The koalas of Ipswich: Opportunities, threats and future viability

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EXECUTIVE SUMMARY

This report was commissioned by the Lock the Gate Alliance to investigate the potential for current and planned coalmines in the Ipswich West area to threaten koalas in the region. It presents a synopsis of current knowledge about the ecology and distribution of koalas in Ipswich, which is a valuable tool for guiding future efforts to conserve this species in Queensland. Based on current knowledge, our estimate is that the Ipswich Local Government Area (LGA) houses some 1546 – 4368 koalas. This estimate needs to be tested with rigorous on-ground surveys, particularly in the urban and peri-urban areas where densities may be significantly higher than we estimate.

On the basis of estimated population size, genetic information and the current and approaching threats, the authors consider the koala population of the Ipswich LGA to be a significant population for the conservation of this species in Australia.

Coal mining in Ipswich appears to be in a period of decline so its negative impacts on koalas in the future will probably diminish, however, valuable resources for conservation are situated on current and expired leases, which should be harnessed to secure the future of koalas in Ipswich.

Serious anthropogenic threats to the future of Ipswich's koalas exist in the form of transport infrastructure and incompatible land uses. The latter, however, also forms a potential resource to be tapped through revegetation, remediation of degraded land and partnerships with landholders.

We recommend an audit of mine site rehabilitation and current and potential koala habitat in the Ipswich LGA, with a focus on the creation of future koala habitat and concurrent pest management, as a means to stem the decline of the koala in south east Queensland.

We also recommend close scrutiny of the development of future transport infrastructure in the Ipswich LGA due to its potential to fragment and isolate koala populations as well as contribute directly to mortality. Transport infrastructure and development for housing need to accommodate the habitat and movement requirements of koalas, and efforts to reconnect isolated habitats are vital to complete an effective approach to koala conservation in the Ipswich LGA.

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INTRODUCTION

The koala *(Phascolarctos cinereus)* is a unique and iconic Australian species and is Queensland's official faunal emblem. Koalas occur from northern Queensland down the east coast of Australia to South Australia and west to central and western Queensland, New South Wales and Victoria. The koala's distribution has contracted in recent decades and much of what remains has been degraded and fragmented.

The Ipswich Local Government Area (LGA) has a rich history of both koala presence and resource development. In recent years, residential and industrial developments have increased and the associated infrastructure, including roads, has consumed significant areas within the natural woodland and agricultural landscape.

Despite this changing landscape, there is a significant population of koalas occurring across the Ipswich LGA. Estimates of koala population numbers are difficult to generate because of the cryptic nature of this species: unless repeated searches using appropriate techniques are employed, such estimates (including ours) need to be regarded with caution. Our estimate is that it numbers above 4000 individuals (lower range estimate 1546 – 4368 koalas). These koalas are genetically distinct from other populations that have been investigated in Australia, and are genetically most similar to the adjacent, endangered Koala Coast population. The distribution of the Ipswich koala population may be changing in response to both negative development pressures and positive revegetation and land management programs, indicating that it is a resilient and important population for the long-term viability of Queensland's koalas.

Ipswich City Council has recently adopted a policy against any new coal mines within its jurisdiction, suggesting that the future threats to koalas associated with mines and related activities may be reducing. However, it is the Queensland state government that determines mining applications, rather than local councils.

In this report we investigate three key resource entities of particular significance to the future of koalas in the Ipswich LGA. These are exploration permits EPC2364 and EPC2127 which affect vast areas between Mt Walker and Grandchester to the west and Purga to the south west respectively; and the mining lease ML4712 and associated mineral development licence MDL172 Bremer View proposal sitting between these two exploration leases. All of these leases cover areas found to house regionally dense koala populations and areas of key habitat for koalas now and into the future.

In addition, our brief review of current road transport infrastructure and planning available from The Queensland Department of Transport and Main Roads, highlights the pressure road traffic will have on this koala population into the future, and the apparent dearth of planning to mitigate such impacts.

Koala conservation in south east Queensland

South east Queensland (SEQ) currently hosts a large number of koalas living in close proximity to urban and peri-urban environments. Koala populations in SEQ are threatened by habitat loss and fragmentation and other impacts of urbanisation including death and injury from traffic, dog attacks and disease. Due to this habitat loss and increasing threats, there continues to be a general trend toward koala population declines in south east Queensland (McAlpine *et al.* 2015). The koala populations in the Koala Coast area of Redland City, Logan City and Brisbane City are estimated to have declined by 26% between 1996-99 and 2005-06 (Queensland Department of Environment and Resource Management "DERM" 2009 - now Department of Environment and Heritage Protection "DEHP" and Department of Natural Resources and Mines "DNRM"). DERM further estimated a 51% decline in the Koala Coast population in the three years to 2008 with an overall decline in the order of 64% over the course of their surveys.

Koalas were listed as 'Vulnerable' in the SEQ Bioregion in 2004 under Queensland's *Nature Conservation Act* (Qld Government 1992). This assessment was based on an estimate of the current population size, the rate of habitat loss and rates of koala mortality for the region. The Nature Conservation (Koala) Conservation Plan 2006 and Management Program 2006-2016 (the "Koala Plan") were prepared by the Queensland Environmental Protection Agency and came into effect on 2 October 2006 with the aims to conserve viable wild koala populations, protect koala habitat and 'promote future land use and development that is compatible with the survival of koala populations in the wild' (Qld EPA 2006).

In addition, the South East Queensland Regional Plan (SEQRP) 2009-2031 aims to enhance koala populations in the region through 'protection, management and the achievement of a net gain in bushland koala habitat and through managing conflict with urban development' (Qld Department of Infrastructure and Planning 2009). This aim is supported by State Planning Policy 2/10: Koala Conservation in South East Queensland and South East Queensland Koala Conservation State Planning Regulatory Provisions. These planning instruments came into effect on May 31st 2010.

In addition, individual councils (including Ipswich City Council) have web resources advising residents and visitors of the best approach for retaining and enhancing koala habitat and protecting koalas from harm.

Koala habitat in Ipswich

Koalas are found in a variety of habitats, from coastal islands to central Queensland and tall *Eucalyptus* trees to low inland woodlands. Their diet is restricted mostly to leaves from *Eucalyptus* trees and they also appear to rely heavily on non-food trees for shelter and shade (Ellis *et al.* 2010).

Koala habitat varies across Queensland, from intact bushland and forests, through to linear riparian and roadside vegetation systems. However systematic field surveys, radio-tracking and large numbers of incidental records indicate that koalas also utilise other environments, such as urban and agricultural areas (Dique 2004). While the conservation value of forested areas with a high density of koalas is obvious, lower density, fragmented, and even developed habitats are also important, because they too can provide habitat links and allow gene flow and dispersal of koalas across the landscape (Dique 2004).

White (1999) described the use of habitat by koalas in the Ipswich region, reporting the use of *Eucalyptus tereticornis, E. crebra, E. tesselaris* and *Corymbia intermedia*. Recent work in the Peak Crossing area confirms the persistence of the group studied by White (1999), proving that the patchwork of habitats in rural areas can sustain koalas in the Ipswich region. Across the Ipswich LGA, koalas will use habitat of varying design, from isolated paddock trees, creek and roadsides, to bushland in reserves. Dique and co-workers (2004) found that significant koala populations existed in residential areas of the Koala Coast and anecdotal reports exist for Ipswich. Vegetation along road verges can also provide significant habitat for koalas (e.g. Ellis unpublished data in the Somerset LGA), but the contribution of these areas to koala populations are hard to quantify. In some cases it may be that they provide significant areas of habitat and house the majority of koalas. However, road verges are managed "ad hoc" (if at all) with regard to wildlife so they can be severely burned (for weed management perhaps) leading to the death of resident koalas (Ellis unpublished data in Somerset LGA) and surveying them can be difficult due to both the danger of working on and around roads and even the subsequent reluctance of local councils to support such efforts.

Failure to find signs of koala presence or habitat use in an area does not necessarily discount it as a potential habitat source. A range of temporal factors, such as fire, drought and anthropogenic impacts can cause localised extinctions, which need not be permanent, if connections persist.

Within populations, some koalas establish residency and hence occupy 'home ranges', however at any site population turnover can be expected to be in the order of 30% per annum (Martin and Handasyde 1990; Ellis *et al.* 2002), indicating the importance of connectivity between and within habitat. Range size is impacted by factors from social dynamics to landscape level attributes, but in the south east corner of Queensland, ranges can vary between 2.4 Ha (Thompson 2006) and 13 Ha (Ellis & FitzGibbon unpublished data).

The koalas studied by White (1999) appear to have occupied large range sizes, compared with their Koala Coast counterparts. Home ranges adjoin or overlap with those of other koalas in a population and may include trees that are visited more frequently than others and they appear to rarely share trees in natural settings (Ellis *et al.* 2009). However, the lessons we learn from undisturbed areas tell a different story to the heavily impacted south east of Queensland (Dique *et al.* 2003), so planning and management needs to be based on locally-collected data.

While cleared, regrowth or remnant vegetation within urban, rural or agricultural environments can all provide potential koala habitat (White 1999), the importance of habitat to koalas in highly fragmented urban and semi-urban environments has not been widely studied (Dique *et al.* 2004) and the relationship between koala density and habitat quality requires further investigation.

The urban centre of Ipswich is situated approximately 40 km west of the Brisbane CBD. The Ipswich Local Government Area (LGA) is approximately 1090 km2 (109,399 hectares), consisting of rural, urban, industrial, mining and agricultural land uses and remnant bushland. Thirty eight different Regional Ecosystems (REs) existed in the Ipswich LGA prior to European settlement (City of Ipswich 2015). Thirty six remain, with almost 80% of the remnant RE cover being made up of only four types (Table 1) (City of Ipswich 2015). Some 43% of this occurs as one RE – 12.9-10.2: Corymbia citriodora, Eucalyptus crebra open forest on sedimentary rocks (City of Ipswich 2015). The four main RE types consist primarily of spotted gum and ironbark associations.

Table 1. Four dominant regional ecosystems found in Ipswich

REGIONAL ECOSYSTEM	DESCRIPTION	% OF EXISTING REMNANT VEGETATION COVER IN IPSWICH
12.9-10.2	*Corymbia citriodora* (Lemon-scented Gum), *Eucalyptus crebra* (Narrow-leaved Ironbark) open forest on sedimentary rocks	42.51%
12.9-10.7	*E. crebra* (Narrow-leaved Ironbark) woodland on sedimentary rocks	16.99%
12.9-10.19	*E. fibrosa* subsp. *fibrosa* (Broad-leaved Red Ironbark) open forest on sedimentary rocks	11.26%
12.8.17	*E. crebra* (Narrow-leaved Ironbark), *E. melanophloia* (Silver-leaved Ironbark) woodland on Cainozoic igneous rocks	6.49%

(Adapted from City of Ipswich 2015a, p.6)

The percentage of remnant vegetation estimated to be remaining in the Ipswich City Council LGA in 2013 was 21.4% or 23,444 hectares (Accad and Neldner 2015). Appendix 1 shows the native vegetation present in the Ipswich LGA, including 'endangered' and 'of concern' areas. Appendix 2 indicates identified wildlife habitat in the LGA (including koala bushland) for significant species mapped as Matters of State Environmental Significance (MSES).

As well as a rich history of resource extraction, the Ipswich LGA has also been home to significant koala research projects – some designed to assess distribution and some investigating aspects of koala biology.

CURRENT KNOWLEDGE REGARDING IPSWICH KOALAS

Koala rescues

Perhaps unfortunately, the Ipswich Koala Protection Society might provide the most comprehensive database of koalas for the Ipswich LGA. Theirs is a database of sick, injured or dead koalas collected by koala carers throughout the area and it reveals details about where koalas and humans come into contact, but also testifies to the persistence of this species across the region. Figure 1 shows the locations of koala rescues in the Ipswich LGA from 1990 - 2015. Concentrations in certain areas may indicate high mortality, for example along the edges of roads, or in urban areas, but may also indicate areas of high visibility, where injured koalas can be easily found.

Several studies conducted through the early 1990s report on koala populations of Ipswich, and current work in the Peak Crossing area is investigating the ecology of koalas today in the rural landscape near the approaching urban front. Today, koalas are still widely distributed across the Ipswich Region, but face some significant threats.

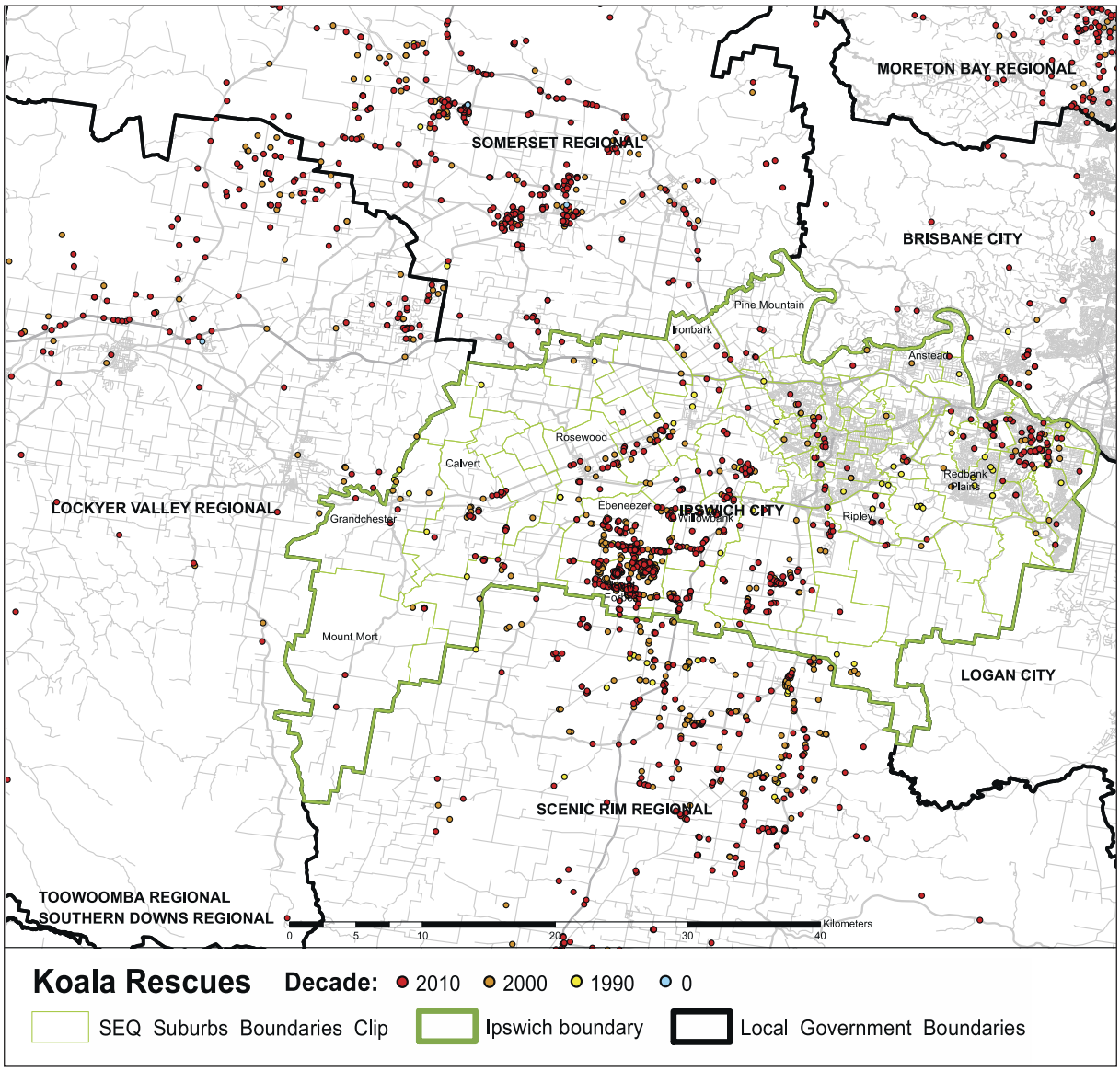

Figure 1. Location of koala rescues from the Ipswich LGA reported at Moggill Koala Hospital 1990 – 2015 (Source: Ipswich Koala Protection Society).

1990: Ellis and team

In 1990 the first report of release of rehabilitated koalas in Queensland was undertaken by one of the authors of this current report. Despite the extensive koala rehabilitation program in the south east of Queensland, which to date has probably rehabilitated and released several thousand koalas (making, it is hoped, a significant contribution to the fight against the population decline), very little has been published regarding the success of such programs. Ellis (Ellis *et al.* 1990) released several koalas that had recovered from road trauma into a population of koalas being studied at Mutdapilly and reported on their survival and movement.

1990 – 1999: White and team

At the same time, also at Mutdapilly, a team led by Neil White (White and Kunst 1990) from Queensland University of Technology was investigating habitat use and ecology of koalas in south east Queensland, using the koalas of Ipswich LGA as the study group. The team also looked into the presence of *Chlamydia* (White and Timms 1994) in the Mutdapilly population – several years before the Koala Coast became the hub of research activity in south east Queensland.

White found that the prevalence of infection ranged from 39 to 71% at Mutdapilly, with no evidence of a trend over time during their work. Although *C. psittaci* (now considered to be *C. pecorum*) was isolated from 46 koalas in their study, only six (9%) of these had clinical signs of disease and most adult females (82%) had back or pouch young present. Females had more urogenital and fewer concurrent ocular and urogenital infections than males. They reported that males occupied home ranges of some 8 hectares, while females where more likely to range within 3.5 Ha at their site. In his PhD thesis, White (1994) concluded that these koalas were not reliant on corridor systems as many regularly moved between habitat remnants across grazing paddocks, making frequent use of isolated trees in paddocks and used multiple patches. His radio-tracking data show that long range movements (> 2 km) may be frequent and that corridors appear less important, but are treated as available habitat. White concludes that the establishment of bio-diversity reserves that also provide for other species may be unnecessary for long-term koala conservation.

OWAD Environment report

OWAD Environment conducted a koala survey using their specialist koala scat-detection dog (Taz) in late 2015. A comprehensive survey of some 155 locations over ten days across Ipswich LGA, this report is an excellent precursor to further research and planning for koala conservation in the region. Scats were found at 44% of the locations including a number of conservation estates, but not Stirling Road Reserve or Haig St Quarry (Woosnam 2015). Koala presence was confirmed on a number of private agricultural properties, as well as parks and urban areas such as Pine Mountain, Leichhardt, Collingwood Park, and Goodna. This report confirms the continued presence of koalas in the Mutdapilly area as well. Notable locations included Mount Grandchester Conservation Estate, Redbank Rifle Range; the Ric Nattrass Environmental Park; White Rock-Spring Mountain Conservation Estate; Flinders-Goolman Conservation Estate; and the Purga Nature Reserve.

Department of Environment and Heritage Protection surveys

Surveys conducted by the Queensland Department of Environment and Heritage Protection between April 2011-April 2012 (unpublished - results available on DEHP website) indicated a broad distribution of koalas across the Ipswich LGA. The suburbs of Ebenezer, Willowbank and Mt Forbes showed the highest koala abundance.

Ipswich Council Community Koala Count

Between 28 September and 5 October 2015, Ipswich City Council coordinated a spot-a-koala program, during which residents were encouraged to survey their property for koalas. Sightings were reported from residential areas such as Collingwood Park, Thagoona and on the Amberley Air force base – where koalas have been known to occur for many years.

Population estimates

A range of techniques has been used to estimate the distribution and abundance of koala populations across Queensland since some of the earliest surveys were conducted (Phillips 1990). Koala population estimates will vary between regions, depending on the habitat types and resources available to conduct surveys. Community-response surveys, daytime and spotlight surveys, koala vocalisations and faecal pellet surveys have all been used to estimate koala density and distribution in Queensland. However, koalas are a cryptic species and can be difficult to detect, often leading to under-estimates of koala densities (Qld EPA 2006) and the even the most rigorous techniques can incorporate errors or result in inadequate estimates (Rhodes *et al.* 2011; Ellis *et al.* 2013).

Although a recent survey of koala scats conducted for Ipswich City Council (Woosnam 2015) surveyed the presence/absence of koalas or their signs on council natural area estates, parks and reserves plus one private property, there are, otherwise, surprisingly few published surveys of koalas in the Ipswich area. Wildlife rescue and hospital records provide a valuable source of information, but they can be biased towards more populated areas and the location and higher speed zones of roads. Data collected through initiatives such as the Australian Koala Foundation's Koala Map and the Koala Tracker are also commendable, however the data collected via such methods tend to be opportunistic and biased towards areas of higher human population. It is therefore difficult to gain an estimate of population size and density for a given area from such records.

The Koala Conservation Plan (Qld EPA 2006) states that the local density of koala populations in Queensland ranges from "0.005 koalas/ha (or 1 koala per 200ha) (Melzer and Lamb 1994) to 2.5 koalas per ha (Gordon *et al.* 1990)". In the Koala Coast (an area of approximately 375km2 located 20km south east of Brisbane, where there is adequate water and koala food trees), Dr Frank Carrick, from the University of Queensland, suggests that there could be up to 0.2-0-4 koalas per hectare (Gerada 2014). Carrick also states that a density of up to 2.5 koalas/hectare may be found in high-quality habitat in this region.

Despite the high level of uncertainly attached to any extrapolated prediction of population estimates, and within a context of presumed decline (McAlpine *et al.* 2015) we undertook to estimate koala population of the Ipswich LGA using a basic but acceptable method. This estimate will be refined according to ground truthing and updated data, and the confidence limits around it will hence reduce, but in order to place the population occurring in the Ipswich LGA in a state and national context, such attempts to define population size are required.

Our approach was to use the distribution of recent koala sightings and previous survey observations (including scat surveys) as a proxy for known distribution of koalas in the LGA. This will be improved as more observations are made. Those regional ecosystems represented in the sighting data can then form the base layer of distribution against which known (local) population densities were applied, based again on surveys within (and beyond) the Ipswich LGA. Finally, applying the area of available habitat to the approximate koala population densities we arrived at a koala population density estimate base on current mapped vegetation in the LGA. This excludes non-habitat such as urban and agricultural areas, both of which are known to retain koalas. In the case of agricultural landscapes, the inability to incorporate vegetation re-growth areas as mapped units is a major impediment to accurate population estimates, as they are significant contributors to koala habitat across Queensland.

Table 2. Estimated koala population size based on estimates of Regional Ecosystem capacity and reported koala presence in the Ipswich LGA

REGIONAL ECOSYSTEM (RE)	DESCRIPTION	AREA OF RE REPORTED IN IPSWICH LGA 2011 (HA)	ESTIMATED KOALA DENSITY (KOALAS PER HA)	POSSIBLE KOALA POPULATION SIZE	REPORTED KOALA PRESENCE IN IPSWICH LGA
12.3.3	*Eucalyptus tereticornis* woodland to open forest on alluvial plains	751	High	225	Scats
12.3.6	*Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains	21	High	6	No reports
12.3.7	*Eucalyptus tereticornis, Callistemon viminalis, Casuarina cunninghamiana* fringing forest	279	High	84	Scats
12.3.10	*Eucalyptus populnea* woodland on alluvial *plains*	21	Medium	4	No reports
12.3.11	*Eucalyptus siderophloia, E. tereticornis, Corymbia intermedia* open forest on alluvial plains usually near coast	47	Medium	9	No reports
12.5.1	Open forest complex with *Corymbia citridora* on subcoastal remnant Tertiary surfaces. Usually deep red soil.	16	Low	0	No reports
12.5.2	*Eucalyptus tereticornis, Corymbia intermedia* on remnant Tertiary surfaces, usually near coast. Usually deep red soil.	4	High	1	No reports

REGIONAL ECOSYSTEM (RE)	DESCRIPTION	AREA OF RE REPORTED IN IPSWICH LGA 2011 (HA)	ESTIMATED KOALA DENSITY (KOALAS PER HA)	POSSIBLE KOALA POPULATION SIZE	REPORTED KOALA PRESENCE IN IPSWICH LGA
12.5.3	*Endangered Eucalyptus tindaliae* and/or *E. racemosa* open forest on remnant Tertiary surfaces	113	Medium	23	No reports
12.8.9	*Lophostemon confertus* open forest on Cainozoic igneous rocks	113	Low	1	No reports
12.8.16	*Eucalyptus crebra, E. tereticornis* woodland on Cainozoic igneous rocks	372	Low-Medium	74	Scats
12.8.17	*Eucalyptus crebra, E. melanophloia* woodland on Cainozoic igneous rocks	1526	Medium	305	No reports
12.8.20	Shrubby woodland with *Eucalyptus racemosa* or *E. dura* on Cainozoic igneous rocks	53	Medium	11	No reports
12.8.24	*Corymbia citriodora* open forest on Cainzoic igneous rocks especially trachyte	455	Low	5	Scats
12.9-10.2	*Corymbia citriodora, Eucalyptus crebra* open forest on sedimentary rocks	9988	Low-Medium	1998	Scats
12.9-10.3	*Eucalyptus moluccana* on sedimentary rocks	513	Low-Medium	103	Scats
12.9-10.4	*Eucalyptus racemosa* woodland on sedimentary rocks	1	Medium	0	No reports
12.9-10.5	Open forest complex often with *Corymbia trachyphloia, C. citriodora, Eucalyptus crebra, E. fibrosa subsp. fibrosa* on quartzose sandstone	154	Low	2	No reports

REGIONAL ECOSYSTEM (RE)	DESCRIPTION	AREA OF RE REPORTED IN IPSWICH LGA 2011 (HA)	ESTIMATED KOALA DENSITY (KOALAS PER HA)	POSSIBLE KOALA POPULATION SIZE	REPORTED KOALA PRESENCE IN IPSWICH LGA
12.9-10.7	*Eucalyptus crebra* woodland on sedimentary rocks	3992	Medium	798	No reports
12.9-10.8	*Eucalyptus melanophloia, E. crebra* woodland on sedimentary rocks	0	NA	0	No reports
12.9-10.12	*Eucalyptus seeana, Corymbia intermedia, Angophora leiocarpa* woodland on sedimentary rocks	246	Low-Medium	49	Scats
12.9-10.17	Open forest complex often with *Eucalyptus acmenoides, E. major, E. siderophobia +/- Corymbia citridora* on sedimentary rocks	701	Low-Medium	140	Scats
12.9-10.19	*Eucalyptus fibrosa* subsp. *fibrosa* open forest on sedimentary rocks	2645	Low /Low-Medium	132	Scats
12.11.5	Open forest complex with *Corymbia citridora, Eucalyptus siderophloia, E. major* on *metamorphics* +/- interbedded volcanics	6	Low	0	No reports
Total	-	**22,017**	-	**3970**	-

(adapted from City of Ipswich 2015b, p.101 and Woosnam 2015, p.8: Low = 0.01, Low-Medium = 0.2, Medium = 0.2, High = 0.3).

The calculations of koala numbers are a minimum population estimate, based on currently-mapped vegetation, but this estimate would indicate that there is a significant koala population present in the Ipswich LGA.

Of the population estimate of 3970 koalas, 2810 koalas are predicted based on Regional Ecosystems known to be koala habitat in which either koalas or their signs (scats) were found within the Ipswich LGA. A further 1160 koalas are predicted to occur in REs from which no positive sightings have been reported for the Ipswich LGA, but in which REs koalas have been found at other locations. It is worth noting that, for example, REs on land zone 8 (young igneous rock such as basalts and rhyolites that form extensive plains, hills, cones and plugs) and 11 (metamorphosed rocks forming ranges, hills and lowlands with shallow, low-fertility soils) are generally considered unsuitable as koala habitat, yet koala scats have been found in these habitats (Woosnam 2015), suggesting that such areas may also be suitable for koalas – hence this informed our predictions.

Calculating the koala population based on predicted density at the upper range, multiplied by land area, results in a slightly higher figure of 4368 koalas, but conversely informing the calculations with minimum population densities observed at other locations in Queensland (for example western *E. populnea* or *E. crebra* – dominated woodlands), results in a lowest estimate of 1546 koalas. These estimates represent the possible fluctuation in population size to be expected based on various factors including seasonal conditions (extended drought for example), stochastic events (fire) or the temporal influence of disease or wild dog predation. It needs to be noted that even with ground truthing by surveys, estimates of local abundance can vary significantly and even the most adept survey teams are likely to underestimate koala populations (Dique *et al.* 2004). Indeed, comparing survey and scat search data with reports of injured koalas reveals that koalas have been reported from areas where surveys revealed few, and across narrow geographical ranges vastly different accounts of koala population densities result. The most recent government data do little more than reinforce this view: surveys of Purga Nature reserve were unable to detect koalas, but a survey of Middle Road in Purga recorded densities in the order of 0.2 koalas per hectare (Qld DEHP online data).

A population in excess of 4000 individuals – which, based on our conservative estimate is likely, occurring in close proximity to major human population centres and having a history of residency (as does this group) is certainly *en route* to achieving significant status under the guidelines of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth 1999). Considering that the total area of Regional Ecosystems remaining in the Ipswich LGA that are assumed to support koalas is only 20% of the total land area and that koalas are also known to occur in both rural and urban areas, the actual number of koalas present is likely to be higher than this.

The large areas of remnant RE (for example 12.9-10.2, 12.9-10.7 and 12.9-10.19) may be important areas for koala conservation and maintaining viable populations, as they demonstrate capacity to support large populations of koalas elsewhere. Dique *et al.* (2004) highlighted the importance of large areas of bushland for koala conservation in the Koala Coast region, as these large areas provided the habitat for the majority of the population. Conversely, some of the largest areas of REs (12.9-10.2 and 12.9-10.19) are considered to be of 'Least Concern', meaning they may not be protected under legislation and this represents an additional threat to the koala population against which mechanisms to preserve such areas are required.

GENETICS AND CONNECTIVITY

Levels of genetic variation may affect fitness in koalas (Sherwin *et al.* 2000). In general, loss of gene flow and therefore genetic variation in species is considered to increase inbreeding, which can lead to reductions in reproductive success, disease resistance and ability to adapt to changing environmental pressures.

Urbanisation is likely to both reduce population size and restrict gene flow (Lee *et al.* 2010). In addition, rivers and major roads may act as barriers to koala movement and therefore gene flow (Dudaniec *et al.* 2012). Small, highly isolated populations are also more susceptible to extinction risks than populations that are connected via animal movement because they have no means of replacing genetic information that might be lost during stochastic events. Thompson (2006) states that 'there is a significant risk that koala populations inhabiting small areas of remnant bushland surrounded by urban areas will be isolated from the interchange with other populations.' Individuals may need to be moved or translocated to these sites in order to maintain populations and this approach could provide an alternative to establishing or maintaining movement corridors, however this option is less preferable than conserving natural populations (Thompson 2006). Indeed, the findings of Thompson (2006) contain warnings for the future of the Ipswich koala population and ideas for its management, particularly with regard to the impact of roads and other development in fragmenting this population.

Research in the Brisbane region suggests that the urban Ipswich koala populations may even be important natural sources for replenishing bushland koala numbers. The Queensland Department of Environment and Resource Management (2009) found that the 59% reduction in koala numbers observed in bushland areas of the Koala Coast (compared to a 30% reduction in urban areas) was a flow on effect of excessive habitat loss and mortality in urban areas. This demonstrates the importance of urban koala populations and the requirement for connectivity to maintain viable koala populations in both urban and bushland areas.

Dudaniec and co-workers (2013) found that the presence of highways or freeways represents a major barrier to gene flow. For the Ipswich area, Lee *et al.* (2010) found that the Warrego Highway acted as a barrier to gene flow, separating koalas in the Ipswich LGA from those in the Esk region to the north of the highway. However, where these barriers are not present, there does appear to be gene flow between LGAs, indicating the importance of local governments working together to sustain koala populations (Lee *et al.* 2010).

Habitat fragmentation arising from residential and infrastructure development can also result in rapid reproductive isolation and genetic differentiation within populations (Lee *et al.* 2010). Improving landscape connectivity within LGAs or between nearby LGAs is likely to be an important factor in facilitating gene flow (Dudaniec *et al.* 2013). For the Ipswich LGA, mitochondrial DNA suggests a unique grouping (Figure 2), which could be evidence of separation of populations over time, however the Geneland clustering reported by Lee *et al.* (2010) (Figure 3, Table 3, Table 4) support the hypothesis that the Ipswich and Beaudesert populations are contiguous and could be managed as a unique entity. These data do point to the uniqueness of the Ipswich – Beaudesert population, and hence its significance as a reservoir of genetic information for the koalas of Queensland.

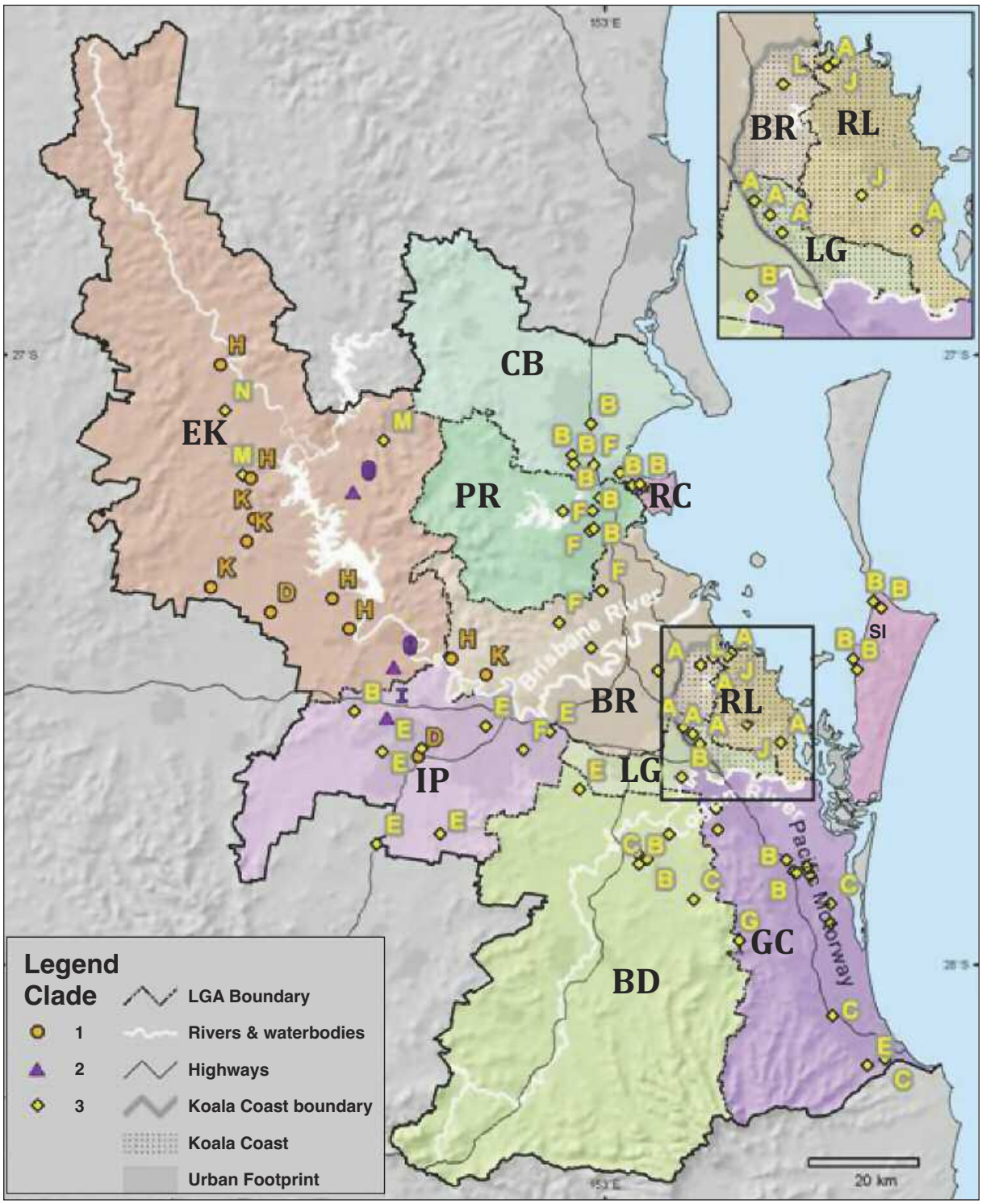

Figure 2. Spatial distribution of mtDNA haplotype clades. LGA abbreviations: BD Beaudesert, BR Brisbane, CB Caboolture, EK Esk, GC Gold Coast, IP Ipswich, LG Logan, PR Pine Rivers, RC Redcliffe, RL Redland, SI North Stradbroke Island. (Koala Coast shown in inset).

(Lee *et al.* 2010)

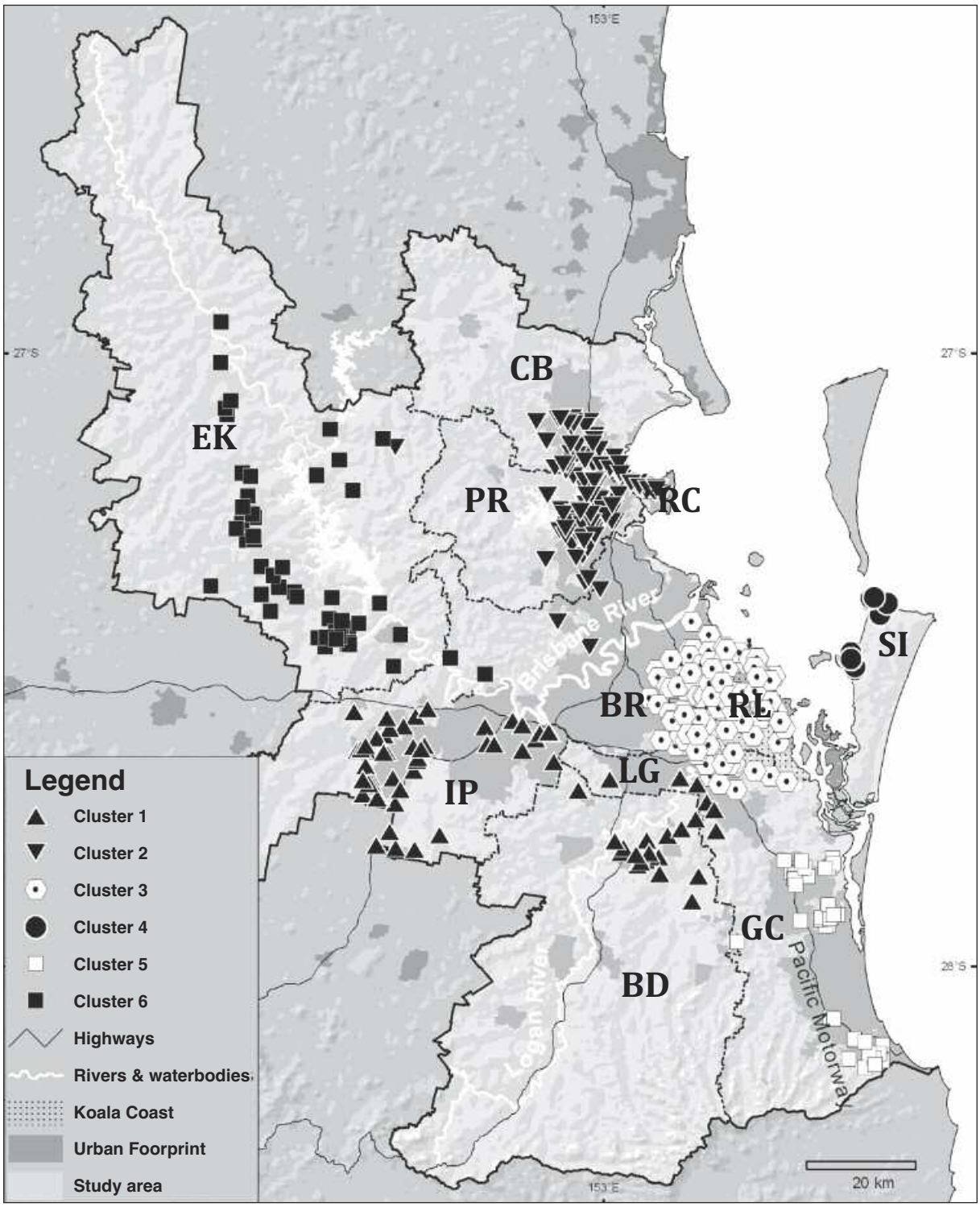

Figure 3. Clusters as determined by Geneland for SEQ Koalas.

Cluster 1 ▲ – Beaudesert, Ipswich; Cluster 2 ▼ – Pine Rivers, Caboolture, Redcliffe;
Cluster 3 ⬡ – Koala Coast (Brisbane, Logan, Redland); Cluster 4 ● – North Stradbroke Island;
Cluster 5 □ – Gold Coast; Cluster 6 ■ – Esk. (Lee *et al.* 2010)

Table 3. Pair-wise population differentiation (FST) between south east Queensland koala populations.

	CLUSTER 2 ▼	CLUSTER 3 ⬡	CLUSTER 4 ●	CLUSTER 5 □	CLUSTER 6 ■
Cluster 1 ▲	0.07	0.08	0.18	0.04	0.05
Cluster 2 ▼		0.10	0.22	0.07	0.04
Cluster 3 ⬡			0.24	0.06	0.11
Cluster 4 ●				0.14	0.18
Cluster 5 □					0.04

Legend: Based on six Geneland clusters estimated from six polymorphic microsatellite loci. (Lee et al. 2010)

Lee *et al.* (2010) found evidence of high genetic diversity across SEQ koala populations and they suggest that koalas of the Koala Coast are genetically differentiated from the broader population in Queensland. Similar findings appear likely for the Ipswich population – recalling that koala populations do not respect LGA boundaries. The later work of Kjeldsen and co-workers illustrates this point: if instead of referring to populations by LGA boundaries, we consider the genetically distinct groups, the koalas contained in the Ipswich LGA are distinct from other populations sampled (Kjeldsen *et al.* 2015).

Table 4. Genetic variation detected at six microsatellite loci in south east Queensland koala populations defined by Local Government Areas for convenience of description.

POPULATION	n	MEAN NO. OF ALLELES	MEAN ALLELIC RICHNESS	AVERAGE OBSERVED HETEROZYGOSITY	AVERAGE EXPECTED HETEROZYGOSITY
Beaudesert	18	7.8	7.8	0.81	0.78
Brisbane	60	7.8	6.3	0.72	0.74
Caboolture	46	7.0	6.3	0.74	0.76
Esk	50	10.2	8.1	0.79	0.80
Gold Coast	48	9.7	7.9	0.73	0.79
Ipswich	50	9.3	7.8	0.73	0.76
Logan	78	6.5	5.5	0.72	0.72
Pine Rivers	62	7.3	6.1	0.73	0.77
Redcliffe	18	6.0	6.0	0.68	0.71
Redland (mainland)	62	6.2	5.2	0.72	0.69
North Stradbroke Island	20	3.5	3.5	0.53	0.56

(Lee *et al.* 2010)

Hence, on the basis of population size, current and approaching threats and genetic differentiation, the koala population of the Ipswich LGA is a significant population for the conservation of this species in Australia.

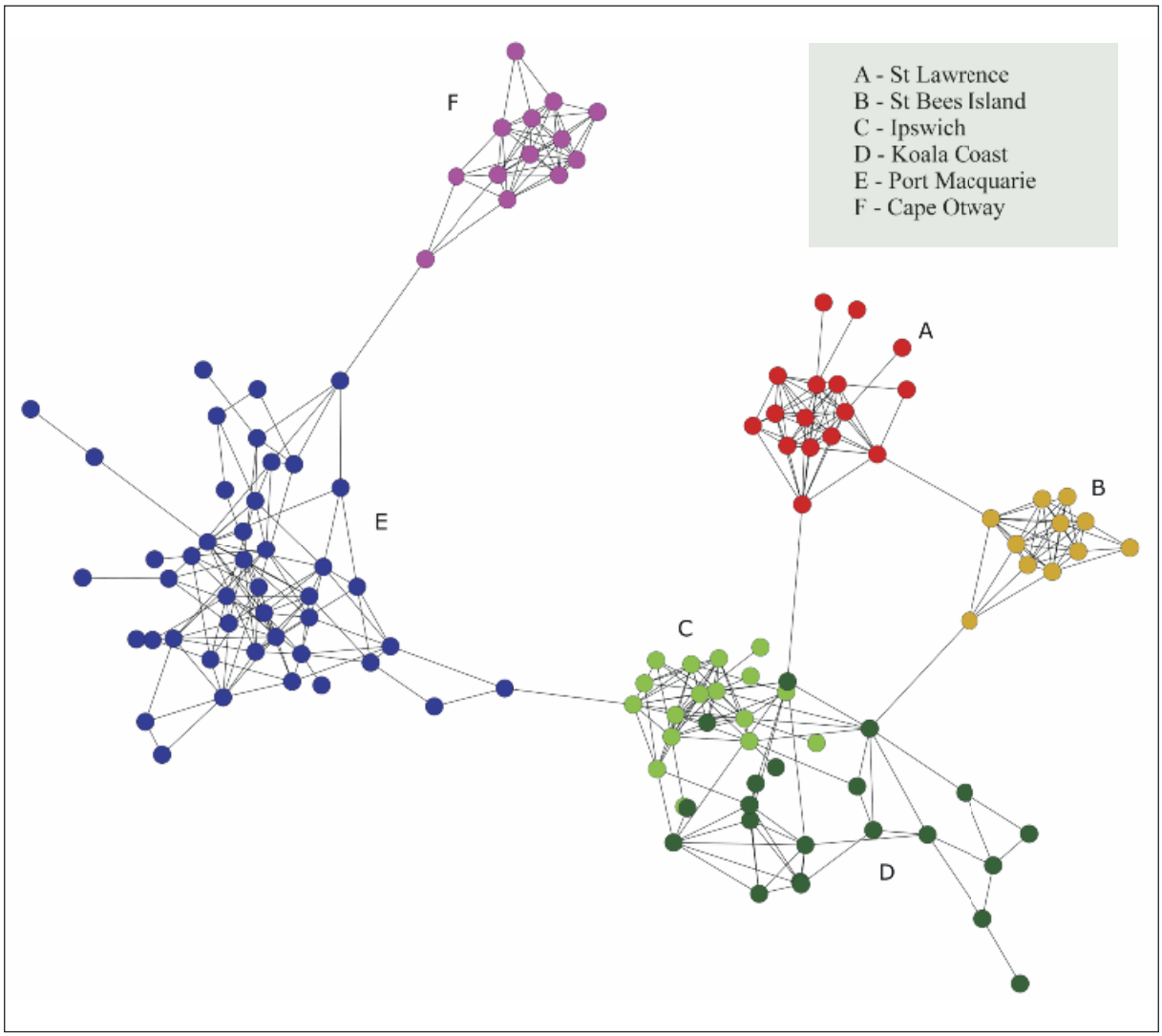

Figure 4. Population clustering of Queensland populations using an isolation by state (IBS) matrix constructed using the NETVIEW v5.0 pipeline visualised at kNN=10 with a NSW and Victorian population added for reference (Kjeldsen et al. 2015).

Conservation significance of the koalas of Ipswich

The Ipswich LGA is included in the Koala District A, or area of highest threat in the Queensland Koala Conservation Plan 2006. In District A, koala population densities are the highest, however the threats associated with habitat destruction and human impacts are also the greatest, resulting in a reduction in the long-term viability of some koala populations (Qld EPA 2006). Ipswich LGA includes areas identified as Koala Conservation Areas, Koala Sustainability Areas and Urban Koala Areas. The Koala Plan recognises Koala Conservation Areas and Koala Sustainability Areas as the most critical to the continued existence of viable koala populations in the wild.

The 2008 survey of the Koala Coast estimated a population of 2279 koalas, representing a 51% decline from the 4611 koalas estimated to be in the area in 2005-2006 and a 64% decline from the original estimate of 6246 (Qld DERM 2009). This represents an estimated loss of 2332 koalas from the region in the three years from 2005 to 2008. These figures demonstrate how rapidly koala numbers can fall in developing urban areas. In this context, our estimate of a minimum population of 3500 - 4500 indicates that the koalas in the Ipswich LGA are also likely to represent a significant population.

Despite the lack of quantitative assessment of the dynamics or size of the Ipswich koala population, the similarities, in terms of development pressure, that exist in this LGA compared to both Pine Rivers and the Koala Coast, suggest that a similar downward trend in population numbers is likely. The pressure of urban development in the Ipswich LGA has seen a significant and comparable increase in the number of proposed and built dwellings in this LGA. In the Ipswich region, agricultural and industrial clearing (as well as for potential mines) only adds to this pressure.

THREATS

Habitat loss

Threats to the long-term persistence of koalas are visible in heavily developed areas, and south east Queensland is one of Australia's fastest growing regions (Qld DERM 2009). The human population of the Ipswich LGA is expected to more than double by the year 2031 (Qld Department of Infrastructure and Planning 2009) and the majority of reports of dead or injured koalas tend to come from developed areas where koalas are readily observed and hence reported (Qld DERM 2009). The Ipswich LGA has a population of approximately 190,000, which, according to the SEQ Regional Plan, is estimated to increase to 435,000 by the year 2031, with an additional 118,000 dwellings to be added between 2006 and 2031 - more than tripling the 52,300 dwellings present in 2006 (Queensland Government Department of Infrastructure and Planning 2009). This area of significant growth is expected to play a key role in the Plan's preferred settlement pattern.

The Koala Plan encourages local governments (in collaboration with the Environmental Protection Agency) to 'undertake further mapping to identify koala habitat and provide additional habitat protection, particularly in the SEQ region and in areas of the state subject to higher growth pressures where koalas and koala habitat are known to occur' (Qld EPA 2006). Where there are areas of non-remnant vegetation, the identification of koala habitat is of particular importance as koalas readily use it as habitat and this vegetation is not necessarily protected from clearing under the Vegetation Management Act (Qld EPA 2006).

In 1999, bushland in the Ebenezer/Mt Forbes area was listed as essential koala habitat (Boyland 2011). However, under the SEQ Regional Plan, Ebenezer is now listed as a Regional Development Area for employment (Qld DIP 2009). Purga is also listed as a residential and employment Identified Growth Area. Developments in these areas would also be likely to require key infrastructure upgrades to regional road networks, water, sewerage, telecommunications and energy (Qld DIP 2009), providing potential for further habitat damage and road impacts.

Habitat loss is considered to be the greatest threat to koala survival. Clearing for urban development, broad scale clearing in rural and peri-urban areas and fragmentation by development creating barriers to movement between retained patches of bushland all contribute to loss of koala habitat (Qld EPA 2006). Poor management, fire, or pest and weed infestations can also lead to bushland becoming degraded (Qld EPA 2006). Recent legislative amendments in Queensland removed the 2006 ban on broad scale land clearing for High Value Agriculture, which provided protection for a considerable amount of Queensland's koala habitat.

Importantly, these changes also removed the 2009 protections for High Value Regrowth (except on leasehold land) and increased the burden of proof on government in cases of illegal land clearing.

As a direct result, around 3.5 times more native vegetation is now being cleared annually in Queensland compared with 2009 (from about 78,000 ha in 2009 to some 278,000 hectares in 2014).

In addition to loss of habitat, fences, roads and cleared land can create barriers to koala movement. This can alter population dynamics, impede gene flow and limit the ability of populations to recover. However, road verges have been shown to support significant numbers of koalas and should not be discounted as a suitable habitat (Ellis unpublished data).

As koala habitats become more fragmented, there is a greater need for koalas to cross roads to access food and shelter resources and to find mates. According to the Qld EPA (2006) after habitat clearing and fragmentation, vehicle related mortality has the most significant impact on koalas. Roadways represent barriers between areas of remaining fragmented habitat. It is predominantly breeding-age animals that are killed by vehicles (Qld EPA 2006) and traffic volume, speed, road position and road design can all affect koala mortality on roads.

Roads and rail, disease and dogs

The Ipswich LGA has major roads and a rail line running through the centre of it, including near Koala Conservation Areas. The majority of traffic strikes recorded in the Ipswich area in 2014 were in speed zones of 80km/hr or above (Queensland Parks and Wildlife Service (QPWS), unpublished) which concurs with reports from the Koala Coast (Preece 2007). Wildlife Queensland advocates reduced speed limits of 60km/hr on roads located near or within koala habitat as koalas injured in accidents where speeds of 60km/hr or less are involved have a greater chance of recovery for release to the wild (Boyland 2011).

This report does not examine the impact of the proposed Southern Freight Rail Corridor, the proposed alignment of which may take it directly through some significant habitat in which koalas are known to reside. The long term effects of such an alignment could be particularly damaging for the koalas of Ipswich, due to fragmentation of the population, loss of habitat and ongoing deaths from vehicular impacts. However, the short term impacts of such a development, as indicated in the Moreton Bay Rail koala study, for which 264 of the 490 koalas encountered have died between March 2013 and December 2015 (Qld DTMR n.d.) could be devastating. Given the low level of disease reported for that population (25% (Qld DTMR n.d.) the loss of some 54% of the population during the construction phase of any project is cause for concern.

Koalas are commonly admitted to the Queensland DEHP's Moggill Koala Hospital for treatment and/or rehabilitation for chlamydial-related diseases and traumatic injuries caused by cars and dogs. Data from the Moggill Koala Hospital indicate that the rate of annual incidental harvest due to road mortality and dog attack in some developed areas of south east Queensland approximates six percent of the population estimate (EPA/QPWS 2006; QPWS 2002; reported in Biolink 2007).

In 2014, the Queensland Parks and Wildlife Service reported the presentation of 64 koalas from the Ipswich region, comprised of 44 sick or diseased (mostly Chlamydia-related and 24 were euthanased or died), 15 from traffic strikes and 5 as a result of dog attack (QPWS, unpublished).

Koalas in the south east corner of Queensland are also impacted by chlamydial disease, but recent work by ours and other teams suggests that there are other causes of mortality affecting populations that may be more important. For example, recent work in the Moreton Bay Regional area found most deaths were due to dog attack. Away from the south east corner, most studies are longitudinal ecological studies, which focus on behavioural ecology (for example) in relatively undisturbed or open landscape systems. In those environments, disease has not been found to be as prominent as in urban systems, and our results confirm this to be the case.

Both domestic and wild dogs can pose a threat to koalas moving between trees. The koala is an arboreal folivore, but it routinely moves across the ground between trees, making it susceptible to attack by dogs. Recent work in south east Queensland has identified dog attack as the single biggest killer of koalas in the Moreton Bay Rail Alignment, and domestic dogs have been found to pose a significant and preventable impact on koala populations, particularly in south east Queensland (Qld EPA 2006). The Queensland Koala Plan states that attacks from domestic dogs are the third most significant known cause of death behind car strikes and habitat clearing. These attacks generally occur in suburban backyards (Qld EPA 2006) but also occur when dogs are allowed off-leash in bushland areas and as a result of wild dog attacks.

Chlamydial disease is a common bacterial infection in koalas, and most wild koala populations are infected. *Chlamydia* can cause a variety of clinical symptoms in koalas including eye infections, which can lead to conjunctivitis and blindness in severe cases; urogenital infections in female koalas, which can lead to infertility or cystitis - which is generally fatal unless treated very early; and respiratory infections (including nasal discharge), which can lead to pneumonia in some cases.

Many koalas in Queensland are infected with Koala retrovirus (or KoRV) – in some cases this will be as high as 100% of all koalas (Ellis unpublished data). This retrovirus may cause suppression of the immune system, leukaemia and lymphoma in koalas, however to date there is no evidence that it affects koalas at a population level.

No detailed assessment of the impact of Chlamydial disease across the Ipswich koala population has been undertaken, but a survey conducted by DEHP (2013 unpublished) describes a disease prevalence of 22% and an observed breeding rate of 42% in the koala populations of the Ipswich LGA. The earlier report of White (1999) found relatively high rates of infection, but also high fecundity and a low level of disease signs, in the population near Peak Crossing, but how this translates across the LGA is unknown.

Climate change and fires

Both wildfires and controlled burns for fuel reduction can kill or injure koalas and destroy or alter their habitat. In unobstructed environments, koalas can usually escape from fires, however in fragmented habitats with barriers such as fences and major roads, this makes it more difficult and may result in higher than normal koala mortality from fires. Fires also result in displacement of koalas and further habitat fragmentation.

Current predictions are that the koala will experience significant range contractions as climate change progresses (Adams-Hosking *et al.* 2011; Seabrook *et al.* 2011; Melzer *et al.* 2013). This will impact the Ipswich koala population through both direct climate pressure on food and shelter tree species, but also demographic pressure exacerbated by intervention and/or immigration in the case that the Ipswich region becomes a refuge for koalas. Changes in the distributions of some koala food trees as well as range contractions are predicted, so refugia, especially those that are thought to have existed during previous climate changes or other environmental challenges, could be critical for conservation of a range of species, including koalas.

There is also evidence that an increased concentration of CO2 in the atmosphere could affect the nutritional quality of the koala's eucalypt food - and this is one of the factors determining the koala's IUCN (2009) listing of the koala as highly vulnerable to climate change. Koala tree choice appears to be influenced by temperature and hence will be affected as the climate changes (Ellis *et al.* 2010). There are indications that both koalas and koala food trees may experience significant decreases in their range as the effects of climate change lead to rapid changes in forest structure and plant composition. Koalas suffer from heat stress and dehydration in extreme temperatures and are highly vulnerable to heatwaves (Gordon *et al.* 1988). Koala population crashes have been observed after heat wave events and in the west of Queensland an 80% decline in the Mulgalands was detected following a 10-year drought (Adams-Hosking *et al.* 2011). By 2050 patchy regions close to coastal areas could be the only climatically suitable habitat remaining in Queensland, and the Ipswich LGA should be one of these refugia.

COAL MINING IN THE IPSWICH WEST REGION

The Ipswich area has a long association with coal mining and has sometimes been referred to as the 'cradle of coal mining' for Queensland. Coal was first found there in 1825 when an outcrop was found on the banks of the upper reaches of the Brisbane River. Coal mining began in Ipswich around 1848 with small-scale operations on shallow coal deposits on the riverbanks. These operations aimed to exploit the success of Queensland's first coal mine, established in 1843 on the riverbank at Redbank for the Hunter River Steam Navigation Company's paddle steamers.

Within 50 years, the Waterstown, Eclipse, Bremer, New Tivoli and Perseverence mines were in production and a dedicated rail line (the Tivoli Branch Railway Line) was built in 1898 from the Railway Workshops to mines in the Tivoli area.

The power station at Mt Crosby (which only closed in 1967) was serviced directly by coal from Tivoli and was the first Southern Electric Authority power station to be located on a coalfield. At its peak, some 300 coking ovens were present in the North Ipswich region, with mines providing coal to barges on the river, which were still seen regularly floating through Brisbane up until the late 1990s.

Mining began at Walloon in the 1870s, at Thagoona in 1889 and near Rosewood in 1904. The Jeebropilly operations closed briefly in February 2007 but re-opened in 2008 and the coal washing plant also processes coal from the New Oakleigh mine at Rosewood.

There are several leases in the Ipswich LGA that are current, subject to renewal, expired leases or no longer operational, and these are indicated below. The more significant operations may be Shenhuo's EPC2364 and Scorpion's EPC2127, Jeebropilly's MDL 171, (Jeebropilly's MDL 157 has expired) and the Bremer View MDL 172.

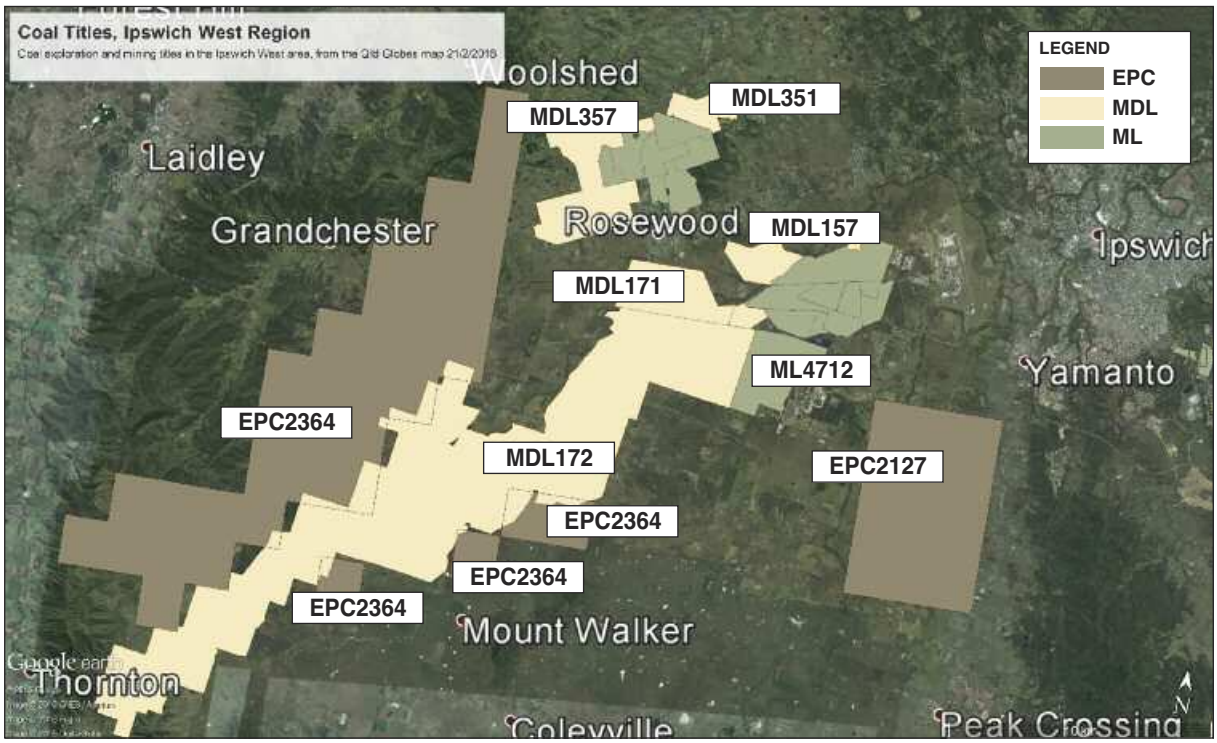

Figure 5. Coal exploration and mining titles in the Ipswich West area (Queensland Globe, State of Queensland 2015)

Table 5. Current granted coal exploration permits and coal production leases. EPC = exploration permit for coal; MDL = mineral development licence; ML = mining lease for minerals/coal. (Source: Qld DNRM 2012)

NUMBER	LOCATION	TYPE	AUTHORISED HOLDER	STATUS / EXPIRY DATE
EPC2127	Purga	Exploration permit	Scorpion Energy Pty Ltd	Renewal lodged
EPC2364	Various	Exploration permit	Shenhuo International Group Pty Ltd	04/12/2017
MDL157	Willowbank	Expansion	Jeebropilly Collieries Pty Ltd	30/09/2016
MDL171	Willowbank	Proposed	Jeebropilly Collieries Pty Ltd	Renewal lodged
MDL351	Rosewood	Proposed	New Hope Collieries Pty Ltd	Renewal lodged
MDL357	Rosewood	Proposed	New Hope Collieries Pty Ltd	Renewal lodged
ML50175	Rosewood	Coal production lease	New Oakleigh Coal Pty Ltd	2020
ML4698	Rosewood	Coal production lease	New Oakleigh Coal Pty Ltd	2020
ML4584	Rosewood	Coal production lease	New Oakleigh Coal Pty Ltd	2020
ML4683	Rosewood	Coal production lease	New Oakleigh Coal Pty Ltd	2020
ML4699	Rosewood	Coal production lease	New Oakleigh Coal Pty Ltd	2020
ML4568	Rosewood	Coal production lease	New Oakleigh Coal Pty Ltd	2020
ML50132	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2019
ML4710	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2030
ML50133	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	Renewal lodged
ML4712	Willowbank	Coal production lease	Zedemar Holdings Pty Ltd (Bremer View & MDL 172)	2023
ML50082	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2023
ML4711	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2030
ML4689	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2016
ML4690	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2016
ML4677	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2024
ML50093	Willowbank	Coal production lease	Jeebropilly Collieries Pty Ltd	2020

EPC 2127 is a large Exploration for Coal permit held by Scorpion Energy, who acquired the lease in June 2015. In 2012, then owner Cuesta planned to drill 14 open holes and four cored holes in exploring this licence, which is based on the Amberley Deposit. According to Cuesta figures there were 40 existing drill holes on the site. Scorpion Energy is a coal exploration and production operation with no listed key Executives. The company was incorporated in 2009, is based in Queensland and since 2011 has operated as a subsidiary of Blackwood Coal Pty Ltd. According to reports from Ipswich Koala Protection Society, several koalas have been presented to the Moggill Koala Hospital from within the boundaries of this lease.

EPC 2364 is an even larger (11000 ha) permit held by Shenhuo International, about which very little information is currently available. Reference to the Ipswich Koala Protection Society reveals a number of reports of koalas from within the boundaries of this lease, but significantly, this lease includes areas around the Mt Forbes and Mt Walker areas, from where some of the highest koala densities have been reported. Queensland Department of Environment and Heritage surveys in the Mt Walker and Mt Forbes areas report koala densities as high as one koala per 3 hectares (Qld DEHP online data). This particular area has also been the site of detailed koala research by both Queensland University of Technology and The University of Queensland, so a body of evidence confirms it to be a valuable area of koala habitat.

In addition to these operations, there are six mining leases in the Rosewood area and ten mining leases in the Willowbank area (shown above in red polygons and below in more detail). These are historical production areas, which should have limited new impacts on koalas in the future, but they are shown to demonstrate their relation to other permits.

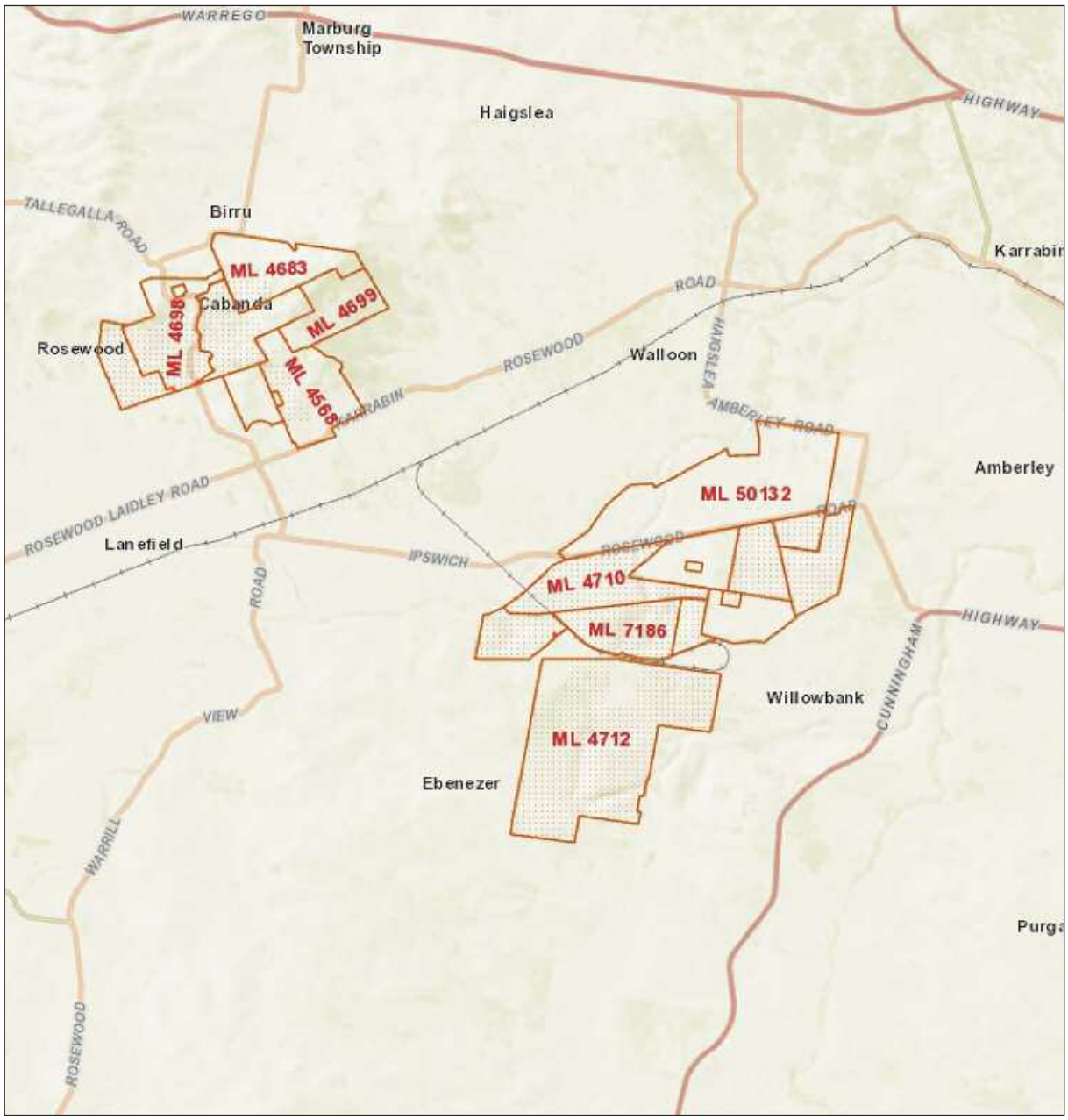

Figure 6. Detail of Rosewood and Willowbank leases. (minesonlinemaps.business.qld.gov.au)

New Hope Coal oversees the Jeebropilly (operational) and New Oakleigh (mining ceased but coal from the stockpile still being transported) mines. Jeebropilly is located 3km from Willowbank, where coal is washed before it is loaded on the West Moreton rail line to Brisbane.

Coal was first produced at the Ebenezer mine (ML4712) in 1988 and by 1994 3 million tonnes (3Mt) was mined annually and the mine employed 120 people. In total, 33.6 Mt was mined and 19.6Mt of coal sold, two thirds of which was for export. Most of the remaining coal in this mine is close to the surface (<100m).

Perhaps the most significant mining permit was held by OGL Resources Limited, which planned to re-open and extend the Ebenezer open-cut coal mine (ML4712, 650 Ha, licensed until 2023) across the large Bremer View mining development lease (MDL172, 9200 Ha). This lease was granted from 5 October 2010 to 31 May 2015. Zedemar Holdings is the current authorised holder of ML4712, but at present the future of the proposal is uncertain and it does not appear on mines online mapping, although it is shown on maps using Queensland Globe. The Bremer View Project covers 9,202ha of private land adjacent to Ebenezer with an estimated resource in the order of 208 Mt.

According to the maps we could source, this project would have a direct impact on some 23,000 acres of agricultural land and company data indicate it would produce some 3 million tonnes of coal per year. Company modelling suggests that servicing the road transport requirements of this mine at peak production would require 7 – 8 trucks per hour added to the traffic heading from the mine. The stalled plan includes mining the Bremer River floodplain, so there are likely to be direct impacts on the Bremer River, which feeds the Brisbane River.

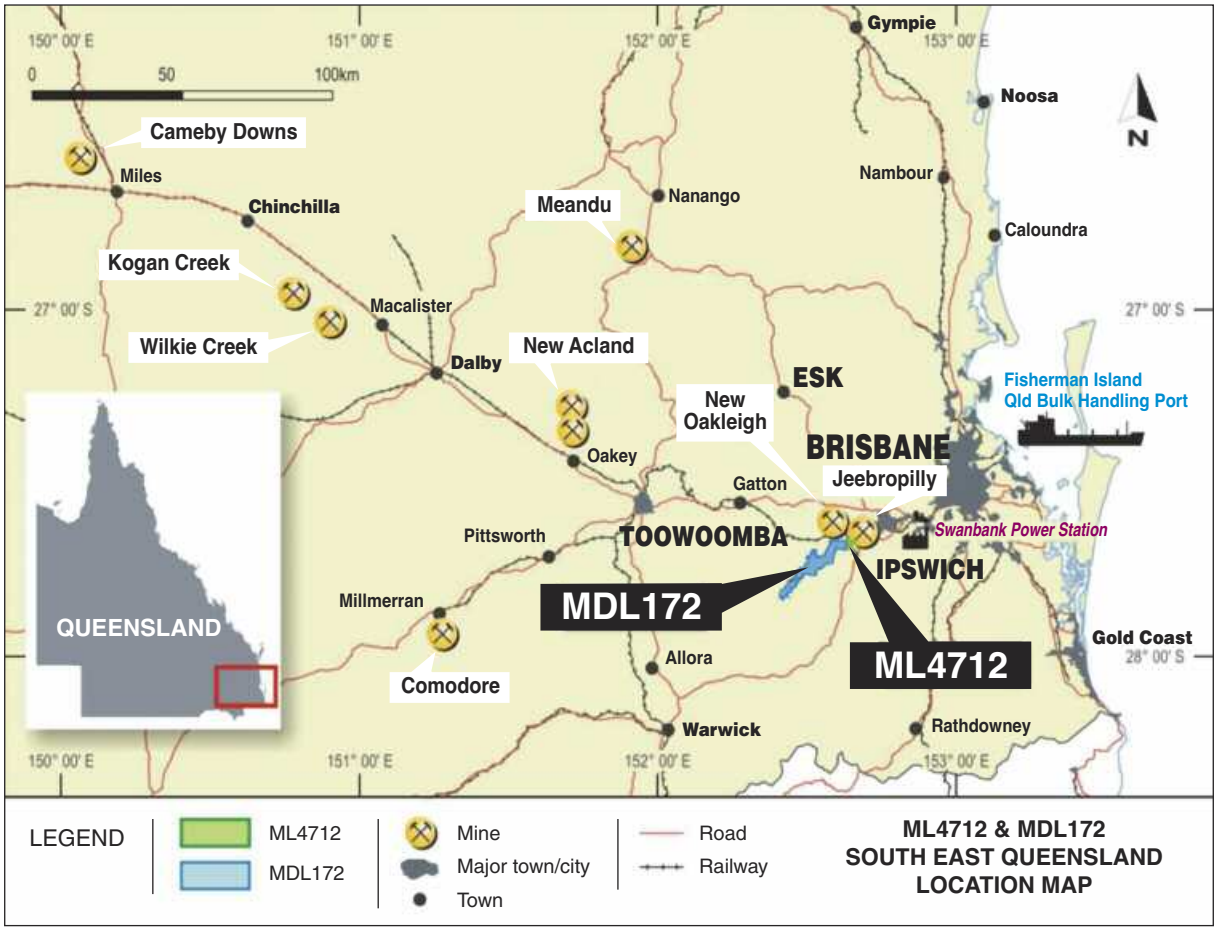

Figure 7. Ebenezer and Bremer View in south east Queensland (OGL Resources Limited Ebenezer & Bremer View Acquisition Presentation Sept 2011 presentation ASX)

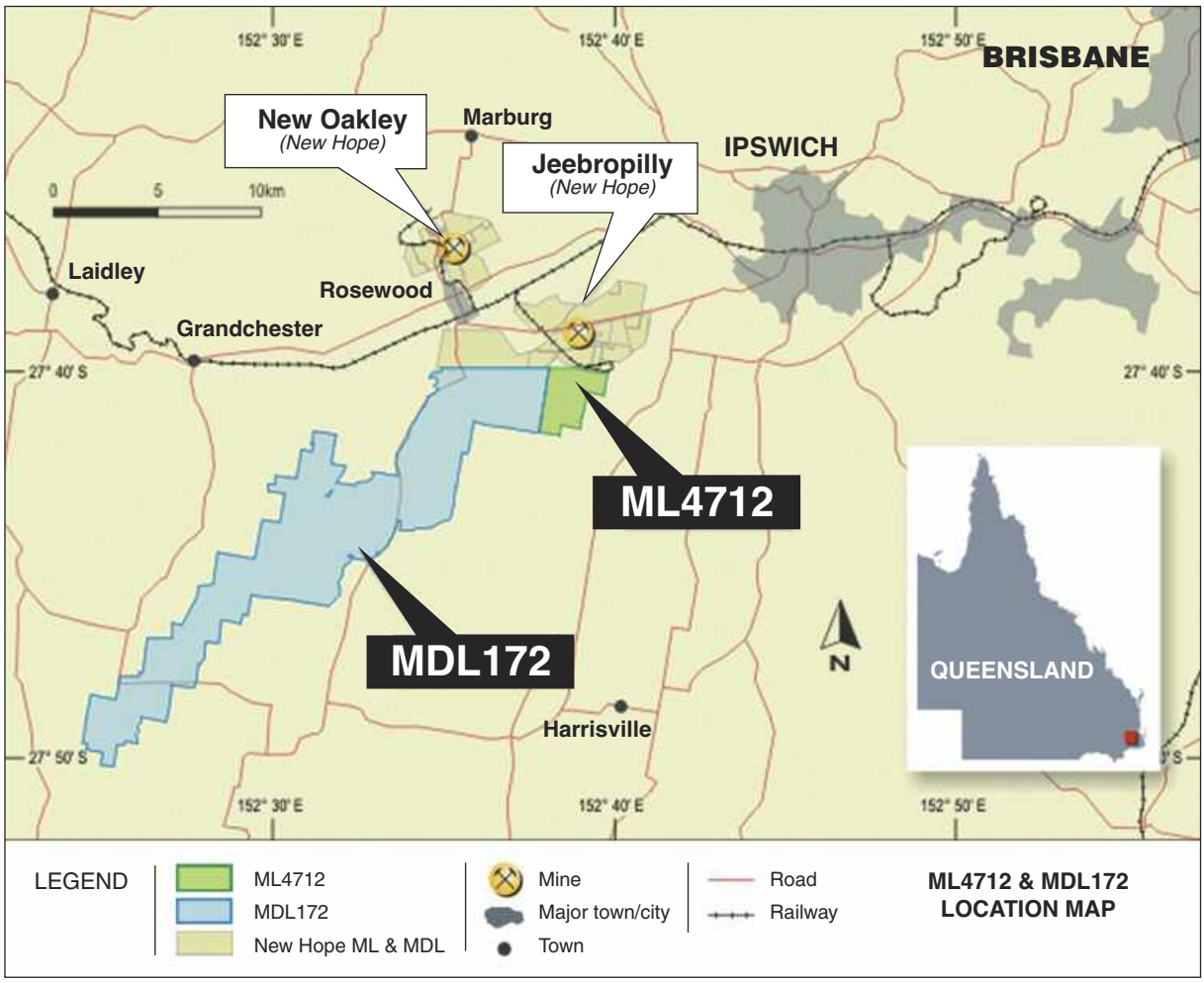

Figure 8. Expanded view of Ebenezer and Bremer View in south east Queensland (OGL Resources Limited Ebenezer & Bremer View Acquisition Presentation Sept 2011 presentation ASX)

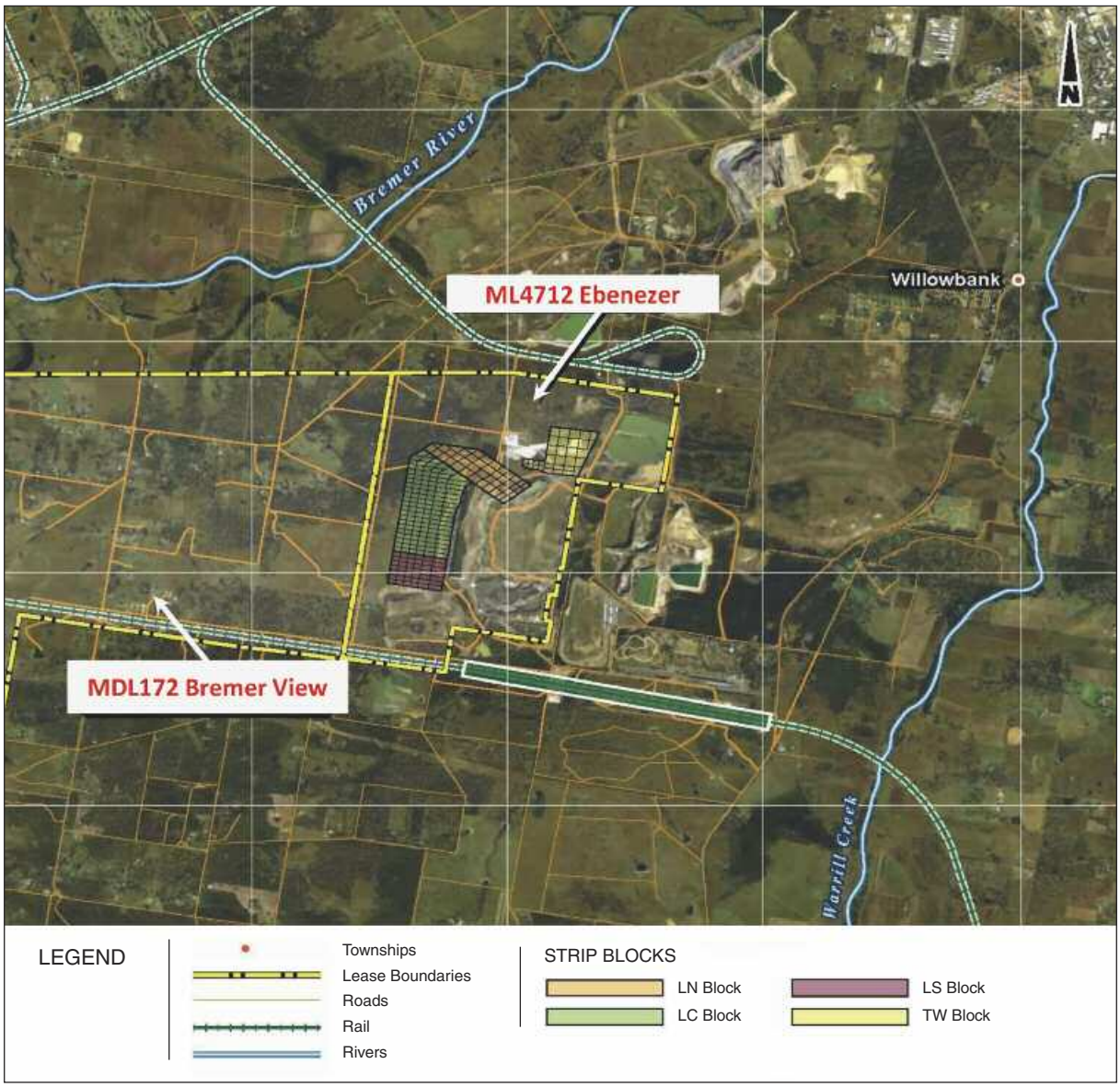

Figure 9. Aerial view of the Ebenezer and Bremer View projects showing mining strips (hatched areas) rail and lease boundaries (yellow). (OGL Resources Limited Ebenezer & Bremer View Acquisition Presentation Sept 2011 presentation ASX)

Currently there is only one operating mine in the region – the Jeebropilly Mine, operated by New Hope Group. The mine commenced operations in 1982 and is an open cut, black coal multi-thin-seam mining operation adjacent to the Amberley Air Base, 23 kilometres west of Ipswich city. It closed briefly in 2007, but re-opened in 2008 and its coal washing plant was kept operating to cater for coal still being produced from the company's New Oakleigh Mine. According to the New Hope Group website there are currently approximately 150 people employed by the mine in the local region.

New Hope's thermal coal operation, New Oakleigh, near Rosewood, closed in January 2013 and is currently undergoing rehabilitation activities.

POTENTIAL IMPACTS OF COAL MINING ON KOALAS IN THE IPSWICH LGA

Koalas and koala habitat are impacted wherever they occur within the footprint of a resource development or ancillary activity. In addition to the mine site, the associated infrastructure and off-site footprint also need to be taken into consideration because off-site impacts can affect far greater numbers of koalas over time. The scale of disturbance to koala habitat in the Ipswich region could constitute a major threatening process to this koala population due not only to the mines themselves, but also the associated infrastructure such as roads and rail lines. Coal extraction now extends as a series of almost contiguous mines spanning hundreds of kilometres across Queensland bringing not just local scale disturbance, but wide ranging impacts associated with roads (for example, but also water, dust, noise and rail). The coal projects planned or approved in the Ipswich LGA have significant potential impacts for koalas. Indeed, the rapidly expanding open-cut mining of coal and coal-seam gas resource developments represent relatively new and nationally significant threats to koalas in a much wider sense, and the Ipswich scenario represents a good case study.

Koala habitat is lost during clearing for mining but, as significantly, intensified traffic on road and rail corridors, combined with changes to the timing of peak traffic loads according to shift work, increases the likelihood of koala deaths from vehicle and train strike well beyond the physical extent of the mining lease. Thousands of kilometres of infrastructure corridors containing road, rail, pipeline and conveyors connect these resource developments across Queensland. In addition, impacts will result from the dormitory and administrative centres and bulk port loading facilities that are required at their node to support these projects.

In Queensland, the road freight network has a primary role in transporting mining products. Growth in key existing mining locations such as the Bowen Basin has led to the identification of various road network constraints, because of efficiency oversize overmass (OSOM) movements. The road network used by and supported by many other consumers is simply unable to cope with this heavy load. These OSOM movements are becoming concentrated in the south east as well as the Darling Downs, Mackay and Fitzroy regions and the key roads are straining under the expanding pressure of use. The potential development of the Surat basin is likely to have direct impacts on the Ipswich LGA due to both road and rail freight lines (rail not considered in this report). Demand by industry for OSOM movements across the state road network is increasing due to the resources sector, and in particular liquefied natural gas (LNG). In 2012–13 22,555 OSOM and special purposes vehicle permits were issued, an increase of 23% from the previous financial year (Qld DTMR 2013). In this timeframe the department also processed and issued 1083 performance based vehicle and non-standard freight vehicle permits and 522 multi-combination vehicle permits (Qld DTMR 2013).

Hence the proposed mining development in the Bremer Valley, similar to the many other resource extraction developments across the state, would result in cumulative impacts on koalas beyond the local area, such as the fragmentation of koala populations that rely on the area of impact for maintenance of genetic integrity. The footprint of the resource projects and the network of infrastructure corridors will be augmented by expansion of urban and peri-urban development to support the various needs of the mine (which may have social benefit in the short term through employment, for example) and will affect an agricultural landscape. Koalas can thrive in these agricultural landscapes, even though they may be largely restricted to refugia such as riparian vegetation and road verges (e.g. Ellis unpublished data, Somerset region), and to less productive landscapes (grazing paddocks with fewer trees) prior to the expansion of mining infrastructure. New rail lines and road infrastructure fragments and destroys large patches of koala habitat, which over time negatively influences koala population demographics and genetics (Lee *et al.* 2013). The outcome is very likely to be the loss of significant numbers of koalas from otherwise stable populations through the fragmentation of populations that are dissected by infrastructure, and the loss of populations in areas where the road impacts are severe or where direct clearing reduces the carrying capacity of the local ecosystem below a viable population.

Taking these broad principles of mining related impacts into account, it is likely that the proposed Bremer View Mine expansion (and indeed other potential lease developments) would add to current and historical impacts on koalas, which can be summarised as follows:

- **Reduction of the amount of current and potential habitat available to koalas.**

  The various exploration licenses and leases extend over significant areas of koala habitat. There is evidence of koala activity across the proposed lease areas, meaning that possible future habitat for several thousand koalas will be lost. If the mines were developed, koala habitat will be lost and koalas will be displaced.

- **Increased mortality associated with road traffic.**

  The predicted increase in truck movements for Bremer View, for example, is in the order of 8-10 per hour, though it is not clear if this is one or two directional, meaning it could be 16-20 vehicles per hour, or one every three minutes added to traffic flow. The proposed on site employment is 150 staff, each of whom will likely travel to site by private vehicle and at a time corresponding with work schedules. Twelve hour shifts are common in Queensland's coal mining industry, with a "7 am to 7 pm" shift standard at several mines. As a result, there could be up to an extra 150 vehicles approaching or departing the mine from various directions in the hour leading up to and following 07:00 and 19:00, or a likely period between vehicles averaging some 60 seconds.

This means that at the time when koalas are likely to be moving from their night feeding to daytime resting tree, or vice versa, they will have approximately 60 seconds to cross roads servicing the mine. There is evidence from other areas of the state of a direct correlation between mining operations coming on stream and koala deaths in the region. For example, increased koala deaths observed on the Peak Downs Highway were correlated with increased mine-related traffic between 2009 and 2013 (Tucker & Clifton 2013). To demonstrate how this may impact koalas, we present below a figure showing actual movement data recorded for koalas using GPS tracking devices in Queensland. Note that the peaks in travel would coincide with times corresponding to highest traffic flow associated with shift changes in 7 to 7 mining operations.

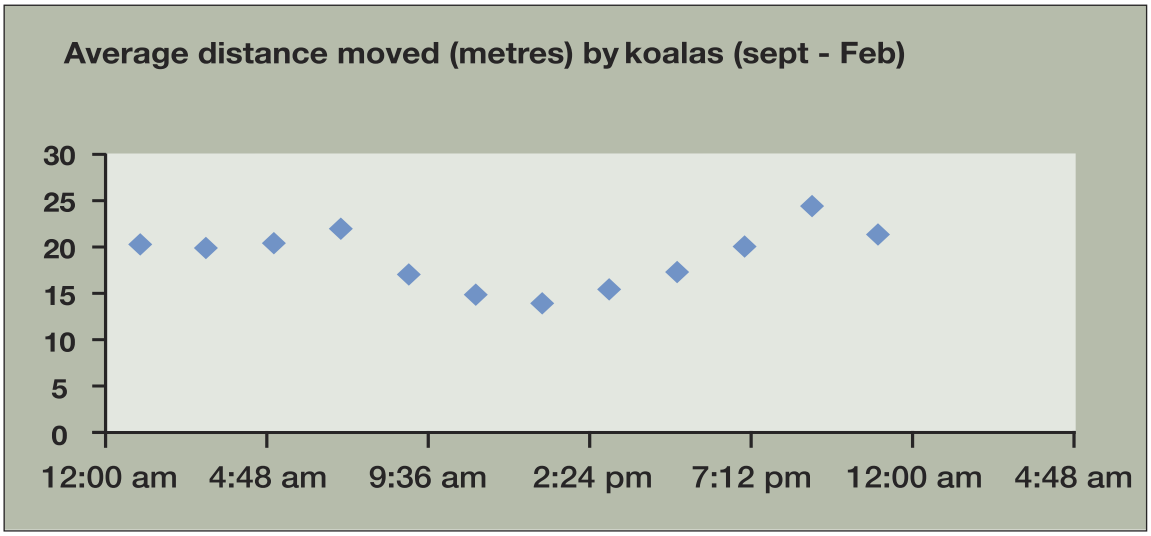

Figure 10. Average distance moved by koalas in relation to the time of day (Ellis *et al.* unpublished data).

Increased noise and dust in the area of the operational mine and transport corridors.

The impact of low frequency noise on koala communication has not been studied, and similarly no reports link dust and koala deaths to date. Indeed, the high occurrence of koala deaths on our roadways suggests that the noise of road traffic is not a deterrent to koalas approaching roads. Koalas have been observed to persist beside and within operating coal mines in central Queensland, where sufficient connected habitat is retained or in rehabilitated areas (FitzGibbon *et al.* 2013).

Vehicular and infrastructure-related fatalities of koalas on the operating mine sites.

Because mines often operate on a 24-hour basis, heavy vehicles negotiating mine roads at night will come into contact with koalas moving around the site. Accidents between haul trucks and koalas are rarely non-fatal for the koala and sometimes go unnoticed and hence, unreported by the driver (Ellis unpublished data for Blair Athol coal mine, central Queensland).

Long term impacts where coal mines are not rehabilitated.

Ipswich is currently home to mines that are in a condition known as "care and maintenance", but the long-term picture of the mined landscape is as vague as is this term. The Queensland Auditor General's report into mining concluded that one reason for mines to enter into care and maintenance was "as a means of avoiding rehabilitation" (Queensland Audit Office 2014). Sites can remain in "care and maintenance" for years and the audit found more than 100 mines placed in this holding pattern, some of which the regulatory bodies were unaware of. Most of the sites examined by the Auditor General had a history of environmental breaches and some had not provided sufficient financial assurance to cover rehabilitation costs. "One of the sampled sites had been in care and maintenance since 1998. For this site, the financial assurance held is $3.8 million while the rehabilitation costs are estimated as $14.2 million," the report states (Queensland Audit Office 2014).

Feral animal management.

Invariably, mining leases are "firearms-free" areas, and access to these sites to conduct feral pest management is not straightforward. For example, even after pest management procedures have passed all internal and external scrutiny (government permitting, internal stakeholder scrutiny – which is problematic due to the risk of neighbouring dogs falling victim to pest management strategies), the access procedures for an open cut coal mine in Queensland include several days of inductions at a cost to the program. As a result, feral animal control is rarely effective on mine sites.

DISCUSSION AND CONCLUSIONS

This report highlights the lack of sound ecological knowledge about the koalas of the Ipswich LGA. Although designed to evaluate the threat of coal mines to koalas in this area, what we have found is that there is a paucity of evidence to determine key elements of the ecology of koalas in the Ipswich LGA that can be used as building blocks for future planning to cater for the needs of this iconic species.

Through the report of OWAD Environment (Woosnam 2015) and accessing the records of the Ipswich Koala Protection Society, we were able to build a picture of a widely distributed koala population of unknown density throughout the Ipswich LGA, so detailed on-the-ground surveys to provide details of population densities in the areas that the koalas occur would be useful to identify key habitats for protection.

At present, the coal mines of the Ipswich LGA represent as much of a potential resource as a threat to koalas: the cessation of mining and potential rehabilitation of land historically used by koalas represents a great opportunity to replace habitat lost to various activities over time.

Conversely, future road and rail infrastructure has the potential to degrade koala habitat, fragment populations and increase mortality across the region. As koala populations in the west of Queensland are predicted to decline in the face of climate variability (Seabrook *et al.* 2013) the Ipswich LGA is seen as a potential climate refuge for koalas: an area where they may persist despite such changes. For this to occur, the habitat and threats need to be managed so that the koalas living there today are able to produce the koalas of the future.

Approaches to conserving koala populations, and biodiversity in general, need to look at development and impacts overall, rather than looking at individual developments and threats in isolation. Without such an approach, valuable habitat is likely to be slowly degraded block by block (the "death of a thousand cuts") until it is no longer viable for population sustainability. Habitat restoration, while it may have value, is not a satisfactory alternative to conserving current habitat. At present, detailed knowledge of the population size, disease rates, tree preferences and genetics of the koalas known to persist in the Purga region (for example) are unknown. Hence, planning for koalas across the region is hindered by a low knowledge base, so revegetation efforts and the management of developments is unlikely to accurately reflect the actual needs of koalas without some luck playing a part.

In order to address this, suitable areas need to be surveyed and information on demographics, health and habitat use generated. In this case the mining leases identified in this report could form a useful reference point from which to start. A detailed investigation into the koala populations of EPC 2127 and EPC 2364 should form the basis of any determination as to the future of such blocks, with smaller mining leases also contributing to general assessments of local populations so that future use or rehabilitation efforts are likely to contribute regionally (through connectivity for example) and locally – through appropriate planting and land management. This may not be straightforward, as identified by White in 1999: his findings suggest that open grazing country with few scattered trees may indeed be a cornerstone of koala ecology in parts of the Ipswich LGA. Whether this relates to the intrinsic value of such landscape features (perhaps isolated trees are more nutritious) or reflects adaptive behaviour of koalas in a changing rural landscape, the features of the landscape that are beneficial to koalas need to be identified and preserved, before they are all gone.

The koalas of Ipswich appear to be genetically most similar to those of Beaudesert, but the links between these populations are under threat, and in both LGAs threats from dogs, cars and development, as well as disease, are present. With development pressure up and down the coast, where most effort has previously been placed for both research and conservation of koalas, the Ipswich group has been relatively neglected, but our study confirms that it is a population with great potential for the future. This is because it is widespread, genetically diverse and the threats it faces are largely manageable.

REFERENCES

Accad, A., and Neldner, J. (2015). Remnant Regional Ecosystem Vegetation in Queensland, Analysis 1997-2013

Adams-Hosking, C., Grantham, H.S., Rhodes, J.R., McAlpine, C., and Moss, P.T. (2011). Modelling climate-change-induced shifts in the distribution of the koala. *Wildlife Researc*h **38**(2), 122-130.

Biolink (2007). Conserving koalas in the Coomera-Pimpama Koala Habitat Area: a view to the future. Final report prepared for Gold Coast City Council

Boyland, D. (2011). Submission to Senate Standing Committee on Environment and Communications: Inquiry into the status, health and sustainability of Australia's koala population. Wildlife Preservation Society of Queensland, Brisbane, wildlife.org.au

Commonwealth of Australia (1999). Environment Protection and Biodiversity Conservation Act.

City of Ipswich (2015). Ipswich Nature Conservation Strategy 2015. City of Ipswich

City of Ipswich (2015b). Ipswich Nature Conservation Strategy 2015 - Background Report. City of Ipswich

Dique, D.S. (2004). The distribution, abundance and dynamics of a regional koala population in south east Queensland. Ph.D Thesis, University of Queensland, Brisbane

Dique, D.S., Preece, H.J., Thompson, J., and de Villiers, D.L. (2004). Determining the distribution and abundance of a regional koala population in south-east Queensland for conservation management. *Wildlife Research* **31**(2), 109-117.

Dique, D.S., Thompson, J., Preece, H.J., Penfold, G.C., de Villiers, D.L., and Leslie, R.S. (2003). Koala mortality on roads in south-east Queensland: the koala speed-zone trial. *Wildlife Research* **30**(4), 419-426.

Dudaniec, R.Y., Spear, S.F., and Storfer, A. (2012). Current and historical drivers of landscape genetic structure differ in core and peripheral salamander populations. *PLoS ONE* **7**(5), e36769.

Dudaniec, R.Y., Rhodes, J.R., Worthington Wilmer, J., Lyons, M., Lee, K.E., McAlpine, C.A., and Carrick, F. N. (2013). Using multilevel models to identify drivers of landscape-genetic structure among management areas. *Molecular Ecology* **22**(14), 3752-3765

Ellis, W., FitzGibbon, S., Melzer, A., Wilson, R., Bercovitch, F., Dique, D., and Carrick, F. (2013). Koala habitat use and population density: using field data to test the assumptions of ecological models. *Australian Mammalogy* **35**(2), 160-165.

Ellis, W., Hale, P., and Carrick, F. (2002). Breeding dynamics of koalas in open woodlands. *Wildlife Research* **29**(1), 19-25.

Ellis, W., Melzer, A., and Bercovitch, F.B. (2009). Spatiotemporal dynamics of habitat use by koalas: the checkerboard model. *Behavioral Ecology and Sociobiology* **63**(8), 1181-1188.

Ellis, W., Melzer, A., Clifton, I., and Carrick, F. (2010). Climate change and the koala *Phascolarctos cinereus* : water and energy. *Australian Zoologist* **35**(2), 369-377.

Ellis, W.A.H., White, N.A., Kunst, N.D., and Carrick, F.N. (1990). Response of koalas *(Phascolarctos cinereus)* to re-introduction to the wild after rehabilitation. *Australian Wildlife Research* **17**(4), 421-426.

FitzGibbon, S, Ellis, W and Carrck, F. (2013) The Koala Venture Research Partnership: an overview of 24 years of regional koala research in central Queensland. In Flint, N. and Melzer, A. (eds), Conserving central Queensland's koalas. pp. 16-12, Koala Research Centre of Central Queensland, CQUniversity Australia, Rockhampton, Queensland

Gerada, M. (2014). Koala Land Report

Gordon, G., Brown, A.S., and Pulsford, T. (1988). A koala *(Phascolarctos cinereus Goldfuss)* population crash during drought and heatwave conditions in south-western Queensland. *Australian Journal of Ecology* **13**(4), 451-461.

Gordon, G., McGreevy, D.G., and Lawrie, B.C. (1990). Koala populations in Queensland: major limiting factors. *Biology of the koala.*, 85-95.

Kjeldsen, S., Zenger, K., Leigh, K., Ellis, W., Tobey, J., Phalen, D., Melzer, A., FitzGibbon, S., and Raadsma, H. (2015). Genome-wide SNP loci reveal novel insights into koala (Phascolarctos cinereus) population variability across its range. *Conservation Genetics*, 1-17.

Lee, K. (2010). Conservation genetics of the koala *(Phascolarctos cinereus)* in Queensland and Northeast New South Wales. Ph.D Thesis, The University of Queensland, Brisbane

Lee, K.E., Ellis, W.A.H., Carrick, F.N., Corley, S.W., Johnston, S.D., Baverstock, P.R., Nock, C.J., Rowe, K.C., and Seddon, J.M. (2013). Anthropogenic changes to the landscape resulted in colonization of koalas in north-east New South Wales, Australia. *Austral Ecology* **38**(3), 355-363.

Lee, K.E., Seddon, J.M., Corley, S.W., Ellis, W.A.H., Johnston, S.D., de Villiers, D.L., Preece, H.J., and Carrick, F.N. (2010). Genetic variation and structuring in the threatened koala populations of Southeast Queensland. *Conservation Genetics* **11**(6), 2091-2103.

Martin, R., and Handasyde, K. (1990). Population dynamics of the koala *(Phascolarctos cinereus)* in southeastern Australia. In 'Biology of the koala.'. (Eds. AK Lee, KA Handasyde and GD Sanson) pp. 75-83. (Surrey Beatty: Chipping Northon)

McAlpine, C., Lunney, D., Melzer, A., Menkhorst, P., Phillips, S., Phalen, D., Ellis, W., Foley, W., Baxter, G., de Villiers, D., Kavanagh, R., Adams-Hosking, C., Todd, C., Whisson, D., Molsher, R., Walter, M., Lawler, I., and Close, R. (2015). Conserving koalas: A review of the contrasting regional trends, outlooks and policy challenges. *Biological Conservation* **192**, 226-236.

Melzer, A., Ellis, W., FitzGibbon, S., and Carrick, F. (2013). Central Queensland's Koala Islands. In 'Conserving central Queensland's koalas.' (Eds. N Flint and A Melzer) pp. 25-28. (Koala Research Centre of Central Queensland: Rockhampton, Queensland)

Melzer, A., and Lamb, D. (1994). Low density populations of the koala *(Phascolarctos cinereus)* in Central Queensland. *Proceedings of the Royal Society of Queensland* **104**(0), 89-93.

Phillips, B. (1990). 'Koalas. The little Australians we'd all hate to lose.' (Australian Government Printing Service: Canberra, Aust) i-ix, 1-104

Preece, H.J. (2007). Monitoring and modelling threats to koala populations in rapidly urbanising landscapes: Koala Coast, South East Queensland, Australia. Ph.D Thesis, The University of Queensland, Brisbane

Queensland Audit Office. (2014). Queensland Government Auditor General Report: Environmental regulation of the resources and waste industries: Report 15: 2013–14, Queensland Audit Office, April 2014.

Queensland Department of Environment and Heritage Protection (DEHP). SEQ koala survey data: Results of Koala Surveys in South East Queensland 2010-2015.
http://www.ehp.qld.gov.au/wildlife/koalas/survey-data.html

Queensland Department of Environment and Resource Management (DERM). (2009). Decline of the Koala Coast koala population: Population status in 2008. Queensland Government Department of Environment and Resource Management

Queensland Department of Infrastructure and Planning (DIP). (2009). South East Queensland Regional Plan 2009-2031. Queensland Government Department of Infrastructure and Planning, Brisbane

Queensland Department of Natural Resources and Mines (DNRM). (2012). Local Area Mining Permit Report: Ipswich City Council, All resources - November 08, 2015

Queensland Department of Transport and Main Roads (DTMR). (2013). 'Moving Freight, A strategy for more efficient freight movement'. Released under Right To Information – DTMR

Queensland Department of Transport and Main Roads (DTMR). (n.d.). Moreton Bay Rail koala tagging and monitoring. http://www.tmr.qld.gov.au/Projects/Featured-projects/Moreton-Bay-Rail/Publications/Moreton-Bay-Rail-Koala-tagging-and-monitoring.aspx

Queensland Environmental Protection Agency (EPA). (2006). Nature Conservation (Koala) Conservation Plan 2006 and Management Program 2006-2016

Queensland Government (1992). Nature Conservation Act (Queensland) 1992

Rhodes, J., Lunney, D., Moon, C., Matthews, A., and McAlpine, C. (2011). The consequences of using indirect signs that decay to determine species' occupancy. *Ecography* **34**, 141-150.

Seabrook, L., McAlpine, C., Baxter, G., Rhodes, J., Bradley, A., and Lunney, D. (2011). Drought-driven change in wildlife distribution and numbers: a case study of koalas in south west Queensland. *Wildlife Research* **38**(6), 509-524.

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

Thompson, J. (2006). The comparative ecology and population dynamics of koalas in the Koala Coast Region of south east Queensland. Ph.D Thesis, The University of Queensland, Brisbane

Tucker, G. and Clifton, D. (2013). What do we know about CQ koalas near rolling infrastructure? In Flint, N. and Melzer, A. (eds), Conserving central Queensland's koalas. pp. 111-114, Koala Research Centre of Central Queensland, CQUniversity Australia, Rockhampton, Queensland

White, N.A. (1994). Habitat utilisation and population dynamics of the koala *(Phascolarctos cinereus)* in the Bremer River catchment, South-east Queensland. PhD Thesis, The University of Queensland.

White, N.A. (1999). Ecology of the koala *(Phascolarctos cinereus)* in rural south-east Queensland, Australia. *Wildlife Research* **26**(6), 731-744.

White, N.A., and Kunst, N.D. (1990). Aspects of the ecology of the koala in southeastern Queensland. In 'Biology of the koala.' (Eds. AK Lee, KA Handasyde and GD Sanson) pp. 109-116. (Surrey Beatty and Sons: Sydney)

White, N.A., and Timms, P. (1994). Chlamydia psittaci in a Koala *(Phascolarctos cinereus)* population in south-east Queensland. *Wildlife Research* **21**(1), 41-47.

Woosnam, O. (2015). Ipswich City Council Koala Survey. OWAD Environment, Brisbane

APPENDIX 1 – NATIVE VEGETATION OF IPSWICH

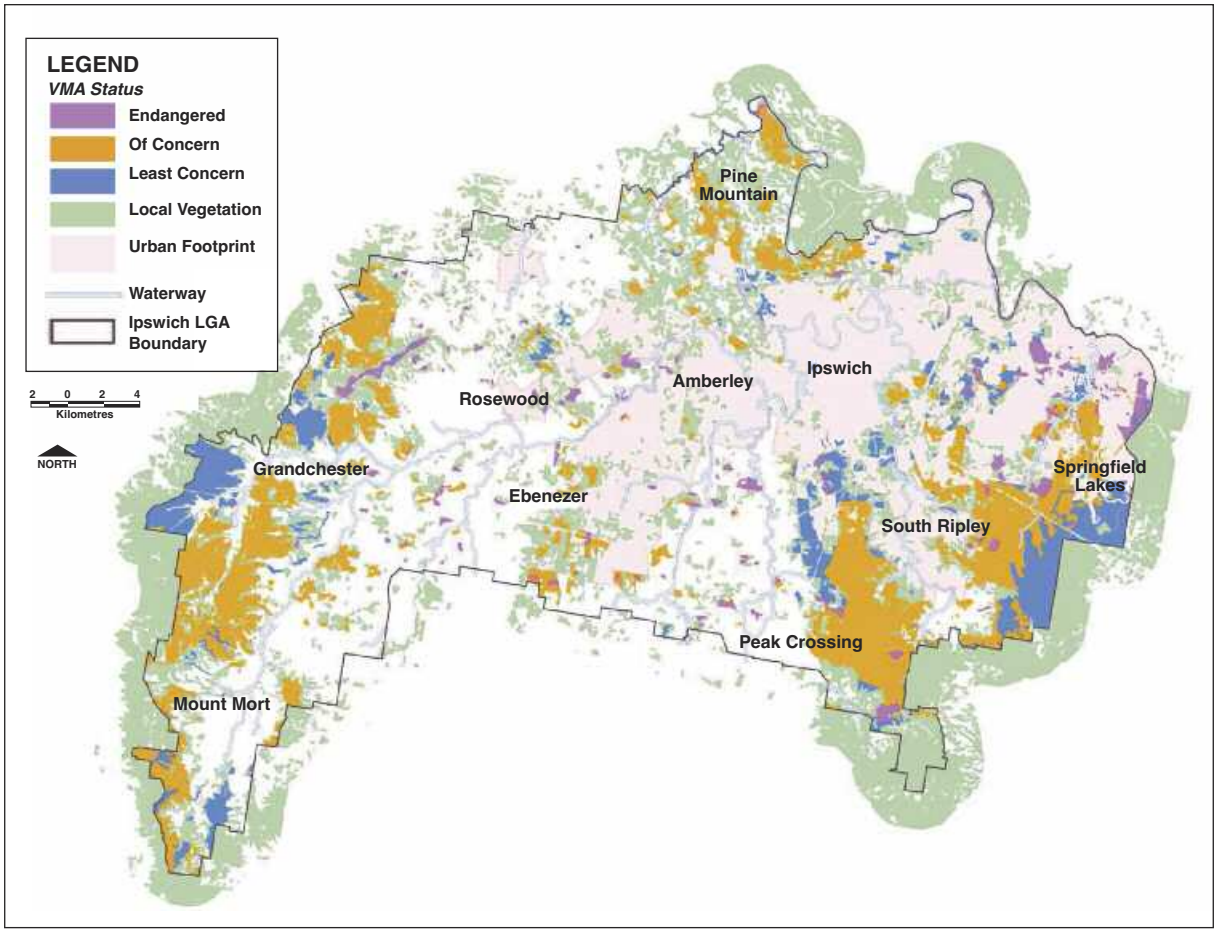

Figure 11. Ipswich's native vegetation framework (City of Ipswich 2015b)

APPENDIX 2 – WILDLIFE HABITAT OF IPSWICH

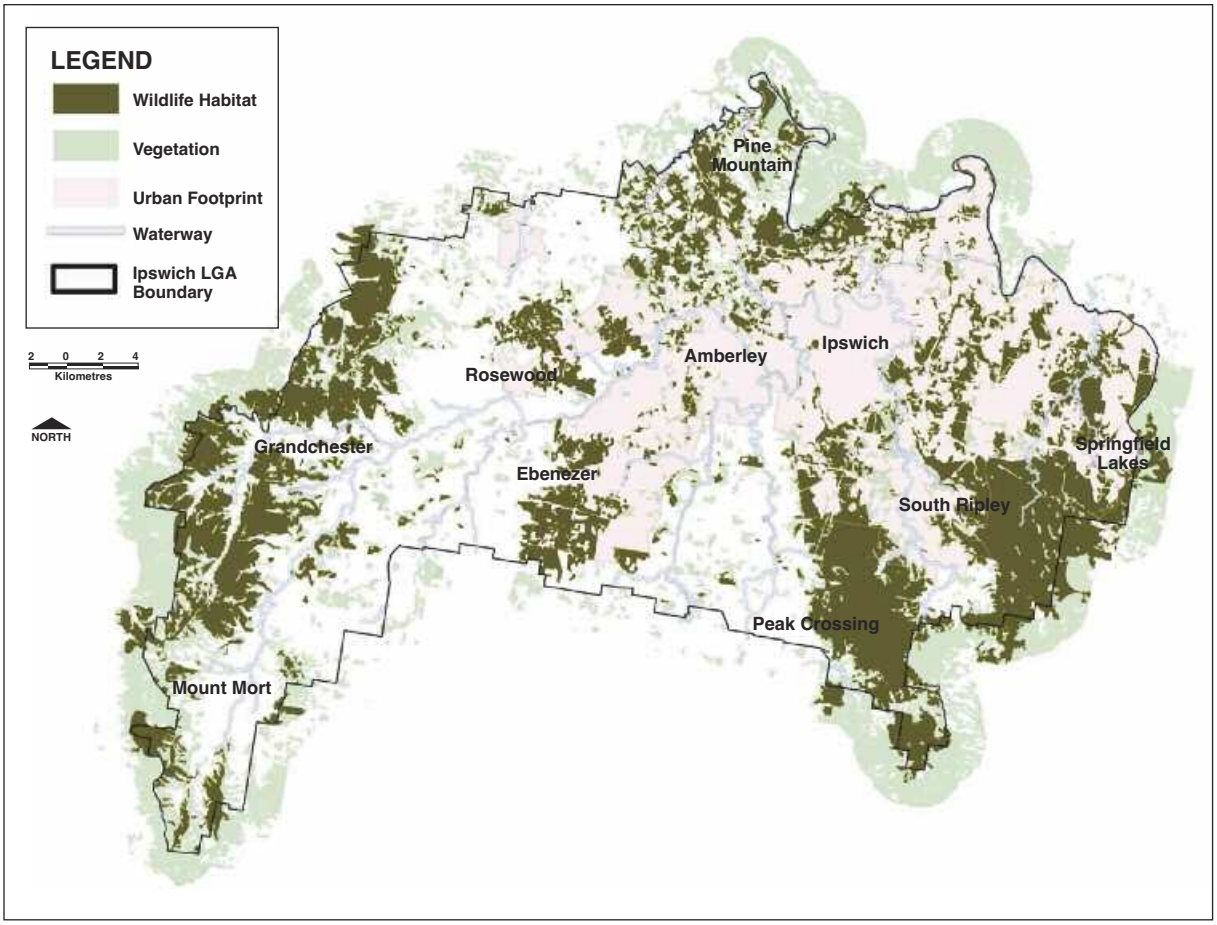

Figure 12. Wildlife habitat, including koala bushland, for significant species mapped as Matters of State Environmental Significance (MSES) - (City of Ipswich 2015b)

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