for the 2010 – 2011 year in the Lismore area there were 306 koalas admitted with 220 mortalities which included 131 with disease, 32 road strike, 17 dog attack and 40 classed as other causes.

Local WIRES koala records have been recently collated by Chris Moon as part of a project to review koala population trends in the Coffs Harbour LGA since their Comprehensive Koala Plan of Management was approved in 2000. For the Coffs Harbour and surrounding area including Raleigh, Valery, Bellingen, Dorriggo Plateau and Nambucca Shire areas a total of 893 cases were reported to WIRES over the period July 2005 to March 2013. A breakdown of these records is shown in Table 2 below.

Reason for Reporting	Number of animals & % of total
Road strike	104 (11.6%)
Sick / health issue	171 (19.1%)
Dog attack	15 (1.7%)
Koala in unsafe place	230 (25.8%)
Enquiry about koala welfare	290 (32.4%)
Other	93 (9.3%)
Total	893

Table 2. Number of koala reported to WIRES for Coffs Harbour region July 2005 – March 2013

A total of 201 of those animals were dead of which 89 were euthanased by a Vet after examination.

A further breakdown in Table 3 below shows those records for the Bellingen LGA area that were reported to WIRES.

Locality	Road	Sick	Dog	Unsafe	Enquiry	Other	Total
Raleigh/Valery	2	16	0	9	11	7	45
Bellingen Area	2	18	0	12	19	15	66
Dorrigo Plateau	0	2	0	1	1	1	5

Table 3. Number of koala reported to WIRES for Bellingen Area July 2005 – March 2013

Records for both the wider Coffs Harbour area and for the Bellingen area indicate that koala health issues are significantly higher than any other reported threats with car strike the second highest. A large percentage of these animals were either dead or euthanased. In the Bellingen area there were no reported dog attacks and road strike was low in comparison to Coffs Harbour. The WIRES figures for Bellingen did not include the road strike numbers for that part of the Pacific Highway (now upgraded to a motorway and fenced) within and just north of the Bellingen LGA boundary within Bongil Bongil National Park.

An investigation of the road mortality prior to and during the highway upgrade in this section of the Pacific Highway (AMBS 2011) reported 65 koala road mortalities from 2000 to 2010. The highest for a particular year was 13 in 2000 and lowest was zero in 2010 (as fauna fencing had been installed). As reported in other areas of the north coast, road strike peaked during the breeding season from August to November with the mean number of deaths in October (AMBS 2011).

Only three other road strike records exist in the Bellingen LGA and these are all on the Pacific Highway in the southern part of the LGA. One record was situated about 300m north of Schnapper Beach Road in 2005, and two records were at North Valla near the southern boundary of the LGA in 2007 and 2009. No road strike records exist on the data base for Waterfall Way from the Pacific Highway turn off to Thora or on any other minor roads.

2.6 Key Findings

- 1216 koala records were collated for the Bellingen LGA of which 878 were deemed suitable for further analysis.
- Koala records were sorted into chronological order and assigned to the last 6 koala generational periods from 1977 – 2013. Records were then split for the two periods 1977 – 1994 (286 records) and 1995 – 2013 (592 records).
- The Extent of Occurrence, the area enclosed by all records for the two different periods 1977 – 1994 and 1995 – 2013, is not significantly different.
- The Extent of Occupancy however, for the two generational periods, indicates that there has been a decline in some areas previously occupied by koalas and this is demonstrated in the lack of activity in the areas west and south of Bellingen and in the South Urunga – Hungry Head areas.

- Generational Persistence grid cells indicate that in a number of areas koala activity has been continuously recorded for 6 koala generations. These key areas are in the far north of the LGA (Cascade National Park and Wild Cattle State Forest area) and a majority of cells in the north east part of the LGA from just north - west of Bellingen township to the coast north of the Bellinger River.
- The records analysis indicates contractions in range in the South Urunga – Hungry Head area and in the area west and south-west of Bellingen around Boggy Creek Road and Scotchman Range Road.
- Koala records south of the Bellinger River are much lower indicating the persistence of a widely dispersed and likely lower density population in this area.
- Recent records north of Valla indicate a small population continuing in this area which links with Newry State Forest. The status of this population requires further research.
- Records over the last three koala generations indicate a koala population persists in the Johnsens Road area west of Dorrigo.

PART 3

3. Koala field surveys

3.1 Introduction

A field based systematic koala survey was undertaken to sample the forested private tenure lands in the study area to supplement the historical koala records analysis and inform landscape scale koala population distribution. The survey method used was a Regularised, Grid-based Spot Assessment Technique (RG-bSAT) based on the methods developed by Phillips and Callaghan (2011) and used in a number of other north coast koala surveys for local government areas including parts or all of the Tweed, Byron, Ballina, Coffs Harbour, Kempsey and Hastings / Port Macquarie areas (Phillips and Hobkins 2010a; 2010b).

The field surveys were based on a survey grid pattern across the forested parts of the study area to specifically determine as best as possible:

- a field based estimate of the Extent of Occurrence and Area of Occupancy within the study area,
- preferred tree usage and preferences of koalas,
- the areas occupied by a koalas, and
- where possible, an estimate of population size.

3.2 Survey Methods

Field survey effort for the study area was varied north and south of the Kalang and Bellinger Rivers based on the number of historic koala records for these areas. North of the Bellinger River a survey grid pattern of 500m was placed over all forested lands and survey sites determined where these grid points intersected with forested areas likely to be koala habitat based on ADS 40 Aerial Photography. For areas south of the Bellinger River, a 1km grid was used to determine survey sites. Using this method some 150 survey sites were identified across the whole study area. Survey sites were excluded where vegetation at the site was deemed unsuitable, or where lands were inaccessible or too difficult to survey (ie steep, weed infected or heavily disturbed). Surveys commenced in early December 2012 and finished in late June 2013. During this time 134 out of the potential 150 sites were surveyed.

Survey sites were located in the field using a GPS and in some cases were moved to within 50m, and in a few cases 100m, of the grid point if the proposed point was disturbed or not accessible and the adjoining area was deemed to be more suitable.

At each survey site between 25 – 30 trees greater than 15cm dbh were sampled for the presence of koala faecal pellets (scats) and the presence of a koala in the tree. For details on the survey sampling method refer to the Spot Assessment Technique (SAT) (Phillips and Callaghan 2011). At each site the closest 25 trees above 15cm dbh (excluding understorey trees such as acacias and other shrubs) were searched for koala scats primarily within 1m of the base of the tree. Searching involved scanning the surface of the ground litter for scats before then searching in and under the leaf litter for a minimum of 2 person minutes per

tree. Additionally, a search for a koala in all trees within a 25m radius of the centre starting point tree was undertaken. If a koala scat was recorded under any of the 25 trees then a further 5 trees were searched and a 1ha transect search was undertaken for any koalas within a 40m by 250m long transect. The objective of the 25m radius and transect search was to enable area-based koala density estimates to be derived.

At each site koala activity was determined by dividing the number of trees which had a koala scat underneath the tree by the total number of trees searched at the site (i.e. 30).

For analysis of koala usage and activity the Bellinger River was used to separate the north and south parts of the study. Activity levels for north of the river were in the category of 'East Coast (med – high)' - 'Low Use' and 'Medium (normal) Use' for south of the river 'East Coast (low)' – 'Medium (normal) Use' for population density activity thresholds in accordance with threshold percentages derived by Phillips and Callaghan (2011). These activity are shown in Table 4 below.

Activity category	Low use	Medium (normal) use	High use
Area (density)			
East Coast (low)	-	≥ 3.33% but ≤ 12.59%	> 12.59%
East Coast (med – high)	< 22.52%	≥ 22.52% but ≤ 32.84%	> 32.84%
Western Plains (med – high)	< 35.84%	≥ 35.84% but ≤ 46.72%	> 46.72%

Table 4. Categorisation of Koala activity into Low, Medium (normal) and High use.
Categories based on use of mean activity level \pm 99% confidence intervals (nearest percentage equivalents) for each of three area/population density categories. (Source: Phillips and Callaghan 2011).

Based on the activity levels for each active site (refer to Table 6), activity levels were separated into three categories as follows 3.33% to < 6.66%, > 6.66% to < 10% and > 10%. These categories are shown in Map 6 and spatially delineate important areas that support resident koala populations. The delineation of activity levels from the field surveys matches favourably with the analysis of koala records and the generational persistence cells derived for the last 6 koala generations.

Population estimates were derived for these koala activity contour mapped areas by using the numbers of koala sighted during the field surveys within the 25m radial and one hectare transect searches taking into account available habitat.

3.3 Results

Koala site surveys

One hundred and thirty four sites (134) were surveyed over the period between mid - December 2012 and late June 2013. A total of 3,541 trees were sampled with 105 individual trees recording one or more scats. Additionally, a koala was observed in a tree at eight survey sites, five koalas being sighted during searches within the 25m radius of the survey point and three koalas observed during the one hectare transects. Table 5 below provides a summary of all tree species sampled, those with scats recorded, minimum and maximum tree diameter and average and indicates trees that recorded individual koalas.

Summary of tree species all field sites						
Tree Species	No of trees sampled	Trees with scats	Tree dia min & max (cm)	Tree dia average (cm)	Koala sighted in SAT Transect	
<i>Acmena Smithii</i>	13		22 - 48	30		
<i>Allocasuarina torulosa</i>	221	2	12 - 66	27		
<i>Angophora costata</i>	23		20 - 59	29		
<i>Banksia integrifolia</i>	3		22 - 28	25		
<i>Callistemon salignus</i>	8		25 - 64	33		
<i>Camphor Laurel</i>	34	1	17 - 82	33		
<i>Casuarina glauca</i>	2		36 - 52	44		
<i>Corymbia gummifera</i>	4		16 - 43	28		
<i>Corymbia intermedia</i>	370	2	15 - 105	36		
<i>Eucalyptus acmenoides</i>	199	3	15 - 137	42		
<i>Eucalyptus ancophila</i>	7		35 - 50	42		
<i>Eucalyptus grandis</i>	183		16 - 85	38	1	
<i>Eucalyptus microcorys</i>	1014	69	15 - 320	41	3	2
<i>Eucalyptus paniculata</i>	2		38 - 62	50		
<i>Eucalyptus pilularis</i>	208		15 - 118	44		
<i>Eucalyptus planchoniana</i>	1		28	28		
<i>Eucalyptus propinqua</i>	231	18	16 - 106	36	1	
<i>Eucalyptus resinifera</i>	42		21 - 104	43		
<i>Eucalyptus robusta</i>	63	1	18 - 95	45		
<i>Eucalyptus saligna</i>	157	3	15 - 125	42		
<i>Eucalyptus siderophloia</i>	180	2	15 - 77	35		
<i>Eucalyptus tereticornis</i>	28		17 - 79	34		
<i>Eucalyptus umbra</i>	2		24 - 28	26		
<i>Ironbark sp</i>	2		40 - 75	57		
<i>Lophostemon confertus</i>	106		15 - 78	34		
<i>Lophostemon suaveolens</i>	12		23 - 58	34		
<i>Melaleuca quinquenervia</i>	21		18 - 85	37		
<i>Melaleuca sieberi</i>	4		28 - 40	35		
<i>Pinus sp</i>	5		17 - 47	25		
<i>Rainforest sp</i>	59		15 - 55	25		1
<i>Stringybark sp</i>	1		30	30		
<i>Syncarpia glomulifera</i>	336	4	15 - 140	31		
Totals	3541	105			5	3

Table 5. Summary of all tree species sampled, those with scats recorded, minimum and maximum tree diameter and average and trees that recorded individual koalas

For a better understanding of koala usage of the study area, survey results were separated for north and south of the Bellinger River as follows.

North of the Bellinger River

A total of 81 sites were surveyed north of the river with 33 sites being active (presence of one or more koala scats). Additionally, five koalas were observed within the 25m radius search and three other koalas within the one hectare transect search. Koala activity levels for the 33 active sites ranged from 3.33% to 40% with an average for all sites being 10%. Refer to Table 6 for details of all sites, activity levels, tree species with scats and their diameter at breast height and where koalas were observed for north of the river.

Active sites and koala sightings were spread across the whole northern section from north – west of Bellingen township up to the northern LGA boundary and out to the coast. Additionally, 22 opportunistic records (17 being koalas scats and 6 of individual koalas) were located in this area during the survey. Only one active site (which included an individual koala) was recorded east of the Pacific Highway in the Repton – North Beach area. Two additional opportunistic koala records were however recorded in this location.

South of Bellinger River

A total of 53 sites were surveyed south of the river with only five sites being active (presence of one or more koala scats). No koalas were observed within the 25m radius search or the one hectare transect search. Koala activity levels for the 5 active sites were low with four sites having a level of 3.33% and one site 6.67% with an average for all sites being 4%. Three additional opportunistic koala records (koala scats) were located in this area with one record of scats in a tallowwood tree near the Trig Station at Mount Lookout on Fernmount Range Trail. A local resident reported sighting two koalas, a female and male, in this tree only a few days before.

Refer to Table 6 for details of all sites, activity levels, tree species with scats and their diameter at breast height and where koalas were observed for south of the Bellinger River.

Recent surveys undertaken as part of the Pacific Highway upgrade have recorded koala activity at a number of sites in the Little Newry and Newry State Forest (D. Owner, pers. comm.). These additional active field sites are primarily on public land which was not a focus for the field surveys as part of this study. Together with the recent record of a female koala with a joey sighted east of the existing Pacific Highway near Snapper Beach Road, these additional active sites provide further evidence of a small number of koalas still persisting in this area.

Summary of Active Sites				
Active Sites North of Bellinger River				
Site No	Activity level %	Tree with scats	Tree species and diameter (koala sighted in tree shown in bold)	Koala in SAT or (in transect)
4	6.67	2	<i>E. microcorys</i> (44); <i>Allocasuarina torulosa</i> (32)	
51	6.67	2	<i>E. microcorys</i> (36), (26)	
186	3.33	1	<i>E. microcorys</i> (68)	
189	6.67	2	<i>E. microcorys</i> (45); <i>Camphor Laurel</i> (26)	
193	3.33	1	<i>E. microcorys</i> (54)	
199	6.67	2	<i>E. microcorys</i> (48), (74)	
209	3.33	1	<i>E. microcorys</i> (58)	
219	10	3	<i>E. microcorys</i> (34), <i>E. saligna</i> (51) <i>E. propinqua</i> (40)	
221	13.33	4	<i>E. microcorys</i> (56) <i>E. propinqua</i> (38), (44), (40)	1
223	13.33	4	<i>E. microcorys</i> (39), (41), (18), (30)	1
228	3.33	1	<i>E. microcorys</i> (61)	
234	6.67	2	<i>E. microcorys</i> ((51), (28)	(1)
235	3.33	1	<i>E. microcorys</i> (18)	
236	10	3	<i>E. propinqua</i> (33), (51), (38)	
242	10	3	<i>E. microcorys</i> (25), (36); <i>E. propinqua</i> (27)	
244	3.33	1	<i>E. microcorys</i> (40)	
247	10	3	<i>E. microcorys</i> (61) <i>E. robusta</i> (61); <i>S. glomulifera</i> (15)	
254	3.33	1	<i>E. microcorys</i> (46)	
255	40	12	<i>E. Microcorys</i> (43)(58)(58)(38)(35)(35)(45)(50)(30)(52); <i>Syncarpia glomulifera</i> (26)(37)	
261	10	3	<i>E. microcorys</i> (36); <i>E. propinqua</i> (58)(41)(36) <i>E. acmenoides</i> (43)	1
263	20	6	<i>E. microcorys</i> (21)(32); <i>E. propinqua</i> (58)(41)(36; <i>E. acmenoides</i> (43)	
266	26.67	8	<i>E. microcorys</i> (22)(18)(29)(16)(38) (15)(20); <i>E. grandis</i> (42)	1 (1)
278	10	3	<i>E. microcorys</i> (21)(75)(72)	
279	23.33	7	<i>E. microcorys</i> (26)(40)(18)(16)(27); <i>E. propinqua</i> (20)(62) <i>Allocasuarina torulosa</i> (45)	
280	16.67	5	<i>E. microcorys</i> (23)(18)(18)(76); <i>Corymbia intermedia</i> (37)	
282	3.33	1	<i>E. microcorys</i> (30)	
308	10	3	<i>E. microcorys</i> (48)(78); <i>E. siderophloia</i> (52)	(1)
321	6.67	2	<i>E. microcorys</i> (34); <i>E. acmenoides</i> (30)	
322	10	3	<i>E. microcorys</i> (33)(48; <i>E. saligna</i> (15))	1
325	6.67	2	<i>E. microcorys</i> (21); <i>E. propinqua</i> (42)	
343	3.33	1	<i>E. propinqua</i> (29)	
359	10	3	<i>E. microcorys</i> (67); <i>E. propinqua</i> (40)(33)	
361	6.67	2	<i>E. microcorys</i> 62); <i>E. siderophloia</i> (55)	
Average 10%		99		5 (3)
Active Sites South of Bellinger River				
95	6.67	2	<i>E. propinqua</i> (39); <i>Syncarpia glomulifera</i> (35)	
130	3.33	1	<i>E. microcorys</i> (32)	
133	3.33	1	<i>E. microcorys</i> (26)	
134	3.33	1	<i>E. saligna</i> (41)	
142	3.33	1	<i>E. microcorys</i> (90)	
Average 4%		6		NIL

Table 6. Summary of all sites north and south of the Bellinger River, activity levels, tree species with scats and their diameter at breast height and were koalas were observed

The field results from all sites showing koala activity indicates that $28.36\% \pm 0.07\%$ (95% CI) of available habitat was being utilised at the time of the survey. This is not significantly different to the area of occupancy derived from the analysis of koala records for the latest three generational periods 1995 – 2013 (being 30.65%).

Koala activity levels

Koala activity levels for all sites that recorded scats were proportioned into three categories 3 – 6%, 6 – 10% and >10%. The outcomes of derived activity levels fit within both East Coast (low) and East Coast (med - high) activity category thresholds (proposed by Phillips and Callaghan (2011)) (refer Table 4 above). The resulting koala activity category map (refer Map 6) verifies the findings of both the koala records and field survey analysis in identifying major population activity cells in the north and north east of Bellingen. This finding, together with the generational persistence mapping (refer Map 4) clearly identifies the presence of a significant koala population in this area.

Other population cells in the activity category 6 – 10 % occur in the north Gleniffer area and south east of Bellingen township. Eight other low activity category areas occur north and north east of Bellingen and four occur south of the Bellinger River.

Limitations during field surveys

The field surveys for this study were based primarily on the presence / absence of koala scats under trees. This technique of sampling larger, regional areas based on the indirect signs of an animals presence is now a well accepted and resource efficient survey method for some cryptic, difficult to detect species. Whilst koalas are arboreal tree dwelling species they are often difficult to detect and often go unnoticed. Koala scats (faecal pellets) however are relatively distinctive and can be more easily located under the trees they have occupied. This approach allows surveys across larger areas and varying landscapes to better detect the presence /absence of koalas.

There are factors however that can influence both the presence of koala scats (persistence over time) and the ability to locate scats (difficulty in searching in some areas). Koala scats decay over time and this time period is influenced by factors such as rainfall, humidity, temperature, location in landscape and influence of invertebrates (insects) (Cristescu *et al* 2012). Additionally, the detection of scats can be influenced by the complexity of the ground cover where searching can be more difficult in locations with dense ground cover species such as the weed species Lantana or in wetter areas where native sedges and reeds occur. For example, Cristescu *et al* (2012) found that wetlands had the worst detectability due to the dense ground cover vegetation and also the quickest decay rate whilst other vegetation in drier locations with a more simple layer of litter had five times better detectability. This result in wetland areas could influence survey results potentially resulting in an erroneous lower value for what is actually important koala habitat.

Given these factors, the persistence at any site of scats and the difficulty of searching ground litter has the potential to influence survey results and where decay factors are higher (eg recent rainfall, high density of invertebrates) and/or ground cover more dense then observation errors and a false negative may result for that location (Rhodes *et al* 2011). This has the potential to under estimate koala presence in some circumstances, however studies

of scat decay rates showed that, on average, scats decay slowly enough to ensure a low false negative error rate (Rhodes *et al* 2011).

During period of this study from December 2012 to June 2013 rainfall for the area was above normal, both in days of rain and rainfall per month. Table 7 below summaries the days of rain and rainfall over this period. Given the above average days of rain and the intensity of some rainfall events, it is possible that scat decay rates may have been influenced by the increased exposure to rain and surface water together with the associated higher humidity microclimate (Cristescu *et al* 2012). If linked with the difficulty of detectability in some locations, the potential for a false negative (no scats detected) at some sites is possible.

Whilst it is considered that the influence of this factor on overall results in this study on average is low given the systematic nature of the survey methodology and the number of sites visited, activity levels at some sites may be lower than otherwise would have been expected for this area.

Wettest day:	209 mm 28th January 2013
Wet days:	93
Dry days:	65
Highest daily rainfall	265mm on 22 nd February
Longest dry period	5 days to 30 th March
Longest wet period	8 days to 27 th February
Total rainfall for period	1469 mm

Table 7. Bellingen Rainfall Statistics for period 01/01/2013- 07/06/2013

3.4 Koala habitat mapping

Introduction

In any one area koalas are relatively selective in the trees they utilise for food and shelter. These usually include a small number of mostly *Eucalyptus* species as primary and secondary food trees together some additional eucalypt and non eucalypt trees that are occasionally browsed and/or used for shelter and resting. The NSW Koala Recovery Plan (DECC 2008) provides in Appendix 2 a comprehensive list of koala food trees in each of the seven koala management areas of the state. Eucalypt species from this list that occur in the Bellingen area include the Primary food tree species Tallowwood *Eucalyptus microcorys*, Forest Red Gum *Eucalyptus tereticornis* and Swamp Mahogany *Eucalyptus robusta*; Secondary food tree species Small-fruited Grey Gum *Eucalyptus propinqua*, Red Mahogany *Eucalyptus resinifera* and Stringbark/supplementary species White Stringybark *Eucalyptus globoidea*.

The identification of specific tree species favoured by koalas for a regional area can be problematic given the varied geological and soil landscape variances and the often complex resulting mix of vegetation communities. Together with other factors such as the fragmentation of remnants, edge effects and the often disturbed nature of vegetation floristic diversity from past clearing, forestry, fire and associated weed invasion, defining and mapping koala habitat can be challenging.

Site topography, soil moisture and soil nutrient status are also recognised as key drivers in determining potential habitat quality and carrying capacity for koalas (Moore and Foley 2005, Phillips and Callaghan 2000).

Preferred Koala Food Trees

A total of 3,541 trees, including 16 eucalypt species and 14 non-eucalypt species, were sampled as part of the 134 surveys sites. Scats were located under 105 individual trees including six eucalypt species and four non-eucalypt species (refer Table 8). Tallowwood and Small-fruited Grey Gum recorded significantly higher scat counts (66% and 18% of all trees with scats) than the other eight species which in total accounted for about 2% each.

Tree Species	Sites	No trees (n)	P ± SE
<i>Allocasuarina torulosa</i>	22	80	0.03 ± 0.02
Camphor Laurel	3	27	0.04 ± 0.04
<i>Angophora costata</i>	1	4	0.00
<i>Callistemon salignus</i>	1	4	0.00
<i>Corymbia intermedia</i>	32	120	0.02 ± 0.01
<i>Eucalyptus acmenoides</i>	14	75	0.04 ± 0.02
<i>E. ancoplia</i>	2	2	0.00
<i>E. grandis</i>	11	52	0.02 ± 0.02
<i>E. microcorys</i>	37	366	0.19 ± 0.02
<i>E. pilularis</i>	10	54	0.00
<i>E. propinqua</i>	18	103	0.17 ± 0.04
<i>E. resinifera</i>	6	15	0.00
<i>E. robusta</i>	1	18	0.06 ± 0.05
<i>E. saligna</i>	11	44	0.07 ± 0.04
<i>E. siderophloia</i>	17	52	0.04 ± 0.03
<i>Lophostemon confertus</i>	7	19	0.00
<i>Syncarpia glomulifera</i>	14	85	0.05 ± 0.02
Rainforest spp.	2	19	0.00
TOTAL TREES		1140	

Table 8. Summary of tree species recorded in active field sites where P = strike rate, n = number of trees, SE = standard error

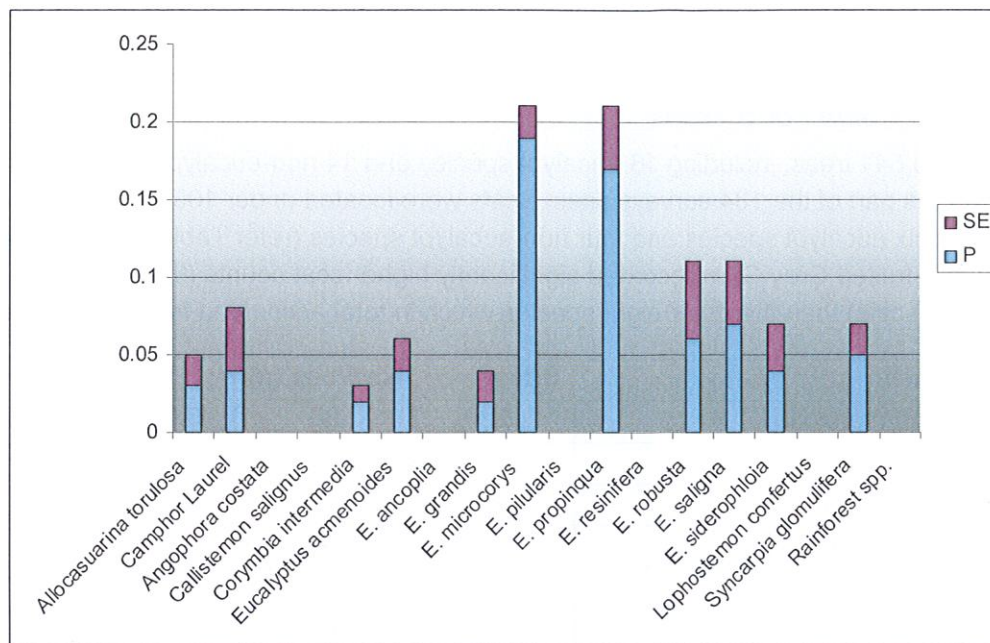


Figure 2. Summary of strike rate result for tree species in active sites where P = strike rate and SE = standard error

For each tree species sampled that recorded one or more scat a proportional index of utilisation referred to as a tree species 'strike rate' was obtained by dividing the number of trees for that species by the number with a scat (based on the methodology developed by Dr Steve Phillips from Biolink Ecological Consultants, Uki). The summary of tree usage and corresponding 'strike rate' for species in Figure 2 above shows the significance of Tallowwood (*Eucalyptus microcorys*) and Small-fruited Grey Gum (*Eucalyptus propinqua*). Secondary usage of Blue Gum (*Eucalyptus saligna*) is also elevated, although this is influenced by the smaller sample size for this species (11 sites and 44 trees sampled). Forest Red Gum (*Eucalyptus tereticornis*) was only sampled at two sites in the coastal area near North Beach /Mylestrom and recorded no koala activity during this study. However records of koala usage of this species occur in the forested area north and west of Mylestrom and in Bongil Bongil National Park near Tuckers Rocks. Swamp Mahogany (*Eucalyptus robusta*) is also very restricted in distribution in coastal Bellingin being found only in some of the more coastal lowland freshwater swamps. It was only sampled at one location near Repton and no koala activity was recorded at that site (site was inundated with water). The species however is a known primary koala food tree and has been recognised in many north coast studies as being significant for koalas (DECC 2008, Biolink 2012, Biolink 2011, Lunney *et al* 1999).

Strike rates for the other eucalypts and non eucalypts such as Forest Oak (*Allocasuarina torulosa*) and Turpentine (*Syncarpia glomulifera*) are consistent with opportunistic browsing and/or sheltering of koalas in areas which are in proximity to, or contain a higher level of, primary food trees such as Tallowwood and Small-fruited Grey Gum.

Koala Habitat Mapping

The vegetation of the Bellingen Shire study area has been mapped by the Office of Environment and Heritage (OEH) Regional Operations Group Coffs Harbour (OEH 2013) to a fine scale using a new vegetation classification for the Northern Rivers Catchment Management area (OEH, 2012a). This classification is to become part of the NSW Vegetation Classification and Assessment (VCA) module of the NSW Vegetation Information System. A total of 53 plant community types within 12,507ha of extant vegetation was mapped in the 22,990ha Bellingen Shire study area. This included 10 dry sclerophyll forests, 7 wet sclerophyll forests, 8 forested wetlands, 10 freshwater wetlands, 2 grasslands, 3 heathlands, 7 rainforests and 6 saline wetlands. Twenty nine (29) of the plant community types are likely to contain and are equivalent to 8 Endangered Ecological Communities (EECs) under the NSW TSC Act and 2 Threatened Ecological Communities under the Commonwealth EPBC Act. Extant vegetation cover was also mapped, including native remnants, rainforest and acacia pioneer, exotic and plantation vegetation.

In accordance with the field survey results, data analysis and species 'strike rates' for koala usage, habitat mapping and classification was based on the following:

1. Tallowwood, Forest Red Gum and Swamp Mahogany are recognised as Primary Food Trees (PFT).
2. Small-fruited Grey Gum where it occurs in association with Tallowwood on better nutrient soils as a Primary Food Tree and where it occurs elsewhere as likely to be of secondary usage.
3. Sydney Blue Gum, Flooded Gum, Grey Ironbark, White Mahogany and Pink Bloodwood show occasional koala use where adjacent to or part of a vegetation community that contains the primary food trees listed in 1 and 2 above.

Potential Koala Habitat	Primary Habitat	Vegetation associations and/or communities wherein "primary" food tree species form $\geq 50\%$ of the canopy.
	Secondary (Class A) Habitat	Vegetation associations and/or communities wherein; <ul style="list-style-type: none"> • "primary" food tree species form 30-50% of the of the canopy or wherein; • "primary" and "secondary" species combine to form $\geq 50\%$ of the canopy or wherein;
	Secondary (Class B) Habitat	Vegetation associations and/or communities wherein "secondary" food tree species form $\geq 50\%$ of the canopy.

Table 9. Rules for classification of vegetation communities into koala habitat ranking based partly on Appendix 3 of the NSW Koala Recovery Plan 2008 and Biolink (2012)

Based on the above classification, 12 vegetation community types and 30 additional vegetation community variances were identified as being of significance as habitat for koalas

in the Bellingen Shire coastal area. These communities contain primary and secondary koala food trees as dominants or co dominants of the forest canopy.

These mapped units were ranked into Primary, Secondary (Class A) and Secondary (Class B) koala habitat and verified against both historic records and location of active field sites. Mapped koala habitat is shown in Map 7 and the areas for each category are summarised in the Table 10 and Table 11 below.

Habitat Type		Area (ha)		% of total forest area
Potential Koala Habitat	Primary Habitat	North	1533	11
		South	700	5
	Secondary (Class A) Habitat	North	267	2
		South	2640	19
	Secondary (Class B) Habitat	North	1097	6
		South	2182	20
	Total	8419		60
	Other vegetation	5511		40

Table 10. Mapped koala habitat classes and % area of total mapped forest communities

Koala Habitat Categories

Vegetation Community Type	Primary	Secondary A	Secondary B	Total
Blackbutt - Red Mahogany - Bloodwood dry open forest				
north			3	3
south			367	367
Broad-leaved Paperbark - Bare Twig Rush swamp sclerophyll open forest of coastal swamps				
north		3		3
Brush Box - Tallowwood - Sydney Blue Gum shrubby wet open forest				
north	613	9		622
south		2025	39	1164
Flooded Gum moist open forest of sheltered lower slopes and gullies				
north	4		972	976
south			661	661
Forest Red Gum - Pink Bloodwood - Grey Ironbark open forest to woodland				
south	21			21
Pink Bloodwood - Thick-leaved Mahogany - Grey Ironbark - Small-fruited Grey Gum grassy open forest				
north		44	24	68
Swamp Mahogany - Willow Bottlebrush - Broad-leaved Paperbark forested wetland				
north	8			8
south	239			239
Tallowwood - Blackbutt moist shrubby tall open forest				
north	82			82
south	515	3		508
Tallowwood - Small-fruited Grey Gum - Forest Oak dry open forest				
north	758	12	2	772
south		1604	12	1616
Tallowwood - Thick-leaved Mahogany - Small-fruited Grey Gum - Grey Ironbark grassy open forest				
north			11	11
south			389	389
Turpentine - Blackbutt - Tallowwood - Forest Oak ferny moist forest				
north	3	106		109
south			800	800
Overall Total	2233	2906	3280	8419

Table 11. Koala habitat mapping areas

3.5 Discussion

The results of this study confirm what is already documented in other studies and the literature regarding koala food tree preferences and selection on the North Coast of NSW. Refer to Appendix 3 of the NSW State Koala Recovery Plan (DECC 2008) and the results of koala habitat studies for the Tweed and Byron coastal areas (Biolink 2011, 2012), East Lismore area (Lismore City Council 2012), Ballina Shire LGA (Biolink 2013), Coffs Harbour City LGA (NPWS 1999), East Kempsey Shire area (Biolink 2010) and the Hastings / Port Macquarie LGA (Biolink 2013).

Primary koala food trees
Tallowwood (<i>Eucalyptus microcorys</i>)
Noting that Tallowwood is common and widespread across the study area on different soil substrates and the latter two species only occur in limited distribution in swamp areas or primarily near the coast.
Swamp Mahogany (<i>Eucalyptus robusta</i>)
Forest Red Gum (<i>Eucalyptus tereticornis</i>)
Small-fruited Grey Gum (<i>Eucalyptus propinqua</i>)
Secondary koala food trees
Flooded Gum (<i>Eucalyptus grandis</i>)
Sydney Blue Gum (<i>Eucalyptus saligna</i>);

These results are consistent with that of studies undertaken in Pine Creek State Forest (Smith and Andrews 1997), the Pine Creek State Forest Koala Plan of Management (State Forests NSW 2000) and for the Pacific Highway upgrade at South Bonville (AMBS 2011). Smith and Andrews (1997) study of Pine Creek State Forest, reported that Tallowwood and Small-fruited Grey Gum were preferred species in both frequency and volume of intake with Forest Red Gum, Sydney Blue Gum and Swamp Mahogany also utilised. Analysis of scats for leaf fragments also showed small percentage in some areas of Forest Oak and overall scat abundance was shown to increase linearly with the abundance of Forest Oak within the forest community (Smith and Andrews 1997).

The Australian Museum Business Services (AMBS) undertook a koala monitoring project over the time period of the Pacific Highway upgrade in the South Bonville north Raleigh area. During that time some 34 individual koalas were radio tracked for a cumulative total time of 12,452 days (mean per koala = 366 days) and a total of 1,986 observations were made of koalas using 39 different tree species. The study found that koalas were recorded most often in Tallowwood, Flooded Gum and Small-fruited Grey Gum (AMBS 2011). This work also recorded koala usage of Turpentine which also recorded some usage in this study, mostly likely as a shelter species for koalas.

Koala habitat North and South of the Bellinger River

Vegetation forest communities and associated koala habitat quality vary on the north and south side of the Bellinger River. This is supported in the both the historical koala records analysis and the results of the field surveys where fewer koala records occur south of the river and a significantly lower number of active sites and associated strike rates were recorded. The reasons for this are not entirely clear but are considered to be related to both soil fertility and a lower rainfall (as a result of rain shadow effect from the coastal range to the north). Forest communities south of the river are more likely to be in the dry sclerophyll forest type with a dry grassy understory where north of the river the moister wet sclerophyll forest types are more dominant.

The drier forest communities south of the Bellinger and Kalang River also represent a greater fire threat to koalas and whilst wild fires have occurred in areas both north and south of the Bellinger River the largest and more recent fires have been in the south west part of the LGA.

Analysis of larger data sets relating to koala food tree usage (Phillips and Hopkins 2010, Phillips *et al* 2011) indicate that whilst Tallowwood is considered a primary food tree for koalas where it occurs on alluvial and other deposited soil landscapes, its usage is significantly lower on low nutrient erosional and residual soil landscapes. Thus on lower nutrient soil landscapes koala carrying capacity (habitat quality) can be markedly lower even with the presence of identified primary food trees such as Tallowwood and Small-fruited Grey Gum. In these circumstances available leaf nutrient, moisture and higher toxins levels may become a limiting factor to koala carrying capacity and therefore equate to larger, less productive koala home ranges and overall abundance. Although speculative, this appears to

4. Threatening processes

Habitat loss, fragmentation and barriers to movement

As discussed previously in this report, clearing of forests in the Bellingen area began in the late 1800's and continued until the mid 1900's. At this point in time most of the productive land on better nutrient soils had been cleared for agriculture including dairying, and many of the remaining areas of forest had been disturbed by logging, fire or weed invasion. This is a similar pattern to use of much of the lands in eastern Australia, where agriculture, forestry and population pressure have impacted on biodiversity.

Historic clearing of the most fertile landscapes is likely to have significantly impacted on koala distribution and abundance in the Bellingen area. The loss and isolation of habitat during this period over many decades would have significantly reduced koala abundance and distribution limiting animals to the remaining patches of vegetation on private lands and to the larger areas of public lands. Based on the results of this study, the reestablishment of koalas into forests considered to have regrown post the 1940 and 50's (i.e. regrowth forests) has, in some areas, been low or non-existent.

Additionally, the influence of isolation and remnant patch size can impact on the ability for koalas to survive threats, particularly where the chance for immigration or recolonising is low. Thus the impacts of fire, forestry, dog attack, road strike, disease and weed invasion can lead to localised extinction in smaller patches and remnants with minimal chance for recruitment.

Maintaining and rebuilding of appropriate corridors and linkages is therefore of paramount importance in providing the habitat connectivity to allow for koalas to move through the landscape to cater for changing threats, ecological and climatic variability's and genetic diversity.

This is an important consideration in the rebuilding and maintenance of landscape connectivity in the coastal Bellingen area to ensure that corridors enable both a north-south and an east-west elevational corridor for koalas and other fauna.

Wild Fire

Wildfire is a part of the Australian bushland and periodically wildfire has occurred across large areas in the Bellingen LGA, more predominately on public lands. Wildfire however, particularly high intensity canopy fires, have the potential to severely impact on koala populations either through direct flame and heat, by smoke inhalation and/or by removal of food resources.

Where populations are low and/or habitat areas are small and isolated, wildfire can lead to a population crash, localised extinction and/or impeded recovery. In these areas the absence of wildfire for at least three koala generations (minimum 18 years) is crucial for population security and recovery.

Map 8 indicates the spatial areas and dates of wildfire in the Bellingen coastal area. The areas mapped are primarily on public lands where fire mapping is better recorded and may not fully represent all wildfires that have occurred across private lands.

Whilst it is not conclusive, wildfire may have played a role in the decline of koalas in the South Urunga and Hungry Head area and may have also been a factor in koala distribution in the drier forest types south of the Bellinger and Kalang Rivers.

Prescribed burns in areas of koala habitat also have the potential to impact on individual animals and in these cases prescribed burns should be of very low intensity, with flame heights below 2 metres and avoid trees occupied by individual animals where possible.

Summary of Wildfire in coastal Bellingen LGA

Date	Location	Hectares
1946 /47	Pine Creek SF	579 ha
1968/69	Pine Creek SF	254 ha
1979/80	Pine Creek SF	21 ha
1980/81	Pine Creek SF (now BBNP)	1294 ha
	Newry SF	215 ha
	Gladstone SF	1768 ha
	Jaanningga NR	21 ha
1986/87	Gladstone SF	503 ha
2001/01	Newry SF	7 ha
	Gladstone SF	160 ha
2002/03	Gladstone SF	9193 ha
	Scotchmans SF	2921 ha
	Newry SF	57 ha

Road strike and mortalities

Road strike and mortality of koalas can be a significant factor in contributing to koala declines in abundance and distribution in areas where roads with moderate to high traffic volumes traverse through koala habitat. Road strike is seasonal and usually peaks in the spring and summer breeding seasons from August to February. Mortalities are also linked to roads with higher traffic volumes, higher speed limits (above 50kph) and where there is poor road side visibility and lighting.

Road strike and mortality in the north Bellingen coastal area has been significantly reduced since the fauna fencing, underpasses and overpass were constructed as part of the Pacific Highway upgrade at Bonville and North Raleigh. Prior to this, 65 koalas were killed on the Pacific Highway within the Bongil Bongil National Park area in the period between 2000 and 2010 with 13 animals killed in one year (2000). After fencing and underpasses were installed in 2010, no animals were recorded as killed in this section of the highway (AMBS 2011).

Koalas and other fauna however do occasionally gain access to the highway from time to time by moving around the fences or down access roads and ramps. A koala was recently

struck by a car and killed (17th September 2013) on the north bound lane of the Pacific Highway at the Pine Creek bridge within the Coffs Harbour City LGA.

Three other koala road mortality records occur for the North Valla part of the Pacific Highway for the periods 2005 – 2009. This part of the Pacific Highway is presently in the final design stages of an upgrade which will bypass the town of Urunga to the west. It is understood that koala fencing and underpasses will be part of the upgrade construction works.

No koala mortality records exist for the Waterfall Way road from Raleigh to Thora even though this road carries high volumes of vehicles and traverses through some areas of koala habitat. A koala was observed however crossing Waterfall Way from south to north in the area about 300m west of Camerons Corner in 1997 (D. Brown OEH pers. comm.)

Dog harassment and attacks

Harassment and attacks by domestic dogs can impact on koalas. This is most prevalent where habitat is fragmented requiring koalas to spend more time on the ground travelling between trees. Areas at most risk are those where urban and rural residential areas adjoin or are interlinked with koala habitat and koalas are more likely to traverse through backyards and adjoining reserves. Dog attacks usually peak during the koala breeding season from August to February when animals are more likely to moving across the landscape.

Whilst no WIRES records exist for dog attacks in the Bellingen area, it is likely that in some cases the incidence of dog harassment and attack goes unreported.

Areas of concern identified during this study are the rural residential areas of Raleigh, Fernmount and Repton and the urban areas of North Bellingen. Koalas are often reported in these areas and, in particular, North Bellingen has a historic number of koala records and an individual animal and koala scats were found in this area during the field surveys. Of concern in the North Bellingen area of the Cemetery is the number of dogs that were reported to be allowed to run unleashed in this area where koalas are often sighted.

The management of dogs is regulated by the *Companion Animals Act 1998* under which dogs in public places must be under the control of a competent person and must not be allowed to roam or attack other animals. A significant part of enforcing the Act is in public education and awareness of the impacts of dogs on koalas. Areas of occupied koala habitat should be dog exclusion zones to ensure koalas are not impacted.

Disease

Disease in koalas is the major contributor to koalas going into care and can lead to population declines in areas where koalas are under harassment or continued stress. In some cases where Chlamydiosis is elevated in the population koala health can be severely compromised and breeding potential of females reduced or lost. Both Chlamydia and the koala retro-virus (KorV) are known from north coast koala populations including Bellingen and it is likely that mortalities due to these diseases are widespread and often unreported.

Sick or injured animals, which often show the clinical signs of Chlamydia including a dirty wet bottom or puss infected eyes, should be reported to WIRES to allow for appropriate assessment and treatment.

Climate Change

The potential impacts from climate change on koalas and their habitat is yet to be fully understood. Research is suggesting however that the effects of increased temperatures and CO₂ levels may influence a number of variables which may prove problematic for koalas. These include an increase not only in extreme hot days and temperature but the number of these days occurring in the one event. Additionally, such events and likelihood of extreme weather conditions such as storms or drought may directly impact individual koalas and, in the case of drought, increase potential for high intensity wildfires.

Increased CO₂ levels in the atmosphere (from 280ppm to 387ppm since the Industrial Revolution) is likely to result in faster plant growth but at the same time also change in the nutrient level (less proteins) and increase the tannin level of eucalypt leaves. As CO₂ levels increase eucalypt leaves are likely to become less suitable to koalas (Red List, Koalas and Climate Change 2009). Adaption by koalas to a lower quality food may be problematic as they simply cannot just eat more leaves and may need to be more selective in leaf and tree choice. This may result in koalas spending more time on the ground and therefore more prone to other threats.

5. Environment Protection and Biodiversity Conservation Act 1999

5.1 Important Population

The koala is listed as a 'Vulnerable' species in NSW under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the Act, proponents undertaking a proposed activity which has the potential to impact on an 'important population' must assess whether the proposal needs to be referred to the Australian Government Department of Sustainability, Environment, Water, Population and Communities. The interim guidelines define an 'important population' as a:

'Population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal,
- Populations that are necessary for maintaining genetic diversity, and/or
- Populations that are near the limit of the species' range.

The results of both the records analysis and field surveys shown that the area north of Bellingen and out to the coast fall within a 'high' activity area that shows the persistence of a continual koala population over six koala generations. This area is therefore likely to support a sedentary population of koalas and by definition meets the interim guidelines for an 'important population' under the EPBC Act (refer Map 9).

Evaluation of the koala populations south of the Bellinger River as an 'important population' is more difficult to establish given the widespread but lower density occurrence of koala records and the lower activity levels derived during the field surveys. Further more detailed investigation of the importance of koala populations present within this area would be necessary as part of the assessment of any proposed activity within this area. This assessment should be undertaken if any activity is proposed in this area to determine

whether a koala population present within this area forms part of an 'important population' under the EPBC Act.

5.2 Habitat critical for the survival of the species

The results of the field survey indicate that parts of the study area contains 'habitat critical to the survival of the koala.' Under the Interim Koala Referral Advice for Proponents (2011), habitat is considered critical to the survival of the koala if 'primary koala food tree species comprise at least 30% of the overstorey trees'.

The vegetation communities within the study area that have been mapped as Primary Koala Habitat contain canopy eucalyptus species dominated by the primary koala food trees Tallowwood, Small-fruited Grey Gum, Swamp Mahogany and Forest red Gum and therefore are considered to meet the definition of 'habitat critical to the survival of the koala'.

6. Conclusion

A long history of land clearing for agriculture and habitat disturbance through forestry, weed invasion and fire has significantly altered the availability and quality of habitat available for koalas in the Bellinghen coastal areas. However this study has found that koalas do persist in many areas and in particular the area north and north-east of Bellinghen township and out to the coast has an important koala population which has recorded evidence of persistence over 6 koala generations or a period of 36 years. This finding is supported in both the analysis of koala records and the results of the field surveys.

Both the records analysis and the surveys also showed a trend of decline in some areas both south and south-west of Bellinghen township and in the coastal areas south of Urunga and in the Hungry Head and Wenonah Headland areas.

South of the Bellinger and Kalang Rivers the koala records analysis and the surveys confirm the presence of a widespread but low density koala population in what is considered lower quality habitat.

In the south-east coastal part of the LGA, in the area of Ballards Road, Oyster Creek and north Valla, including the northern part of Jagun Nature Reserve and the eastern part of Little Newry State Forest, the analysis of koala records shows a historical and more recent small number of koalas persisting in these areas. No activity was recorded at any of the field survey sites in this area, although recent surveys undertaken as part of the Pacific Highway upgrade recorded koala activity in Little Newry and Newry State Forest and a koala and joey were recently recorded east of the Pacific Highway. More research is required to determine the distribution and viability of the koala population in this area.

Observed occupancy rates calculated from the records analysis (30.65%) and the field surveys (28.36%) are below optimal level (50% per Phillips *et al* 2011) but are similar to those observed for other north coast studies (eg 28% in the Byron Coast Koala Habitat Study, Biolink 2011). To allow for improved occupancy rates, population expansion and recovery the management of threats and rehabilitation of linkages to reduce fragmentation of habitat is required.

7. Recommended Management Actions

1. To ensure effective and targeted management of koalas and their habitat it is recommended that the study area be divided into four Koala Management Precincts (KMP) as follows.

KMP 1 - North and North-east Bellingen north of the Bellinger River to the coast

Significant area of occupied koala habitat which adjoins the larger habitats of Pine Creek State Forest and Bongil Bongil National Park and links to the coastal range and hinterland.

KMP 2 - South of the Bellinger River to the coast

Widespread and dispersed area of koalas occurring at lower density in generally lower quality habitat.

The above KMAs should be used to spatially target and designate key issues for koala recovery and management actions in the preparation of a Comprehensive Koala Plan of Management for the coastal part of Bellingen Shire Council. The primary objective of this plan should be the management in perpetuity of a free-ranging koala population across the area by way of habitat protection, rehabilitation and restoration (linkages), reduction of threats, community education and awareness and appropriate management of koala welfare and health.

2. For the purposes of the EPBC Act the area designated in Map 9 should be considered as meeting the criteria as an 'important population' and therefore any proposed activity that may result in a negative impact on koalas should be referred to the Australian Government Department of Sustainability, Environment, Water, Population and Communities.
3. Subject to funding and resources, further field surveys and data analysis should be undertaken in the south east and south west part of the LGA to establish the distribution and status of the koala population in this coastal area and in and around the Boggy Creek Road area.

8. References

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

Ellis W.A., Carrick F., Lundgren P., Veary A. and Cohen B. 1999. The use of faecal cuticle examination to determine the dietary composition of koalas. *Australian Zoologist* **31**: 127-133.

Clancy, G. and Turbill, J. (1992). Third Fauna and Flora Report South Urunga Development Area. Unpublished report to Bellingen Shire Council.

Cork, S.J., Hume, I.D. and Foley, W.J. 2000. 'Improving habitat models and their utility in koala conservation' *Conservation Biology* **14**(3):660 - 668.

Cristescu, R. H., Goethals, K., Banks, P. B., Carrick, F. N. and Frère, C. 2012. "Experimental Evaluation of Koala Scat Persistence and Detectability with Implications for Pellet-Based Fauna Census," *International Journal of Zoology*, vol. 2012, Article ID 631856.

Crowther, M. S., Lunney, D., Lemon, J., Stalenberg, E., Wheeler, R., Madani, G., Ross, K. A. and Ellis, M. (2013), Climate-mediated habitat selection in an arboreal folivore. *Ecography*.

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

Dique, D. S., de Villiers, D. L., & Preece, H. J. 2003a Evaluation of line-transect sampling for estimating koala abundance in the Pine Rivers Shire, south-east Queensland, *Wildlife Research*, **30**: 127-133.

Fisher, J and Murray, J. 2000. State Forests of New South Wales. North East Region, Koala management plan : Pine Creek State Forest, State Forests of NSW, North East Region, Coffs Harbour, NSW

Gall, B.C. 1980. 'Aspects of the ecology of the Koala *Phascolarctos cinereus* in Tucki Tucki Nature Reserve, NSW. *Australian Wildlife Research* **7**: 167 – 176.

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

Lunney, D, Moon, C., Matthews, A. and Turbill, J. 1999 *Coffs Harbour City koala plan of management*. Unpublished report to Coffs Harbour City Council, New South Wales. National Parks and Wildlife Service.

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

Phillips, S., Hopkins, M. and Warnken, J. 2011. Splines in the sand: Modelling metapopulation structure across the landscape to provide greater planning certainty for an arboreal marsupial (Koala *Phascolarctos cinereus* Goldfuss).

- Phillips, S. 2000a. Population trends and the koala conservation debate. *Conservation Biology* 14(3): 650-659.
- McLean, N. and Handasyde, K.A. 2006. Sexual maturity, factors affecting the breeding season and breeding in consecutive seasons in populations of overabundant Victorian koalas (*Phascolarctos cinereus*). *Australian Journal of Zoology* 56: 385-392.
- Moore, B.D. and Foley, W.J. 2005. Tree use by koalas in a chemically complex landscape. *Nature* 435: 488-490.
- Phillips, S., Hopkins, M. and Shelton, M. 2011. Tweed Coast Koala Habitat Study. Unpublished report to Tweed Shire Council. Biolink Pty Ltd Ecological Consultants.
- Phillips, S. and Hopkins, M. (2011). Byron Coast Koala Habitat Study. Unpublished report to Byron Shire Council. Biolink Pty Ltd. Ecological Consultants.
- Rhodes, J.R., Ng, C.F., de Villiers, D.L., Preece, H.J, McAlpine, C.A., Possingham, H.P. (2011). Using integrated population modelling to quantify the implications of multiple threatening processes for a rapidly declining population. *Biol Cons.* 144: 1081-1088.
- Senate Report (2011). The Koala – saving our national icon. Environment and Communications Reference Committee. Commonwealth of Australia. Canberra.
- Smith, A. and Andrews, S. 1997. Koala habitat, abundance and distribution in Pine Creek State Forest. An unpublished report to State Forests of NSW.