



Assessment of Koalas

And

Koala Habitat Use

On

BMA Peak Downs Mine

*August 2009*

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Submitted: August 2009

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## 1. INTRODUCTION

Over their range on the eastern Australian mainland, koalas (*Phascolarctos cinereus*) occur in areas of different vegetation composition at a range of densities. Most populations have experienced some degree of destruction of koala-preferred habitat and the main process threatening koala persistence and conservation appears to be habitat loss through developmental encroachment (Phillips *et al.*, 2000; Reed and Lunney 1990). If the major threat to koalas is habitat loss, understanding the type of habitat that koalas utilise and their patterns of use across their range is critical to protecting and increasing key habitat resources.

Physiological studies of plant compounds and their impact on koala nutrition and role in diet selection cannot be overlooked in the understanding of koala habitat use. Many studies have examined the concept of tree preference or utilisation using daytime roosting observations or the presence of faecal material and comparing these data to the proportion of tree species in the community (White and Kunst 1990; White 1999; Tun 1993; Phillips *et al.*, 2000; Hindell and Lee 1990; Hindell and Lee 1988; Hindell *et al.* 1985; Gall 1980; Ellis *et al.*, 2002).

Searches for koala scats have been used to indicate the level of use of sites by koalas (Lunney 2000). Using a 20 x 20 m quadrat, Lunney (2000) aimed to assess whether a site was active (scats present) or inactive (scats absent). Further, the extent of activity at sites was determined according to the proportion of all trees at the site that had scats located beneath them. The research further assigned preference to species, based on the proportional scat presence for each species (the proportion of each species that had scats beneath them). Though intuitive, this relationship is untested.

Faecal pellets provide unequivocal evidence of the occurrence of koalas at a site. However, beyond this, assertions that the presence of koala faecal pellets can be used to accurately predict diet preferences (Phillips *et al.* 2000, Lunney 2000) are so far free of supporting data.

Dique *et al.* (2004) took what is a comparatively unusual step, in the contemporary context, of predicting koala densities on the basis of observations of koalas. Their lower prediction for the number of koalas inhabiting an area of south east Queensland took into account the distribution of koalas across the region and they argue, persuasively, that those predictions based on actual koala occurrence as opposed to "preference" based - extrapolations, will have most conservation and management utility. Further, these authors highlight the need to "ground- truth" areas that have been identified as having high conservation value but which have not been sampled in other reports.

Diet information is only one of a range of characteristics upon which management strategies should rely. Characteristics such as patterns of movement between trees; use of non-fodder trees and their relevance; social interaction (Mitchell 1990); impacts of pathogens and diseases; and predator influence can impact on the use of areas by koalas. In general, understanding tree utilisation allows a prediction of the optimal species composition and structure for areas to be made, something of keen interest to habitat restoration projects.

This project had a single broad goal, *i.e.* by examining a range of tree associations across BMA Peak Downs Mine leases for signs of use by koalas we aimed to describe the use of the site by these animals. In addition, diet analysis was undertaken to establish an assumption-free picture of the species that were being eaten by koalas at Peak Downs.

## 1.1. Study Site Characteristics

Peak Downs Mine (PDM) is located in the Bowen Basin coalfields within the Brigalow Belt Bioregion. Local communities of Moranbah and Dysart support these coal-mining operations. PDM is situated to the east of a raised, sedimentary escarpment that overlies the coal deposits. The open cut coal mining operation strips off these sedimentary rocks/soils derived there from to access the coal deposits. The sedimentary rock is generally fine grained and this predominates on the western portions and raised areas of the lease.

Drainage patterns fall into four main systems across the study site into:

- Cherwell Creek at the northern extent of the lease;
- Harrow Creek through the central northern part of the lease;
- Boomerang Creek to the south of the lease area; or
- via more meandering ephemeral waterways.

All of these streams ultimately flow eastward and drain into the Isaac River.

The infrastructure of PDM is located along the central western perimeter of the coal deposits with the mine progressing eastward across the sand and clay plains and alluvium of the aforementioned streams. To the west and east of the area of current mine infrastructure and operations, the study site is presently dominated by natural landscapes and associated biota.

## 1.2. Nomenclature and Terminology

For the purposes of this report, the study site refers to the lands within the BMA PDM lease area. The term study area refers generally to the lands surrounding the study site, i.e. the Dysart, Peak Downs and Moranbah districts. A survey area is an area within the study site where timed, area searches for evidence of koala occurrence, i.e. animals, scats, characteristic scratches etc., were undertaken.

Survey areas were selected on the basis that they reflect the habitat characteristics of more widespread habitat types which were representative of the area to be investigated, and/or provide examples of notable habitat types which should be investigated because of their potential to support and/or provide habitat for koalas, for example, riparian communities along waterways.

Within this report, the definition of a Regional Ecosystem (RE) follows that provided by Sattler and Williams (1999), i.e. a vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil. This definition forms the basis of the *Vegetation Management Act 1999* (VMA), which also defines the "pre-clearing extent" of a regional ecosystem as the extent of the regional ecosystem before it was cleared.

## 2. METHODOLOGY

### 2.1. Desktop Assessments

A variety of existing information was reviewed to assist in establishing an appropriate field survey program. Information sources included, but were not be limited to the following

- EcoServe & LAMR (2005a, b, c & d), EcoServe & LAMR (2006), EcoServe (2005). EcoServe (2006a, b, c & d), EcoServe (2007), WBM Pty Ltd (1999), WBM Pty Ltd (2002); and
- Recent aerial photography.

### 2.2. Field Investigation Program

The field survey program was undertaken from the 15<sup>th</sup> to the 19<sup>th</sup> of June 2009 inclusive. The principal investigator was Andrew Veary with assistance in the field from Brian Clark (PDM).

Surveys for koalas and their evidence of occurrence (i.e. koala pellets and/or characteristic scratches on trees) were undertaken at individual survey areas. Survey areas were selected on the basis of habitat type and structure, and also on geographical distribution to provide complete sampling coverage of the study site.

Sampling at each survey area was undertaken by walking in a clover-leaf pattern from a central point. Each person walked one leaf of the clover, returning to the start point after 30 minutes, resulting in a search effort of 60 minutes per area.

Each researcher moved from tree to tree through the pattern, examining the base of more-or-less randomly selected trees. Once a tree was chosen for sampling, an area within two metres of the base was inspected for any koala faecal pellets and the trunk examined for scratches. The canopy of each tree was also visually inspected for koalas.

Data were collected using the "Cybertracker" software (Cybertracker.org) using handheld PDAs (Hewlet Packard 2710) which collected GPS information via a Bluetooth link to a lightweight GPS unit worn by the researcher (HICOM BT Accuracy  $\pm$  4m). Data included, but was not limited to: tree species; understorey vegetation; soil type; landform; and type of koala evidence observed (i.e. animal, scat, scratch etc.).

Those trees that had either a koala, scat or signs of koalas were recorded as an individual GPS datum point. In those areas that were searched yet no evidence of koalas were observed, a GPS datum point was taken for that area and a tree species representative of the vegetation community and habitat was recorded.

Figure 2-1 identifies the locations of each of the survey areas for this project.

### 2.3. Diet Analysis`

Recent koala scats that were observed (i.e. less than approximately one week old) were collected and analysed to determine the dietary species composition by identifying tree species by the leaf fragments which have signature cuticle patterns (see Figure 2-2)

Diet analysis was undertaken according to the following method.

Koala faecal pellets that were collected in the field were stored and refrigerated in resealable plastic bags. Several pellets were selected for analysis from each of the survey areas where

scats were collected. The scats were ground and bulked according to collection site or replicate.

Subsamples of each sample were taken such that a spoonful was aliquoted to a centrifuge tube and 10 ml 6.25% NaOCl (bleach) was added by an eppendorf pipette.

Samples were left at room temperature for 24 hours then rinsed thoroughly with distilled water until all traces of bleach were removed.

The samples were then stained with 1.5% gentian violet stain (1.5 g  $C_{25}H_{30}ClN_3$  in 100 ml  $H_2O$ ) for approximately 10 minutes at room temperature.

The samples were drained of stain and 10 ml of 5% ethanol was added to tubes. Slides were made from the stained samples now fixed in alcohol.

Up to three slides per survey area, depending on the number of scats collected, were made for each sample. This resulted in a total of 30 slides. These slides were used for observations and the best slides used for microscopic examination at 100 and 400 magnification. Scoring was done on 100 fragments.

These slides were examined and compared against reference slides of leaf fragments collected from trees in central Queensland that had been prepared in the same manner as the faecal slides.

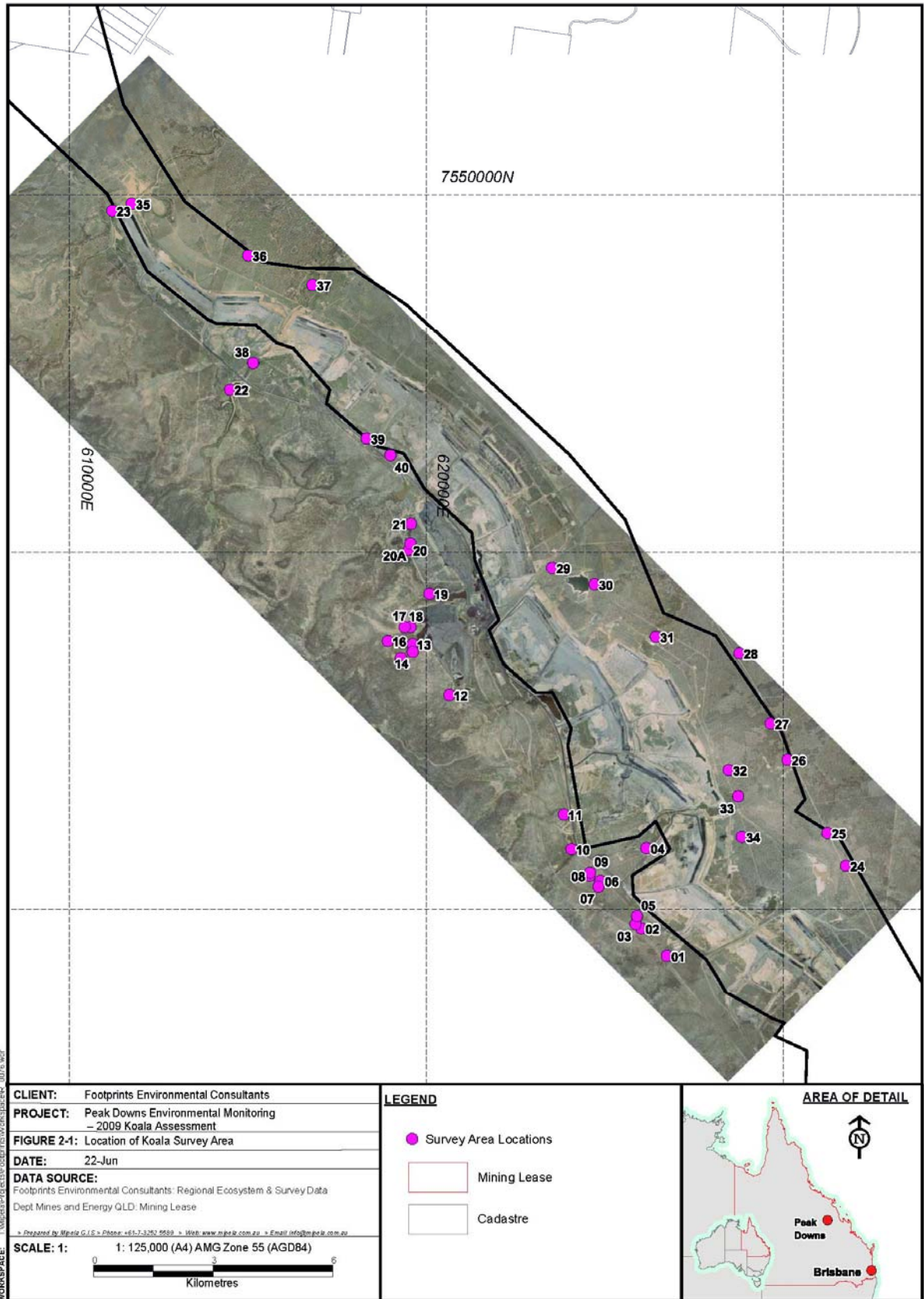


Figure 2-1 Location of Koala Survey Areas

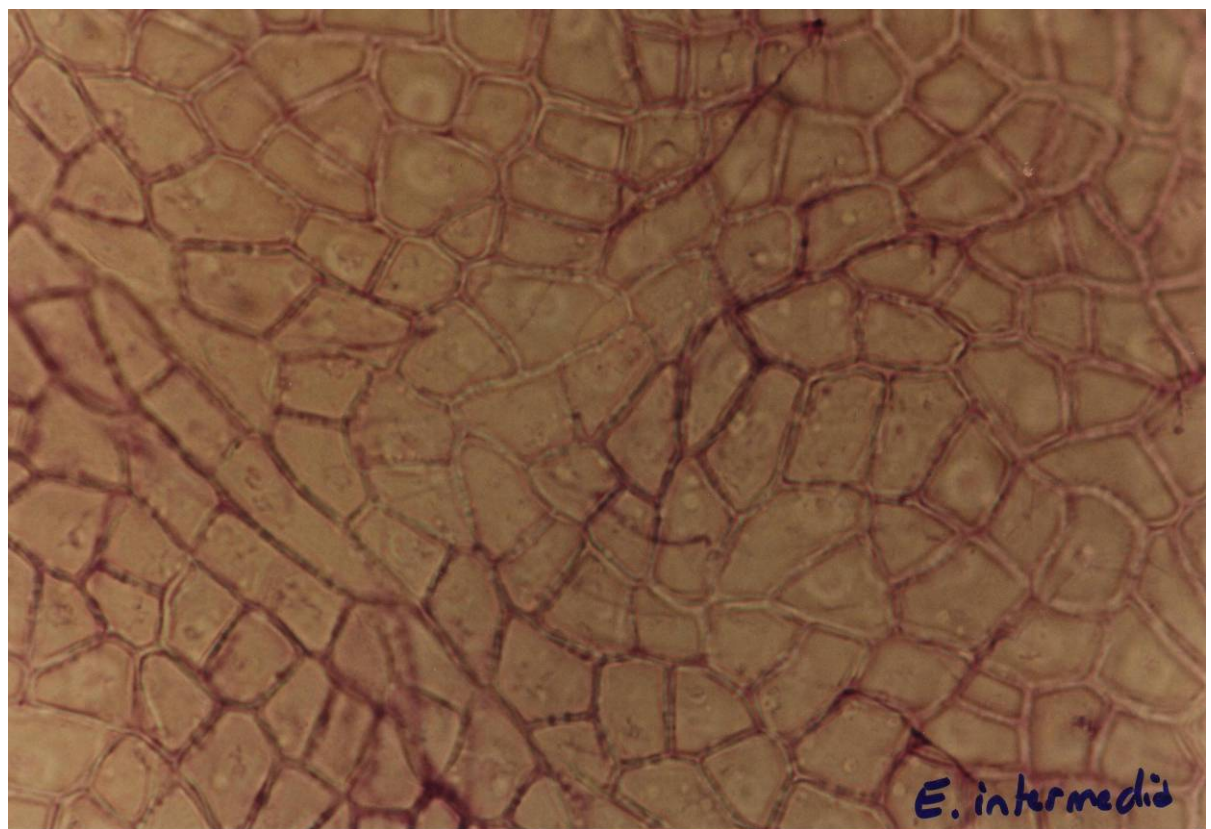
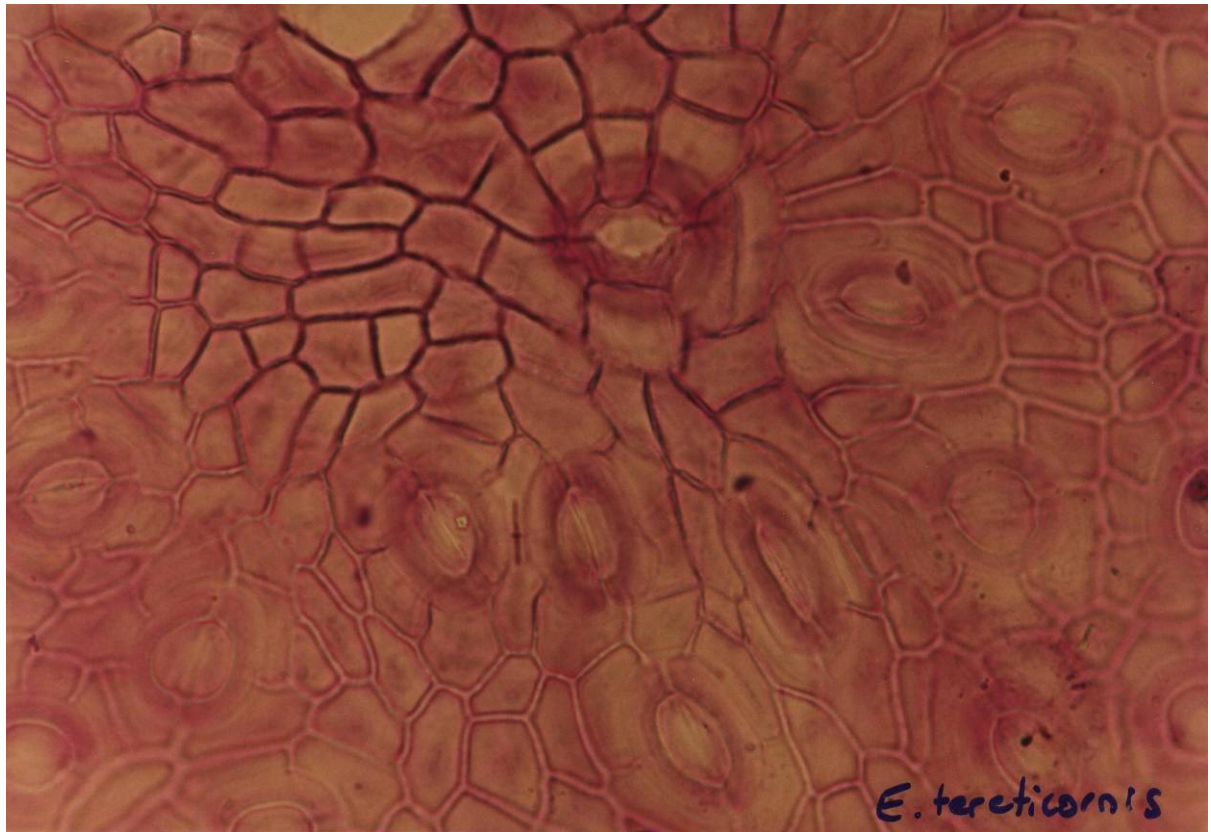


Figure 2-2 Examples of *Eucalypt* spp. leaf cuticle signature patterns

### 3. RESULTS AND INTERPRETATION

#### 3.1. Koala Evidence and Tree Species

Forty one survey areas were searched for the evidence of koalas as detailed in Figure 3-1.

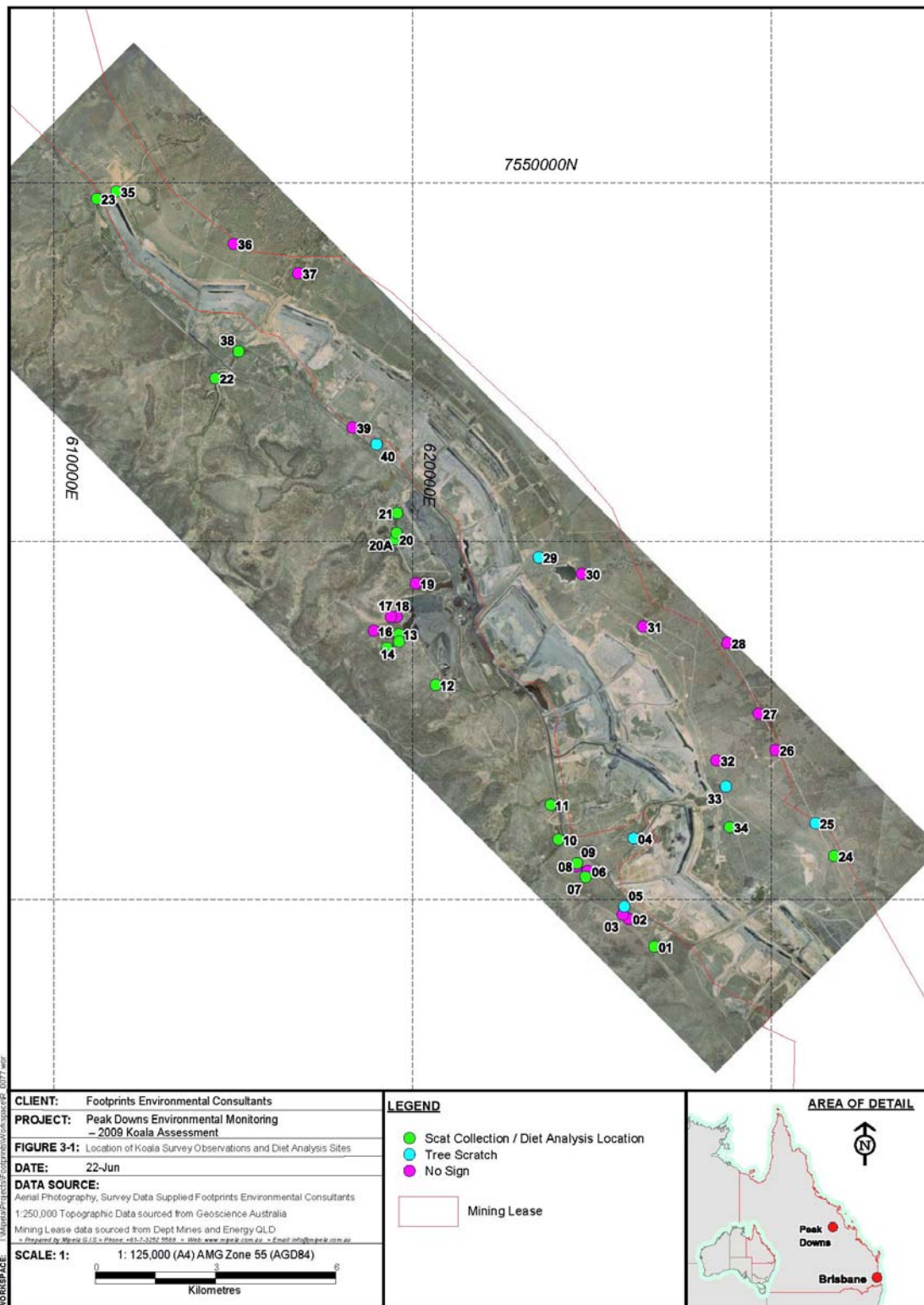


Figure 3-1 Location of Koala Survey Observations and Diet Analysis Sites

No signs of koala activity or presence were detected at 17 of these 41 sites, 41%. Of the remaining 24 sites, traces of koala presence, i.e. scratches on trees, were observed at six sites (15%). Scats, old and fresh, were observed at 18 (44%) of survey sites. Fresh scats were collected for diet analysis at 15 of these 18 areas, representing 37% of the survey areas.

Scats were found under 32 trees from six tree species (*Corymbia citriodora*, *C. clarksoniana*, *Eucalyptus crebra*, *E. leichhardtii*, *E. melanophloia* and *E. tereticornis*). The highest proportions of scat present were under *E. crebra* (50%) and *E. tereticornis* (31.3%). Table 3-1 summarises the tree species where the observations were made.

**Table 3-1 Observed Signs of Use by Koalas of Tree Species**

Tree Species Examined	# Trees with Scat	% Trees with Scat	# Trees with Signs	% Trees with Signs	% of Total Trees
<i>C. citriodora</i>	1	3.1			2.5
<i>C. clarksoniana</i>	1	3.1			2.5
<i>E. cambageana</i>		0.0	1	12.5	2.5
<i>E. crebra</i>	16	50.0			40.0
<i>E. leichhardtii</i>	2	6.3			5.0
<i>E. melanophloia</i>	2	6.3			5.0
<i>E. tereticornis</i>	10	31.3	7	87.5	42.5
<b>Totals</b>	<b>32</b>		<b>8</b>		

With regard to signs of koalas, it is not surprising that evidence of scratches were only observed on smooth-barked trees. This pattern is due to Koala scratches being obvious and easily identifiable on these trees as they have a smooth bark where claw scratches are more readily observable (see Figure 3-2 below).

Full details of all survey site locations and observation type are presented in Appendix A.



**Figure 3-2 Characteristic Koala Scratch Marks on a Smooth-barked Tree**

As per previous surveys conducted in 2006, more signs of the presence of koalas were found in searches conducted on the western side of the mining operations. Evidence of koala occurrence was also observed within the operational areas of the mine, along Cherwell Creek in the north and Boomerang Creek in the South.

### 3.2. Koala Evidence and Regional Ecosystems

Koala scats were found across a variety of regional ecosystems on the study site (see Table 3-2 and Figure 3-3). The majority of scats were collected from riparian zones (i.e. RE codes 11.3.x), representing 50% of all scats collected. Likewise, riparian zones also dominated the observations of tracks/scratches, with 66% of observations from this land zone.

**Table 3-2 Summary RE Codes of Scat and Positive Observations**

Survey Area	Koala Sign*	Regional Ecosystem Code	VMA# Status
P01	S	11.4.3/11.4.8/11.4.9	Endangered
P07	S	11.5.3/11.5.1	Not of concern
P09	S	11.9.2/11.9.9/11.5.3	Not of concern
P10	S	11.3.25/11.3.2	Of concern
P11	S	11.3.25/11.3.2	Of concern
P12	S	-	
P13	S	-	
P14	S	-	
P15	S	-	
P20	S	+	
P20A	S	11.7.2	Not of concern
P21	S	11.7.2	Not of concern
P22	S	11.3.25	Not of Concern
P23	S	11.3.25	
P24	S	11.3.25/11.3.2	Of concern
P34	S	11.5.3	Not of concern
P35	S	+	
P38	S	11.3.1	Endangered
P04	T	11.3.25/11.3.2	Of concern
P05	T	11.5.3/11.5.1	Not of concern
P25	T	11.3.25/11.3.2	Of concern
P29	T	11.3.25/11.3.2/11.4.3/11.4.8/11.4.9	Endangered
P33	T	11.3.25/11.3.2	Of concern
P40	T	11.5.3	Not of concern

\* Koala Sign: S = Scat; T = Track

- = No RE Mapping

# VMA = Vegetation Management Act 1999.

+ = Cleared/non-remnant vegetation

When comparing the positive observations of koalas, i.e. survey areas where animals, scats and/or signs were observed, 22% (4 of 18 data) of records came from Land zone 5 REs and 56% (10 of 18 data) of the observations were within Land Zone 3 REs, recent alluvium of creeks and riparian systems.

The increase in positive observation recording is due to the characteristics of the *E. tereticornis* tree. These trees have a soft, smooth bark on which characteristic koala scratches can be easily identified *c.f.* *E. crebra* and/or *E. populnea* which both have rough, hard bark which do not show up scratches.

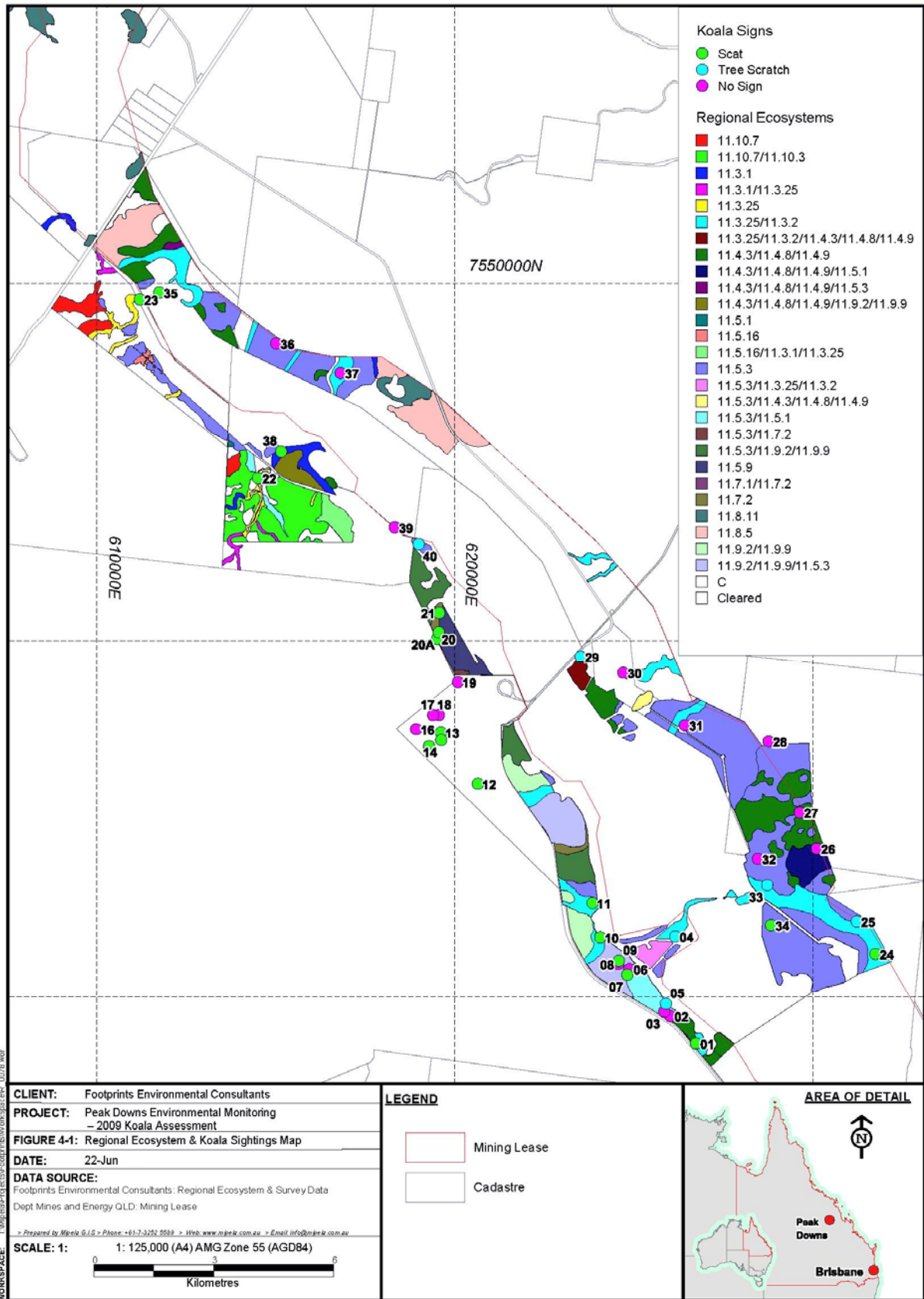


Figure 3-3 Location of Survey Sites and Regional Ecosystem mapping

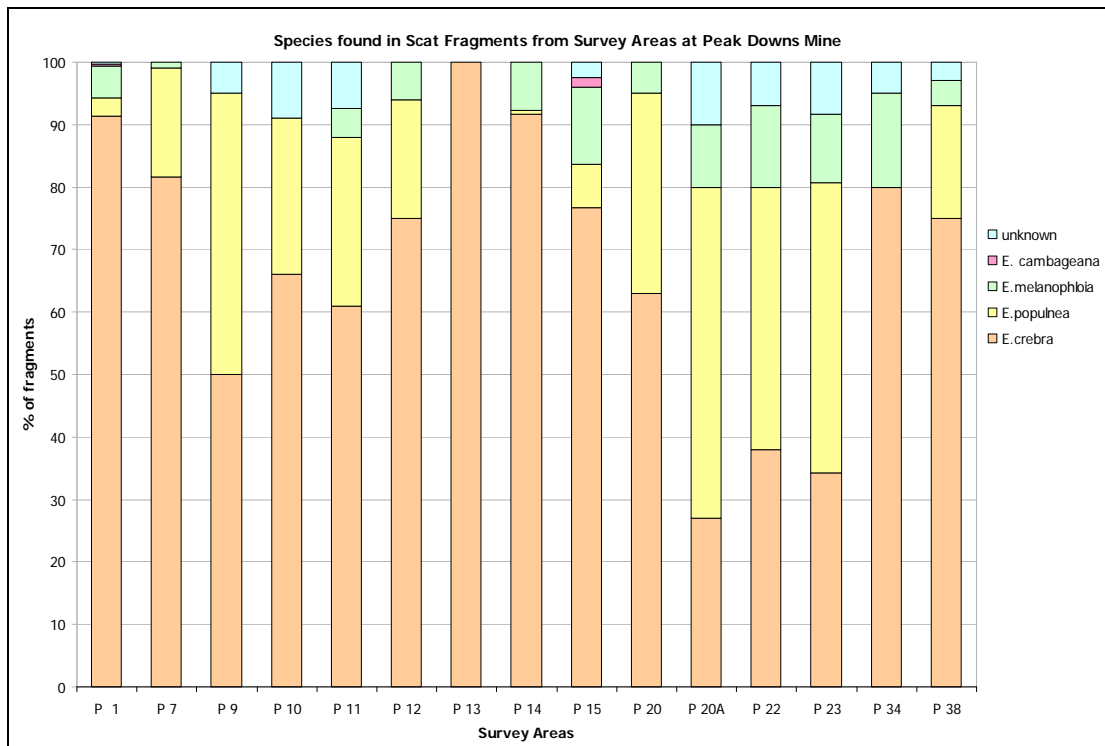
### 3.3. Koala Diet Analysis

Samples were chosen from 15 survey areas for the diet analysis to provide a good geographical spread across the study site (see Table 3-3 below). Four primary species of trees were identified from the scats collected from across PDM. These species were *E. crebra*, *E. populnea*, *E. melanophloia* and *E. cambageana*. A few leaf cuticle fragments observed from the scats were unidentifiable, however, this was a very small percentage of the total analysis.

**Table 3-3 Koala Diet Analysis Summary**

Survey Areas	<i>E. crebra</i>	<i>E. populnea</i>	<i>E. melanophloia</i>	<i>E. cambageana</i>	Unknown species
	narrow leaved red ironbark	poplar box	silver leaved ironbark	Dawson gum	
P1	91.3	3.0	5.0	0.3	0.3
P7	81.7	17.3	1.0	0.0	0.0
P9	50.0	45.0	0.0	0.0	5.0
P10	66.0	25.0	0.0	0.0	9.0
P11	61.0	27.0	4.7	0.0	7.3
P12	75.0	19.0	6.0	0.0	0.0
P13	100.0	0.0	0.0	0.0	0.0
P14	91.7	0.7	7.7	0.0	0.0
P15	76.7	7.0	12.3	1.5	2.5
P20	63.0	32.0	5.0	0.0	0.0
P20A	27.0	53.0	10.0	0.0	10.0
P22	38.0	42.0	13.0	0.0	7.0
P23	34.3	46.3	11.0	0.0	8.3
P34	80.0	0.0	15.0	0.0	5.0
P38	75.0	18.0	4.0	0.0	3.0

This data is presented graphically in Figure 3-4 below.



**Figure 3-4 Dietary Analysis of Koala Scats**

## 4. CONCLUSIONS AND RECOMMENDATIONS

Studies have confirmed that the relationship between the presence of scats at the base of a tree and the use of those trees by koalas is unreliable. As such, while the presence of koalas can be confirmed by the presence of scats, the absence of scats does not mean koalas have not used the tree (Ellis *et al.* 2006; Ellis *et al.* 1998). This situation has been observed in the local region when no scats were found under the canopy of a tree in which a koala was found, either on the day the koala was seen or subsequently.

This phenomenon leads to a cautionary approach to assessing habitat use by koalas using scat presence or other signs of use by koalas. Statistically, the probability of a type two error, where absence of koalas is assumed incorrectly on the basis of the absence of scats, can be as high as 30 % (Ellis *et al.* 2006). Consequently, caution should be exercised in predicting the amount of use of survey areas that were found to have few or no signs of use by koalas. However, it is reasonable to draw some conclusions based on the general patterns we observe and we have done this.

Other studies in central Queensland have identified *E. tereticornis* (Ellis *et al.*, 1995), *E. populnea* (Ellis *et al.* 2002) and *E crebra* (Melzer 1994) as species with particular value to koalas in this area. From this assessment, it was observed that koala pellets were found *E. crebra* and *E. tereticornis* more than other *Eucalyptus* or *Corymbia* spp. examined on the study site.

The distribution of signs of use by koalas across the different regional ecosystems present on the study site warrants further investigation as it can provide valuable inputs to the assessment of conservation value of sites for koalas. At other locations in central Queensland, *E. crebra* and *E. melanophloia* have been identified as being of particular significance to koalas. These tree species are well represented in observations of use on the study site. Similarly, observations suggest that the *E. tereticornis* woodlands and gully lines (11.3.25) are of particular value to the local koala population. In a similar fashion, the occurrence of *E. populnea*, a known koala food species (Ellis *et al.* 2002) and dominant in RE 11.5.3 on the study site, particularly on the eastern side of the operations, correlated well with the occurrence of signs of use by koalas, accounting for 22% of the observational records.

The diet of koalas on the study site bears greater investigation, and it may be that a full reference library of tree species from the Peak Downs Mine site be developed. There appears to be significant regional variations in leaf cuticle stomatal patterns and sizes. The leaf library used for this study was developed for an area further to the south west, and another leaf library developed for coastal regions was used as a comparison.

That said, it is of note that *E. crebra* and *E. populnea* formed the majority of leaf cuticle fragments in the scat that was collected. This indicates that these species, at the time of year that the scat was collected, are important food resources for the local koala population.

Of particular interest was the evidence collected from vegetation communities along Cherwell, Harrow and Boomerang Creeks on the eastern side of the haul road, within the current operational areas of the mine. Remnant vegetation, both riparian and adjacent open woodland, has been retained along the creek sections that pass from west to east through the open-cut pit workings. This has formed vegetated corridors in an otherwise cleared landscape. Koala evidence collected from within these habitats indicates that koalas are using these retained vegetation corridors, potentially providing important habitat facilitating west to east movements through the operational areas. As a result, it is strongly recommended that these areas of remnant vegetation be actively managed and enhanced, through protection from further fragmentation and also via active rehabilitation, to ensure

that the values associated with these corridors are maintained for koalas and also the wide range of other native faunal species which utilise such corridors for movement through the study site (e.g. passerine birds, microbats, kangaroos, reptiles, etc.).

The information collected on the tree species utilised by koalas can provide valuable data when deciding which tree species to include into mined land rehabilitation, if the rehabilitation is to potentially support suitable habitat for the local koala population. From this limited survey, it can be seen that *E. crebra*, *E. tereticornis* and *E. populnea* have some importance at this time of year. However, it must be stated that koalas utilise a wide range of tree species, which, from the methods used for this assessment, were not identified in this survey. In addition, the REs within creek zones and on broad sand plains (Land Zone 5) are also important for local koalas.

Consequently, it is strongly recommended that PDM consider the following future work with respect to koalas:

- Develop a leaf cuticle reference library for the local region for future diet analysis.
- Undertake replicate surveys of koala habitat usage and diet analysis.
- Implement a koala radio tracking program to investigate the daily habitat use patterns of koalas on-site and in the immediate vicinity.

These detailed investigations can provide valuable data which can be used for the management of koalas in the region. Management of this key stone species will also provide broader biodiversity management of the habitats supported outside of the operational areas for many other fauna species, including several threatened species listed at State and Federal levels.

## 5. BIBLIOGRAPHY

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

Dique, D., Penfold, G., Thompson J., Leslie R., and Preece H. (2001). Koala distribution and density in southeast Queensland: the accuracy and precision of koala surveys. In: *The Research and Management of Non-Urban Koala Populations*. (K. Lyons, A. Melzer, F. Carrick, and D. Lamb, eds.). Koala Research Centre of Central Queensland, Rockhampton. p. 105–121.

EcoServe & LAMR (2005a). *Biodiversity, Threatened Species and Regional Ecosystems Survey – Summer 2005*. An unpublished report prepared for BMA Coal Peak Downs Mine.

EcoServe & LAMR (2005b). *A Review of Habitat Values for Biodiversity and Species of Conservation Significance*. An unpublished report prepared for BMA Coal Peak Downs Mine.

EcoServe & LAMR (2005c). *An Investigation of Flora, Fauna and Biodiversity Values associated with Brigalow Remnants along the Proposed Heyford Back Access Road*. An unpublished report prepared for BMA Coal Peak Downs Mine.

EcoServe & LAMR (2005d). *A Review of Habitat Values for Biodiversity and Species of Conservation Significance*. An unpublished report prepared for BMA Coal Saraji Mine.

EcoServe & LAMR (2006). *Baseline Flora and Fauna Assessment of the Isaac River Expansion Project*. An unpublished report prepared for BMA Coal (Corporate).

EcoServe (2005). *Vertebrate Fauna Survey of Remnant Habitats associated with One Mile Dam and Surrounds*. An unpublished report prepared for BMA Coal Saraji Mine.

EcoServe (2006a). *Aquatic Terrestrial Vertebrate Fauna Survey of Peak Downs Mine*. An unpublished report prepared for BMA Coal Peak Downs Mine.

EcoServe (2006b). *2006 Winter Vertebrate Fauna Survey Of Remnant Habitats*. An unpublished report prepared for BMA Coal Peak Downs Mine.

EcoServe (2006c). *Assessment of Koalas and Koala Habitat Use*. An unpublished report prepared for BMA Peak Downs Mine.

EcoServe (2006d). *2006 Vertebrate Fauna Survey of Selected Remnant Regional Ecosystems*. An unpublished report prepared for BMA Coal Saraji Mine.

EcoServe (2007). *Assessment of Koalas and Koala Habitat Use*. An unpublished report prepared for BMA Coal Saraji Mine.

Ellis W, Fitzgibbon S and Carrick FN (2006). *Koala Ecology: known knowns, known unknowns and unknown unknowns; 2006 1-4 September 2006*; Wellington, New Zealand.

Ellis WAH, Carrick FN, 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.

Ellis WAH, Melzer A, Carrick FN and Hasegawa M. (2002a). *Tree use, diet and home range of the koala (Phascolarctos cinereus) at Blair Athol, central Queensland*. Wildlife research 29:303-311.

Ellis WAH, Melzer A, Green B, Newgrain K, Hindell MA and Carrick FN. (1995). *Seasonal variation in water flux, field metabolic rate and food consumption of free-ranging koalas (Phascolarctos cinereus)*. Aust J Zool 43(1):59-68.

- Ellis WAH, Sullivan BJ, Lisle AT and Carrick FN. (1998). *The spatial and temporal distribution of koala faecal pellets*. Wildlife Res 25(6):663-668.
- Gall BC. (1980). *Aspects of the Ecology of the Koala, Phascolactos cinereus (Goldfuss), in Tucki Tucki Nature Reserve, New South Wales*. Australian Wildlife Research 7:167-176.
- GHD Pty Ltd (2004). *BHP Billiton Mitsubishi Alliance Peak Downs Mine Fauna Survey Report*. An unpublished report prepared for BMA Peak Downs Mine.
- Hindell MA and Lee AK. (1990). *Tree preferences of the koala*. In: Lee AK, Handasyde KA, Sanson GD, editors. *Biology of the Koala*. Sydney: Surrey Beatty and Sons. p 117-121.
- Hindell MA, Handasyde KA, Lee AK. (1985). *Tree species selection by free-ranging koala populations in Victoria*. Australian Wildlife Research 12:137-144.
- Hindell MA, Lee AK. (1988). *Tree use by individual koalas in a natural forest*. Australian Wildlife Research 15:1-7.
- Melzer A. (1994). *Aspects of the ecology of the koala (Phascolarctos cinereus) in the semi-humid woodlands of Central Queensland*. [PhD]. Brisbane: The University of Queensland.
- Mitchell P. (1990). *The home ranges and social activity of koalas - a quantitative analysis*. In: Lee AK, Handasyde KA, Sanson GD, editors. *Biology of the Koala*. Sydney: Surrey Beatty and Sons. p 171-187.
- Phillips S, Callaghan J, Thompson V. (2000). *The tree species preferences of koalas (Phascolarctos cinereus) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, New South Wales*. Wildlife research 27:1-10.
- Reed P, Lunney D. (1990). *Habitat loss: the key problem for the long-term survival of koalas in New South Wales*. In: Lunney D, Urquhart CA, Reed P, editors. *Koala summit: Managing koalas in New South Wales*. Hurstville: NSW National Parks and Wildlife Service. p 9-31.
- Sattler, P.S. and Williams, R. D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Queensland Environmental Agency, Brisbane.
- WBM Pty Ltd (1998). *Peak Downs Mine: Aquatic and Terrestrial Fauna Wet and Dry Season Surveys*. An unpublished report prepared by WBM Pty Ltd for BHP Coal Peak Downs Mine.
- WBM Pty Ltd (1999). *Assessment of Rehabilitation Enhancement Works*. An unpublished report prepared by WBM Pty Ltd for BHP Coal Peak Downs Mine.
- WBM Pty Ltd (1999). *Wet Season Survey of Terrestrial and Aquatic Fauna of Saraji Mine*. An unpublished report prepared for BMA Coal Saraji Mine.
- WBM Pty Ltd (2002). *Jacaranda Pit IAS – Terrestrial Vertebrate Fauna Assessments - Saraji Mine*. An unpublished report prepared for BMA Coal Saraji Mine.
- White NA and Kunst ND. (1990). *Aspects of the ecology of the koala in southeastern Queensland*. In: Lee AK, Handasyde KA, Sanson GD, editors. *Biology of the koala*. Sydney: Surrey Beatty and Sons. p 109-116.
- White NA. (1999). *Ecology of the koala (Phascolarctos cinereus) in rural south-east Queensland, Australia*. Wildlife research 26:731-744.

## APPENDIX A KOALA OBSERVATION DATABASE

Table A-1 Detailed Koala Survey Database Summary

Waypoint	Easting	Northing	Koala Signs			Observation under/on/in tree					
						1	2	3	4	5	6
P01	626738	7528692	S			E. crebra	E. crebra	E. crebra	E. crebra	E. tereticornis	
P02	626016	7529461			N						
P03	625856	7529581			N						
P04	626162	7531701		T		E. tereticornis					
P05	625900	7529803		T		E. tereticornis					
P06	624873	7530788			N						
P07	624821	7530629	S			E. crebra	E. crebra	E. crebra	E. crebra	E. crebra	E. crebra
P08	624570	7530931			N						
P09	624583	7531017	S			E. melanophloia	E. melanophloia				
P10	624067	7531673	S			C. clarksonia	E. tereticornis				
P11	623851	7532639	S			E. tereticornis	E. tereticornis	E. tereticornis			
P12	620646	7535974	S			E. crebra					
P13	619618	7537415	S			E. tereticornis					
P14	619622	7537200	S			E. leichhardtii	E. leichhardtii				
P15	619285	7537031	S			E. crebra	E. crebra	C. citriodora			
P16	618922	7537503			N						
P17	619557	7537898			N						
P18	619395	7537895			N						
P19	620092	7538824			N						
P20	619511	7540051	S			E. crebra					
P20A	619557	7540231	S			E. crebra					
P21	619568	7540780	S			E. crebra					
P22	614505	7544540	S			E. tereticornis					
P23	611206	7549554	S			E. tereticornis	E. tereticornis				
P24	631751	7531211	S			E. tereticornis	E. tereticornis	E. tereticornis	E. tereticornis	E. tereticornis	
P25	631231	7532122		T		E. tereticornis	E. tereticornis	E. tereticornis			
P26	630114	7534164			N						
P27	629641	7535177			N						
P28	628770	7537163			N						

Waypoint	Easting	Northing	Koala Signs			Observation under/on/in tree						
						1	2	3	4	5	6	
P29	623520	7539550		T		E. tereticornis						
P30	624711	7539089			N							
P31	626429	7537621			N							
P32	628464	7533877			N							
P33	628732	7533146		T		E. tereticornis						
P34	628836	7532016	S			E. tereticornis						
P35	611748	7549748	S			E. tereticornis						
P36	615013	7548302			N							
P37	616813	7547478			N							
P38	615152	7545284	S			E. tereticornis						
P39	618325	7543168			N							
P40	618994	7542699		T		E. cambageana						
<b>Totals</b>			<b>18</b>	<b>6</b>	<b>17</b>	<b>24</b>	<b>10</b>	<b>6</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>1</b>
<b>Percentages</b>			<b>44</b>	<b>15</b>	<b>41</b>							

Table A-2 Detailed Koala Survey Database Tally

Waypoint	Easting	Northing	Koala Signs			Tree Species where Observation Made						Total Tree Observation	Total Tree Species	
						E. crebra	E. tereticornis	E. melanophloia	C. clarksoniana	C. leichhardtii	C. citriodora			E. cambageana
P01	626738	7528692	S			4	1						5	2
P02	626016	7529461			N									
P03	625856	7529581			N									
P04	626162	7531701		T			1						1	1
P05	625900	7529803		T			1						1	1
P06	624873	7530788			N									
P07	624821	7530629	S			6							6	1
P08	624570	7530931			N									
P09	624583	7531017	S					2					2	1
P10	624067	7531673	S				1		1				2	2
P11	623851	7532639	S				3						3	1
P12	620646	7535974	S			1							1	1
P13	619618	7537415	S				1						1	1
P14	619622	7537200	S						2				2	1
P15	619285	7537031	S			2				1			3	2

Waypoint	Easting	Northing	Koala Signs			Tree Species where Observation Made						Total Tree Observation	Total Tree Species	
						E. crebra	E. tereticornis	E. melanophloia	C. clarksoniana	C. leichhardtii	C. citriodora			E. cambageana
P16	618922	7537503			N									
P17	619557	7537898			N									
P18	619395	7537895			N									
P19	620092	7538824			N									
P20	619511	7540051	S			1						1	1	
P20A	619557	7540231	S			1						1	1	
P21	619568	7540780	S			1						1	1	
P22	614505	7544540	S				1					1	1	
P23	611206	7549554	S				2					2	1	
P24	631751	7531211	S				5					5	1	
P25	631231	7532122		T			3					3	1	
P26	630114	7534164			N									
P27	629641	7535177			N									
P28	628770	7537163			N									
P29	623520	7539550		T			1					1	1	
P30	624711	7539089			N									
P31	626429	7537621			N									
P32	628464	7533877			N									
P33	628732	7533146		T			1					1	1	
P34	628836	7532016	S				1					1	1	
P35	611748	7549748	S				1					1	1	
P36	615013	7548302			N									
P37	616813	7547478			N									
P38	615152	7545284	S				1					1	1	
P39	618325	7543168			N									
P40	618994	7542699		T							1	1	1	
<b>Totals</b>			<b>18</b>	<b>6</b>	<b>17</b>	<b>16</b>	<b>24</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>47</b>	<b>27</b>
<b>Percentages</b>			<b>44</b>	<b>15</b>	<b>41</b>	<b>59</b>	<b>89</b>	<b>7</b>	<b>4</b>	<b>7</b>	<b>4</b>	<b>4</b>		

Table A-3 Regional Ecosystem Database

Waypoint	Easting	Northing	Koala Signs			Regional Ecosystem Analysis
P01	626738	7528692	S			11.4.3/11.4.8/11.4.9
P02	626016	7529461			N	
P03	625856	7529581			N	
P04	626162	7531701		T		11.5.3/11.5.1
P05	625900	7529803		T		11.3.25/11.3.2
P06	624873	7530788			N	
P07	624821	7530629	S			11.5.3/11.5.1
P08	624570	7530931			N	
P09	624583	7531017	S			11.9.2/11.9.9/11.5.3
P10	624067	7531673	S			11.3.25/11.3.2
P11	623851	7532639	S			11.3.25/11.3.2
P12	620646	7535974	S			No Mapping
P13	619618	7537415	S			No Mapping
P14	619622	7537200	S			No Mapping
P15	619285	7537031	S			No Mapping
P16	618922	7537503			N	
P17	619557	7537898			N	
P18	619395	7537895			N	
P19	620092	7538824			N	
P20	619511	7540051	S			Cleared
P20A	619557	7540231	S			11.7.2
P21	619568	7540780	S			11.7.2
P22	614505	7544540	S			11.3.25
P23	611206	7549554	S			11.3.25
P24	631751	7531211	S			11.3.25/11.3.2
P25	631231	7532122		T		11.3.25/11.3.2
P26	630114	7534164			N	
P27	629641	7535177			N	
P28	628770	7537163			N	
P29	623520	7539550		T		11.3.25/11.3.2
P30	624711	7539089			N	
P31	626429	7537621			N	
P32	628464	7533877			N	
P33	628732	7533146		T		11.3.25/11.3.2/11.4.3/11.4.8/11.4.9
P34	628836	7532016	S			11.5.3
P35	611748	7549748	S			Cleared
P36	615013	7548302			N	
P37	616813	7547478			N	
P38	615152	7545284	S			11.3.1
P39	618325	7543168			N	
P40	618994	7542699		T		11.5.3
<b>Totals</b>			<b>18</b>	<b>6</b>	<b>17</b>	
<b>Percentages</b>			<b>44</b>	<b>15</b>	<b>41</b>	

S = Scat; T = Track; N = No Sign

Table A-4 Detailed Diet Analysis Database

Slides	Peak Downs Sites	E. crebra	E. populnea	E. melanophloia	E. cambageana	unknown
80a	PDM 1	92	2	4	1	1
80b	PDM 1	89	0	11	0	0
80c	PDM 1	93	7	0	0	0
	Mean	91	3	5	0	0
81a	PDM7	72	27	1	0	0
81b	PDM7	88	12	0	0	0
81c	PDM7	85	13	2	0	0
	Mean	82	17	1	0	0
82	PDM9	50	45	0	0	5
83	PDM10	66	25	0	0	9
84a	PDM11	60	18	6	0	16
84b	PDM11	72	22	0	0	6
84c	PDM11	51	41	8	0	0
	Mean	61	27	5	0	7
85	PDM12	75	19	6	0	0
86	PDM13	100	0	0	0	0
87a	PDM14	92	0	8	0	0
87b	PDM14	96	2	2	0	0
87c	PDM14	87	0	13	0	0
	Mean	92	1	8	0	0
88a	PDM15	79	7	10	2	2
88b	PDM15	80	6	6	4	4
88c	PDM15	71	8	21	0	0
	Mean	77	7	12	0	4
89	PDM20	63	32	5	0	0
90	PDM20A	27	53	10	0	10
91a	PDM22	38	41	0	0	21
91b	PDM22	42	38	20	0	0
91c	PDM22	34	47	19	0	0
	Mean	38	42	13	0	7
92a	PDM23	35	41	22	0	2
92b	PDM23	43	37	0	0	20
92c	PDM23	25	61	11	0	3
	Mean	34	46	11	0	8
94	PDM34	80	0	15	0	5
95	PDM38	75	18	4		3