Australian Koala Foundation

The Australian Koala Foundation (AKF)

Koala Population Estimates
Explanation of Methodology

&

Recommendations to the
Threatened Species Scientific Committee (TSSC)

Threatened Species Assessment of *Phascolarctos cinereus* (Koala)

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Contents

Introduction

In early 2005 the Australian Koala Foundation (AKF) Board of Directors recognised the need to derive current estimates for Australia's koala population, in order to provide baseline figures with which future population estimates could be compared and monitored. The methodology outlined below builds upon that initial work. Further impetus for the project was generated by the AKF's Nomination for listing the koala as Vulnerable under the EPBC Act, with the aim of addressing the questions and inevitable controversy generated by any attempt to derive an accurate population estimate of Koalas throughout their geographic range.

The Australian Koala Foundation (AKF) has worked towards improving the identification and conservation of Koala habitat throughout New South Wales, Queensland and Victoria using the Koala Habitat Atlas (KHA) methodology (Phillips *et al.,* 2000; Phillips & Callaghan, 2000). KHAs provide a sound underpinning for Comprehensive Koala Plans of Management which may be adopted by Local Governments in order to identify and protect key koala habitat areas and to provide strategic direction for habitat restoration programs, threat mitigation measures, community awareness, and ongoing monitoring and reporting.

In designing the methodological steps outlined below, AKF has drawn on the collective research funded and managed by the AKF under the auspices of many eminent koala scientists (some of whom were employed by AKF and others in academia) in Australia. Mr. David Mitchell, Dr. Stephen Phillips, Mr. John Callaghan, Mr. Rolf Schlagloth, Dr. Douglas Kerlin. It has also called upon the research of Dr. Alistair Meltzer, Dr. Bill Foley, Dr. Stephen Cork, Professor Peter Timms, Dr. Jeff McKee, Dr. Rosemary Booth, Professor Paul Canfield, Dr. Mark Krockenberger, Dr. Robert Close, Mr. Tristan Lee, Dr. Damien Higgins. Dr. Clive McAlpine, Dr. Leonie Seabrook. Ms. Christine Hoskings, Dr. Jonathan Rhodes, Professor William Sherwin, Dr. Greg Baxter, Dr. Guy Castley, Ms. Alexa Mossaz, Dr. Bronwyn Houlden, Dr. Lester Pahl, Dr. John Woolcock, Dr. Julie Haynes. See Appendix 2 for a list of AKF funded research.

The methodological steps taken to create the Koala Habitat Atlas (KHA) is derived from an amalgamation of research resulting from the above scientists. These fields of research are continually improving and with these adjustments, follows adjustments in AKF's methodological approach to estimating koala populations.

In addition to the peer reviewed research papers AKF has drawn on and contributed to, we draw your attention to amount of time AKF scientific staff, some of which are those mentioned above, have spent researching in the field. 400 days, each with four people, equaling 1600 days working, collecting data from the bush and recording the reality of their surroundings. This has resulted in an unprecedented data base of 80,000 individually measured trees (available to all researchers) and 2000 field sites across the koala's natural range.

Methodology

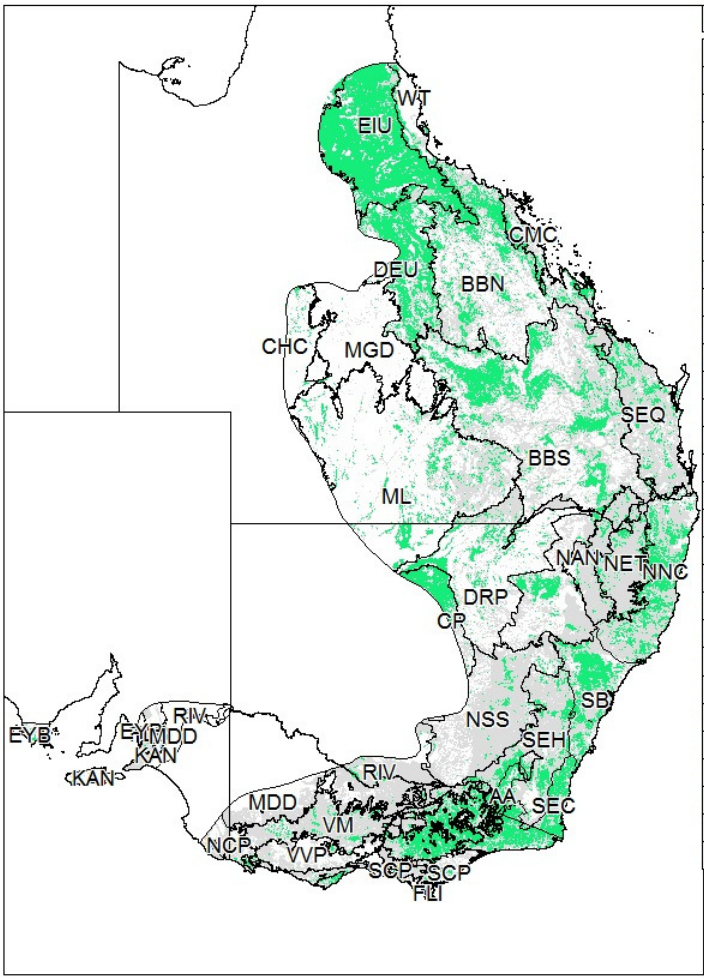
Koala Habitat Mapping

Koala habitat mapping was based on the Native Vegetation Information System (NVIS) mapping. The Australian Native Vegetation Assessment 2001 (Cofinas & Creighton, 2001) reports that the NVIS mapping is focused on major vegetation groups and broad-scale vegetation clearing, and that the mapping products are designed primarily for use at national and State-wide scale and for simple regional vegetation descriptions. The NVIS mapping involved compilation of a wide range of data sources with varying capture scales (Cofinas & Creighton, 2001).

The NVIS dataset used in this analysis is the now-superseded Version 1; at a future stage the analysis can be performed using NVIS Version 3 data, however this would require computing power somewhat beyond the AKF's present capabilities. NVIS Version 1 delineates 23 major vegetation groups (MVGs) in Australia. The MVGs which include trees used by koalas include: Eucalypt tall open forests, Eucalypt open forests, Eucalypt woodlands, Eucalypt open woodlands, and Callitris forests and woodlands. These MVGs are hereafter referred to as potential Koala habitat.

It is important to note that, with a cell size of 0.01 degrees or approximately 1 km^2, the dataset does not show riparian habitats. However, as of 2005 (when this analysis was first conducted), NVIS Version 1 was the only uniform vegetation mapping covering the range of the koala. Again, it is envisaged that these analyses will be redone when feasible, using NVIS Version 3 which, with a cell size of 100 metres, will capture riparian habitats more effectively.

For our analysis the area within the approximate koala distribution in mainland Australia, was clipped from the Australia-wide NVIS dataset and MVGs that do not typically contain eucalypts were removed using the Vertical Mapper grid analysis add-on in MapInfo 7.5. Interim Bioregions (IBRA 5.1) were then intersected with the remaining NVIS cells (Figure 1). The number of eucalypt cells in each Bioregion were tallied, producing an estimate for the area of available potential koala habitat used for subsequent population modeling.



Code	Bioregion_Name
AA	Australian Alps
BBN	Brigalow Belt North
BBS	Brigalow Belt South
CHC	Channel Country
CMC	Central Mackay Coast
CP	Cobar Peneplain
DEU	Desert Uplands
DRP	Darling Riverine Plains
EIU	Einasleigh Uplands
EYB	Eyre Yorke Block
FLB	Flinders Lofty Block
FLI	Flinders
KAN	Kanmantoo
MDD	Murray Darling Depression
MGD	Mitchell Grass Downs
ML	Mulga Lands
NAN	Nandewar
NCP	Naracoorte Coastal Plain
NET	New England Tableland
NNC	NSW North Coast
NSS	NSW South Western Slopes
RIV	Riverina
SB	Sydney Basin
SCP	South East Coastal Plain
SEC	South East Corner
SEH	South Eastern Highlands
SEQ	South Eastern Queensland
VM	Victorian Midlands
VVP	Victorian Volcanic Plain
WT	Wet Tropics

Figure 1: Bioregions within Koala's geographic range with potential koala habitat. NVIS 2001 eucalypts=green, NVIS 1750 eucalypts green and grey, white=not suitable.

Field data collection

Since 1994 the Australian Koala Foundation (AKF) has conducted field work at 1,995 field sites across the natural range of the koala (Figure 2). At each field site, koala habitat utilisation and tree species preferences were assessed using the KHA methodology, supported by the Spot Assessment Technique (SAT) where appropriate (for more details, refer to Phillips *et al.*, 2000; Phillips & Callaghan, 2000).

In brief, both the KHA and the SAT employ a standardised faecal pellet search methodology. At each site, living trees (with the exception of tree ferns, palms and cycads) with a diameter at breast height (dbh) of at least 100mm are identified and marked. A systematic search for koala faecal pellets is conducted beneath each of the marked trees, with a cursory inspection of the undisturbed ground surface, followed (if no faecal pellets are initially detected) by a more thorough inspection involving disturbance of the leaf litter and ground cover within the prescribed search area (a radius of 1m around the base of each tree). At each tree, searching is conducted for two-person minutes, or until a koala pellet is found. Field plot sites are categorised as either 'active' or 'inactive' on the basis of whether koala faecal pellets were present or absent. Searches for koalas are also conducted at each field site.

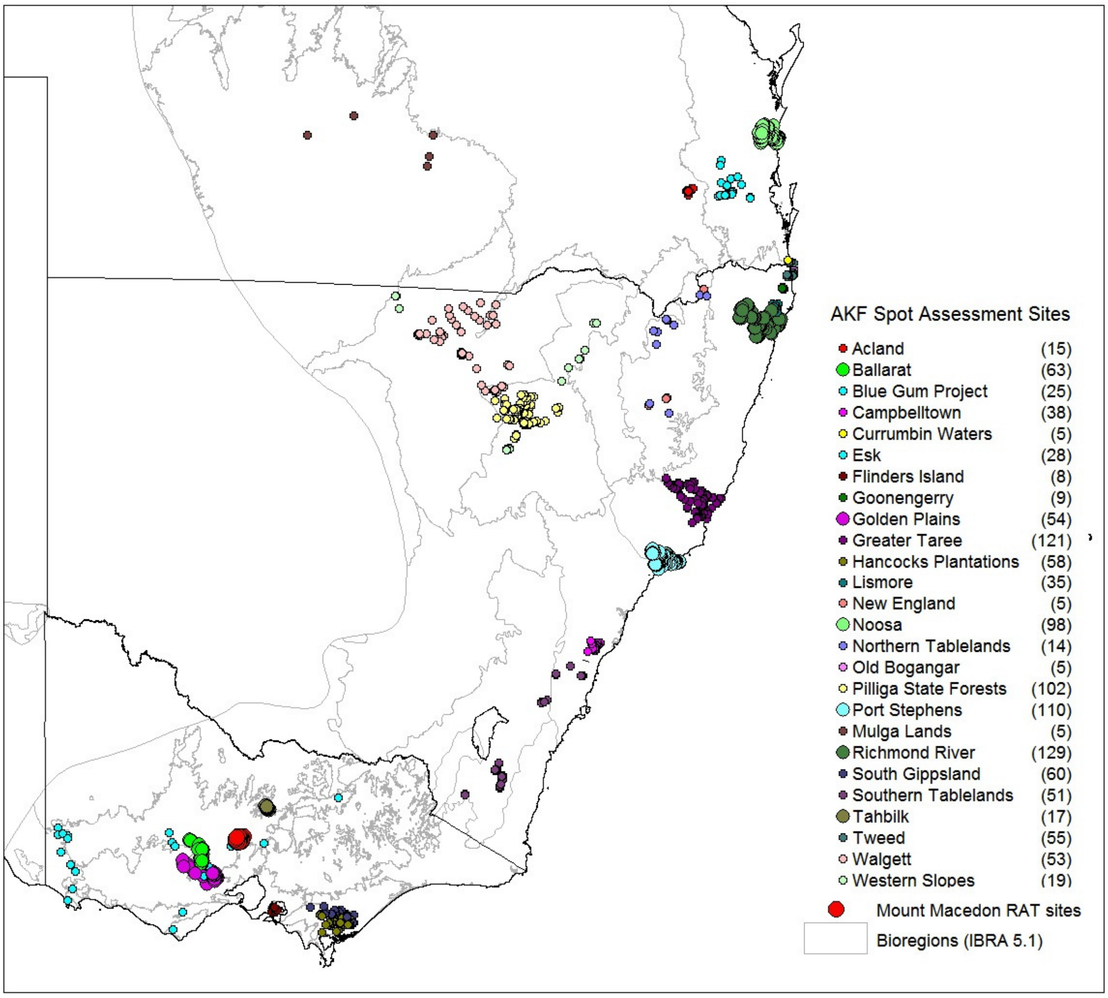


Figure 2: Locations of AKF SAT and RAT field sites. Larger circles (with presence/absence data) were used in analysis.

Tree species preferences are identified on the basis of statistical examination of variation (heterogeneity) amongst strike rates (i.e., the proportion of surveyed trees for each given species that recorded koala pellet evidence), for tree species data that satisfy validation criteria, using G-tests for independence, followed by analysis of use versus availability. Tree species are subsequently ranked into primary and secondary koala habitat tree species (collectively referred to as preferred species), and supplementary species.

Prior analysis has indicated that some tree species can be of significantly greater importance to koalas when occurring on particular substrates, generally those with higher nutrient status and moisture availability (Phillips et al. 2000; Phillips & Callaghan 2000). Where there is significant variation in soil types and underlying geology within a study area, the tree use dataset is grouped accordingly and the analysis is repeated for each grouping.

Following the identification and ranking of local tree species preferences, detailed vegetation and soil landscape classifications and accompanying descriptions are used to assign primary, secondary, and marginal koala habitat categories to a detailed vegetation map of the study area. These habitat rankings subsequently inform the preparation of a GIS-based Koala Habitat Atlas (KHA) map for the study area. A KHA represents a ranked koala habitat map (Callaghan et al., *in review*)

While there has been some criticism of the SAT methodology in the literature (Dique et al., 2004), it is important to note that the SAT was developed to provide a rapid, cost effective assessment of koala tree species preferences. The presence of faecal pellets under trees does not indicate feeding by koalas, or provide any indication of the amount of time spent in a particular tree; analysis of the contents of faecal pellets could be used to establish a firmer link between tree use as a food resource and pellet presence/ absence. However, given the desire to develop a rapid and cost effective assessment methodology, and given that the results of SAT sampling generally reflect the scientific consensus with regards to important koala habitats, we feel that the SAT has merit. It is critical to note that the SAT merely provides an assessment of koala habitat quality, and does not, in and of itself, provide any estimates of koala abundance. It does however provide information on Koala distribution within a study area as shown for the former Noosa Local Government Area in Figure 3.

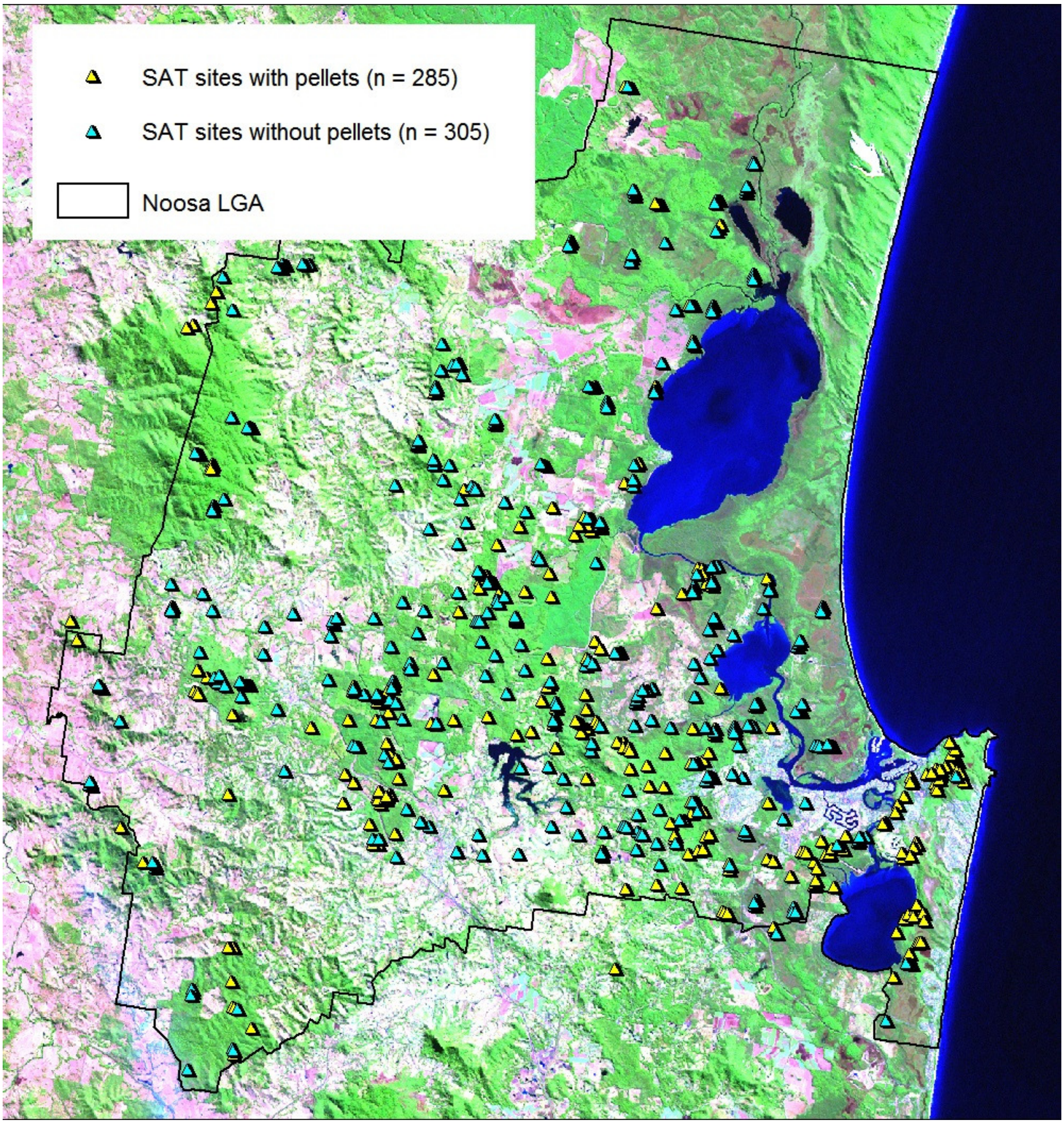


Figure 3: Spot Assessment sites for former Noosa LGA. Yellow = sites with fecal pellets, blue = without. 48% of sites recorded pellets. (Note: map includes additional sites excluded from population modeling).

Estimating Koala Abundance

Koala abundance was estimated based on one of two methods. Where available, data pertaining to koala home range sizes was utilised to help with estimation of koala density and abundance. For example, data collected by the AKF on the Tweed Coast in northern NSW provided helpful estimates of average koala home range size, and extent of home range overlap (Table 1; AKF unpub. data). For locations where home range data was available from previous studies by koala researchers, estimates of koala abundance were more straight-forward, with narrower confidence limits.

For locations that lacked koala home range data, we constructed models for population estimation using parameters derived from available published sources from similar or nearby regional areas.

Table 1. Koala home range sizes from the Tweed Coast, northern NSW (AKF unpub. Data).

State	Area	Male			Female			Overlap
		Min.	Max.	Mean	Min.	Max.	Mean	(%)
NSW	Tweed Coast	10.78	42.78	20.3	1.84	16.28	8.82	20

Modeling Koala Abundance

Parameters of the Model

Previous attempts to estimate the abundance and population status of koalas in Australia have been criticised for failing to adequately consider variation across the species range. For example, a previous population viability analysis was criticised for only using reproductive parameters from a single population, rather than using parameters derived from a wider sample of populations. In this study, we have instead collated data from field study sites across the species range, and from sources in the scientific literature, to reflect the broad variation in koala habitat quality and population density.

In order to capture variation in this collated data; we assume that the reported values for the different sites are representative of various probability distributions that capture the variation across the whole country (including unsampled sites). For example, while the sampled proportion of active sites ranges from 0.3 to 0.7, we might expect that we could find values across the country ranging from 0 to 1, but that the sampled values from 0.3 to 0.7 are indicative of the shape of the probability distribution which describes the proportion of active sites. We can determine the most likely probability distributions from which those numbers may have been derived. We use a beta distribution for those parameters which are limited between 0 and 1 (proportions), and a Weibull distribution for other, positive parameters. By sampling randomly from these distributions in an iterative fashion, the results generated provide a robust estimate of koala abundance. To Illustrate this process, Figure 4 displays a sample beta probability distribution, generated to model the proportion of preferred koala habitat in a landscape (mean = 0.33, 95% confidence intervals = .04, .73).

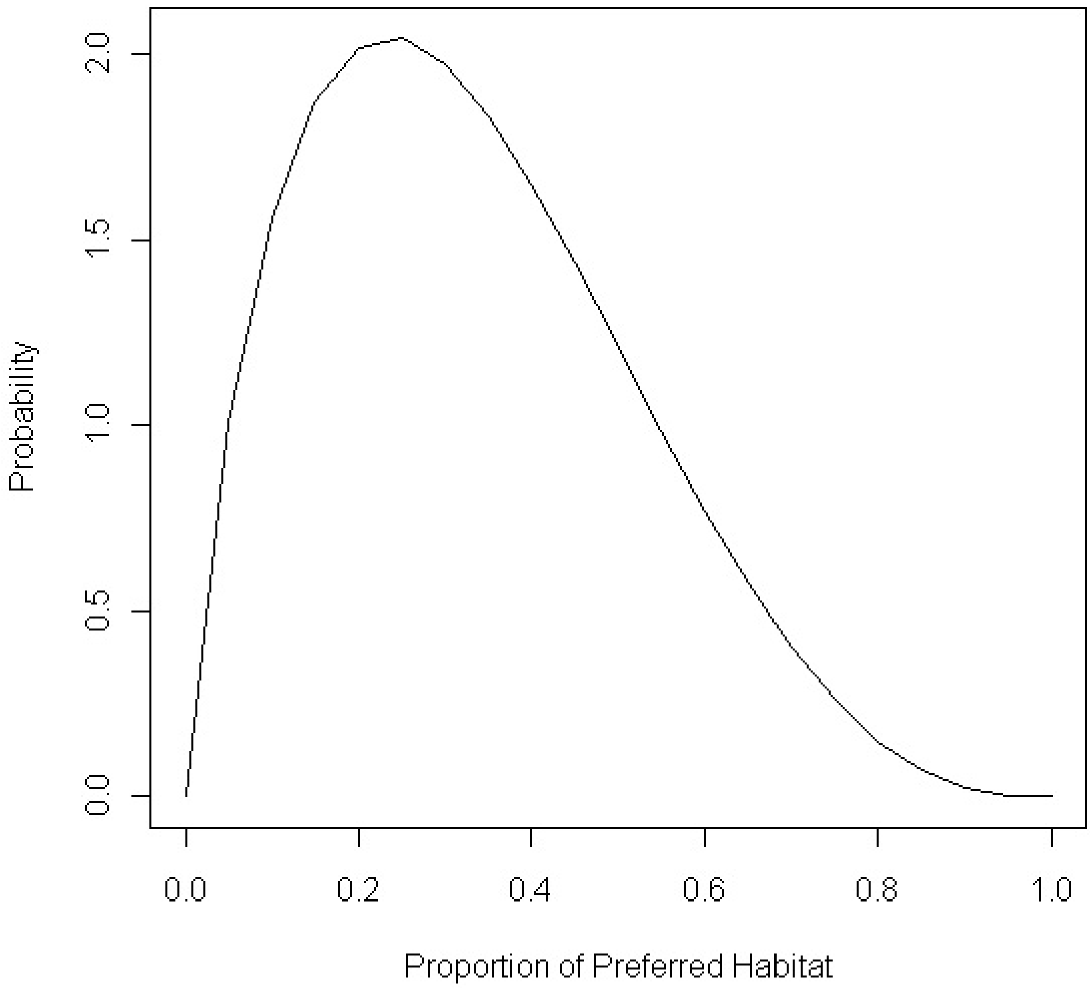


Figure 4: Beta Probability distribution modeling the proportion of preferred habitat. Note that this distribution is based on all available data, rather than the closest three study areas.

To better reflect regional variation in the population dynamics of koalas, parameters for koala populations in any given area were determined using data from the three nearest study areas. Where there was insufficient available data to model each geographic group separately, parameters were modelled using all available data.

We specify model parameters as probability distributions; distributions are constructed to provide four model parameters: the proportion of occupied habitat, the proportion of preferred habitat, koala densities, and the proportion of koalas in preferred habitat, relative to supplementary habitat.

Analyses were conducted using the R software environment for statistical computing and graphics (Ihaka and Gentleman, 1996).

Proportion of Occupied Habitat

The KHA methodology typically involved a combination of random stratified and targeted survey techniques for site selection; the non-random nature of sampling makes inferences problematic. However, in a small number (6) of study areas, SAT sites were randomly determined *apriori*. These study areas provide an ideal data set to evaluate the proportion of habitat occupied by koalas. The proportion of occupied habitat was assessed using data from six study areas, where SAT surveys had been conducted at randomly selected sites (Table 2). Other study areas were excluded from this compilation as sites were only selected where evidence of koalas was found (pellets or sightings). The proportion of occupied habitat was modelled by fitting a beta probability distribution to available data.

Table 2. The proportion of active sites within randomly sampled study areas. Mean proportion of active sites 0.664, s.d.= 0.145

Study Area	State	Number of sites sampled	No of active sites	Proportion active
Golden Plains	Vic	134	76	0.567
Tahbilk	Vic	90	60	0.667
Hanging Rock	Vic	74	27	0.365
Port Stephens LGA	NSW	110	79	0.718
Richmond River LGA	NSW	127	90	0.709
Noosa	QLD	98	66	0.673
Ballarat	VIC	100	76	0.76
Campbelltown	NSW	38	18	0.473
Taree	NSW	126	84	0.667
Tweed Coast	NSW	53	39	0.736
Strzelecki Ranges	VIC	62	54	0.871

Proportion of Preferred Habitat

Data pertaining to the proportion of total potential habitat (all eucalypt forests and woodlands) classified as preferred habitat was compiled from 13 Koala Habitat Atlases (KHAs) (Table 3). The proportion of preferred habitat was modelled by fitting a beta probability distribution to available data.

Table 3. Koala Habitat Atlas results for the proportion of preferred koala habitat in each KHA area.

Study Area	State	Total Area (ha)	Total Potential Koala Habitat (ha)	Proportion of Preferred Habitat
Ballarat LGA	Vic	70912.25	6903	68.872
HVP Native Forest	Vic	34072	27308	32.353
Golden Plains	Vic	165606.75	39939	30.271
Tahbilk	Vic	11698.24	3522	35.484
Port Stephens LGA	NSW	85582.73	41699	12.928
Hawkes Nest	NSW	1180.21	390	8.592
Campbelltown LGA	NSW	31045.88	15881	15.258
Greater Taree LGA	NSW	367648.53	170681	52.835
Richmond River LGA	NSW	197625.95	77376	38.088
Tweed Coast	NSW	43072.68	8980	55.979
Walgett LGA	NSW	1420134.73	441929	5.851
Pilliga State Forests	NSW	389751	368798	40.785
SEQ Bioregion (Queensland Only)	QLD	6061480.57	2219568	36.609

Koala Densities

Data on koala densities was drawn from the available scientific literature (Table 4). For most studies, minimum and maximum density estimates were available. However, for two studies (Eden and Central Queensland), only a mean estimate was provided. A Weibull probability distribution reflecting the observed variation in density was constructed. Mean density was calculated by assuming reported densities came from a normal distribution, and that the minimum and maximum densities reported represent the 95% confidence intervals (CI) of this distribution. Similarly, observed minimum density and observed maximum density estimates were assumed to reflect the 95% CI of the modelled Weibull distribution.

Table 4. Koala density estimates drawn from the literature.

State	Location	Koalas/ha		Source
		Min	Max	
SA	Kangaroo Island	0.11	5.01	Masters *et al* 2004
Vic	Fragmented Habitats	8.6	8.9	Mitchell 1990; cited in Meltzer *et al* 2000
Vic	Phillip Island and Brisbane Ranges	0.7	1.6	Hindall 1984; cited in Meltzer *et al* 2000
NSW	Eden	0.006		Jurskis and Potter 1997; cited in Meltzer *et al* 2000
NSW	Northeast	4	8	Meltzer *et al* 2000
NSW	Tucki Tucki	1	7	Gall 1980
QLD	Mulgalands	0.001	2.513	Sullivan *et al* 2004
QLD	Southeast	0.02	1.26	Dique *et al* 2004
QLD	Central	0.01		Melzer and Lamb 1994; cited in Meltzer *et al* 2000
QLD	Southeast	1	3	Gordon *et al* 1990, Hasegawa 1995; cited in Meltzer *et al* 2000

The proportion of koalas in preferred habitat

Koala densities/sightings are expected to be higher in preferred habitats as compared to supplementary habitats. However, as a result of landclearing targeting higher fertility soils, koalas are often forced to occupy lesser quality, supplementary habitats on poorer soils. We modelled the proportion of koalas sighted in preferred habitats to incorporate differences in local koala occurrence related to habitat quality.

Observations of koalas were recorded throughout the course of KHA surveys,. Sighting data was also available from the Department of Sustainability and Environment in Victoria, the Department of Environment and Climate Change in New South Wales, and the Department of Environment and Resource Management in Queensland. Sighting data was overlaid onto KHA mapping to determine the number of sightings for preferred and supplementary koala habitat categories. Records for areas mapped as 'cleared land' were assigned to the closest preferred or supplementary habitat within 100m, or beyond this distance were deleted. Observations at the same site on the same day were assumed to represent the same animal unless explicitly documented otherwise and deleted so as to minimise duplications.

We used this data to assess the proportion of koalas in preferred habitat (Table 5); modelled using a beta probability distribution.

Table 5. Koala Habitat Atlas results for the number of sighted koalas in preferred habitat.

Study Area	State	No.of Koalas Sighted	Proportion of Sightings in Preferred Habitat
Hanging Rock	Vic	34	0.735
Ballarat	Vic	46	0.694
Golden Plains	Vic	91	0.363
HVP Native Forest	Vic	56	0.304
Tahblik	Vic	3	0.333
East Tweed	NSW	225	0.644
Richmond River	NSW	55	0.836
Greater Taree	NSW	514	0.512
Port Stephens	NSW	2189	0.245
Pilliga	NSW	58	0.638
Walgett	NSW	35	0.057
Southeast Queensland	QLD	1045	0.372

Modeling Koala Abundance

Koala abundance modeling was undertaken on a bioregion by bioregion basis. For each bioregion, we generated a distribution of estimated abundances after conducting 10 000 iterations of the following model:

> The abundance of koalas in preferred koala habitat in bioregion *i* was calculated using the area of available koala habitat in the bioregion as determined through koala habitat mapping (a_i). We estimate the area of habitat actually inhabited by koalas by modeling the proportion of occupied habitat (o).
>
> Given the area of occupied habitat, we can determine the proportion likely to be classified as preferred habitat (*p).* Koala abundance was calculated by modeling koala density (d). Note that we assume that previous estimates of koala density are biased; previous studies have introduced sampling bias to estimates of koala density by calculating densities based on abundances at discrete sites where koalas are known to be present, these results are then extrapolated to areas with no known koala populations. Our methodology instead assumes that koala density estimates are appropriate for areas of occupied habitat, rather than total available habitat.
>
> Estimated koala abundance was adjusted to consider the effect of the modelled proportion of preferred habitat (*p*), and proportion of koalas sighted in preferred habitat (*s*), to reflect any inherent variation in habitat usage. Koala sightings were taken from Wildlife Atlas records.

For each iteration of the model, we randomly generate values for parameters *p, o, d and s* by sampling from the respective described probability distributions. We assumed the true abundance for each bioregion lies between the 95% percentile intervals of the generated distribution of abundances.

Finally, estimated abundance was modified where additional information was available from other sources, including research investigators, wildlife carers and verified government sources. A flow chart of the process is illustrated in Figure 5. For the final map, Bioregion population estimates were proportionately redistributed to Federal electorates.

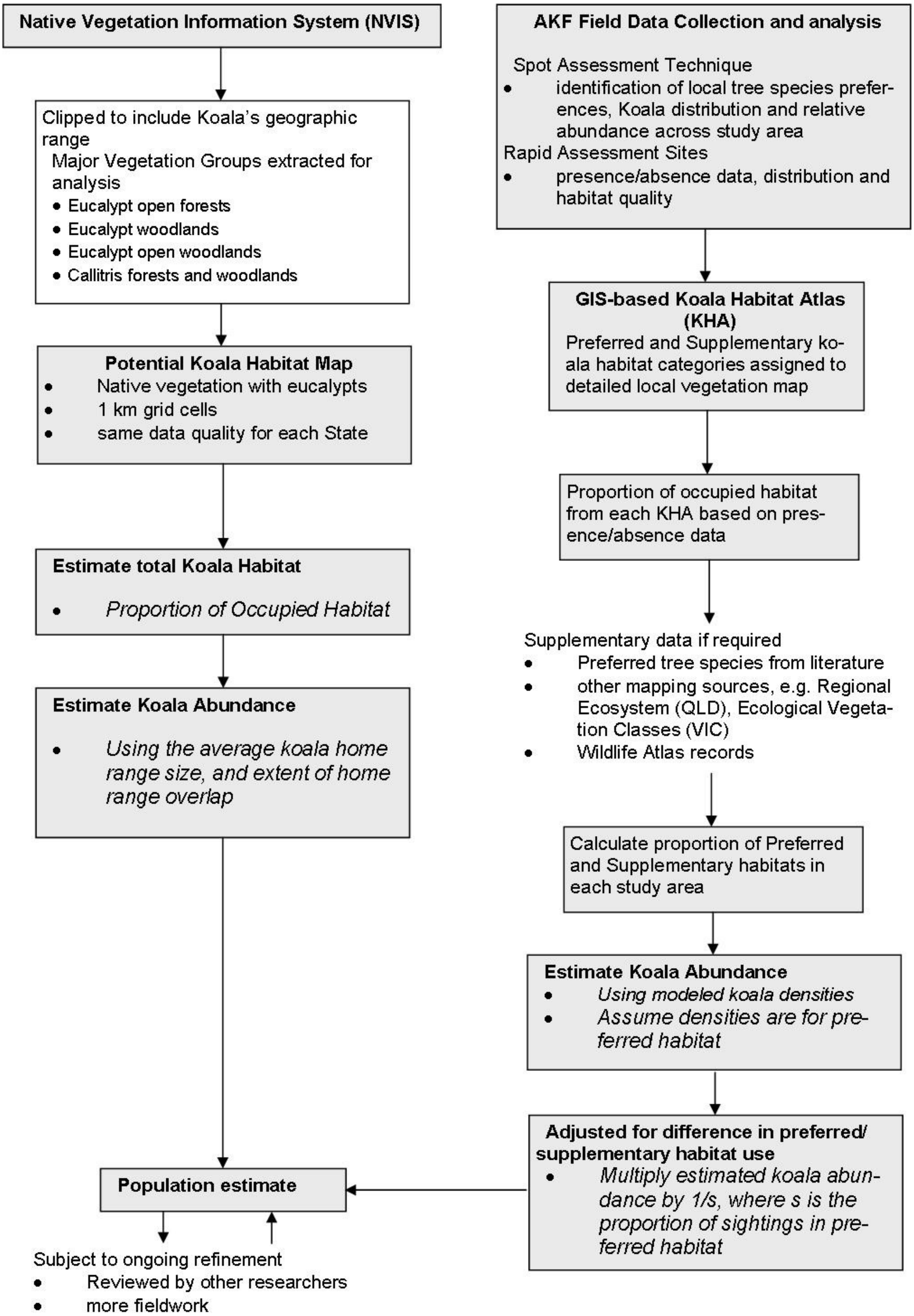


Figure 5: Modeling Process

Discussion

We have sought to formulate a repeatable methodology for calculating meaningful estimates of koala population size and distribution across eastern Australia.

Whilst the methodology is open to criticism and will require ongoing refinement, the AKF holds that it draws credibility by incorporating the best available data from a wide range of sources. It provides a starting point for future monitoring programs and a sound basis for refining population estimates in collaboration with koala researches throughout the koala's remaining geographic range.

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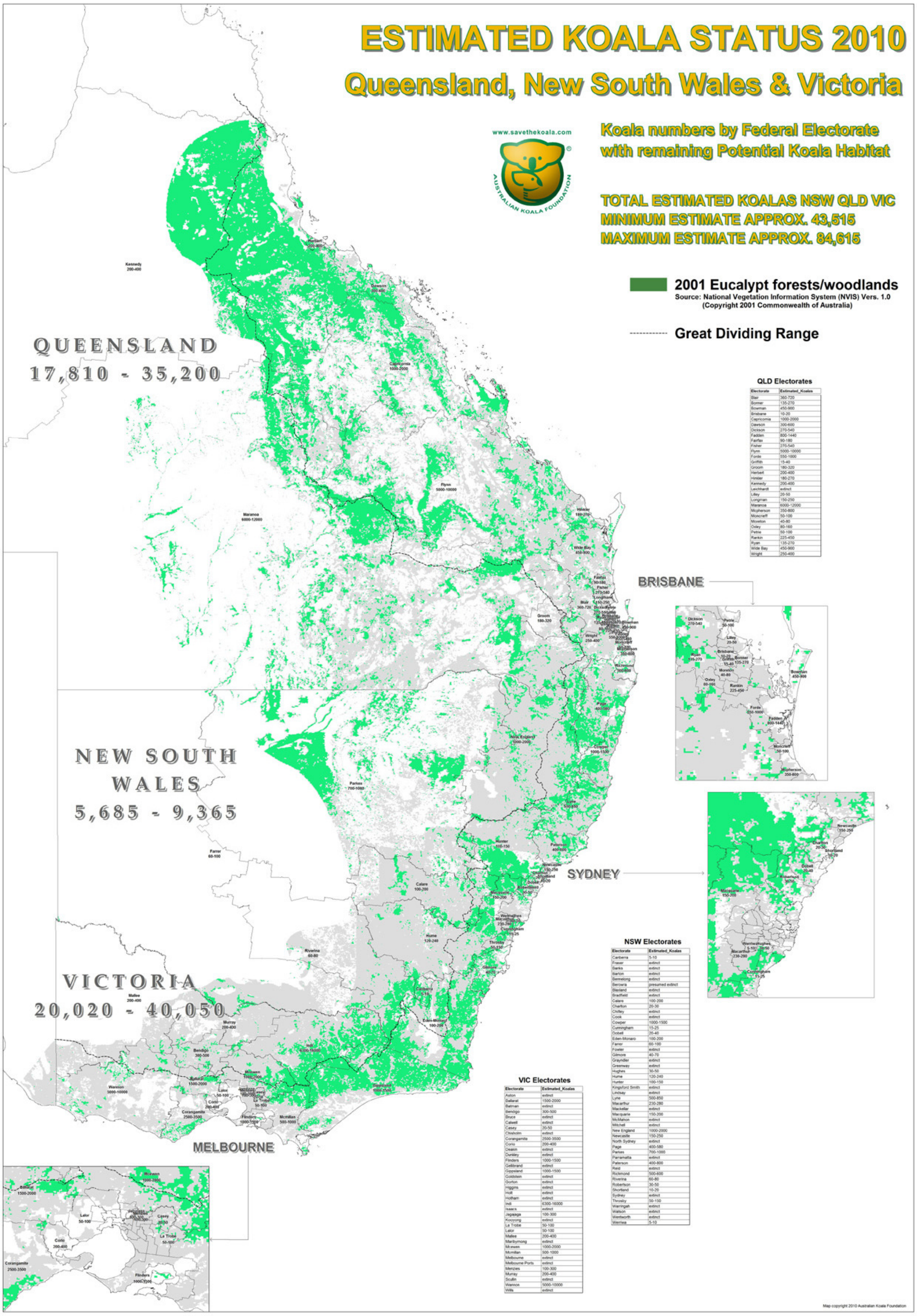
APPENDIX 1

Revised Koala Status Estimate June 2010, Queensland, New South Wales, Victoria



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APPENDIX 3

AUSTRALIAN KOALA FOUNDATION

The international organisation dedicated to saving the koala and its habitat

Conservation of the wild koala and its habitat is of global significance

15th June 2010

The Honourable Peter Garrett MP
Minister for Environment Protection, Heritage and the Arts
PO Box 6022
House of Representatives
Parliament House
Canberra ACT 2600

Dear Mr. Garrett

Re: Listing of Koala as Vulnerable under the EPBC Act

On behalf of the Australian Koala Foundation (AKF) I write to advise that the koala should be listed as Vulnerable under the EPBC Act.

Over our twenty four year history, the AKF has funded university research, in-house research, but more importantly has instigated state of the art innovative habitat mapping and the writing of Koala Plans of Management for many communities around Australia. Our efforts have cost in excess of $8m.

This has led us to have unprecedented data over the whole of the Australian koala landscape with 80,000 individually measured trees in nearly 2000 field sites. This is not something you can peer-review.

What this field data gives is innate confidence and when our Chairman, Mr. Robert Gibson insisted, in 2006 (after the previous koala listing rejection), that my team produce the attached Koala Habitat Atlas and estimated koala numbers, we created it based on our own fieldwork and from the scientific literature in Australia. It is galling to AKF that by and large your Department has refused to acknowledge this work. In recent days we have asked the Chancellor of University of Queensland to make it known to you that this is not the case and of course researchers from all over the country have advised us, and hopefully you, of our massive contribution to the literature. Their papers are identified in our methodology document.

As we send you our methodology for our Koala Numbers – I am mindful of the past and I hope that in your deliberations about the koala you take into account the precautionary approach and why the koala is so important to Australia.

When AKF looks at the TSSC nomination – you have not been able to establish a compelling argument for the numbers in 2006 – at 390,000. You have failed to produce significant science to support that argument and worse still have not been able to articulate numbers today. Without that, how can you predict decline?

AKF is going to try and put this simply:

In 2006 your document estimates approximately 400,000 koalas and you have no estimate for now in 2010. Why not?

If AKF is right and there are no more than 100,000 koalas, then the decline is 75% which more than meets the decline needed for a vulnerable listing – it would even meet Endangered.

If AKF doubles it figures to 200,000, then the decline is 50% - which again more than meets the Vulnerable listing for a 30% decline.

If AKF trebled the figures to 300,000 – then the decline is 25% which almost sneaks in for the 30% decline. There are not 300,000 koalas in Australia.

We absolutely dispute the Central Queensland Koala Numbers in the Brigalow Belt – of between 70,000 and 215,000. You have no evidence to support that.

We absolutely dispute the koala numbers in Victoria of 73,000, but even if we do accept them, it would still allow a national Vulnerable listing to apply.

We absolutely dispute the koala numbers in the Victorian Strathbogies.

We absolutely dispute koala numbers in the Otways – and the Victorian Government has produced no more than 4 field sites to support their assertions.

So, it comes to who is right? And are you, as Minister prepared to take a precautionary approach which is mandated in the legislation? We urge you to do so. We urge you not to believe the State Governments who say they are capable of protecting the environment. If the States had done a good job up until now, the koala hospitals would not be full of patients or dead bodies and the recent review of the National Koala Strategy 1998, would not have said it didn't work. The new Strategy will be more of the same. Ironically I watched as the document was watered down by State and Federal bureaucrats.

So, here is our document and we are confident there are no more than 100,000 koalas in Australia and if you, or your Committee, or the States provide adequate information for us to change our view then we would do so. You will see in our methodology document, the work that underpins our thoughts on koala numbers has the cream of Australian koala scientists behind it and represent over 100 peer reviewed papers.

AKF scientists will be happy to provide advice to the TSSC should you need it. Dr. Kerlin, recently graduated from Glasgow University, and Mr. John Callaghan before him have created the modeling and both of them and AKF's Mr. David Mitchell will be happy to visit Canberra should you require this.

The Australian Koala Foundation also knows that we have the voice of the people behind us and they believe the koala should be protected as Vulnerable. They have watched their koala populations decline before their eyes in recent years with development and infrastructure projects running rampant over environmental legislation.

Yours,

Deborah Tabart OAM
Chief Executive Officer

cc. Associate Professor Robert Beeton