The utility of regularised grid-based 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

November 2007

biolink pty ltd
ecological consultants

PO Box 196 Uki NSW 2484
Tel 02 6672 6966
Fax 02 6672 6077
www.biolink.com.au

Project Team

Principal Consultant	Dr. Stephen Phillips
Supporting Ecologist	Ms. Marama Hopkins

Acknowledgements

The fieldwork underpinning this project was supported by staff from DECC (Chris Allen, Mike Saxon, Max Beukers, Dimitri Young, Jacqui Miles, Shaan Gresser & Julian Brown), SFNSW (Kelly Rowlands, Julia Clark, Neil Hampshire, Peter Shuman, Simon Van Holst, Michael Anderson & Ron Douch), Southern Rivers CMA (Justin Gouvernet and Andrew Taylor), Bega Aboriginal Land Council (Erika Luff, Ross Thomas & Wayne Bell) and community volunteers Yuri Wiedenhoffer, Penny Amberg, Andrew Bond, Christian Bond, Eleanor Stalenberg, Steve, Victoria and Liam Reed, Mick Otton, Laurence Stokes, Alison Treweek, Dean Turner, Andrew Zelnik, Yvette and Geoff Huntley, Pete Burns and Rowan McDonald. David and Libby Bright (Ngairin B & B) provided accommodation and an excess of refined country hospitality. Our thanks to all of you for your support and enthusiastic participation.

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
Ahem

Summary

This report describes the results of a pilot study investigating the utility of a regularized, grid-based 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.

Sampling was undertaken using Spot Assessment Technique (SAT) methodology, initially applied at 350m sampling intersections 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 indicating 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 a 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 Woolybutt *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 broad-scale application and suitability of regularised, grid-based SAT sampling to effectively address issues of koala conservation and management in the south-east forests. As a preliminary field survey technique we advocate sampling similar forest types at 500m intervals initially with a mandatory increase in sampling intensity to 350m intervals when koala activity is detected. Further and until such a time as more is known about key issues such as total population size, factors influencing tree selection and the conservation status of koala populations in the south-east forests generally, we advocate a precautionary approach to management. Preliminary recommendations include the application of management buffers to areas of known activity, and a hands-off approach to disturbance of known cells that mandates a no-logging, no-fire management scenario in addition to feral animal control. Monitoring of koala activity on a regular (yearly) basis hereafter is also advocated for the purposes of informing localised population trends.

Introduction

Koalas have had a complex and at times controversial management history in south-eastern NSW (Cork et al. 1995). The historical record (Lunney *et al* 1997) confirms a once large and robust koala population widely distributed throughout the coastal hinterland and ranges. 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 south-east 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, NSW 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.

A landscape-based 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 distribution of free-ranging koala populations across heterogeneous landscapes. Submitted to *Biological Conservation*). Underpinned by the Spot Assessment Technique (SAT) of Phillips & Callaghan (Appendix 1), the technique(s) detailed in the manuscript deliberately aim 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 occur in the south-east forests and hence its utility for the purposes of resolving issues of koala distribution and density in such areas was unknown.

A notion to "explore" systematic SAT sampling arose as a proposed management action from FSCKMF Scientific Workshop in June, 2006 (FSCKMF Appendix 1 refers). Accordingly, the purpose of this pilot study was to trial the aforementioned methodology 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 (± 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. Available vegetation mapping (modeling?) indicated an area ostensibly 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 1950s; 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^{o} 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 a AGD66 datum to assist their 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 the Spot Assessment Technique (SAT). 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 progressed, 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 was undertaken in accord with procedures detailed in Phillips et al (submitted), employing regularized splining, minimal (0.1) weighting and a constant 12 nearest neighbour 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.

We accepted that boundaries modeled by the aforementioned process were indicative rather than definitive and potentially possessed a measure of flexibility and/or uncertainty 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 $n(1-p) \geq 5$ 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 15th – 29th 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*, Woolybutt *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 fieldwork. Table 1 details the tree species sampled during the course of the field survey. No koalas were observed within any of the 72 x 0.196ha radial searches that were undertaken, nor were any observed opportunistically during the course of the survey.

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.

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-eucalypts			
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**	

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 reported 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 inclination 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 ~ 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 (~ 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_{adj} = 6.2380 P = 0.0442, 2_{df}) while also inferring *E. longifolia* to be the most preferred tree species (Fig. 5).

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**	**p**
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**	

Note: We did not consider the taxonomic resolution of "stringybark" species present in the study area sufficiently reliable 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.

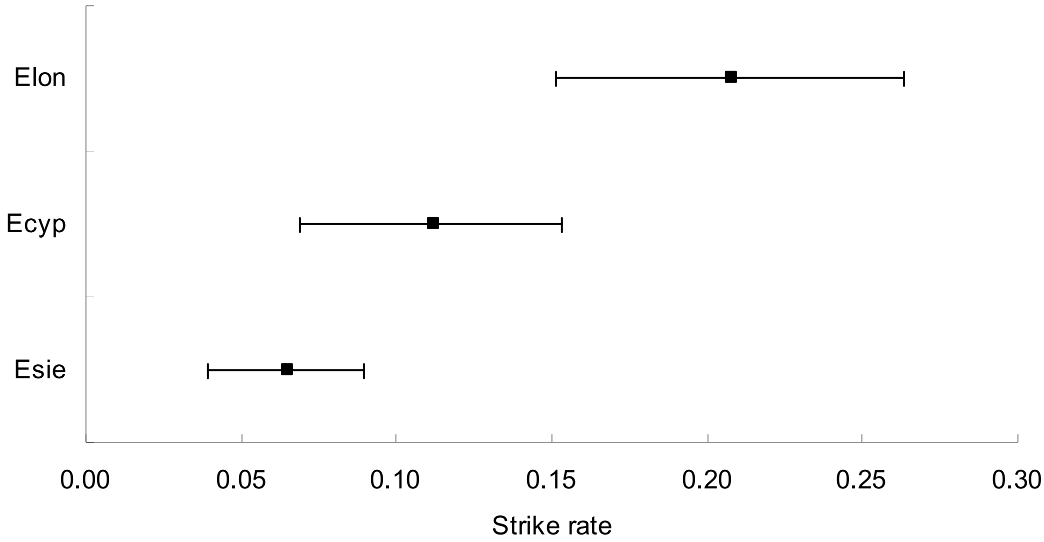

Figure 5. Strike rates (proportion of trees with koala faecal pellets within active SAT sites) ± standard error for Woollybutt (Elon), Monkey Gum (Ecyp) and Silvertop Ash (Esie).

Discussion

The results of this pilot study have confirmed the ability of a regularised, grid-based sampling 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. What follows below reflects our current thoughts…

1. Issues associated with modeling low activity levels.

The tendency of sites with activity to cluster was expected and is concordant with both 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 3% activity contour for boundary delineation, reflecting the lowest level of activity able to be detected by the minimum 30-tree sample 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 activity being significant, we also modeled the hypothetical 1% activity contour, noting that it invariably coincided with the greater proportion of our required management buffers in the majority of cases.

Throughout the study area, scats were generally hard to find, reflecting what will be an ongoing issue in terms of future studies that rely on 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 cluster (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 leads to disinterest and/or apathy, 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 detected metapopulation outliers rather than a primary source population. To this end the cells we have identified likely reflect individual home range areas rather than koala aggregations *per se*. Support for this notion comes from the overall low activity levels that were recorded, observations of consistency in scat size (suggestive of single/younger animals), along with that 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 readily 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 by DECC. 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. 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 (e.g. 750m – 1km). 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 on average 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 interval^2/10000 = 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 2000). 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 in NSW & SE Qld suggest that approximately 50% of available habitat is generally occupied by demographically stable koala metapopulations (Phillips et al submitted). While still a novel concept in terms of koala management, this notion makes ecological sense and further infers a need for management to both recognize <u>and</u> 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, Appendix 1 refers) of the available habitat at this point in time. Given the historical narrative and generally 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, 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) intended 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” iwarrants the cells we have identified be classified as A Class Habitat accordingly, as should the management buffer and proposed linkage area (see below). However, we are reluctant to pursue other 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. However, such things are perhaps best left for further discussion once the implications of this report have been absorbed. With this in mind the following recommendations are preliminary in nature and intended for discussion purposes rather than being non-negotiable outcomes.

(i) *Further Surveys*

- Agencies give consideration to the use of the technique(s) described in this report as a useful tool to assist longer term koala management, conservation and survey purposes.

(ii) *Fire Management*

- Fire management practices including the use of low intensity burns for the purposes of hazard reduction should not be undertaken within areas of known koala activity.

- Agencies to incorporate the location of koala population cells into fire management planning so as to be capable of mounting a strategic defense of known activity areas in the event that they are threatened by wildfire.

(iii) *Linkage areas*

- area(s) spanning the closest points of contact between otherwise isolated population cells should ideally be designated as a habitat linkage area(s), be 350 – 500m in width and managed as if they were occupied.

(iv) *Silviculture*

- silvicultural practices such as timber harvesting for woodchip and/or sawlogs and/or thinning operations should not be undertaken within koala population cells nor associated buffer and habitat linkage areas.

(v) *Feral Animal Control*

- Evidence of excessive dog and/or fox activity within designated koala activity area should be followed up with a targeted control program.

(vi)*Pre-logging surveys*

- Pre logging surveys should ideally cover a minimum habitat block of 500ha centered over that area proposed for logging, sampling initially at 500m sampling intersections, increasing to 350m in areas where koala activity is detected.

(vii) *Ongoing monitoring*

- Monitoring of koala activity on a regular (yearly) basis hereafter is also advocated for the purposes of informing localised population trends.

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., Esson, C., Moon, C., Ellis, M., and Mathews, A. 1997. A community-based survey of the koala Phascolarctos cinereus in the Eden region of south-eastern 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. 2000. Population Trends and the Koala Conservation Debate. *Conservation Biology* 14(3), 650 – 659.

Appendix 1

The Spot Assessment Technique

Appendix 2

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

Note: 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).