DISTRIBUTION, HABITAT USE AND STATUS OF KOALA POPULATIONS IN THE FORESTS OF SENSW

Report of the koala survey program undertaken by the South East Forests Koala Research Project 1996-8

Funded by the Commonwealth Government through the South East Forests Regional Adjustment Committee

South East Forests Conservation Council

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SUMMARY

Since 1996 the South East Forests Koala Research Project (SEFKRP) has undertaken fieldwork in the forests of South east NSW to collect data on the distribution, habitat use and the status of remnant Koala populations. This work was funded by the Commonwealth Government through the South East Forests Regional Adjustment Committee.

The Project received differing advice as to the most suitable non-intrusive survey method to be used in forests such as these where remnant Koala populations and individuals are widely scattered. After trialing a method recommended by the CSIRO, it adopted those used by the Australian Koala Foundation (AKF). The Foundation uses a statistically quantifiable approach to the assessment and mapping of Koala habitat, based assessing whether Koala faecal pellets are present or absent beneath identified tree species in sites used by Koalas.

There was a significant level of voluntary participation in field surveys, particularly in the earlier stages of the Project. Despite limited funds seven people were employed. Several of these people commenced with the project as volunteers. Each staff member showed remarkable dedication and contributed many hours voluntarily to the work.

Although extensive fieldwork was undertaken, and staff proved their ability to locate evidence of Koalas and also of breeding females if they are present, the only evidence of a breeding aggregation was located in the Murrah State Forest and even these animals appear to be widely scattered. No other area has yielded comparable results. The evidence of Koala distribution and habitat use supports information from other sources that Koala numbers in the region are extremely low and have continued to decline in recent years.

The data gathered in Murrah and Bermagui State Forests have enabled the identification of slope classes, browse species and tree size ranges (as measured by the diameter at breast height) preferred by Koalas in forests growing on Ordovician metasedimentary geologies. Although insufficient data were collected in forests growing on granite geologies to provide statistically reliable analysis, these suggest that the same browse species are important for Koalas in these areas. Of all the coastal and hinterland forests in the region, xx% are growing on these geologies.

In the Murrah/Bermagui area Koala faecal pellets were recorded from beneath 11 species of Eucalypt and 8 species of non-Eucalypt. Analysis of the data established that the two species most preferred by Koalas in the Murrah area are Mountain Grey Gum *(E.cypellocarpa*) and Woollybutt *(E.longifolia)*. Other species receiving comparable but less significant levels of utilisation include White Stringybark *(E. globoidea*), Yellow Stringybark *(E. muelleriana*) and Coast Grey Box *(E. bosistoana*). The levels of utilisation for *E. cypellocarpa*, *E. longifolia*, *E. globoidea* and *E. muelleriana* were strongly density dependent.

Data were also gathered from areas intensively logged in the Murrah for a project to model Koala habitat for the Comprehensive Regional Assessment (CRA). Comparative analysis of these data reveals significant changes in forest structure and tree species composition with a reduced proportion of Koala browse species in regrowth forests compared with that found in multi-aged forests in the same area. These changes may pose a significant long-term threat to Koalas in intensively logged forests. Data on growth rates of preferred tree species are a critical element when assessing harvesting impacts on Koala habitat in production forests. The growth data provided by SFNSW for the region are considered in this context.

SEFKRP data formed the basis of a preliminary regional model of Koala habitat that was used

by the CRA. This was primarily based on disturbance (logging) history information and selected Vegetation Types in which preferred Koala feed tree species are well represented.

The results of this research project provide a basis for recommendations and strategies to facilitate the recovery of the species in the EMA. These have been provided to the NSW government to assist the development of a regional Koala Recovery Plan. An essential component of this Plan will be an ongoing monitoring program that will assess whether: 1) specific Koala areas continue to be occupied; 2) the females in known breeding areas continue to have young; 3) Koala numbers remain stable; and 4) the pattern of tree species use by Koalas in different areas continues. This project has facilitated the establishment of a team of competent fieldworkers who are able to undertake this work.

1. INTRODUCTION

1.1 **The Region; Koala history, research and forest management**

The South East Forests are found primarily on the escarpment and foothills of the South Coastal Range of NSW. The region sustained an abundant Koala population that endured extensive fragmentation and degradation of its habitat during the second half of the 19th Century, primarily through clearing for agriculture of the more fertile and undulating areas. This precipitated the population crash of the species in the first decade of the 20th Century (Lunney and Leary 1988). Since then Koala numbers have been low and records widely scattered (Lunney et al 1997).

The management of remaining Koala habitat in production forests has remained controversial, primarily because of the practice of intensive logging, known as intensive logging, that is undertaken without knowledge of the status and habitat requirements of the species. These operations commenced in 1968 with the establishment of Harris Daishowa's woodchip mill at Eden. The area of forest that was clearfelled was gradually increased and since 1976, approximately 5000 ha of the region's forests have been heavily logged each year, with over 90% of the timber felled exported as woodchips to the Japanese paper industry (State Forests 1995). The recent history of timber harvesting, particularly in Koala areas, is appended (Appendix 1).

Since the work of Lunney and Leary (1988) and Lunney and Reid (1989) both State Forests NSW (SFNSW) the National Parks and Wildlife Service (NPWS) and the local conservation movement have initiated research projects. These are described in Appendix 2.

1.2 The South East Forests Koala Research Project

The Project was initiated by the South East Forests Conservation Council (SEFCC), funded by the Commonwealth Government through the South East Forests Regional Adjustment Committee and guided by the Australian Koala Foundation and the NSW Government appointed South East Forest Koala Research Committee (SEFKRC). This Committee has been reorganised and now considers Koala research matters across NSW.

When it was originally formulated in 1993 the Project proponents intended a study of a breeding aggregate of Koalas in Central Tantawangalo, then the most important known population in the region (Allen in Cork et al 1995). Following advice from the SEFKRC, this was broadened to be a community based and region-wide survey and became known as the South East Forests Koala Research Project (SEFKRP). The use of non-intrusive survey techniques was considered paramount because the species appeared to be endangered and because of the high death-rate of radio-tracked Koalas in a SFNSW study (Bali and Delaney 1997). The Project commenced in July 1996 and is ongoing.

This report describes the surveys and research undertaken by the SEFKRP across the region and

provides an analysis of the results. Data from active sites have been analysed for tree species preference by the principal ecologist from the Australian Koala Foundation and his findings are included in this report.

The Project was developed and undertaken within difficult circumstances. Koala survey methods and habitat modelling, and the conservation of the species and the habitat that sustains it, had been extensively debated within the scientific literature, government departments and the local community and had remained largely unresolved. This was particularly the case with low-density Koala populations such as those found in the region (eg Cork 1995, Bali and Delaney 1996). In this context the SEFKRC has had an important role in guiding the directions of the Project, particularly in changing its original focus on a specific Koala area to that of a region-wide survey program. Although the results demonstrate the wisdom of this guidance, the Project has been subjected to public criticism by the timber industry for not focusing on the particular area that was the subject of the original research proposal.

The debate concerning appropriate survey methods for low-density populations centred on differing approaches by the CSIRO and the Australian Koala Foundation. The project trialed both and found those used by the Foundation were more appropriate, primarily because of cost restraints and because of the widely scattered nature of Koala habitat use in the region.

Soon after the Project's surveys commenced the NSW and Commonwealth governments began a major assessment of the ecological, economic and sociological values of the region's forests. Based on the results of these assessments the governments planned to sign a Regional Forest Agreement that was intended to provide secure woodchip and sawlog resources to industry and a world class reserve system (Commonwealth 1992). Staff from the SEFKRP were contracted to undertake further surveys in the Murrah/Bermagui area and provide a habitat model of that area. SEFKRP data were also provided and formed the basis of the regional model of Koala habitat that was used in the Process. The fieldwork was completed in October 1997, after which surveys by the SEFKRP were continued, primarily in other areas.

2. STUDY AREAS

Since the primary research objective was to gather information on Koalas' tree species preferences, survey effort was concentrated in the two areas where there are recent records of Koalas; ie the Bermagui/Murrah and Yurammie/Tantawangalo areas. Surveys were also undertaken other areas in the region where Koala evidence has been recorded in the past two decades. These are shown in Figure 1

Figure 1: MAP OF AREAS SEARCHED

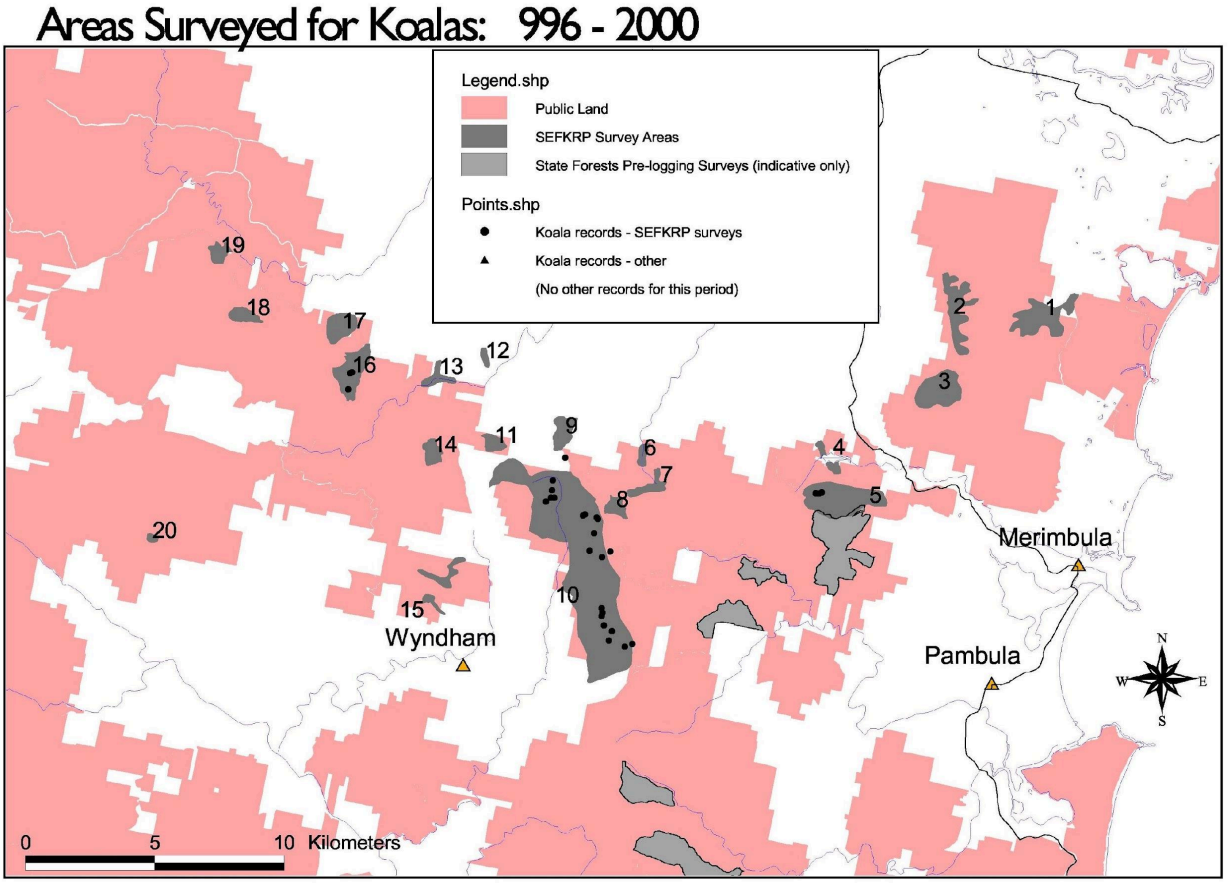
2.1 BERMAGUI/MURRAH FORESTS

The Murrah/Bermagui forests are part of the coastal 'Five Forests' between Tathra and Bermagui, in the north-east of the Eden Management Area. These forests contain mixed eucalypt species, with rainforest in most of the larger gullies. The geology is primarily Ordovician metasedimentary. The remnants of what is regarded as higher quality Koala browse species (eg. *E. tereticornis*) still remain as retained trees on cleared private land and roadside verges in the area. A population of Koalas is known to have persisted in the remaining forested areas for many years (Lunney, 1996; Fanning, 1990). The home range of one of the Koalas radio-tracked between 1994 and 1996 by SFNSW was in the adjacent Bermagui State Forest (Jurskis and Potter 1997).

The forests have been exploited for timber over the past century, mainly selective operations for sleepers and sawlogs until the 1970's. Since the mid-1970's, the coastal forests have been subject to intensive logging for pulp and sawlogs on a short (40 year) rotation (see **Appendix**

X: Timber harvesting - recent history). Following recommendations by Cork (1995) a portion of Murrah SF and all of Bermagui State Forest was designated as a "Koala Moratorium Area" in SFNSW (1994). In order to provide interim protection, integrated logging was excluded from these areas until a Plan of Management for Koalas in the region was agreed and implemented by relevant government agencies. The area in Murrah SF outside the moratorium area was made available for logging because State Forests considered the soil types and forest types to be unsuitable for Koala habitat (Cork 1995).

Figure 2: MAP OF AREAS SEARCHED IN OTHER AREAS



2.2 TANTAWANGALO/YURAMMIE FORESTS

The Tantawangalo and Yurammie Forests link the coastal and hinterland forests in the centre of the region. They are largely found on a mountain ranges that were too rugged and, in places, too infertile, to be cleared by early settlers. They form a range that extends from the coast to the hinterlands the Bega Valley. These forests also consist of a range of eucalypt and rainforest communities growing on varying, primarily granitic and metasedimentary geologies.

Timber harvesting has also been undertaken in these forests for many years, although to a lesser extent than in the Murrah/Bermagui Area, primarily because it is less accessible. Intensive logging commenced in western Yurammie State Forest in 1973. Over the following twenty years the first cutting cycle was undertaken in most of this forest.

Lunney and Reed (1990) quote Recher et al (1980), Braithwaite (1983) and Harris Diashowa (1986) to confirm the presence of Koalas in this area. The latter two speak of numerous reports, particularly in the Myrtle Mountain area. This was targeted for intensive logging, probably because it contained relatively easily accessible areas with high timber volumes. Information concerning the immediate impact of these operations on the remnant Koala populations in this area is not available. Two male Koalas were subsequently radio-tracked by State Forests in this area between 1993 and 1996. Intensive logging was also undertaken in nine compartments in

the nearby Tantawangalo State Forest between 1987 and 1994. SFNSW radio-tracked a young male Koala in this area between 1991 to 1994 (Jurskis and Potter 1997).

As recommended by Cork (1995) a Koala Moratorium Area was also established in this area in 1993 (SFNSW 1994).

2.3 OTHER AREAS

Between October 1996 and June 1997 the SEFKRP also undertook sweep searches for Koala faecal pellets in areas where Koala faecal pellets had been found, or animals sighted, by SFNSW or Tantawangalo Catchment Protection Association (TCPA) survey teams between one and six years previously. These areas were as follows:

- Wolumla Peak, East Yurammie SF;
- Wyndham Trig, West Yurammie SF;
- Chalkhills Fire Trial -Mataganna catchment,
- West Yurammie SF; north and south of Boben Rd, Tantawangalo SF;
- Tantawangalo NP; Compartment 1382, Cathcart SF;
- Compartment 1415, Coolangubra NP;
- South Nullica State Forest
- Tanja SF (animal sighted in 1991 - no faecal pellets recorded).

In addition, the research team also searched parts of the following areas where Koala evidence has been recorded since 1980:

- Bournda NR;
- Wallaga Lake NP; and
- Chalkhills Fire Trail, Tantawangalo SF.

3 PROJECT METHODS

3.1 STRATIFIED SURVEYS

Fieldwork to generate data on tree species preference commenced in September 1996 with stratified transect based surveys in the Bermagui /Murrah and Tantawangalo /Yurammie State Forests. With input and advice from the CSIRO and NPWS, transect locations were selected to provide a representative sample based on aspect, altitude and growth stage. Plots were selected along the transect to give a representative sample of slope positions.

Each plot was located and searched for Koala faecal pellets using the plot assessment method developed by the AKF (described below). Approximately 850 hours were spent in the field locating and undertaking these plot assessments. Using this method, Koala faecal pellets were found in two (2) plots. The very low number of positive results reflected the scattered nature of Koala evidence in the region and suggested that, given the cost restraints, insufficient data could be gathered with this method to undertake robust statistical analysis.

3.2 SWEEP SEARCHES

Following advice from the Australian Koala Foundation (AKF**)** sweep searches for Koala faecal pellets were trialed. Where possible, members of the research team searched in lines stretching from ridge to gully and worked along the contour of slopes. The areas searched were then recorded on a map. In the first week of this trial, areas in the north of the EMA were searched, including Murrah and Bermagui State Forests, Bermagui Nature Reserve and Wallaga Lake National Park. Twelve (12) active sites (ie with Koala faecal pellets) were found in Murrah State Forest and one (1) in Bermagui SF. Searches were initially concentrated in areas where there was previous Koala evidence and/or records. In the first week of sweep searches, it was decided to search an area roughly between the active sites already located, where there had been

no previous evidence or record of Koalas. Seven (7) active sites were found in this area on that day. The total search time for this week was 276 hours.

With the success of this approach, and following consultation with the Australian Koala Foundation and the project's Advisory Committee, stratified surveys were discontinued and the project concentrated on searching for evidence using the method described above.

The total time spent by the SEFKRP on sweep surveys amounted to 2,667 hours or 444.5 person days (6 hours per person day).

3.3 SURVEY METHOD FOR HABITAT MODELLING FOR THE COMPREHENSIVE REGIONAL ASSESSMENT PROCESS

Staff from the Project were also contracted to develop a habitat model for the Comprehensive Regional Assessment Process for the Bermagui/Murrah area. The data from the tree species preference plots revealed that while slope position and aspect had been reasonably well sampled in this area, few of the plots were in areas that had been subject to intensive logging. Additionally, recording of stems less than 100 mm DBHob had not been undertaken in the twelve (12) plots located in recently logged and regrowth areas. This information was required to provide data on all tree species in regrowth forest areas.

During preparation for fieldwork for the CRA, information on the extent of the data, plot methods and areas searched was presented to and endorsed by experts from the CSIRO Division of Wildlife and Ecology.

Based on that expert advice, the existing plot data were stratified using the following criteria:

- slope position (1. gully/lower slope 2. mid-slope 3.upper slope/ridge);
- aspect (4 sectors -30/119;120/209; 210/299; 300/29 degrees);
- growth stage and disturbance (1: relatively undisturbed (MAF) ; 2: young forest where intensive logging had not been undertaken; 3: young forest where intensive logging had been undertaken (RGF)

As all Koala evidence in the Murrah areas had been located in forests growing on Ordovician metasediments, geology was not included as a stratum.

The representativeness of strata that had been sampled in sweep surveys and those where active sites had been located was then assessed and found to be adequate in the multi-aged forest (MAF) plots. It was concluded that it would not be possible to gain a representative sample of the young forest stratum that had not been subject to intensive logging. Surveys within areas of intensive logging regrowth were undertaken to gain a representative record of those strata. At least three (3) plots from MAF and intensive logging Regrowth Forest (RGF) within each strata combination were obtained.

3.4 ASSESSMENT AT ACTIVE SITES; VARIABLE RADIUS PLOTS

Each location where Koala faecal pellets were located was designated as an active site and the tree under which the pellets were found was recorded as the centre tree of the plot. A minimum of 25 trees with a diameter at breast height over bark (DBHob) of 100mm or greater were marked with flagging tape. A 'tree' is defined as: "*a live woody stem of any plant species (excepting palms, cycads, tree-ferns and grass-trees)* ".

A minimum radius of 10m applied to variable radius plots. The radius of the plot was measured and recorded. The DBHob and species of each tree in the plot was also recorded and a 1m search for Koala faecal pellets, involving leaf litter removal, was made around the base of each tree. Where a single faecal pellet was found within the search areas of one or more trees, the

pellet was scored against each tree respectively. These were recorded as pellets present at trees. Apart from the centre tree, the flagging tape was removed as each tree was assessed.

Other environmental characteristics of each plot were also recorded (See Appendix 1)

Fixed radius plot assessments were undertaken in 'null' plots and are discussed below in XXX

3.5 NULL SITES: FIXED RADIUS PLOTS

No active sites were found in young forest in sweeps of RGF, so these plots were designated as null plots. The size of these plots was derived from the median radius of active plots (14 metres).

During sweep searches in these areas, sites which were representative of slope, aspect and vegetation were selected as null sites. Plots are dissected into quadrants and each stem over breast height is recorded as per the variable radius plots. Stems less than 100 mm DBHob are assigned to classes of either 49mm or less, or 50mm to 99 mm.

3.6 DATA RECORDING

A data sheet was used to record plot details of trees and other environmental and geographical attributes. Since the commencement of the CRA fauna surveys (February 1997), a similar data sheet to that used by other fauna survey teams was also completed. Examples of these data sheets are provided in **Appendix XXX**.

4. RESULTS

4.1 ACTIVE SITES LOCATED

The only area outside the Bermagui/Murrah and Tantawangalo/Yurammie forests where active sites were located was in South Nullica State Forest.

Areas Searched	Hours	Active sites
Bermagui NR	109	4
Wallaga Lake NP	58	0
Murrah/Bermagui SF's	550	64
West Yurammie	585	15
East Yurammie	179	3
Tantawanglo	225	4
Nullica	100	3
Coolangubra	36	0
Bournda NR	132	0
TOTAL	1974	93

Table 1: Areas searched, hours search time and number of active sites in each area

NB Table does not contain information on surveys undertaken in November/December 1997 in areas where positive callback were recorded in September 1996, nor those areas where surveys of areas sustaining breeding females were undertaken in February 1998.

4.2 ANALYSES OF DATA FROM THE MURRAH/BERMAGUI FORESTS

The Murrah and Bermagui Forests accounted for nearly 80% of active sites located. The ensuing data were analysed to provide information on tree species, growth stage, forest structure, tree sizes, and slope classes preferred by Koalas.

4.2.1 TREE SPECIES PREFERENCES

The data on tree species preferences were analysed by the Principal Ecologist of the Australian Koala Foundation. This analysis follows.

A total of 2,043 individual trees were assessed comprising 15 species of *Eucalyptus* and 14 species of non-eucalypt from 76 independent sites. Koala faecal pellets were recorded from beneath 11 species of *Eucalyptus* and 8 species representing other genera (Table 1). Activity levels associated with the 76 sites ranged from 3.3% to 28% (Mean activity level = 11.286%, std dev = 5.949).

Tree Species	No.Sites	*n*	*P*	Tree Species	No.Sites	*n*	*P*
A. Eucalypts				**B. Non-eucalypts**			
E. agglomerata	30	191	0.073	*Acacia cognata*	10	22	0.091
E. bosistoana	17	40	0.200	*A. falcata*	17	37	0.054
E. cypellocarpa	15	41	0.220	*A. mearnsii*	4	20	0.050
E. globoidea	21	120	0.167	*Acmena smithii*	6	20	0.100
E. gummifera	24	112	0.071	*Allocasuarina littoralis*	52	368	0.087
E. longifolia	62	285	0.214	*Angophora floribunda*	22	49	0.041
E. muelleriana	54	342	0.123	*Backhousia myrtifolia*	7	71	0.042
E. tricarpa	45	138	0.080	*Exocarpus cupressiformis*	7	7	0.143
E. consideniana	6	23	0.304	*Acacia implexa*	1	1	-
E. maculata	3	41	0.024	*A. longifolia*	1	1	-
E. seiberi	24	90	0.044	*A. irrorata*	5	5	-
				Pittosporum undulatum	1	1	-
E. botryoides	3	5	-	*Persoonia lineara*	1	1	-
E. elata	1	1	-	*Tristaniopsis laurina*	1	1	-
E. paniculata	1	2	-				
E. smithii	2	8	-				
Total Trees		**1439**				**604**	

Table 2: Data relating to tree use by Koalas derived from 76 radial based assessments in the Bermagui/Murrah area. Species are grouped in order of the extent to which they satisfied the two criteria adopted for analyses purposes.

Use of Eucalypts

The primary data set comprised of eight species of *Eucalyptus*. The range of strike rates varied from 0.214 for *E. longifolia* to 0.080 for *E. tricarpa* (Table 1). There was significant

heterogeneity amongst the strike rates when tested for Goodness of Fit ($G = 29.473 > \chi^2_{[6].001}$). The results of an unplanned test for homogeneity using simultaneous test procedures established the presence of two homogeneous data sets as detailed in Table 2. Mountain Grey Gum *E. cypellocarpa* and Woollybutt *E. longifolia* were isolated by this process as the most preferred by Koalas in the study area. An intermediate group comprised of the Coast Grey Box *E. bosistoana*, White Stringybark *E. globoidea* and Yellow Stringybark *E. muelleriana* could also be associated with the most preferred species. Red Ironbark *E. tricarpa*, Red Bloodwood *E. gummifera,* and Blue-leafed Stringybark *A. agglomerata* were the least preferred species.

Tree spp	*Ecyp*	*Elon*	*Ebos*	*Eglo*	*Emue*	*Etri*	*Eagg*	*Egum*
S/Rate	.220	.214	.200	.167	.123	.080	.073	.071
Hds 1	**X**	**X**	**X**	**X**	**X**			
Hds 2			**X**	**X**	**X**	**X**	**X**	**X**

Table 3: Extent of homogeneity amongst the levels of utilisation for eight species of *Eucalyptus* in the Bermagui - Murrah primary data set (Critical Value $G = 18.475 = \chi^2_{[7].01}$). The descriptor "Hds" refers to each of the homogeneous data sets established using simultaneous test procedures.

The levels of utilisation for the most preferred species were clearly density dependent (*E. cypellocarpa*: F=8.32, rsq = .410, sigF = $.014_{[12]}$; *E. longifolia*: F=23.71, rsq = .283, sigF = $<.001_{[60]}$) as were those of *E. globoidea* and *E. muelleriana* (*E. globoidea*: F = 6.97, rsq = .268, sigF = $.016_{[19]}$; *E. muelleriana*: F = 16.04, rsq = .236, sigF = $<.001_{[52]}$). Conversely, that of *E. bosistoana* appeared to be independent of density (F = 1.92, rsq = .114, sigF = $.186_{[15]}$).

The secondary data set contained three species of *Eucalyptus* - Yertchuk *E. consideniana*, Silvertop Ash *E. seiberi* and Spotted Gum *E. maculata*. The strike rates of these species ranged from 0.3 for *E. consideniana* to 0.071 for *E. maculata* (Table 1). The extent of variation amongst the strike rates was significant ($H = 9.869 > \chi^2_{[2].05}$). The primary cause of heterogeneity related to the observed strike rate of *E. consideniana* which was significantly higher than that of the other two species (*E. consideniana* vs *E. seiberi*: $U = 138_{[23,6]}$, $P < .025$; *E. consideniana* vs *E. maculata*: $U = 21_{[6,3]}$, $P < .025$).

The use of non-eucalypts

Koala faecal pellets were also recorded from beneath 8 species of non-eucalypt. Given that only one species *Allocasuarina littoralis* satisfied the criteria for inclusion in a primary data set, the extent of variation amongst each species was determined using a Kruskal-Wallis Anova. As detailed in Table 1, the range of strike rates varied from 0.14 for *Exocarpus cupressiformis* to 0.04 for *Angophora floribunda* and *Backhousia myrtifolia*. However, the extent of variation was not determined as significant ($H = 9.0484 < \chi^2_{[7].05}$), nor were their individual strike rates indicative of significant levels of use.

Independence

The presence of the two most preferred tree species *E. cypellocarpa* and *E. longifolia* was determined to have a positive influence on the strike rates of other tree species in the study plots ($G_{adj} = 5.017 > \chi^2_{[1].05}$). However, the co-efficient of association in this regard was very weak (φ

= 0.05) suggesting that the indicated result was likely to be conservative. Application of a t-test based purely on activity levels indicated that the differences between plots which contained *E. cypellocarpa* and/or *E. longifolia* and those from which both species were absent was not significant ($t = 1.74_{[72]}$, $P > .05$).

4.2.2 DENSITY DEPENDENCE

When logical regression analysis was applied to levels of use of secondary and supplementary food trees, *E. cypellocarpa*, *E. longifolia*, *E. globoidea* and *E. muelleriana* were found to be strongly density dependent. This means that the "strike rate" for individual species was inversely related to the number of trees of that particular species present at the site.

4.2.3 OVERLAYING THE MURRAH/BERMAGUI RESULTS WITH REGIONAL VEGETATION MODEL

The Vegetation Model provided for the Comprehensive Regional Assessment Process indicates that the two dominant vegetation communities in the 'Five Forests' area are Type 32 (Coastal Dry Shrub Forest: Woollybutt) and Type 34 (Brogo Dry Shrub Forest). The Five Forests are the only area in the EMA region where these vegetation types occur together in significant stands.

Keith and Bedward (1997) provide tables showing the frequency of occurrence of plant species in their vegetation survey plots. Although these tables do not indicate the number of plants of each species found in these plots, they do provide a reasonable guide as to their relative abundance in each Vegetation Type (see Tables 1 and 2 below).

Table 6: Frequency (% occurrence in samples) of selected tree species in Vegetation Types 32 and 34, compared with Veg. Types 33 and 46 (Keith and Bedward, 1997 Draft).

TREE SPECIES	VEG. TYPE 32	VEG. TYPE 34	VEG. TYPE 33	VEG. TYPE 46
Acmena smithi		6		
Alec. subl		13		
A. floribunda	28	25		22
E. aglommerata	33			28
E. botroides	5			
E. consideniana				
E. cypellocarpa	**36**	**31**		
E. elata	10	25		
E. globoidea	**14**	**44**		**61**
E. gummifera	5			56
E. longifolia	**67**	**31**		
E. maculata	19	19		
E. muellereana	**62**	**25**		**6**
E. paniculata	5			
E. sieberi	10			72
E. smithii	14	6		6
E. tricarpa	43	6		
P. undulatum	10	63		

Analysis of the overstorey component in these tables reveals that in Vegetation Type 32, the secondary and supplementary feed tree species *E longifolia, E. muellerana* and *E. globoidea* form approximately 42% of the dominant overstorey tree species. In Vegetation Type 34, where *E. cypellocarpa* is also present, it is a little over 55%. This is considerably more than the 30%

cut-off point used by the AKF to determine whether a vegetation community should be considered to be Koala habitat (see 6.1 Tree Species Preferences).

Type 32 appears to be primarily a ridge and mid-slope association, while Type 34 is found in the lower slopes and smaller gullies reference. The SEFKRP data suggests that all slope positions are important to Koalas in the study area and it therefore seems reasonable to conclude that Koalas regularly move between both vegetation types.

The other vegetation community most commonly found in the study area is Type 46 (Lowland Dry Shrub Forest). This occurs in Bermagui Nature Reserve, to the south of the Bega River and the north west of Murrah SF. ***Also Veg type 33***

Keith and Bedward (1997) found no evidence of any secondary Koala feed trees in this community and also that *E. sieberi* had the highest frequency of the overstorey species in the sampled plots. Surveys in areas containing this vegetation community failed to detect evidence of Koalas. No other Vegetation Type occurring in the study area meets the habitat criteria defined by the Australian Koala Foundation Habitat Atlas (see discussion).

Jurskis and Potter (1997) found that one radio-tracked Koala in the study area used rainforest areas in extreme weather. Cork (1995) also suggests that mesic gullies are likely to provide refuge during wildfire. On the basis of the above information, the CRA vegetation model that maps the distribution of Vegetation Types 32 and 34, with associated rainforest communities, provides the foundation for this study's Koala habitat model. This approach is limited by inadequacies in using a vegetation model as a basis for habitat modelling. This is discussed next.

4.2.4 COMPARISON BETWEEN VEGETATION MODEL AND SEFKRP DATA

The vegetation data recorded by the SEFKRP was analyzed to assess, where possible, which vegetation type would have been recorded for the vegetation model at each of the survey plots. These were compared with the vegetation predicted by the CRA vegetation model to be present at those sites. A correlation of approximately 60% occurred. An analysis of the vegetation data for the Tantawangalo/Yurammie plots revealed a similar correlation (see below).

Such a low correlation might result from one or more of the following:

- the level of disturbance has been such that the vegetation community has been significantly altered;
- vegetation communities merge into one another in a more complex way than is suggested by the model;
- inaccuracies, however slight, occur in delineating the boundaries between the vegetation types and the SEFKRP plot locations.
- near pure stands of some overstorey species are not delineated within the vegetation communities.

In most instances the discrepancy between the vegetation model and the data recorded by the SEFKRP is between Vegetation Types 32 & 34 in Murrah SF. Since both these communities are included in the habitat model, the lack of correlation in these instances does not affect the outcome. Nevertheless this indicates that the areas modeled as Koala habitat can only be considered as a guide until more accurate and detailed vegetation maps become available. This has implications for future management strategies for this area.

4.2.5 GROWTH STAGE, STRUCTURAL AND TREE SIZE PREFERENCES

Of the eighty active sites located in the Murrah Bermagui Forests, **XXX** were in MAF areas. **XXX** were located in retained trees in areas that had been intensively logged. No active sites were found in young forest growing in these areas. Because the areas searched were stratified into MAF, RGF1 and RGF2 the results demonstrate a clear preference for MAF areas.

The Koalas' preference for larger trees is demonstrated in Table 5. The results also demonstrate that the use of larger trees is greater than their availability in RGF plots. Areas where Koala faecal pellets were found generally had less intensive disturbance, although small stems (A class) accounted for nearly 50 % of the stands in variable radius plots (see **Figure xxx**).

Table 5: Size Classes of Eucalypts with and without Koala faecal pellets in all active MAF plots

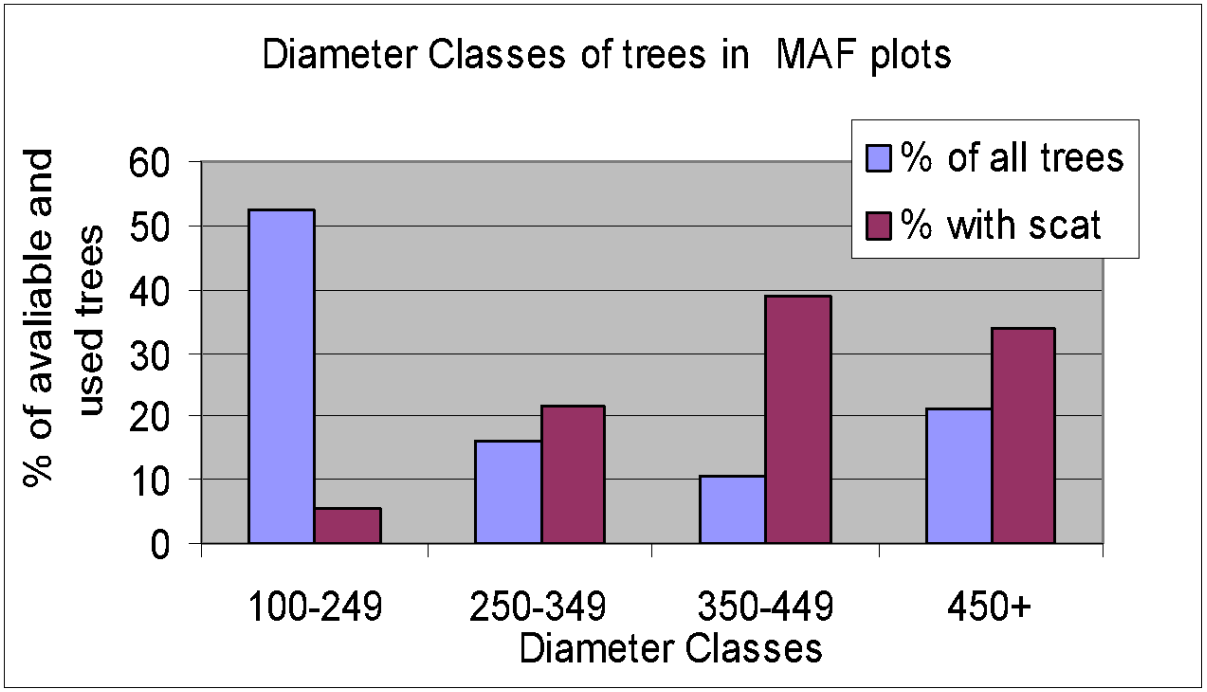


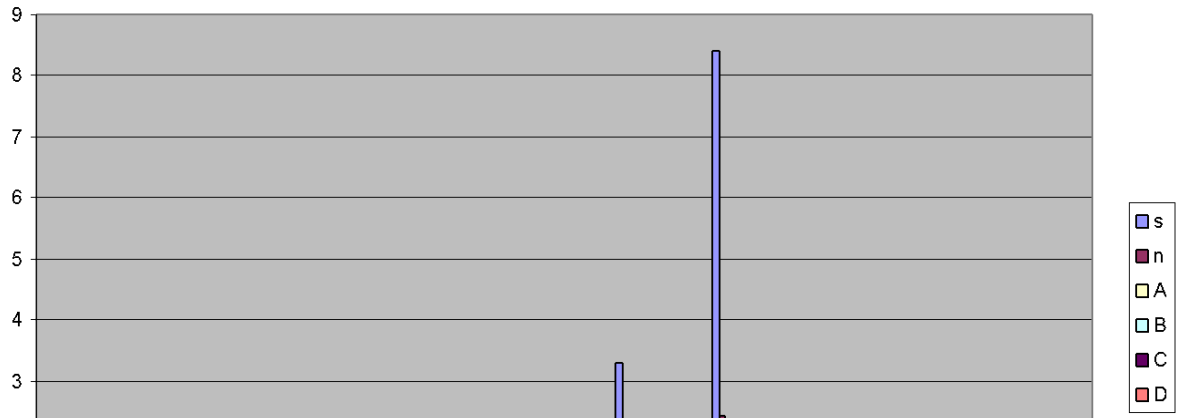
Table 5 indicates that preferred size classes (94% of trees with scat) represent less than half of the trees available in MAF plots. This proportion reflects the level of previous disturbance in coupes that have not yet undergone intensive logging.

In RGF areas there were significantly fewer large trees and a greater proportion of non -eucalypt species. The reduction in large trees of preferred browse species is more pronounced due to the bias in tree removal based on species.

Consideration of the 'A' and 'B' classes in RGF reveals that 57% of the 'A' class and 44% of the 'B' class stems are non-eucalypt species. In MAF plots, 52% of 'A' class and 25% of 'B' class are non-eucalypt species.

Non-eucalypt and *Allocasuarina littoralis* stems account for 76.5 % of the <50mm and 53 % of the 50-99mm classes in regrowth forests.

Table 5: % of Eucalypt Species, Stem Frequency and Size Distribution in RGF



A feature of the RGF data is the comparatively high frequency of *E. sieberi* in the retained and regrowth DBH classes, compared to other Eucalypts (See Table 2). The frequency of *E. sieberi* in small stems after intensive logging is illustrated in Figure 3, demonstrating that this species responds readily to disturbance.

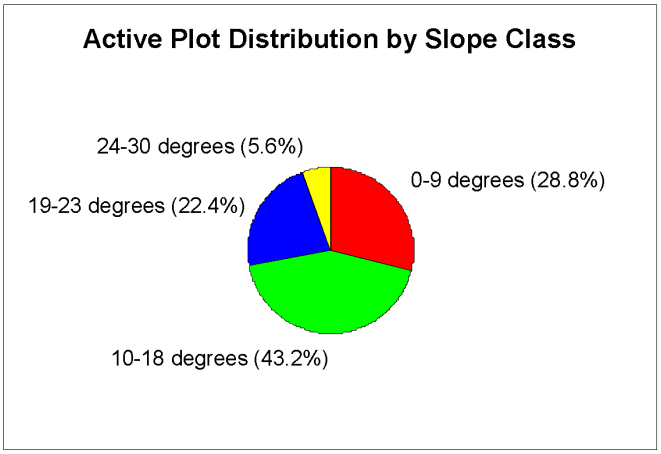
Table 6: Frequency (% occurrence in samples) of selected tree species in **MAF (all trees) and RGF (trees >250mm dbh) samples**

TREE SPECIES	MAF	RGF
Other Species TOTAL	67	76
E. cypellocarpa	21	21
E. elata	0	5
E. bosistoana	22	13
A. floribunda	29	32
E. globoidea	28	13
E. agglomerata	39	45
E. smithii	3	18
E. longifolia	82	63
E. tricarpa	59	42
E. muellerana	71	74
E. gummifera	32	8
E. maculata	4	0
E. paniculata	1	0
E. sieberi	32	58
A. littoralis	68	92

4.2.6 SLOPE CLASS PREFERENCES

The steepness of slopes on which active plots were located in the Bermagui/Murrah Forests is represented in the following pie chart. Slope is stratified into 5 classes. The steepest slope where an active plot has been located in the Murrah area is 26 degrees.

Figure X: Distribution of active plots according to slope class



4.2.7 ACTIVE SITES IN AREAS SUSTAINING BREEDING FEMALES IN THE BERMAGUI/MURRAH FORESTS

During the surveys undertaken in the Bermagui/Murrah area koala faecal pellets of consistently different sizes were located under trees in three geographically distinct areas. This evidence indicated that there were at least three female koalas with young in the area. No other evidence of breeding activity was found in any other area.

In a separate survey in February 1998, further searches for koala faecal pellets were undertaken in two of these breeding areas. In a search lasting 125 hours, 38 active sites were located. Thus the success rate in locating active sites in areas sustaining breeding females was more than twice that of locating them in other areas of the Murrah/Bermagui Forests.

4.3 DATA ANALYSIS FROM THE YURAMMIE/TANTAWANGALO FORESTS

4.31 TREE SPECIES PREFERENCES IN THE YURAMMIE/TANTAWANGALO FORESTS

TABLE

Table X: Tree species preferences in the Tantawangalo/Yurammie Forests

4.32 SURVEYS OF HABTAT FORMERLY SUSTAINING BREEDING AGGREGATE IN CENTRAL TANTAWANGALO

Several surveys were undertaken in an area in Cental Tantawangalo known to be sustaining a breeding aggregate of koalas, and where koala faecal pellets were relatively easy to locate (Jurskis et al 1994 and Allen in Cork et al 1995). The initial surveys were undertaken in November 1996. Four active sites were located, but all of these consisted of old koala faecal pellets. Two further surveys were undertaken in 1997 in the same area but no further active sites

were located. These results suggested that the breeding aggregate had disappeared from this area.

4.4 SURVEYS IN AREAS WHERE CALLBACK RESPONSES WERE RECORDED

220 hrs were spent sweep searching around sites reported by SFNSW as eliciting a response by a Koala during a SFNSW, Daishowa and NPWS regional taped call playback survey (unpublished data, 1997). These sites were in Nadgee, Nullica, Coolangubra, Bournda (west), Brogo, Mumbulla, Murrabrine, Narira Creek and Murrah. One (1) active site was found in Murrah SF (see Appendix 2).

5 BACKGROUND TO DATA ANALYSES

Background information on the following is provided to assist the discussion on the data presented in the previous section:

- The socio-biology of koalas;
- The habitat definitions and food tree categories and used by the Australian Koala Foundation;
- the vegetation model used in the Comprehensive Regional Assessment Process;

5.1 THE SOCIOBIOLOGY OF KOALAS

Jurskis and Potter (1997) consider that a study focusing on a Koala population is merely a study focusing on many individuals. This conclusion seems at odd with other studies. For example, Mitchell (1991) concluded that breeding aggregates of Koalas establish highly complex societies that delineate a matrix of home range areas. Lee and Martin (1988) and Mitchell (1991) concluded that, at the aggregation level, social cohesion is maintained through a complex interaction of tree usage, scent marking, vocalisations and other antagonistic/ idiosyncratic behaviour patterns. Phillips (submitted A) concludes that a stable breeding population will comprise an "aggregation" or "cluster" of Koalas that is presided over by an alpha male. Associated with this male are 2-4 females, along with juveniles and/or sub-adult Koalas of varying ages and levels of dependency.

The alpha male and breeding females maintain long-term and probably life-long fidelity to their respective home range areas Krockenberger (1993). Phillips (submitted B) reported a dramatic decline in Koala numbers at Tucki Nature Reserve following social dislocation brought about by a translocation program. Over twenty years later, the population has not recovered. He concluded that the ad hoc destruction and/or modification of habitat in areas that once supported breeding populations could precipitate the same effect.

An understanding of the above socio-biological factors and vulnerability that koala societies have to impacts that reduce numbers or destroy habitat will help accurately evaluate the current status of koalas in the region.

5.2 HABITAT AND FOOD TREE CATEGORIES

The Australian Koala Foundation Koala Habitat Atlas is based on the following food tree categories (Phillips and Callaghan submitted):

Primary food tree

A tree species that returns a statistically significant "strike rate" of approximately 50% or greater when compared to other congeners on the basis of a random and stratified sampling protocol, and which demonstrates a level of utilisation which can also be shown to be independent of, but commensurate with density.

Secondary food tree

A tree species that returns a "strike rate" which is generally less than 50% but which is significantly higher when compared to other congeners on the basis of a random and

stratified sampling protocol, and which demonstrates a level of utilisation which is clearly density dependent.

Supplementary food tree

A tree species that similarly returns a "strike rate" of less than 50% and cannot be necessarily isolated as the subject of significantly higher levels of utilisation, when compared to other congeners, on the basis of a random and stratified sampling protocol and which similarly demonstrates a density dependent level of utilisation.

From these definitions the AKF employs the following habitat categories.

Primary habitat

Floristic alliances and/or associations wherein primary food tree species for Koalas comprise greater than or equal to 50% of the dominant overstorey tree species.

Secondary habitat

a) *Floristic alliances and/or associations wherein primary food trees comprise, on average, significantly less than 50% but generally more than 30% of the dominant overstorey tree species; or*

b) *recognisable floristic alliances and or associations wherein, on average, primary food trees comprise less than 10% of the dominant overstorey tree species; and recognisable floristic alliances and or associations wherein the presence of secondary food species plus supplementary food species together comprise 30% or greater of the dominant overstorey tree species; (Primary food tree species absent).*

Marginal habitat

Recognisable floristic alliances and or associations wherein secondary plus supplementary food species together comprise significantly less than 30% of the dominant overstorey species.

Using the above categories the data gathered from all the active sites in the region indicates that the koalas studies are only accessing secondary and supplementary species in secondary habitat.

5.3 VEGETATION MODEL USED IN THE CRA

5.4 REGIONAL KOALA HABITAT MODEL FOR THE CRA

6. DISCUSSION

6.1 REGIONAL DISTRIBUTION

With the Murrah/Bermagui results the South East Forests Koala Research Project staff have proved their ability to locate evidence of Koalas consistently and relatively quickly where there is a breeding aggregate and that they are also able to locate evidence of breeding females if they are present. No other area has yielded comparable results.

The only other area where the survey results confirm that Koalas are persisting in the region is in the Tantawangalo/Yurammie area. These confirm the results in Lunney et al (1997) that these two areas are the most significant for koalas known in the region.

However, the failure to locate evidence of breeding females in this latter area and, the apparent local extinction of the breeding aggregate in Central Tantawangalo, suggests a significant population decline in this area. This is particularly as Braithwaite (1983) states that koalas were "*repeatedly reported*" in this area before and during intensive logging operations that were

undertaken in 1979. The Yurammie Forest was the only area where his region-wide surveys found evidence of koalas, although these did not extend as far as Bermagui/Murrah.

One method for estimating population size is to calculate and average the home range sizes for koalas provided by Jurskis and Shields (1996) and overlay this with the known koala area in the Murrah. Excluding the dispersing young male who covered an area of over 2000 ha, the average home ranges (MCP) of the koalas studied by Jurskis and Shields (1995) is 270ha. The area in which the majority of faecal pellets have so far been found in the Murrah covers approximately 5000 ha. Assuming minimal overlap (as was also found by Jurskis and Shields1996) this would give a population of between 15 and 20 animals.

Even if the home range sizes in this area were smaller that those calculated by Jurskis and Shields (1996), it is difficult to believe that more than twenty koalas remain there. This particularly as much of this area has been subjected to intensive logging and now contains densely-stocked stands of young regrowth and extensive areas of bellbird-infested dieback, both of which are avoided by koalas.

A credible and reasonable interpretation of the available information and scattered nature of Koala records is that although there could be other breeding aggregates it is highly unlikely that a population the size of that in the Murrah could have escaped detection. This is particularly given the level of public interest and the amount of fauna research and surveys that have been undertaken in the region. More likely, if any do persist they would probably number no more than just a few animals. It is therefore the conclusion of staff from the SEFKRP that probably no more than 50 koalas remain in the region. This conclusion differs from population estimates of over 1000 animals that have been provided by SFNSW staff (Jurskis and Potter 1997 and Shields 1997).

6.2 HABITAT PREFERENCES FROM MURRAH/BERMAGUI FORESTS

6.2.1 PREFERENCE FOR MATURE TREES

The Koala's preference for larger trees is revealed in the Murrah/Bermagui data. This is also demonstrated in data provided by the SFNSW radio-tracking study (Jurskis and Shields 1995). This preference has also been found in other koala areas (Hindell 1984, Martin 1989, Melzer 1995 and Hasegwa 1995).

6.2.2 PREFERENCE FOR MULTI-AGED FORESTS

The higher number of active sites found in multi-aged forests in the Bermagui/Murrah area demonstrate that the koalas in this area have a preference for the areas that have not suffered intense impacts from either from fire and intensive logging.

6.2.3 DENSITY DEPENDENT LEVELS OF USE

The levels of use of secondary and supplementary food trees, *E. cypellocarpa*, *E. longifolia*, *E. globoidea* and *E. muelleriana* were strongly density dependent. This means that the "strike rate" for individual species was inversely related to the number of trees of that particular species present at the site. This same pattern has been noted in a similar study of the low density koala population in Cambelltown (Phillips and Callaghan 1997) and indeed appears to be the pattern of use of secondary and supplementary species across the Koala's range.

This is not the case for primary food trees, which are utilised independently of their density. This suggests that in areas where they do not have access to primary feed trees, susch as now appears to be the case in the region, Koalas are consistently highly selective of the trees that they feed in. The large home range sizes of the radio-tracked Koalas described by Jurskis and Potter (1997) could, in part, be a consequence of this feeding requirement.

The reasons for this pattern of use of secondary and supplementary food trees are not known. A range of factors may determine the palatability of browse for Koalas. This includes:

- the impact of site (particularly soil moisture and fertility) conditions on individual trees;
- the Koalas' need to feed sparingly from a variety of tree species over a short period of time because of the nutritional contents of the foliage;
- the eucalypt communities' phenological patterns within the animal's home range;
- allopathic factors;
- other factors yet to be combinations of some or all of the above.

Since it is thought that Koalas rarely select the same tree (Jurskis and Potter 1997) and given the parlous state of knowledge of the dietary requirements of Koalas, it is not possible to predict which and when individual trees will provide suitable browse.

6.2.4 TREE SPECIES DIVERSITY IN KOALA HABITAT

The data collected to date by the SEFKRP demonstrates that other tree species are sustaining the Koalas in the study area, particularly the larger trees. For example, *E agglomerata,* blue-leafed stringybark, had a strike rate of more than 25% in trees that were over 400dbh.

Landsberg and Cork (1997) state that the potentially regular availability of young foliage may help to explain why eucalypt forests are inhabited by Koalas. They refer to the work of Davey (1994) and Kavanagh (1994) which concluded that all folivorous marsupials prefer young foliage when it is available.

Whilst it is clear from the SEFKRP data that this does not mean the foliage of young trees, it may be that the diversity of eucalypt species producing young foliage over an extended period is a key factor in the Koala's ability to survive and breed in the region. Data generated by the CRA (NPWS 1998) suggests that the Bermagui/Murrah area, probably because of its more favourable growing conditions and eucalypt diversity, has the most extended period of flowering times for eucalypts in the region.

6.2.5 TREE SPECIES CHANGES IN REGROWTH AREAS

The Bermagui/Murrah data revealed a significant change in species composition in areas that had been intensively logged. In particular *Eucalyptus sieberi* and *Allocasuarina littoralis* were favoured by intensive logging. Neither of these are Koala browse species.

These results are supported by other referenced material: Kirkpatrick *et al*. (1991, cited Norton, 1997) concluded that changes in environmental conditions following forestry activities in eucalypt forests used for wood production in south east NSW and East Gippsland, (Victoria) resulted in *Eucalyptus sieberi* becoming widespread and dominant in many areas that it would not normally occupy. Mosley and Costin (1992) describe *E. sieberi* as a prolific seeder and colonising species that is encouraged by logging and burning to extend from its ridgetop position, down-slope to areas occupied by moister mixed species forests. They conclude that the spread of this species pose

Should the predominance of *E. sieberi* persist to maturity, significant changes in the over-storey diversity will have occurred. The frequency of *E. sieberi* in the > 450 mm class retained after logging was found to be twice that of other species suitable for pulp in RGF plots.

The large proportion of *Allocasuarina littoralis* stems in RGF plots (58.3% of stems to 249 mm DBHob) presents major problems in terms of rehabilitative strategies necessary for the implementation of a Koala recovery plan. The *Allocasuarina* genus may positively affect the growth of eucalypts due to its ability to fix nitrogen in the soil (Attiwill and Leeper, 1987). In some circumstances, however, it interacts with eucalypts in a manner that causes the latter's depletion or local extinction. During the 1983 drought in south-eastern Tasmania, *Allocasuarina*

verticillata was the tree species that exhibited the least damage and mortality (Kirkpatrick and Marks,1985). During this and subsequent droughts, there was considerable mortality of eucalypts where they occurred as an overstorey in low closed forest to *Allocasuarina verticillata*. Before an intense fire in 1967, some areas that were grassy woodland dominated by eucalypts are now (1995) *Allocasuarina verticillata,* as a result of subsequent fire and eucalypt dieback.

The proportion of retained species unsuitable for pulp production (*E. longifolia, E. tricarpa, E. gumifera, E. bosistoana*) is generally higher than pulp species in RGF. The saplings of these slow growing hard and/or red timbers could suffer from the effects of competition from the faster growing species, potentially increasing mortality rates for these species.

6.2.6 GROWTH RATES IN REGROWTH AREAS

The growth rates of the various tree species in the EMA are largely unknown. This is because the long-term research required to validate the modelled growth of trees resulting from intensive logging is not available or has not been undertaken. For the CRA the modelled growth rates of *E. sieberi* trees resulting from wildfire have been used.

There is no information on the growth rates of species found to be preferred by Koala in the EMA.

The data provided by SFNSW for the CRA on growth rates for trees in the EMA has been compared to permanent growth plot (PGP) data from the rest of NSW (G. Hall, FRAMES Technical Committee, 1997). The comparison revealed that the modelled growth rates for the EMA are more than twice that of the PGP growth rates for the rest of NSW State forests. It should be noted that the PGP's in northern NSW are "*located in better quality eucalypt stands*" (Carter, 1994).

6.3 IMPLICATIONS FROM THE TANTAWANGALO/YURAMMIE DATA

6.4 DEVELOPING A ROBUST MODEL OF KOALA HABITAT

The CRA vegetation model was not intended to map the distribution of particular tree species. Rather its intention was to map those communities in which particular plant communities are well represented. Although the fieldwork required to map the distribution of these species is probably not feasible, trials are planned by the AKF for fine-scale remote sensing in an attempt to delineate the individual spectral image of tree species.

6.5 DISCUSSION SUMMARY

The availability of suitable browse profoundly influences the distribution and ranging patterns of Koalas. At the same time, the need for contact and interaction with other Koalas is also a determinant of these patterns.

THe reduction in preferred tree species in the preferred size classes after intensive logging has a significant impact on the amount of browse available. It is probable that Koalas would need to extend the area of their home- ranges after this degree of disturbance. This may force them into the home ranges of other Koalas and potentially disrupt the social cohesiveness of the population.

The additional demands placed on female Koalas in degraded habitat may impact on the health of adult and young. The fecundity of female Koalas may also be adversely influenced by degraded habitat.

Eucalypt species with the greatest stem frequency in regrowth plots are not, with the exception of *E. muelleriana*, preferred species. Their predominance reflects the intent of management to encourage the regeneration of species suitable for pulp production.

Although the occurrence of E. *longifolia* (as retained trees) in regrowth forest is comparable to the Vegetation typing (see Table 1), after disturbance, this and other preferred species do not, appear to be regenerating with the same frequency as non - preferred species.

The impact of disturbance on the distribution of eucalypt species requires more research to determine the potential suitability of regrowth areas to provide habitat for Koalas.

The fieldwork undertaken for this project has provided a data base that far exceeds that of any other Koala area in SENSW and provides the necessary inputs for a habitat model for Koalas in these forests. The research data demonstrates that Koalas benefit from diversity of tree species, larger trees, moderate slopes and minimally disturbed habitat.

The potential changes to overstorey species identified during the research highlight the imperative for forest management regimes that are capable of responding to the habitat requirements of Koalas. The future management of these forests will be integral to the continued survival of this Koala population.

Further research is needed to establish the following:

- home ranges, particularly of breeding females
- population, fecundity and mortality
- genetic status
- factors influencing the selection of specific feed trees
- socio-biology - how the population interacts across the landscape
- the long-term potential of regrowth areas as Koala habitat
- habitat loss due to dieback, clearing and development.

The South East Forests Koala Research Project is establishing the framework for this in conjunction with the Australian Koala Foundation. A priority for ongoing work is detailed and accurate vegetation mapping.

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