The utility of regularized, grid-based SAT (RGB-SAT) sampling for the purposes of identifying areas being utilized by koalas (*Phascolarctos cinereus*) in the South-east Forests of NSW – a Pilot Study.



Report to NSW Dept. Environment & Climate Change

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The Wapengo Prayer

Our grid what be in Wapengo Unbiased be its way Some koalas will come There must still be some Left in these forests, as there are elsewhere Give us this day our daily scat Forgive us our misidentifications As we forgive those who find only Possum poo Lead us not into Lantana And deliver us from ticks please For splining gives us answers Activity the key Let's help koalas live forever

Summary

This report describes the results of a pilot study to investigate the utility of a regularized, grid-based (RGB) sampling protocol to assist the process of identifying important koala habitat areas in the south-east forests of New South Wales. The study area was a section of the Mumbulla State Forest to the west of Wapengo Lake.

RGB sampling was undertaken using Spot Assessment Technique (SAT) methodology, initially applied at 350m sampling intersections but latterly extended to 500m in response to initial results. Seventy two field sites were sampled. Koala activity was recorded in 19 sites, with a median activity level of 10% (range: 3.33% -16.67%). Interpolation of activity data within the 1275ha captured by our sampling strategy using a combination of regularized splining and contouring resulted in three primary clusters of koala activity being identified, the first covering an area of approximately 86ha that independently coincided with the general area wherein a koala with joey was sighted in July/August 2007. A second, larger cell of koala activity at least 118ha in size was also revealed to the north east, adjoining another cell at least 70ha in size that extended beyond the study area boundary. A number of smaller cells were also evident, some of which may be peripheral range elements of the abovementioned cells or the presence of additional animals, or both. A comparison of the modeling output obtained by sampling at 350m intersections as opposed to 500m intersections indicated a tendency for the latter to significantly under-estimate the extent of koala activity.

Analysis of the small data set of tree species/faecal pellet associations from sites within which koala activity was recorded inferred a foraging ecology within the study area that appears focused on preferential utilization of Woollybutt *E. longifolia* and Monkey Gum *E. cypellocarpa*, while Silver-top Ash *E. sieberi* was the least preferred. The role of Stringybarks (*E. globoidea*, *E. muelleriana* and *E. agglomerata*) was unable to be resolved due to taxonomic uncertainty, while the relative importance to koalas of other tree species in the study requires a larger data set. Further work on factors influencing food tree selection by koalas in the south east forests is warranted.

No koalas were sighted during the survey; hence the actual number of individuals and/or koala home range areas constituting the identified cells remains unknown. However, based on a considered appraisal of our results, we consider it likely that the activity cells we have identified are attributable to no more than 3 - 5 koalas. The

fact that koala activity clearly continued beyond the limits of our study area in at least one locality alludes to the presence of additional koalas in the general area. In general terms and despite the small number of animals, the results are encouraging and give rise to some optimism that there may be more koalas in the coastal forests between Tathra and Bermagui than previously considered. However, we caution against extrapolating the results of this pilot study to other areas without the appropriate data.

Overall, the results obtained by this pilot study support consideration of the broadscale application and suitability of RGB-SAT sampling to effectively address issues of koala conservation and management in the south-east forests. However, until such a time as more is known about underlying, key issues such as population size, factors influencing tree selection and the conservation status of koala populations in the south-east forests generally, we advocate the need for a minimal disturbance approach to the management of known cells until such a time as appropriate management guidelines have been developed.

Introduction

Koalas have had a complex and at times controversial management history in southeastern NSW (Cork et al. 1995). The historical record (Lunney and Moon 1988; Lunney and Leary 1988; Lunney *et al* 1997) confirms the presence of a once large and robust koala population widely distributed throughout the coastal hinterland and ranges. Based on current knowledge regarding the relationship between the type/density of preferred koala food trees and habitat carrying capacity (Phillips 2000a), koala densities were likely to have varied across this area from high in the riverine/lowland Red Gum (*E. tereticornis*) forests to lower in associated upland areas. Regardless, hunting for the fur trade in the early part of the 20th Century, clearing for agriculture, fire and timber harvesting have all been implicated in what has otherwise been a dramatic and protracted decline.

Ongoing community concern about the conservation status of koalas in the southeast forests has rightly manifested in one or more nominations to have the population listed as endangered for purposes of the *Threatened Species Conservation Act 1995*, a process that has been hindered by disparate views about population size, genetics and management boundaries. More recently, the NSW Dept. of Environment and Climate Change (DECC) commissioned work which resulted in a Far South Coast Koala Management Framework (FSCKMF). Consultative in approach, the aim of the FSCKMF (Eco Logical 2006) was essentially to synthesise available knowledge, establish management and conservation protocols, and promulgate a series of time-related management actions intended to assist koala recovery and management efforts in the southeast forests.

The RGB-SAT approach to the assessment of koalas and their habitat has only recently been developed and submitted for peer-review (Phillips, S., Hopkins, M. and Warnken, J. Modelling the population distribution of an arboreal marsupial (Koala *Phascolarctos cinereus* Goldfuss) across heterogeneous landscapes. Submitted to *Biological Conservation*). Underpinned by the Spot Assessment Technique (SAT) of Phillips & Callaghan (Appendix 1), RGB-SAT sampling aims to provide a simple, unbiased and robust sampling tool that addresses the issue of determining and delineating koala metapopulation boundaries for the purposes of providing conservation and planning certainty. The approach has been largely developed in areas where koala densities are typically higher (e.g. ~0.2 – 0.43 koalas/ha) than is known to currently occur in the south-east forests and hence it's utility for the

purposes of addressing similar issues for low-density koala populations remained unknown.

A notion to "explore" systematic SAT sampling arose as a proposed management action from the FSCKMF Scientific Workshop in June, 2006 (FSCKMF Appendix 1 refers). Accordingly, the purpose of this pilot study was to trial RGB-SAT sampling over an area within which koala activity was known to occur. Impetus for the survey came about with the sighting of koala in July/August 2007 by local residents Wayne Bell and Daniel Jones. Subsequent follow-up work by DECC (Allen 2007) recorded faecal pellets from several localities in the immediate area.

Methods

Study Area

The initial koala sighting occurred in the Wapengo catchment area of the Mumbulla State Forest. Figure 1 illustrates the general locality of the sighting (\pm 100m), including sites examined in the course of follow-up field work by Allen (2007).

Topography, Vegetation & Disturbance History

The study area presented as a system of largely southwesterly draining catchments with undulating to hilly topography that varied in altitude from ~20m to 160m asl. The vegetation model utilized for this project indicated an area largely dominated by dry sclerophyll forests of Monkey Gum *E. cypellocarpa*, Coastal Grey Box *E. bosistoana* and Ironbark *E. tricarpa* on ridgetops and mid-slopes, to wetter communities of *E. cypellocarpa*, Yellow Stringybark *E. muelleriana*, Messmate *E. obliqua*, Manna Gum *E. viminalis*, Rough-barked Apple *Angophora floribunda* and Gully Gum *E. smithii* dominating lower slopes and drainage lines. Small pockets of rainforest were also indicated.

Four fire events that varied in intensity and coverage are known to have occurred within the study area (1940s, 1952, 1968 & 1980) while timber harvesting practices including woodchipping have been ongoing since at least the early 1900s; additional silvicultural treatment in the form of "Timber Stand Improvement" is also indicated in many areas.

Survey Methodology

A systematic approach was used to survey for evidence of koala activity. In order to ensure a uniform and unbiased distribution of sampling effort throughout the study



area, a diagonally aligned (45° from the horizontal plane) 350m x 350m grid was initially overlain on a map of the study area (centred over that area of the recent sighting and in which koala faecal pellets had also been recorded) and the resulting grid-cell intersections selected as sampling points where they intersected areas of native forest (Figure 2). The use of this particular grid design provided us with a default 500m x 500m regular grid for sampling purposes in the event that a potential increase in the distance between sampling points was supported by field data. UTM coordinates for each grid-cell intersection were then determined and uploaded into a 12 parallel-channel GPS receiver navigating on an AGD66 datum to assist location in the field. We operated within a flexibility rule of 5% of sampling interval when selecting the centre tree for a given SAT site; thus a maximum of ± 17m at 350m sampling intersections and ± 25m at 500m sampling intersections was permitted in order to optimise the probability of detecting koala activity in terms of potential scat visibility and site floristics in each instance. Once located, each point was sampled using SAT methodology. An intensive search for koalas was also undertaken within a 25m radius (0.196ha) of the centre tree at each SAT site.

Given the uncertainty associated with sampling low-density koala populations and in order to maximise the probability of finding faecal pellets, initial field work examined the potential advantage that might be obtained by increasing the minimum diameter at breast height (dbh) for sampled trees from the 100mm otherwise specified by the SAT methodology, to 150mm & 200mm respectively, thus potentially increasing the area being sampled by each SAT site. Subsequent sites restricted sampling to those trees above 150mm dbh. Sampling of the study area initially commenced with 350m sampling intersections as illustrated in Figure 2 and increased to 500m intersections as sampling progressed. As the study proceeded, field site selection was guided by the previous day's results with a view to ensuring that any evidence of koala activity was pursued and/or blocked in to the maximum extent possible within the time that was available.

Data Analysis

Koala activity modeling

Modeling of the activity data was undertaken in accord with procedures detailed in Phillips et al. (submitted), employing regularized splining, minimal (0.1) weighting and a constant 12 nearest neighbor data points per region. Contouring of model output



was subsequently applied in order to identify and isolate the 3% activity contour, this being the minimum activity level resulting from a 30 tree sample.

For modeling purposes, un-sampled sites surrounding the final study area boundary were given a default zero activity level with the exception of those immediately adjacent to sites in which koala activity was recorded at the edge of the study area but not able to be sampled due to time constraints. These sites were not assigned an activity level, thus allowing the model to predict the likely location of activity boundaries at these locations, with activity contours excised by the study area boundary.

It should be noted that boundaries modeled by the aforementioned process are indicative rather than definitive and potentially possess a measure of flexibility/tension that is commensurate with sampling intensity.

Tree preferences

Tree use data was extracted only from sites in which koala faecal pellets had been recorded. In order for the data set for a given tree species to be considered useful for analysis purposes it had to have been derived from a minimum of 7 spatially independent SAT sites and have a sample size such that np and $n(1-p) \ge 5$ where n = number of trees (of species x) sampled and p = proportion of trees (of species x) that had koala faecal pellets recorded within the prescribed search area. Accordingly, potential differences in strike rates between species were analysed using a non-parametric, unplanned *G*-test for homogeneity using simultaneous test procedures.

Results

Field survey

Field survey was undertaken over the period $15^{th} - 29^{th}$ October 2007 during which time 72 sites were formally assessed for approximately 60 person days of survey effort. The most common tree species sampled were Silvertop Ash *Eucalyptus sieberi*, Woollybutt *E. longifolia* and the "stringybarks" *E. globoidea* and *E. muelleriana*. Evidence of habitat use by koalas (i.e. presence of koala faecal pellets) was recorded in ~28% (20/72) of the sampled sites wherein koala activity ranged from 3.33 - 16.67% (median activity score (active sites only): 10%). A total of 2,160 trees were assessed, comprising 11 species from the genus *Eucalyptus* and at least 7 species of non-eucalypt. Specimens of either Messmate *E. obliqua* or Manna Gum *E. viminalis* as predicted by the vegetation map/model were not recorded during the course of the field survey. No koalas were observed within any of the 72 x 0.196ha radial searches that were undertaken, or were any observed opportunistically during the course of the survey.

Species	Common name	Trees sampled	Sites
Eucalypts			
Eucalyptus.agglomerata	Blue-leaved Stringybark	39	7
E. bosistoana	Coast Grey Box	68	21
E. botryoides	Bangalay	92	10
E. cypellocarpa	Monkey Gum	194	39
E. elata	River Peppermint	16	1
E. globoidea	White Stringybark	212	28
E. longifolia	Woollybutt	282	54
E. muelleriana	Yellow Stringybark	221	35
E. sieberi	Silvertop Ash	344	47
E. smithii	Ironbark Peppermint	80	15
E.sp	Unidentified eucalypt	4	4
E. tricarpa	Mugga Ironbark	36	20
Stringybarks		303	37
Non-eucalvpts			
Acacia spp	Acacia spp	137	29
Allocasuarina littoralis	Black She-oak	58	20
Angophora floribunda	Rough-barked Apple	66	36
Exocarpos cupressiformis	Cherry Ballart	5	4
Rainforest spp.	-	3	2
Total		2160	

 Table 1. Number of each tree species sampled for koala faecal pellets during field sampling and number of SAT sites in which the species was recorded.

Koala activity modeling

Clusters of koala activity were readily apparent in the study area with surface modeling of the data using a three percent activity level threshold delineating a number of discrete areas. At least 3 primary cells were identified, the first of which (86ha in size) effectively encapsulated the general area of the July/August koala sighting investigated by Allen (2007). A larger cell approximately 118ha in size was located to the northeast, abutting another at least 70ha in size and which extended into forested areas to the east. Commencement of yet another cell was also inferred in the extreme southwestern corner.

A review of the plotted results derived from 350m sampling intersections confirmed our earlier speculation that a casting of sites at 500m intersections would be successful in detecting koala activity and hence sampling interval was increased accordingly once initial 350m sites had been completed. Figure 3 illustrates modeling output based on the use of 350m and 500m sampling intersections respectively (Fig. 2 refers, central cells only). As alluded to in the preceding sentence but in terms of the area(s) captured, sampling at 500m intersections has clearly been effective in detecting koala activity but is conservative when it comes to modeled output, in this instance capturing an area of \sim 73ha. In contrast, sampling at 350m intersections has better detailed the full extent of koala activity such that the resulting modeling also captures a significantly greater area (\sim 131ha).

Figure 4 illustrates final modeling output for our study area using data from all sites that were sampled. This model includes a nominal 175m management "buffer" around the central cell(s), while remaining cells have been afforded a 250m management buffer, the determination of which in each instance is a commensurate value based on 50% of the sampling interval in those areas.

Tree Preferences

Koala faecal pellets were recorded beneath at least 6 Eucalyptus species and at least 1 species of non-eucalypt (Table 2). Woollybutt E. longifolia, Monkey Gum Eucalyptus cypellocarpa and Silvertop Ash E. sieberi were the only tree species with data sets that met the criteria for statistical analysis, returning strike rates (active sites only) of 21%, 11% and 6% respectively. Analysis of these data confirmed significant heterogeneity (G_{adi} = 6.2380 P = 0.0442, 2_{df}) while also inferring E. longifolia the preferred 5). to be most tree species (Fig.

Wapengo Koala Study



Figure 3. Koala activity cells as modelled using [A] 350m sampling intervals and [B] 500m sampling intervals within the central portion of the study area



Digital data and aerial photography supplied by DECC



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Table 2. Tree species utilisation data from Wapengo study area for the 18 sites within which koala faecal pellets were recorded. Data from one additional site is not included because the tree species/pellet association was not recorded. * includes trees identified on relevant data sheets as either *E. agglomerata*, *E. globoidea*, *E. muelleriana* or "stringybark".

Species	No. Sites	n	р
Eucalypts			
E. bosistoana	6	20	0.05
E. botryoides	2	9	0.33
E. cypellocarpa	9	54	0.11
E. longifolia	12	53	0.21
E. sieberi	14	93	0.06
E. smithii	3	9	0.00
E. tricarpa	7	10	0.00
Stringybarks*	19	240	0.05
Non-eucalypts			
Acacia spp.	8	52	0.02
Allocasuarina littoralis	6	15	0.00
Angophora floribunda	9	14	0.00
Exocarpus cupressiformis	1	1	0.00
Total		570	

<u>Note:</u> We did not consider the taxonomic resolution of "stringybark" species present in the study area sufficiently robust to support categorization and analysis below what is otherwise presented in Table 2. The situation was made more complex because of the large number of young trees within the sites we sampled, often coupled with the knowledge (based on mature fruits observed during scat searches) that more than one species was invariably present.



Figure 5. Strike rates (proportion of trees with koala faecal pellets within active SAT sites) ± standard error for Woollybutt (Elon), Monkey Gum (Ecyp) and Silvertop Ash (Esie).

Discussion

The results of this pilot study have confirmed the ability of the RGB-SAT protocol to not only detect evidence of habitat utilisation by koalas in a low carrying capacity landscape, but also to effectively delineate the extent of areas that are currently being utilized and/or occupied. This is an encouraging outcome which bodes well for future koala conservation and management efforts in the south-east forests. Given the limited knowledge regarding factors that are currently limiting the distribution and abundance of koalas in the southeast forests, and in order to maintain a focus on relevant issues, we have structured our discussion around the following points:

1. Issues associated with modeling low activity levels.

The tendency of sites with activity to be spatially correlated (i.e. clustered) was expected and is both concordant with knowledge regarding the ranging patterns of free-ranging koalas generally, and consistent with similar studies we have undertaken elsewhere in eastern Australia. Thus we are confident that the results presented in this report are an accurate reflection of koala distribution within the study area.

Our modeling for this pilot study relied upon a 3% activity contour for boundary delineation, reflecting the lowest level of activity able to be detected by the minimum

30-tree sample otherwise required by the SAT methodology. Lower activity thresholds are possible but clearly require increasing the number of trees/SAT site, a concept that we consider neither feasible nor cost effective. In order to examine the premise of any lower activity being significant, we also modeled the hypothetical 1% activity contour, noting that it invariably coincided with the greater proportion of the required management buffers in the majority of cases.

Throughout the study area, koala scats <u>were</u> generally hard to find, reflecting what will be an ongoing issue in terms of future studies that utilise this technique whereby a momentary lapse in concentration can potentially result in a false negative. While this concern is arguably lessened by the tendency of active sites to be spatially correlated (thus increasing chances of adjoining site(s) being positive), there will be a need for field teams to be both well-trained and highly motivated. Time spent in the field will also be an issue: too much field work with no return can lead to disinterest and/or lapses in concentration, further diminishing the chances of finding faecal pellets.

2. Individual Home Range areas or Metapopulation cells?

These terms are not necessarily mutually exclusive. Interpretation of the results we have obtained in the context of our experience with broader area/higher density koala populations elsewhere in eastern Australia (refer Appendix 2) lead us to speculate that we have located metapopulation outliers rather than a primary source population. To this end the cells we have identified likely reflect individual home range areas rather than large koala aggregations *per se*. Support for this notion comes from the generally low activity levels that were recorded, observations of consistency in scat size (suggestive of single/younger animals), and size of the modeled activity cells. Hence we consider that the likely number of koalas detected in our study area as somewhere between 3 and 5 individuals, and that larger cells of koala activity will occur in close proximity to those detected by this study.

3. Ecological History, Vegetation map/models & Tree preference data

We have currently made a formal approach to SFNSW for all available digital data relating to ecological history of the study area. While no clear trends in terms of where koala activity was recorded and where it wasn't are overtly apparent (based on a perusal of hard copy maps) at this juncture, it is likely that koala data collected over a larger area will be required before any meaningful attempt at drawing correlations

between the location of koala activity and ecological history of the forest can be made.

Given that each of our SAT sites also serves as a *de facto* point-based vegetation sample of the tallest and mid-stratum communities, we note that initial examination of the associated floristic data would result in vegetation community descriptions quite different from that indicated by the underlying vegetation map/model used in this instance. In particular we note both the apparent absence of some species (notably *E. obliqua* and *E. viminalis*), as well as considerable differences in species dominance data. These observations generally attest to the unreliability of the map/model for purposes of identifying and/or modeling potential koala habitat and we consequently stress the importance of both reliable vegetation community mapping and ground-truthing for such an exercise should it be undertaken.

The tree use data set obtained by this study is not large or robust enough to unequivocally resolve issues of tree selection by koalas in these forests save for reiterating the obvious importance of species such as *E. longifolia* and *E. cypellocarpa*. Moreover, tree selection by free-ranging koalas in low carrying capacity landscapes will invariably involve some complex, edaphic-influenced leaf chemistry processes (Moore and Foley 2005). Hence management of the tree resource in areas being utilised by low-density koala populations will not be a matter of simply ensuring that adequate numbers of preferred food tree species are retained.

4. What is the optimal sampling intensity?

A key element underpinning the efficacy of the approach we have detailed herein is the concept of sampling at a scale that is relevant to the species of interest. From this perspective and notwithstanding implications associated with 1 above, our results thus far indicate that the majority of koala activity would not have been detected if sampling was undertaken at a coarser resolution (i.e. 750m - 1km sampling intervals). Further, we have also been able to demonstrate that sampling at 500m intervals is effective in detecting koala activity, when modeled it has the potential to yield an overly conservative result, while 350m clearly provides necessary detail. This information is useful because it indirectly infers potential koala home range areas that are smaller than that which has previously been reported (Jurskis and Potter 1997). Indeed, based on the presumption that in areas where koala activity was recorded (sampling interval²/10000 = approximate size of occupied habitat block), and that the primary habitat cells that were identified reflect the ranging

patterns of single animals, home range areas of between 50ha and 100ha are inferred.

5. Occupancy Issues

Population cells such as have been identified in this report are a dynamic rather than static phenomenon, the boundaries of which can be expected to change over the course of successive koala "generations", the measure of which has been estimated to be 5.6 - 7.8 years (Phillips 2000b). The direction of such change (i.e. expansion or contraction) is dependent upon several factors including:

(i) the level of historical disturbance prior to assessment,

(ii) the size and proximity of any source population(s),

(iii) the availability of suitable habitat in proximity to that currently being occupied by resident koala populations,

(iv) habitat linkages to assist processes of emigration and recruitment, and

(v) extant threatening processes.

Results from our studies elsewhere suggest that approximately 50% of available habitat is generally occupied by demographically stable koala metapopulations (Phillips et al. submitted). While for many this is a novel concept in terms of landscape-scale koala management, this notion makes ecological sense and infers the need for management to both recognize and make allowance for metapopulation contraction and expansion over time in response to ongoing recruitment and/or attrition events. It is currently unknown however whether this rate of occupancy will be applicable to management of low density populations in the south-east forests. Results from this study suggest an occupancy rate for the study area of between 8% and 30% (depending on how one chooses to interpret the activity levels – Table 2 in Appendix 1 refers) of the available habitat at this point in time. Given the historical narrative and general consensus regarding widespread decline throughout the southeast forests generally, it is more likely than not that regardless of where the occupancy falls within that range, it is currently less than optimal. This consideration mandates not just the need to remove and/or minimize known and potential threatening processes from those areas known to be currently occupied, but also to effectively buffer such areas from adverse impact, accommodate the need for population expansion, and ensure that effective habitat linkages are in place to facilitate ongoing recruitment processes.

6. Implications arising from the FSCKMF

Amongst other things, the FSCKMF proposed a series of landscape classifications (A – D, pp 23 – 24 of FSCKMF refer) that were promoted to both afford protection and influence management activities within koala habitat areas so designated. Clearly, the fact we have documented one or more areas of "current use" warrants the cells and immediately adjoining areas we have identified be classified as A Class Habitat accordingly. However, we are reluctant to pursue other FSCKMF landscape classifications beyond these boundaries and moreover, caution against extrapolation of the results we have obtained thus far to any areas beyond our study area boundary.

7. Buffers

As detailed earlier, the 175m and 250m buffers we have applied for the purposes of this particular study have their basis in the tension that is inherent in the modeled boundaries. Hence they are not arbitrary measures but a reflection of the sampling interval that has been applied in each instance. In practice buffer width can be reduced by corresponding increases in sampling intensity such that, in the case of this particular study, they could theoretically be reduced to around 80m - 90m with further sampling (i.e. 175m sampling intersections) if so required. However, any trade-off in terms of optimal buffer width must be measured in terms of potential gain *vs* effort required to defend it.

8. Where to from here?

From our perspective there are potentially many avenues that can now be explored in a more optimistic light than has otherwise been illuminating koala conservation and management in the southeast forests. Indeed, given the results obtained by this study, at this stage we can do no more than encourage more widespread application and utility of RGB-SAT sampling for koala habitat assessment and population/forest management purposes. However, until such time as fundamental issues of population size and distribution, factors influencing tree selection and the conservation status of koala populations in the south-east forests generally is better understood, we stress the need to adopt a minimal disturbance approach to management guidelines for such areas and the surrounding landscape have been developed. We would be happy to assist this process if so required.

References

Allen, C. 2007. Notes on preliminary koala survey, Wapengo 25 – 26/09/07. Internal report, NSW Department of Environment and Climate Change.

Cork, S. J. 1995. *Koala conservation in the south-east forests: consultancy for the NSW National Parks and Wildlife Service and State Forests of New South Wales.* National Parks and Wildlife Service (NSW).

Eco Logical (Aust). 2006. *Far South Coast Koala Management Framework*. Report to NSW Department of Environment and Climate Change.

Jurskis, V., and Potter, M. 1997. Koala Surveys, Ecology and Conservation at Eden. *Research Paper No. 34*. State Forests of New South Wales.

Lunney, D., and Leary, T. 1988. The impact on native mammals of land use changes and exotic species in the Bega district, New South Wales, since settlement. *Australian Journal of Ecology* **13**: 67 - 92.

Lunney, D., and Moon, C. 1988. An ecological view of the history of logging and fire in Mumbulla State Forest on the South Coast of New South Wales, pp 23 – 61 in: K. J. Frawley and N. M. Semple (Eds) Australia's Ever Changing Forests. Proceedings of the First National Conference on Australian Forest History. *Special Publication No. 1.* Department of Geography and Oceanography, Australian Defence Force Academy, Cambell ACT.

Lunney, D., Esson, C., Moon, C., Ellis, M., and Mathews, A. 1997. A communitybased survey of the koala *Phascolarctos cinereus* in the Eden region of southeastern New South Wales. *Wildlife Research* 24(1), 111 - 128.

Moore, B. D., and Foley, W. J. 2005. Tree use by koalas in a chemically complex landscape. *Nature* (letters) **435**, 488 – 490.

Phillips., S. 2000a. Tree Species preferences of the koala as a basis for the determination of Management Units for recovery planning in NSW. Report to NSW Koala Recovery Team/National Parks & Wildlife Service.

Phillips, S. 2000b. Population Trends and the Koala Conservation Debate. Conservation Biology 14(3), 650 - 659.

Phillips, S., Hopkins, M., and Warnken, J. (submitted). Modelling the population distribution of an arboreal marsupial (Koala *Phascolarctos cinereus* Goldfuss) across heterogeneous landscapes. *Biological Conservation*.

Appendix 1

The Spot Assessment Technique

The Spot Assessment Technique: a tool for determining levels of localised habitat use by Koalas *Phascolarctos cinereus*.

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Summary

In order to more effectively conserve koalas, the National Koala Conservation Strategy promotes development of reliable approaches to the assessment of koala habitat. This paper describes a localised, tree-based sampling methodology that utilises the presence/absence of koala faecal pellets within a prescribed search area around the base of trees in order to derive a measure of koala activity. Confidence intervals associated with koala activity data from 405 randomly selected field plots within which koala faecal pellets were recorded have been utilised to assign threshold values for three population density/habitat biomes in eastern Australia. Subject to the need for a precautionary approach to data interpretation in areas that support naturally occurring, low-density koala populations, the approach is expected to assist field-based assessments by researchers, land managers and others interested in clarifying aspects of habitat utilisation by free-ranging koalas, especially where identification of important areas for protection and management is required.

Key-words. Spot Assessment Technique, Koala, *Phascolarctos cinereus*, SEPP 44, habitat assessment, survey techniques.

Introduction

The primary aim of the National Koala Conservation Strategy (NKCS) is to conserve Koalas (*Phascolarctos cinereus*) by retaining viable populations throughout their natural range (Australian and New Zealand Environment and Conservation Council (ANZECC) 1998). In order to develop a better understanding of the conservation biology of koalas, Objective three of the NKCS promotes the need for development of consistent and repeatable approaches to assessment of koala populations, in addition to the need for survey work to establish correlates of habitat quality at both broad geographic scales and the individual-tree scale within preferred habitats (ANZECC 1998).

The primary responsibility for conservation of free-ranging koalas and their habitat rests with State, Territory and Local Government authorities. In this regard State Government authorities in New South Wales and Queensland have enacted specific planning policies and/or strategic planning measures to assist koala conservation. However, the ability of these strategies to achieve their stated conservation objectives is hindered in part by the lack of standardised and reproducible methodologies that can be applied to the task of habitat assessment in the first instance.

In this paper we present a technique that we believe contributes to the need for a reliable approach to objectively assessing koala habitat use. An unreviewed progenitor to this work (Phillips and Callaghan 1995) was originally circulated to a limited audience following the Australian Koala Foundation's 1995 conference on the status of Koalas, its purpose at that time to promulgate an approach that could potentially assist field-based assessments by ecological consultants, land managers and others interested in quantifying aspects of habitat utilisation by free-ranging koalas. Much has happened since then such that the purpose of this work is to further refine the initial approach in the light of additional field studies and in so doing, formally supersede the earlier work.

Background to the approach

Traditionally, knowledge relating to habitat utilisation by free-ranging koalas has been reliant on opportunistic observations or radio-tracking data (Robbins and Russell 1978; Martin 1985; Hindell *et al.* 1985; Hindell and Lee 1987; 1988; White and Kunst 1990; Reed *et al.* 1990; Hasegawa 1995; Melzer and Lamb 1996; Pieters and Woodhall 1996). In other instances, emphasis has been placed on benign indicators such as accumulated faecal pellet counts (Moon 1990; Munks *et al.* 1996; Pahl 1996). However, both of the preceding approaches can be problematic. Firstly, existing models for determining tree preferences by free-ranging Koalas (Hindell *et al.* 1985) require a number of assumptions to be met which do not appear to hold in heterogeneous forest communities (Phillips 1999;

Ellis *et al.* 2002). Secondly, while accumulated faecal pellet counts can elucidate issues of koala abundance (Sullivan *et al.* 2002, 2004), they have proved of limited value when used to infer the importance of various tree species, (Munks *et al.* 1996; Pahl 1996). The ability to census and interpret faecal pellet deposits can also be influenced by other variables including visibility, tree morphometrics and insect activity (Achurch 1989; Melzer *et al.* 1994; Pahl 1996; Ellis *et al.* 1998; Sullivan *et al.* 2003). Scratch marks on trees are also an unreliable indicator of habitat use – they cannot be detected on some species whereas others retain them for long periods of time, nor is it always possible to confidently distinguish Koala scratches from those of other arboreal animals.

Studies of free-ranging koalas have established that those in stable breeding aggregations arrange themselves in a matrix of overlapping home range areas (Lee and Martin 1988; Faulks 1990; Mitchell 1990). Home range areas vary in size depending upon the quality of the habitat (measurable in terms of the density of preferentially utilised food tree species) and the sex of the animal (males tend to have larger home range areas than females). Long-term fidelity to the home range area is generally maintained by adult koalas in a stable population (Mitchell 1990; Phillips 1999, Kavanagh *et al.* 2007). An additional feature of home range use is the repeated use of certain trees, some of which may also be utilised by other koalas in the population (Faulks 1990; Mitchell 1990; Phillips 1999; Ellis *et al.* 2002).

Given the preceding considerations, it follows that areas being utilised by resident koala populations must also be characterised by a higher rate of faecal pellet deposition (see Lunney *et al.* 1998). For the purposes of this paper, we propose the term "areas of major activity" to describe such localities, regarding them as synonymous with the term "*Core Koala Habitat*" as defined by the NSW Government's *State Environmental Planning Policy No.* 44 (Koala Habitat Protection), in addition to being core elements of Koala Habitat Areas as defined by the Nature Conservation (Koala) Conservation Plan 2006 and Management

Program 2006 – 2016 (Environment Protection Agency/Queensland National Parks and Wildlife Service 2006).

The Spot Assessment Technique

The Spot Assessment Technique (SAT) is an abbreviated form of a methodology developed by the Australian Koala Foundation for purposes of the Koala Habitat Atlas project (Sharp and Phillips 1997; Phillips et al. 2000; Phillips and Callaghan 2000). This approach is probability-based and utilises a binary variable (presence/absence of faecal pellets within a prescribed search area around the base of trees) to determine tree species preferences, along with a commensurate measure of koala "activity" (number of trees with faecal pellets present divided by total number of trees in the plot) within a 40m x 40m (1600m²) plot. Given that the selection of Atlas field plots is based on replication and stratification by soil landscape and vegetation associations in the first instance, the data presented for the purposes of this paper reflects a random selection of field sites within which koala faecal pellets were recorded. The SAT approach arose from observations of consistency within the four smaller (20m x 20m) sub-quadrats that otherwise comprise Atlas field plots and the consequent realisation that a smaller plot size would essentially provide the same empirical outcomes in terms of both tree species/faecal pellet associations and koala activity. However, the number of trees sampled in a smaller site is critical to any meaningful estimate of activity hence we have adopted the latter as the more important variable for the purposes of this technique.

Table 1 details results from Atlas plots that have been undertaken across a variety of habitat types and landscapes utilised by koalas in eastern Australia. To this end, while significant differences between mean activity levels from low and medium - high density Koala populations of the eastern seaboard are believed to reflect real differences in habitat quality and thus koala density (Table 1 - Southeast Forests/Campbelltown *vs* Port Stephens/Noosa: Levene's test: F = 0.086, P > 0.05; t = -7.877, P < 0.001), we submit that similar differences

between medium - high density populations of the eastern seaboard and those from more western areas (areas generally receiving less than 600mm of rainfall annually) (Port Stephens/Noosa vs Pilliga/Walgett – Levene's test: F = 0.925, P > 0.05; t = -4.743, P < 0.001), more likely reflect differences in faecal pellet longevity as a consequence of aridity than they do habitat quality *per se*.

The SAT involves an assessment of koala "activity" within the immediate area surrounding a tree of any species that is known to have been utilised by a koala, or otherwise considered to be of some importance for koala conservation and/or habitat assessment purposes. In order of decreasing priority, selection of the centre tree for a SAT site should be based on one or more of the following criteria:-

- 1. a tree of <u>any species</u> beneath which one or more koala faecal pellets have been observed; and/or
- 2. a tree in which a koala has been observed; and/or
- 3. any other tree known or considered to be potentially important for koalas, or of interest for other assessment purposes.

In order to establish a meaningful confidence interval for the activity level of a given SAT site, a <u>minimum</u> of thirty (30) trees must be sampled. For assessment purposes, a tree is defined as "*a live woody stem of any plant species (excepting palms, cycads, tree ferns and grass trees) which has a diameter at breast height (dbh) of 100mm or greater*" (Phillips *et al.* 2000). In the case of multi-stemmed trees, at least one of the live stems must have a diameter at breast height over bark (dbhob) of 100 millimetres or greater.

Applying the SAT

1. Locate and uniquely mark with flagging tape a tree (the centre tree) that meets one or more of the abovementioned selection criteria;

2. differentially mark the 29 nearest trees to that identified in Step 1,

3. undertake a search for koala faecal pellets beneath each of the marked trees based on a cursory inspection of the undisturbed ground surface within 100 centimetres¹ from the base of each tree, 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.

An average of approximately two person minutes/tree should be dedicated to the faecal pellet search. In practice, more time will be spent searching beneath larger trees than smaller trees. For assessment purposes, the search should be concluded once a single koala faecal pellet has been detected or when the maximum search time has expired, whichever happens first. This process should be repeated until each of the 30 trees in the site has been assessed. Where the location of faecal pellets falls within overlapping search areas brought about by two or more trees growing in close proximity to each other, both should be positively scored for pellet(s). For more detailed reporting purposes, information relating to the site's location (UTM co-ordinates or Lat/Long), selection criteria, tree species assessed (and their dbh), and the radial area searched should also be recorded. Faecal pellets should not be removed from the site unless some verification (i.e. that they are in fact koala faecal pellets) is necessary.

Calculation and interpretation of Koala activity levels

The activity level for a SAT site is simply expressed as the percentage equivalent of the proportion of surveyed trees within the site that had a koala faecal pellet recorded within the prescribed search area. For example, given a sample of 30 trees, 12 of which had one or more faecal pellets recorded within the prescribed search area – the resulting activity level would be determined as 12/30 = 0.4 = 40 per cent.

¹ The <u>minimum</u> distance within which (on average) 50% of the total number of koala faecal pellets beneath the canopy of a given tree will be located (Jones 1994).

From the data sets presented in Table 1, we propose use of mean activity levels ± 99 per cent confidence intervals to define the limits of "normal" koala activity. Based on the threshold values that result we can then recognise three categories of koala activity as detailed in Table 2. Subject to qualifications regarding the need for a precautionary approach to low activity levels in some instances (see below), where the results of a SAT site returns an activity level within the range prescribed for low use, we suggest that the current level of use by koalas is likely to be transitory. Conversely, where a given SAT site returns an activity level within the prescribed range for medium (normal) to high use - the level of use is indicative of more sedentary ranging patterns and is thus within an area of major koala activity.

A precautionary approach to activity levels in low use areas.

Ideally, SAT site activity levels should only be interpreted in the context of location-specific habitat utilisation data (e.g. Lunney *et al.* 1998; Phillips *et al.* 2000; Phillips and Callaghan 2000). Low activity levels recorded in what might otherwise be considered important koala habitat may be a result of contemporary koala population dynamics and/or historical disturbances including logging, mining, fire frequency, agricultural activities and urban development. Such considerations should not necessarily detract from the potential importance of such habitat for longer-term koala conservation, particularly if koala food trees are present and koalas are known to occur in the general area. Application of a "Koala Habitat Atlas" type methodology over the larger area in conjunction with an understanding of ecological history (e.g. Knott *et al.* 1998) would be useful to clarify such issues.

Low activity levels can also be associated with low-density koala populations. Stable, low-density koala populations occur naturally in some areas (Melzer and Lamb 1994; Jurskis and Potter 1997; Phillips and Callaghan 2000; Ellis *et al.* 2002; Sullivan *et al.* 2006). Koala density in such areas generally reflects the absence of "primary" food tree species and reliance by the population on

"secondary" food tree species only (Phillips and Callaghan 2000; Phillips 2000). While secondary food tree species will return significantly higher levels of utilisation when compared to other *Eucalyptus* spp. in the area, their level of use (as determined by field survey) will generally tend to be both size-class and/or density dependent when compared to a primary food tree species (size-class and/or density <u>in</u>dependent) (Phillips *et al.* 2000; Phillips and Callaghan 2000; Phillips 2000). Because the autecology of koalas inhabiting areas without access to "primary" food tree species remains poorly understood at this point in time, we propose a precautionary approach whereby the presence of any activity in areas occupied by naturally occurring, low density populations should be regarded as ecologically meaningful for conservation and management purposes.

Recommended Applications

The SAT is suitable for use in conjunction with land-use planning activities and/or policies that require koalas and their habitat to be assessed, especially where identification of important areas for protection and management is required. The technique is also suitable for monitoring purposes. However, the design and detail of sampling protocols that could be developed using the SAT approach are beyond the scope of this paper. Further information and advice regarding application and use of the SAT, interpretation of activity levels, and its application to the task of determining broad-scale tree species preferences, can be supplied if required. The authors would also be thankful for any feedback regarding application of SAT methodology for any of the purposes indicated in this paper.

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References

Achurch, H.M. (1989) *Tree utilisation by Koala (Phascolarctos cinereus) populations with regard to their geographic distribution within close proximity to the city of Brisbane*. Honours Thesis, University of Queensland, St Lucia.

Australian and New Zealand Environment and Conservation Council. (1998) *National Koala Conservation Strategy*. Environment Australia, Canberra, Australia.

Ellis, W.A.H., Sullivan, B.J., Lisle, A.T. and Carrick, F.N. (1998) The spatial and temporal distribution of Koala faecal pellets. *Wildlife Research* **25**, 663–668.

Ellis, W. A. H., Melzer, A., Carrick, F. N., and Hasegawa, M. (2002) Tree use, diet and home range of the koala (*Phascolarctos cinereus*) at Blair Athol, central Queensland. *Wildlife Research* **29**, 303 – 311.

Environment Protection Agency/Queensland National Parks and Wildlife Service. (2006) Nature Conservation (Koala) Conservation Plan 2006 and Management Program 2006 – 2016. Queensland Government – Environment Protection Agency.

Faulks, J. (1990) *The ranging behaviour of Koalas*. Honours Thesis, Southern Cross University (formerly University of New England, Northern Rivers), Lismore, NSW, Australia.

Hasegawa, M. (1995) *Habitat Utilisation by Koalas (Phascolarctos cinereus) at Point Halloran, Queensland*. Masters Thesis, University of Queensland, Australia.

Hindell, M.A., Handasyde, K.A. and Lee, A.K. (1985) Tree species selection by free-ranging Koala populations in Victoria. *Australian Wildlife Research* **12**, 137–144.

Hindell, M.A. and Lee, A.K. (1987) Habitat use and tree preferences of Koalas in a mixed eucalypt forest. *Australian Wildlife Research* **14**, 349–360.

Hindell, M.A. and Lee, A.K. (1988) Tree use by individual Koalas in a natural forest. *Australian Wildlife Research* **15**, 1–7.

Jones, M. (1994) The use of scats to assess koala habitats in northern New South Wales. Unpub. Integrated Project, School of Resource Science and Management, Southern Cross University, Lismore, New South Wales.

Jurskis, V. and Potter, M. (1997) *Koala Surveys, Ecology and Conservation at Eden.* Research Paper No. 34. State Forests of New South Wales, Australia.

Knott, T., Lunney, D., Coburn, D. and Callaghan, J. (1998). An ecological history of Koala habitat in Port Stephens Shire and the Lower Hunter on the Central Coast of New South Wales, 1801 – 1998. *Pacific Conservation Biology* **4**, 354–368.

Lee, A. and Martin, R. (1988) *The Koala – A Natural History*. NSW University Press, Sydney, Australia.

Lunney, D., Phillips, S., Callaghan, J. and Coburn, D. (1998) A new approach to determining the distribution of Koalas and conserving their habitat: a case study from Port Stephens Shire on the central coast of New South Wales. *Pacific Conservation Biology* **4**, 186–196.

Martin, R.W. (1985) Overbrowsing, and Decline of a Population of the Koala, *Phascolarctos cinereus*, in Victoria I. Food Preference and Food Tree Defoliation. *Australian Wildlife Research* **12**, 355–365.

Melzer, A., Schneider, M. A., and Lamb, D. (1994) Insects associated with the faecal pellets of the Koala, *Phascolarctos cinereus* Goldfuss. *Australian Entomologist* **21**(3), 69 – 70.

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**, 89–93.

Melzer, A. and Lamb, D. (1996) Habitat utilisation by a central Queensland Koala colony. *Koalas – Research for Management* (ed G. Gordon), pp. 17–26. World Koala Research Incorporated, Brisbane, Australia.

Mitchell, P. (1990) The home ranges and social activity of Koalas - a quantitative analysis. *Biology of the Koala* (eds A.K. Lee, K.A. Handasyde and G.D. Sanson), pp. 177–187. Surrey Beatty and Sons, Sydney, Australia.

Moon, C. (1990) Koala corridors: A case study from Lismore. *Koala Summit – Managing Koalas in New South Wales* (eds D. Lunney, C.A. Urquhart and P. Reed), pp. 87–92. NSW National Parks and Wildlife Service, Sydney, Australia.

Munks, S. A., Corkrey, R. and Foley, W.J. (1996) Characteristics of arboreal marsupial habitat in the semi-arid woodlands of northern Queensland. *Wildlife Research* **23**, 185–195.

Pahl, L. (1996) Koala and bushland survey of west and central Logan City. *Koalas - research for management* (ed G.Gordon), pp. 82–92. World Koala Research Incorporated, Brisbane, Australia.

Phillips, S.S. (1999) Habitat utilisation by the Koala (*Phascolarctos cinereus*) – towards a new approach for effective conservation and management. PhD Thesis, School of Resource Science and Management, Southern Cross University, Lismore, Australia.

Phillips, S. S. (2000) Tree species preferences of the Koala *Phascolarctos cinereus* as a basis for the delineation of management areas for recovery planning in New South Wales. Unpub. report to NSW National Parks and Wildlife Service/Koala Recovery Plan.

Phillips, S. and Callaghan, J. (1995) The Spot Assessment Technique for determining the significance of habitat utilisation by Koalas. Unreviewed addendum to *Proceedings of a conference on the status of the Koala in 1995*. Australian Koala Foundation, Brisbane, Australia.

Phillips, S. Callaghan, J. and Thompson, V. (1996) *The Koala Habitat Atlas -Project No. 6: Port Stephens Local Government Area*. Australian Koala Foundation, Brisbane, Australia.

Phillips, S. and Callaghan, J. (1997) *Koala Habitat Atlas, Project No. 5: Campbelltown Local Government Area*. Australian Koala Foundation: Brisbane.

Phillips, S., Callaghan, J. and 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.

Phillips, S. and Callaghan, J. (2000) Tree species preferences of a Koala (*Phascolarctos cinereus*) population in the Campbelltown area south-west of Sydney, New South Wales. *Wildlife Research* **27**, 569–575.

Pieters, C.W. and Woodhall, P.F. (1996) Daily movement patterns and habitat utilisation of Koalas (*Phascolarctos cinereus*) exposed to different levels of habitat modification. *Koalas - research for management* (ed G.Gordon), pp. 23–28. World Koala Research Incorporated, Brisbane, Australia.

Reed, P.C., Lunney, D. and Walker, P. (1990) A 1986-1987 survey of the Koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution. *Biology of the Koala* (eds A.K. Lee, K.A. Handasyde and G.D. Sanson), pp. 55–74. Surrey Beatty and Sons, Sydney, Australia.

Robbins, M. and Russell, E. (1978) Observations on Movement and Feeding Activity of the Koala in a Semi-natural Situation. *The Koala – Proceedings of the Taronga Symposium* (ed T. Bergin), pp. 29–41. Zoological Parks Board of NSW, Sydney, Australia.

Sharp, A. and Phillips, S. (1997) Koalas, Science and Conservation. Saving Our Natural Heritage – The Role of Science in Managing Australia's Ecosystems (eds
C. Copeland and D. Lewis), pp. 290–301. Halstead Press, Sydney, Australia.

Sullivan, B. J., Baxter, G. S., and Lisle, A. T. (2002) Low-density Koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. I. Faecal pellet sampling method. *Wildlife Research* **29**, 455 – 462.

Sullivan, B. J., Baxter, G. S., and Lisle, A. T. (2003) Low-density Koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. III. Broad-scale patterns of habitat use. *Wildlife Research* **30**, 583 – 591.

Sullivan, B. J., Baxter, G. S., Lisle, A. T., Pahl, L., and Norris, W. M. (2004) Lowdensity Koala (*Phascolarctos cinereus*) populations in the mulgalands of southwest Queensland. IV. Abundance and conservation status. *Wildlife Research* **31**, 19 – 29.

White, N.A. and Kunst, N.D. (1990) Aspects of the ecology of the Koala in southeastern Queensland. *Biology of the Koala* (eds A.K. Lee, K.A. Handasyde and G.D. Sanson), pp. 109–116. Surrey Beatty and Sons, Sydney, Australia.

Table 1. Mean activity levels and related measures of central tendency (expressed as percentage equivalents) associated with habitat utilisation by Koalas from six areas in eastern Australia. Data relates to sites within which koala faecal pellets were recorded and has been pooled to reflect three major categories of Koala activity which correspond to low and med-high density Koala populations of the tablelands and areas east of the Great Dividing Range, and those of more western areas respectively. Koala densities for the east coast, low density category are arbitrarily defined at ≤ 0.01 Koalas/ha. (Data sources: ¹South-east Forests Conservation Council, unpub. data; ²Phillips and Callaghan 1997; ³Phillips and Callaghan 2000; ⁴Phillips *et al.* 1996; ⁵Phillips *et al.* 2000; ⁶AKF, unpub.data; ⁷Phillips 1999; ⁸AKF unpub. data; ⁹AKF unpub. data).

Area	Pop. Density	No. sites	No. trees	A/level	SD	SE	99% CL
East Coast							
S/E Forests ¹	Low	111	2979	11.85	6.84	0.65	1.70
Campbelltown ^{2, 3}	Low	20	1194	6.52	4.72	1.06	3.02
Pooled		131	4173	11.03	6.82	0.60	1.56
East Coast							
Port Stephens ^{4, 5}	Med - high	76	3847	23.65	23.63	2.71	7.16
Noosa ⁶	Med - high	63	1647	32.55	22.05	2.78	7.38
Pooled		139	5494	27.68	23.27	1.97	5.16
Western Plains							
Pilliga ^{7, 8}	Med - high	98	3656	42.52	22.78	2.30	6.05
Walgett ⁹	Med - high	37	990	38.01	27.66	4.55	12.37
Pooled		135	4646	41.28	24.19	2.08	5.44

Table 2. Segregation of Koala activity into Low, Medium (normal) and High use categories based on use of mean activity level \pm 99 per cent confidence intervals (nearest percentage equivalents) from each of the three area/population density categories indicated in Table 1.

Activity category	Low use	Medium (normal) use	High use
Area (density)			
East Coast (low)	< 9.47%	≥ 9.47% but ≤ 12.59%	> 12.59%
East Coast (med – high)	< 22.52%	≥ 22.52% but ≤ 32.84%	> 32.84%
Western Plains (med – high)	< 35.84%	≥ 35.84% but ≤ 46.72%	> 46.72%

Appendix 2

Koala Metapopulation Model for the Coomera – Pimpama Koala Habitat Area, Gold Coast, Queensland.

<u>Note</u>: the following figure details koala metapopulation boundaries for an area of approximately 3500ha to the east of the Pacific Motorway and north of the Coomera River in south eastern Queensland. Notice the large (source) cell in the west with smaller outliers of varying size to the east. Sampling intersections varied from 250m – 350m. Koala densities were estimated at 0.23 koalas/ha overall with a population size estimate of approximately 510 animals (Source: Biolink (2007). Koala Habitat and Population Assessment for Gold Coast City. Report to Gold Coast City Council).

Gold Coast City Council Koala Habitat Mapping & Population Assessment

