The Koala Habitat Atlas

Project No 6: Port Stephens Local Government Area

Draft Report

Prepared for Port Stephens Council

by

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CONTENTS

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EXECUTIVE SUMMARY

An assessment of tree preferences and habitat utilisation by Koalas was conducted in the Port Stephens Local Government Area over the period November, 1994 to March, 1996. A total of 8,764 trees comprising 5,419 eucalypt and 3,345 non-eucalypt trees from 96 primary plot sites and 14 supplementary quadrats were assessed during the study.

Habitat utilisation parameters and tree species preferences from a Koala's perspective were determined on the basis of a comparative analysis of the summed proportional strike rates for each of the tree species sampled according to their respective occurrence on each of the main geomorphological units recognised for the purposes of the study. The results have established that three species of eucalypt namely Forest Red Gum *Eucalyptus tereticornis*, Swamp Mahogany *E. robusta* and Drooping Red Gum *E. parramattensis* (including the sub species *E. parramattensis decadens*) are currently the subject of preferential utilisation by Koalas in the study area. Preferential utilisation of Swamp Mahogany and Drooping Red Gum occurs on Aeolian and Swamp soil landscapes of Quaternary origin, whereas preferential utilisation of Forest Red Gum appears restricted to erosional soil landscapes associated with the Nerong and Patterson Volcanics and Transferral and alluvial deposits of both Quaternary and Permian origin respectively. Significant levels of use of the Broad-leafed Paperbark *Melaleuca quinquinervia* also occur when this species is growing in association with or in close proximity to areas containing the preferentially utilised species.

High levels of use of other species of eucalypt in the study area can be shown to be a phenomena associated with the presence of either one or all of the preferentially utilised species. Elsewhere in the study area habitat relationships remain speculative and could not be accurately ascertained due to a paucity of koala activity indicators, a phenomena best demonstrated by the number of inactive sites containing Tallowwood, a species which can otherwise be shown to be the subject of preferential utilisation by Koalas throughout its range in NSW regardless of soil type. Historical research supports a conclusion reached by field based assessments and extensive foot based traverses of the study area that the Port Stephens Koala population is diminished to the extent that it is now largely confined to discrete areas on the Tilligerry Peninsula and associated areas of the Tomago sandbeds containing the preferentially utilised tree species and their associated communities; even within this area there are areas of both primary and secondary habitat which no longer support extant Koala populations.

Based on a speculative but considered estimate of a total population for the study area of between 350 and 500 animals, the remaining Koala population/s of the study area are clearly endangered and the "effective" population size is rapidly approaching the minimum required to afford the population a guaranteed measure of long term survival, more so given the consequences of recent detrimental impacts including

fires and the clearing of significant areas of primary and secondary habitat for the purposes of sand mining and urban expansion.

Notwithstanding the statutory protection afforded the Koala by the *National Parks and Wildlife Act 1974*, *State Environmental Planning Policy No. 44 (Koala Habitat Protection)* and more recently the *Threatened Species Conservation Act 1995,* the study concludes that, realistically, the long term conservation and management of the population inhabiting the study area is largely in the hands of Local Government and the community. Threats to the continued survival of the koala population in the study area are numerous and include wildfire, the ongoing loss of habitat for agriculture, urban expansion and sand mining purposes, predation by domestic and feral animals, and excessive mortalities brought about by motor vehicles. These issues in turn exacerbate the potential for otherwise benign, stress dependent pathogens such as *Chlamydia spp* to further contribute to population decline.

In order to address these issues a number of measures are urgently recommended to give some effect to the implications that arise from this study. Such recommendations include *inter alia,* an immediate moratorium on the further destruction and modification of primary and secondary habitat areas, the recognition and establishment of urban koala management zones with appropriate controls on motor vehicle speeds and the keeping of domestic dogs and legal sureties to enforce proposed Tree Preservation Orders and Covenants. Major reviews of the existing Local Environmental Plan and Development Control Plans relating to current and proposed urban developments in the study area are also recommended, as is a program to re-establish breeding aggregations of Koalas in areas of otherwise potentially suitable habitat west of the Pacific Highway.

1.0 INTRODUCTION

1.1 Habitat Utilisation by Koalas

The Koala *Phascolarctos cinereus* is an obligate folivore which feeds primarily on the genus *Eucalyptus*. Throughout its range in eastern and south-eastern Australia, the species has been recorded as utilising a wide variety of eucalypt and non-eucalypt species (Murray, 1988; Hindell & Lee, 1990; Phillips, 1990). While these accounts tend to portray Koalas as opportunistic feeders, within a particular area from one to three species of eucalypt will be regularly utilised (primary use trees) while a variety of other species, including some non-eucalypts, appear to be utilised opportunistically for feeding or other behavioural purposes (Hindell & Lee, 1991; Phillips, 1990). Edaphic characteristics are also considered to further influence the suitability of several important browse species (Cork, 1992).

In a socially stable population, individual Koalas have overlapping home range areas. Within each animal's home range area are a disproportionately small number of trees that are visited repeatedly

(Eberhard, 1972; Faulks, 1990; Mitchell, 1990; Phillips, unpub data). Fidelity to the home range area by the constituent Koalas is long term and can extend over many years (Lee & Martin, 1988; Mitchell, 1990; Mitchell and Martin, 1990). Increasing evidence provided from the records of local Koala welfare groups further suggests that, in the absence of undue disturbance, such fidelity within the framework of a stable breeding aggregation may extend for the term of the resident Koala's lifespan.

The home range areas required by Koalas vary in response to social factors and habitat quality. The sex of the animal is also important. Female Koalas tend to occupy smaller home range areas than males. While this may be a function of the significantly larger body size of male Koalas generally, it is also typical of a polygynous social structure wherein the home ranges of breeding males overlap those of several adult females.

The relatively sedentary and localised movements of Koalas in a socially stable breeding aggregation are a stark contrast to the movements of dispersing sub adults (of both sexes) and other transient members of Koala society. These animals, often surplus males, tend to maintain ephemeral home ranges and are capable of movements in excess of 40-50km (Phillips, unpub data). Breeding activity usually initiates the dispersal phase of sub-adults. Clearly, the movements and survivorship of dispersing sub-adults and other nomadic members of Koala society are significant within the context of maintaining recruitment levels and genetic vigour in otherwise clustered and spatially segregated breeding aggregations.

Apart from the more widely known problems associated with the presence of endemic Chlamydial organisms in free ranging koala populations, the problems facing wild Koalas have not been documented to the same extent as those resulting from studies of disturbed or intensively managed populations. While pathogens such as *Chlamydia spp* are an important component of the Koala's natural history and clearly play a role in the natural regulation of undisturbed populations, increasingly fire and activities such as logging and sand mining can be shown to be having a significant impact on Koala populations, particularly where food tree species are being effected. Wildfire can potentially result in mortality as high as 60-70% of an area's breeding population, with recovery dependant upon factors such as the size and composition of the remaining population, recruitment levels from adjoining populations and the subsequent frequency and intensity of further fire. Additionally, activities such as logging, sand mining, clearing for agriculture and urban development can contribute to social instability through the removal of home range trees in the first instance, and nutritional stress through the removal of important browse species in the second. Both of these factors contribute to social disolution, a reduced reproductive potential, increased susceptibility to disease and population decline. In an urban environment, Koalas are known to face elevated threats associated with domestic dog attack and road mortality. In addition, predation by feral animals, particularly dogs and foxes, is increasingly being recognised as a significant issue affecting the conservation and management of Koala populations occupying rural, semi-rural and bushland areas.

The management of free ranging Koala populations is problematical. Despite legislation promulgated to provide protection for Koalas and other Australian wildlife, Koala populations in New South Wales at least, are continuing to decline (Reed & Lunney, 1990). Nor is there any evidence, with the possible exception of some island populations in Victoria and South Australia, to support a contention that the decline is not more widespread. In reality, the effective conservation and management of Koalas in association with urban, agricultural and silvicultural activities, requires more than simply protecting what are believed to be the "right" trees, ensuring the retention of a few arbitrarily selected food trees, or plantings to compensate for the removal of more mature trees. Inevitably, the lack of any realistic assessment and consideration of the needs of Koala populations leads to a gradual decline in Koala numbers to the point where localised extinctions are often the end result (Smith & Smith, 1990; Phillips, 1991). The ability of Koala populations to apparently sustain themselves following a deleterious impact is more a reflection of the species relative longevity than it is any other factor, a contention most recently incidentally recorded by Lunney and Moon (1993) in their recording of localised extinctions occurring up to 16 years after habitat alienation in the Coffs Harbour area for the purposes of urban expansion.

There is little doubt that broadacre clearing and wholesale destruction of Koala habitat, together with the *ad hoc* removal of trees which otherwise allow Koala populations to maintain their social stability and nutritional well being, are the most important factors contributing to declining Koala populations in many areas.

1.2 Description of the Study Area

Location

Port Stephens is located approximately 200 kilometres north of Sydney on the mid north coast of New South Wales (Figure 1) and is bounded by the latitudes 32^0 35’ and 32^0 50’ south and longitudes 151^0 30’ and 152 ^{0} 30’ east. The Port Stephens Local Government Area (the study area) covers a total area of just over 97,000 ha. The Pacific Highway bisects the study area, passing through the towns of Raymond Terrace and Karuah. Urban areas located on the southern shoreline of Port Stephens include Nelson Bay, Shoal Bay, Fingal Beach, Corlette, Salamander Bay, Lemon Tree Passage and Soldier’s Point, all of which are popular tourist destinations. A significant proportion of the study area includes the Hunter Water Board’s Tomago Catchment area which extends from Tomago to Port Stephens in the north-east. Away from the coast, rural and forestry activities constitute significant landuses.

Climatic Conditions

Annual rainfall in the Port Stephens area averages 1,325 mm annually at the Nelson Bay RSL Weather Station. Rain occurs throughout the year without a great degree of seasonality. Average monthly rainfall may range from 125 mm in January to slightly over 50 mm in September. Average annual temperature typically ranges in Port Stephens from 7^{o} C to 28^{o} C. Peak temperatures ($15\ ^{o}$ - 25^{o} C) tend to occur from December through February, and low temperatures (7^{o} - 20^{o} C) from June to August. Typically, daily temperature fluctuate approximately 10^{o} C within any given 24 hour period.

Topography and Geomorphology

The landscape of the Port Stephens Shire is quite unique, consisting of the water body itself, extensive estuaries and dune systems, volcanic outcroppings and a large rural hinterland. A significant and highly visible component of the geomorphological attributes in the easternmost area of the Shire are undulous, shifting sand dunes along the coastline, the outer barrier dunes typically ranging from 15 to 30 m in height (Croft, 1982; Wilks, 1989).

The following five physiographic regions have been identified by the a recent Soil Conservation Service Report provided to Port Stephens Council.

The **Coweambah Hills** consist of gentle undulations to steep low hills on Carboniferous sediments and volcanics to the north. The gentler slopes have usually been cleared for agricultural purposes and the steeper slopes are typically managed as hardwood forests. Major soil types include Yellow and Red Podzols on the slopes, and Bleached Loams along drainage plains. The **Medowie Lowlands** occur on estuarine plains, broad footslopes, and smaller areas of alluvium, and have Soloth as the major soil type. The **Tomago Coastal Plain** occurs along the coastal strip, and consists predominantly of Quaternary Sands supporting a relatively diverse pattern of vegetation communities ranging from dry and open eucalypt forest and tall dry heath to swamp and wetlands (Wilks, 1989). The **Karuah Mountains** are steep hills from 100 to 260 m ASL, on Nerong Volcanics. The **Nerong Hills** are a complex array of steep hills on Carboniferous and Permian soil types.

Tall open forests are typically found in the physiographic regions of the Nerong Hills and Coweambah Hills. While the Nerong Hills remain predominantly uncleared or are being managed for their timber resource, the Coweambah Hills have been extensively cleared for grazing. The volcanic Karuah Hills consist of predominantly uncleared open forest or woodland with a shrubby understory. The Medowie Lowlands are predominantly cleared with occasional areas of tall open forest or woodland with a shrub understory.

Port Stephens was identified as one of the richest Koala sites in New South Wales in a 1986-87 survey which otherwise concluded that "....the Koala population in New South Wales has suffered major contraction of range since European settlement and will contract further as remaining localities continue to be modified by land clearing, fire, continued stocking and urban expansion" (Reed *et al*, 1990). In recognition of the area's perceived importance, in 1990, preparation of a Koala Management Plan was initiated jointly by the NSW National Parks and Wildlife Service, Port Stephens Council and the Hunter Koala Preservation Society. To this end a Draft Plan of Management was subsequently placed on Public exhibition in September, 1994. Following the catastrophic 1994 bushfire season and in response to increasing national and international concern about the welfare of the Port Stephens Koala population, the

Australian Koala Foundation resolved to prepare a Koala Habitat Atlas for the Port Stephens Local Government Area.

1.3 Study Objectives

The Port Stephens Shire has long been recognised as a significant area for Koalas and is a focus of attention for Port Stephens City Council's strategic planning. The Australian Koala Foundation has undertaken this study for the Port Stephens City Council in accordance with the following objectives:

a) to quantify tree preferences and habitat utilisation;
b) to delineate areas of Primary and Secondary Koala Habitat;
c) to examine the relationship of this information in terms of SEPP No. 44;
d) to identify threatening processes; and
e) to recommend measures to provide Koala populations with a measure of long term viability.

2.0 METHODOLOGY

2.1 Assessment of Habitat Utilisation by Koalas in the Study Area

Habitat utilisation and tree preferences of Koalas in the study area were assessed using a plot based methodology developed by the Australian Koala Foundation for the purposes of the Koala Habitat Atlas Project. Plot selection in accordance with the methodology is stratified and essentially random but influenced by the need to sample the range of edaphic and floristic variables in a given study area to the fullest extent possible and to ensure that corresponding data sets are compiled for each tree species; this latter consideration in particular inevitably leads to the introduction of some bias as sampling proceeds over the longer term.

2.2 Site Selection

The study area was originally sudivided into its respective geomorphologial units. These areas were overlain with a 1:25000 vegetation map of the study area which had earlier been prepared by Envirosciences Pty Ltd for the purposes of the Port Stephens Draft Koala Management Plan. Within the floristic boundaries so delineated, plot localities were determined using a 50m grid based numerical overlay with independently generated random numbers used to determine plot location. The resulting site co-ordinates were then transferred to GPS units to assist their location in the field. Independent replicates for each of the identified vegetation associations occurring on each particular geomorphological unit were also generated to permit statistical analysis of the results.

Statistical validation of data sets requires a minimum data set for each tree species, a consideration which further influences the number of required plot sites, dependent upon the density of that species within plots targeted to sample that species. Plot sites were dispersed as widely as possible over the distribution of each vegetation association on each substrate throughout the study area. To reduce the risk of survey data being significantly influenced by edge effects, wherever possible, field plots were excluded from sites adjacent to major habitat disturbances such as recent bushfire, urban development and/or major roads.

2.3 Assessment of Field Sites

Once located in the field, establishment of each 40m x 40m primary field site involved using a compass, measuring tape and flagging tape to designate the corners of four 20m by 20m quadrats on the basis of bearings along each of the four cardinal compass points (North, South, East and West) from a central reference point. The central reference point served as a corner for each of the four quadrats which were then given an alphabetical designation A, B, C and D in a clockwise direction with "A" always being located in the north-western quadrat. Data from each respective quadrat was recorded in corresponding columns of a specific Koala Habitat Atlas Site Recording Form. Supplementary field sites, normally in the form of a circle with a minimum radius of 10m, were also employed to gather additional data using the criteria of Phillips and Callaghan (1995).

The aspect (in degrees) from the approximate centre of each 20m X 20m quadrat was recorded and every tree with a diameter at breast height (DBH) of 100mm or greater was marked with flagging tape to be later removed as each tree was assessed.

Tree species were recorded using a four letter code based on the first initial of the Genus name and the first three initials of the species name. For the purposes of the Atlas methodology a "tree" was defined as: *"a live woody stem of any plant species (excepting palms, cycads, tree-ferns and grass-trees) which has a diameter at breast height (dbh) of 100 mm or greater".*

The diameter at breast height was measured and the base carefully inspected for the presence of Koala faecal pellets. All Koala faecal pellets falling within a circle of radius 100cm from any point at the base of each tree were counted and the total number recorded. If the tree species identity was not known it was recorded as such but still assessed using the protocol prescribed by this methodology. However, flagging tape was not removed in order that the tree could be found again if necessary; leaf samples, seed capsules and/or flowers or fruits along with a general description of the tree were also collected to enable the plant's taxonomic identity to be ascertained.

The faecal pellet count was initiated with a precursory inspection of the area described above followed by a more thorough inspection of the substrate; including disturbance of leaf litter and any ground cover. Approximately two person minutes were devoted to the faecal pellet search at each tree. Once counted and recorded, all pellets were replaced at the base of the tree. Where the distribution of pellets fell within the search catchments of two or more trees the above protocol was applied to the extent that the total number of pellets within a 100cm radius of each tree were recorded independently.

2.4 Data Analysis

"Active" and "Non-Active" Sites

To avoid biasing results where the recorded absence of faecal pellets was possibly a consequence of historical factors rather than poor Koala habitat quality *per se*, field plots were initially categorised as either "active" or "non-active" sites on the basis of whether koala faecal pellets were present (active) or absent (non-active). Only "active" plots from each of the major geomorphological units were considered for analysis purposes.

Faecal Pellet Counts, Strike Rates and Activity Levels

The range, mean, standard deviation and median score associated with the faecal pellet counts were calculated from all trees in the study area which had one or more faecal pellets recorded beneath them and for both "eucalypt" and "non-eucalypt" categories.

For the purposes of subsequent analyses no further consideration was given to the total number of faecal pellets beneath any tree, rather they were considered to be either present or absent, thereby transforming the results into enumerative data. For each tree species a proportional "strike rate" was determined based on the number of individual trees which had one or more Koala faecal pellets recorded beneath them, divided by the total number of trees of that species recorded in the respective plot. Strike rates for each species were then summed for each active plot and pooled for each of the geomorphological units being assessed.

Activity levels for each plot were expressed as a percentage equivalent of the quotient derived by dividing the total number of trees (of all species) which had one or more faecal pellets beneath them by the total number of trees (of all species) in the plot.

Tree Preferences and Habitat Utilisation

Tree species preferences and habitat utilisation considerations were determined from a pooled and comparative analysis of the results from all "active" plots. In this regard, data sets for each of the tree species within a given geomorphological/floristic unit were only regarded as valid for assessment purposes when:

a) the data set had been obtained from at least 7 independent but otherwise "active" sites;

b) np (the number of trees of a particular species multiplied by the proportion of those trees observed with one or more faecal pellets beneath them) and $n(1-p)$ were both at least as large as 5; and

c) the calculation of 95% Confidence Limits for the estimate were between 1% and 20% of the sample estimate so obtained, the level of rigour being determined by the estimated strike rate for the species being assessed (Figure 2).

Figure 2. Level of sampling rigour (upper bar equals plus/minus 20%, 10%, 1%) applied in response to both low and high strike rates respectively to demonstrate significant deviations from a normal approximation.

Analyses of the results from field work involved both parametric and non-parametric procedures. Due to differences in sample size, the extent of variation amongst the ranked strike rates for eucalypt and non-eucalypt data sets respectively were assessed using Krusskal-Wallis 1-way Anova's with the *Z* statistic derived from one-tailed Mann Whitney U - Wilcoxon Rank-sum Tests used to test indications of preferential utilisation between species. Chi-square tests were used to test for significant differences between the summed proportional strike rate for each species on a plot by plot basis, strike rates for each species being pooled whenever the expected frequency (F) in any given plot was less than 5; continuity corrections were applied in all cases where one degree of freedom resulted from aspects of the analytical process.

The potential for relationships to exist between the levels of use by Koalas and the density of tree species subsequently shown to be the subject of preferential utilisation were examined in the first instance by Spearman's Rank Correlation Procedure, with evidence of significant relationships further examined using selected components of multiple regression analysis. T-tests were also utilised to examine *post hoc* relationships between activity levels and the presence of tree species subsequently determined by those procedures detailed above to be the subject of preferentially utilisation by koalas.

All statistical analyses utilised followed protocols and procedures detailed by Dunn (1964), Bhattacharya & Johnson (1977) and Berenson *et al* (1988) and were largely undertaken using SPSS 6.1 software.

2.5 Compilation of Attribute Layers for Modelling Purposes

Spatial data comprising vector based and discrete cell maps relating to relevant physio-geographic and botanical components of the the study area were compiled on Hewlett Packard Apollo Workstations running Genamap 6.2 and related software. Data layers were geo-referenced to real world co-ordinates and rasterised to 25m pixels for analysis purposes. Habitat parameters were defined on the basis of density weighted attributes relating to the presence of the preferentially utilised tree species within their associated communities, the latter determined from data derived from the field based plots and from field notes accompanying the vegetation map. These attributes were then intersected with underlying soil landscape data and associated geological attributes which were then modelled across the entire study area.

Attribute	**Scale**	**Source**	**Accuracy(est)**
Geology	1:250000	DMR	80% (50-100m)
Soil Landscapes	1:100000	DLWC	Unknown
Vegetation	1:25000	AKF	85-90%
Contours	n.a.	LIC	10m.
Drainage	n.a.	LIC	10m.
Cultural	n.a.	LIC	10m.

Table 1: Attribute layers assembled for modelling purposes (DMR = Dept. Mineral Resources; DLWC = Dept. of Land & Water Conservation; AKF = Australian Koala Foundation; LIC = Land Information Centre; n.a. = not applicable).

2.6 Vegetation Mapping

Accurate vegetation mapping was considered to be the most critical component of the data layers required for modelling purposes. Initial field work quickly established inadequacies with the existing vegetation map to the extent that production of a new map became inevitable. Mr Robert Payne of Ecological Surveys & Management was subsequently engaged to prepare a new vegetation map of the entire study area (Figures 3 and 4). To this end interpretation of 1:25,000 stereo aerial photograph coverage (1994) was undertaken to identify and detail vegetation to structural level with boundaries transferred onto 1:25,000 topographic map sheets for use in the field.

The vegetation was described structurally according to the classification of Specht (1984) and the floristic standard of the National Herbarium of New South Wales at a selected number of locations. For each structural type approximately 40 quadrats each 20m square were used to collect detail for the vegetation descriptions with the most commonly occurring plant species noted within each quadrat. At the end of the investigation all commonly occurring plant species recorded within each structural type were combined to provide an overall description of each association. Where necessary, plant specimens were collected and matched against voucher specimens held at the National Herbarium of New South Wales. Intensive field survey and ground truthing of the mapping was conducted between December, 1994 and March, 1995.

2.7 Historical Distribution of Koalas in the Study Area

In consultation with the the NSW National Parks & Wildlife Service, further work was initiated regarding the collation of records and other information relating to the historical distribution of Koalas in the study area. This work was initially commenced as a component of the Draft Port Stephens Koala Management Plan and Ms. Tiffany Knott, a researcher for the initial project, was again contracted to complete this task on behalf of both the NPWS and the Australian Koala Foundation.

3.0 RESULTS

A total of 8,764 trees comprising 5,419 eucalypt and 3,345 non-eucalypt trees from 96 primary plot sites and 14 supplementary quadrats (Figure 5) were assessed during the study (Appendix 1).

3.1 Quaternary Soil Landscapes

Forty nine primary plot sites and nine supplementary quadrats were sampled. A total of 4,298 trees were assessed, comprising 19 species of eucalypt and 12 species of non-eucalypt. Thirty eight of the 49 primary plots sampled contained evidence of utilisation by Koalas, with faecal pellets recorded from beneath 13 species of eucalypt and 9 species of non-eucalypt (Table 2). High levels of activity by Koalas were found to be primarily restricted to localised areas of the Tilligerry Peninsula and Tomago Sandbeds supporting Aeolian, Swamp and Transferral soil landscapes.

Quaternary Deposits

EUCALYPTS

Swamp Mahogany	*Eucalyptus robusta*
Forest Red Gum	*E. tereticornis*
Sydney Peppermint	*E. piperita*
Red Bloodwood	*E. gummifera*
White Stringybark	*E. globoidea*
Brown Stringybark	*E. eugenoides*
Blackbutt	*E.pilularis*
Grey Ironbark	*E.siderophloia*
Scribbly Gum	*E. signata*
Red Mahogany	*E. resinifera*
Drooping Red Gum	*E. paramattensis*
Bangalay	*E. botryoides*
Tallowwood	*E. microcorys*

NON-EUCALYPTS

Broad-leaf Paper-bark	*Melaleuca quinquinervia*
Prickly Paperbark	*M. styphelioides*
Paperbark	*M. linearifolia*
Paperbark	*M. nodosa*
Swamp Oak	*Allocasuarina glauca*
Black She Oak	*A. littoralis*
Forest Oak	*A. torulosa*
Smooth- barked Apple	*Angophora costata*
Saw Toothed Banksia	*Banksia serrata*

Table 2. Species of eucalypt and non-eucalypt which had one or more Koala faecal pellets recorded beneath them and which were growing on soil landscapes associated with Quaternary Deposits in the Study Area.

The total number of trees with one or more Koala faecal pellets recorded beneath them comprised 1,056 of the 4,298 trees assessed. The number of Koala faecal pellets recorded beneath eucalypts ranged between 1 and 388 ($x = 9.45$, $\sigma = 23.25$, $n = 691$) and the number of koala faecal pellets recorded beneath non-eucalypts ranged between 1 and 204 ($x = 6.58$, $\sigma = 17.66$, $n = 365$). The highest faecal pellet count was recorded beneath a *Eucalyptus parramattensis* at Site PS051 (n=388). High pellet counts were also recorded at Site PS043, with over 100 pellets found under three *E. parramattensis* (n= 151, n=126, n=120) and two individuals of *Melaleuca nodosa* (n=204, n=159). Additionally, a single *Angophora costata* at Site PS030 had 134 faecal pellets beneath it. There was no significant difference between the average number of faecal pellets found beneath eucalypts and those found beneath non-eucalypts.

Tree Preferences

Data sets suitable for statistical analyses were obtained for 6 of the 13 eucalypt species beneath which faecal pellets were consistently recorded and for 4 of the non-eucalypt species. The range of strike rates for those eucalypt species with valid data sets varied from 0.55 for *Eucalyptus robusta* to 0.10 for *E.tereticornis* (Appendix 1). No significant variation amongst the strike rates was apparent (Chi-square = 10.19, 7df, p=0.18). However, there were significant differences between the strike rates for each species (Table 3).

	Eter	***Epip***	***Egum***	***Epil***	***Esig***	***Epar***
Erob	2.23*	1.53	2.41*	1.61*	2.19*	0.63
Eter		1.13	0.71	0.26	0.34	1.62*
Epip			0.40	0.58	0.75	1.22
Egum				0.00	0.20	1.64*
Epil					0.11	0.97
Esig						1.27

Table 3: Values of the Z Statistic derived from Mann-Whitney U - Wilcoxon Rank Sum W Tests of pooled strike rates for six species of eucalypt on Quaternary Deposits in the Study area (* indicates significant difference).

The strike rates of both Swamp Mahogany *E. robusta* and Drooping Red Gum *E. parramattensis* were significantly higher than those of the remaining eucalypt species and neither demonstrated any significant decrease in strike rate associated with increasing density.

Of the non-eucalypts, the range of summed proportional strike rates varied from 0.30 for *Melaleuca quinquinervia* to 0.08 for *Melaleuca stypheloides*. There was significant variation amongst the ranked strike rates (Chi-square = 11.15; 4df; p=0.02) but only *M.quinquinervia* demonstrated a strike rate which differed significantly from other non-eucalypts (Table 4).

	Acos	***Msty***	***Bser***	***Mnod***
Mqui	2.37*	2.50*	2.33*	2.91*
Acos		0.71	0.43	0.89
Msty			0.18	0.18
Bser				0.22

Table 4: Values of the Z Statistic derived from Mann-Whitney U - Wilcoxon Rank Sum W Tests of pooled strike rates for four species of non-eucalypt on Quaternary Deposits in the Study area (* indicates significant difference).

Activity levels of the 38 "active" plots sampled on Quaternary deposits ranged from 1.3% to 90.3% (x = 31%, σ = 23%). The highest activity level was recorded from an *E. robusta* dominated community (Site PS001) on the Tilligerry Peninsula.

There were significant but equivocal differences in the summed proportional strike rates for both eucalypts and non-eucalypts on a plot by plot basis. Strike rates otherwise indicative of a significant deviation from either the mean or summed proportional strike rates were established by Chi-square analyses for *E.gummifera* (0.59 @ sites PS006, 0.62 @ PS030), *E.piperita* (0.47 @ site PS045), *E.pilularis* (1.0 @ site PS030), *E.signata* (0.52 @ sitePS070) and *Melaleuca quinquinervia* (0.95 @ site PS001 & 0.45 @ site PS073).

Activity levels were significantly higher in those plots containing *E. robusta* and/or *E. parramattensis* when compared to those not containing the two species. Of the 11 "non-active" sites, two (PS075 and PS023) contained the otherwise preferentially utilised species *E. robusta*.

3.2 Nerong and Paterson Volcanic Based Soil Landscapes

The remaining geomorphological units in the study area comprise highly erodible, low nutrient and largely acidic to slightly alkaline soil landscapes of low to medium fertility predominately derived from

Carboniferous substrates (Nerong and Paterson Volcanics). Localised areas of highly fertile soils primarily occur in association with alluvial plains of the Hunter and Paterson Rivers but these areas have largely been cleared for agriculture and no longer support large forested areas.

Field based assessments from habitat units associated with the Nerong and Paterson Volcanics group generally failed to provide substantive data sets. A total of 47 primary plot sites and 5 supplementary quadrats were sampled. A total of 4,466 trees were assessed, comprised of 25 species of eucalypt and 12 species of non-eucalypt. 25 of the 47 primary plots sampled contained evidence of utilisation by Koalas, with faecal pellets recorded from beneath 22 species of eucalypt and 4 species of non-eucalypt (Table 5).

Nerong and Paterson Volcanics

EUCALYPTS		
Forest Red Gum	*Eucalyptus tereticornis*	(p=0.84; n=37)
Stringybark	*E. eugenoides*	(p=0.50; n=16)
Sydney Peppermint	*E. piperita*	(p=0.44; n=18)
Narrow-leafed Ironbark	*E. crebra*	(p=0.32; n=22)
Grey Gum	*E. punctata*	(p=0.23; n=56)
White Mahogany	*E.acmenoides*	(p=0.18; n=179)
Red Bloodwood	*E. gummifera*	(p=0.14; n=42)
Spotted Gum	*E. maculata*	(p=0.10; n=83)
Stringybark	*E. capitellata*	(p=0.30; n=12)
Broad-leafed White Mahogany	*E. umbra*	(p=0.29; n=14)
Red Mahogany	*E. resinifera*	(p=0.25; n=4)
Grey Ironbark	*E. paniculata*	(p=0.22; n=9)
Blackbutt	*E. pilularis*	(p=0.20; n=10)
Grey box	*E. moluccana*	(p=0.18; n=11)
Stringybark	*E. agglomerata*	(p=0.11; n=9)
Red Ironbark	*E. fibrosa*	(p=0.02, n=51)
Grey Ironbark	*E. siderophloia*	(p=0.07; n=28)
Grey Gum	*E. canaliculata*	NA
Narrow-leafed Red Gum	*E. dwyeri*	NA
Tallowwood	*E. microcorys*	NA
Sydney Blue Gum	*E. saligna*	NA
Flooded Gum	*E. grandis*	NA
NON-EUCALYPTS		
Smooth-barked Apple	*Angophora costata*	
Prickly Paper-bark	*Melaleuca styphelioides*	
Forest Oak	*Allocasuarina torulosa*	
Turpentine	*Syncarpia glomulifera*	

Table 5. Species of eucalypt and non-eucalypt which had Koala faecal pellets recorded beneath them and which were growing on remaining geomorphological units within the study area.

In contrast to the results obtained from sites on Quaternary Deposits, the total number of trees with one or more Koala faecal pellets recorded beneath them collectively comprised less than 8.0% of the 4,466 trees assessed (as opposed to 27% on Quaternary Deposits). The number of Koala faecal pellets recorded beneath eucalypts ranged between 1 and 294 ($x = 9.15$, $\sigma = 29.11$, $n = 273$) and the number of koala faecal pellets recorded beneath non-eucalypts ranged between 1 and 204 ($x = 4.91$, $\sigma = 5.37$, $n = 68$). There was no significant difference between the average number of faecal pellets found beneath eucalypts and those found beneath non-eucalypts. The highest faecal pellet count was recorded from beneath a *Eucalyptus moluccana* alongside *E. maculata* at Site PS074 (n=294) in the Uffington State Forest in the far west of the study area.

Notwithstanding the above and despite a sampling effort equivocal to that undertaken on the Quaternary deposits, valid faecal pellet/tree species associations could not be determined due to the widespread paucity of koala activity indicators. Only one eucalypt species was assessed to the confidence level specified by the criteria (White Mahogany
E. acmenoides - summed proportional strike rate = 0.18; $\sigma = 0.15$; $n = 179$ from 4 independent sites and one pooled sample combining the results from 5 other sites). The remaining eucalypt species beneath which Koala faecal pellets were found were at best represented by inadequate enumerative datasets which otherwise failed to meet the standards set for modelling purposes. Extensive foot based traverses of the study area in response to the paucity of faecal pellet evidence additionally failed to detect any areas of significant koala activity. Given the similarities in soil landscapes and underlying geology, the results were pooled for further analyses.

Collectively, the activity levels of the 25 "active" plots on the remaining geomorphological units of the study area ranged from 0.5% to 92.6% ($x = 17.7\%$, $\sigma = 26\%$). The highest activity levels were recorded from a localised *E.tereticornis* dominated community on podzolic soils associated with the Nerong Volcanics in the Rookes Point area of Tinalba Bay on the Tilligerry Peninsula. While confirming that significant activity levels are widespread within this particular area, the discrete and highly localised nature of the habitat unit effectively compromises the independence of at least two of the sites for statistical purposes. By removing all 5 sites related to this particular area from the activity level calculations, the revised figures for the pooled results range from 0.5% to 18% ($x = 5.9\%$, $\sigma = 5.76\%$) thus providing a more accurate reflection of the results otherwise obtained.

The lack of valid data sets for tree species occuring across particular substrates precluded a detailed comparison and analyses of substrate influenced utilisation rates. The only possible exception to this was Forest Red Gum, the levels of use of which appeared to differ significantly depending on the substrate being sampled. Whereas the results obtained from Quaternary sand deposits were not supportive of a significant level of utilisation of Forest Red Gum, as detailed above, preferential utilisation of this species was strongly indicated on erosional soil landscapes associated with the Nerong Volcanics. Similarly, limited observations of the levels of use of Forest Red Gum on Transferral soil landscapes of Quaternary origin also suggest significant utilisation levels. However, such conclusions in this latter case could not be substantiated and/or validated due to the complete absence of Koala activity indicators in similar sites.

Also of interest was the fact that, of the 22 non-active plots, 8 contained tree species such as Tallowwood *E. microcorys* a species which is known to be the subject of preferential utilisation by Koalas on substrates identical to that found in the study area (AKF, unpublished data). The potential for koalas to exploit this species in the study area is adequately demonstrated on the Raymond Terrace Golf course where plantings of this species are clearly favoured by Koalas.

4.0 DISCUSSION

The results of this study support a model of habitat utilisation by Koalas in the study area that is specifically focussed on no more than two to three species of eucalypt: Forest Red Gum, Swamp Mahogany and Paramatta Gum, all of which can be shown to be the subject of preferential utilisation by Koalas in the study area. A fourth species Tallowwood, is also considered likely. Preferential utilisation is not uniform however, Forest Red Gum appears to be preferentially utilised on alluvial deposits of Quaternary origin and volcanic substrates but arguably of lesser importance on other substrates, especially if either or both of the other two species are available. Notwithstanding issues associated with habitat destruction, fire and the depredations of both motor vehicles and dogs on the Koala population which are discussed below, those tree species established to be the subject of preferential utilisation must otherwise be considered to be the major limiting factor affecting the distribution and abundance of Koalas in the study area.

Derivation of the Habitat model

Algorithms resulting in the construction of cell-based boolean overlays based on intersecting attributes of the bio-physical environment which collectively constitute Koala habitat provide the major thrust of modelling for the purposes of the Koala Habitat Atlas.

For the purposes of the Koala Habitat Atlas, the Australian Koala Foundation recognises the following Koala habitat categories:

Primary Koala Habitat: recognisable floristic alliances and/or associations wherein tree species known to be both preferentially utilised by Koalas **and demonstrating a strike rate which is independant of density** are a dominant or co-dominant component of the overstorey vegetation.

Secondary Koala Habitat: recognisable floristic alliances and/or associations wherein
Secondary (A) Habitat tree species known to be preferentially utilised by Koalas, on average, constitute less than 35% of the overstorey vegetation.

Marginal Koala Habitat: recognisable floristic alliances and/or associations wherein
Secondary (B) Habitat tree species known to be preferentially utilised by Koalas are largely absent or otherwise occur at very low densities (<10%).

Habitat Value "Unknown": recognisable floristic alliances and/or associations wherein tree species considered likely to be the subject of preferential utilisation by Koalas, but whose value cannot be quantified due to an absence of activity indicators, are a dominant or co-dominant component of the overstorey vegetation.

Thus Aeolian and Swamp soil landscapes of Quaternary origin which are supporting forest and/or woodland communities dominated by one or the other (or both) of the preferentially utilised species *E. robusta* and *E. parramattensis* comprise Primary Habitat for the purposes of the Habitat Atlas. Similarly, Transferral and Alluvial soil landscapes, also of Quaternary origin, which are supporting forest communities dominated by the preferentially utilised species *E. robusta* and/or *E. tereticornis* will also be identified as Primary koala habitat for the purposes of the Atlas, as have erosional soil landscapes derived from Nerong volcanics which are supporting forest communities dominated by

E. tereticornis. Each of these areas are provided with a 100m buffer for planning purposes, based on the extent to which activity by Koalas will overlap into the adjoining forest and/or woodland communities. In several areas, notably on the Tilligerry Peninsula, the provision of such buffers has resulted in otherwise localised and disjunct areas of primary habitat becoming contiguous.

A categorical breakdown of Koala habitat in the Port Stephens study area based on the results of fieldwork and resultant modelling (Figure 6) has been determined as follows:

Habitat Type	**Area (Ha)**	**Percent of Land Area**
PRIMARY HABITAT	3,284.7	4.0
PRIMARY HABITAT BUFFER	2,484.1	3.0
SECONDARY HABITAT (A)	2,897.8	3.5
SECONDARY HABITAT (B)	32,965.7	39.9
UNKNOWN HABITAT	163.2	0.2
OTHER VEGETATION	7,679.5	9.3
MAINLY CLEARED	33,130.2	40.1
OTHER (Water Bodies)	15,052.7	
TOTAL	**97,658.5**	**100 %**

Each of the three habitat categories can constitute critical habitat from the Koalas perspective (Core Habitat for the purposes of SEPP N0. 44), depending on whether or not such areas are currently supporting breeding aggregations of Koala. However, each differs significantly in terms of its relevance to the long term management of Koalas. The Primary habitat category contains high density populations of the preferentially utilised species. In the absence of results which suggest a level of use which is density dependant, it follows that Primary Habitat areas will also have a correspondingly higher carrying capacity with resulting smaller home range areas required by the resident koalas. In contrast, areas of secondary habitat have a lower carrying capacity and support lower density populations, the individual koalas within them requiring larger home range areas in response to the lower densities of the preferentially selected species. Thus the effective conservation and management of both Primary and Secondary Habitat areas are integral to the long term future of koalas in the study area, they differ only in their potential carrying capacity.

Preferentially utilised tree species may occasionally occur in areas of Secondary (B) Habitat (*Marginal Habitat*). However, the carrying capacity of Marginal Habitat is lower again than any of the preceding categories and it is subsequently considered unlikely to be capable of supporting breeding aggregations.

Thus the habitat categories recognised by the Atlas clearly focus on carrying capacity. While such distinctions are necessary from a long term management perspective, they do not lessen the importance of the preferentially utilised tree species wherever they occur in the study area.

The strong association between the presence of the preferentially utilised species *E. robusta* and *E. parramattensis* and high koala activity levels supports a contention that the higher than expected strike rates on other tree species in these areas which are not otherwise the subject of preferential utilisation are primarily due to the presence of these particular species. It is also clear that significant levels of activity also extend into adjoining areas of otherwise secondary habitat. In this regard it is not so much the nutritional value of these tree species that is important, rather it is their proximity to those species subject to preferential utilisation and to this end they must be considered an important habitat component from the koalas perspective, providing secure roosting and interaction areas in addition to opportunistic browsing opportunities. The importance of these areas for modelling purposes has been accommodated by provision of a 100m “activity” buffer around all areas of Primary Habitat.

Distribution and Status of the Port Stephens Koala Population

Habitat categories with the greatest potential for effective long term conservation and mamagement of the Port Stephens Koala population are those areas of Primary and Secondary Habitat which collectively comprise less than 8.0**%** of the forested areas of the study area. However, fieldwork has also established that the greater proportion of this combined area is no longer supporting extant koala populations. This phenomena is most notable in western and northern areas of the study area where all evidence suggests a widely dispersed, low density population largely comprised of nomadic and/or transient individuals, rather than well established relatively sedentary breeding aggregations. This contention is supported by the generally low activity levels recorded in these areas during the fieldwork, the high proportion of inactive sites which otherwise contain species known to be preferentially utilised by Koalas and the extensive foot based traverses of these areas.

The low activity levels of Koala activity in the western parts of the study area support a contention of widespread localised extinctions. While low activity levels are arguably consistent with the ranging patterns of koalas on low nutrient sites, the levels of activity recorded on the erosional soil landscapes associated with the Nerong Volcanics on the Rookes Point suggest that high activity should be evident in areas being utilised by Koalas. Low activity levels are not necessarily an imediment to habitat assessment, as has been demonstrated by the Campbelltown Koala Habitat Atlas (Phillips and Callaghan, 1996), where Koala activity on low nutrient sandstones and shales can readily be quantified to the extent indicated in the preceding paragraphs.

Interpretation of the field data is consistent with that information provided by the historical account of a formerly widespread distribution. The following extracts from the historical account prepared by Knott (1995) confirm that Koalas were once relatively widespread within forests of the Port Stephens area including the western areas as evidenced by the following quotes:

Mr Gavin Scott, a resident of the Shire, recalled that his father, who owned 2,500 acres between Mclement Swamp Rd and Brandy Hill in the 1890's, often saw koalas:

"It was heavily timbered when he bought it...well, naturally, all the fauna was around then.... bears...they were plentiful, plentiful enough that people used to, well, hit them with sticks and knock them out!...nobody had any respect for animals, flora or fauna. It was so plentiful" (Interview, Aug 1993).

Mr Scott also recalled that a neighbour of his fathers, who owned property closer to Seaham, often heard koalas calling on his land. By the time Mr Scott was born (1910) koalas had disappeared from the area, and he has neither heard, nor seen one in his lifetime, despite working on the property in the same way his father had.

Mr Darrel Campbell of Raymond Terrace recalls that his uncles shot koalas in the Karuah area in the early 1900's, and that he and his friends shot them during the depression years, both to sell the pelts to a fur trader in Newcastle and to feed the dogs (Interview, 1993).

In 1916, 6,500 acres of unalienated land (called the Tomago sandbeds) was set aside by the Waterboard for future use, due to its unique ability to retain water (Armstrong, 1967). The Broken Hill Propriety Co Ltd also relinquished its ownership of the Stockton sandbeds (below Long Bight Swamp) to the Waterboard in 1925. Other areas in the Port Stephens Shire containing sandbeds were acquired until, by 1967, 40 square miles of sandbeds were controlled by the Waterboard (Armstrong, 1967).

Parts of Waterboard administered lands have been subject to widespread clearing. One such permanent instance was associated with construction of Grahamstown Reservoir in 1957. Other instances have been the result of mineral sands mining operations.

The Grahamstown basin consisted of Swamp Mahogany and Tea Trees in the low lying areas and Blackbutt, Ironbark and White Mahogany on the ridges (Mr C. Cambell, Interview, 1995). Duckhold Road which joined Medowie to Raymond Terrace, had large Swamp Mahogany's (three feet thick through the trunk) growing down either side of it and back to the Schroder pump station. Mr Cambell worked for the Waterboard for over thirty years and assisted in the clearing of Grahamstown dam:

"In different stages we'd go out and see the odd koala bear in the trees and we decided to leave little colonies of trees (Swamp Mahogany) behind as we cleared it. So the bears would gather in the trees and then we'd pull the trees down with care and catch the koalas and go and let them go ... behind the rangers cottage in the mahogany swamp...every now and then, all depends how thick they were, we'd take half a dozen, a dozen, or twenty at a time, maybe once or twice a week...went on for a period of around three months".

This historical insight and the results obtained from the field survey component are strongly supportive of a contention that Koala populations have failed to re-establish themselves.

In the remaining eastern parts of the study area, high and medium density Koala populations with activity levels consistent with those expected to be associated with sedentary breeding aggregations are now largely restricted to discrete areas of Primary and Secondary Habitat located on the Tilligerry Peninsula. Even in this area however, it is possible to demonstrate that several areas of otherwise suitable Primary and Secondary Habitat are no longer supporting stable breeding aggregations.

Thus the ammount of koala habitat remaining and that proportion of it currently being utilised by the species is disproportionate. Conservatively, we would estimate that as much as 80% of the secondary habitat categories are no longer being utilised by koalas, as is between 40-60% of the remaining areas of primary habitat. In this regard, the likely size of the Port Stephens Koala population cannot be large. In reality it is likely to be well below 1000 individuals distributed over the entire study area and realistically somewhere between 350-500 animals in total, the bulk of which are now clearly restricted to localised areas of primary and secondary habitat on the Tilligerry Peninsula and associated areas of the Tomago sandbeds. From a State and regional perspective, the Port Stephens Koala Population is clearly endangered, with an effective population size approaching the minimum required to ensure a measure of long term viability.

Consistency with State Environmental Planning Policy No. 44

State Environmental Planning Policy No. 44 - Koala Habitat Protection (SEPP 44) commenced operation in New South Wales on the 13th February, 1995 for the purposes of "...encourag(ing) the proper conservation and management of areas of natural vegetation that provide habitat for Koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline."

Aside from requiring the preparation of Koala management plans in relation to specific development applications where "core" Koala habitat is involved, SEPP 44 further encourages Councils to prepare comprehensive Koala management plans for their respective local government areas in accordance with set guidelines. These guidelines are currently under review as are relevant schedules of the SEPP that relate to Local Government Areas and Feed Tree Species respectively.

In this regard the areas of primary Koala habitat recognised for the purposes of the Port Stephens Koala Habitat Atlas are inconsistent with those which otherwise may have resulted with the stringent application of current SEPP No. 44 criteria in terms of the scheduled Feed Tree species. In particular, Drooping Red Gum *E. parramattensis* is clearly a critical resource for Koalas in the Port Stephens LGA but as yet is not recognised as such by the SEPP for the purposes of identifying "potential koala habitat". Additionally, Schedule 2 of the SEPP further specifies Scribbly Gum *E. signata* as a Feed Tree Species. While this may be the case in some areas outside of the Port Stephens study area, its application for that purpose in the Port Stephens study area is not supported by the Atlas results which suggest a level of opportunistic use otherwise associated with proximity to either or both of the two preferentially utilised species.

Additionally, the results of linear correlation analyses support a contention that the level of use of either of the two preferentially utilised species *E. robusta*, *E. parramattensis* and *E. tereticornis* (the latter species dependent on substrate) are independent of density, thus establishing the importance of single trees of these species within a given floristic community. In this regard a strict adherance to the existing SEPP criteria of *"....at least 15% of the total number of trees in the upper or lower strata of the tree component.."* for the purposes of identifying "potential" koala habitat would fail to capture significant areas of secondary koala habitat in the study area and should clearly be disregarded for the purposes of koala mangement in the Port Stephens Local Government Area.

Notwithstanding the above, all areas of primary and secondary habitat as defined by the Atlas are potentially "Core" habitat as defined by the SEPP depending on whether or not these areas are currently supporting breeding aggregations of Koalas. Indeed, for reasons detailed in Phillips, Callaghan and Staines (1996), the Atlas makes no distinction between those habitat areas currently supporting breeding aggregations and those that are not.

Descriptions of Primary Habitat

1. Communities dominated by Swamp Mahogany *E. robusta* and/or Parramatta Red Gum *E. parramattensis* (including the endangered sub species *E. parramattensis decadens*), growing on Aeolian and Swamp Landscapes associated with Quaternary Deposits of largely Pleistocene origin; associated secondary species of some significance include Smooth-barked Apple *Angophora costata*, Forest Oak *Allocasuarina torulosa* and Broad-leaved Paperbark *Melaleuca quinquinervia*. Primary Habitat supports very high densities of both species (*E. parramattensis* - Mean density = 85.4%; σ = 15.3%, n = 20 sites and *E. robusta* - Mean density = 78.3%, σ = 21.7%, n = 17 sites);

2. Communities dominated by Swamp Mahogany *E.robusta* growing on Transferral Landscapes associated with alluvial deposits of Quaternary origins; and

3. Communities dominated by Forest Red Gum *E. tereticornis* growing on Erosional Landscapes of predominantly yellow podzolics and lithosols associated with Nerong Volcanics.

<u>Descriptions of Secondary Habitat</u>

Secondary Habitat
(*Secondary Habitat A*)

1. Forest communities on Aeolian Swamp or Transferral Soil Landscapes of Quaternary origin supporting specimens of *E. robusta* and/or *E. parramattensis* as sub-dominant components of the overstory;

2. Forest communities on Transferral Soil Landscapes of Quaternary origin supporting specimens of *E. robusta* and/or *E. tereticornis* as sub-dominant components of the overstory; and

3. Forest communities on erosional landscapes supporting specimens of Forest Red Gum *E. tereticornis* as a sub-dominant component of the overstory.

Marginal Habitat
(*Secondary Habitat B*)

Communities containing low densities of any of those species known to be the subject of preferential selection by Koalas in the study area. Also included in this category are areas supporting Tallowwood *E. microcorys* a species which sometimes occurs at sufficient densities in some areas to warrant classification as Secondary Habitat.

Limitations of the Atlas Model

Comparison of completed Atlas field sites with the revised vegetation map prepared for the purposes of the study established an initial accuracy measure of 81%, with 89 of the 110 point samples provided by study plots conforming to the vegetation communities delineated regardless of considerations associated with potential GPS inaccuracies and other mapping errors. Subsequent ground truthing and further refinement of the vegetation map suggest that at least 85-90% accuracy has been achieved.

5.0 RECOMMENDATIONS

1. That Council seek the support of State Government and other agencies for an immediate moratorium on all land use activities currently threatening remaining areas of primary and secondary habitat known to be supporting Koalas.

2. That Council seek the support of the local community, including the Native Animal Trust Fund, the Hunter Valley Koala Preservation Society and the NSW National Parks & Wildlife Service to identify land for the purposes of re-establishing one or more Koala populations in areas of suitable habitat west of the Pacific Highway.

3. That Council actively encourage community based reporting of Koala sightings from the western areas of the Shire with a view to monitoring and indentifying possible locations of breeding aggregations.

4. That Council, in consultation with the NSW National Parks & Wildlife Service, amend the Draft Port Stephens Koala Management Plan and related Local Environment Plan(s) to reflect the location of known primary habitat areas in accordance with clause 15(b)(i) of *State Environmental Planning Policy No. 44 - Koala Habitat Protection*.

5. That Council liase with the Hunter Water Corporation and the NSW National Parks & Wildlife Service for the purposes of broadening the existing feral dog and fox control programs to areas of bushland vested in the responsibility of Council.

6. That Council modify existing Bushfire Management Plans to reflect the presence of known breeding aggregations of koalas in the first instance and all areas of primary and secondary habitat (Class A) thus far identified by the Koala Habitat Atlas with a view to the development of fire management strategies to minimise the potential for wildfire in these areas. Such strategies might include:

(i) construction of radiation zones and/or specified hazard reduction areas outside of or adjoining the buffer areas around primary habitat; and

(ii) development of contingency plans designed to secure areas of primary habitat as a priority response in the event of threat from wildfire.

7. That Council move to designate and seek community support for the recognition of "Urban Koala Management Zones" around those areas listed below and with a view to retaining remaining areas of primary and secondary habitat and their resident Koala populations. Nominated areas include but should not be limited to the following:

a) Rookes Point
b) Salt Ash
c) Lakeside
d) Lemon Tree Passage

Measures for discussion in terms of the proposed management zones should include:

(i) the establishment of dog free zones over the short to medium term with an agreed attrition program for currently owned domestic dogs and a prohibition on the acquisition/introduction of any further dogs into the management zone;

(ii) the placement of approved vehicle calming devices in the urban environment in order to restrict the maximum vehicle speed to 40km/hr; and

(iii) encouraging a measure of stewardship on behalf of the communities involved in the above for the purposes of pro-active habitat management and an increased involvement in all aspects of Koala management in the Local Government Area.

8. That Council continue to liaise with the Department of Urban Affairs and Planning regarding necessary changes to SEPP No. 44 insofar as it relates to the effective management and conservation of Koalas in the Port Stephens Local Government Area.

Guidelines for Development within Proposed Urban Areas Known to be Utilised by Koalas

a) Identify and delineate areas of significant Koala Habitat including individual trees or clusters of trees known to be important to Koalas in the area, including a stadia survey showing the locations and taxonomic identity of all trees known to be preferentially utilised by Koalas;

b) Ensure that subdivision designs ensures the retention of all trees known to be preferentially utilised by Koalas to the extent that the trees do not and will not pose a threat to any resulting dwelling;

c) Ensure that a subdivision design overlay demonstrates effective retention of significant Koala use trees to the satisfaction of the NSW National Parks and Wildlife Service;

d) Ensure that subdivision designs are accompanied by corresponding Landscape Plans that ensure a minimum planting of at least one of the preferentially selected tree species, or an appropriate alternative, identified by this study as significant in terms of utilisation by Koalas within the study area, for every two residential allotments created;

e) Ensure that trees identified for retention are further protected by Covenant in accordance with the *Conveyancing Act*, together with a legal surety (bond) provided by the developer to ensure that the

Covenant can be legally enforced (where necessary) for a minimum period of five years following the issuing of any Development Consent;

f) Prohibit the keeping of domestic dogs;

g) Provide road design standards, by means of traffic calming devices and other methods approved by Port Stephens City Council, in order to restrict vehicle speeds to a maximum of 40 km/hr at all times; and

h) Ensure that environmental consultants appointed to undertake Koala assessments are accredited and/or recognised Koala authorities and are independently appointed by Council with costs to be born by the developer.

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Site No.	Erob	P	Eter	P	Epip	P	Egum	P	Eeug	P	Epil	P	Esig	P	Epar	P
PS001	50	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS005	118	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS006	6	1	0	0	0	0	27	16	0	0	12	5	0	0	0	0
PS010	42	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS020	0	0	52	1	0	0	0	0	0	0	0	0	0	0	0	0
PS026	0	0	0	0	0	0	5	2	0	0	0	0	5	1	0	0
PS028	0	0	0	0	0	0	10	1	15	1	0	0	0	0	0	0
PS030	28	23	0	0	0	0	21	13	0	0	12	12	0	0	0	0
PS031	26	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS033	39	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS035	0	0	0	0	0	0	7	1	0	0	6	1	0	0	0	0
PS040	0	0	10	3	0	0	0	0	11	4	0	0	0	0	0	0
PS041	0	0	8	3	0	0	0	0	3	2	0	0	0	0	0	0
PS042	0	0	0	0	0	0	0	0	0	0	0	0	18	17	0	0
PS043	0	0	0	0	2	1	0	0	0	0	0	0	0	0	77	56
PS044	0	0	0	0	10	1	0	0	0	0	0	0	74	22	0	0
PS045	0	0	0	0	81	38	10	4	2	2	0	0	0	0	2	1
PS046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	143	85
PS047	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0
PS049	0	0	0	0	0	0	0	0	0	0	13	2	0	0	0	0
PS051	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	83
PS054	0	0	0	0	0	0	16	2	0	0	0	0	59	9	0	0
PS056	0	0	0	0	0	0	33	0	0	0	7	0	0	0	0	0
PS057	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS058	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS060	0	0	0	0	0	0	3	1	9	1	0	0	0	0	0	0
PS061	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS063	18	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS064	5	5	0	0	0	0	0	0	0	0	0	0	0	0	64	21
PS065	0	0	0	0	0	0	19	6	0	0	0	0	45	12	0	0
PS066	0	0	0	0	0	0	13	8	0	0	19	6	0	0	8	6
PS069	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	12
PS070	0	0	0	0	0	0	0	0	0	0	0	0	46	24	1	0
PS071	0	0	0	0	0	0	7	4	0	0	8	6	0	0	0	0
PS073	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS096	0	0	0	0	0	0	21	3	0	0	0	0	29	1	0	0
PS097	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0
PS098	0	0	0	0	17	6	6	1	0	0	0	0	0	0	0	0
PS099	0	0	0	0	15	4	5	1	0	0	0	0	1	1	2	1
PS101	2	1	0	0	0	0	0	0	0	0	0	0	18	3	0	0
PS102	4	1	0	0	0	0	0	0	0	0	0	0	13	0	0	0
PS103	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0
PS106	0	0	0	0	0	0	0	0	0	0	0	0	20	7	0	0
PS107	5	2	0	0	0	0	0	0	0	0	0	0	15	5	0	0
PS109	0	0	0	0	7	2	21	6	0	0	0	0	0	0	0	0

PS110	0	0	0	0	39	20	0	0	0	0	0	0	0	0	0	0
n	348	193	76	8	171	72	224	69	40	10	90	32	371	103	494	265
p	0.55		0.105		0.42		0.31		0.25		0.36		0.28		0.54	
n*p*	191		7		72		69		10		32		104		267	
n(1-*p*)	157		63		99		155		30		58		275		227	
x	0.55				0.36		0.34						0.32		0.52	
σ	0.23		0.035		0.13		0.18		0.07		0.05		0.27		0.22	
SE	0.01				0.01		0.01						0.01		0.01	
95% CL (lower)	0.53		0.035		0.34		0.32		0.13		0.26		0.25		0.52	
95% CL (upper)	0.57		0.175		0.38		0.36		0.39		0.46		0.31		0.56	

Appendix 1. Data summary on a plot by plot basis for eucalypt species assessed on Quaternary Deposits. Only active sites are included. Values beneath P for each species indicate the actual number of trees beneath which one or more Koala faecal pellets were recorded (Erob= *Eucalyptus robusta;* Eter=*E. tereticornis*; Epip=*E. piperita;* Egum= *E. gummifera;* Eeug= *E. eugenoides;* Epil= *E. pilularis*; Ehae= *E. haemostoma;* Epar= *E. paramattensis*).

Site No.	Mqui	P	Acos	P	Msty	P	Bser	P	Mnod	P	Ator	P
PS001	22	21	0	0	0	0	0	0	0	0	0	0
PS005	0	0	5	4	1	0	0	0	0	0	0	0
PS006	0	0	9	4	0	0	14	4	0	0	0	0
PS010	15	5	0	0	0	0	0	0	0	0	0	0
PS020	0	0	0	0	86	1	0	0	0	0	0	0
PS026	0	0	33	5	0	0	14	0	0	0	0	0
PS028	0	0	15	1	0	0	0	0	1	0	0	0
PS030	2	2	14	9	4	2	10	4	2	0	0	0
PS031	79	21	0	0	0	0	0	0	0	0	0	0
PS033	5	2	0	0	0	0	0	0	0	0	0	0
PS035	0	0	12	0	0	0	9	3	0	0	0	0
PS040	0	0	0	0	31	3	0	0	150	23	0	0
PS041	0	0	2	0	26	6	0	0	111	10	0	0
PS042	0	0	18	0	0	0	0	0	0	0	0	0
PS043	0	0	0	0	0	0	1	1	8	6	0	0
PS044	0	0	0	0	0	0	0	0	0	0	0	0
PS045	0	0	0	0	0	0	4	1	0	0	0	0
PS046	0	0	0	0	1	0	0	0	1	0	0	0
PS047	0	0	8	1	0	0	14	0	0	0	0	0
PS049	7	3	12	1	0	0	20	1	0	0	0	0
PS051	0	0	0	0	0	0	0	0	4	4	0	0
PS054	0	0	5	0	0	0	1	0	1	0	0	0
PS056	0	0	16	2	0	0	12	0	0	0	0	0
PS057	0	0	3	0	0	0	0	0	1	0	0	0
PS058	141	34	0	0	0	0	0	0	0	0	0	0
PS059	100	11	0	0	0	0	0	0	0	0	0	0
PS060	0	0	14	3	0	0	0	0	0	0	36	8
PS061	84	8	1	0	0	0	0	0	0	0	0	0
PS063	51	11	1	1	0	0	0	0	0	0	0	0
PS064	1	1	8	2	0	0	0	0	0	0	0	0
PS065	0	0	41	10	0	0	0	0	0	0	0	0
PS066	0	0	3	2	0	0	0	0	0	0	0	0
PS069	0	0	0	0	0	0	0	0	17	1	0	0
PS070	0	0	0	0	0	0	0	0	0	0	0	0
PS071	0	0	28	20	0	0	1	0	0	0	0	0
PS073	211	94	0	0	1	0	0	0	28	2	0	0
PS096	0	0	0	0	0	0	1	0	2	0	0	0
PS097	0	0	11	0	0	0	0	0	0	0	0	0
PS101	0	0	1	0	0	0	0	0	0	0	0	0
PS102	0	0	6	0	0	0	0	0	0	0	0	0
n	718	213	265	65	150	12	100	14	324	46	36	8
p	0.30		0.25		0.08		0.14		0.14		0.22	
np	213		66		12		14		46		8	
n(1-p)	505		199		138		86		278		28	

Appendix 2. Numbers of non eucalypts assessed on a plot by plot basis on the Quaternary Sands. Only sites with statistically valid data sets are included. Values beneath P for each species indicate the actual number of trees beneath which one or more

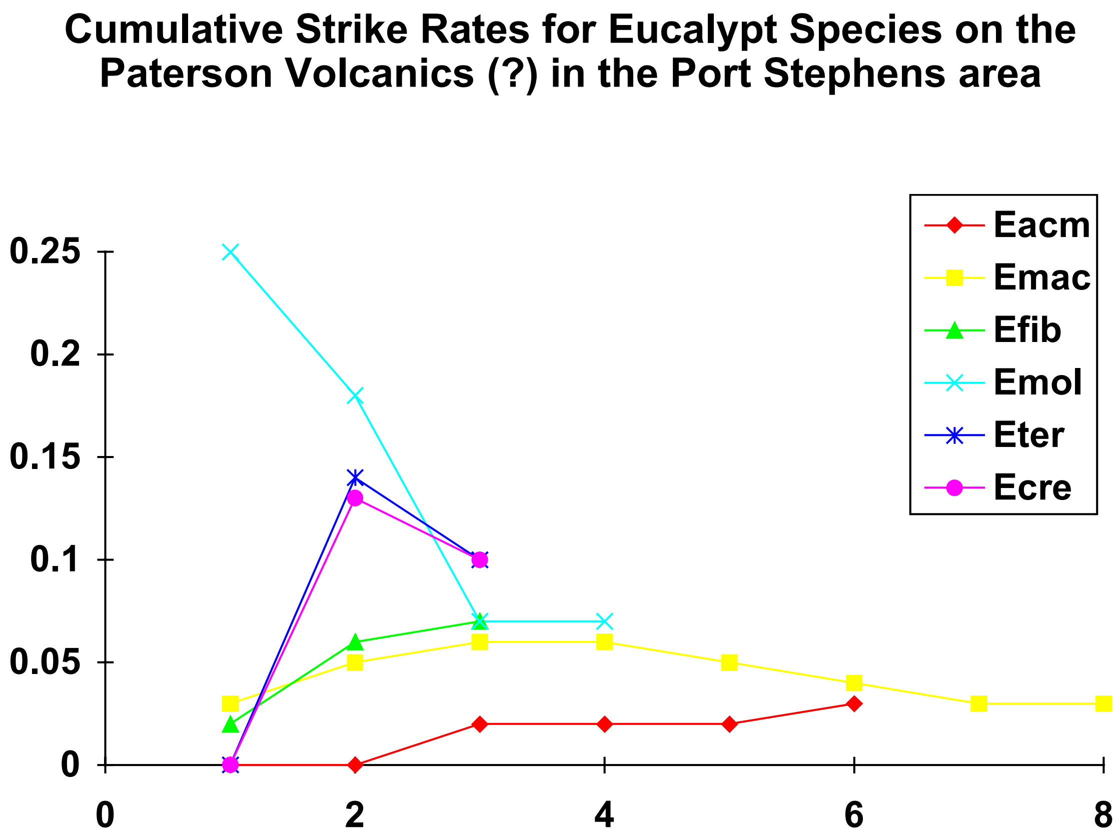
Koala faecal pellets were recorded (Mqui= *Melaleuca quinquinervia*; Acos= *Angophora costata;* Msty= *Melaleuca styphelioides;* Bser= *Banksia serrata;* Ator= *Allocasuarina torulosa*).

Site No.	Eter	P	Epip	P	Egum	P	Eacm	P	Epun	P	Emac	P	Ecre	P
PS002	19	18	0	0	0	0	0	0	0	0	0	0	0	0
PS003	0	0	14	6	10	4	14	10	0	0	0	0	0	0
PS004	0	0	0	0	0	0	34	13	0	0	0	0	0	0
PS011	0	0	0	0	0	0	32	7	27	7	17	0	22	7
PS014	0	0	0	0	18	1	10	1	1	0	0	0	0	0
PS019	0	0	0	0	0	0	36	1	7	0	2	0	0	0
PS022	3	0	0	0	0	0	0	0	0	0	50	3	0	0
PS036	0	0	12	0	29	0	0	0	0	0	0	0	0	0
PS039	0	0	0	0	0	0	28	1	0	0	7	0	0	0
PS050	0	0	1	0	11	1	15	5	0	0	26	5	0	0
PS053	0	0	0	0	0	0	9	0	5	1	14	0	0	0
PS092	21	19	0	0	0	0	0	0	0	0	0	0	0	0
PS093	9	7	3	2	0	0	1	1	0	0	0	0	0	0
PS100									0	0	6	0		
PS104									**2**	**1**				
PS105									**4**	**2**				
n	52	44	30	8	68	6	179	39	46	11	122	8	22	7
p	85%		27%		9%		22%		24%		7%		32%	
np	44		8		6		39		8		8		7	
n(1-p)	8		22		62		140		32		108		15	

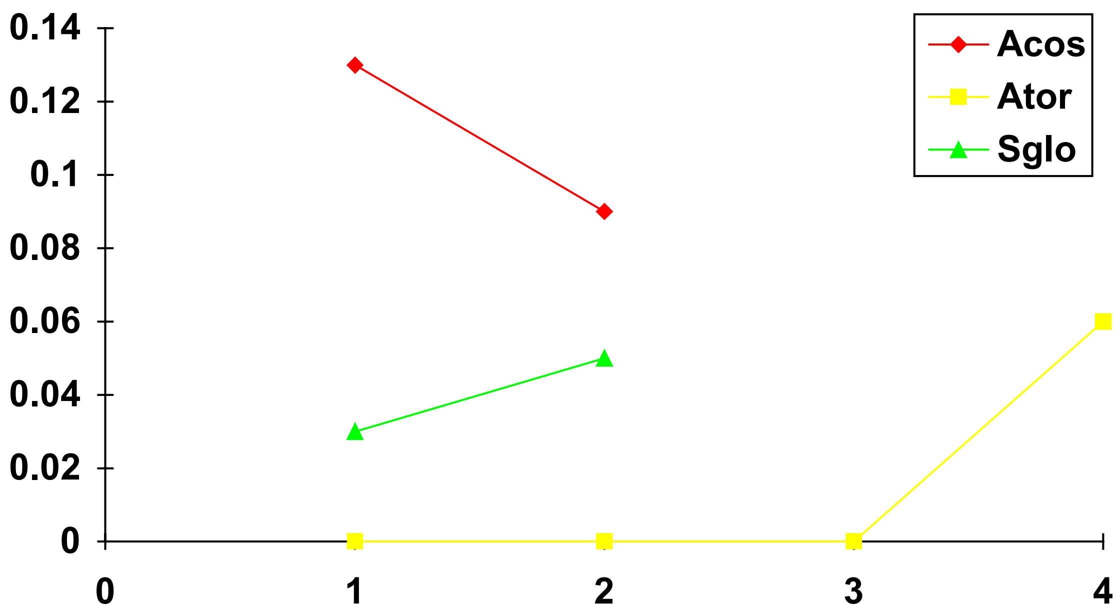
Appendix 3. Numbers of eucalypts assessed on a plot by plot basis on the Nerong Volcanics. Only sites with statistically valid data sets are included. Values beneath P for each species indicate the actual number of trees beneath which one or more Koala faecal pellets were recorded (Eter=*Eucalyptus tereticornis*; Epip= *E. piperita;* Egum= *E. gummifera;* Eacm= *E. acmenoides;* Eeug= *E. eugenoides;* Epun= *E. punctata*; Emac= *E. maculata;* Ecre= *E. crebra*)

Site No.	Agla	P	Acos	P
PS002	2	2	6	5
PS003	0	0	12	4
PS004	0	0	8	2
PS011	0	0	0	0
PS014	0	0	27	3
PS019	0	0	2	0
PS022	0	0	0	0
PS036	0	0	6	0
PS039	0	0	38	0
PS050	0	0	21	2
PS053	0	0	4	0
PS092	27	17	3	3
PS093	0	0	15	9
PS095	0	0	0	0
n	29	19	142	28
p	66%		0.197	
np	19		28	
n(1-p)	10		114	

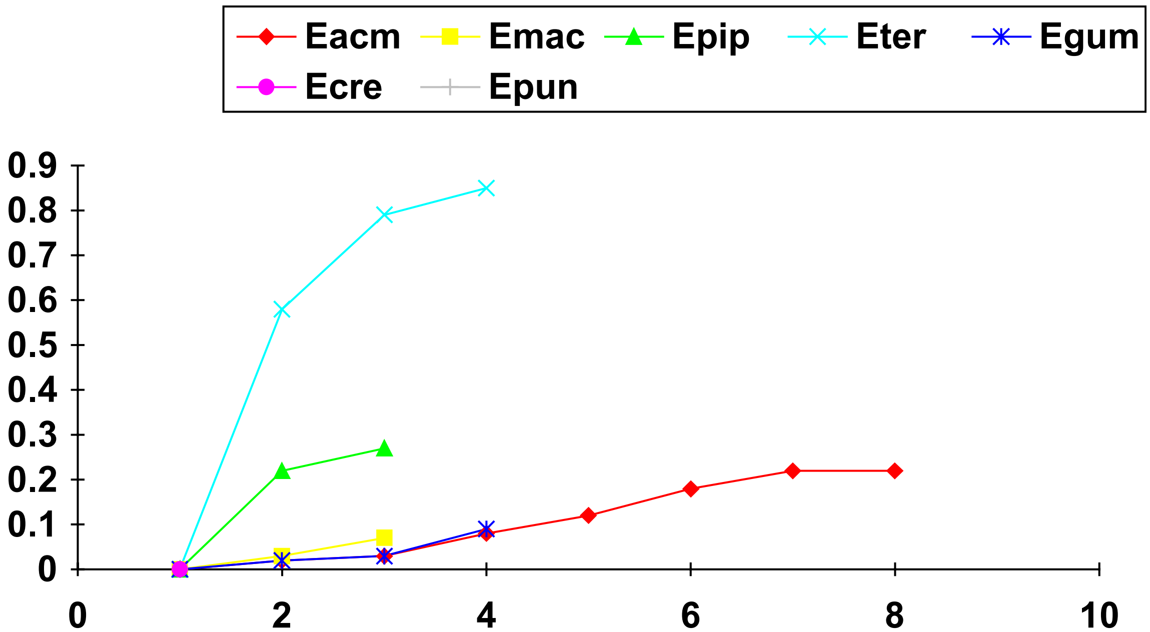
Appendix 4. Number of non eucalypts assessed on a plot by plot basis on the Nerong Volcanics. Only sites with statistically valid data sets are included. Values beneath P for each species indicate the actual number of trees beneath which one or more Koala faecal pellets were recorded (Agla= *Allocasuarina glauca;* Acos= *Angophora costata)*


Cumulative Strike Rates for Eucalypt Species on the Paterson Volcanics (?) in the Port Stephens area
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
Eacm
Emac
Efib
Emol
Eter
Ecre

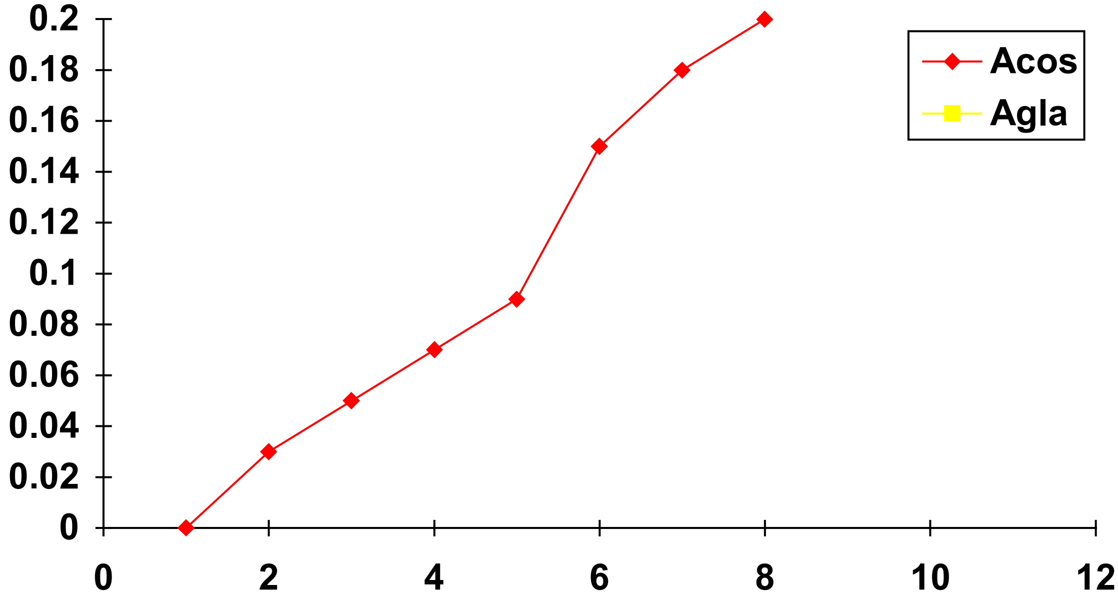
Cumulative Frequencies for Non-Eucalypt Species on the Paterson Volcanics(?) in the Port Stephens Area

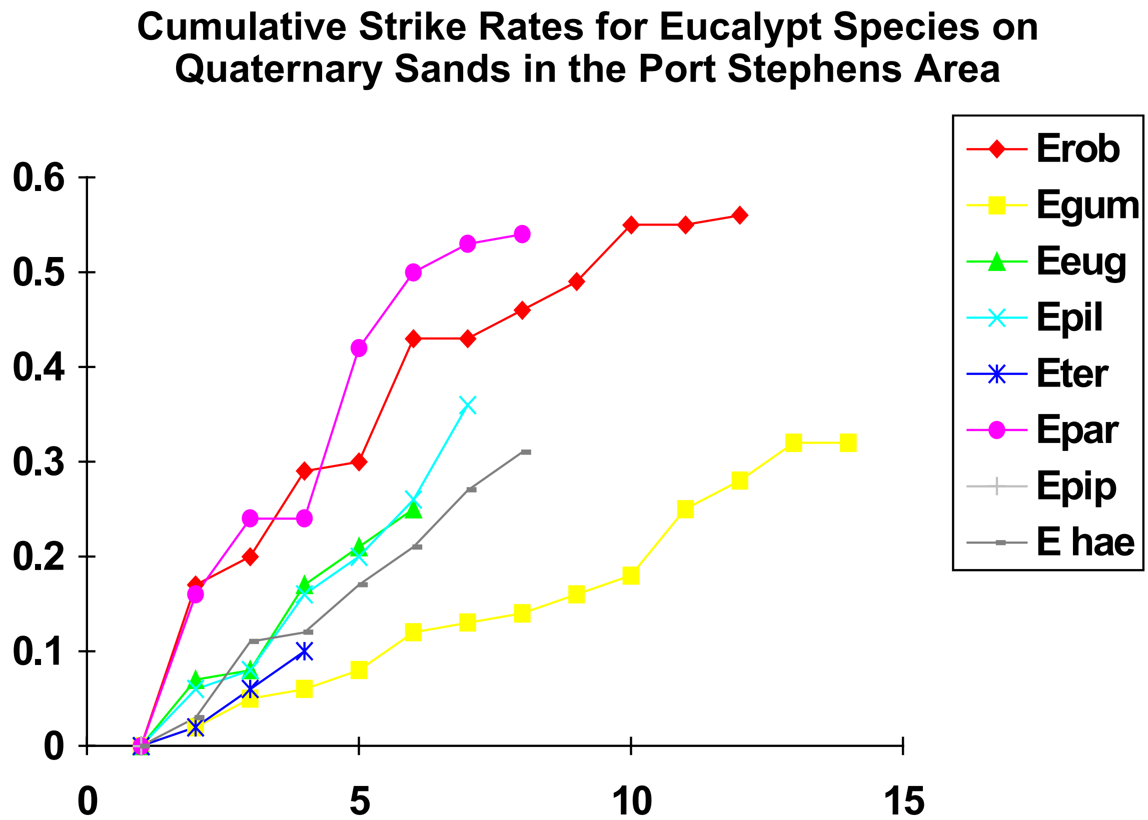


Cumulative Frequency Strike Rates for Eucalypt Species on Nerong Volcanics in the Port Stephens Area



Cumulative Frequency of Strike Rates for Non-Eucalypts on Nerong Volcanics in the Port Stephens Area





Cumulative Strike Rates for Eucalypt Species on Quaternary Sands in the Port Stephens Area
Erob
Egum
Eeug
Epil
Eter
Epar
Epip
E hae
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15

Cumulative Frequencies for Non-Eucalypt Species on Quaternary Soils in the Port Stephens Area