# BALLARAT CITY COUNCIL

# COMPREHENSIVE KOALA PLAN OF MANAGEMENT

## PART 2: RESOURCE DOCUMENT

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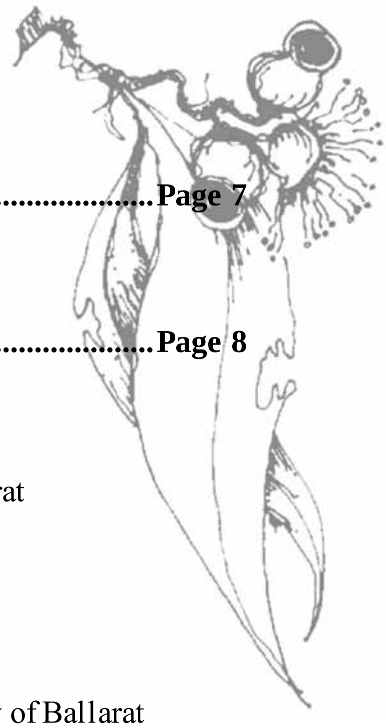

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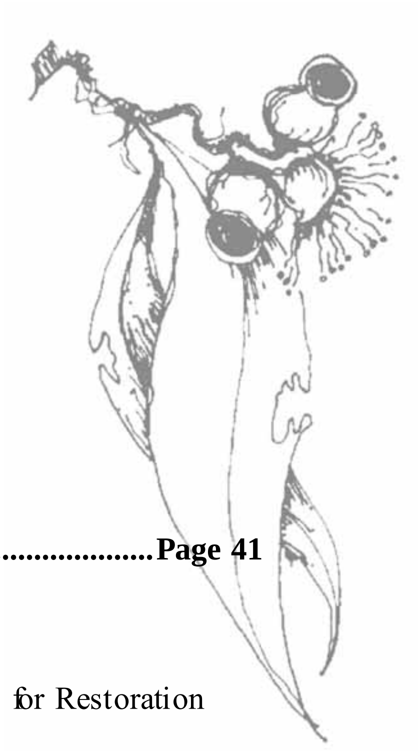
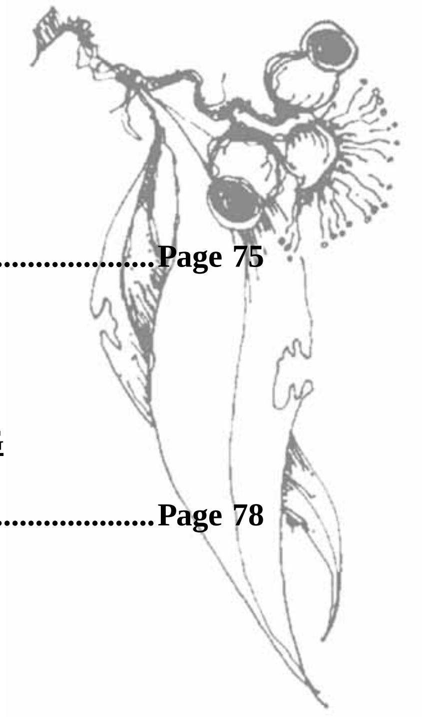
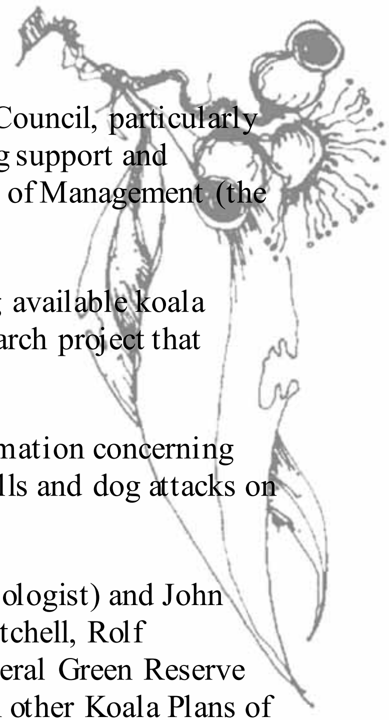


**<u>OTHER MATTERS</u>**





# ACKNOWLEDGEMENTS

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Shirley Mitchell (Sebastopol Wildlife Shelter) provided anecdotal information concerning koala welfare issues in the Ballarat area as well as data on koala road kills and dog attacks on koalas.

Field surveys were conducted by the late Lynne Bailey (former AKF Biologist) and John Callaghan (former AKF Chief Ecologist) with assistance from Dave Mitchell, Rolf Schlagloth, Michiala Bowen, and a number of volunteers, including several Green Reserve teams and overseas tourists. Sections within this document are based on other Koala Plans of Management that have been authored or co-authored by John Callaghan (former AKF Chief Ecologist).

We particularly appreciate the ongoing support received from the City of Ballarat IT and GIS teams and the Parks & Environment section.

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# 1. INTRODUCTION

## 1.1 Aims and Objectives of the Resource Document

The Ballarat City Council Comprehensive Koala Plan of Management (the Plan) consists of two parts. The Plan (Part 1) includes a brief synopsis for each of the management topics, together with specified management actions.

This document – Part 2 - Resource Document, includes detailed coverage and analysis of each of the management topics. The aims of this document are to:

- Inform the implementation processes of the Plan;
- Ensure that management of the koala and the processes and environmental conditions that affect its survival are as well understood as possible;
- Ensure that actions taken are based on the best possible information and scientific analysis.

The overall objective of this Resource Document is to ensure that the Purpose of the Plan is achieved, namely:

*"To provide for the long-term survival of koala populations within the City of Ballarat through the implementation of actions aimed at safeguarding the koala within its natural range within the City."*

## 1.2 Identification of Authors

This document has been prepared by the Australian Koala Foundation (AKF). The principal authors are Rolf Schlagloth *(B.App.Sc.; AKF Liaison Officer, Victoria) and* Hedley Thomson *(MBA, BTRP, FPIA, CPP; planning & environmental management consultant)* who provided the content relating to land use planning and environmental policies and generally reviewed and revised the document for the Ballarat and Victorian context. GIS operations were led by Dave Mitchell *(BSc; AKF GIS Specialist).* Sections within this document are based on other Koala Plans of Management that have been authored or co-authored by John Callaghan *(B.App.Sc., Assoc.Dip.App.Sc.; former AKF Senior Research Ecologist and Head of Conservation and Research).*

# 2. BACKGROUND

## 2.1 The City of Ballarat

This management plan relates to koalas and their habitat in the City of Ballarat, located 110 kms west of Melbourne, Victoria. The City covers an area of 738.4 sq. km, much of which has been cleared for agricultural purposes and for softwood plantation. Freehold land occupies most of the flat plains in the western two-thirds of the study area. Remnant eucalypt forests are predominantly located in the east on areas of public land associated with the poorer soils of the midland slopes and the Great Dividing Range. These forests are utilised for a wide range of activities including recreation, timber production, water production and for conservation purposes (LCC 1980). The Western Freeway runs east-west through the centre of the City whilst the Midland Highway runs from the south-east through to the north of the City. The City is part of a region under the traditional custodianship of the Wathaurong tribe. The municipality comprises the City of Ballarat and the small townships of Learmonth, Buninyong and Cardigan Village. It has an estimated population of 88,000.

**Table 11: Population Growth within the City of Ballarat from 1996**

| Year | Approx. Population |
|---|---|
| 1996 | 79,109 |
| 1997 | 79,718 |
| 1998 | 80,444 |
| 1999 | 81,392 |
| 2000 | 82,585 |
| 2001 | 83,599 |
| 2002 | 84,846 |
| 2003 | 85,851 |
| 2004 | 87,148 |

(Source: ABS Estimated Resident Population Catalogue number: 2305.00)

Ballarat adjoins the municipalities of Moorabool Shire (to the east) that separates Ballarat from the outer suburbs of Melbourne; Hepburn Shire (to the north); Pyrenees Shire (to the west); and Golden Plains Shire (to the south) that separates Ballarat from Geelong.

## 2.2 Physical Environment

### Geology and Geomorphology

The municipality of the City of Ballarat lies in the Victorian Midlands and Victorian Volcanic Plain Bioregions (Environment Australia 2002), and straddles the Continental Divide at one of its lowest points. Elevation and relief is generally low on the Volcanic Plain apart from numerous volcanic scoria cones and a small section of higher volcanic plateau on the eastern margin of the City. The Victorian Midlands has generally higher elevation and relief, it is comprised of highly eroded Cambrian and Ordovician sedimentary shales, the oldest rocks in the area, and metamorphic rocks that form the hills in the eastern third of the City with an additional small area on the City's southern boundary. Devonian granite hills in the northwest of the City include the granite outcrops at Mt. Bolton and Mt. Beckworth and are also included in the Victorian Midlands Bioregion, as is a small area of Devonian granodiorite straddling the eastern boundary of the City around the Gong Gong and Kirks Reservoirs. Relics of Tertiary sands and gravels can be found at Sago Hill in the south-west of the City. The most recent geomorphologic unit is the Newer Volcanics scoria cone and associated lava flows of Mt. Buninyong which is located in the east of the City (LCC 1980). Simplified topography is shown in Figure 1.

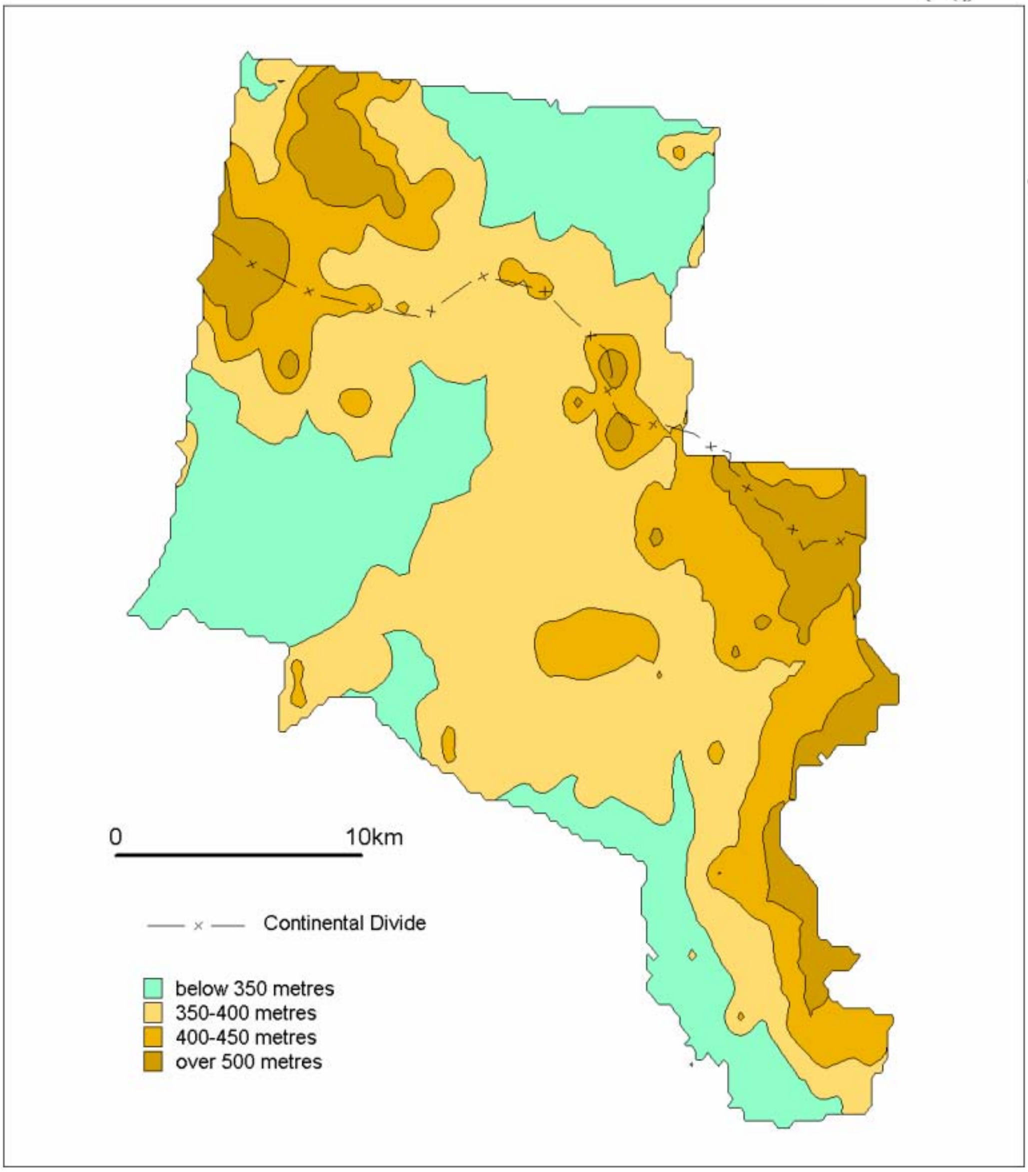



Figure 1: Topography of the City of Ballarat

Volcanic Plain geology also includes Pliocene and Pleistocene fluvial gravel and silt deposits. Simplified geology is shown in Figure 2.

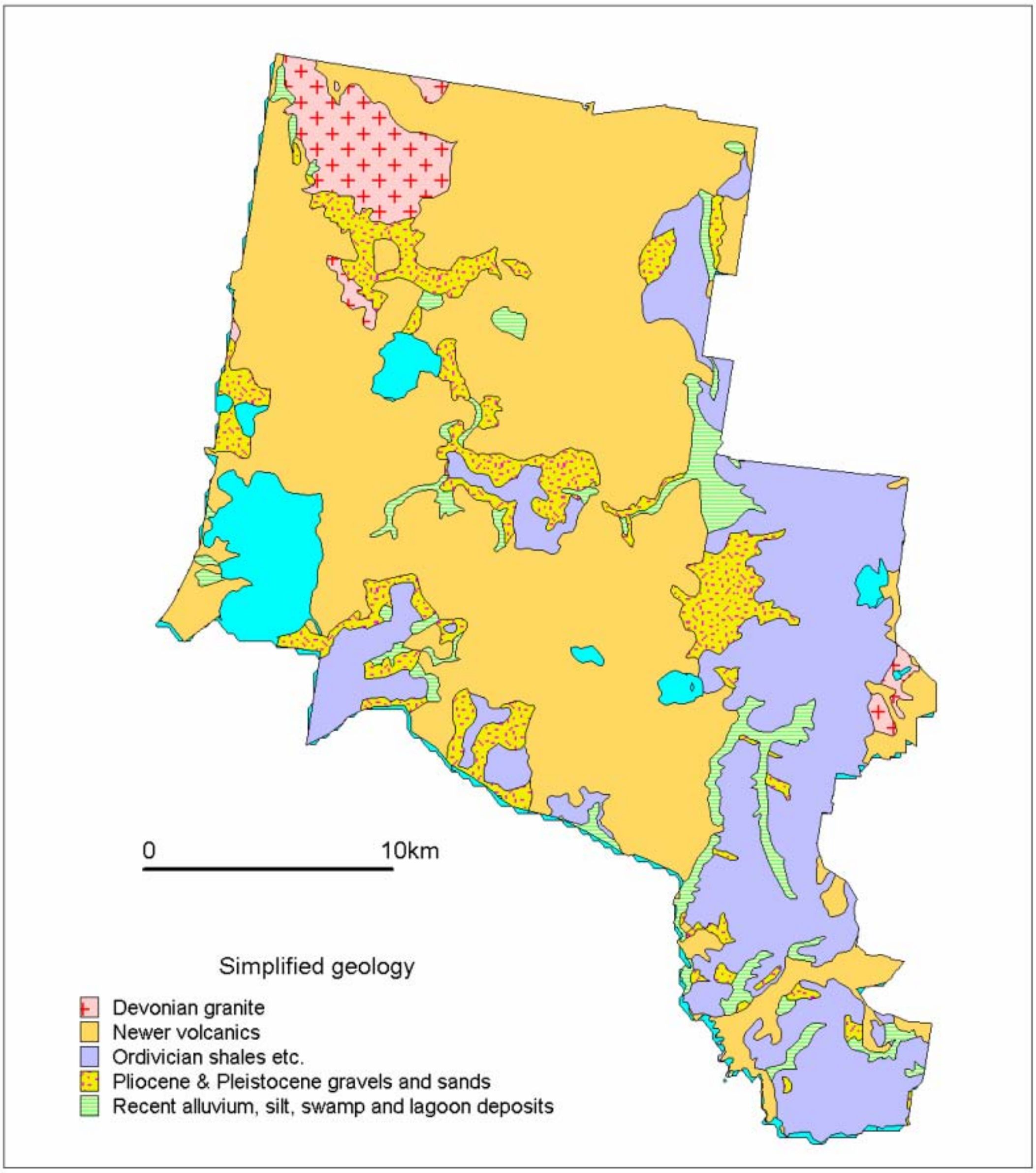



Figure 2: Simplified geology of the City of Ballarat

The City of Ballarat is located within the upper-most portions of three major river basins, each managed by a separate catchment management authority. These are known as the Barwon, Hopkins and Loddon River catchments with each being managed by the Corangamite, Glenelg Hopkins and North Centre Catchment Management Authorities respectively. From these catchments, water flows into the ocean at Barwon Heads, Warrnambool and Goolwa in South Australia (via the Murray River) respectively.

**Climatic Conditions**

Ballarat receives an average 705 mm of rain per year, with a winter maximum (COB 2006) and lower readings to the west and higher readings to the north-east in the Great Dividing Range (LCC 1980). Rainfall in the City is influenced by south-westerly and north-westerly air-streams, which produce higher rainfall in the more elevated areas. Over the past decade, rainfall has fallen to two thirds of the historical average.

Mean maximum temperatures vary from 24.9°C (January) to 10°C (July) (COB 2006) and mean daily minimum temperatures range from 11.4 ºC in February to 3.3 ºC in July. Evapotranspiration is in the order of 600 mm per year (Bureau of Meteorology 2006).

## 2.3 Biotic Environment

### Vegetation Communities

Natural vegetation units are predominantly located in the east of the study area on relatively infertile Ordovician derived soils. Smaller areas of natural vegetation are located on the fertile Newer Volcanics derived soils at Mt Buninyong, on Devonian derived granitic soils at Mt. Bolton, and on Tertiary deposited sands and gravels at Sago Hill. Much of the natural vegetation in the study area has been subject to disturbance from logging, mining and fire. Messmate Stringybark was favoured by settlers because of its structural qualities, with the bark being suitable for roofs of huts and even for the fact that it was able to be used as fire wood when still green. Amongst other reasons, these factors would have contributed immensely to the loss and fragmentation of koala habitat seeing that large areas of Ballarat would have been covered by this species which is one of the species of eucalypts preferred by local koalas.

Although large areas of remnant vegetation are found on public land, significant remnant vegetation still remains on private land in the south-east of the study area in the Grenville Forest block and at Mt Bolton in the north-west.

The Land Conservation Council (LCC 1980) has identified six broad eucalypt associations in the study area:

- Manna Gum open forest with associated Narrow-leaf Peppermint *(Eucalyptus radiata)* and Swamp Gum *(E. ovata)* is found in many of the drainage lines throughout the study area. Broad gullies on Ordovician derived soils carry Swamp Gum and/or Yarra Gum *(E. yarraensis)*.
- Messmate Stringybark *(E. obliqua)* dominated open forest with associated Narrow-leaf Peppermint and Candlebark *(E. rubida)* is found on the higher rainfall areas of the Great Dividing Range around the White Swan Reservoir in the north-east of the study area.
- Messmate Stringybark dominated open forest with a wide range of associated eucalypt species including Narrow-leaf Peppermint, Scent Bark *(E. aromaphloia)*, Broad-leaf Peppermint *(E. dives)*, Candlebark and Swamp Gum are distributed both north and south of the Great Dividing Range on gentle ridges and slopes. This association is found on Ordovician derived soils in the north-east of the study area through to the north side of Union Jack Reserve in the south-east.
- Messmate Stringybark/Brown Stringybark *(E. baxteri)* dominated open forest is found on gentle ridges and slopes on Ordovician derived soils in the Canadian Forest and Grenville Forest blocks. Associated species include Broad-leaf Peppermint, Scent Bark, Narrow-leaf Peppermint, Red Stringybark *(E. macrorhyncha)*, Swamp Gum and Candlebark.
- Scent Bark/Broad-leaf Peppermint dominated open forest is found on drier sites and ridges on Ordovician derived soils and are predominantly found in the Nerrina area and in the south-east of the study area.
- Messmate Stringybark/Manna Gum open forest is found on the Newer Volcanics derived

soils of Mt. Buninyong.

Research undertaken by the AKF and its associated researchers between 1996 and 2004 has provided significantly more detail about the City's native vegetation and its importance as koala habitat and food sources and therefore the vital role it plays in the survival of the koala in the City of Ballarat and surrounding areas, in particular the presence of Manna Gum and Messmate Stringybark.

**Fauna Communities**

The region's native forest areas are the prime habitat for a diverse range of native animals. Many species are found within the fringe areas of native forests, farmland, rural residential and some urban areas such as Nerrina and Mt Helen. Within urban areas some species of birds have adapted to and prefer the much modified environment. Native birds, reptiles and amphibians have an important role in reducing pest insect attacks giving healthier crops and pastures and therefore can reduce the need for chemical applications.

Many threats are present in these same areas near to or adjacent to the wildlife's preferred habitat. Domestic dogs and cats that are not managed properly pose threats to a range of species, e.g. koalas, small ground or near ground nesting bird species.

Some agricultural chemical uses may also reduce the condition and abundance of food sources. Conversely crop production can provide an abundance of food sources for short periods. Some industries and workplace practices provide an unwise abundance of food for species such as the Silver Gulls, particularly at tips, school grounds and car parks.

Miners Rest, Winter and Flaxmill Swamps are part of valued systems used by migratory birds in particular.

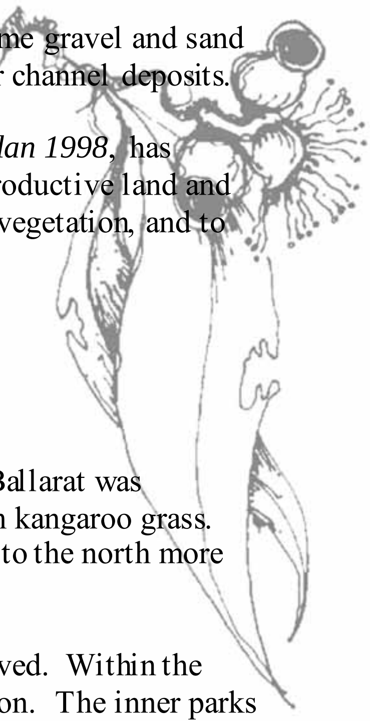
Habitat changes have drastically reduced native fish numbers throughout Victoria. The waters of the Ballarat region have been severely modified through the clearing of forest in the catchments, mining activities, pollution, urbanization, altered flow rates, sediment loads and stream profiles, removal of riparian vegetation and the introduction of alien fish species. Consequently, native fish populations are few and fragmented in their distributions. However, the region has great potential for habitat restoration and the re-introduction of a range of native fish to its many lakes, reservoirs, dams and swamps.

## 2.4 Settlement History & Its Impact on the Ecology of Ballarat

### 2.4.1 Introduction

The first white settlers to the region came in the 1830s to graze cattle and sheep. The gold rush from the 1850s to the early twentieth century devastated much of the natural vegetation along the streams and on the hills that surrounded the gold settlement of Ballarat. Although endowed with areas of productive farmland, used mainly for crops and grazing, salinity (in the south and the north-east) and erosion (in the east and north-west) are issues in the City.

Much of the development of the Ballarat region has been based on the exploitation of minerals. The region is still recognised as a significant gold mineralisation province. Non metallic minerals are also mined such as kaolin clay and silica, together with a substantial



extractive stone industry based predominantly on basalt quarries, with some gravel and sand sourced from old deep lead mine waste dumps, formed from ancient river channel deposits.

The City of Ballarat in its land management plan, the *Ballarat Strategy Plan 1998*, has embraced a philosophy of urban consolidation to counteract the loss of productive land and adverse impacts on the natural environment, in particular areas of native vegetation, and to assist in the management of salinity and erosion problems.

### 2.4.2 The Original Vegetation of the City of Ballarat

*Source: Urban Nature Conservation in the Greater Ballarat Area (1989).*

In the journals of George Robinson (Presland 1977) the country around Ballarat was described as undulating with open forest, the ground thickly covered with kangaroo grass. Mount Buninyong however is described as thickly timbered and the land to the north more open with "stunted gum, peppermint, honeysuckle, cherry tree etc".

Much of the original vegetation as described by Robinson has been removed. Within the inner urban environment, reserves of natural fauna and flora are uncommon. The inner parks and reserves consist of traditional exotic landscape types with emphasis on floral displays, cropped lawns, etc. with little native flora. Away from the inner urban areas, however, a number of sites carry native vegetation of varying quality. These include Mount Buninyong, Nerrina Historic Reserve and the Creswick Forest, the Canadian State Forest, the Union Jack Reserve and Lakes Burrumbeet and Learmonth.

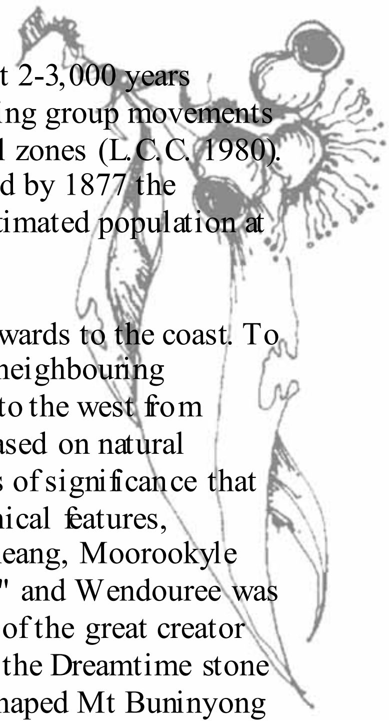
Areas of private land in the Ballarat also have important nature conservation values. These include residential and rural areas where native vegetation has been retained, such as in Mount Helen, Mount Clear, Buninyong, Scotsburn and Durham Lead. However many of these areas are still subject to extensive development for both residential and hobby farm purposes.

There is good evidence from Noosa Shire in Queensland that the chance of koalas being present declines rapidly as the percentage of koala habitat or forest falls below around 60-70% of the landscape (Figure 3). Similar evidence from Port Stephens on the New South Wales central coast suggests that the probability of koalas being present falls as the percentage of koala habitat or forest falls below around 40% (Figure 3). Where the percentage of primary and secondary habitat represents less than around 30% (Port Stephens) to 50% (Noosa) of the landscape, then there is a greater likelihood of koalas being absent. Although the amount of primary and secondary habitat is crucial, the importance of the total amount of forest in the landscape indicates that having adequate amounts of marginal or low quality habitat, in conjunction with primary and secondary habitat, is an important component for maintaining viable koala populations.

### 2.4.3 The Aboriginal Community

*Source: Ballarat Region Conservation Strategy (1999) and Urban Nature Conservation in the Greater Ballarat Area (1989)*

Little is known of the prehistory of Victoria, but studies suggest that the area was settled sometime between 18,000 and 30,000 years B.P.



Studies by the Victorian Archaelogical Survey suggest that over the past 2-3,000 years Aborigines operated a relatively specialized subsistence strategy involving group movements to exploit food resources seasonally available in different environmental zones (L.C.C. 1980). From around 1834 European settlers had a rapid and decisive impact and by 1877 the indigenous population in Western Victoria had fallen to 170 from an estimated population at the time of contact of approximately 1,800 persons.

The Wathaurung people occupied most of the Ballarat region and southwards to the coast. To the north-east from Daylesford there lived a sub-group of Kurung with neighbouring communities of Jajawurrong to the north from Clunes and Tjapwurong to the west from Beaufort. Each community held its own tract of land with boundaries based on natural features. In the Ballarat district there are more than 100 indigenous sites of significance that have been identified to date. Many Aboriginal place names of geographical features, localities and properties such as Mt Warrenheip, Gong Gong, Kooroocheang, Moorookyle and Bolwarrah have survived. Indeed, Ballaarat signifies "resting place" and Wendouree was translated as "be off". We know that Lal Lal Falls was the special place of the great creator Bunjil (Bungal) and legends tell about the emu lady of Burrumbeet and the Dreamtime stone axe battle at the place of red gums (Warrebaal, Pitfield Plains), which shaped Mt Buninyong and Mt Elephant. Langi Ghiran is significant for its rock paintings. Stone wells can be seen near Talbot and Aboriginal oven mounds remain in grazing paddocks in the vicinity of Mt Beckworth.

The locations and significance of ritual grounds were known to only a single custodian and that knowledge may be lost forever as the present Aboriginal community of Ballarat (estimated to number 1,000) is largely represented by persons displaced from other areas. The original inhabitants of the region shared the age-old belief of oneness with the land, with deep spiritual ties and absolute economic dependency. The Koori people saw themselves as custodians, holding the land in trust and caring for it responsibly as it passed from generation to generation. The elders had an intricate knowledge of geography, seasonal changes and the uses for the hundreds of plants and animals that sustained them.

Little is known about how local indigenous people utilised koalas. However, Ted Lovett, the chairperson for the Ballarat Aboriginal Cooperative explained during a personal communication that the Wathaurung people had a varied diet, although their main food sources were plants. It is known that there were some thousands of plant species that provided food and medicine. The Wathaurung also ate fish and eels. Meat played a smaller part in the Wathaurungs' diet, as it was far easier to gather rather than to hunt for food in forested areas.

Exact details on the utilisation of koalas for cloaks, etc are not readily available. However, we know from other communities, e.g. the D'harawal, that koalas did not form any part of their diet because they believed that the koalas were once a clan of their group, who, because they did not share their warm cloaks during a time of great cold, and who stole the water of the other clans, grew claws on their feet, and were banished to the tree tops as punishment. That is also why the koalas only drink water during times of drought, and why they leave a print the same as a human thumb when they walk upon the ground.

### 2.4.4 European Settlement

**Removal of Vegetation**

Much of the native vegetation that existed in the City prior to settlement has been removed or substantially modified. Remnant native vegetation exists in small pockets on private land scattered across the City as well as along linear reserves (waterways, road reserves, rail reserves) and on other public land. Remnant native vegetation includes trees, shrubs, grasses and herbs. The Australian Terrestrial Biodiversity Assessment 2002 (http://audit.deh.gov.au/ANRA/vegetation/docs/biodiversity/bio_assess_contents.cfm) identifies that within the Victorian Volcanic Plains Bioregion, of which Ballarat is a part, "greater than 95% of all native vegetation has been cleared. Seventy-eight ecological vegetation classes and floristic communities have been mapped in the Bioregion. Fifteen percent of these are probably extinct and 78% threatened. Plains grassland and grassy woodlands once covered three quarters of the sub region. Today only approximately 1% remains, and much of this is degraded." The report classifies the Victorian Volcanic Plains as being in the "highest stress class".

**Population Distribution in what is now the City of Ballarat**

Several strategic development plans identify environmentally sensitive land in the Buninyong and Canadian Wards and acknowledge the need to use caution when considering population expansion in these areas; e.g. Canadian Valley Outline Development Plan 2005, Ballarat Region Conservation Strategy 1999.

The eastern half of the City, where the urban areas of Ballarat are concentrated, contains the majority of treed native vegetation, together with vegetated corridors along the Yarrowee River and its tributaries.

### 2.4.5 Bushfires in the City of Ballarat

Bushfires are an infrequent occurrence in the City of Ballarat, owing to the City containing few large areas of native vegetation on public land, the Canadian Forest, which is subject to frequent fuel reduction burns, being the exception. Major threats of bushfire have in the past come from the Creswick Forest to the north and from the Enfield Forest to the south. However, a small number of fires have been documented that originated from within the pine plantations that are located mainly in the Mt Clear and Canadian areas. Most native vegetation on public land in City of Ballarat is found on relatively small allotments with little connectivity to other forested areas, therefore reducing the risks for a fire gathering speed and posing a threat to the local koala population.

### 2.4.6 Koala Sightings and Koala Hunting within the City of Ballarat

There are very few historical records and data available on koalas in the Ballarat area. It appears that they were either rarely observed or not reported on in the lives of the early settlers. Most of the historical information available on koalas within the area is anecdotal, held by people whose families have lived in the area for generations.

It appears that koalas in Ballarat suffered the same fate as the majority of koala populations in

Victoria. The only time koalas appear to have been reported in the historical literature for the area prior to the 1960s was around the turn of the century when they were hunted for their skins. Koala populations in Victoria declined drastically during the early1900s. By the 1930s, the koala on the Victorian mainland was thought to be confined to a few remnant populations in South Gippsland and the Mornington Peninsula (Lewis 1954).

Several re-introductions of koalas into the Ballarat area initially in the 1950s and 60s from French Island and on an irregular basis up to as late as 1997 form the basis of what we refer to as Ballarat's koala population today. This fact is supported by several residents interviewed during the Ballarat Residents Koala Survey, who reported no sightings of koalas in the 1940s but a reappearance of individuals in the late 1950s.

## 2.5 Conclusions

Many variables may have contributed to the distribution of today's koala population in the City of Ballarat. Vegetation removal for agriculture and activities associated with gold mining probably account for the greatest influence especially when considering historical aspects. In more recent times, after re-introduction of koalas to Ballarat, the ongoing urban sprawl is the driving force for changes to koala habitat and therefore koala distribution.

Following European settlement, clearing of forests and woodlands on the most arable lands may have contributed to the contraction of the koala population to the poorer Messmate / Peppermint dominated country of the Canadian Valley area. Prior to clearing, the arable land may have provided the most preferred habitat for koalas. Subsequently, today primary koala habitat has been significantly reduced to a few isolated / fragmented areas.

The information supplied by Ted Lovett from the Ballarat Aboriginal Cooperative suggests that indigenous people would have had little impact on the local koala population, as it appears that koalas did not constitute part of their diet.

Bushfires within the current City of Ballarat area appear to have had little influence on the present distribution of koalas in the area.

# 3. METHODOLOGY

The methodology and results that follow in relation to the Vegetation Mapping and Field Survey components of the Plan are also presented in the Ballarat Koala Habitat Atlas (Callaghan, Mitchell, Thomson & Bailey 2004). The **field survey methodology** is presented in detail within a paper (Phillips & Callaghan 2000) published in *Wildlife Research*. The full paper is included as Appendix 1 to this document.

## 3.1 Community-based Koala Survey

### 3.1.1 Introduction

The Ballarat Community-based Koala Survey (2002) was modelled on that undertaken in conjunction with preparation of the Draft Port Stephens Koala Management Plan (1994). The layout for reporting the results of the community survey is based on that included within the Draft Port Stephens Koala Management Plan (1994) and the subsequent approved and adopted Port Stephens Council Plan (2001).

The survey sought to obtain both contemporary and historical records of community koala sightings for the City of Ballarat within the living memory of residents. The survey also sought to gauge community attitudes to a range of potential management options for the conservation of the local koala population.

### 3.1.2 Methods

The Ballarat Residents Koala Survey has been reported on separately from this Plan and the entire document including description of the methodology is available via the City of Ballarat's webpage at: http://www.ballarat.vic.gov.au/Files/Ballaratresidentskoalasurvey.pdf

The information from the written part of returned surveys was recorded as coded data within an Access database, while records of koalas were entered into a data base and subsequently displayed in a GIS based mapping program.

## 3.2 Vegetation Mapping

Accurate vegetation mapping was considered to be the most important of the data layers required for koala habitat identification.

The vegetation map compiled for this report represents the culmination of many years work by many organisations and individuals. The map was commissioned to provide vegetation information specifically for the development of a Koala Habitat Atlas and Koala Planning Map for the City of Ballarat, as part of the comprehensive Koala Plan of Management prepared by the Australian Koala Foundation for the City.

The level of detail in this map is unprecedented for a map covering such a large area (73,870 ha), with 59 distinctive forest / woodland vegetation types and communities identified and mapped.

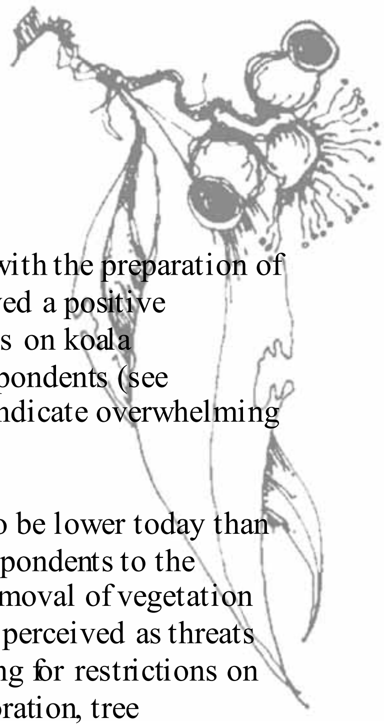
Vegetation data in the form of 163 field sites was collected by the AKF, the Centre for Environmental Management (University of Ballarat) and University of Queensland researchers over the period 1996-2004, primarily for the purposes of koala habitat assessment and koala habitat use. Data collected included species and diameter-at-breast-height (dbh) for all trees with dbh greater than 10 cm within a 20-metre radius. For vegetation mapping specifically, 72 additional vegetation sites were collected in 1996, a further 39 sites within the City in 2003-2004 and 176 sites within a five kilometre buffer around the City in 2004. These "secondary sites" were collected to fill in perceived gaps in the vegetation information derived from koala habitat data, and consisted of either estimated species abundance or species foliage projective cover depending on the various field data collectors.

State Forest Resource Inventory (SFRI) GIS data was supplied for Crown Lands within the City by the Department of Sustainability and Environment. This data contains information on forest structure and species composition (DSE 2001). Of 1,318 polygons in this dataset, 953 contained actual species information. Inspection of this data in conjunction with collected field data indicated that many polygons could be confidently split on the basis of aspect and the species mix redistributed. Additional aerial photo interpretation undertaken by the Centre for Environmental Management was also incorporated into the mapping.

Additional vegetation data was collected opportunistically and noted directly onto maps printed for this purpose. This data was invaluable for identifying isolated forest fragments. A draft version of the map was circulated to local botanical experts for comment, with the resulting information being incorporated into the final map.

### 3.3 Koala Habitat Atlas - Field Survey

Habitat utilisation and tree species preferences of koalas in the study area were assessed using a plot based survey methodology developed by the Australian Koala Foundation for the purposes of the Koala Habitat Atlas Project. The survey methodology involves random stratified plot site selection, in conjunction with targeted surveys to sample the range of edaphic and floristic variables to the fullest extent possible and to ensure that statistically useful data sets are compiled for each tree species. The methodology is detailed in the Ballarat Koala Habitat Atlas (Callaghan, Mitchell, Thomson & Bailey 2004) and in Phillips and Callaghan (2000).



# 4.0 RESULTS

## 4.1 Community-based Koala Survey

The Ballarat Community-based Koala Survey was undertaken to assist with the preparation of a Koala Plan of Management for the City of Ballarat. The survey received a positive response, highlighting the importance that the Ballarat community places on koala conservation. Overall, the numerous and varied comments made by respondents (see http://www.ballarat.vic.gov.au/Files/Ballaratresidentskoalasurvey.pdf) indicate overwhelming support for koala conservation in the City of Ballarat.

There was a general indication that residents perceived koala numbers to be lower today than in the past. The main concerns to koala survival, as expressed by the respondents to the survey, were logging of native forests, housing developments and the removal of vegetation on private land and along roadsides. Roaming dogs and roads were also perceived as threats to koala safety. Interestingly the overall percentage of respondents calling for restrictions on dog ownership, traffic management, more tree planting and habitat restoration, tree preservation orders as well as stronger planning controls was higher than the percentage of respondents that felt these issues pose a threat to koalas. This suggested that the community has concerns about the environment in general, in addition to issues that relate specifically to koala conservation.

The survey indicated support for habitat restoration programs and tree preservation followed by restrictions on dog ownership, traffic management or speed restrictions, stronger planning controls, employment of a Council wildlife specialist, and use of covenants over private land.

Employment of a wildlife officer in Council was seen as being able to greatly assist with planning to meet the needs of wildlife in conjunction with future development within the City, including provision of advice to Council planning staff. Other possible duties of a wildlife officer were identified as:

- Coordination of flora and fauna and biodiversity surveys,
- Preparation of grant applications for conservation programs,
- Coordination of habitat restoration programs,
- Weed and feral animal surveys and management, and
- Provision of advice to the public,
- Community education.

Continuing commitment by the Ballarat City Council towards koala conservation means that the Australian Koala Foundation Liaison Officer will be able to undertake these tasks and thereby continue the work of widening the level of koala-based education and conservation work throughout the Ballarat community.

In addition, Council officers in various areas of Council's operations, including Strategic Planning, Statutory Planning and Parks and Environment, are also involved in carrying out these duties to varying degrees. However, most of this work is carried out incidentally to the main duties of staff and therefore requires additional recognition as legitimate and necessary in terms of their essential roles and the task of implementing the Koala Plan of Management.

Actions contained in Part 1 set out tasks to be undertaken by Council staff to assist with implementation of the Plan.

## 4.2 Vegetation Mapping

The emphasis of the vegetation mapping has been on identifying the Forest and Woodland Vegetation communities within the City of Ballarat according to the dominant eucalypt (tree canopy) species, which is important for the purposes of the Koala Plan of Management.

PATN Version 3.03 Pattern Analysis software (Belbin 2004) was used to group sites with similar species composition characteristics.

Underlying geology was the major environmental determinant in association grouping in the PATN analysis.

Aspect was the least-important environmental factor in the association measures, which is somewhat surprising considering the influence of aspect apparent from field observation. It may be that this variable has a more direct influence on species presence, for example the rarity of *E. obliqua* (Messmate) and *E. viminalis* subsp. *viminalis* (Manna Gum) on drier northern aspects.

In the following vegetation community descriptions, vegetation communities are grouped firstly according to the five broad geological types shown in Figure 2, and then as alphabetical subgroups detailing the particular mixes of species as defined by PATN and supplementary field data. Within each geological group the subgroups intergrade between dominant species ratios depending on the environmental factors used in the PATN analyses. The subgroup or community name describes whether the community is predominately found as open forest and/or woodland. The total area is also shown for each community.

The full details of the **vegetation analysis** are included in Appendix 1. The information includes details of the specific geographic locations of each vegetation community and the variants within each community, in terms of species composition.

The following vegetation communities are those that have been identified in conjunction with the **mapping exercise** (see Appendix 5). Many of the identified communities are small in area and most have been reduced extensively by clearing for settlement over the past 150 years. **The data collected illustrates the dramatic and irreparable loss of native vegetation in the City and therefore the unequivocal importance of protecting and enhancing the areas of woodland vegetation that remain for broad ecological reasons as well as for the koala.**

**The data identifies the area of each vegetation community as a percentage of the total area for each geological area in which that vegetation community is located, figures that dramatically highlight the loss of native vegetation on most geologies with the exception of the relatively infertile Ordovician geologies, which nonetheless have been heavily degraded due to the impacts of gold mining and subsequent settlement.**

**<u>Group A: Vegetation Communities on Devonian Granite and Granodiorite</u>** - percentage of total geological area: **18.2%**

**1.** *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) woodland / scattered woodland (132.5 ha).
**2.** *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) with *Eucalyptus obliqua* (Messmate) open forest / woodland (127.1 ha).
**3.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) open forest / woodland (192.2 ha).
**4.** *Eucalyptus ovata* (Swamp Gum) open forest / woodland (1.3 ha).
**5.** *Eucalyptus ovata* (Swamp Gum) / *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland (37.4 ha).
**6.** *Eucalyptus ovata* (Swamp Gum) with *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) open forest / woodland (13.4 ha).
**7.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) / Mixed eucalypt open forest / woodland (41.0 ha).
**8.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus ovata* (Swamp Gum) and *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest /woodland (18.3 ha).

Total vegetation: 563.2 ha.

**Structure:**
*Canopy:* 10-15 metres in height
*Understorey:* 6-10 metres in height, sparse
*Shrub layer:* 1-3 metres in height, sparse
*Ground flora:* < 1 metre in height, sparse to dense

**Floristics:**
*Understorey:* The understorey tree layer consists of *Acacia melanoxylon, Exocarpus cupressiformis* and *Acacia mearnsii.*
*Shrub layer:* Mostly scattered *Acacia paradoxa*. *Solanum laciniatum* occurs in disturbed sites. *Correa reflexa* is found on rocky outcrops on Mount Beckworth.
*Ground flora:* The ground layer is dominated by *Pteridium esculentum* and grasses including *Danthonia geniculata* and *Stipa sp.*. *Lomandra longifolia* and *Poa labillardieri* occur, particularly in the wetter gullies.

**<u>Group B: Vegetation Communities on Newer Volcanics</u>** - percentage of total geological area: **0.75%**

**9.** *Eucalyptus brookeriana* (Brooker's Gum) with *Eucalyptus rubida* (Candlebark) and *Eucalyptus radiata* (Narrow-leaf Peppermint) woodland (2.4 ha).
**10.** *Eucalyptus melliodora* (Yellow Box) scattered woodland (23.1 ha).
**11.** *Eucalyptus obliqua* (Messmate) open forest / woodland (24.9 ha).
**12.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus ovata* (Swamp Gum) and *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (5.2 ha).
**13.** *Eucalyptus obliqua* (Messmate) with *E. viminalis* subsp. *viminalis* (Manna Gum) and *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest (50.9 ha).
**14.** *Eucalyptus obliqua* (Messmate) with *E. viminalis* subsp. *viminalis*) (Manna Gum)

open forest / woodland (69.5 ha).

**15.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland (43.4 ha).

**16.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus dives* (Broad-leaf Peppermint) open forest / woodland on Newer Volcanics (4.7 ha).

**17.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus obliqua* (Messmate) open forest / woodland (6.6 ha).

**18.** *Eucalyptus aromaphloia* (Scentbark) / *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) open forest/scattered woodland (68.7 ha).

Total vegetation: 299.4 ha.

**Structure:**

*Canopy:* 20-22 metres in height
*Understorey:* 5-12 metres in height, sparse
*Shrub layer:* 1-3 metres in height, isolated plants to very sparse
*Ground flora:* < 1.5 metres in height, dense

**Floristics:**

*Understorey: Acacia melanoxylon* is the most common small tree. Other species include *Exocarpus cupressiformis* and *Acacia mearnsii* .

*Shrub layer:* Scattered shrubs can include, *Acacia paradoxa, Acacia verticillata, Daviesia leptophylla, Leptospermum continentale* and *Pultenaea gunnii.*

*Ground flora: Pteridium esculentum* is consistently found in this community. Other species can include *Poa sieberiana* var. *sieberiana, Poa labillardieri, Chionochloa pallida* and *Dianella revoluta.* Occasional scattered populations of *Bursaria spinosa*, *Pimelia axiflora*, *Pultenaea daphnoides* and *Goodia lotifolia*

**Group C: Vegetation Communities on Ordovician geology** - percentage of total geological area: **32.5%**

**19.** *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (44.6 ha).

**20.** *Eucalyptus aromaphloia* (Scentbark) with *Eucalyptus obliqua* (Messmate) open forest / woodland (70.1 ha).

**21.** *Eucalyptus aromaphloia* (Scentbark) / *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (42.1 ha).

**22.** *Eucalyptus dives* (Broad-leaved Peppermint) with *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (39.9 ha).

**23.** *Eucalyptus dives* (Broad-leaved Peppermint) with *Eucalyptus aromaphloia* (Scentbark) and/or *Eucalyptus obliqua* (Messmate) open forest / woodland (509.7 ha).

**24.** *Eucalyptus dives* (Broad-leaved Peppermint) / *Eucalyptus obliqua* (Messmate) open forest / woodland (628.4 ha).

**25.** *Eucalyptus obliqua* (Messmate) woodland (68.4 ha).

**26.** *Eucalyptus obliqua* (Messmate) open forest / woodland (353.3 ha).

**27.** *Eucalyptus obliqua* (Messmate) / *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (474.5 ha).

**28.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus dives* (Broad-leaved Peppermint) open forest / woodland (885.8 ha).

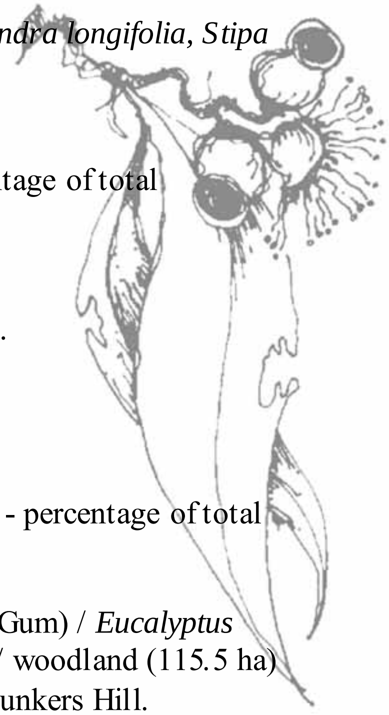
**29.** *Eucalyptus obliqua* (Messmate) / *Eucalyptus dives* (Broad-leaf Peppermint) /

*Eucalyptus baxteri* (Brown Stringybark) open forest / woodland (311.2 ha).
**30.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus dives* (Broad-leaved Peppermint) and *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (598.7 ha).
**31.** *Eucalyptus rubida* (Scentbark) / *Eucalyptus melliodora* (Yellow Box) open forest / woodland (46.4 ha).
**32.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus ovata* (Swamp Gum) open forest / woodland (106.7 ha).
**33.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus radiata* (Narrow-leaf Peppermint) and *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (754.7 ha).
**34.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus rubida* (Candlebark) open forest / woodland (97.0 ha).
**35.** *Eucalyptus obliqua* (Messmate) with *E. viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland (87.8 ha).
**36.** *Eucalyptus ovata* (Swamp Gum) open forest / woodland (30.7 ha).
**37.** *Eucalyptus ovata* (Swamp Gum) with *Eucalyptus obliqua* (Messmate) and Peppermint open forest / woodland (111.4 ha).
**38.** *Eucalyptus ovata* (Swamp Gum) with *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland (4.7 ha).
**39.** *Eucalyptus ovata* (Swamp Gum) / *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest (37.6 ha).
**40.** *Eucalyptus radiata* (Narrow-leaf Peppermint) with *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (53.9 ha).
**41.** *Eucalyptus radiata* (Narrow-leaf Peppermint) with *Eucalyptus obliqua* (Messmate) open forest / woodland (75.8 ha).
**42.** *Eucalyptus radiata* (Narrow-leaf Peppermint) / *Eucalyptus rubida* (Candlebark) scattered woodland/scattered trees (38.6 ha).
**43.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus obliqua* (Messmate) open forest (117.7 ha).
**44.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus ovata* (Swamp Gum) open forest (70.4 ha).

Total vegetation: 5,555.07 ha.

**Structure:**
*Canopy:* generally 12-18 metres in height, but can be across the range of 10-22 metres
*Understorey:* 3-12 metres in height, sparse to very sparse
*Shrub layer:* 1-3 metres in height, very sparse to medium dense
*Ground flora:* < 1.5 metres in height, sparse to dense

**Floristics:**
*Understorey: Acacia melanoxylon* is the most common small tree. Other species include *Exocarpus cupressiformis, Acacia mearnsii* and *Acaia dealbata* . *Allocasaurina littoralis* is found in some areas.
*Shrub layer:* Scattered shrubs can include *Acacia paradoxa, Acacia verticillata, Daviesia leptophylla, Epacris impressa* and *Pultenaea gunnii.* Occasional populations of *Bursaria spinosa, Leptospermum continental, Leptospermum myrsinoides, Xanthorrhoea australis, Pimelia axiflora, Pultenaea daphnoides, Goodia lotifolia, Pomaderris sp., Cassinia spp.* are also present.
*Ground flora: Pteridium esculentum* is consistently found in these communities. Other species can include *Xanthorrhoea minor, Poa sieberiana* var. *sieberiana, Poa*



*labillardieri, Chionochloa pallida, Danthonia geniculata, Lomandra longifolia, Stipa spp.* and *Dianella revoluta.*

**Group D: Vegetation Communities on Recent Alluvial Soils** - percentage of total geological area: **1.0%**

**45.** *Eucalyptus yarraensis* (Yarra Gum) woodland (5.5 ha).
**46.** *Eucalyptus camaldulensis* (River Red Gum) woodland (29.2 ha).

Total vegetation: 34.7 ha.

**Group E: Vegetation Communities on Pliocene/Pleistocene Gravels** - percentage of total geological area: **7.9%**

**47.** *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) / *Eucalyptus aromaphloia* (Scentbark) / *Eucalyptus obliqua* (Messmate) open forest / woodland (115.5 ha) This community is found on Pliocene gravels/Ordovician low rises at Bunkers Hill.

**48.** *Eucalyptus ovata* (Swamp Gum) woodland (5.4 ha). This community occurs only on Pliocene gravel alluvial fan outwash derived from Bunkers Hill; its areal extent has been reduced by gravel extraction.

Total vegetation: 120.9 ha.

**Group F: Vegetation Communities on Various Geologies**

**49.** *Eucalyptus aromaphloia* (Scentbark) open forest / woodland on Ordovician shales and Pliocene/Pleistocene gravels and sands (i.e. low nutrient) (140.0 ha).
**50.** *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (33.2 ha). *E. radiata* is the only species in this community, which occurs on more fertile soils on several different geologies.
**51.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) / *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (50.9 ha).

Total vegetation: 224.1 ha.

**Total vegetation – groups A to F: 563.2 ha.**

**Group G: Planted / non-indigenous Species** – 3,221.2 ha.

**52.** Native forest regrowth (155.8 ha). Most regrowth areas are small, with the largest patches found on Mt Bolton.
**53.** *Eucalyptus globulus* subsp. *globulus* (Tasmanian Bluegum) plantations (595.9 ha).
**54.** *Pinus radiata* (Monterey Pine) plantations (2,046 ha).
**55.** Native forest with a high proportion of mature *Pinus radiata* (51.6 ha).
**56.** Other planted *Eucalyptus* species (88.0 ha). This group includes species planted in urban areas and on farms as shelterbelts and windbreaks.
**57.** *Salix* spp. (Willow) woodland (25.9 ha). *Salix* spp. occur along many watercourses,

sometimes with other exotic species.

**58**. Exotic tree species (233.5 ha). Includes urban and rural tree plantings, occasionally with some remnant native species interspersed.

**59.** Unknown communities (24.5 ha).

## 4.3 Koala Habitat Atlas - Field Survey Results

A total of 3,031 trees comprised of 2,901 eucalypts and 130 non-eucalypts from 63 plot sites were assessed during the field survey component. A detailed presentation and discussion of the survey results has been provided in the ***Ballarat Koala Habitat Atlas*** at Appendix 2.

The Ballarat Koala Habitat Atlas (Callaghan, Mitchell, Thomson & Bailey 2004) identified the extent and distribution of koala habitat in the City based on a categorisation of the forest and woodland communities in terms of the relative abundance of preferred tree species in conjunction with the soil types. The field survey results and subsequent analysis support a model of koala habitat utilisation in the City of Ballarat that is primarily based upon the **Manna Gum *Eucalyptus viminalis ssp. viminalis*** as the preferred food source of koalas. This eucalypt species was shown to be the subject of significant levels of utilisation by koalas in the study area. However, it has also been identified that the relative lack of this species within the City means that **Messmate Stringybark *Eucalyptus obliqua*** is utilised extensively by koalas as a substitute food source. These two tree species are best described as 'primary' koala food tree species and **constitute the preferred koala food trees for the City of Ballarat** and their identification as such provides the basis for the koala habitat model and associated mapping (See Chapter 5).

Blue Gum *Eucalyptus globulus ssp. globulus* was classed as a likely 'primary' koala food tree species when occurring outside of a plantation situation.

Brown Stringybark *Eucalyptus baxteri* and Rough-barked Manna Gum *Eucalyptus viminalis ssp. cygnetensis* were used to a lesser extent but were still used significantly and were therefore classified as 'secondary' koala food tree species.

Koalas are also known to utilise a number of other *Eucalyptus* and non-eucalyptus tree species within the City of Ballarat including *Acacia Melanoxylon* (Blackwood) which was identified by as receiving the most significant use by koalas amongst the non-eucalyptus tree species.

The criteria used to categorise and model koala habitat for the Ballarat Koala Habitat Atlas are outlined in Section 5.1.

Densities for species were determined on the basis of data from field based Atlas plot assessments together with descriptions for each of the identified floristic associations provided in the vegetation mapping report.

# 5. KOALA HABITAT IDENTIFICATION AND MAPPING

## 5.1 Koala Habitat Categories

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

**Primary Habitat**

*Areas of forest or woodland where primary koala food tree species comprise at least 50% of the over-storey trees.*

Manna Gum *Eucalyptus viminalis ssp. viminalis* has been identified as the 'primary' koala food tree species for the City of Ballarat with Messmate Stringybark *E. obliqua* substituting in this role owing to the overall lack of *E. viminalis ssp. viminalis* within the City. Blue Gum *E. globulus ssp. globulus* has been classed as a likely 'primary' koala food tree species when occurring outside of a plantation situation. The Australian Koala Foundation and the plantation industry are currently investigating the relationship between Blue Gum plantations and koalas. Results from this investigation might influence the final classification of the species.

Approximately 2,651 hectares of Primary Koala Habitat was identified and mapped in the City of Ballarat.

**Secondary Habitat (Class A)**

*Areas of forest or woodland where primary koala food tree species comprise less than 50% but at least 30% of the over-storey trees; or*

*Areas of forest or woodland where primary koala food tree species comprise less than 30% of the over-storey trees, but together with secondary food tree species comprise at least 50% of the over-storey trees; or*

*Areas of forest or woodland where secondary food tree species alone comprise at least 50% of the over-storey trees (primary koala food tree species absent).*

Brown Stringybark *Eucalyptus baxteri* and Rough-barked Manna Gum *Eucalyptus viminalis ssp. cygnetensis* have been classified as 'secondary' koala food tree species. If Manna Gum *E. viminalis ssp. viminalis* were more prevalent within the City, then Messmate Stringybark *E. obliqua* would also be classified as a 'secondary' koala food tree species.

Approximately 2,651 hectares of Secondary (Class A) Koala Habitat was identified and mapped in the City of Ballarat.

**Secondary Habitat (Class B)**

*Areas of forest or woodland where primary koala food tree species comprise less than 30% of the over-storey trees; or*

*Areas of forest or woodland where primary koala food tree species together with secondary* *food tree species comprise at least 30% (but less than 50%) of the over-storey trees; or*

*Areas of forest or woodland where secondary food tree species alone comprise at least 30% (but less than 50%) of the over-storey trees (primary koala food tree species absent).*

Approximately 2,288 hectares of Secondary (Class B) Koala Habitat was identified and mapped in the City of Ballarat.

**Secondary Habitat (Class C)**

*Areas of forest or woodland where koala habitat is comprised of secondary and supplementary food tree species (primary koala food tree species absent except for possible scattered individual trees), where secondary food tree species comprise less than 30% of the over-storey trees.*

Approximately 4,752 of Secondary (Class C) Koala Habitat was identified and mapped in the City of Ballarat.

**Marginal Habitat**

*Areas of forest or woodland where koala habitat is comprised of secondary and/or supplementary food tree species, where secondary food tree species comprise less than 10% of the over-storey trees.*

Approximately 7,660 hectares of Marginal Koala Habitat was identified and mapped in the City of Ballarat.

**Unknown Habitat Value**

Areas of forest or woodland containing tree species considered likely to be the subject of significant levels of utilisation by koalas, but whose value cannot be quantified due to an absence of koala faecal pellet evidence.

## 5.2 Preparation of the Koala Habitat Planning Map

The ***Ballarat Koala Habitat Planning Map*** is depicted in Appendix 3.

In preparing the Koala Habitat Planning Map it was decided that Primary and Secondary Class A Koala Habitat categories from the Koala Habitat Atlas should be combined to define **Preferred Koala Habitat**. This decision was supported by the results from the intersection of koala records with the Koala Habitat Atlas.

Secondary Class B and C Koala Habitat from the Koala Habitat Atlas were renamed as **Supplementary Koala Habitat** for the Koala Habitat Planning Map.

**Marginal Koala Habitat** remained the same for both the Koala Habitat Atlas and the Koala Habitat Planning Map.

**Habitat Buffers** were added to all Koala Habitat areas, before **Habitat Linking Areas over**

**Supplementary Habitat** and certain other categories of habitat were included to complete the Koala Habitat Planning Map.

A separate ***Habitat Linking Areas for Restoration Map*** that shows potential habitat links connecting all categories of koala habitat, including Habitat Linking Areas over Mainly Cleared Land is also included in Appendix 3. **This map highlights those areas that could be revegetated and managed to provide important links between all areas of identified koala habitat, in the process helping to restore some of the original bushland character of these identified areas of the City and helping to implement relevant Council environmental strategies, including the LINCS (Linear Network of Communal Spaces) Strategy.**

It is recommended that **Core Koala Habitat** should include all areas **of Preferred and Supplementary Koala Habitat, Habitat Buffers and Habitat Linking Areas over Supplementary Habitat**. **Core Koala Habitat** should also include those areas where site-specific assessments indicate moderate or high koala activity in accordance with the Spot Assessment Technique (Phillips & Callaghan 1995).

**Habitat Buffers**

Habitat Buffers can contribute to the long-term survival of Preferred Koala Habitat by ensuring that incompatible *uses* or *developments* do not occur on immediately adjacent lands. Habitat Buffers may afford protection to Preferred Koala Habitat by minimising the detrimental impact of "edge effects" such as nutrient impacts, wind damage and weed invasion. Habitat Buffers provide for the likely extension of significant koala activity beyond areas of Preferred Koala Habitat. Even Habitat Buffers that extend over Mainly Cleared Land and Other Vegetation containing only scattered trees can perform this latter function. Such areas should be considered for habitat restoration projects where appropriate. In addition, Habitat Buffers over Supplementary Habitat (which provide a buffer to Preferred Koala Habitat) warrant protection and management through performance standards equivalent to those for Supplementary Koala Habitat.

A 100m Habitat Buffer was added to all Preferred Koala Habitat in recognition of the significance of this habitat category.

**Habitat Linking Areas**

The identification and effective management of Habitat Linking Areas is considered essential for effective conservation of koala populations. They potentially provide opportunities for the safe movement of dispersing sub-adult koalas between breeding populations or into areas of vacant habitat. Depending upon features such as the size and quality of the koala habitat they contain, Habitat Linking Areas may also provide opportunities for koalas to establish home ranges either as extensions from active breeding aggregations, or as an alternative for those animals that may be unable to establish a home range within higher quality habitat.

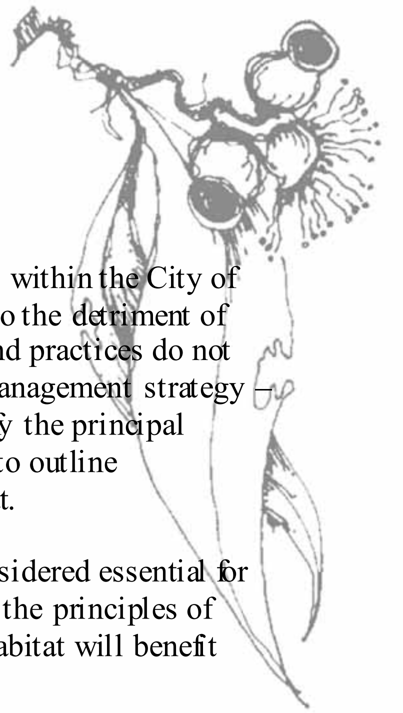
As koalas are capable of travelling considerable distances between trees (Moon 1990; Prevett 1991), Habitat Linking Areas that overlap with Mainly Cleared Land and Other Vegetation may still perform important functions. Such areas should be considered for habitat restoration projects where appropriate. Habitat Linking Areas over Supplementary Habitat should be subject to equivalent development standards to those applied to Supplementary Koala Habitat.

The process for modelling the Habitat Linking Areas involved the use of MapInfo GIS software to assign links wherever a temporary 3,500m buffer around 100 metre-buffered Preferred and Supplementary Koala Habitat areas either joined or overlapped, over areas of native vegetation.

### 5.3 Conservation Status of the Ballarat Koala Population

The habitat categories with the greatest potential for effective long-term conservation and management of the Ballarat koala population includes the Primary and Secondary (Class A) Koala Habitat, collectively designated as the Preferred Koala Habitat on the Koala Habitat Planning Map. Preferred Koala Habitat comprises a total area of 4,939 hectares or approximately 15.85% of the total area of the City and 28.3% of remaining forested lands. Supplementary Koala Habitat comprises a further 4,752 hectares or approximately 15.26% of the total area of the City and 27.2% of remaining forested lands.

Despite the wide degree of community interest in the koala in Ballarat and research that has been done over the years by various organisations, including the University of Ballarat and, more recently, the AKF, it is not possible to say how many koalas are living in Ballarat's native vegetation. The work that has been done to date has established the habitats used by koalas and accordingly where they can be found but not in what numbers. To determine koala numbers, various new research tasks, including the radio-tracking of koalas within all their different habitats, are required in order to establish the koalas' home-ranges, then to extrapolate this information across the habitat mapping that has been done.



# 6. HABITAT CONSERVATION

## 6.1 Introduction

In the absence of careful management, the remaining koala habitat areas within the City of Ballarat have the potential to become further degraded and fragmented to the detriment of koalas and other native species. Existing land management strategies and practices do not relate specifically to the restoration of koala habitat. Consequently, a management strategy – the Ballarat Koala Management Plan - is considered necessary to identify the principal impacts on koalas associated with the use and development of land and to outline opportunities to optimise koala habitat quality within the City of Ballarat.

Effective strategies to both conserve and to restore koala habitat are considered essential for the long-term survival of koalas in the City of Ballarat. Consistent with the principles of biodiversity conservation, the conservation and enhancement of koala habitat will benefit other local species of both native fauna and flora.

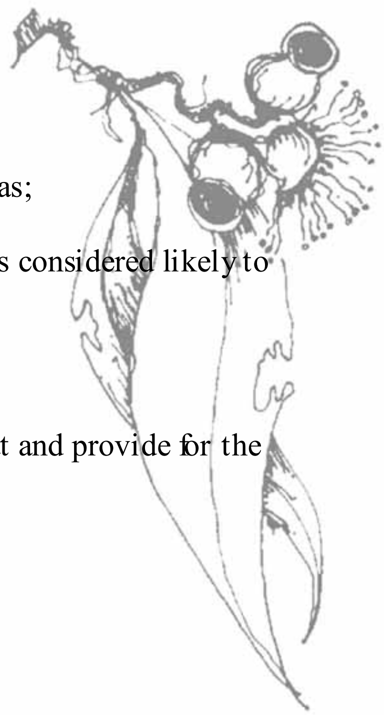
There are excellent opportunities to integrate the requirements for koala habitat conservation contained in the Plan with existing City strategies and policies, particularly at a time when a number are under review, will shortly be reviewed or where existing land management practices can be modified to incorporate the conservation of existing koala habitat. Relevant City strategies and policies include:

- The Ballarat Region Conservation Strategy 1999 (being re-packaged to apply to the City area as the *Ballarat Environmental Sustainability Strategy 2006*) – under review;
- The *Ballarat Municipal Strategic Statement* (and hence the implementation of the Ballarat Planning Scheme) – to be reviewed in 2007;
- The *Ballarat Open Space Strategy* – proposed for 2006-07.

Relevant strategic, management and regulatory processes do not just apply to those that are the responsibility of the City Council, but also those under the auspices of:

- The Department of Sustainability and Environment; e.g. Native Vegetation Framework implementation, Land for Wildlife program, management of areas such as the Canadian and Creswick Forests;
- Parks Victoria - management policies for areas such as the Nerrina Historic Reserve;
- Central Highlands Water – management of the land around reservoirs and the South Ballarat Treatment Plant for which the Authority is responsible in eastern Ballarat.
- Vicroads – management of roadside vegetation along State highways, e.g. the Midland and Western highways.

Integration with the work of community groups such as the Ballarat Environment Network Inc, through management of the BEN Biodiversity Reserves, a number of which exist in the eastern, bushland part of the City, and with private landowners is also going to be important in the effective management of koala habitat.



## 6.2 Objectives

The objectives of this chapter are to:

i) Identify principal impacts of land degradation on koala habitat areas;

ii) Identify areas where degradation to koala habitat has occurred or is considered likely to occur;

iii) Identify options for conserving koala habitat; and

iv) Provide an effective strategy to conserve and enhance koala habitat and provide for the long-term survival of koalas in the City of Ballarat.

## 6.3 Detrimental Impacts on Koala Habitat Areas

### 6.3.1 Koala Habitat Destruction, Degradation and Fragmentation

Habitat destruction and degradation have devastating effects on populations of koalas and other fauna. As well as potential death or injury to koalas during habitat clearing, habitat destruction and degradation is likely to increase pressure on adjacent habitat as remaining animals are confined to smaller areas, with individuals forced to live under sub-optimal conditions. The long-term effects on koala populations may include increased incidence of disease and mortality, and in severe cases, potential localised extinctions.

Habitat fragmentation can have significant implications for koalas and other fauna populations due to deleterious effects of inbreeding and increased threats from domestic and feral dogs, foxes, motor vehicles and bushfires. This is a particularly significant issue, given the current unknown size and density of the remaining local koala population. Hume (1990) contends that habitat fragmentation is the primary threat to koalas.

In addition to the aforementioned deleterious effects, koalas occupying fragmented habitat may also suffer nutritional stress, rendering them more susceptible to disease (Hume 1990). If one considers that the Ballarat koala population, as with most mainland koala populations, suffers from the sexually transmitted disease, *Chlamydia*, which in many cases severely affects reproductive success and general health of koalas, then the loss of any animals due to whatever factors is of considerable concern.

### 6.3.2 Feral Animals

Feral animals including dogs, foxes, cats and others are known to inhabit the City of Ballarat. Feral animals, particularly feral or roaming domestic dogs and foxes and to a lesser extent feral cats, are considered a threat to koalas and are addressed in Chapter 10 - Feral Animal Management.

The impact of feral animals such as dogs and foxes on koalas is exacerbated when habitat is fragmented, as koalas are forced to spend more time on the ground moving between trees, thus making them more vulnerable to predation (Hume 1990). Hence, restoration of fragmented habitat, in conjunction with measures aimed at controlling feral animals, should help to reduce the impact of feral animals on koalas.

### 6.3.3 Weed Infestation

Weeds could potentially impact on koala habitat by inhibiting natural germination and re-growth of native plant species including koala food trees and by affecting soil nutrient availability. The colonisation of koala habitat by infestations of weeds, particularly ground cover weeds can inhibit the germination and growth of native plant seedlings. Exotic grasses often replace native shrubs in areas where fires are frequent and tend to exclude the regeneration of native species. The impact of restricting future generations of koala food trees from colonizing a site involves the habitat being dominated by senescing trees with limited or no replacement koala food trees. The implementation of a weed control program to restore degraded koala habitat will assist in providing an essential food source for koalas in the long term.

### 6.3.4 Bushfires & Fire Management

Severe bushfires have the potential to significantly affect koala habitat and koala populations. Changed fire regimes can have a detrimental effect on koala habitat. Regular wildfire or hazard reduction burning can reduce or eliminate the growth of seedling koala food trees therefore leaving areas with only mature eucalypts remaining and no replacement trees (as per weeds). Fire tolerant species could eventually dominate and lead to changes in the plant community.

Habitat fragmentation can exacerbate the harmful effects of bushfires, with recolonisation of severely burnt habitat by koalas made difficult, or in some cases impossible, where these areas are isolated from unburnt habitat supporting breeding aggregations of koalas.

### 6.3.5 Urban Settlement & Rural Development

The most obvious degradation of koala habitat within the City of Ballarat has resulted from agricultural and urban development and the provision of services such as roads, water, sewage and electricity.

While the long-term survival of koalas within urban environments is questionable, koalas do currently exist in and/or adjacent to the Nerrina, Canadian and Buninyong wards.

## 6.4 Conservation Options

A number of options are available to conserve koala habitat through existing legislation, programs run by government agencies and planning instruments. The appropriate option for conserving a particular area of koala habitat will depend upon a number of factors including the nature of the habitat, its conservation significance and the land tenure.

### 6.4.1 Threatened Species Legislation

Fauna and flora considered to require specific management and protection can be listed under Victoria's *Flora and Fauna Guarantee Act 1988*. To date the koala has not been listed, despite attempts by the AKF and other community animal welfare and wildlife bodies to have this occur. The response from the Department of Sustainability and Environment, the State government department responsible for administering the Act and making recommendations about additions to the listing of species, has determined on the basis of evidence available to it that the koala is not a species threatened owing to small, fragmented populations or lack of suitable habitat. This differs from the situation in New South Wales where the koala is listed under that State's Threatened Species Act.

The Act details processes considered to be threatening to fauna and flora. The following listed threatening processes are of particular relevance to the management of the koala:

- Habitat fragmentation as a threatening process for fauna in Victoria.

- High frequency fire resulting in disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

- Inappropriate fire regimes causing disruption to sustainable ecosystem processes and resultant loss of biodiversity.

Although the koala is not listed as a threatened species under the Act, **the Act's objectives are applicable to the conservation of all of the State's flora and fauna a**nd the threatening processes listed are as much a threat to the survival of the koala as they are to other, rarer species.

The need for legislative protection is a matter the AKF is pursuing at national level. Completion and progressive implementation of the Ballarat Koala Plan of Management will provide important information about whether or not special protection is required, and what forms protection should best take to assist with the survival of the koala nationally. Strategically, one reason for pursuing the protection of the koala on a nation-wide basis is to spread the risks to which the koala is subject; e.g. disease, loss of habitat, genetic inbreeding, dog attacks, thus reducing the risk of the koala becoming a threatened or vulnerable species.

### 6.4.2 Land Use Planning

The *Planning and Environment Act 1987* establishes both the strategic and statutory framework for land use and environmental planning in Victoria. The Act establishes various mechanisms for managing land use with planning schemes based on municipal areas being at the heart of the system. The Act includes provisions for issuing planning permits (development approvals), amending planning scheme provisions and enforcing scheme controls and planning permit conditions.

Planning schemes include:

- **A Municipal Strategic Statement (MSS)** – a policy statement expressing land use, development and sustainability goals and strategies to achieve those goals for the municipality. It usually contains written commentary, including tables and maps, as background to the goals and strategies. There is opportunity to amend the MSS to include goals and strategies relating to the management of the koala;

- **The State Planning Policy Framework (SPPF)** – this part is common to all planning schemes in the State, being a statement of the State Government's policy on matters considered to be of state-wide or particularly strategic importance. Major environmental policies, linked to land use planning, are highlighted in this Framework, including the Native Vegetation Framework. The Victorian Koala Strategy is not mentioned in the SPPF. Council cannot amend the SPPF, however, the City of Ballarat and the AKF could request the State Government to amend the Framework to include appropriate reference to the Strategy. This inclusion would encourage and give direction to other councils to look at planning for survival of the koala;

- **Local Planning Policy Framework (LPPF)** – this part is developed by the individual council to express a council's position and approach on what it sees as priority land use planning and development matters, in particular how the development of land to accommodate particular uses is to be carried out; e.g. residential, commercial and industrial areas' development policy, stormwater management, open space provision. There is opportunity to amend the LPPF to include policy about how development should be undertaken to provide or allow for the presence of koalas in areas identified as containing koala habitat;

- **Land Use Zones** – zones are used to allocate areas of the municipal area for primary uses; e.g. residential, commercial, industrial, open space, farming, rural living, environmental protection. Land use zones, as a rule, are allocated across the whole of the municipal area. Zones frequently include controls relating to the density of allowable subdivisions of land. There is opportunity to alter existing land use zonings to provide zones, such as the Environmental Rural Zone, that are appropriate to areas frequented by koalas, in particularly those areas identified as Preferred Koala Habitat;

- **Overlay controls** – can be allocated to parts of a municipal area to control or manage particular aspects of the use and development of land as they may affect existing attributes of the land, particularly those of recognised natural or built heritage value; e.g. the management of native vegetation, historic buildings, structures, trees and landscapes. There is opportunity to amend the Ballarat Planning Scheme to apply overlay controls – most notably the Environment Significance Overlay (ESO) – to recognise the presence of Core Koala Habitat and to include provisions about the protection and enhancement of that habitat and to include requirements relating to the use and development of land that recognise and provide for the presence of koalas in the area by including a Schedule to the ESO in the planning Scheme. During 2006, Council is proposing introducing additional native vegetation protection controls through the extension of the Vegetation Protection Overlay. It would be advantageous to introduce proposed ESO provisions in conjunction with these additional vegetation protection controls in view of the strong association between the presence of native vegetation generally and Core Koala Habitat;

- **Specific use and development controls** – can be used to manage particular aspects of individual land uses; e.g. car parking provision, landscaping requirements. These controls generally apply to uses and developments no matter which zone or overlay control affects the use. Development provisions relating to matters such as koala-friendly forms of fencing or the control of domestic pets would be included under a Schedule to the ESO.

**Environmental Rural Zone**

The objectives of the Environmental Rural Zone are:

- To give effect to the environmental outcome specified in the schedule to this zone.
- To conserve and permanently maintain flora and fauna species, soil and water quality and areas of historic, archaeological and scientific interest and areas of natural scenic beauty or importance so that the viability of natural eco-systems and the natural and historic environment is enhanced.
- To encourage development and the use of the land which is in accordance with sound management and land capability practices, and which takes into account the environmental sensitivity and the bio-diversity of the locality.

**Other Zones**

Other zones within the Ballarat Planning Scheme that provide some degree of protection for koala habitat in accordance with their objectives and restrictions on development are the Rural Zone and the Rural Living Zone.

**Outline Development Plans (ODPs)**

The purpose of an Outline Development Plan is to provide for the comprehensive planning of areas proposed for urban development. ODPs specify in some detail the location for urban facilities such as schools, shops, open space and public facilities. They also set out a preferred main road layout and specify requirements for infrastructure services. They will also specify requirements for special features and areas that require special protection; e.g. native vegetation.

Ballarat City Council has recently completed the Canadian Valley ODP (2005). This ODP specifically recognises the existence and importance of koala habitat in Canadian Valley, drawing attention to the fact that through community consultation on the ODP, the local community recognised this importance. Thus the ODP includes specific provisions relating to the protection of koala habitat in the areas. This is a very significant achievement in terms of koala protection and management of important koala habitat in a rapidly developing part of Ballarat. It is proposed that this ODP will be incorporated into the Ballarat Planning Scheme, thereby having statutory effect.

Other ODPs are planned in the near future for Miners Rest and western Ballarat. Neither area contains koala habitat. In the future, ODPs may be prepared for Nerrina, Brown Hill and Ballarat East, all three areas containing significant areas of koala habitat. Information to be submitted with development applications;

**6.4.3 Development Assessment**

Many uses and developments are controlled by provisions contained within the Planning Scheme. The relevant uses or developments must comply with these provisions in order not to be in breach of the planning scheme, whether or not a planning permit is required for that use or development.

Many uses and developments require planning approval in the form of a planning permit, as well as needing to comply with provisions ht are set out in the planning Scheme. Extensive conditions can be placed on planning permits, dealing with matters such as:

- Controls on any proposed tree clearing;
- Requirements for habitat restoration works;
- Traffic management; and
- Guidelines for the positioning of building envelopes, landscape plantings, fence construction, and domestic pet ownership.

These conditions can be very specific in their application but will need to be consistent with the policy content of the Planning Scheme, as set out in the various components of the Scheme as set out above.

Planning permit conditions are enforceable by Council under the provisions of the *Planning and Environment Act 1987.*

### 6.4.4 Department of Sustainability and Environment

The Department of Sustainability and Environment (DSE) has statutory responsibilities for the conservation, protection and management of the State's natural heritage. The DSE in conjunction with Parks Victoria is not only responsible for the management of National Parks and other public reserves through contracted service arrangements, State Forests, aboriginal and historic sites and relics, but also for the protection of the State’s flora and fauna species, ecological research, implementation of recovery programs under the *Fauna and Flora Guarantee Act 1988*, the conservation of threatened species and the maintenance of biodiversity, in particular through the Native Vegetation Framework 2002 and its associated programs, including BushTender.

Implementation of the Framework is primarily the responsibility of the Department. Guidelines have recently being issued for the purpose of providing guidance to councils when considering applications to remove native vegetation. The response from parties concerned about the loss of native vegetation in Victoria has been that the guidelines are generally inadequate, to the point where they have moved the emphasis away from the Framework’s key requirement to achieve a net gain in native vegetation in the State to an emphasis on facilitating development through extensive use of the offset approach. Adoption and progressive implementation of the Ballarat Koala Plan of Management will assist in a positive and proactive way to redress this major deficiency by having policies and habitat management programs implemented that support the key objectives of the Framework, so vital to the survival of the koala in Victoria.

The Department manages important koala habitat in the Canadian and Creswick State Forests. Neither forest is used for logging purposes but both contain considerable areas of preferred and supplementary koala habitat. Both forests should be managed for their fauna and flora values and as such their designation as State Forests should be changed and be managed by Parks Victoria. These changes would assist greatly with protecting these areas for their demonstrative natural environmental values.

### 6.4.5 Other Government Authorities

Approximately 1,300 hectares of land within the City of Ballarat is managed by Central Highlands Water (CHW) for catchment protection and as buffer areas around wastewater treatment plants. Parts of these areas contain significant native vegetation and therefore koala habitat values that require proper management for that purpose. Over the past 15 years, CHW has set a fine example in native vegetation management through a range of actions including protecting existing vegetation, enhancing its lands through revegetation programs and working with the Council and community groups in facilitating implementation of LINCS Strategy programs.

Parks Victoria manages 33,343 hectares of land within the City, of which only 850 hectares is within or close to areas containing koala habitat and is directly managed by the agency. Another 1,050 hectares of land containing koala habitat (the Mt Buninyong Scenic Reserve) is managed under delegation by the City of Ballarat. Part of Parks Victoria's approach to managing this land is to protect its native vegetation, which is a significant natural asset. Unfortunately, because of proximity to urban Ballarat and ease of access, these areas are frequented by trail bikes and considerable damage has been caused to the natural environment as a result, as well as disturbance being caused to the koala population. Controlling use by trail bikes riders is notoriously difficult but is an issue that requires attention in both Parks Victoria-controlled areas and State Forests.

### 6.4.6 Private Land Holders

A substantial amount of the identified koala habitat within the City of Ballarat is in private ownership. Consequently, private landholders will have a significant role in providing for the long-term conservation of koalas and koala habitat within the City. Irresponsible land management on private lands could contribute to the further loss of koalas and koala habitat.

The Plan urges private land holders to consult with Council and/or the Department of Sustainability and Environment wherever a proposed development or activity on their lands is likely to affect koala habitat, whether requiring consent or otherwise. These authorities can then provide advice on appropriate procedures in accordance with the relevant legislation and planning instruments and recommend measures to reduce and/or ameliorate likely effects on the habitat of koalas.

Ballarat City Council, through the AKF Liaison Officer and its Statutory Planning unit, can also provide advice to private landholders on appropriate measures to improve koala habitat values for degraded areas of former habitat (see Chapter 7 - Habitat Restoration).

### 6.4.7 Voluntary Conservation Agreements

The Trust for Nature operates the very effective Conservation Covenants programs. A conservation covenant is a voluntary agreement between the Trust and the owners of privately owned land. The covenant is placed on the title of the land to ensure that natural bushland is permanently protected. The Trust for Nature is a non-profit, independent organisation working to assist private landowners to protect the native habitat on their property. Landowners can receive assistance in the form of land rates and tax concessions if their property is protected in this way. The Trust for Nature also provides professional advice about how to manage the covenanted habitat. The covenanting process has been very successful in ensuring the long-term and entirely voluntary protection of very important habitat areas throughout Victoria. Contact details for the Trust are provided in Appendix 6.

The Land for Wildlife program is similar to the Conservation Covenants program in that it is entirely voluntary, but differs from it in that Land for Wildlife recognises that the properties involved with the program will generally have as their primary purpose uses other than habitat protection. Hence Land for Wildlife properties often include farms or rural residential properties. The aim of the scheme is to have landowners to improve the natural habitat values of their land, and to integrate these into the overall use of their properties. Also the program is not limited to private land but in particular extends to land managed by the community; e.g. local parks, schools. The scheme is supported by staff from the Department of Sustainability and Environment and members of the Bird Observers' Club of Australia. A distinctive sign is provided to the landholder; these are now well known around the State and provide a clear indication of the owner's commitment to effective environment conservation and habitat management. Contact details for the Department of Sustainability and Environment are provided in Appendix 6.

### 6.4.8 Register of the National Estate

The Australian Heritage Commission operates under the *Australian Heritage Commission Act 1975* to identify and maintain a register of places that are part of the 'National Estate'. In accordance with the *Australian Heritage Commission Act 1975*, potential national estate places include habitats of endangered species of plants and animals (Bates 1992).

Nominations for the Register of the National Estate can be made to the Commission by State governments and their departments, local government, voluntary bodies and individuals. Under Commonwealth legislation the Register does not lead to a preservation order, but rather, directs the attention of developers and consent authorities to the need to address heritage considerations in assessing the likely impacts of developments or activities (Bates 1992).

Significant koala habitat areas in the City of Ballarat should be considered for potential nomination for inclusion on the Register of the National Estate. The case for inclusion would need to be justified in terms of both the National and State Koala Strategies, the evidence of the Plan generated from the results of the community survey and Koala Habitat Atlas and the results of the work of the AKF in other Victorian municipalities, including Golden Plains Shire. It would be beneficial in support of the listing that it be pursued at the national level by the AKF in conjunction with its campaign for national protection of the koala and with the City of Ballarat through the results achieved from implementing the Ballarat Plan.

## 6.5 Management Strategies

### 6.5.1 Planning as a Broad Concept

The emphasis of a successful management strategy for habitat conservation should be around planning as an overall concept, using both statutory and non-statutory methods to achieve results. Statutory methods include use of the Ballarat Planning Scheme as outlined above. Non-statutory methods include the use of voluntary conservation agreements, the provision of advice to private landowners and the development of strong working relationships with the Department of Sustainability and Environment (DSE). An integrated approach, that combines encouragement and support with the implementation of appropriate development controls, is likely to achieve the best level of success.

### 6.5.2 Public Commitment

The public comments that the Ballarat City Council makes about the value of protecting koala habitat are very important in terms of sending a message to the community, including to the urban development industry, about the priorities of the Council and what it sees are important matters for the Ballarat community.

As a land manager, like DSE and Parks Victoria, the Ballarat City Council can provide strong support for koala habitat protection through the way it manages its open space reserves, how it supports that approach through the resources it provides and the way in which it involves the community in the management of those areas.

### 6.5.3 Incentives

The use of incentive-based measures to encourage voluntary conservation and the management and restoration of koala habitat should be viewed as an integral component of implementing the Plan across the board, meshing in with the other components of the Plan; e.g. community education, on-ground projects, land use planning and development processes, enforcement procedures and research and monitoring.

The development of suitable measures should include consultation with landowners to identify those incentives that will be both feasible for Council and appealing to land owners and should have a relationship with the other components of the Plan (as mentioned above). Some possible incentive measures are:

**Habitat management grants** [on-ground projects]: Council operates a Community Grants program that focuses on community development, including support for community organisations. A similar program could be devised to support environment improvement initiatives being undertaken by community groups that include the protection and enhancement of native fauna habitat where that habitat has been identified as having significant value. Council could also work with landowners who have important habitat on their land in applying for grants managed by agencies such as the local catchment management authorities and DSE.

**No cost habitat assessments** [on-ground projects, research and monitoring]: carrying out habitat assessments as part of the preparation of property land management plans is an excellent way of improving landowners' knowledge of the biodiversity value of their land and guiding development of the land management plan. Given that much remaining koala habitat is on private land, carrying out habitat assessments is an excellent way of improving overall knowledge of the presence and condition of koala habitat within Ballarat. Habitat assessments usefully cost in the order of some hundreds of dollars, at least, so enabling them to be under taken at no or reduced cost would be a significant incentive to landowners to have an assessment undertaken. Further incentive would be provided if the carrying out of an assessment was linked to obtaining a grant for habitat management.

**Rate rebates** [land use planning and development]: rate rebates are a common form of incentive, used by councils to encourage favourable outcomes in the way land is managed. Typically rate rebates are offered to encourage landowners to carry out weed control works, retain or enhance existing native vegetation, to retain a favoured land use or to maintain heritage buildings. Councils recognise that there can be community benefit in having landowners manage their properties in a certain way and rate rebates can be used as recognition of the costs that may be involved in landowners providing this wider benefit.

**Development Incentives** [land use planning and development]: permitting a greater density of development on part of a development site in return for the retention or enhancement of habitat on another part of the site is a typical development incentive used to ensure the retention of important habitat. Reducing payments for infrastructure contribution costs in exchange for the transferring of land into public ownership and allowing for the removal of native vegetation on the development site in exchange for the purchase or provision of vegetated land in another location ('offset' arrangements) are other methods that are used.

There is a tendency, however, for incentives associated with gaining development approval to disadvantage the habitat values of a site, as the primary purpose of pursuing this type of incentive is generally to gain additional advantages in relation to the development, rather than for the habitat *per se*.

**Transferable Development Rights** [land use planning and development]: transferable development rights is a concept that has been in existence for many years but because it is complicated and often costly to put in place, has rarely been used, certainly in the case of Victoria. The concept involves being able to transfer plans for a development that might otherwise to be approved from one site to another site. Difficulties with the concept in practice include finding an alternative site with the same desirable attributes as the original site (which may include the presence of native vegetation), finding a site that can be readily purchased and deciding who pays the costs involved in translating the development to an alternative site, when one is found.

It is more likely that if the habitat values of the proposed development site are that high that development should not proceed, that it would be more straightforward for a public agency to purchase the site.

**Community recognition** [community education and awareness]: Council runs community recognition schemes such as Citizen of the Year whilst the Ballarat Environment Network runs the bi-annual Ballarat Environment Awards. There are other community awards' schemes across a wide range on interests that recognise the activities of community members in those interests. It would not be difficult for the Plan Implementation Committee to arrange a similar scheme for landowners and groups involved in habitat conservation. One way would be to add an additional category to the Ballarat Environment Awards program. There could be a financial incentive (i.e. prizes) associated with the award.

Any of these incentives could be introduced in conjunction with an agreement with Council to maintain the habitat values of the land, consistent with the nature and effect of the particular incentive. The incentives could also be used in conjunction with other voluntary land management agreements such as Land for Wildlife (DSE/Bird Observers' Club of Australia) and Conservation Covenants (Trust for Nature).

# 7. HABITAT RESTORATION

## 7.1 Introduction

As with the *conservation* of koala habitat, it is essential that a complementary strategy be in place for the *restoration* koala habitat as part of ensuring the long-term survival of koalas in the City of Ballarat. As the available resources for restoration works are finite, such a strategy must recognise that potential areas for habitat restoration will need to be prioritised to ensure the maximum possible benefit in terms of koala conservation within the City.

Koala habitat restoration projects in the City of Ballarat will need to involve a range of activities including revegetation (plantings), assisted regeneration (e.g. weed control to provide for natural regeneration to replace mature eucalypts in existing habitat; fencing to exclude livestock) and reconstruction. Selection of the most suitable approach for different sites will depend upon the specific requirements to achieve recovery of the vegetation communities. Assisted regeneration techniques are most appropriate where natural recovery potential is high, whilst more intensive revegetation and reconstruction activities may be necessary in more heavily cleared and disturbed areas where the potential for natural recovery is low (Greening Australia 1999).

As with habitat conservation, there are excellent opportunities to integrate the requirements for koala habitat restoration and enhancement into existing City programs, particularly those involving the enhancement of habitat through revegetation works that utilise appropriate indigenous species. Relevant programs include:

- Implementation of relevant recommendations of *the Ballarat Environmental Sustainability Strategy 2006*;
- Implementation of the *Ballarat Planning Scheme* through the application of appropriate planning permit conditions associated with native vegetation retention and enhancement, particularly where associated with implementation of the Native Vegetation Framework;
- The *LINCS (community revegetation and environmental education) program* – being rejuvenated through a three year (2005-08), Corangamite Catchment Authority-funded program.

As with habitat conservation, there are opportunities for government and semi-government authorities to use their resources and programs to enhance native vegetation habitat within the City. The three catchment management authorities that cover the City area manage funding programs aimed at restoring the natural environment. Again, there are excellent opportunities to integrate outcomes of the Ballarat Koala Management Plan in terms of habitat restoration and enhancement with these programs.

Habitat reconstruction, as defined by Saunders and Hobbs (1995), involves recreating the ecological requirements of the target species. For koalas this will include revegetation with suitable trees for food, shelter and social interaction. However, Saunders and Hobbs (1995) maintain that habitat reconstruction means more than simply replanting vegetation. It also involves facilitating the restoration of other ecosystem components and processes that are vital to ecosystem function. Thus, the restoration of koala habitat should ideally involve more than simply replanting suitable species of trees. Habitat restoration projects should also involve measures to ameliorate impacts from relevant threatening processes.

## 7.2 Objectives

The objectives of this chapter are to:

iii) Identify and discuss appropriate means of addressing impacts and restoring habitat values;

iv) Detail criteria to be used to derive a prioritised list of habitat areas to be restored; and

v) Identify means of implementing koala habitat restoration.

## 7.3 Intended Aims of Revegetation Works

Hobbs (1993) identifies four ways in which revegetation works can benefit nature conservation. Firstly, revegetation can be used to create buffer strips around existing remnants of native vegetation. This serves to protect the remnant from the harmful effect of external factors (known as ‘edge effects’) such as nutrient inputs, wind damage and weed invasion. Additionally, if native species are used to establish buffers then they can also provide extra habitat.

Secondly, revegetation can aim to re-establish linkages between currently isolated habitat patches. Linking patches of habitat has the potential to ameliorate some of the detrimental effects of habitat fragmentation, for example by facilitating the exchange of genetic material between sub-populations and thus reducing the chance of inbreeding, by allowing fauna access to additional resources, or by facilitating the dispersal of sub-adult koalas and recolonisation of unoccupied habitat. High priority will be given to projects aimed at restoration of areas identified as Linking Habitat in the Koala Habitat Planning Map (Appendix 3). These areas are likely to play a significant role in the long-term conservation of koala populations within the City, including those that occupy otherwise fragmented habitat.

Thirdly, revegetation can be used to extend existing habitat. This is done to a degree by establishing buffers and links but could for example also increase the number of trees available for use by koalas for food and/or shelter.

Finally, revegetation can be aimed at enhancing the quality of existing habitat, both to increase its worth as habitat and to stop the encroachment of land degradation such as dieback, soil salinisation, and soil erosion, thus helping prevent any further decline in habitat quality.

The habitat restoration program established by the Plan will include revegetation works that attempt to address each of these four aims. Each of these aims, if achieved, has the potential to contribute to the conservation of the Ballarat koala population.

Revegetation works could address an individual aim, or may address several aims concurrently. There may be circumstances where preference needs to be given to one aim over another; for instance it may be desirable to use resources to enhance the quality of existing habitat ahead of restoring links between habitat areas.

A list of suitable species for planting, based upon native species present in nearby koala habitat, should be prepared for each site where revegetation (plantings) will be a necessary component of the restoration activities.

## 7.4 Criteria for the Identification and Prioritisation of Areas for Restoration

The development of a prioritised list of habitat areas to be restored will be a time consuming task, due to the many different criteria that need to be considered, and the level of detail, which should be included. It is proposed that the Implementation Committee in conjunction with the Council department responsible for bushland regeneration and the Australian Koala Foundation restoration develop a prioritised list of restoration projects for inclusion in the Plan. Criteria for developing a detailed list of priority habitat restoration areas are outlined below.

### 7.4.1 Size of Habitat Patches

Notwithstanding the influence of preferred browse species, it makes intuitive sense that for patches of similar habitat, larger patches will have the potential to support greater numbers of koalas than smaller patches. Given this, revegetation aimed at enhancing, buffering, adding to or linking *larger* remnants will generally be given priority over *smaller* areas of native vegetation. However, there may be instances when several small habitat patches collectively have the same potential to support koalas as a single large patch of similar size. Under such circumstances priority would be assigned using other criteria, for example the effort required for restoration (see Section 7.4.6).

The minimum patch size, below which a viable koala population cannot be supported, will depend to some extent on the level of patch connectivity. For example, if several small patches are very close together they may function as a single larger patch if koalas can move freely and safely between them. However, if a patch is highly isolated, then it would need to be much larger to support a viable population. Isolated habitat patches of two hectares in size, for example, are likely to be of little use as breeding habitat for koalas as this equates roughly to the smallest home range size for an individual koala. In a fragmented coastal landscape in Noosa Shire, Queensland, evidence of critical patch size requirements have been shown, with koalas 50% more likely to be absent in patches less than around 50 hectares in size. Further, there is some evidence to suggest that once patches become smaller than around 150 hectares in size the chance of koalas being present starts to decline. In some landscapes, for example in Port Stephens, New South Wales, patch size appears to be less critical, although quantity of habitat remains important (McAlpine and others 2006).

If habitat patches are close enough to each other for koalas to move freely between them on a daily basis then they are considered to be highly connected, providing there are no major barriers such as roads, fences, or significant threats such as wild dogs or roaming domestic dogs. In general, koalas could be expected to move between habitat patches on a daily basis if they are separated by distances no greater than 100-200 m and provided there are no significant barriers or threats. In Port Stephens, the median daily movement distances of female koalas was found to be just less than 100 m, with males moving slightly longer daily distances (McAlpine and others 2006).

In assessing the significance of patch size it will be important to estimate the minimum viable patch size with the potential to be utilised by members of the koala population. This would contribute to ensuring that resources are not wasted on unviable habitat areas. Determination of a minimum viable area will be influenced by the nature and quality of the habitat in the first instance.

### 7.4.2 Shape of Habitat Patches

The shape of habitat patches is important as it determines the perimeter to area ratio, which in turn usually influences the impact of edge effects. Patches with a high perimeter to area ratio, for example long and narrow patches, are usually subject to greater edge effects than those with lower ratios. Patches that are more susceptible to edge effects will generally require more active management and in extreme cases will not be viable over the long term.

### 7.4.3 Type of Koala Habitat

The *types* of koala habitat that comprise an area of koala habitat need to be considered when assigning priority to restoration works, as different habitat types will vary in their value to the long-term conservation and management of koalas. Priority for restoration works should be given where this involves areas containing Preferred Koala Habitat over those containing Secondary Habitat, which in turn should be given priority over areas containing Marginal Habitat. Where two remnants both contain a particular type of habitat, especially Preferred Koala Habitat, priority should be assigned on the basis of the extent and shape of the respective habitat types; e.g. restoration works involving a remnant with a larger area of Primary Habitat would be ranked higher that that involving a remnant with a smaller area of Primary Habitat. Again, exceptions to this rule may occur for example where several small patches of Primary Habitat have the potential to be effectively linked through restoration.

### 7.4.4 Size of Koala Population/Presence of Extant Populations

Whilst a precise koala population estimate for the City of Ballarat is not available, substantial data concerning the distribution of the population has been compiled by the Australian Koala Foundation. This information will assist with initial priority setting for restoration works and refinements as additional data becomes available via the Plan monitoring program. Priority should be given to works that would be likely to benefit a greater number of koalas. That is not to say that habitat that does not support extant populations should be neglected. The existence of vacant habitat may prove crucial in the future. However, initial resources should be directed to those patches that currently support koalas, particularly where prospects for long-term survival of the population are considered to be good and are likely to be significantly enhanced by restoration activities to ensure that habitat values are maintained.

### 7.4.5 Presence of Threats to Koalas

When planning revegetation works it is necessary to consider the potential threats to koalas when they use replanted areas in the future. In the City of Ballarat the main threats to be considered in this regard are habitat destruction which involves the removal of key food resources, continuing urban and/or semi-rural encroachment into or adjacent to significant areas of koala habitat, motor vehicles, and roaming domestic/feral dogs. Revegetation works may in fact be detrimental to koalas if they increase the risks associated with such threats. For instance, revegetation works that involve the planting of trees in the vicinity of a major road could result in more koalas being hit by motor vehicles. Similarly, plantings that attract koalas to urban areas may result in a greater number of dog attacks on koalas. The latter problem should be addressed by programs aimed at minimising threats to koalas associated with domestic dogs. The former problem is probably best managed by avoiding revegetation works in the immediate vicinity of major roads.

Prior to establishing a home range (or territory), koalas can disperse relatively long distances, up to around 10 kilometres, although distances of around three to four kilometres are more commonly observed. Therefore, in theory, patches separated by distances of up to three to four kilometres may remain relatively well connected for a koala sub-population, depending on the level of forest cover and potential threats or barriers between patches. However, despite the fact that koalas are relatively mobile, the isolation of patches has been found to be an important predictor of koala occurrence, with koalas more likely to occur in patches close to other patches than in isolated patches. This supports the concept that the landscape matrix between patches has an important impact on connectivity. In urban and semi-urban landscapes, koalas may suffer elevated mortality due to dog attacks and vehicle collisions, reducing their ability to successfully move between patches. In addition, barriers such as fences, buildings and major roads can reduce connectivity (McAlpine and others 2006).

### 7.4.6 Effort Required for Restoration

In deciding how best to allocate resources to restoration works consideration needs to be given to the effort that will be required to achieve the goals of each project. The effort required will depend on the goals that are set (see Section 7.4.9 for further discussion on goals), and will also be a function of the degree of modification that has occurred to the area in question (Hobbs and Hopkins 1990). Areas in which ecosystems have been highly modified will require greater efforts for restoration than those that have been modified to a lesser degree (e.g. by partial clearing, or lesser still, by changed fire or grazing regimes; Hobbs and Hopkins 1990). Thus, a decision has to be made on whether resources are used to redress less substantial modifications at a number of locations, or to address instances where the degree of modification has been high in fewer locations, or a combination of the two.

Although the construction of revegetated corridors has been advocated as a means of connecting habitat patches, the effectiveness of such measures remains unclear. Some studies suggest that corridors of trees may be of little use to koalas, while others show some evidence for the use of corridors of sparse trees by koalas. Where blocks of habitat, especially those separated by up to three to four kilometres, have no linking habitat between them, the restoration of habitat corridors or habitat patches should be considered to act as ‘stepping-stones’. Habitat corridors should ideally be hundreds of metres wide in order to avoid large edge effects, such as an increased incidence of dog attacks. Irregular-shaped patches of habitat that act as ‘stepping- stones’ may suffer less from edge effects than a linear corridor and for this reason may be preferable when restoration of a wide corridor is impractical (McAlpine and others 2006).

### 7.4.7 Current Land Tenure and Land Use Zoning

Current *land tenure* is an important factor to consider as this will ultimately determine whether planned restoration works can be carried out. Decisions on which works should be given priority should be made on the basis of other criteria, but recourse should be made to the land tenure to establish whether permission for works can be obtained, whether the land owner or land management agency can assist with the works, and importantly who will be responsible for the ongoing maintenance of any plantings or weed control. Long-term security of restored areas will also be a critical issue. Private landowners may be prepared to enter into a voluntary Conservation Covenant through the scheme managed by the Trust for Nature, join the Land for Wildlife scheme managed by the Department of Sustainability and Environment or enter into a Section 173 Agreement under the Planning and Environment Act 1987, a binding agreement that is placed on the title of the affected property.

*Land use zonings* also need to be considered. The benefit of restoration works could be compromised, or rendered totally ineffective, if for instance, future development occurs in areas zoned for significant development where restoration works have been undertaken. Thus, priority should be given to areas where the land use zoning is unlikely to result in future development and consequent degradation of restored habitat. Alternatively, if areas of restored habitat have been or need to be carried out in areas zoned for development, rezoning of the land to an appropriate zoning that emphasises the importance of retaining the vegetation should be considered.

### 7.4.8 Pre-European Vegetation of the Area

*Historical studies* that give insight into the distribution of plant communities prior to European settlement need to be considered for at least two reasons. Firstly, they provide guidance on where certain species should be planted, which is needed if revegetation is aimed to restore the mosaic of plant communities that existed before European settlement. Secondly, these studies can be used to estimate the extent to which habitat areas were connected in the past. This has important long term implications when considering the reestablishment of links between habitat areas, due to potential detrimental effects on population genetics when two previously isolated populations of a species are connected (Soule and Gilpin 1991).

### 7.4.9 Other Considerations

There is a need to define the *goals* of each restoration project (Hobbs and Hopkins 1990). In particular, a decision needs to be made on whether the goal is to restore the ecosystem to what is was prior to modification, which would perhaps be of greater benefit to other species and in addressing land degradation generally. Alternatively, the goal may be species-specific, i.e. to restore koala habitat. Consideration also needs to be given to what goals are achievable (Hobbs and Hopkins 1990).

*Monitoring* should be undertaken wherever possible to evaluate the *success* and *cost* effectiveness of restoration projects.

## 7.5 Provision of Nursery Stock

In order to undertake the necessary habitat restoration work, an adequate provision of nursery stock will be required. Existing nurseries and/ or community groups that currently produce tubestock could be approached to provide suitable species for planting. The stock to be used for restoration projects should ideally be propagated from local provenance seed, ideally from trees that are known to be favoured by koalas in the local population. Propagated trees should be planted in the same locality in which the seed stock was sourced, a practice that is currently already applied by Council. The ability to respond in this way has been enhanced in recent years with the development of the Ballarat Community Indigenous Plants Nursery, managed by the Ballarat Environment Network Inc through a joint agreement between the City Council, the Network and the University of Ballarat.

## 7.6 Management Strategies

As identified above, there are many factors inherent in devising a successful habitat restoration strategy. There can also be conflicts with other influences, including competing uses for land and management issues such as the need for fire protection. The most important drivers for a successful Habitat Restoration Management Strategy are therefore *Prioritisation* and *Co-ordination*.

### 7.6.1 Priority Setting for Restoration Projects

There are many factors that need to be taken into account when deciding the priorities for carrying out Habitat restoration projects. As pointed out above, it is important for various reasons to set priorities for habitat restoration. The first priority for habitat restoration is to determine sites that will enhance existing koala habitat. Generally this will mean targeting Core Koala Habitat, in particular Habitat Linking Areas, in order to enhance the value of Preferred Koala Habitat.

Other factors to take into account in establishing priorities include:

- The criteria listed above;
- The size of areas contemplated for restoration work;
- The resources, including financial and supervisory, available for the work;
- The ease with which the work can be undertaken; e.g. is the site weed infested, difficult to work on, difficult to access.

Generally speaking, sites that can be restored more readily; i.e. because they have some remnant native vegetation already existing – should be chosen before more difficult sites. It is preferable to re-establish sites where the chances of success are good, rather than concentrate resources into difficult sites where results may be more problematic, with the chance that more readily restorable sites decline, meanwhile, through a lack of attention.

### 7.6.2 Co-ordination of Habitat Restoration Projects

Effective habitat restoration can be carried out effectively by a small number of dedicated and trained personnel, but often it is carried out by volunteers, meaning the work becomes very labour intensive, requiring a substantial number of people to carry out the work required. In either situation, the effective involvement of these resources requires considerable organisation and it is imperative that proper project planning is carried out well in advance of any restoration work proceeding.

Specific, dedicated resources are required to do the required planning, organising and publicising of activities. Ordering of plant stock and other materials and the identification and set out of restoration sites needs to be undertaken well in advance of dates for planting and related activities. Educational material and occupational health and safety information needs to be compiled where community groups are involved and contact made with groups in the first place to arrange and confirm their participation. A high degree of coordination is required to ensure that all aspects of a restoration program are effectively carried out, in order that the best results are achieved and to ensure satisfaction for the parties involved.

At present Ballarat City Council contracts the Ballarat Environment Network to facilitate re-vegetation projects with a large number of community groups and schools. The Network has proven, through its skilled staff and extensive community contacts, to be highly effective in delivering this service.

Groups who can assist with habitat restoration programs include community groups, such as the Nerrina Environmental Preservation Association Inc., Friends of Union Jack, school groups and the numerous landcare groups that exist in the City, including the Leigh Catchment Group, South Ballarat Urban Landcare Group and Garibaldi Environment Group. Other resources include people directed to carry out community service, ecotourism groups, and employment programs such as the Federal Government's Green Corps and Work for the Dole programs.

There is no substitute for good planning in order to achieve optimum results.

# 8. TRAFFIC MANAGEMENT

## 8.1 Introduction

A large number of respondents (77.8%) to the Ballarat Community-based Koala Survey (2002) indicated that they would support 'Traffic Restrictions' to help conserve Koalas in the City of Ballarat.

The management strategies addressed in this chapter aim to reduce the risks of koalas being struck and killed or injured on roads within the City of Ballarat.

## 8.2 Objectives

The objectives of this chapter are to:

i) Identify roads and/or sections of roads within the City of Ballarat where koalas are known to cross and/or be hit by traffic; and

ii) Detail relevant management strategies and recommendations to reduce the risk of koala road fatalities and increase community awareness.

## 8.3 Information on Koala Road Mortality

A total of 1,241 records of koalas were obtained from the community through the Community-based Koala Survey, with 215 of these sightings being on or alongside a road.

The Survey by its nature reveals only a small proportion of actual koala road fatalities but 86 koala incidences (collisions of koalas with vehicles that resulted in either death or injury) were reported. The AKF has been able to obtain many more reports from wildlife carers and other concerned individuals that are awaiting dissemination and analysis. An initial count shows a further 127 injuries or deaths to koalas resulting from collisions with cars.

Anecdotal evidence suggests that the majority of koalas injured by collisions with cars or from dog attacks do not survive treatment and only very few are successfully released back into the wild.

The significance of the impact of road fatalities is likely to be even greater than the raw data already suggests. One needs to multiply the data by a factor of at least two to include those sightings that were not reported and for those animals that were injured and escaped into the native vegetation where the koala most likely would have died from its injuries.

This information, in mapped form, is illustrated in Appendix 4: Koala Black Spots, Conflict Areas & Problem Areas.

### 8.4 Relationship between Koala Fatalities and Traffic Speed

The available data set for the City of Ballarat has not yet been fully analysed. However, funding is being sought to allow for the analysis of data through a research project to be able to permit any conclusions with respect to koala fatalities and traffic speed. Data analyses undertaken in conjunction with the Port Stephens Plan suggest that the greater the speed of the vehicle, the less the likelihood of a koala surviving a collision. Evidence from Port Stephens and Campbelltown suggests that the majority of collisions will result in death of the koala, despite the designated traffic speed.

Other factors likely to influence the chance of koalas being hit while attempting to cross a road include:

- ❖ Features of the roadside environment such as the width of the cleared zone between the road edge and adjacent trees,
- ❖ The width of gravel shoulders,
- ❖ The presence of roadside drains,
- ❖ The height of roadside vegetation,
- ❖ The degree of habitat disturbance in adjacent areas, and
- ❖ The nature of any roadside lighting.

These factors may affect driver ability to see a koala before it attempts to cross onto the roadway.

Koalas are likely to be most active in terms of movements within their home range during the breeding season from approximately October to April. During this period the number of koalas hit by cars tends to increase, as has been demonstrated with respect to the Port Stephens koala population in the Port Stephens Koala Management Plan 2001.

Attempts to reduce koala-vehicle collisions by measures such as reduced speed limits and underpasses have generally only shown limited success. Therefore, a combination of measures together with careful design of road networks and traffic flow to minimise impacts on koalas would be a better approach. This should include careful consideration of placement of new roads, to avoid areas within or adjacent to koala habitat. Further, upgrading existing roads to carry greater traffic volumes or for improved safety is likely to be less detrimental to koala populations than building new roads, although the location of roads remains a crucial consideration.

Not only do roads increase koala mortality rates, they also tend to form barriers to movement because either few koalas can successfully cross without suffering mortality, or because of physical barriers, such as fences or retaining walls. This effect reduces connectivity between patches and increases habitat fragmentation. On existing roads, with very high traffic volumes, and/or high traffic speeds, it may be appropriate to construct exclusion fencing in known black spot areas. This measure creates a physical barrier to movement, offset by the benefit of reducing direct mortality rates. However, this could potentially have the negative effect of isolating parts of a population. The preferred approach should always be to avoid the construction of new roads that bisect koala habitat or that are located between blocks of habitat (McAlpine and others 2006).

### 8.5 Disturbance to Habitat

Habitat disturbance may result in koala movements beyond that associated with normal home ranging behaviour. This might include efforts to re-establish contact with other members of the local population or to satisfy nutritional requirements. Such forced movement may involve road crossings and subsequent conflict with vehicles.

### 8.6 Identification of Collision Areas

Interpretation of the above information in conjunction with the Koala Habitat Planning Map has allowed a number of apparent black spots, conflict areas and potential problem areas to be identified.

#### 8.6.1 Koala Black Spots

For the purpose of this Plan, a Koala Black Spot is defined as a section of sealed road where four or more koala collisions have been recorded within one kilometre or less apart. A distance of at least 500 metres is included at either end of the cluster of records. Where two or more Koala Black Spots have been identified in close proximity (e.g., within a few hundred metres), they are combined to form one larger black spot strip or zone.

Koala Black Spots in Ballarat by this definition are most parts of Geelong Road from Recreation Road, Mt Clear to Buninyong, the Midland Hwy from Scotsburn to just west of the Buninyong Golf Club, except for the centre of the township of Buninyong and Gear Avenue, Mt Helen where it meets Yankee Flat Road.

Each of these sections of roadway either passes through or adjoins Preferred Koala Habitat or occurs within identified Habitat Linking Areas.

Interestingly, these locations contain speed zones ranging from 60 kph to 100 kph, indicating that koalas are susceptible to injury and death within areas subject to what would normally be regarded as relatively low speeds in terms of traffic behaviour.

#### 8.6.2 Conflict Areas

For the purpose of the Plan, a Conflict Area is defined as a section of sealed road, other than an identified Koala Black Spot, where two or three koala collisions have been recorded within ~ 500m or less apart. A distance of at least 300m is included at either end of the cluster of records.

Conflict Areas in Ballarat by this definition are Geelong Road, Mt Clear north of the intersection with Recreation Road, sections of the Western Hwy, Daylesford Road and Springs Road, Brown Hill.

### 8.6.3 Problem Areas

For the purpose of the Plan, a Problem Area is defined as either:

- A section of sealed road where isolated koala road collisions have been recorded, or
- A section of sealed road where no koala collisions have been recorded, but which passes through or is within 100m of a patch of Preferred Koala Habitat. A distance of at least 100m is included at either end of isolated records.

Problem Areas in Ballarat by this definition are the Midland Hwy from the Buninyong Golf Course to Magpie, Gear Avenue and Greenhill Road, Mt Helen, short sections of the Buninyong – Mt Mercer Road, sections of Pryors Road, Garibaldi, the eastern sections of Whitehorse Road and Eureka Street, Lofven St in Nerrina and Water St in Brown Hill.

### 8.6.4 Association between Roadside Vegetation as a Food Source and Incidences of Collisions

A further habitat-linked issue is that a general lack of preferred koala food trees in particular areas may attract koalas to feed in food trees located along roads. It is not unusual for the bulk of remaining suitable native tree species in an area to be located within road reserves, with surrounding land having been cleared many years previously for farming and other purposes. Being attracted to this food source, the exposure of koalas to road traffic is amplified over and above the risk to koalas created by the need for the animals to cross roads.

The loss of koalas due to this type of 'fatal attraction' has a further, flow-on impact in that this behaviour creates a 'sink' effect, whereby koalas killed as a result of moving into the road traffic environment to feed are soon replaced by other koalas seeking a food source.

Insufficient research has been carried out to understand the extent of the 'sink effect' but clearly there are implications for the management of vegetation along roadsides, including species selection in re-vegetation projects, and the need for strategies aimed at retaining and enhancing koala habitat generally to take this factor into account; i.e. to create suitable, interconnected areas of koala habitat away from and not requiring the crossing of major roads by koalas. The need to research this issue is seen as a high priority for the Implementation Committee to pursue.

## 8.7 Management Strategies

A number of potential management strategies could be used to reduce the risk of koala road fatality or injury. Determination of the appropriate strategy will require consideration of the characteristics of adjacent habitat and the roadside environment, in conjunction with an assessment of the management options. Management options that could be used in the development of a management strategy are outlined as follows.

**Fatality Signs**

Signs may be used to highlight koala road fatalities in identified Koala Black Spots. Fatality signs should be updated annually in order to keep the community, and more specifically drivers, informed of the known impact.

**Wildlife Reflectors**

The authors consider it unlikely that wildlife reflectors would provide an effective means of reducing koala road mortality. These reflectors, which are fixed to guide posts, were originally developed in Europe where deer present a major traffic management problem. The most suitable height to position reflectors for koalas has not been determined.

**Koala Warning Signs**

In urban areas of Port Macquarie the koala warning sign design illustrates a koala sitting in a tree. More recent designs, such as those used in Coffs Harbour and Port Stephens, illustrate a Koala walking along the ground. The impact of koala warning signs could be enhanced by using painted sections across the roadway to designate the start and end of identified high koala risk areas.

**Exclusion Fencing**

A number of designs have been developed for koala exclusion fences. One design consists of a flat metal surface facing away from the road, with fence support structures on the side closest to the road.

A design trialled in Southeast Queensland involved cyclone mesh fencing supported firmly at the base and left floppy at the top. In parts of Northern NSW cyclone mesh fencing has been used with a metal strip attached near the base.

Potential problems associated with exclusion fencing include the following:

- ❖ Exclusion fences contribute to habitat fragmentation which may lead to reductions in genetic diversity, increased vulnerability to disease and bushfires, and reduced long-term viability of koala populations;
- ❖ Exclusion fences would act as a barrier to other species of native fauna;
- ❖ Exclusion fences could prevent other fauna from escaping bushfire;
- ❖ Exclusion fences would be impractical where there are a number of property accesses as the design requires a continuous fence-line; and
- ❖ Exclusion fences could inhibit access to adjacent bushland for fire fighting.

**Road Crossings**

Road crossing strategies attempt to direct or regulate koala crossings of roads. Four potential methods are available:

- ❖ Koala underpasses;
- ❖ Koala crossings; and

- Koala overpasses and road bridges that link habitat.

- **Koala Underpasses**

Current fauna underpass designs often consist of 1.5m to 2m diameter pipes. Larger box-style culverts of up to around 3m by 3m have been installed on sections of road in several areas of NSW. Koala-proof fencing is generally used in an attempt to direct koalas to underpasses for road crossing.

The long-term effectiveness of underpasses has yet to be determined but on current evidence they appear ineffective. As arboreal mammals, koalas are considered unlikely to enter a narrow pipe under a road. Prevett (1991) argues that koalas are highly dependent upon smell and may be deterred if other animals such as foxes or dogs, or a dominant male koala use the underpass. Evidence from the Ballarat Bypass (Western Freeway) project shows that underpasses are completely ineffective in providing a viable means for koalas to cross roads. There is no evidence that the underpasses provided at Woodmans Hill have ever been used by koalas. A study by the University of Ballarat has shown that only one fox used the concrete pipe tunnel under the Bypass during the study.

The Western Freeway (Ballarat Bypass) was constructed in 1994 with the aim of allowing through traffic travelling west or north of Ballarat to avoid central Ballarat when continuing their journey along the Western, Midland or Sunraysia Highways. The Bypass transverses koala habitat in the eastern part of the municipality (Woodsmans Hill, Brown Hill and Nerrina) and was constructed with a koala proof fence on either side. While koala road kills have been rare after the construction of this fence, there is no potential for koala movement between habitat areas on either side of the road. A tunnel system designed, to allow for some wildlife movement, has proven not to be appropriate to allow koalas to reach habitat on either side, thus basically fragmenting habitat and disrupting normal koala dispersion movements from north to south.

During an AKF conference in Ballarat Casper Pieters (2002) showed examples from his PhD research that identified the need for large, wide and open overpasses for the uninterrupted movement of wildlife and especially koalas to continue. Some koala crossings and road kills still occur along the unfenced section of the Western Highway through Warrenheip. However, koala habitat here is not as continuous and of the same quality as in Nerrina.

Future road designs should consider the impact on koalas and their habitat in more detail well before construction is even contemplated.

- **Koala Crossings**

Koala crossings are also largely un-trialled. Like underpasses and bridges, they may necessitate the use of exclusion fencing to direct koalas to a control point on the road for crossing. This method would reduce the length of road that could be crossed, and could be coupled with appropriate signs, slow speed zones and road markings at koala crossings. This could potentially result in a reduction in collisions with koalas. In some cases it may be possible to identify road sections where koalas are most likely to cross due to the location of adjoining habitat. It may be feasible to install slow speed zones or other measures at these locations.

- **Koala Overpasses and Road Bridges**

Koala overpasses and bridges used to span roads in order to connect to areas of koala habitat are also considered worth trialling. These methods obviously involve considerable expense. However, these options should be considered where there is no practicable alternative for linking significant koala habitat areas.

An example in Ballarat of where an existing bridge links areas of native vegetation across a major road is the case of the pedestrian footbridge over the Ballarat Bypass at Nerrina. This bridge provides a link between the Messmate vegetation of the Yarrowee River corridor/Monte Christo Reserve and the forested areas in Nerrina and the Creswick forest. Despite the fact that koalas were known to traverse this area prior to the construction of the Bypass, it is not known whether koalas have ever used the bridge, and indeed in accordance with previous research, use by koalas is considered unlikely. However, it would be worth reviewing and monitoring the situation at Nerrina as a way of providing evidence about the efficacy of providing bridges and overpasses to facilitate koala movements over major roads.

**Speed Reduction**

As indicated earlier, the proportion of koala fatalities from vehicle collisions appears to decrease with reductions in the speed zone.

Speed reductions would need to incorporate the following:

- Agreement/consent from VicRoads;
- Endorsement from the Victoria Police who would be responsible for enforcing reduced speed limits;
- Extensive public consultation and media coverage to ensure community awareness and support; and
- Appropriate sign posting.

A successful media campaign and public exhibition would be critical to inform drivers and to promote community acceptance of speed reduction. A less preferred option in this regard would be to use speed advisory signs similar to those used for road bends, crests and curves. In some instances speed reductions could be facilitated with the introduction of appropriate vehicle calming devices such as speed humps or chicanes.

**Roadside Clearance**

The amount and height of vegetation on the side of roads is likely to have an effect on koala collisions. A cleared roadside verge may allow koalas to be seen by drivers at an earlier stage, thus increasing the likelihood of avoiding a collision.

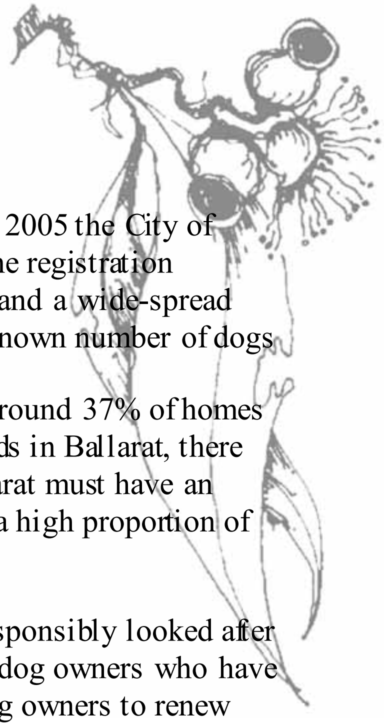
This strategy could be implemented by regular slashing of roadside areas.

**Injured Wildlife Information Signs**

When a koala or any native animal is hit by a vehicle and survives, it is important that the animal receives quick and appropriate attention. One method of informing people of appropriate action and contacts when they encounter injured fauna is to provide roadside information signs.

**Street Lighting**

Improving driver visibility is a further means of minimising koala road fatalities in known risk areas. The installation of suitable lighting to illuminate the roadway would aim to increase driver response time in the event of an animal venturing onto the road.



# 9. DOG MANAGEMENT

## 9.1 Introduction

Prior to the special registration campaign conducted Ballarat in October 2005 the City of Ballarat's dog register included approximately 9,500 dogs. Following the registration campaign, which included door knocking of properties by Council staff and a wide-spread publicity program, approximately 15,500 dogs were registered. An unknown number of dogs would still be unregistered, but Bureau of Animal Welfare (www.pets.info.vic.gov.au/community/petshome) figures indicate that around 37% of homes across the nation have a dog. Based on approximately 40,000 households in Ballarat, there should be about 15,000 registered dogs, a figure that indicates that Ballarat must have an unusually high rate of dog ownership and that the campaign resulted in a high proportion of the likely total number of dogs being registered.

However, vigilance in ensuring that dogs are registered and therefore responsibly looked after is always required. Council recently sent out 4,500 reminder notices to dog owners who have not renewed registrations that were required in March 2006. Getting dog owners to renew registrations is an annual battle, familiar to all councils. As a follow-up to the registration campaign, Council will be publicising the threat to issue fines as a way of 'encouraging' owners to re-register their dogs and cats.

Irresponsible dog ownership potentially results in substantial numbers of uncontrolled, roaming domestic dogs. These roaming dogs, particularly large dogs and dog packs, pose a significant threat to koalas that occupy habitat within and adjacent to urbanised areas.

Elevated mortality due to dog attacks is a key conservation concern for koalas, as noted in the rapidly urbanising coastal areas of Queensland and New South Wales. Studies from areas with relatively high human populations report that dog attacks account for between ~ 5% and 40% of total recorded mortalities. This can have dramatic negative consequences for the viability of koala populations near urban areas. Elevated mortality rates in koalas due to dog attacks has been shown to be a key contributor to the decline in koala populations. Dog attack mortality is particularly a problem where high densities of dog ownership coincide with koala habitat and koala population. Such areas need to be identified and prioritised for implementation of measures to reduced dog attacks on koalas, especially for large and medium-sized dogs (McApline and others 2006).

## 9.2 Objectives

The objectives of this chapter are to:

i) Minimise the risk of dog attacks on koalas;

ii) Increase public awareness of the problem of dog attacks on native fauna; and

iii) Promote responsible dog ownership.

### 9.3 Reports of Dog Attacks on Koalas

The Ballarat Community-based Koala survey produced 11 reports of dog attacks on koalas in the City in the period from 1995 to 2002. In addition data provided by local wildlife carers has provided many dozens of confirmed reports of dog attacks on koalas, a majority of these koalas reportedly dying as a result of the attacks.

**A project, partially funded by Ballarat City Council, the Australian Koala Foundation and industry, planned to commence in August 2006 and to be completed by December 2006, will investigate more accurate details on koalas that are attacked by dogs, seasonal influences, the relationship of habitat quality to likelihood of attack and the chances of survival or recovery from these attacks.** The project will include an analysis of the information held by wildlife carers and Council's Animal Control Officers about dog attacks.

### 9.4 Management Strategies

It would be unrealistic to contend that dog attacks on koalas could be totally eradicated. However, it is possible to implement measures that can effectively reduce the incidence of roaming domestic dogs within koala habitat areas, especially at night. Areas where high dog ownership densities coincide with koala habitat need to be a priority. Measures can include increased policing of dog control and registration requirements, education programs for dog owners, prohibiting dog ownership in new residential areas adjacent to koala habitat, impounding roaming dogs, requiring dogs to be kept within an enclosure or inside dwellings at night, provision of additional off-leash dog exercise areas away from koala habitat (McAlpine and others 2006). The most effective method of minimising dog attacks is considered to be through the promotion of ***responsible dog ownership***. A strategy to promote responsible dog ownership should involve the following:

- Community education regarding the importance of responsible dog ownership;
- Establishment of a set of community standards to define and help to promote and regulate responsible dog ownership; and
- Establishment of a penalty system to reflect community attitudes to irresponsible dog ownership.

The following management strategies are available to Council:

- Dog Control through enforcement of the ***Domestic (Feral & Nuisance) Animals Act 1994***;
- Preparation of a Domestic Animal Management Plan;
- Provision of dog exercise areas; and
- Establishment of a targeted education program.

#### 9.4.1 *Domestic (Feral & Nuisance) Animals Act 1994*

Council's Animal Control Officers are responsible for enforcement of the ***Domestic (Feral & Nuisance) Animals Act 1994***. Staff deal with dogs at large and issue on-the-spot infringements and undertake court prosecutions as appropriate. Council staff, however, have no responsibility for dealing with wildlife, other than reporting incidences of injury to the Department of Sustainability and Environment or local wildlife shelters for attention.

It is clearly legislated that dogs should be either contained within the boundaries of the owner's property or be under effective control by means of a chain, cord or leash when in a public place. Despite this legislation and continual press reports outlining the problems, some owners still allow their dogs to roam free. The irresponsible actions of these owners can result in problems such as dogs defecating on other people's property, attacking and injuring people or animals (including native fauna), causing a traffic hazard or causing a general nuisance.

The economic and environmental costs associated with irresponsible dog ownership are incurred by Council and the community.

With respect to the protection of native animals from attack by dogs, the following sections of the ***Domestic (Feral & Nuisance) Animals Act 1994*** are particularly relevant:

- **Section 31. Authorised officer able to destroy dog or cat found at large in certain areas**

  "(1) An authorised officer may destroy any dog or cat found at large—
  (a) in any area which is designated as a control zone under a management plan made under an Act which is a relevant law within the meaning of the **Conservation, Forests and Lands Act 1987**; or
  (b) in any area classified as a conservation zone under a planning scheme under the provisions of the **Planning and Environment Act 1987**."

- **Section 42. Power of Councils to make local laws**

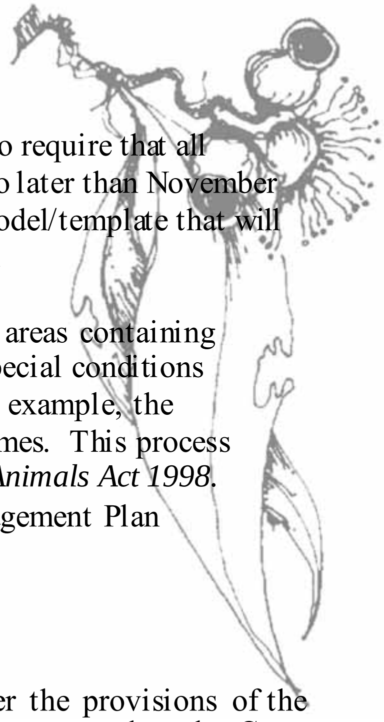
  "A Council may make a local law for or with respect to all or any of the following—
  (b) prohibiting or regulating the keeping of dogs or cats in a specified area of the municipal district of the Council where threatened native fauna are at risk of attack."

- **Section 43. Power of authorised officer to destroy animals at large in specified areas**

  "If a Council has made a local law prohibiting the keeping of dogs or cats in a specified area of the municipal district of the Council, an authorised officer may destroy any prohibited animal found at large in that area."

- **Section 44. Power of Councils to require restraint of animals**

  "(1) If a Council has made a local law prohibiting the keeping of any dog or cat in a specified area of the municipal district of the Council, the Council may require the owner of any dog or cat kept in that area immediately before the law is made—
  (a) to confine the animal indoors or in a totally enclosed pen on the owner's premises; and
  (b) when the animal is outside the owner's premises, to confine the animal to an enclosed vehicle.
  (2) The Council must give the owner notice in writing of this requirement."



**Domestic Animal Management Plan**

In 2005, the ***Domestic (Feral & Nuisance) Animals Act*** was amended to require that all councils in Victoria prepare a Domestic Animal Management Plan by no later than November 2008. The Bureau of Animal Management is currently developing a model/template that will be provided to councils to assist them in the development of these plans.

It is hoped that these plans will enable councils, for example, to identify areas containing species, such as koalas, that are vulnerable to predation by dogs, with special conditions developed to protect native species. These conditions could include, for example, the requirement that owners keep their dogs on their own properties at all times. This process would be similar to that provided in the New South Wales *Companion Animals Act 1998*. Under that Act, councils may prepare a Local Companion Animal Management Plan containing such requirements.

**Legal Action**

In order for legal action to be taken against the owner of a dog under the provisions of the ***Domestic (Feral & Nuisance) Animals Act 1994***, evidence has to be presented to the Court which proves beyond reasonable doubt that a specified incident in contravention of the Act occurred, and that the accused is the owner of the dog in question. This may involve use of any one or more of the following:

- A witness to the attack who is prepared to give evidence in Court;
- The witness being able to recognise the dog;
- Photographic evidence of the attack
- Expert evidence that the attack was perpetrated by a dog.

**Dog Problem Areas**

Dog problem areas have been identified from the recorded locations of dog attacks on koalas within Ballarat and on the basis of advice from the Ballarat City Council regarding areas where dogs are known to roam uncontrolled.

There is a tendency for this problem to be concentrated in areas not containing koala habitat, such as Delacombe, Sebastopol and Wendouree, but certain areas of eastern Ballarat are also noted for the number of roaming dogs. The problem is directly connected to a less than responsible attitude to dog ownership.

A particular problem involves the tendency of some dog owners to release their dogs at night to roam, which is difficult to police. Again, further research and analysis of the problem of roaming dogs is required, with this information than forming the basis for an on-going public education campaign. Such a campaign would build on the initiatives already taken by Council to promote responsible dog ownership and existing State Government initiatives, such as the model Domestic Animal Management Plan, developed through the use of the levy obtained from dog registration fees

**Impounding of Dogs**

Ballarat City Council Animal Control Officers are responsible for dog enforcement within the City. The duties of the Animal Control Officers principally involve impounding stray or roaming dogs, however, Animal Control Officers also undertake public awareness campaigns within the City, advocating dog de-sexing, the requirement for dog registration and responsible ownership of dogs.

People should be aware that they may take photographs or video recordings of a straying dog in a public place so that the owner can be located and appropriate action taken.

### 9.4.2 Dog Exercise Areas

Within the City of Ballarat, dogs must be "on leash" in the following locations:

- ❖ Any area that is signed requiring dogs to be on lead;
- ❖ Within 50 metres of playground equipment;
- ❖ Within 50 metres of any cooking equipment, table and chairs in a reserve;
- ❖ Within 50 metres of the high water mark of Lake Wendouree;
- ❖ Within 50 metres of any parade, procession or organised gathering;
- ❖ Ballarat Botanical Gardens;
- ❖ Gong Reserve in Buninyong;
- ❖ Eureka Stockade Reserve;
- ❖ Lake Esmond Reserve;
- ❖ Any strip shopping centre or mall;
- ❖ Any walking path or shared footpath.

Therefore, other public reserves not included above are locations where dogs may be exercised off leash (as long as effective control of the dog is maintained). Reserves that Council promotes as being suitable off leash areas include Victoria Park, Moreshead Park, M. R. Power Reserve, Russell Square and Pearce's Park. None of these reserves are within or located close to areas of koala habitat

Council has responsibility for the provision of public areas for dog owners to exercise their animals. However, it is important that these areas do not conflict with Preferred or Supplementary Koala Habitat. It is important for koala/dog conflict to be minimised in public reserves where koala habitat exists.

Signposting at public reserves is an important means of advising people whether dogs are allowed and if so under what restrictions.

### 9.4.3 Education

The role of education in promoting responsible dog ownership cannot be overestimated. The ***Domestic (Feral & Nuisance) Animals Act 1994*** requires all councils to prepare a Domestic Animal Management Plan by no later than November 2008. Although the format for these plans has not yet been established, it is highly likely that there will be a strong emphasis on the responsible ownership of dogs, utilising clear and continuing community education programs to emphasise the benefits of and support the many reasons why dog and cat owners should look after their animals in a responsible way.

Aside from the future use of these plans, other actions can be taken immediately by Council. These should include issuing press releases each year prior to the commencement of the koala breeding season and initiating publicity when a series of dog attacks occurs or when an owner has been successfully convicted as result of a dog attack on a koala.

Overall, because of the proven importance of community education in a matter such as this, the preparation of a community education program about the interactions that occur between dogs and koalas should be a central and high priority task in implementing the Ballarat Koala Plan of Management.

# 10. FERAL ANIMAL MANAGEMENT

## 10.1 Introduction

The City of Ballarat is known to contain a range of feral animal populations including wild dogs, foxes, cats, and rabbits. It is likely that feral animals currently affect land administered by each of the principle land management agencies and organisations, as well as private lands within the City of Ballarat. The principle land management agencies in the City of Ballarat include Ballarat City Council, Central Highlands Water, the Department of Sustainability and Environment and Parks Victoria.

Several feral animal species known to occur in the City of Ballarat are considered to have the potential to impact upon koalas.

## 10.2 Objectives

The objectives of this chapter are to:

i) Outline the potential impacts of feral animals on koalas;

ii) Identify the issues to be addressed by feral animal management; and

iii) Develop a suitable strategy, as required, to reduce the impact of feral animals on koalas.

## 10.3 Likely Impacts of Feral Animals on Koalas

From the range of feral animal species known to occur within the City of Ballarat, feral dogs have the greatest potential to impact directly upon koalas. Foxes and to a lesser extent feral cats are also considered to have the potential to take small or debilitated koalas. However, like domestic dogs, feral dogs are known to be capable of killing even large, healthy adult koalas.

### 10.3.1 Wild or Roaming Domestic Dogs

The potential for wild or roaming domestic dogs to attack and kill koalas in the City of Ballarat is evidenced by the predation of a number of koalas across koala habitat in Ballarat as reported from the Ballarat Community-based Koala Survey (2004) and wildlife carer records.

### 10.3.2 Foxes

Foxes are known to prey upon native fauna as well as upon other introduced species such as rabbits.

The capacity of foxes to take koalas was confirmed by Dr. Andrew Krockenberger during the course of his Ph.D. research, which focussed on a koala population near Nowendoc in north-eastern NSW. As reported in the July 1992 Australian Koala Foundation Newsletter, Krockenberger confirmed that at least six koalas had been scavenged after death by foxes in his study area over a twelve-month period. He was confident that three of these six koalas were actually killed by foxes.

#### 10.3.3 Feral Cats

Feral Cats are known to occur in most habitats across Australia including many offshore islands. The diet of feral cats in Australia is known to be highly varied, and to include a range of small to medium-sized mammals (Newsome 1991). Feral cats are likely to present only a minor threat to koalas, although they may have the potential to take young koalas.

### 10.4 Management Issues

Feral dogs, foxes and cats appear to be present within the City of Ballarat, however there are no definitive figures as two numbers or impacts at this time.

Current research, including the evidence provided by the Ballarat Community-based Koala Survey, has not identified the activities of feral animals as being a priority issue for action at this time. It is considered therefore that the situation should be monitored through observations, receipt of reports from the community and through further survey work as part of the overall program for implementing the Plan and that in the event that feral animals are identified as a management issue, then priority areas should be identified for feral animal management programs. At that time, the identification of priority areas would be carried out with reference to the Koala Habitat Planning Map. For example, areas of Preferred Koala Habitat where feral dogs or roaming domestic dogs are known to occur should be identified as priority areas for wild dog management.

### 10.5 Options for a Management Strategy

In light of the low impact of feral animals on the local koala population at the present time, it is considered the most appropriate approach to the management of feral animals is for the Plan Implementation Committee to keep a 'watching brief' over the issue. Whilst the Committee could consider feral animal issues generally within the City, those associated with impacts on native fauna and koalas in particular should be conferred a priority. At the appropriate time, the Committee should seek to develop an effective community awareness program concerning feral animal management an appropriate means to receive ongoing feral animal reports and to monitor the effectiveness of management practices.

In the event that there is a need for a coordinated and effective feral animal management strategy, the Committee could initiate this project with other stakeholders concerned about the presence and activities of feral animals in the City of Ballarat. If this eventuality arises, the co-ordinated approach should be adopted by all relevant land management agencies in the City. This would maximise the efficiency of management practices and minimise the likelihood of rapid re-colonisation by feral animals of a particular management area following treatment. Any feral animal strategy should be prepared utilising relevant legislation, research findings, previous experience, knowledge of effects on target and non-target species, ethical standards concerning animal research and environmental suitability.

# 11. FIRE MANAGEMENT

## 11.1 Introduction

Bushfire management features prominently in the policies and practices of government and land management agencies within the City of Ballarat. This is particularly the case with respect to the Country Fire Authority, which has considerable fire fighting resources including a number of local volunteer and professional fire brigades operating throughout the City. The Department of Sustainability and Environment has responsibility for fire prevention and the fighting of fires on public land, including land managed by Parks Victoria.

As far as the Ballarat City Council is concerned, fire management responsibilities are currently determined by the *Country Fire Authority Act 1958*. This Act requires Council to appoint a Municipal Fire Prevention Officer and a Municipal Fire Prevention Committee and to develop a Municipal Fire Prevention Plan. The Committee provides for a coordinated approach to bushfire management through the preparation and implementation of the Municipal Fire Prevention Plan. The Ballarat City Council is responsible for convening and servicing the Committee. This structure, however, is currently under review (June 2006).

Although bush fire has an important role in biological processes, bush fires, particularly recurrent bushfires resulting from acts of arson, represent a significant threat to wildlife and vegetation assemblages. Bush fires within the City of Ballarat are considered to have the potential to significantly impact upon koala habitat and local koala populations.

## 11.2 Objectives

The objectives of this chapter are to:

i) Identify and monitor the impacts of bushfires on koalas and koala habitat in the City of Ballarat;

ii) Identify relevant ecological issues that should be addressed through bushfire management programs; and

iii) Recommend appropriate measures to minimise potential adverse effects of bushfires on koalas and koala habitat within the City.

## 11.3 Koalas and Bushfire

Under most circumstances, low intensity bushfires or prescribed (fuel reduction) burns are not considered likely to significantly affect koala numbers. In contrast, high intensity bushfires are known to kill many animals, including koalas. While high intensity bushfires are likely to dramatically reduce fauna populations over the short-term, studies of some species and their habitat following bushfire suggest that their long-term survival may not be threatened by high intensity bushfire (Catling 1991).

However, the ability of fauna species to recolonise a specific area of habitat following a high intensity bushfire is likely to be affected by a number of factors including:

- The extent and intensity of the bushfire;
- The rate and nature of habitat regeneration;
- The capacity of adjacent fauna populations to provide adequate levels of recruitment to re-colonise burnt areas; and
- The impact of threats posed by factors such as feral and native predators, and traffic which could affect the potential for re-colonisation from adjacent unburnt habitat, as well as potentially affecting survival of any fauna occupying regenerating habitat.

When intense bushfires affect extensive areas of significant habitat for species such as koalas, the impact at the population level could be dramatic over both the short and long-term. This is particularly likely where habitat has already been highly fragmented, often as a result of development activity, and where the young in the population have been predominantly eliminated.

### 11.4 Koala Habitat and Associated Plant and Animal Communities

Examination of the long-term impacts of fire requires consideration of the fire regime. The fire regime is the pattern of fire over time and across the landscape (Pickett and White 1985). Components of the fire regime include intensity, frequency and season of occurrence (Gill 1975). High frequency fires resulting from arson could cause changes to koala habitat by reducing the survival of juvenile trees and potentially causing the decline of populations of species utilised by koalas. Similarly, apart from temporary browse loss and tree degradation, over the medium-term, frequent low-intensity fuel reduction burns, which are a common feature of fire management practices, could potentially alter species composition by favouring particular species whilst discouraging or eliminating other species.

The majority of *Eucalyptus* species are generally capable of surviving a fire: they can grow new shoots from epicormic buds protected from the fire by bark or in underground lignotubers (Williams and Gill 1995). However, this ability to survive a fire is dependent on the presence of a number of features (e.g. fire resistant bark, stores of buds and energy (starch) reserves), which may not develop in juvenile plants for several years (Keith 1996). In the interim such plants are likely to be killed by fire, and if a series of fires occurs with such frequency that the aforementioned features are unable to develop, then all such juveniles may be lost, senescent adults will not be replaced, and the population will decline (Keith 1996). Even plants that have developed energy reserves and a store of buds can be killed by frequent fires if the interval between fires is insufficient to allow for their replenishment (Keith 1996). Both adult and juvenile eucalypts could be killed in this way.

Fuel reduction burns are more likely to affect juvenile eucalypts, as it would be expected that the crown of adult eucalypts would remain largely intact. The season of burning can also be important; energy reserves may be low after periods of rapid plant growth, thus making plants more vulnerable to fires that occur soon after such growth periods (Cremer 1973). Research that addresses these issues as they relate to tree species that are significantly utilised by koalas and other native fauna in the City of Ballarat should be given high priority.

Under-storey species that survive a fire and re-sprout from protected buds may be affected in a similar manner to that outlined above (see review by Williams and Gill 1995). Species that are usually killed by fire and rely on regeneration from seed could also be lost under a regime of high fire frequencies if plants are killed before they set seed or if stores of seed (e.g. in the soil) are depleted before they can be replenished (Benson 1985; Keith 1996). Low intensity fires such as fuel reduction burns may prevent the germination of seeds of species where high temperatures act as germination cues (Auld and O'Connell 1991). Changes in the under-storey composition are likely to impact on fauna; Catling (1991) noted that frequent low intensity fires could result in simplification of forest structure by reducing shrub cover, which in turn may lead to long-term reductions in the abundance and diversity of fauna species.

Over the past twenty years, a great deal of work has been undertaken on bushfire behaviour in Australia. Generally the emphasis of this work has been on how to control fires and on the protection of assets and property. More emphasis is required on the ecological impacts of fire behaviour and there is a great need to link all aspects of bushfire research to ensure multiple benefits are achieved.

It is recommended that priority be given to research to determine fire management strategies that best meet the objectives of: dealing with the threat of arson; protecting people and property; reducing the risk of injury or death to koalas; and providing for the long-term conservation of koala habitat and associated plant and animal communities within the City.

## 11.5 Fire Management Planning

### 11.5.1 Municipal Fire Prevention Committee

Fire Management responsibilities are currently determined by *the Country Fire Authority Act 1958*, with this Act requiring the appointment of a Municipal Fire Prevention Officer, a Municipal Fire Prevention Committee and development of a Municipal Fire Prevention Plan by municipal councils. This structure, however, is currently undergoing change with the implementation of a new Integrated Municipal Fire Management Planning structure. It is not expected, however, that the new process will specifically identify the need to account for matters affecting the management of koalas and koala habitat, having what has been described as a broader strategic focus towards the management of fire and fire behaviour (Bellingham pers. com. 2006).

The current Municipal Fire Prevention Committee consists of:

- The Municipal Fire Prevention Officer as Executive Officer of the committee,
- One City of Ballarat Councillor,
- The Country Fire Authority Manager of Community Safety (Midlands/Wimmera area),
- One member from each of the brigades and Brigade Groups within the municipal area, and
- One representative each from the Department of Sustainability and Environment (DSE), Central Highlands Water, VicRoads and Hancocks Plantations (private company managing areas of pine and blue gum plantations in the City).

To date there have been no nominations received from community groups to partake in membership of the Committee, which is provided for under the ***Country Fire Authority Act***, despite wide-spread advertising for community feedback prior to the adoption of the current Municipal Fire Prevention Plan. To date there has also been little interest from the community in taking up opportunities to attend public meetings or comment on the Plan, which is unfortunate, given the importance of the Plan to both the management of the environment and the protection of property.

The Committee meets four times a year as a minimum, but the Executive can be called to meet should the need arise at any time.

The current format of the Municipal Fire Prevention Plan and Committee will change significantly towards the end of 2006, given the impending outcomes of the Integrated Fire Management Planning process.

The City of Ballarat Municipal Fire Prevention Plan, whilst not focusing specifically on the requirements of the koala, recognises the significance of fire on the environment and seeks to alter fire regimes (where possible) to prevent the loss of biodiversity. The Plan highlights the requirement to consult with DSE and Council staff where there are identified areas of significant conservation value, to ensure appropriate fire prevention strategies are implemented. Fire prevention works on roadsides are undertaken in conjunction with Council's Roadsides Management Plan.

### 11.5.2 Fuel Reduction Burning Programs

Fuel reduction burning is a technique commonly used to reduce fuel loads in high fire risk areas. Bush and forest areas close to urban areas are often given priority for fuel reduction burns. In the case of Ballarat, this means forested areas such as the Canadian and Creswick State Forests - areas of important koala habitat – that are adjacent to closely settled residential areas are subject to a relatively high frequency of fuel reduction burns. Little if any research has been done in Ballarat either on the impact this regime has on the koalas themselves or on their habitat. This is of particular importance as much of the area being burned under current arrangements contains primary koala habitat. The exact extent of the area being burned would need to be checked against the Koala Habitat Atlas as part of research to be carried out on fuel reduction burning impacts.

The requirement for forest and woodland burning in Ballarat for ecological purposes, particularly as related to the food requirements of the koala, needs to be established. Because bushfires are relatively infrequent in Ballarat, it is not clear what frequency and extent of fire will benefit or dis-benefit the region's koalas. Research on the effects of fuel reduction burning should be linked to the wider scope for research outlined in Section 11.4.

## 11.6 Mapping Bushfires

Recent research indicates that it may be possible to use satellite imagery for the purposes of bushfire history mapping as an alternative to conventional methods, which often rely heavily upon the availability of post-fire aerial photograph coverage.

Digital and visual analysis of Landsat TM imagery data could potentially be used for the purposes of identifying burnt vegetation, mapping fire boundaries and fire intensity, and for monitoring post-fire regrowth on the basis of spectral reflectance values.

## 11.7 Management Strategies

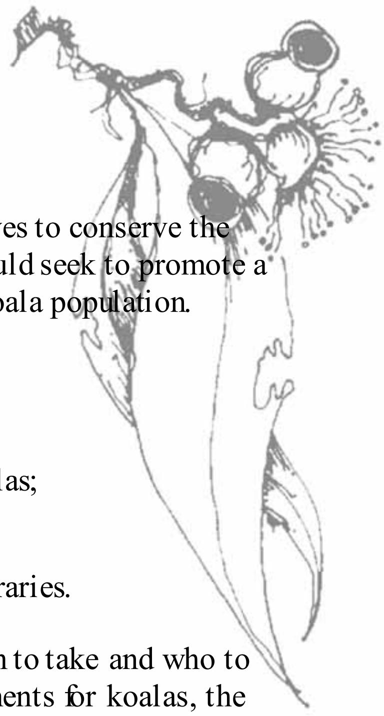
### 11.7.1 Research

Research is at the heart of understanding the relationship between fire behaviour, the ecological requirements of the koala and its habitat and the need to protect property and human life. The requirements and reasons for fuel or hazard reduction burning can differ significantly from the requirements for ecological burning. There can, however, be a coincidence of purpose; i.e. burning is a natural part of the ecology of eucalypt forests and woodlands and generally it is preferable for both ecological and fuel reduction purposes to burn during the autumn. Matters such as of frequency and extent of burning are likely to be issues requiring resolution.

### 11.7.2 Planning for the Koala in Fire Management Programs

Whilst current fire management processes may make provision for protection or conservation of biodiversity values in general, in the absence of specific management guidelines for the koala, the impact of current practice on that species cannot be gauged. On-going research, as pointed out above, is important, however, with the production of the Ballarat Koala Plan of Management, there is sufficient information available to modify existing fir management plans and therefore current practice to recognize the needs of the koala and its habitat.

It therefore would be most advantageous for the Ballarat Municipal Fire Prevention Plan to be modified to include areas of **Preferred and Supplementary Koala Habitat and vegetated Habitat Buffers and Habitat Linking Areas** as specific environmental assets and accordingly to develop appropriate fire management methods. This should occur in conjunction with the work of the Plan Implementation Committee, particularly any on-going fire research programs undertaken or auspiced by the Committee.



# 12. EDUCATION & PUBLICITY

## 12.1 Introduction

Public education is considered to be an important component of initiatives to conserve the koala population in the City of Ballarat. Public education programs would seek to promote a sense of stewardship and increase awareness of the plight of the local koala population. These programs may involve:

- Education within schools and community groups;
- Utilising local media to heighten awareness of issues relating to koalas;
- Educational literature such as information brochures; and
- Information displays in buildings such as Council Chambers and libraries.

Members of the public should be informed on issues such as what action to take and who to contact if they encounter an injured or distressed koala, habitat requirements for koalas, the importance of responsible dog ownership and the need to drive with caution in signed koala road risk areas. Education objectives need to focus on informing people about the importance of retaining, managing and restoring koala habitat in the area, which is essential to the ongoing survival of the Ballarat koala population.

## 12.2 Objectives

The objectives of this chapter are to:

i) Heighten public awareness regarding the presence of koalas in the Ballarat area;

ii) Ensure information on issues relating to koalas is made readily available;

iii) Inform the local community on ways they can contribute to the conservation of the Ballarat koala population; and

iv) Inform the local community on appropriate action in cases where sick, injured, distressed or dead koalas are encountered.

## 12.3 Educational Strategies

### 12.3.1 Information Brochures

It is recommended that initial resources should focus on providing an information brochure to outline koala conservation issues addressed in this Plan and inform people on ways they can contribute to koala conservation in the City of Ballarat.

### 12.3.2 Sign Posting

The following roads within City of Ballarat currently have Koala Warning Signs: Geelong Road, Mt Helen, Midland Highway, Scotsburn and Yankee Flat Road, Buninyong. Specific recommendations regarding road signage have been addressed in Chapter 8 - Traffic Management.

### 12.3.3 Environmental Education

The Ballarat City Council currently provides environmental education through specific programs (e.g. delivery of the ‘Green Schools’ program as part of implementing the LINCS Strategy) and through articles in Council newsletters and through information brochures on water resource and waterways’ management, habitat conservation and restoration and recycling and waste management, including through programs provided by the Highlands Regional Waste Management Group.

The involvement of the Ballarat City Council with school environmental groups and community groups as perceived through presentations by the AKF Liaison Officer has been beneficial to koala conservation. It would be advantageous for Ballarat City Council to continue with this liaison, particularly with schools that adjoin areas containing koala habitat. This would continue to provide opportunities for school participation with implementation and ongoing maintenance of local koala habitat restoration projects, such as undertaken by Council through the ‘Greening Ballarat’ and LINCS Yarrowee River Restoration programs.

### 12.3.4 Telephone Hold Recordings

Information could be relayed to the public through the existing telephone hold systems at the Ballarat City Council concerning koalas and their conservation requirements.

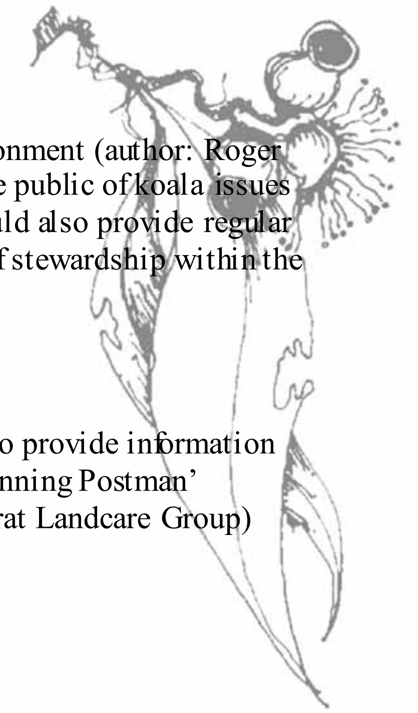
## 12.4 Publicity & the Media

### 12.4.1 Press Releases

Press releases provide an opportunity to communicate to a wide range of people through print and/or radio. Press releases could target specific issues such as the importance of responsible dog ownership and the potential impacts on koalas from roaming domestic dogs/wild dogs. Press releases should also be issued to encourage reporting of koala sightings to AKF’s Liaison Officer with Council.

### 12.4.2 Community Service Announcements

Commercial television and radio stations provide 30 seconds of free air for public awareness campaigns. Community Service Announcements could be used in conjunction with press releases to target specific koala conservation issues within the City of Ballarat.



### 12.4.3 Weekly Columns

The Ballarat 'Courier' produces a weekly section on our natural environment (author: Roger Thomas). The section could be extended to include notifications to the public of koala issues and request reports of koala sightings within the City. The articles could also provide regular updates on the status of the local koala population and foster a sense of stewardship within the community.

### 12.4.4 Newsletters

There are many examples of community newsletters that can be used to provide information about and engage the community in the care of the koala; e.g. 'The Running Postman' (Ballarat Environment Network Inc), 'Wildlife Whistler' (South Ballarat Landcare Group) and 'MyBallarat' (City of Ballarat).

# 13. FUNDING

## 13.1 Introduction

The ability of this Plan to meet the identified objectives will partly depend upon funding for implementation. Funding can be sought from a number of sources including state and federal government grants, Council revenue, and private or corporate sponsorship. Appropriate funding sources need to be identified for the actions in the Plan that require financial input.

## 13.2 Objectives

The objectives of this chapter are to:

i) Identify potential sources of funding for implementation of the Plan; and

ii) Provide a strategy to ensure the necessary levels of funding are achieved.

## 13.3 Funding Sources

### 13.3.1 Government Grants

A number of State and federal government departments operate environmental funding programs. Some of the more relevant programs include the following:

**a) CMA (Catchment Management Authority) Grants**

The CMAs could be approached to seek funding to assist in implementation of certain actions from the Plan.

Types of grants and their criteria are constantly changing but funds are regularly made available for education, research, restoration and rehabilitation. Recommended initiatives detailed in the Habitat Restoration, Monitoring, Education and Research Chapters may well be able to attract funding from the CMAs.

**b) Natural Heritage Trust (Envirofund)**

Envirofund is the local action component of the Commonwealth Government's Natural Heritage Trust program. The funding allocations assist communities to undertake local projects aimed at conserving biodiversity and promoting sustainable resource use. Community groups and individuals can apply for grants of up to $50,000 to carry out on-ground work and actions targeting local problems. Bushland and waterway restoration and management projects that eventuate from the recommendations of the Habitat Restoration Chapter (Chapter 7) may be able to attract funding from the Envirofund Program.

Other programs such as Bushcare also offer potential for funding habitat conservation works.

### 13.3.2 Ballarat City Council

Councils have significant responsibilities in environmental management, including the management of open space and the implementation of planning policies and regulations concerned with the protection of native vegetation. The ways in which councils use their resources and make decisions in relation to these matters are major influences affecting the future retention and enhancement of koala habitat. The re-setting of priorities for the maintenance of open space areas; e.g. increased emphasis on expenditure for bushland retention and enhancement rather than on sporting grounds or formal gardens, and reassessing the extent of resources applied to ensuring compliance with planning controls and planning permit conditions aimed at limiting vegetation removal, are areas where results can be achieved without necessarily requiring an increase in expenditure by councils. Similarly, through its existing information and publicity programs, councils can exert considerable influence through the messages that they present. Additional expenditure in these areas will, of course, increase the impact of programs aimed at protecting and enhancing habitat.

### 13.3.3 VicRoads

VicRoads are likely to contribute funds towards relevant projects detailed in Chapter 8 and Section 5.4.4 of the Plan.

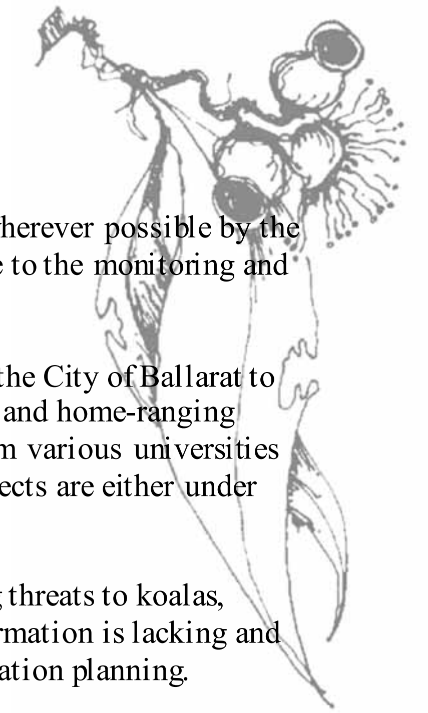
### 13.3.4 Conservation Groups

A number of conservation groups are actively involved with koala issues in the City of Ballarat, including the Western Victorian Wildlife Group (WVWG) and the Australian Koala Foundation (AKF).

The WVWG cares for sick, injured or orphaned native wildlife including koalas under licence from the Department of Sustainability and Environment.

### 13.3.5 Private Funding Sources

Private organisations are sometimes willing to assist with koala conservation efforts and may be prepared to contribute funds toward implementation of the Plan, particularly for projects likely to gain positive media coverage. Businesses, philanthropic organizations and service clubs are all potential funding sources, whether in cash or in kind.



# 14. RESEARCH

## 14.1 Introduction

Koala management planning and decision-making should be guided wherever possible by the outcomes of rigorous scientific research. Research can also contribute to the monitoring and evaluation of the effectiveness of management programs.

A number of koala research projects have already been undertaken in the City of Ballarat to investigate matters such as tree species preferences, habitat utilisation and home-ranging behaviour. Much of this work has been undertaken by researchers from various universities and the Australian Koala Foundation. A number of new research projects are either under way or proposed for the next three years.

Limitations on both financial and staff resources, as well as increasing threats to koalas, accentuates the importance of directing research into areas where information is lacking and where results are most likely to contribute to improving koala conservation planning.

## 14.2 Objectives

The objectives of this chapter are to:

i) Encourage and facilitate koala research focusing on topics where current information is inadequate or incomplete;

ii) Ensure effective utilisation and application of research findings towards koala management practice and decision-making;

iii) Encourage ongoing involvement of final year and postgraduate university students and university staff in koala research within the greater Ballarat area; and

iv) Facilitate the involvement of volunteers in suitable koala research projects.

## 14.3 Potential Future Koala Research Projects

There are currently 3 scientific papers in preparation that deal with koala research conducted in full or part in Ballarat with others to come over the next couple of years:

- *"Are habitat relationships in fragmented forest landscapes similar across regions for wide ranging species? A koala case study."* (Clive McAlpine, Michiala Bowen, John Callaghan, Daniel Lunney, Jonathan Rhodes, David Mitchell, and Hugh Possingham).

- "*Identifying regional variation in habitat-occupancy thresholds: A koala case study.*" (John Callaghan, Jonathan Rhodes, Clive McAlpine, Carol de Jong, Daniel Lunney, Michiala Bowen, David Mitchell, and Hugh Possingham).

- "*Explaining koala occurrence at multiple ecological scales in Ballarat, Victoria,* *Australia*". (Stephanie Januchowski, Clive McAlpine, John Callaghan, Carol Griffin, Michiala Bowen, Dave Mitchell and Dan Lunney).

In addition, the following list identifies a number of research topics that could potentially enhance koala management planning and practice within the City of Ballarat. The list is intended as a preliminary guide only:

- Monitoring of koala numbers over time, to include setting up monitoring sites that examine change in tree usage by koalas for certain areas and radio-tracking of local koalas to supplement these monitoring sites.

- Collation, analysis and regular updating of reports on koala road incidents from veterinarians and wildlife carers.

- Investigation of mapped Koala Habitat Linking Areas in the City of Ballarat to assist in developing a prioritised list of potential habitat restoration projects.

- Evaluation of potential methods for reducing koala road mortality including the use of underpasses or overpasses, slow-speed zones, warning signs and driver education.

- Identification of potential release sites for hand-reared or rehabilitated koalas, where it is determined to be inappropriate to release at the encounter site.

- Ongoing research into the success of koala rehabilitation and release programs.

- Research into re-colonisation of habitat following bushfire.

- Ongoing research concerning the effects of predation by roaming domestic dogs, wild dogs and foxes on koalas within the City.

- Identification of lands within the City where 'Conservation Agreements' could benefit koala habitat conservation and management.

- Evaluating the effect of fuel reduction programs on Ballarat's koalas and koala habitat.

- Investigating the impact that the spread of lerps has on the koalas' food resource and therefore on the conservation of the species. The ongoing drought has contributed to a spreading of lerps that especially affect some *Eucalyptus* species, including the koala food trees *E. ovata* (Swamp Gum) and particularly *E. viminalis* (Manna Gum). There is anecdotal evidence that because of the lack of quality food associated with the prolonged drought koalas increase and prolong their movement on the ground and extend their home ranges in search of food and often water and by doing so, increase their exposure to collisions with cars and attacks by dogs. An opportunity would exist to test this hypothesis during a controlled trial at the Ballarat wildlife Park if funding can be found.

- Researching the relationship between the presence of preferred koala food trees along roads and koala mortality and the 'sink' effect created by koalas killed as a result of moving into the road traffic environment to feed being replaced by other koalas seeking a food source in order to establish principles for the management of vegetation along roadsides.

- Follow-up postal survey each five years to assist with assessment of the ongoing conservation status of koalas, and public attitudes and perceptions towards koala management within the City of Ballarat.

- Evaluation of the effectiveness of the Ballarat Koala Plan of Management, in conjunction with the monitoring program (see Chapter 15).

# 15. MONITORING PROGRAM

## 15.1 Introduction

An ongoing monitoring program will be commenced in conjunction with the adoption of the Ballarat Plan. As part of this program a number of performance indicators will be identified to provide a means to determine the level to which key outcomes have been achieved and to quantify the success or failure of the measures specified in the Plan. The monitoring program will also include a procedure to be followed should the Plan fail to meet the identified performance indicators. A proposal for funding the monitoring program should also be specified. It is intended for the Plan to be regularly reviewed and amended if necessary to reflect the findings of the monitoring program.

The monitoring program will require the ongoing commitment and support of Ballarat City Council. It is proposed that the responsibility for co-ordinating the monitoring program be assigned to a suitably qualified Council Officer, in conjunction with the AKF, or to the AKF's Liaison Officer.

## 15.2 Objectives

The objectives of this chapter are to:

i) Identify suitable performance indicators upon which to gauge the success of the Plan over time;

ii) Detail an appropriate ongoing monitoring program including identification of those responsible for undertaking the program;

iii) Detail a suitable funding proposal for the monitoring program;

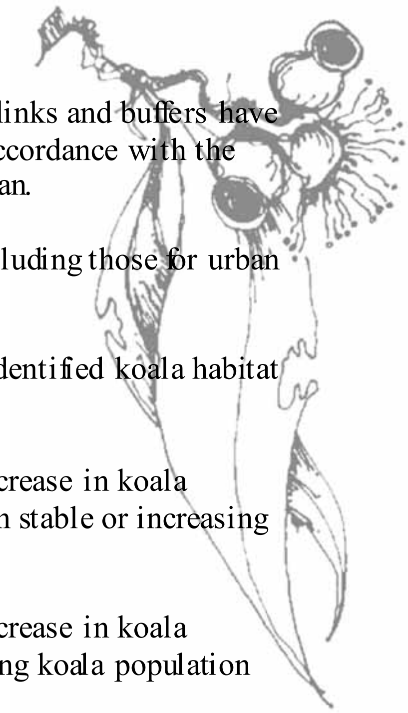
iv) Specify a procedure to be followed should the Plan fail to meet any of the identified performance indicators;

v) Define the procedure for bi-annual reporting on the status of koala populations and Koala habitat within the City of Ballarat; and

vi) Define an acceptable procedure for bi-annually reviewing and potentially amending the Plan if necessary. This procedure will also be important for resolving issues concerning fine scale accuracy of koala habitat mapping.

## 15.3 Performance Indicators

This section identifies the performance indicators to be used by the Plan Implementation Committee to periodically evaluate the Plan. The performance indicators consist of a number of specific conservation outcomes that will be used to assess the success or failure of the Plan's recommendations.



These conservation outcomes are:

- ❖ Preferred Koala Habitat areas together with the associated habitat links and buffers have been successfully protected and managed throughout the City in accordance with the Habitat Conservation and Restoration measures specified in the Plan.

- ❖ Annual koala population estimates indicate that koala numbers including those for urban areas are stable or increasing.

- ❖ Habitat restoration programs have been successfully initiated for identified koala habitat linking areas over cleared or heavily degraded lands.

- ❖ Annual statistics either do not indicate an increase or indicate a decrease in koala mortality due to collisions with motor vehicles, in conjunction with stable or increasing koala population estimates for identified Black Spot areas.

- ❖ Annual statistics either do not indicate an increase or indicate a decrease in koala mortality due to dog attacks, in conjunction with stable or increasing koala population estimates for identified high risk dog attack areas.

### 15.4 Monitoring Program

The monitoring program will aim to periodically update the status of the koala population and available koala habitat within the City of Ballarat. The status of the koala population will be assessed in terms of estimated koala numbers, evidence of breeding activity, records of mortality, and estimated distribution of koalas within the City. The program will also seek to record changes in the amount and quality of available koala habitat as well as changes in the levels of habitat utilisation. The impact of threatening processes upon the koala populations will be monitored to determine the level of success or failure of the measures in the Plan. The relative significance of each threatening process will also need to be regularly assessed to ensure resources are focused in the highest priority areas.

#### 15.4.1 Koala Habitat

The vegetation and koala habitat mapping shows the distribution of plant associations and koala habitat across the City of Ballarat at the time of survey. It will be necessary to periodically update the vegetation map to incorporate subsequent clearing or regrowth of native vegetation and to allow for any fine-scale refinement of plant association classifications and mapping. Amendments to the vegetation map may necessitate changes to the koala habitat mapping. Because the process to amend these maps is complex it is proposed that this procedure be carried out no more frequently than once a year, to allow all necessary amendments to be incorporated together. In the interim it will be necessary to make Council's planners and the Department of Sustainability and Environment aware of any necessary amendments to ensure that any proposed development or activity likely to affect that area can be assessed accordingly.

It is proposed that the procedure for this notification will be that where it is likely that changes to the vegetation and koala habitat mapping will be necessary, the relevant areas will be cross-hatched on the Koala Habitat Planning Map to denote the need for revision. This will be done on the digital version of these maps that will be held by the Implementation Committee and provided in digital and hard copy form to Council's planners and to the Department of Sustainability and Environment and other stakeholders, together with a written description of the property details and the recommended reclassification of the vegetation.

It is recommended that Council purchase the latest available satellite imagery for the City of Ballarat at four-year intervals to assist with ongoing monitoring and review of the Plan as well as for other Council management needs. These images should be interpreted in consultation with the Australian Koala Foundation to identify changes in the extent of each category of koala habitat resulting from incremental habitat loss, degradation or fragmentation and over the longer term, with habitat restoration works.

Council should undertake to maintain a register of any koala habitat clearing activities and habitat restoration projects within the City. Matters listed on the register that indicate substantial disturbance to Preferred Koala Habitat should be investigated and included in six-monthly monitoring reports to the Plan Implementation Committee.

### 15.4.2 Koala Population

The following methods should be used to assist with the establishment of population estimates, to detect animals in areas where they had not previously been reported and for the purposes of the ongoing monitoring program:

**<u>Urban Populations</u>**

**Gathering and Analysis of Koala data**

Continuation of the current City of Ballarat-Australian Koala Foundation partnership would ensure that the on-going gathering of koala sightings data and analysis of the records was facilitated. The database could be analysed in conjunction with other koala records, and the amount of each category of koala habitat, to estimate change in the likely size, status and distribution of urban koala populations within the City.

Through the current partnership arrangement, the Koala Liaison Officer receives a great deal of information from the community about the presence, behaviour and mortality of koalas which is vital to the compiling of accurate records and for planning for the survival of the koala. In return, the Liaison Officer is able to provide advice about the best ways to manage and to be aware of the needs of koalas in urban areas in particular; e.g. management of dogs, planting of appropriate vegetation.

**<u>Non-urban Populations</u>**

**Transect Searches**

Annual transect-based searches of designated sites should be co-ordinated by Council and/or the AKF. These searches should be conducted during daylight hours using volunteers.

Transect-based searches will be conducted during mid-spring each year. Search sites should be determined by Council in conjunction with the AKF and should be replicated each search period. The conduct of searches including areas searched, search procedures and search effort should be consistent for each search period, although there may be justification for identifying additional search areas over time.

Search areas should be selected to incorporate identified areas of Preferred Koala Habitat and wherever possible should include areas where evidence of known koala activity and preferably where breeding females have been recorded.

Detailed search protocols and procedures for distribution to potential participants should be prepared by Council in conjunction with the AKF. A training session would be required for search team leaders prior to each annual search, which would include methodology and techniques for conducting searches for koalas, communication protocols and emergency procedures in the event of injury.

Council should record the location of each koala observation together with other relevant details in both map form and on a database at Ballarat City Council following each search period. The data should be analysed and interpreted in conjunction with AKF to estimate the likely maximum size and apparent status of non-urban koala populations within the City. The outcomes of these analyses should be included in the annual Plan monitoring reports.

**Spot Assessment Technique (SAT)**

In addition to the above surveys, the distribution and status of koala populations within the City will be assessed and reported annually through systematic application of the Australian Koala Foundation's Spot Assessment Technique (Phillips & Callaghan 1995); see Appendix 7). This technique relies upon the recording of koala faecal pellet evidence and consequent koala activity levels at assessment sites.

A minimum of ten SAT sites should be established by Council in consultation with the AKF in each of the Preferred, Supplementary and Marginal Koala Habitat categories. Five spot assessment sites in each habitat category should be located in areas where koala activity and/or koalas have previously been recorded. The remaining sites within each habitat category should be located in areas where there is no previous evidence of use by koalas. Where possible, the latter sites should be located within two kilometres of an area of habitat where the activity level recorded during Koala Habitat Atlas fieldwork suggested occupation by a stable breeding aggregation.

SAT results should be compared with those from previous monitoring periods and should be used, together with the estimates for urban and non-urban populations and the total amount of each category of habitat within the City, to estimate the likely status of the City-wide koala population. These results and estimates should be incorporated into the annual Plan monitoring reports.

The estimated status of the koala population in the City should be assessed each reporting period in terms of changes in local and City-wide population estimates, evidence of breeding activity, the recorded distribution of Koalas in the City, mortality statistics and potentially in the future, the outcome of a Population Viability Analysis.

**Population Viability Analysis (PVA)**

Population Viability Analysis is a process that aims to provide an indication of the likelihood that a particular population of a species will become extinct within a specified time, and under a certain set of circumstances (Possingham *et al.* 1993). While PVA can be carried out using various methods including experimentation, observation or by comparison with other species that have similar life histories, this process often involves the application of complex computer simulation models (Possingham 1995). These simulation models provide as output the probability of extinction of the population for the given time and set of circumstances (Possingham 1995). The necessary items for input will vary according to the model used for the analysis and the objectives of the simulation, but can include attributes such as home range size, population densities, fecundity, mortality, population growth and movement (see for example; Lindenmeyer and Possingham 1996). These models can also incorporate the impact of catastrophes such as bushfire (Possingham 1995).

According to Possingham (1995), PVA can provide new insights into the conservation requirements of a particular species as well as highlighting aspects of a species' biology requiring further research. Use of PVA involves the application of 'sensitivity analysis' to the results generated from computer simulation models. Sensitivity analysis is carried out by repeating PVA simulations while systematically varying the values of input parameters to determine which cause significant change to the probability of a population extinction (Possingham 1995). PVA can potentially be used to rank management options, in conjunction with a sensitivity analysis to test the ranking (Possingham *et al.* 1993).

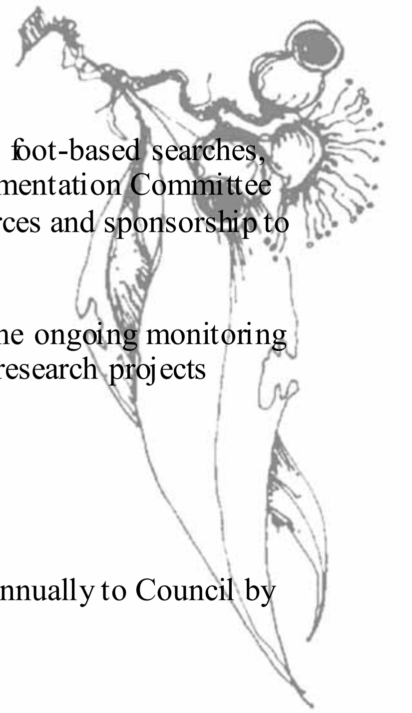
While the necessary data may not be available at present to undertake a comprehensive Koala Population Viability Analysis, the approach could be employed to demonstrate that a number of factors are likely to affect the long-term viability and persistence of the Ballarat Koala population. As more information becomes available for the local Koala population, the potential for effectively using PVA will be enhanced as will the potential for such a model to guide the future refinement of management strategies.

It is suggested that Council liaise with the AKF to investigate the potential for developing a koala specific model for undertaking PVA for the City of Ballarat, which could form an important component of the monitoring program.

### 15.4.3 Threatening Processes

The impacts of threatening processes, in addition to those associated with land clearing, will also be reported on an biannual basis including road mortality, dog attacks, feral predators, bushfires, and incidence of disease.

A register should be maintained to record any cases dealt with by Council's Local Laws Officers involving domestic dog attacks on koalas. Council outdoors staff should be encouraged to report any sightings of dead koalas by the roadside. The register should be maintained by the Implementation Committee in conjunction with the AKF Liaison Officer, in the event that Council agrees to the continuation of the current BCC-AKF partnership.



## 15.5 Funding and Participants

Funding will be required for monitoring programs including promotion, foot-based searches, spot assessments, data base management, and data analysis. The Implementation Committee will be responsible for seeking the necessary funding, assistance, resources and sponsorship to implement the ongoing monitoring program.

Local community organisations should be encouraged to contribute to the ongoing monitoring program and could provide a critical resource. Potential post-graduate research projects involving aspects of the monitoring program should be promoted.

## 15.6 Reporting

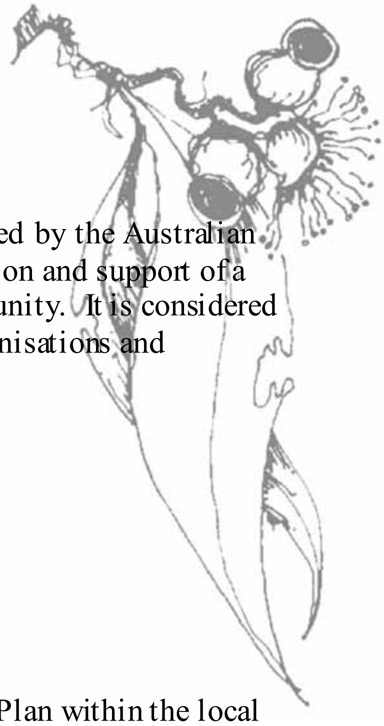
The findings of the ongoing monitoring program should be reported biannually to Council by the Plan Implementation Committee, following adoption of the Plan.

## 15.7 Plan Review and Amendment

The Plan should be formally reviewed by the Plan Implementation Committee at the end of each twelve-month period following adoption. Where failure to meet any one or more of the Performance Indicators has been reported, the Plan Implementation Committee should determine whether the measures established by the Plan require amendment.

It will also be necessary for the Plan Implementation Committee to undertake an annual review of the established Performance Indicators, the monitoring program and the extent to which the recommendations of the Plan have been implemented. Failure to meet Performance Indicators could potentially indicate that measures proposed by the Plan are either not adequate or are not being effectively implemented or alternately, that the indicators selected are unrealistic. In either case, action should be taken by the Plan Implementation Committee to ensure that necessary amendments are made to measures and/or their implementation, or to the Performance Indicators. It may be necessary to amend the Performance Indicators as more information is collected and collated, particularly with respect to the estimated status or size of the local Koala population.

Any proposed amendments to the Plan, for example, for the revision of the vegetation and Koala habitat maps, should be determined by Council following the receipt of a report from the Implementation Committee. Amendments to the Plan will require approval by Council.



# 16. IMPLEMENTATION

## 16.1 Introduction

This Comprehensive Koala Plan of Management (Plan) has been prepared by the Australian Koala Foundation on behalf of Ballarat City Council with the co-operation and support of a number of agencies, organisations and individuals from the local community. It is considered essential to provide for the ongoing involvement of these agencies, organisations and individuals for the effective implementation and updating of the Plan.

## 16.2 Objectives

The objectives of this chapter are to:

i) Provide a formal framework for implementation of the Plan;

ii) Facilitate the ongoing involvement, support and promotion of the Plan within the local community; and

iii) Provide for ongoing monitoring, evaluation and updating of the Plan.

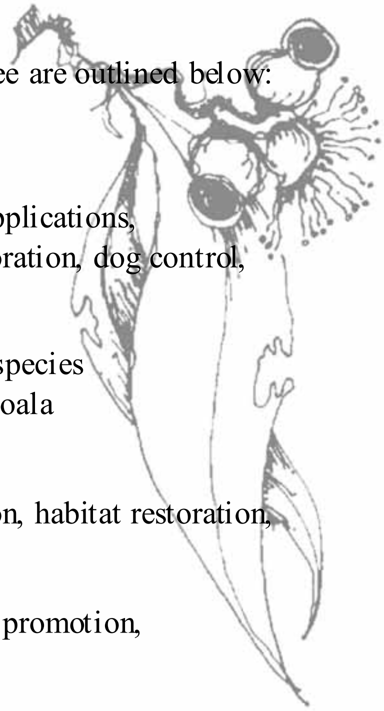
## 16.3 Implementation Strategy

### 16.3.1 Implementation Committee

A Plan Implementation Committee should be established to ensure the recommendations of the Plan are effectively implemented. Core members should include an officer from the Ballarat City Council (BCC), the Department of Sustainability and Environment (DSE), a member from the public via the Ballarat Environment Network (BEN) and a representative from the AKF.

Representatives from other organisations including VicRoads (VR), the Country Fire Authority (CFA), Western Victorian Wildlife Group (WVWG), Central Highlands Water (CHW) Parks Victoria (PV) and researchers should be called upon for input as required by the Implementation Committee.

Given the wide range and number of tasks required to be undertaken or coordinated by the Committee, professional and administrative support should be provided through engaging a part-time Executive Officer. This position should be supported by the Ballarat City Council both financially and in terms of office space, etc. Funding options other than rate revenue should be explored to support this position



Principal areas of responsibility for each representative on the Committee are outlined below:

**Core Members** **Principal Areas of Responsibility**

**Council**..................Land use planning, rezoning and development applications, habitat protection and management, habitat restoration, dog control, traffic management, ecotourism, funding advice.

**DSE**........................Habitat protection and management, threatened species legislation, conservation agreements, research, koala welfare, koala management on DSE lands.

**AKF**......................Habitat protection issues, publicity and promotion, habitat restoration, planning application assessments, monitoring.

**BEN**......................Habitat protection issues, habitat restoration and promotion, environmental education.

**Occasional Members**

**CHW**................. Koala management on Central Highlands Water-managed land.

**VicRoads**......... Advice on relevant projects and road mortality relief measures.

**CFA/DSE**.............. Advice on fuel reduction and bushfire management.

**Researchers**............Advice on outcomes from local koala research.

**WVWG**..................Koala care and rehabilitation, volunteer assistance with research and monitoring.

The Implementation Committee should convene immediately following formal endorsement and adoption of the Plan and should meet at least quarterly over the first twelve month period and then as often as considered necessary by the Committee.

The Committee should seek to ensure the relevance of the Plan over time through revision as necessary. Any amended Plan will require formal approval from Council.

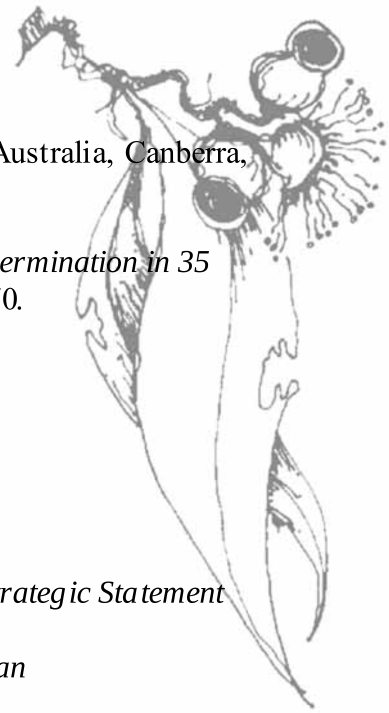
The Implementation Committee should seek to promote and publicise any major events concerning implementation of the Plan including opportunities for involvement of the local community.

### 16.3.3 Other Actions

The partnership between the Ballarat City Council and the AKF has resulted in a very productive and positive arrangement in terms of the management of the koala within the City. Community awareness with respect to the circumstances affecting the koala and how the community needs to respond to the requirements of the species if it is to survive in the City and surrounding areas has been raised substantially as a result of the initiative. In addition, there has been a high degree of integration between City environmental management and land use planning processes and the work of the Project Officer that has benefited the Council, the AKF and the community generally.

To effectively implement the Plan, it is important that the Ballarat City Council continue to provide support to the AKF for the Liaison Officer position. The Liaison Officer will provide important scientific knowledge and practical expertise to the Implementation Committee and as such will provide guidance to the Committee in its deliberations over implementation of the Plan.

It would therefore be very beneficial for Council and the AKF to enter into a further agreement to continue the current partnership arrangement for a further 5 years from the expiration of the current arrangement.



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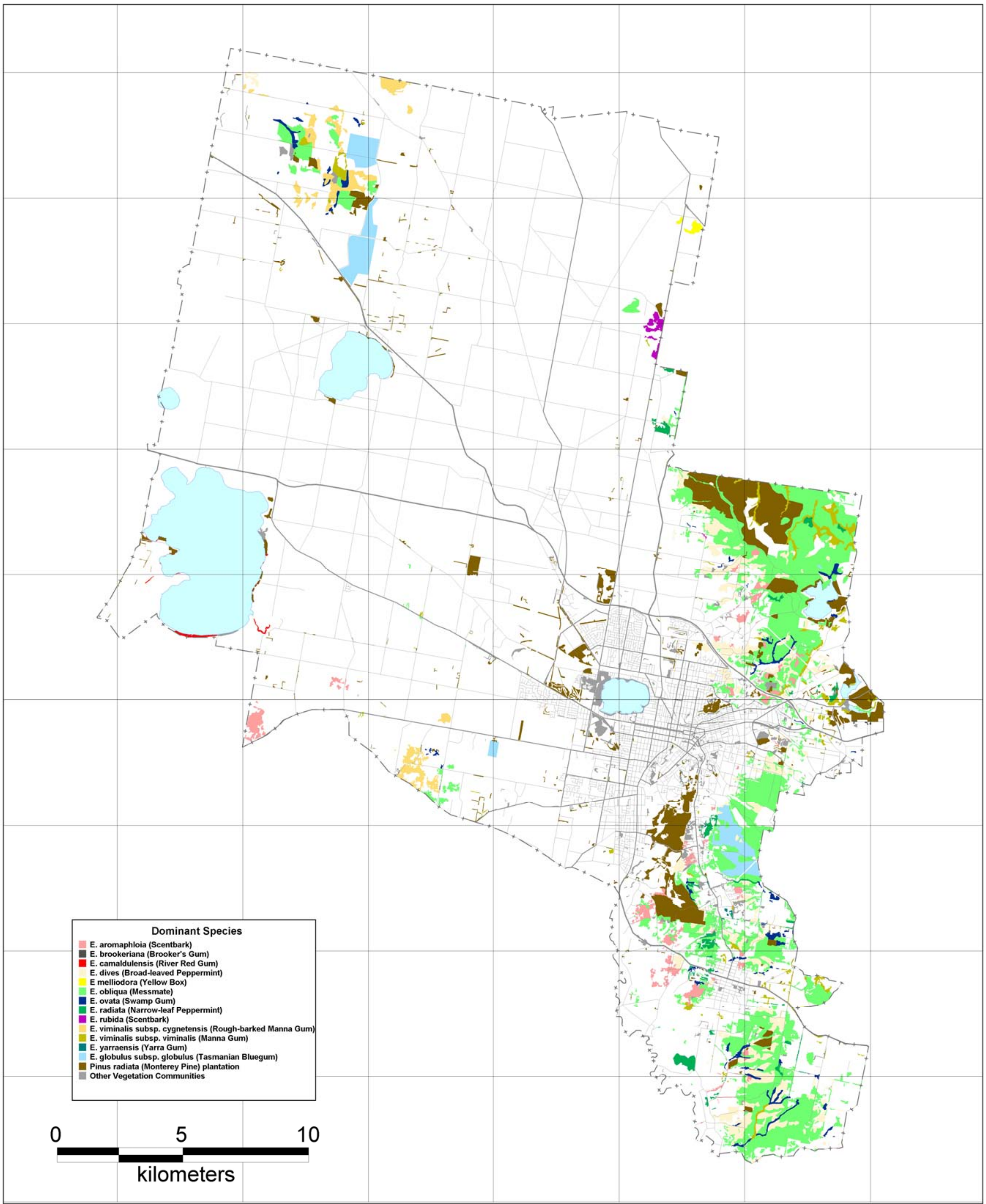
# ***APPENDICES***

**APPENDIX 1**: Vegetation Mapping and Field Survey Methodology




AUSTRALIAN KOALA FOUNDATION

# CITY OF BALLARAT
# KOALA PLAN OF MANAGEMENT
## Simplified Vegetation Map

AUSTRALIAN KOALA FOUNDATION

CITY OF BALLARAT

**JULY 2006**

Map Grid Of Austraia (MGA94) Zone 54
shown at 5 km intervals

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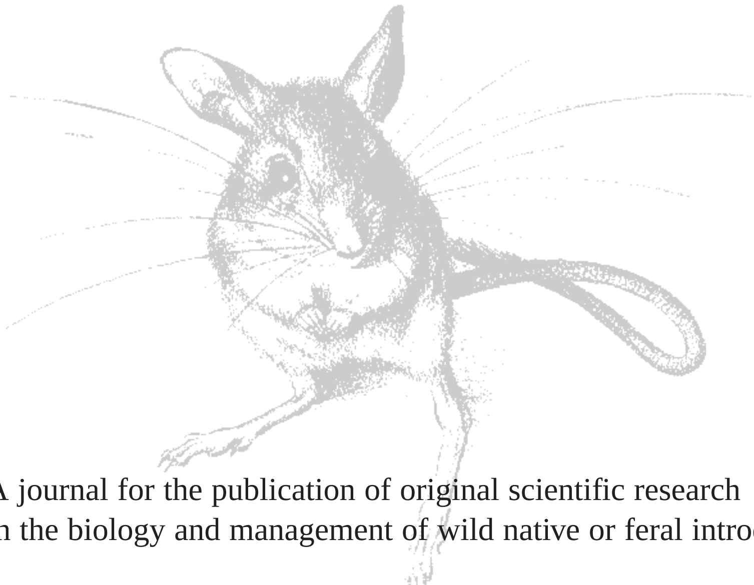
Volume 27, 2000

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# Tree species preferences of koalas (*Phascolarctos cinereus*) in the Campbelltown area south-west of Sydney, New South Wales

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*Abstract.* Tree species preferences of a koala population inhabiting a small area of forest and woodland in the Campbelltown area, south-west of Sydney, were investigated over a two-year period. In total, 2499 trees from 45 independent field sites were assessed, with tree species preferences determined on the basis of a comparative analysis of proportional data relating to the presence/absence of koala faecal pellets. The results established that grey gum (*Eucalyptus punctata*) and blue-leaved stringybark (*E. agglomerata*) were most preferred by koalas in the study area, but only when growing on shale-based substrates. The preferential utilisation of *E. punctata* and *E. agglomerata* on substrates derived from shales, compared with that recorded for the same species on sandstones, suggests that their use by koalas was influenced by differences in nutrient status between substrates. Regression analyses further identified a trend for use of at least one of the preferred species (*E. punctata*) to be more commonly associated with larger trees. Results are discussed in terms of their relevance to issues of resource availability and the need to reconsider, by way of a hierarchical approach, the use of food trees by koalas generally. The presence of *E. punctata* and *E. agglomerata* and their occurrence in conjunction with shale-based substrates are considered to be important limiting factors affecting the present-day distribution and abundance of koalas in the Campbelltown area.

## Introduction

Koalas (*Phascolarctos cinereus*) are obligate folivores that feed primarily on the genus *Eucalyptus*. Throughout their range in eastern Australia, koalas have been recorded as utilising a wide variety of eucalypt and non-eucalypt species (Hawkes 1978; Lee and Martin 1988; Hindell and Lee 1990; Phillips 1990; White and Kunst 1990; Melzer and Lamb 1996; Lunney *et al.* 1998). While some of these accounts portray koalas as opportunistic browsers, as a general rule only some *Eucalyptus* species will be preferentially utilised in a given area while others, including some non-eucalypts, appear to be utilised opportunistically for feeding or other purposes (Lee and Martin 1988; Hindell and Lee 1990; Phillips 1990), or because they occur in close proximity to preferred food tree species (Phillips *et al.* 2000). Soil nutrient levels are also considered to influence the palatability of some tree species for koalas (Cork and Braithwaite 1996).

The Campbelltown area supports one of the few remaining koala populations of the Sydney region. Koalas in the area became well known during the late 1980s when the potential impact of a proposed residential development on the Wedderburn Plateau became the subject of community debate (Dobson 1990; Papps 1990; Sheppard 1990; Close 1993). The aim of this study was to examine habitat being utilised by koalas in the area, with the specific objective of determining the most preferred food tree species.

## Methods

### *Study area*

Campbelltown is located approximately 40 km south-west of Sydney, New South Wales. The Campbelltown Local Government Area (CLGA) (33°58′–34°10′S, 150° 44′–150°56′E) is bounded to the south-west by the Nepean River and to the north-east by the Georges River. The northern section of the Wedderburn Plateau is located in the south-eastern portion of the CLGA (Fig. 1).

The western and northern areas of the CLGA are characterised by gentle undulating rises associated with Wianamatta shale formations. In contrast, the easterly and southerly portions of the CLGA are characterised by Hawkesbury sandstone geomorphology, with steep, near-vertical cliffed benches along the Georges River, sometimes with wide, stepped platforms exposing interbedded shale layers. Elevations in the CLGA range from approximately 150 m above sea level in the gorges, to 240 m above sea level on the plateau. As detailed in Phillips and Callaghan (1996), the vegetation is predominantly woodland with stringybarks (*Eucalyptus* spp.) and red bloodwood (*Corymbia gummifera*) as dominant canopy species. Grey gum (*E. punctata*) becomes dominant where interbedded lenses of shale occur but tends to be replaced by blackbutt (*E. pilularis*) in areas where sandstone-derived substrates predominate. To the south, the vegetation changes to communities dominated largely by hard-leaved scribbly gum (*E. sclerophylla*), *C. gummifera* and blue-leaved stringybark (*E. agglomerata*). Other areas support woodlands with *E. pilularis* and Sydney red gum (*Angophora costata*) as the dominant canopy species. Wet heathlands under a woodland canopy of Sydney peppermint (*Eucalyptus piperita*), *A. costata* and *C. gummifera* also occur, interspersed with pockets of whipstick ash (*E. multicaulis*). [Note: The tree species nomenclature adopted in this study, including common names, follows that of Harden (1990, 1991, 1992) with the exception of the bloodwoods. Hill and

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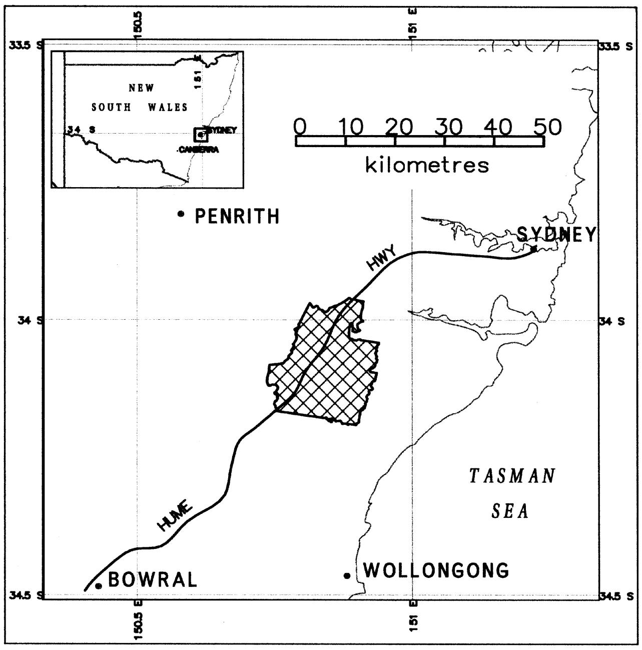


**Fig. 1.** Location of the Campbelltown Local Government Area (cross-hatched area).

Johnson's (1995) revision, which places bloodwoods in the new genus *Corymbia*, has subsequently been applied.]

*Field site selection and assessment*

Field work was initiated in 1994. Tree species preferences and activity levels associated with habitat utilisation by 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 (Sharp and Phillips 1997; Phillips *et al.* 2000). The study area was initially sub-divided into its respective geological units based on maps obtained from the Department of Mineral Resources. These areas were then overlain with a 1 : 25 000 scale vegetation map specifically prepared for the study (see Phillips and Callaghan 1996). Potential field site localities were determined by selecting a discrete area of vegetation, the boundaries of which conformed to those occurring on the vegetation map, but which could also be associated with a given geological unit (i.e. shale or sandstone). Such areas were then partitioned using a 50 m × 50 m grid-based numerical overlay. Independently generated random numbers were used to determine final plot locations, and the site co-ordinates for the centre of each grid cell so selected were then transferred to hand-held Magellan 'Trailblazer' GPS units to assist their location in the field. A series of independent replicates for each of the identified vegetation communities occurring on each particular geological unit were also generated to facilitate the collection of statistically useful data on the use of different tree species by koalas.

Once located in the field (to ±50 m), each plot was established by using a compass, measuring tape and flagging tape to designate the corners and mid-points of a 40 m × 40 m (0.16 ha) square orientated along each of the four cardinal compass bearings from a central reference point. Towards the latter part of the study, supplementary field sites in the form of variable radius plots (Phillips and Callaghan 1995) were also employed to gather data; this latter approach afforded greater flexibility for the purposes of site selection while utilising the same assessment protocols as those described below, and was specifically employed when koala faecal pellets were opportunistically encountered in the field during foot-based traverses of the area.

Within each plot, an area on the ground prescribed by a distance of 100 cm from any one point around the base of each tree was carefully inspected for the presence or absence of koala faecal pellets, the search initiated with a precursory inspection of the area described above, followed by a more thorough inspection of the substrate (including disturbance of the leaf litter and any ground cover). Where the distribution of faecal pellets fell within overlapping search areas brought about by two or more trees growing close to each other, the number of pellets within the area of overlap were allocated to each tree accordingly (i.e. without regard for the other). Approximately two person-minutes were devoted to the faecal pellet search at each tree. The diameter at breast height (dbh) of each tree was also recorded, a 'tree' being defined as 'a live woody stem of any plant species (excepting palms, cycads, tree-ferns and grass-trees) that had a diameter at breast height (dbh) of 100 mm or greater' (Phillips *et al.* 2000).

For a given tree species '$i$' the results from each active field site (i.e. those plots in which koala faecal pellets were detected) were pooled to obtain a proportional index ($P_i$) – hereafter referred to as the 'strike-rate' – that was derived by dividing the total number of individual trees of species '$i$' that had one or more koala faecal pellets recorded beneath them ($p_i$) by the total number of trees of that species sampled ($n_i$). Derived in this way, the strike-rate ($P_i = p_i / n_i$) also serves as a conditional probability estimator (±s.e.) related to the use of a given tree species by koalas.

*Activity levels and tree species preferences*

Activity levels for each plot were expressed as the percentage equivalent of the quotient obtained by dividing the total number of trees (all species) that had one or more koala faecal pellets recorded within the prescribed search area divided by the total number of trees (all species) in the plot. Activity levels were assumed to be normally distributed.

Tree species preferences were determined from a comparative analysis of the results from all 'active' plots. It was initially intended that the data set for a given tree species would be regarded as valid for assessment purposes only when it had been obtained from at least seven independent sites on a given geological unit. In conjunction with other qualifiers, data sets that satisfy this criterion are considered part of a primary data set comprising those tree species that are frequently utilised by koalas and thus most likely to be of importance in terms of sustaining the population (Phillips *et al.* 2000).

Fieldwork quickly established that koala activity in the CLGA was localised. Initial plot assessments followed by extensive vehicle- and foot-based traverses generally failed to detect evidence of koalas outside of an area immediately adjacent to, and north of, the Wedderburn Plateau. Further field work was subsequently concentrated in this area. Even in this area, however, evidence of koalas was uncommon and the likelihood of gathering sufficient data on each of the tree species being utilised to the extent specified in the preceding paragraph was considered poor. Because of this, the minimum number of active sites required to validate a given tree species was reduced ($n = 3$) and the extent of variation amongst the strike-rates of species in eucalypt and non-eucalypt data sets respectively was assessed using a Kruskal–Wallis Anova, with the $U$ statistic derived from Wilcoxon two-sample tests used to test for significant differences in strike-rates between species. Data associated with plots wherein no faecal pellets were detected were subsequently reviewed in the light of results obtained from the active plots. Preliminary analyses of the data assumed no substrate bias. For those tree species identified as being most preferred, Kendall's Robust line-fit method was used to investigate the potential for relationships between tree size (dbh) and strike-rate.

All statistical analyses followed protocols and procedures detailed by Sokal and Rohlf (1995) and were largely undertaken using BIOMStat 3.2 and SPSS 6.1 software. Unless otherwise indicated, the significance level used in all tests was 0.05. Means are shown with standard errors.

**Table 1. Pooled data for all tree species contained in the 20 active sites that had been utilised by koalas in the Campbelltown Local Government Area**

Substrate type: A, sandstone-based; B, shale-based. P indicates the proportion of trees in each instance that had faecal pellets recorded in the prescribed search area beneath each tree. *n* = the total number of trees sampled; s.e. = standard error

| Eucalypts | Substrate | No. sites | *n* | P | s.e. | Non-eucalypts | Substrate | No. sites | *n* | P | s.e. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *E. agglomerata* | A | 4 | 19 | 0.316 | 0.107 | *Allocasuarina littoralis* | A | 1 | 11 | 0.000 | |
| *E. agglomerata* | B | 6 | 58 | 0.190 | 0.052 | *A. littoralis* | B | 2 | 17 | 0.000 | |
| *E. capitellata* | A | 3 | 36 | 0.056 | 0.038 | *Angophora bakeri* | A | 1 | 18 | 0.056 | 0.054 |
| *E. capitellata* | B | 1 | 2 | 0.000 | | *A. costata* | A | 7 | 42 | 0.024 | 0.024 |
| *E. consideniana* | A | 1 | 14 | 0.000 | | *A. costata* | B | 11 | 76 | 0.013 | 0.013 |
| *E. multicaulis* | A | 2 | 33 | 0.000 | | *A. subvelutina* | A | 1 | 3 | 0.000 | |
| *E. multicaulis* | B | 1 | 3 | 0.000 | | *Banksia serrata* | A | 6 | 54 | 0.000 | |
| *E. paniculata* | A | 1 | 1 | 0.000 | | *B. serrata* | B | 5 | 20 | 0.050 | 0.049 |
| *E. paniculata* | B | 1 | 3 | 0.000 | | *Corymbia gummifera* | A | 9 | 177 | 0.006 | 0.006 |
| *E. pilularis* | A | 2 | 20 | 0.000 | | *C. gummifera* | B | 10 | 221 | 0.050 | 0.015 |
| *E. pilularis* | B | 5 | 41 | 0.024 | 0.024 | *C. eximia* | B | 1 | 1 | 0.000 | |
| *E. piperita* | A | 2 | 18 | 0.000 | | *Hakea sericea* | B | 1 | 1 | 0.000 | |
| *E. piperita* | B | 4 | 26 | 0.154 | 0.071 | *Leptospermum trinervium* | A | 1 | 2 | 0.000 | |
| *E. punctata* | A | 4 | 44 | 0.068 | 0.038 | *L.trinervium* | B | 1 | 3 | 0.000 | |
| *E. punctata* | B | 10 | 154 | 0.169 | 0.03 | *Melaleuca hypericifolia* | A | 4 | 7 | 0.000 | |
| *E. sclerophylla* | A | 1 | 17 | 0.000 | | *M. hypericifolia* | B | 4 | 12 | 0.083 | 0.08 |
| *E. sclerophylla* | B | 2 | 4 | 0.250 | 0.217 | *M. linariifolia* | A | 1 | 3 | 0.000 | |
| *E. sieberi* | A | 2 | 20 | 0.050 | 0.049 | *Persoonia pinifolia* | A | 1 | 2 | 0.000 | |
| *E. sieberi* | B | 2 | 3 | 0.333 | 0.272 | *P. pinifolia* | B | 1 | 1 | 0.000 | |
| | | | | | | *Syncarpia glomulifera* | A | 2 | 15 | 0.267 | 0.114 |
| | | | | | | *S. glomulifera* | B | 4 | 28 | 0.036 | 0.035 |
| Total trees | | | 516 | | | | | | 714 | | |

## Results

In total, 2499 trees, comprising 1159 eucalypts and 1340 non-eucalypts from 45 field plots, were assessed. Evidence of tree use, specifically the presence of koala faecal pellets, was observed in 20 of the 45 field plots, with faecal pellets recorded from beneath 7 *Eucalyptus* species and 6 species of non-eucalypt (Table 1). Activity levels of the 20 plots that contained evidence of use by koalas ranged from 1.2% to 18.4% (mean ± s.e. = 6.49 ± 1.05 %).

The extent of variation in strike-rate amongst the 7 *Eucalyptus* species that satisfied the sampling criteria was significant when pooled across substrates (Kruskal–Wallis ANOVA: $H_{adj} = 14.919 > \chi^2_{0.05[6]} = 12.592$). Details relating to a comparison of strike-rates between each of the seven species are provided in Table 2, the results indicating that *E. punctata* and *E. agglomerata* received significantly higher levels of utilisation than the other species. Strike-rates for *E. sieberi* and *E. sclerophylla* did not appear to differ significantly from that of *E. punctata* and/or *E. agglomerata*. However, examination of the data indicated that the propinquity of *E. sieberi* and *E. sclerophylla* to that of *E. punctata* and *E. agglomerata* was attributable to results from two sites where faecal pellets were recorded beneath one of only two specimens sampled in each case, thus indicating a disproportionately higher level of use (0.5) than that which might be realistically expected, a phenomenon further compounded by the small sample sizes associated with the former species in each instance.

Notwithstanding the potential influence of substrate on the presence/absence of some tree species, the paucity of faecal pellet evidence generally precluded a comparison of strike-rates for each of the seven species between the two geological substrates sampled. *E. capitellata* was poorly represented in plots from shale sites whereas *E. piperita* and *E. pilularis*, while present in a number of active plots from sandstone sites, did not have koala faecal pellets observed beneath them. The following analyses consequently focussed on those species that were common to both substrates and consistently associated with koala activity.

**Table 2. Critical values of the *U* statistic as they relate to between-species comparisons across sandstone- and shale-based substrates for seven *Eucalyptus* species utilised by koalas**

Eagg = *E. agglomerata*, Ecap = *E. capitellata*, Epil = *E. pilularis*, Epip = *E. piperita*, Epun = *E. punctata*, Esie = *E. sieberi*, Escl = *E. sclerophylla*. Comparisons that resulted in significant differences at $P \leq 0.05$ are underlined

| | Ecap | Epil | Epip | Epun | Esie | Escl |
|---|---|---|---|---|---|---|
| Eagg | <u>34</u> | <u>60</u> | <u>48</u> | 76 | 28 | 20 |
| Ecap | | 18 | 15 | <u>47.5</u> | 8.5 | 6 |
| Epil | | | 22 | <u>86</u> | 19 | 13 |
| Epip | | | | <u>69</u> | 16 | 11 |
| Epun | | | | | 38 | 27 |
| Esie | | | | | | 6.5 |

### *Hawkesbury sandstones*

Twenty-five plots were assessed. In total, 1335 trees, comprising 12 *Eucalyptus* species and 15 species of non-eucalypt, were sampled. Nine of the 25 plots contained evidence of use by koalas, with faecal pellets recorded from beneath *E. agglomerata, E. capitellata, E. punctata* and *E. sieberi*. The mean activity level on sandstone-based substrates was 3.44% ± 0.7%. The extent of variation in strike-rate amongst the four species was not statistically significant (Kruskal–Wallis ANOVA: $H_{adj} = 3.198 < \chi^2_{0.05[3]} = 7.815$).

### *Wianamatta shales*

Twenty plots were assessed. In total, 1164 trees, comprising 12 *Eucalyptus* species and 12 species of non-eucalypt, were sampled. Eleven of the 20 plots provided evidence of use by koalas, with faecal pellets recorded from beneath *E. agglomerata, E. pilularis, E. piperita, E. punctata, E. sclerophylla* and *E. sieberi*. The mean activity level on shale-derived substrates was 9.0% ± 1.4%.

Useful data was restricted to four of the six *Eucalyptus* species beneath which faecal pellets were consistently recorded, those relating to *E. sieberi* and *E. sclerophylla* being excluded due to their poor representation (2 sites each) and small sample sizes ($n = 3$ and $n = 4$ respectively). The extent of variation in strike-rate amongst the four species was significant (Kruskal–Wallis ANOVA: $H_{adj} = 9.066 > \chi^2_{0.05[3]} = 7.815$), with results of a comparison of strike-rates between the four species establishing that *E. punctata* was the most preferred (Table 3). It was also evident that the strike-rate of *E. agglomerata* did not differ significantly from that of *E. punctata*, but nor did it differ significantly from that of *E. piperita*.

Regression analyses established that the use of *E. punctata* was positively associated with larger-sized trees ($\tau = 0.5521$, $z = 1.558$, $P = 0.05$). A similar trend was also evident for *E. agglomerata* but was not significant ($\tau = 0.3333$, $z = 0.939$, $P = 0.17$).

Tests for differences in the strike-rates of *E. punctata* and *E. agglomerata* between substrates, as well as tests for differences between substrate-based activity levels, were also undertaken. The strike-rates for *E. punctata* were signifi-

**Table 3. Critical values of the *U* statistic as they relate to between-species comparisons for four species of *Eucalyptus* utilised by koalas on shale-based substrates**

Eagg = *E. agglomerata*, Epil = *E. pilularis*, Epip = *E. piperita*, Epun = *E. punctata*. Comparisons that resulted in significant differences at $P \leq 0.05$ are underlined

| | Epil | Epip | Epun |
|---|---|---|---|
| Eagg | 25 | 16.5 | 39 |
| Epil | | 11 | <u>48</u> |
| Epip | | | <u>31</u> |

cantly higher on shale-based substrates than for the same species on sandstone-based substrates ($U$ = 36, $P$ < 0.05), whereas that of *E. agglomerata* was not ($U$ = 16.5, $P$ > 0.05). Activity levels of sites on shale-derived substrates were also significantly higher than those on sandstone-derived substrates (Levene's test: $F$ = 3.65, $P$ > 0.05; $t_{[18]}$ = –3.25, $P$ < 0.01).

### *Use of non-eucalypts*

Faecal pellets were recorded beneath six species of non-eucalypt (Table 1). Analysis was restricted to five species: *Angophora costata*, *Banksia serrata*, *Corymbia gummifera*, *Melaleuca hypericifolia* and *Syncarpia glomulifera*, the data for *Angophora bakeri* being excluded because of its representation in only one active site. The extent of variation in strike-rate amongst the five species was not significant across substrates (Kruskal–Wallis ANOVA: $H_{adj} = 6.837 < \chi^2_{0.05[4]} = 9.488$). However, when substrate-based levels of utilisation were analysed there was significant variation amongst the three species of non-eucalypt beneath which faecal pellets were recorded on sandstone-based substrates (Kruskal–Wallis ANOVA: $H_{adj} = 9.563 > \chi^2_{0.01[2]} = 9.210$). A between-species comparison indicated that the heterogeneity was primarily associated with *Syncarpia glomulifera* (Table 4). Despite the presence of a more substantive *S. glomulifera* data set ($n$ = 28 trees from 4 sites) and the presence of faecal pellets beneath an additional two species (*Banksia serrata* and *Melaleuca hypericifolia*) there was no significant variation amongst the use of the same species when growing on shale-based substrates (Kruskal–Wallis ANOVA: $H_{adj} = 4.745 < \chi^2_{0.05[4]} = 9.488$).

### *Inactive sites*

In total, 25 inactive sites were assessed during the course of field work. Inactive sites were associated with both substrate types and collectively contained 14 species of *Eucalyptus* and 15 species of non-eucalypt (Table 5). *Corymbia gummifera* was the tree species most commonly associated with inactive sites.

**Table 4. Critical values of the *U* statistic as they relate to between-species comparisons for four species of non-eucalypt utilised by koalas on sandstone-based substrates**

Acos = *Angophora costata*, Bser = *Banksia serrata*, Sglo = *Syncarpia glomulifera*, Cgum = *Corymbia gummifera*. Comparisons that resulted in significant differences at $P \leq 0.05$ are underlined

| | Bser | Sglo | Cgum |
|---|---|---|---|
| Acos | 21 | <u>12</u> | 25.5 |
| Bser | | 27 | 27 |
| Sglo | | | <u>16</u> |

**Table 5. Pooled data for all tree species associated with the 25 sites within which there was no evidence of use by koalas**

Substrate type: A, sandstone-based; B, shale-based. $n$ = the number of trees sampled

| Tree species | Substrate | No. sites | $n$ |
|---|---|---|---|
| Eucalypts | | | |
| *E. agglomerata* | A | 12 | 55 |
| *E. agglomerata* | B | 6 | 60 |
| *E. capitellata* | A | 1 | 7 |
| *E. consideniana* | B | 1 | 2 |
| *E. crebra* | A | 2 | 17 |
| *E. crebra* | B | 1 | 2 |
| *E. fibrosa* | B | 1 | 1 |
| *E. moluccana* | A | 4 | 84 |
| *E. moluccana* | B | 1 | 2 |
| *E. multicaulis* | A | 4 | 66 |
| *E. multicaulis* | B | 1 | 42 |
| *E. paniculata* | B | 1 | 2 |
| *E. pilularis* | A | 2 | 33 |
| *E. pilularis* | B | 3 | 67 |
| *E. piperita* | A | 7 | 16 |
| *E. punctata* | A | 8 | 41 |
| *E. punctata* | B | 6 | 83 |
| *E. sclerophylla* | A | 1 | 7 |
| *E. sclerophylla* | B | 3 | 15 |
| *E. sieberi* | A | 2 | 2 |
| *E. sieberi* | B | 1 | 1 |
| *E. tereticornis* | B | 1 | 38 |
| Total trees | | | 643 |
| Non-eucalypts | | | |
| *Allocasuarina littoralis* | A | 2 | 21 |
| *A. littoralis* | B | 2 | 2 |
| *Angophora bakeri* | A | 2 | 69 |
| *A. costata* | A | 9 | 84 |
| *A. costata* | B | 2 | 16 |
| *A. subvelutina* | B | 3 | 13 |
| *Banksia serrata* | A | 7 | 29 |
| *B. serrata* | B | 2 | 3 |
| *Casuarina cunninghamiana* | A | 1 | 1 |
| *Corymbia gummifera* | A | 11 | 177 |
| *C. gummifera* | B | 8 | 108 |
| *C. eximia* | A | 2 | 2 |
| *C. maculata* | B | 2 | 31 |
| *Exocarpos cupressiformis* | A | 1 | 5 |
| *Hakea sericea* | A | 1 | 2 |
| *H. sericea* | B | 2 | 2 |
| *Melaleuca hypericifolia* | A | 7 | 25 |
| *M. hypericifolia* | B | 1 | 1 |
| *M. linariifolia* | A | 1 | 4 |
| *Persoonia pinifolia* | A | 6 | 14 |
| *Syncarpia glomulifera* | A | 1 | 16 |
| *S. glomulifera* | B | 1 | 1 |
| Total trees | | | 626 |

## Discussion

The results suggest a model of habitat utilisation by koalas in the Campbelltown area that is focused on two species of *Eucalyptus*: grey gum (*E. punctata*) and blue-leaved stringybark (*E. agglomerata*), both of which were shown to be the subject of significantly higher levels of utilisation than other *Eucalyptus* species and especially when occurring in conjunction with shale-based substrates.

*Eucalyptus punctata* is distributed along the New South Wales central coast from south of Nowra to the Liverpool Ranges, where it grows in forest and woodland communities on low- to medium-fertility soils (Harden 1991). The importance of *E. punctata* as a browse species for koalas has been known for some time (Hawkes 1978; Robbins and Russell 1978; Lee and Martin 1988; Phillips 1990) and the species has been the subject of a number of studies that investigated the relationship between its use by koalas and that of foliar essential oils (Eberhard *et al.* 1975; Southwell 1978), nitrogen (Harrop and Degabriele 1976; Cork 1986) and digestible energy (Cork *et al.* 1983). While confirmation of *E. punctata* as a preferred food tree species was not unexpected given the widespread acknowledgment of its perceived importance to koalas, the suggestion that *E. agglomerata* is equally important was not so expected. It is thus of interest that our results are consistent with that determined in a pilot study by Ellis *et al.* (1997), who reported *E. agglomerata* as one of two tree species (the other being *E. punctata*) most commonly found in an analysis of faecal pellet material from koalas in the same area.

Aside from the recent corroboration of our findings by Ellis *et al.* (1997), significant use of *E. agglomerata* by koalas has not been previously reported in the literature. *E. agglomerata* occurs on the central tablelands, central and southern coast of New South Wales and adjacent parts of eastern Victoria (Brooker and Kleinig 1990). In a related context but otherwise based on an assumption that the tree species being utilised by a koala was a food tree, Hindell *et al.* (1985) and Hindell and Lee (1987) also reported a seasonally based preference for a related species (red stringybark, *E. macrorhyncha*) on the basis of their work on tree use by koalas in Victoria.

The significance of both *E. punctata* and *E. agglomerata* on substrates derived from shales, compared with that recorded for the same species on sandstones, suggests that the importance of these two tree species from a koala's perspective may be influenced by changes in the nutrient status of the soil. Such a notion is concordant with that predicted by the 'resource-availability' hypothesis (Bryant *et al.* 1985; Coley *et al.* 1985) whereby the relative availability of plant nutrients and free carbon determine the amount and type of defence that some tree species employ against folivores. Accordingly, the hypothesis advocates that trees growing in low-nutrient substrates defend themselves against folivores such as koalas by incorporating excess carbon into a phenolic-based defence system (Cork and Braithwaite 1996). While the extent to which this relationship influences use by koalas across the small suite of their preferred food tree species remains to be determined, the results of this study at least appear consistent with the hypothesis.

In areas such as Campbelltown where consequences of the resource-availability hypothesis appear to be evident, it could be implied that habitat quality from the koala's perspective will be more complex than simply a measure of the relative abundance of preferred food tree species. Indeed, in assuming some variability in the availability of nutrients throughout an otherwise homogeneous substrate, one might also suspect a corresponding degree of intraspecific variation in the palatability of key food tree species. The phenomenon of intraspecific variation in the use of some tree species by koalas has been noted by several authors. Robbins and Russell (1978) reported that utilisation of some *E. punctata* was preferred over others of the same species in their study of koalas in the Muogamarra Nature Reserve near Sydney. Similarly, Hindell *et al.* (1985) and Hindell and Lee (1987) also reported intraspecific variation in the use of certain tree species by Victorian koalas. Recently, Lawler *et al.* (1998) reported a relationship between a decrease in food intake by koalas and increased levels of terpene and DFPs (diformyl phloroglucinols) and established a measure of intraspecific variation of these compounds amongst individuals of *E. ovata* and *E. viminalis.* As suggested by Lawler *et al.* (1998), it is reasonable to assume that such variation might also be a feature of other *Eucalyptus* species browsed by koalas. If this is true, in the case of *E. punctata* at least, the tendency for koalas to preferentially select larger trees of this species is of interest. While an alternative explanation for this relationship could simply be one of refuge and/or security on the part of an arboreal, non-hollow-dwelling marsupial such as the koala, we suggest that larger trees may also have greater access to soil nutrients or be more successful in the competition for limited nutrients and, because of this, have a lesser need to devote resources to the production of terpenes and DFPs. While results for the CLGA are arguably influenced by the small data sets we were able to compile, they are nonetheless strongly supported by data we have on other species in the grey gum complex (e.g. *E. propinqua*, *E. biturbinata and E. canaliculata*) and some stringybark species (AKF, unpublished data).

### *Implications arising from the study*

The low activity levels and strike-rates associated with each of the preferred tree species in the CLGA are very different to those obtained from forest and woodland communities occurring on Quaternary deposits in the Port Stephens area on the north coast of New South Wales. Using an identical approach to that described herein, Phillips *et al.* (2000) reported a mean activity level of 32.41% ± 4.0% in addition to percentage equivalent strike-rates of 55.5% ± 3.6% and 53.6% ± 3.1%, respectively, for the preferentially utilised tree species *E. robusta* and *E. parramattensis*. Such disparity suggests a fundamental difference in the relative abundance of koalas between the two areas and indirectly provides further support for the notion of a low-density koala population in the

Campbelltown area, as suggested by Close (1993). Unfortunately, the extent to which the low koala population density has been influenced by historical land-use practices (i.e. logging of preferred food tree species, land clearing for agriculture and urban expansion) or other threatening processes such as fire and predation, cannot be ascertained. Nonetheless, we suspect that koala abundance in the area most likely reflects habitat quality and its associated carrying capacity more than it does other factors, especially given the persistence of a localised population in the area since before the turn of the century (Close 1993). Further, we speculate that the low activity levels we have reported may be typical of those to be expected from habitat utilisation by koalas in low-nutrient environments, whereby a sparsely distributed food resource dictates a requirement for relatively large ranging patterns by resident animals in the population. A similar conclusion in this regard was reached by Melzer and Lamb (1994) in their study of low-density koala populations in the brigalow belt of central Queensland.

The differences between the results obtained by Phillips *et al.* (2000) and those reported in this study with respect to the different strike-rates for the preferred food tree species suggests that it might be possible to segregate koala food trees into at least two hierarchical categories. As argued by Phillips *et al.* (2000), the high strike-rates and density-independent utilisation of *E. robusta* and *E. parramattensis* clearly categorised both as ‘primary’ food tree species for koalas. On the basis of the results described herein, we propose that preferred tree species such as *E. punctata* and *E. agglomerata*, which tend to exhibit a much lower but still significantly high level of utilisation than other *Eucalyptus* species and which demonstrate evidence of more complex issues associated with their use by koalas, constitute what might best be described as ‘secondary’ food tree species.

Notwithstanding issues associated with habitat modification, fire and the depredations of feral and domestic dogs, the presence of *E. punctata* and *E. agglomerata* and their occurrence in conjunction with higher-nutrient, shale-based substrates should be considered as major limiting factors influencing the distribution and abundance of koalas in the CLGA. However, our work has also demonstrated that not all of the available habitat in the area is being utilised. This notion is strongly supported by the high proportion of inactive sites on higher-nutrient substrates that contain *E. punctata* and *E. agglomerata*, and by the extensive foot-based traverses we conducted in the study area. Therefore, we suspect that the number of koalas inhabiting the CLGA is lower than that potentially capable of being supported by the total area of suitable habitat. Given the apparent isolation and associated low probability of adequate levels of recruitment from outside of the study area, together with impacts associated with the aforementioned threatening processes, it is our view that the koala population in the CLGA is in need of careful management if its long-term survival is to be assured. Lastly, this study has also highlighted some of the problems that can be encountered when working with localised wildlife populations occupying correspondingly small areas of habitat. Recent advances in dealing with the design of suitable sampling strategies for such populations (Thompson and Seber 1996) will undoubtably improve future studies of this kind.

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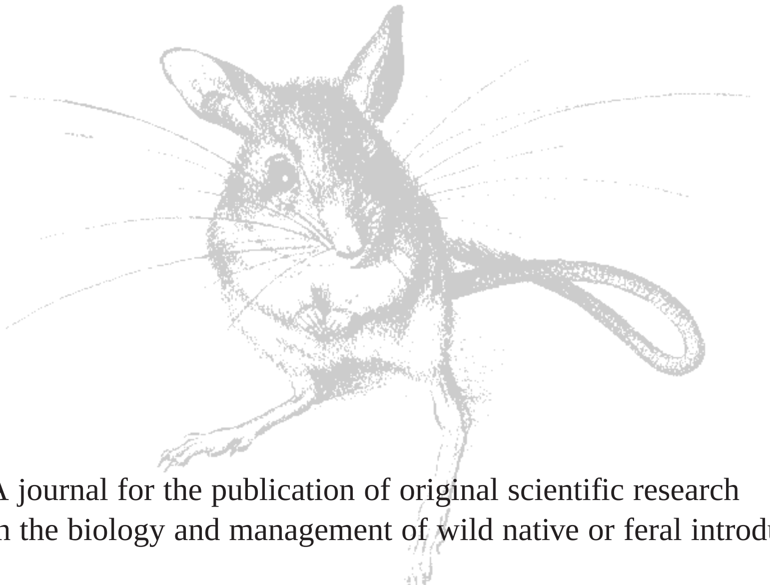

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# The tree species preferences of koalas (*Phascolarctos cinereus*) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, New South Wales

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*Abstract.* An assessment of the tree species preferences of koalas inhabiting forest and woodland communities growing on Quaternary deposits in the Port Stephens area, New South Wales, was undertaken between November 1994 and March 1996. Using a plot-based methodology, 3847 trees were sampled, comprising 15 *Eucalyptus* species and 17 species of non-eucalypt. Evidence of tree use by koalas, specifically the presence of koala faecal pellets, was recorded from beneath 10 *Eucalyptus* species and 9 species of non-eucalypt. Tree species preferences were determined by analyses of log-likelihood ratios derived from data based on the presence/absence of koala faecal pellets, rather than on gross counts. This approach confirmed significant variation in the levels of utilisation amongst and between different tree species, and that two in particular – swamp mahogany (*E. robusta*) and drooping red gum (*E. parramattensis*) – were most preferred. Increases in the levels of use of other tree species were also positively associated with the presence of *E. robusta* and/or *E. parramattensis*. Levels of utilisation of *E. robusta* and *E. parramattensis* did not alter significantly in response to changes in their respective densities, suggesting that the relative abundance of both was important in terms of understanding the carrying capacity of vegetation communities utilised by koalas. The results have established the success with which an enumerative approach to the interpretation of faecal pellet data can be utilised to clarify the tree species preferences of koalas. Application of the approach for habitat assessment and mapping purposes is also discussed.

## Introduction

The koala (*Phascolarctos cinereus*) is an obligate folivore that feeds primarily on the genus *Eucalyptus* (Martin and Lee 1984). Throughout their range in eastern Australia, koalas have been reported as utilising a wide variety of eucalypt and non-eucalypt species, aspects of which have been discussed by various authors (Hindell *et al.* 1985; Lee and Martin 1988; White and Kunst 1990; Hindell and Lee 1990; Phillips 1990; Melzer 1995; Melzer and Lamb 1996). While some of these accounts tend to portray koalas as opportunistic in terms of their tree species preferences, it has been generally acknowledged that, within a particular area, only a few of the available *Eucalyptus* species will be preferentially utilised while others, including some non-eucalypt genera, appear to be browsed opportunistically or used for other behavioural purposes (Lee and Martin 1988; Lee and Carrick 1989; Phillips 1990; Pahl and Hume 1990; Hindell and Lee 1990). Soil nutrients are also believed to influence the suitability of some food tree species (Cork and Braithwaite 1996).

A common theme in the literature on the management of free-ranging koala populations is a perception that habitat destruction represents the greatest threat to long-term conservation of the species (Lunney *et al.* 1990; Phillips 1990; Gordon 1996). If this is true, then it is clear that habitat must be conserved. Unfortunately, there is little agreement among researchers as to which tree species are most preferred by koalas (Phillips 1990). As a consequence, uncertainty about how best to define koala habitat (Cork *et al.* 1990; Hume 1990; Norton and Lindenmayer 1991; Norton and Neave 1996) and which are the most preferred tree species in a given area (Phillips 1990; Sharp and Phillips 1997) tends to overshadow and undermine the more pressing need to effectively conserve it, an issue that is exacerbated by the absence

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of an approach to habitat assessment that is broadly accepted by the scientific community.

The Port Stephens area was identified as one of the richest koala sites in New South Wales by a 1986–87 survey (Reed *et al.* 1990). Effective long-term management of the area's koala population will be contingent upon a detailed understanding of its habitat requirements. The purpose of this study was to examine habitat utilisation by koalas in that part of the Port Stephens Local Government Area (the LGA) considered to support most of the koala population (Callaghan *et al.* 1994). The study was undertaken with a view to identifying those tree species of most importance to koalas in the area. In doing so, the study also aimed to initiate a substrate-based approach that had broader ramifications for koala conservation by not only contributing further to an understanding of habitat use by the species, but also by providing a means by which the resolution of differences regarding tree preferences and the assessment of koala habitat could be achieved.

## Methods

### *Study area*

The Port Stephens LGA covers an area of approximately 97 000 ha and is located some 200 km north of Sydney on the central coast of New South Wales (Fig. 1). A significant proportion of the LGA constitutes a body of Quaternary deposits known as the Tomago Coastal Plain, an area of more than 35 000 ha largely comprising sandbeds of Pleistocene and Holocene origin separated by a low-lying inter-barrier of estuarine flats (Matthei 1995; Murphy 1995). To the north and west, alluvial Quaternary deposits derived from other geological strata also adjoin the sandbeds; however, such areas were excluded from this study due to their differing origins, vegetation types and more complex pedology[1].

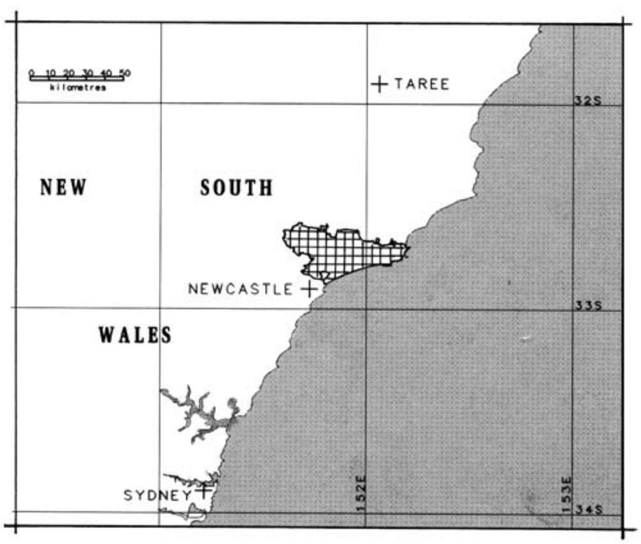


**Fig. 1.** Location of the Port Stephens Local Government Area (cross-hatched area) on the central coast of New South Wales.

### *Selection of field sites*

Vegetation maps of the Tomago Coastal Plain at a scale of 1 : 25 000 and that had been prepared for the Port Stephens Draft Koala Management Plan (Callaghan *et al.* 1994) were used to assist selection of field sites. The maps identified a mosaic of broad vegetation types from forest and woodland communities variously dominated by smooth-barked apple (*Angophora costata*), swamp oak (*Casuarina glauca*), broad-leafed paperbark (*Melaleuca quinquenervia*), blackbutt (*Eucalyptus pilularis*), scribbly gum (*E. signata*), red bloodwood (*Corymbia gummifera*), swamp mahogany (*E. robusta*) and drooping red gum (*E. parramattensis*), to wetlands and coastal heaths dominated by *Melaleuca* spp., *Leptospermum* spp. and *Banksia* spp.

To minimise the potential for possible edge effects, a 150-m exclusion zone was applied over ecotonal areas and to boundaries of vegetation communities affected by disturbances such as recent fire, urban development or major arterial roads. Field site localities were then chosen by arbitrarily selecting a discrete area of vegetation, the boundaries of which conformed with that delineated on the vegetation map. The selected area was then partitioned using a 50 m × 50 m grid-cell-based numerical overlay. Final site selection was then determined by the first correspondence of a given cell number with one from a series of independently generated random numbers. AMG co-ordinates for the centre of each grid cell so selected were then ascertained and transferred to Magellan 'Trailblazer' GPS units to assist location in the field. At least four independent replicates were initially generated for each of the major vegetation communities. Given that the use of such areas by koalas and the abundance of various tree species within a particular vegetation community could not be predicted with certainty, sampling was also driven by the need to ensure that statistically useful data sets were compiled for each tree species; additional sites were subsequently generated as required.

### *Assessment of field sites*

Once located in the field (to ±50 m), each site was established by using a compass, measuring tape and flagging tape to designate the corners and midpoints of a 40 m × 40 m (0.16 ha) plot oriented along each of the four cardinal compass bearings from a central reference point. Towards the latter part of the study, supplementary field sites in the form of variable radius plots (Phillips and Callaghan 1995) were also employed to gather additional data; this latter approach afforded greater flexibility for the purposes of site selection while utilising the same assessment protocols, and was specifically used to increase sample size and the number of independent replicates for otherwise poorly sampled tree species.

Within each field site, an area on the ground prescribed by a distance of 100 cm from any one point around the base of each tree was carefully inspected for the presence of koala faecal pellets. All koala faecal pellets within the radial search area were recorded, the count initiated with a precursory inspection of the area described above, followed by a more thorough inspection of the substrate that included disturbance of the leaf litter and any ground cover. Where the distribution of faecal pellets fell within overlapping search areas brought about by two or more trees growing in close proximity to each other, the number of pellets within the area of overlap were allocated to each tree accordingly (i.e. without regard for the other). Approximately 2 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. For purposes of the study a 'tree' was defined as a live woody stem of any plant species (excepting palms, cycads, tree-ferns and grass-trees) that had a diameter at breast height (dbh) of 100 mm or greater.

[1]Quaternary landscape data provided in the related work by Lunney *et al.* (1998) includes the results from sites that were located on these alluvial substrates.

### Data analysis

*'Active' and 'inactive' sites*

In order to describe the extent of habitat use that could be attributed to a given field site, 'activity levels' for each were expressed as the percentage equivalent of the quotient derived by dividing the total number of trees (all species) that had one or more faecal pellets within the prescribed search area by the total number of trees (all species) sampled in the field site. For the purposes of statistical analyses, variation in activity levels was assumed to be normally distributed.

To avoid the potential for biasing results whereby the recorded absence of koala faecal pellets in a given field site was possibly a consequence of factors other than poor koala habitat quality *per se*, completed field sites were categorised as either 'active' or 'inactive' on the basis of whether pellets were present or absent respectively. Only 'active' field sites were considered for analysis in the first instance; data relating to 'inactive' sites were subsequently reviewed in the light of results obtained by the approach detailed below.

*Faecal pellet counts*

The average number of faecal pellets observed within the prescribed search area beneath each tree was calculated from trees in both 'eucalypt' and 'non-eucalypt' categories. Variances associated with the average score in each category were tested for homogeneity and the appropriate *t*-test used for comparative purposes.

*Tree preferences and habitat utilisation*

Recent studies have concluded that the use of counts of accumulated faecal pellets for determining tree species preferences is problematical (Melzer *et al.* 1994; Hasegawa 1995; Pahl 1996). Because of this, no further consideration was given to the total number of faecal pellets recorded beneath each tree; rather, they were considered to be either present or absent, thus transforming the association between tree species and their use by koalas into that being measured by a binary variable. For a given tree species '$i$', the results from each active field site were pooled to obtain a proportional index ($P_i$) – hereafter referred to as the 'strike rate' – which was simply derived by dividing the total number of individual trees of species '$i$' that had one or more koala faecal pellets recorded beneath them ($p_i$), by the total number of trees of that species sampled ($n_i$). Thus, $P_i = p_i / n_i$.

Data sets for each tree species were regarded as most appropriate for analysis purposes when (a) the data set had been obtained from at least 7 independent 'active' sites, and (b) $n_iP_i$ and $n_i(1 - P_i)$ were both at least as large as 5. Data that satisfied these criteria were considered part of a primary data set containing those tree species that were being frequently utilised by koalas and thus most likely to be of some importance in terms of sustaining the population. Log-likelihood ratios were used to examine the extent of variation amongst the strike rates for each tree species in the primary data set. Significant heterogeneity was addressed by a re-arrangement of data sets for each species in order of decreasing strike rate and the resulting hierarchical model was then tested for homogeneity using simultaneous test procedures. Logistic regression was used to investigate the relationship between density (no. of live stems per 0.16 ha) and the number of trees with pellets in each active field site for each species isolated by the above procedure as being most preferred. Density figures for relevant tree species were obtained directly from that recorded in study plots and a likelihood-ratio test was used to examine the significance of each relationship, the results being presented as simplified logit models in each instance.

The extent of variation amongst strike rates for those tree species that failed to satisfy the minimum criteria for inclusion in the primary data set was examined using a Kruskal–Wallis ANOVA. Where significant heterogeneity was indicated, between-species comparisons were undertaken using the $U$ statistic derived from a Wilcoxon two-sample test.

A *post hoc* test of association ($G$-test of independence) was also undertaken to examine the relationship between the number of trees with pellets in each field site and the presence/absence of those tree species identified as most preferred by koalas in the study area; the phi coefficient ($\phi$) was calculated to determine the strength of any association.

Statistical procedures utilised for the study followed procedures detailed by Sokal and Rohlf (1995) and Agresti (1996); BIOMstat 3.2 and SPSS 6.1 software were employed for critical components of the data analyses.

## Results

Data were collected from 58 independent field sites (Fig. 2). In total, 3847 trees were assessed, collectively comprising 15 *Eucalyptus* species and 17 species of non-eucalypt. In all, 41 of the field sites contained evidence of utilisation by koalas, with faecal pellets recorded from beneath 10 *Eucalyptus* species and 9 species of non-eucalypt (Table 1). Activity levels (variable radius plots excluded) ranged from 2.9% to 90.3% [mean = 32.41 ± 4% (s.e.)].

Of the 3107 trees present in active sites, 977 had koala faecal pellets recorded within the prescribed search area beneath each tree. The number of faecal pellets recorded beneath individual *Eucalyptus* species ranged from 1 to 388 (mean = 8.89, median = 3, mode = 1, $n$ = 666) while the number of pellets recorded beneath individual tree species of non-eucalypt genera ranged from 1 to 204 (mean = 7.15, median = 2, mode = 1, $n$ = 311). Although a higher number of faecal pellets tended to be found under 'eucalypts' than 'non-eucalypts', the difference was not statistically significant (Levene's Test: $F = 1.487$, $P > 0.05$; $t_{[975]} = -1.19$, $P > 0.05$).

*Tree species preferences*

Data sets that met the specified criteria for inclusion in the primary data set were obtained for 5 of the 10 *Eucalyptus* species and for 5 non-eucalypt species. Of the eucalypts, the range of strike rates varied from 0.293 for *Eucalyptus signata* to 0.555 for *Eucalyptus robusta*. There was significant heterogeneity amongst strike rates when tested for Goodness of Fit ($G_{adj} = 69.8282 > \chi^2_{0.001[4]} = 18.467$). Using a critical value of $\chi^2_{[4]} = 9.4878$, the results of an unplanned test for homogeneity using simultaneous test procedures subsequently established the presence of two homogenous data sets within the sample (Table 2). Both *E. robusta* and *E. parramattensis* were isolated by this process as the most preferred tree species. There was no significant difference between the strike rates of *E. robusta* and *E. parramattensis* ($G_{adj} = 0.271 < \chi^2_{0.05[1]} = 3.841$). However, that of *E. piperita* was significantly lower when compared with the pooled *E. robusta / E. parramattensis* data sets ($G_{adj} = 8.586 > \chi^2_{0.01[1]} = 6.635$). Regression analyses further established that the proportion of *E. robusta* and *E. parramattensis* that had faecal pellets recorded within the prescribed search area did not alter significantly in response to changes in the number of live stems (*E. robusta*: $G^2(M_O) = 0.567$, $P = 0.451$; *E. par-*

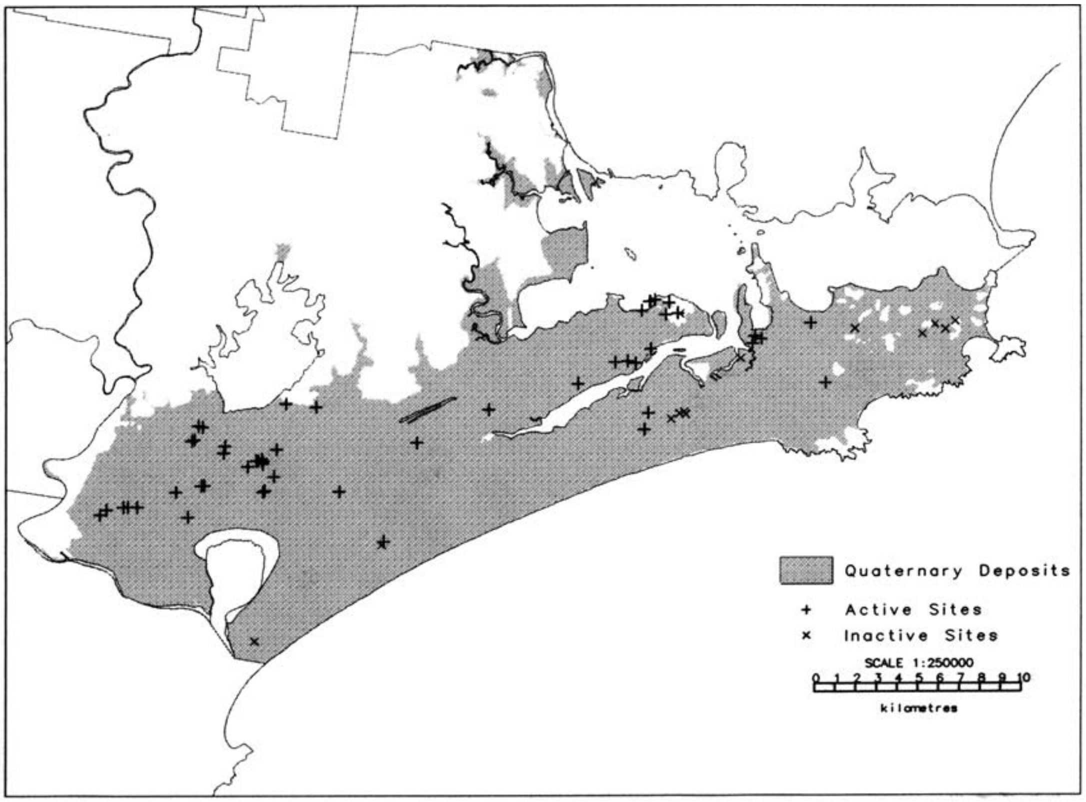


**Fig. 2.** Distribution of active and inactive field sites.

**Table 1. Pooled results derived from 41 sites utilised by koalas in the Port Stephens area**
For each tree species, the total sample size ($n_i$) and the number of independent sites in which it was represented are detailed. Strike rates ($P_i$) are presented ± s.e.

| Species | No. sites | $n_i$ | $P_i$ | Species | No. sites | $n_i$ | $P_i$ |
|---|---|---|---|---|---|---|---|
| Eucalypts | | | | Non-eucalypts | | | |
| *E. robusta* | 14 | 348 | 0.555 ± 0.036 | *C. gummifera* | 16 | 224 | 0.308 ± 0.056 |
| *E. parramattensis* | 9 | 494 | 0.536 ± 0.031 | *M. quinquenervia* | 12 | 718 | 0.297 ± 0.032 |
| *E. piperita* | 7 | 171 | 0.421 ± 0.058 | *A. costata* | 22 | 263 | 0.247 ± 0.053 |
| *E. pilularis* | 8 | 90 | 0.356 ± 0.085 | *B. serrata* | 12 | 101 | 0.139 ± 0.092 |
| *E. signata* | 13 | 351 | 0.293 ± 0.045 | *M. nodosa* | 10 | 175 | 0.131 ± 0.070 |
| *E. eugeniodes* | 3 | 26 | 0.154 ± 0.180 | *M. stypheloides* | 5 | 33 | 0.242 ± 0.152 |
| *E. globoidea* | 3 | 7 | 0.286 ± 0.319 | *C. glauca* | 2 | 8 | 0.250 ± 0.306 |
| *E.* spp. | 3 | 6 | 0.167 ± 0.368 | *M. linearfolia* | 1 | 3 | 0.600 ± 0.365 |
| *E. resinifera* | 2 | 10 | 0.100 ± 0.300 | *A. torulosa* | 1 | 36 | 0.222 ± 0.147 |
| *E. botyroides*[A] | 1 | 4 | 1.000 | Others (8 spp.) | 8 | 33 | |
| Others (3 spp.) | 3 | 6 | | Total trees | | 1594 | |
| Total trees | | 1513 | | | | | |

[A] species not native to the area.

*ramattensis*: $G^2(M_O) = 1.414$, $P = 0.235$). Scatterplots associated with the respective regression models are detailed in Figs 3 and 4.

Strike rates of the three other *Eucalyptus* species (*E. eugenioides*, *E. globoidea* and *E.* spp.) that were represented by data sets that did not satisfy the minimum standard for inclusion in the primary data set were also examined. The extent of variation amongst the strike rates for these three species was not significant (Kruskal–Wallis ANOVA: $H = 0.473 < \chi^2_{0.05[2]}$), nor did their respective strike rates (0.154, 0.286 and 0.167) indicate a level of utilisation by koalas that was similar to that recorded for the two most preferred species. Data relating to the remaining *Eucalyptus* species (*E. resinifera* and *E. botyroides*) beneath which faecal pellets were recorded were not considered suitable for analysis purposes.

**Table 2. Extent of homogeneity amongst the strike rates ($P_i$) for the five *Eucalyptus* species most frequently utilised by koalas**
The descriptor 'HDS' refers to each of the homogeneous data sets established using simultaneous test procedures. Erob = *E. robusta*, Epar = *E. parramattensis*, Epip = *E. piperita*, Epil = *E. pilularis*, Esig = *E. signata*

| Tree spp. | Erob | Epar | Epip | Epil | Esig |
|---|---|---|---|---|---|
| $P_i$ | 0.555 | 0.536 | 0.421 | 0.356 | 0.293 |
| HDS1 | × | × | × | | |
| HDS2 | | | × | × | × |

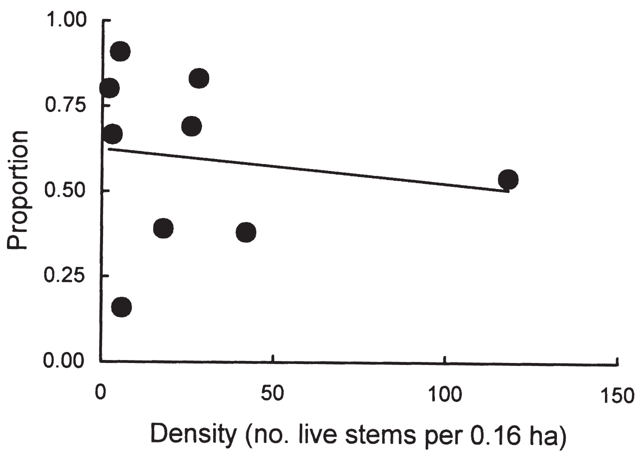


**Fig. 3.** Scatterplot associated with the simplified logit model for swamp mahogany (*E. robusta*). Regression model describes relationship between the proportion of trees with pellets ($P$) and the density of live stems per 0.16 ha. Intercept (logit) = 0.349 ± 0.235 (s.e.); regression coefficient. $b = -0.002 \pm 0.003$ (s.e.).

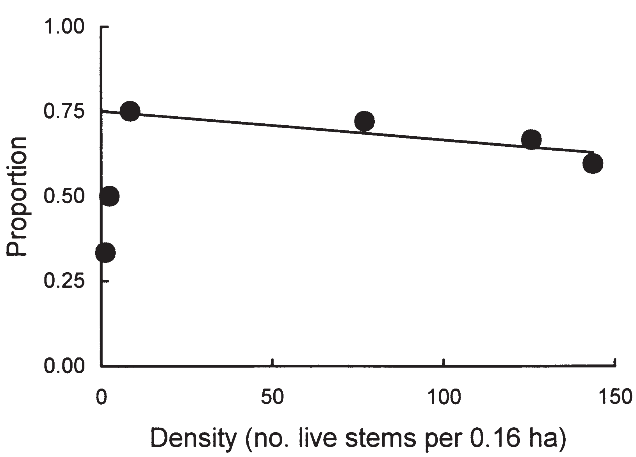


**Fig. 4.** Scatterplot associated with the simplified logit model for drooping red gum (*E. parramattensis*). Regression model describes relationship between the proportion of trees with pellets ($P$) and the density of live stems per 0.16 ha. Intercept (logit) = 1.084 ± 0.424 (s.e.), regression coefficient $b = -0.004 \pm 0.003$ (s.e.).

Of the non-eucalypts, the range of strike rates varied from 0.308 for *Corymbia gummifera* to 0.131 for *Melaleuca nodosa* (Table 1). There was significant heterogeneity amongst the strike rates when tested for Goodness of Fit ($G_{adj} = 33.6789 > \chi^2_{0.001[4]} = 18.467$). Using a critical value of $\chi^2_{[4]} = 9.488$, an unplanned test for homogeneity using simultaneous test procedures (all replicates) resulted in the identification of three homogeneous data sets. *C. gummifera* and *M. quinquenervia* received the highest levels of utilisation (Table 3).

**Table 3. Extent of homogeneity amongst the strike rates ($P_i$) for the five species of non-eucalypt most frequently utilised by koalas**
The descriptor 'HDS' refers to each of the homogeneous data sets established using simultaneous test procedures. Cgum = *Corymbia gummifera*, Mqui = *Melaleuca quinquenervia*, Acos = *Angophora costata*, Bser = *Banksia serrata*, Mnod = *Melaleuca nodosa*

| Tree spp. | Cgum | Mqui | Acos | Bser | Mnod |
|---|---|---|---|---|---|
| $P_i$ | 0.308 | 0.297 | 0.247 | 0.139 | 0.131 |
| HDS1 | × | × | × | | |
| HDS2 | | | × | × | |
| HDS3 | | | | × | × |

**Table 4. Tree species represented in the 17 inactive sites (those that showed no evidence of use by koalas)**
The total sample size ($n_i$) and the number of independent sites associated with each tree species are detailed

| Species | No. sites | $n_i$ |
|---|---|---|
| Eucalypts | | |
| *E. pilularis* | 8 | 105 |
| *E. grandis* | 2 | 38 |
| *E. resinifera* | 2 | 34 |
| *E. umbra* | 2 | 29 |
| *E. piperita* | 2 | 27 |
| *E. robusta* | 2 | 17 |
| *E. microcorys* | 1 | 34 |
| *E. tereticornis* | 1 | 11 |
| *E. agglomerata* | 1 | 2 |
| *E. capitellata* | 1 | 3 |
| *E. parramattensis* | 1 | 14 |
| *E. signata* | 1 | 5 |
| *E.* spp. | 1 | 8 |
| Total trees | | 327 |
| Non-eucalypts | | |
| *Angophora costata* | 11 | 132 |
| *Banksia serrata* | 6 | 70 |
| *Corymbia gummifera* | 4 | 45 |
| *Leptospermum* sp. | 2 | 4 |
| *Acacia* sp. | 1 | 5 |
| *Casuarina glauca* | 1 | 88 |
| *Melaleuca quinquenervia* | 2 | 69 |
| Total trees | | 413 |

The results of the *post hoc* test of association provided strong evidence that the presence of *E. robusta* and/or *E. parramattensis* had a positive influence on the strike rates for other tree species ($G = 99.926 > \chi^2_{0.001[1]} = 10.828$). The level of this association was moderately strong ($\phi = 0.218$).

*Inactive sites*

Seventeen field sites were deemed 'inactive' due to the absence of koala faecal pellets. From these sites 740 individual trees were sampled, comprising 13 *Eucalyptus* species and 7 species of non-eucalypt. *E. pilularis* and *Angophora costata* were the tree species most commonly associated with non-active sites (Table 4).

**Discussion**

Studies relating to the use of faecal pellets to determine aspects of habitat use by koalas have increased in recent years (Hasegawa 1995; Melzer 1995; Phillips and Callaghan 1995; Munks *et al.* 1996; Pahl 1996; Jurskis and Potter 1997). Of these, the works of Hasegawa (1995) and Pahl (1996) represent significant attempts to determine localised food tree preferences by using accumulated faecal pellet counts in conjunction with relative abundance data and the formulae of Hindell *et al.* (1985) to derive preference indices. However, while this approach provides useful insights into preferred species, the cut-off line between tree species being preferentially utilised and those being the subject of more opportunistic utilisation cannot be determined with certainty. Further issues associated with pellet counts suggested that their suitability for determining feeding preferences was problematic (Hasegawa 1995; Pahl 1996). However, in concluding that accumulated faecal pellet counts were not especially useful in establishing the feeding habits of koalas, Hasegawa (1995) incidentally established that, on the basis of the presence of faecal pellets *per se,* the tree species with the highest proportional level of use by koalas in his study area was also the most preferred food tree (on the basis of identification of cuticle fragments in koala faecal pellets). This finding has significant implications for the results of this study given that the approach we have taken similarly identifies tree species with the highest proportional representation. That we have succeeded in isolating tree species with levels of utilisation that are significantly higher than those of their congeners and other non-related tree species allows us to be confident that we have successfully identified the preferred food tree species in this instance. This study is consequently the first to employ a faecal pellet–based methodology that unequivocally identifies preferentially utilised tree species from amongst a suite of others also known to be commonly utilised by koalas.

The results provide cogent support for a model of habitat use by koalas inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens LGA that is primarily focused on the preferential utilisation of only two *Eucalyptus* species. Drooping red gum (*E. parramattensis*) has largely been overlooked in studies associated with the tree species preferences of koalas, only Hawkes (1978) having previously noted that the species was reportedly browsed by koalas. A possible reason for this lack of prominence in the koala literature is that *E. parramattensis* has a relatively limited geographic range in eastern Australia, its distribution being restricted to localised areas of the central coast and tablelands of New South Wales (Hawkes 1978; Brooker and Kleinig 1990; Harden 1991).

In contrast to *E. parramattensis,* swamp mahogany (*E. robusta*) has frequently been reported as a food tree species for koalas (e.g. Hawkes 1978; Wicks 1978; Lee and Martin 1988; Summerville 1990; Pahl *et al.* 1990). *E. robusta* occurs in a narrow band along the east coast of Australia from near Nowra on the south coast of New South Wales to north of Yeppoon on the central Queensland coast, favouring low, swampy sites and estuarine alluvial soils (Hawkes 1978; Harden 1991; Brooker and Kleinig 1996). Congreve and Betts (1978) also regarded *E. robusta* as 'promising feed' in their study of feeding preferences demonstrated by an introduced koala population at Yanchep in Western Australia. However, the status of *E. robusta* in terms of its importance as a 'preferred' food tree for koalas has been equivocal and/or largely anecdotal, nor has it been quantified until the present study. By example, Pahl *et al.* (1990) listed *E. robusta* as a 'primary' food source for koalas but did not specify the criteria upon which such a distinction was made. Conversely, Lee and Martin (1988) listed *E. robusta* as an 'occasional' food tree. *E. robusta* did not figure prominently in the work of Reed *et al.* (1990), nor was it mentioned by Phillips (1990) in his discussion of tree species preferences arising out of the National Koala Survey data.

Inconsistencies such as those above are indicative of the confusion that exists concerning the importance of some tree species to koalas. While there is broad agreement amongst researchers that only a few tree species will be favoured by koalas in any one area, most have persisted in maintaining a somewhat catholic approach when detailing the most preferred species. Hawkes (1978) considered *E. tereticornis* (along with *E. punctata*) as 'staple browse' for koalas in coastal New South Wales. Citing the work of others, Hindell and Lee (1990) unequivocally stated that the preferred tree species for koalas in New South Wales were *E. camaldulensis* and *E. tereticornis*, whereas Phillips (1990) described Sydney blue gum (*E. saligna*) as '… most popular with New South Wales Koalas …'. Such generalisations further serve to highlight the urgent need for an understanding of the tree species preferences of koalas at a much finer scale than has hitherto been applied. Similar views have been expressed by other workers (Cork *et al.* 1990; Norton and Neave 1996) in suggesting that management of localised koala populations required a more precise assessment of the quality and nature of the food resource than that which was currently available. Consistent with this latter view, and based on the knowledge that a significant association between a given tree species and the presence of faecal pellets can be a reliable indicator of feeding preferences (Hasegawa 1995), the results of this study are strongly supportive of a notion that *E. parramattensis* and *E. robusta* function as primary food tree species for koalas on the Tomago Coastal Plain.

In comparison with the obvious importance of *E. robusta* and *E. parramattensis*, the strike rates of the remaining *Eucalyptus* species and those of other genera such as *Corymbia*, *Melaleuca* and *Angophora* are generally not indicative of significant levels of utilisation by koalas. This view is concordant with that of Lee and Martin (1988) and Hasegawa (1995), who observed that even in cases where non-eucalypts were fed upon, the foliage of the preferred eucalypt species (*E. viminalis* and *E. tereticornis* respectively) consistently made up the bulk of the diet. Structural complexity and a tendency to commonly occur in association with preferred species may also be involved in the higher levels of utilisation of the non-eucalypts *C. gummifera*, *M. quinquenervia* and *A. costata*. The presence of cuticle fragments of species such as *M. quinquenervia* and *Corymbia intermedia* by Hasegawa (1995) confirm that some incidental browsing of these species also occurs.

The regression models presented for *E. robusta* and *E. parramattensis* are significant in terms of further clarifying the function and importance of primary food tree species to koalas generally. That the proportion of trees with pellets does not differ significantly in response to changes in density clearly indicates that lesser or greater numbers of koalas are likely to be associated with such changes. Thus, the models are supportive of a notion that a greater number of animals are utilising the resource in response to an increase in the density of live stems. A similar conclusion based on observations of free-ranging koalas was made by Hindell and Lee (1987), who reported a positive correlation between koala densities and the relative abundance of the preferred food tree, *E. viminalis*, in the Brisbane Ranges, while Mitchell (1990) noted that larger home-range areas (and therefore lower koala densities) occurred in areas where the preferred tree species were more sparsely distributed, despite the presence of a variety of other *Eucalyptus* species.

Observations such as those above are of relevance in terms of determining the importance of a given vegetation community for koalas. Cork *et al.* (1990) considered that the key to mapping koala habitat was a consideration of tree communities rather than individual tree species. However, as the results of this work and the above studies suggest, individual tree species, where they can be shown to be the subject of preferential use by koalas, are a critical consideration in terms of understanding carrying capacity. Moreover, we would suggest that an understanding of which tree species are important and which are not clearly increases the likelihood of finding koalas or evidence thereof, while also permitting the relative worth of the vegetation communities being utilised by koalas to be ascertained with a greater degree of confidence than that which is currently being practised.

The autecological importance of *E. robusta* and *E. parramattensis*, as determined by this study, is difficult to quantify further at this stage. The presence of faecal pellets within the prescribed search area beneath the greater proportion of *E. robusta* and *E. parramattensis* sampled (55.5% and 53.6% respectively) provides direct evidence that such trees had been utilised by koalas on at least one occasion. On the basis of the low central-tendency statistics associated with the faecal pellet counts and the probability issues associated with maintenance of such a consistently high strike rate (see also Ellis *et al.* 1998), it is considered that an even greater measure of importance should be attributed these two species than that which has been evidenced by the results. To this end we propose that primary food tree species such as *E. robusta* and *E. parramattensis* represent a finite resource for koala populations. As such, and notwithstanding issues associated with habitat destruction, fire and the depredations of motor vehicles and dogs on the Port Stephens koala population (Callaghan *et al.* 1994), *E. robusta* and *E. parramattensis* should be considered as major limiting factors affecting the distribution and abundance of koalas on the Tomago Coastal Plain.

The positive influence of the two most preferred tree species on the strike rates of other tree species lends further support to the preceding argument by inferring that the extent of differences between *E. robusta* and *E. parramattensis* and those of other tree species are likely to be greater than that evidenced by the results. We suspect it is not so much the nutritional value of these other tree species that results in the increased levels of use, but rather their proximity to the most preferred species. Regardless, vegetation communities in which these increased levels of utilisation occur should be recognised as important habitat components for the purposes of koala management, given that they undoubtedly provide secure roosting and/or social interaction areas in addition to supplementary browsing opportunities.

The results of this study also allow other issues associated with the identification of koala habitat to be pursued. While the distribution of *E. robusta* and *E. parramattensis* on the Tomago Coastal Plain tends to be mutually exclusive, both are essentially limited by micro-edaphic considerations including soil type, drainage patterns, topography and proximity to the water table (Hawkes 1978; Harden 1991; Brooker and Kleinig 1996). By overlaying soil landscape data (Matthei 1995; Murphy 1995) with a vegetation map of the Tomago Coastal Plain, it could be argued that aeolian, swamp and estuarine soil landscapes of Quaternary origin that support vegetation communities containing one or the other, or both, of the preferentially utilised species *E. robusta* and *E. parramattensis*, should constitute significant koala habitat in the study area. In this regard Lunney *et al.* (1998) recently established a high degree of overlap (91%) between a habitat 'model' based on such an approach (Phillips *et al.* 1996) and the results of an independent community-based survey that provided information on localities where koalas were most frequently observed.

Activity levels such as those recorded during the process of this study can potentially provide an important indicator of the extent to which contemporary koala populations are utilising the resources available to them. Thus, the consistent lack of activity indicators such as faecal pellets in vegetation communities containing tree species that are not known to be preferred by koalas are arguably a further measure of their lesser importance. Alternatively, once it has been determined that a particular tree species on a given substrate is the subject of preferential utilisation, we would argue that the complete absence of activity indicators such as faecal pellets from areas containing such tree species provides substantive evidence in support of localised extinction processes associated with historical and contemporary range contractions. For example, three tree species that figure prominently in the inactive sites associated with this study – *E. pilularis*, *C. gummifera* and *A. costata* – collectively form a distinctive vegetation community within the study area. Given that these species have not been shown to be the subject of preferential utilisation in their own right, it appears reasonable to conclude that vegetation communities comprised solely of these species will be of only marginal importance as koala habitat, except where they occur immediately adjacent to those communities and/or areas wherein preferentially utilised tree species occur. Inactive sites that contain *E. robusta* and/or *E. parramattensis*, on the other hand, could not be similarly discounted, especially given recent evidence in support of a once-abundant and widespread koala population in the study area that could clearly be associated with at least one of the above species (Knott *et al.* 1998).

We conclude by reiterating that the resolution of issues associated with the identification of significant food trees for koalas has long acted as an impediment to effective conservation and management of the species. However, we believe that the approach detailed in this study offers some assistance towards an accurate determination of critical koala habitat components over large forested areas in eastern Australia. The extrapolation of field-based results such as those detailed herein, combined with detailed vegetation maps that provide a contemporary assessment of the distribution and composition of native vegetation communities, also offers an alternative approach for habitat modelling and/or mapping purposes. Hierarchical habitat categories based on densities and/or relative abundance of the most preferred tree species would also seem an appropriate measure by which to plan for the effective conservation of extant koala populations, more so given the clear relationship between this variable and the carrying capacity of the vegetation communities in which they grow. Given its ability to overcome problems associated with accumulated pellet counts, the use of a binary variable for the purposes of interpreting faecal deposits by koalas potentially has widespread application. Further development of the approach could facilitate a greater insight into the nature of habitat use by koalas while allowing habitat management and conservation issues to be clarified with a greater degree of certainty than is currently being achieved.

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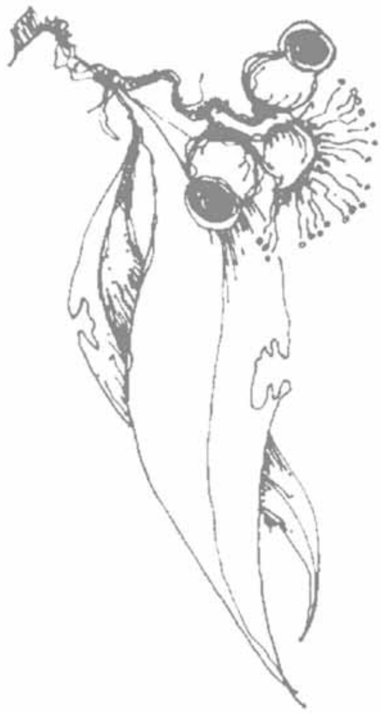
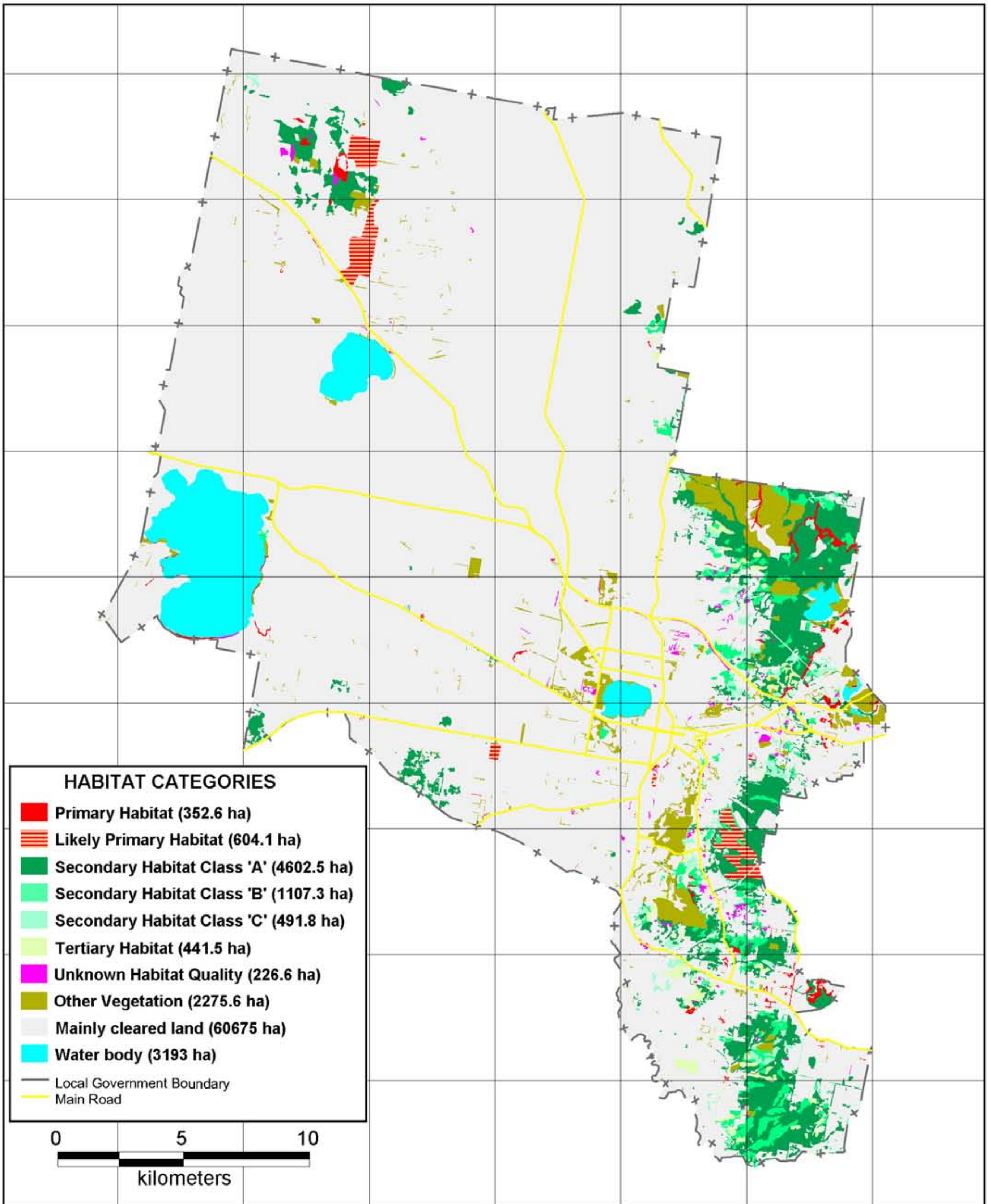


**APPENDIX 2**: Ballarat Koala Habitat Atlas




AUSTRALIAN KOALA FOUNDATION

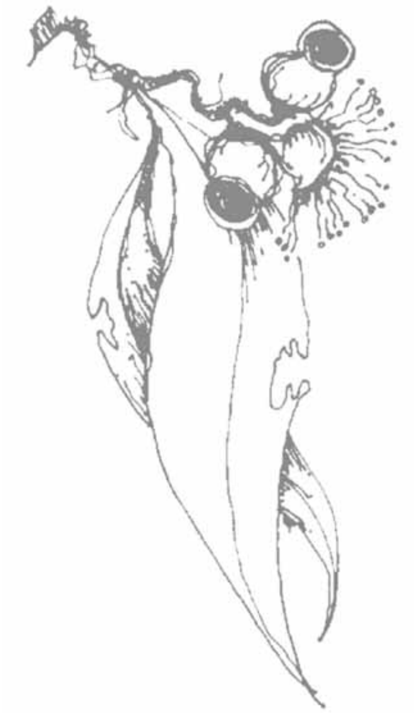
CITY OF BALLARAT

KOALA PLAN OF MANAGEMENT

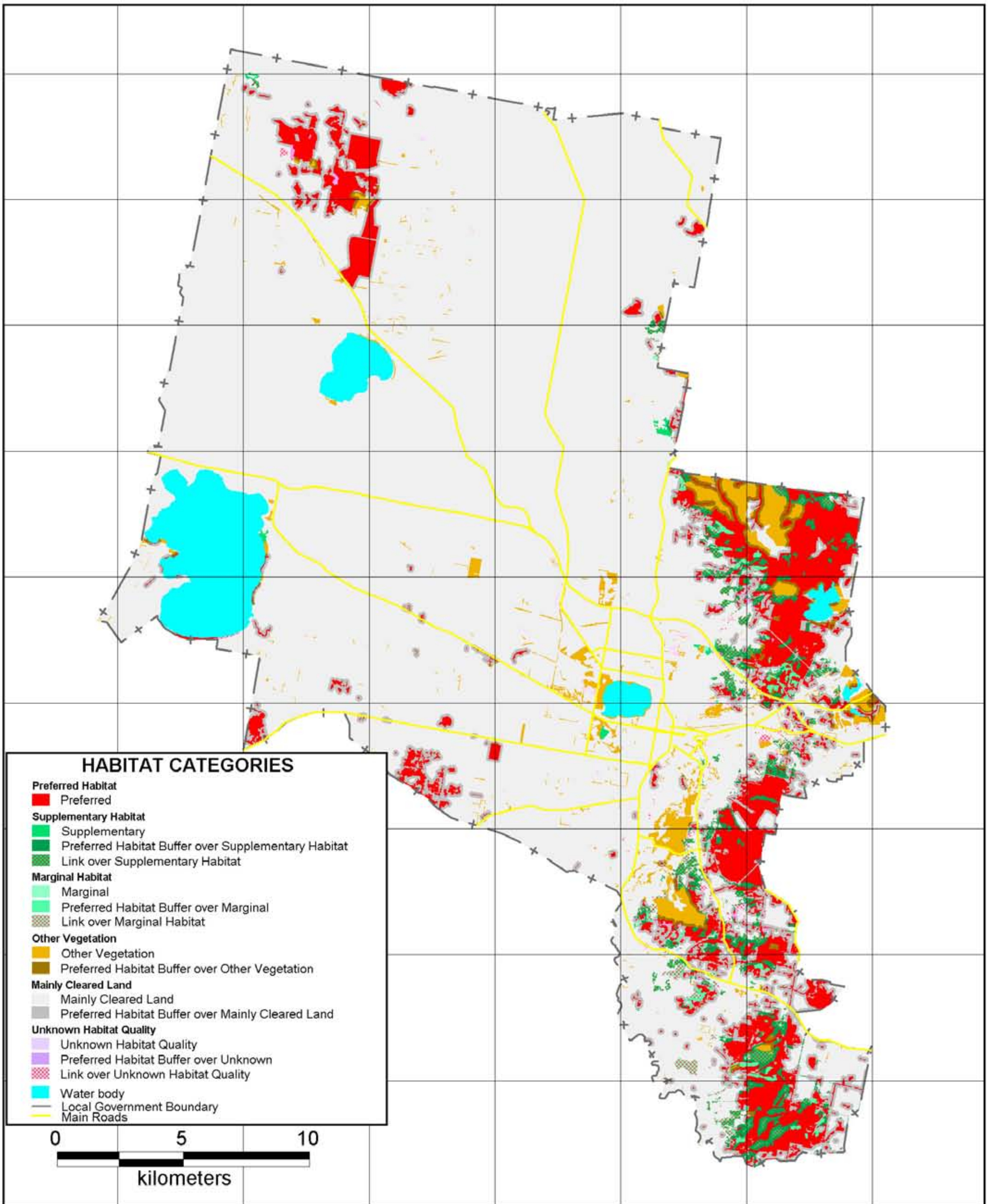
Koala Habitat Atlas

JULY 2006

Map Grid Of Australia (MGA94) Zone 54
shown at 5 km intervals



**APPENDIX 3**: Koala Habitat Planning Map

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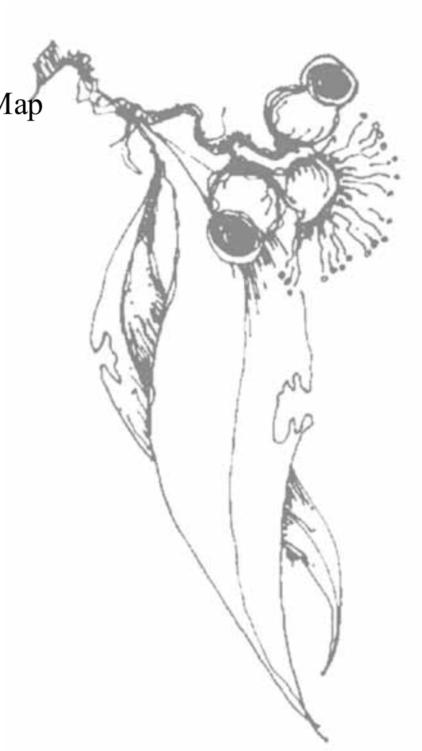
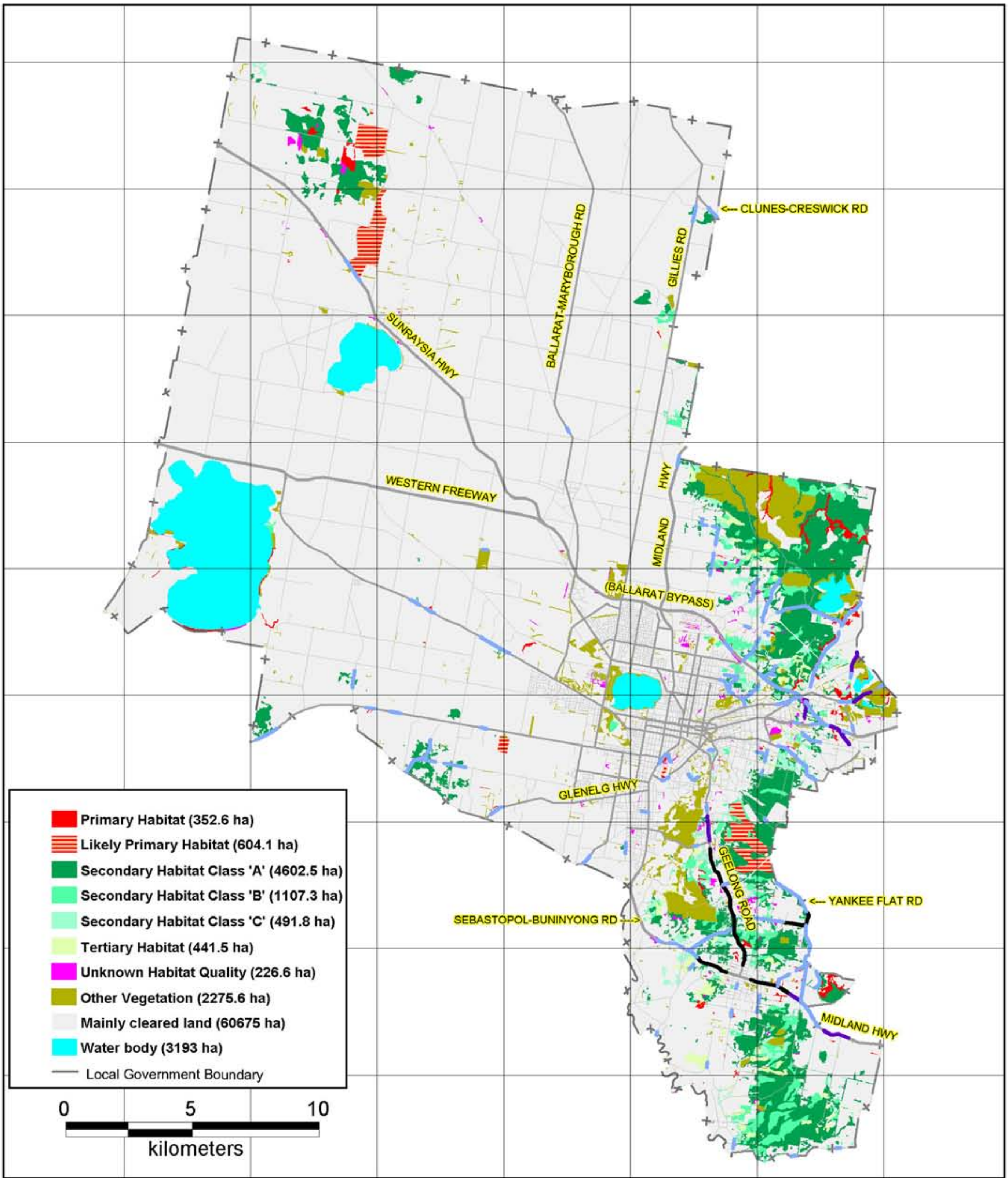
**KOALA PLAN OF MANAGEMENT**
**Koala Planning Map**

**JULY 2006**

**Map Grid Of Australia (MGA94) Zone 54 shown at 5 km intervals**

**APPENDIX 4:** Koala Black Spots, Conflict Areas & Problem Areas Map






**AUSTRALIAN KOALA FOUNDATION**

**CITY OF BALLARAT**

**KOALA PLAN of MANAGEMENT**

**Black Spot Areas, Conflict Areas, and Potential Problem Areas**

**JULY 2006**

**Map Grid Of Australia (MGA94) Zone 54**
**shown at 5 km intervals**

CITY OF BALLARAT

Freeway or Highway
Arterial road
Other roads
Koala Black Spots
Conflict Areas
Potential Problem Areas

**APPENDIX 5**

# City of Ballarat Forest and Woodland Vegetation

## Introduction

This report and accompanying map was commissioned to provide vegetation information specifically for the development of a Koala Habitat Atlas and Koala Planning Map for the City of Ballarat Local Government Area, as part of a Comprehensive Koala Plan of Management prepared by the Australian Koala Foundation for the City of Ballarat.

## Vegetation Data

Vegetation data in the form of 163 field sites was collected by AKF, Centre for Environmental Management (Ballarat University) and University of Queensland researchers over the period 1996-2004, primarily for the purposes of koala habitat assessment and koala habitat use. Data collected included species and diameter-at-breast-height (dbh) for all trees with dbh greater than 10 cm within a 20-metre radius. For vegetation mapping specifically, 72 additional vegetation sites were collected in 1996, a further 39 sites within the LGA in 2003-2004, and 176 sites within a 5-km buffer around the LGA in 2004. These "secondary sites" were collected to fill in perceived gaps in the vegetation information derived from koala habitat data, and consisted of either estimated species abundance or species foliage projective cover depending on the various field data collectors.

State Forest Resource Inventory (SFRI) GIS data was supplied for Crown Lands within the LGA by the Department of Sustainability and Environment. This data contains information on forest structure and species composition (DSE 2001). Of 1318 polygons in this dataset, 953 contained actual species information. Inspection of this data in conjunction with collected field data indicated that many polygons could be confidently split on the basis of aspect and the species mix redistributed. Additional aerial photo interpretation undertaken by the Centre for Environmental Management was also incorporated into the mapping.

Additional vegetation data was collected opportunistically and noted directly onto maps printed for this purpose. This data was invaluable for identifying isolated forest fragments. A draft version of the map was circulated to local botanical experts for comment, with the resulting invaluable information being incorporated into the final map.

## Satellite / Aerial Photography Imagery

Satellite data, including SPOT panchromatic data at a resolution of 10 metres, was supplied by Land Victoria for the project. Orthorectified aerial photography (taken in 2001)over the Ballarat and Buninyong urban areas and nearby forest areas with a resolution of 0.4 metres was supplied by COB. Photography between Ballarat and Creswick was supplied by Hancocks Victorian Plantations (photos taken in 1996) and scanned at a resolution of one metre. Photography (1994 date) covering the forested remainder of the LGA was supplied by Land Victoria and scanned at a resolution of one metre. Scanned aerial photos were registered in the GIS but not rectified, rather, satellite imagery was used to position derived polygons to an estimated "worst accuracy" of approximately 20 metres on Mt Bolton.

## GIS Environment and Additional GIS Data

MapInfo software was the primary GIS used for data creation (digitising and attribute data). Most of the externally acquired GIS data was in the Australian Map Grid (Zone 54) map projection with the 1966 Australian Geodetic Datum (AGD66). The final map is also in this projection.

Satellite and airborne radiometrics images were manipulated using ENVI software to produce several images to aid in vegetation classification, however no automatic image classification routines were used.

Ancillary GIS layers used included a digital terrain model (elevation, slope and aspect), drainage lines, cadastre, 1:250,000 Geology, and a soil map derived from airborne radiometrics (output from a University of Ballarat MSc thesis by Brad Sharkey).

## Minimum Mapping Unit

The smallest mapping unit is an area of 0.1 hectares or 1000 $m^2$ in open areas. In forested areas the smallest delineated polygons are approximately 0.2 ha.

## Vegetation Map Attributes

The vegetation map has the following attributes with the actual attribute column name shown in brackets:

1. Community code (Comm_code)

This is an integer code for each Community name.

2. Community Name (Community_name)

Name of the community as described in this report.

3. Tree Species Polygon Coding (SFRI_code)

Vegetation polygons were digitised by distinguishing areas of different colour, texture (including crown density, shape and size) and consideration of landscape position. Polygons were then attributed with a species composition code derived from the SFRI coding but with greater detail to allow more accurate assessment of forest communities as koala habitat. The coding method is illustrated in Figure 3.

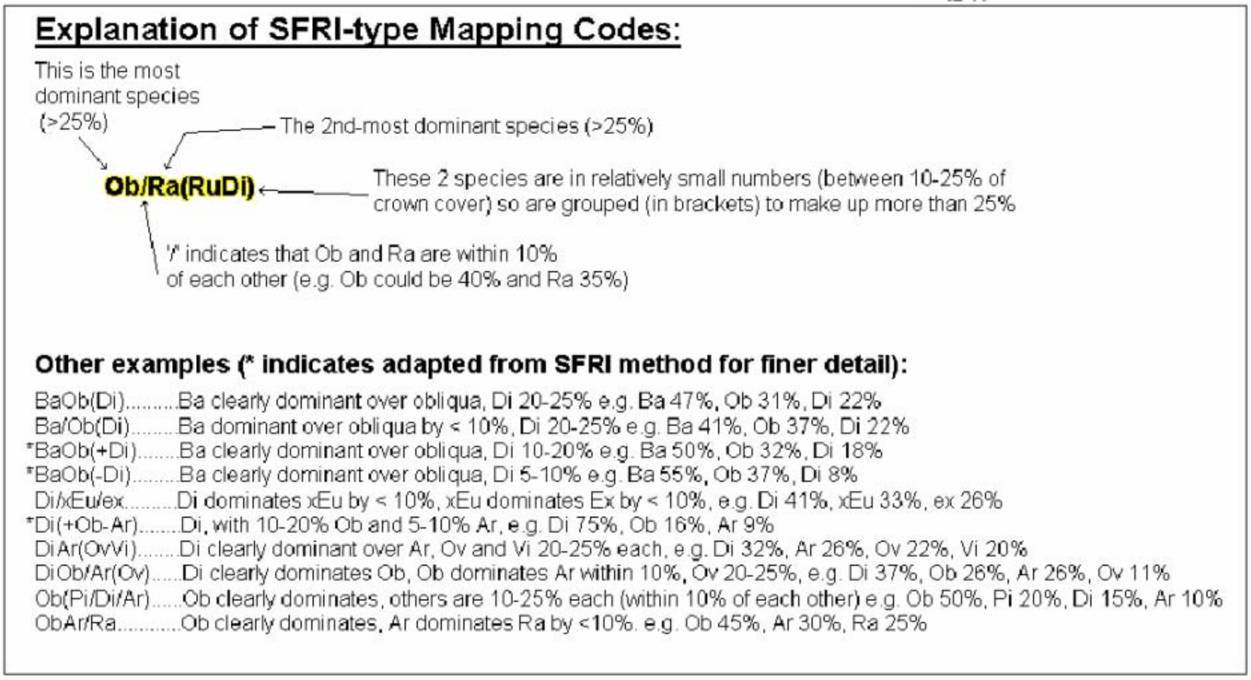



Figure 3: Explanation of Vegetation Map polygon species coding. 2-letter codes represent species found in Ballarat LGA

4. Structure (Structure)

Forest structure was attributed to each polygon based on the density of tree crowns within the polygon. Five possible densities are attributed to vegetation polygons. These densities were subjectively estimated from aerial photography and not foliage projective cover measured at data sites, and are an indication only of the ratio of tree crown area to ground area of each polygon.

1 Open Forest. Tree crowns cover more than 80% of the ground.
2 Woodland. Tree crowns cover 50-80% of the ground.
3 Open Woodland. Tree crowns cover 30-50% of the ground.
4 Scattered Woodland. Tree crowns cover 10-30% of the ground.
5 Scattered Trees. Tree crowns cover less than 10% of the ground.

5. Simplified Geology Group (Geology_group)

Each polygon contains the simplified geology description shown in Figure 2, automatically inserted using a "polygon-within-polygon" feature in MapInfo software. The geology group, derived from 1:250,000 geology, may not reflect the actual geology due to accuracy problems inherent in large-scale datasets.

6. Data source (Data_source)

This attribute describes the source of the information used to identify each polygon as described in Table 1. The attribute may contain several sources of information, as well as changes made to the SFRI coding as a result of additional information and corrections.

| Source code | Description |
|---|---|
| ap | aerial photography interpretation |
| Bnnn | Uni QLD Spot Assessment site number |
| bu | Ballarat Uni data |
| dg | David Grant |
| dm | Dave Mitchell field inspection |
| etm | Landsat Enhanced Thematic Mapper |
| gj | Gavin Jamison |
| k | Kurtis Noyce |
| lb | Lynne Bailey field inspection |
| Lnn | Lynne Bailey vegetation site |
| mb | Michaela Bowen field inspection |
| RA | Robert Amor |
| rs | Rolf Schlagloth field inspection |
| sannn | AKF Spot Assessment site number |
| sfri | SFRI data (polygon and species) |
| SFRI linew | SFRI data (polygon only) |
| TO | Tim D'Ombrain |

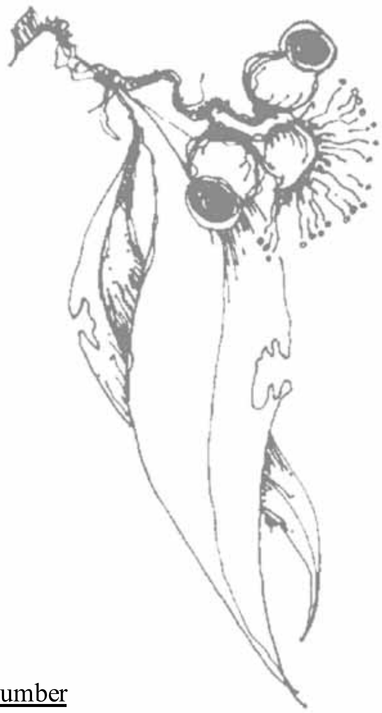


Table 1: Polygon data information source codes. ‘nnn’ denotes a number

7. Accuracy Assessment (Acc)

Each vegetation map polygon was assigned a subjective accuracy assessment as shown in Table 2. An accuracy assessment of ‘1’ indicates the highest level of confidence in both identification of the polygon species mix (SFRI coding) and the areal extent of the coded polygon and reflects information obtained from one or more of the sources shown in Table 1. This level of confidence would be achieved by the presence of collected field data in the polygon and clearly delineated polygon extent evident from colour and/or texture changes in the aerial photograph, or by the SFRI mapping. This level of confidence could potentially be assigned to nearby polygons having the same landscape position in addition to colour and texture. Decreasing levels of assigned accuracy reflect less confidence in SFRI coding and/or areal extent of polygons, with a level of ‘4’ indicating the least confidence and identifying polygons where it would be desirable to direct resources to upgrade map accuracy in the future. Finally, there are 30 polygons with totally unknown species information.

| Accuracy level | No. of polygons | % |
|---|---|---|
| 1 | 1441 | 59.6 |
| 2 | 391 | 16.2 |
| 3 | 491 | 20.3 |
| 4 | 64 | 2.6 |
| Unknown type | 30 | 1.2 |
| Total | 2417 | 99.9 |

Table 2: Accuracy Assessment

8. Area (Area_ha)

The area of each individual polygon is shown in hectares to one decimal place. The 7 largest polygons are plantations, the largest native forest polygon has an area of 90.9 ha.

9. Total Area (Total_area)

The total area of each community in hectares is listed as an attribute in addition to the area of each polygon.

## PATN Analyses

Basal area was calculated for each measured tree (eucalypts only), species total basal area at each site was converted to a percentage of the total basal area at each site and PATN Version 3.03 Pattern Analysis software (Belbin 2004) was used to group sites with similar species composition characteristics. Other species, for example acacias, were not used in the analyses. Although acacias were likely to be present at many sites, the fact that only trees with minimum dbh of 10 cm were recorded would have introduced bias between sites with recordable acacias and those sites with acacias under 10 cm dbh.

Sites containing non-indigenous trees were excluded leaving 158 sites for analysis. Tree species used in the analysis as dependent variables are shown in Table 3.

| Species | Code |
|---|---|
| *Eucalyptus aromaphloia* | Ar |
| *Eucalyptus baxteri* | Ba |
| *Eucalyptus camaldulensis* | Ca |
| *Eucalyptus viminalis subsp. cygnetensis* | Cy |
| *Eucalyptus dives* | Di |
| *Eucalyptus melliodora* | Me |
| *Eucalyptus obliqua* | Ob |
| *Eucalyptus ovata* | Ov |
| *Eucalyptus radiata* | Ra |
| *Eucalyptus rubida* subsp. *rubida* | Ru |
| *Eucalyptus viminalis* | Vi |

Table 3: Species used in PATN analysis

| Variable | Code |
|---|---|
| Easting (AMG Zone 54) | East |
| Northing (AMG Zone 54) | North |
| Koala activity (% of trees at site with faecal pellets) | Activity |
| Ordinal value for Geology type | Geol code |
| Ordinal value for Soil type | Soil code |
| Soil potassium content from airborne radiometrics (%) | potg |
| Soil uranium content from radiometrics (ppm) | urag |
| Total count (potassium, uranium, thorium) from radiometrics | timg |
| Elevation from digital terrain model | Elev |
| Slope from digital terrain model | Slope |
| Aspect from digital terrain model | Aspect |

Table 4: Environmental variables used in PATN analysis

Site data was augmented with the environment variables shown in Table 4.

All data were used in the initial PATN run, using Flexible UPGMA (Un-weighted Pair Group Using Arithmetic Averaging) and default values of
$\beta = -0.1$, and the Gower dissimiliarity measure (Belbin 2004). Number of groups was set higher than the recommended 13 groups (square root of the number of plots) with 25 groups

arbitrarily selected for initial PATN analysis.

Inspection of the Bray-Curtis and Gower association histograms in the initial analyses suggested that 18 groups were sufficient to define the vegetation communities. PATN was run with this number of groups selected, and using 3 methods to measure association.

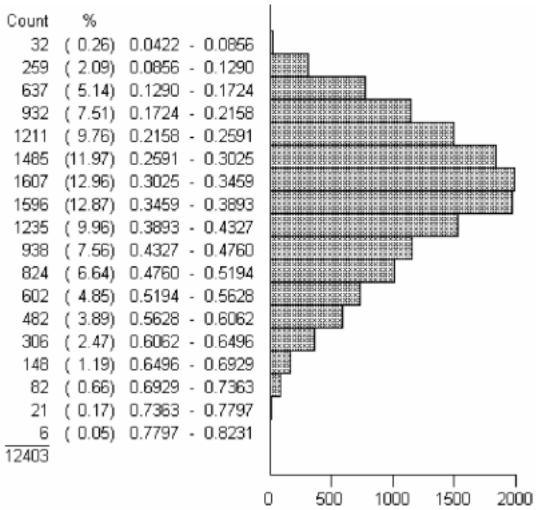
Firstly, species data only (percentage basal area for each species at each site) was analysed in PATN. Secondly, the complete dataset (Tables 3 and 4 combined) was analysed in PATN using the Gower measure of association to reduce the influence of large values, for example AMG map coordinates. Finally, data were standardised using a PATN function (range standardisation) to similiarly reduce bias towards large values (Belbin 2004). Evaluation of the results was possible in PATN using the following methods.

The Kruskal-Wallis statistic shows the significance of each variable in the partitioning of groups, shown in Table 5. The proportion of *Eucalyptus obliqua* (Ob) at sites has the most influence on partitioning of sites, with *Eucalyptus camaldulensis* (Ca) having the least influence due to its presence at one site only.

| **Raw data** | | **Species data** | | **Standardised** | |
|---|---|---|---|---|---|
| Gower metric | | Bray & Curtis | | Bray & Curtis | |
| **Variable** | **Kruskal-Wallis** | **Variable** | **Kruskal-Wallis** | **Variable** | **Kruskal-Wallis** |
| Ob | 114.203224 | Ob | 146.623912 | Ob | 109.064642 |
| Soil code | 100.650074 | | | North | 104.898421 |
| East | 100.447216 | | | Soil code | 104.348314 |
| North | 98.753847 | | | East | 99.262827 |
| Di | 94.247501 | Di | 109.22418 | Di | 96.161263 |
| Geol code | 91.609511 | | | Geol code | 91.747566 |
| potg | 81.855564 | | | Elev | 87.315139 |
| Elev | 78.346449 | | | potg | 84.043466 |
| Activity | 69.540385 | | | urag | 67.644756 |
| Vi | 68.173681 | Vi | 94.944229 | Activity | 66.506565 |
| urag | 67.559705 | | | Vi | 62.963843 |
| Ar | 57.797 | Ar | 67.382791 | Slope | 58.575403 |
| Slope | 56.836426 | | | Ar | 53.500827 |
| Ra | 46.705865 | Ra | 52.589383 | Ra | 47.929606 |
| timg | 40.007892 | | | timg | 38.743024 |
| Ov | 35.089265 | Ov | 40.4389 | Ov | 33.199146 |
| Cy | 27.822542 | Cy | 33.85395 | Cy | 30.652603 |
| Aspect | 26.898167 | | | Aspect | 30.361647 |
| Ba | 21.465332 | Ba | 20.542326 | Ba | 21.45914 |
| Ru | 6.692072 | Ru | 11.584565 | Ru | 8.131932 |
| Me | 5.886792 | Me | 5.887031 | Me | 5.886792 |
| Ca | 2.962264 | Ca | 2.962264 | Ca | 2.962264 |

Table 5: Kruskal-Wallis statistics rank the influence of each variable on the grouping of sites

Another evaluation technique is the measure of association. In PATN, association measures close to '0' imply close matching between a site and its group centroid, values close to '1' imply the inclusion of the site in that group is rather tenuous. Figure 4 indicates that taking into account the environmental values from the GIS produces much stronger site-group associations than using the stand-alone species data which has a large number of associations close to '1'.



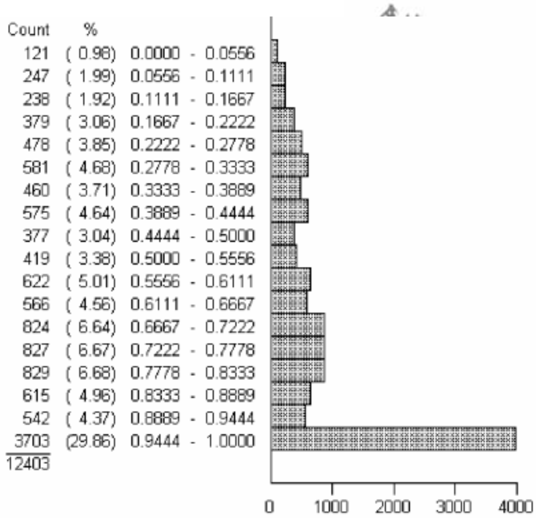




Fig 4a) Species data and environmental variables Fig 4b) Species data only
Figure 4: Comparison of Bray and Curtis association measures

Finally, PATN offers MCAO, a Monte-Carlo randomised test of correlation significance. Table 6 shows the $r^2$ correlations and the results of this test for two of the group ordination methods. The 'MCAO (%)' column is analagous to significance levels, MCAO (%) = 0 corresponds to significance = 0.001. With all variables (standardised Bray & Curtis), Ar has MCAO = 12% (significant at 0.12), possibly indicating that Ar is not well-correlated with environmental variables. Similiarly, with the Species (Bray & Curtis), Ba has MCAO = 1% (significant at 0.01), an indication that this species is not as well-correlated as the other species are with each other.

| **All variables (standardised Bray & Curtis)** | | | **Species (Bray & Curtis)** | | |
|---|---|---|---|---|---|
| **Variable** | **r-squared** | **MCAO (%)** | **Variable** | **r-squared** | **MCAO (%)** |
| Ob | 0.856 | 0 | Ob | 0.856 | 0 |
| Di | 0.701 | 0 | Di | 0.701 | 0 |
| Vi | 0.683 | 0 | Vi | 0.683 | 0 |
| Cy | 0.339 | 0 | Cy | 0.339 | 0 |
| Ov | 0.323 | 0 | Ov | 0.323 | 0 |
| Ra | 0.286 | 0 | Ra | 0.286 | 0 |
| Geol code | 0.24 | 0 | | | |
| Activity | 0.205 | 0 | | | |
| potg | 0.181 | 0 | | | |
| Elev | 0.172 | 0 | | | |
| Soil code | 0.159 | 0 | | | |
| North | 0.156 | 0 | | | |
| East | 0.152 | 0 | | | |
| Ar | 0.143 | 12 | Ar | 0.143 | 0 |
| Ba | 0.105 | 0 | Ba | 0.105 | 1 |
| Me | 0.099 | 0 | Me | 0.099 | 0 |
| Ca | 0.091 | 2 | Ca | 0.091 | 0 |
| Ru | 0.079 | 5 | Ru | 0.079 | 0 |
| urag | 0.067 | 0 | | | |
| Slope | 0.058 | 0 | | | |
| timg | 0.034 | 0 | | | |
| Aspect | 0.031 | 1 | | | |

Table 6: $r^2$ correlations and MCAO significance tests

Aspect was the least-important environmental factor in the association measures, which is somewhat surprising considering the influence of aspect apparent from field observation. It may be that this variable has a more direct influence on species presence, for example the rarity of *E. obliqua* (Messmate) and *E. viminalis* subsp. *viminalis* (Manna Gum) on drier northern aspects.

The groups obtained from the standardisation procedure with all variables were adopted with results from the other methods used to adjust the groups where necessary to overcome errors or inaccuracies in the environmental data. Possible sources of these inaccuracies include the spatial accuracy of geology and soil maps.

It should be noted that the analysed field data did not cover all areas of the LGA. The approximately 200 secondary sites collected (mainly within a 5 km buffer surrounding the LGA, but many within the LGA) used a rapid assessment technique where species proportions were estimated rather than measured, precluding use of this data in PATN. This data was incorporated into the vegetation map, with extra vegetation communities not included in the PATN analysis added.

Field data was anomalous with the SFRI mapping in some cases, particularly in the number of communities containing *Eucalyptus radiata* (Narrow-leaved Peppermint). Comparisons with field data were possible for 20 SFRI polygons containing field sites. In these 20 polygons 10 field sites actually contained *E. radiata*. The other field sites recorded *E. dives* (Broad-leaved Peppermint). Where possible the SFRI mapping was changed to reflect the field data. Where this was not possible, additional vegetation communities were raised. Problems associated with distinguishing between peppermints are not likely to affect koala habitat categories as they are not regarded as koala food trees.

## Vegetation Communities

Underlying geology was the major environmental determinant in association grouping in the PATN analysis. In the following vegetation community descriptions, vegetation communities are grouped firstly according to the five broad geological types shown in Figure 2, and then as alphabetical subgroups detailing the particular mixes of species as defined by PATN and supplementary field data. Within each geological group the subgroups intergrade between dominant species ratios depending on the environmental factors used in the PATN analyses. The subgroup or community name describes whether the community is predominately found as open forest and/or woodland. The total area is also shown for each community.

## Group A: Vegetation Communities on Devonian Granite and Granodiorite

**1.** *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) woodland / scattered woodland on Devonian granite (132.5 ha). This community only occurs on the lower slopes of Mts Beckworth and Bolton on more southerly aspects, and on steep north-easterly aspects on Mt Bolton. It is likely that this community was more widespread prior to clearing for farming.

**2.** *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) with *Eucalyptus obliqua* (Messmate) open forest / woodland on Devonian granite (127.1 ha). Soils are sandy loams with bleached subsurface containing fine gravel with high potassium levels. This community only occurs on Mts Beckworth and Bolton, generally on northerly aspects. *E. viminalis* subsp. *cygnetensis* is clearly dominant, *E. viminalis* subsp. *viminalis* may be present, and *E. aromaphloia* rarely present.

**3.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) open forest / woodland (192.2 ha). In this community, found on southerly aspects on Mt Bolton, *E. obliqua* is clearly dominant and occasionally the only species.

**4.** *Eucalyptus ovata* (Swamp Gum) open forest / woodland (1.3 ha). There are two small patches of this community on footslopes of Mt Bolton along drainage lines.

**5.** *Eucalyptus ovata* (Swamp Gum) / *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland (37.4 ha). This community is found on watercourses on Mt Bolton. On the surrounding lower slopes small patches of this community occur on farmland. *E. obliqua* is usually present and *E. viminalis* subsp. *cygnetensis* may be occasionally present.

**6.** *Eucalyptus ovata* (Swamp Gum) with *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) open forest / woodland (13.4 ha). This community occurs in gullies on Mt Bolton on southerly aspects.

**7.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) / Mixed eucalypt open forest / woodland (41.0 ha). *E. viminalis* subsp. *viminalis* is dominant, usually on northeasterly aspects of Mt Bolton with *E. aromaphloia* and *E. viminalis* subsp. *cygnetensis* and sometimes with *E. obliqua.* The area of this community has been reduced by gravel extraction.

**8.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus ovata* (Swamp Gum) and *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland on Devonian granodiorite (18.3 ha). This community has limited distribution around Gong Gong and Kirks Reservoirs on midslopes and near watercourses. *E. viminalis* subsp. *viminalis* is clearly dominant, *E. radiata* is a minor species in this community.

**Group B: Vegetation Communities on Newer Volcanics**

**9.** *Eucalyptus brookeriana* (Brooker's Gum) with *Eucalyptus rubida* (Candlebark) and *Eucalyptus radiata* (Narrow-leaf Peppermint) woodland (2.4 ha). This very restricted community occurs on Newer Volcanics in one location on a broad low rise between the Western Freeway and Kirks Reservoir.

**10.** *E. melliodora* (Yellow Box) scattered woodland (23.1 ha). Two small patches of pure *E. melliodora* on gently-sloping Newer Volcanics-derived soils are located between Creswick-Clunes Road and the railway line near the north-eastern edge of the LGA. This community was probably much more extensive in similar landscape positions which have been extensively cleared for grazing.

**11.** *Eucalyptus obliqua* (Messmate) open forest / woodland on Newer Volcanics (24.9 ha). The best examples of this community are found on the northwest slopes of Mt Buninyong. In other areas the community is mostly open woodland in farming areas.

**12.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus ovata* (Swamp Gum) and *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (5.2 ha). Found on gently-sloping Newer Volcanics, for example near Greenhill Rd, this community also occurs on watercourses, for example Union Jack Ck at Mt Helen. *E. obliqua* is clearly dominant in this community.

**13.** *Eucalyptus obliqua* (Messmate) with *E. viminalis* subsp. *viminalis* (Manna Gum) and *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest (50.9 ha). *E. obliqua* is clearly dominant in this community, found in the area just west of Glen Park in the northeast of the LGA on richer volcanic-derived soils adjacent to farmland.

**14.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus viminalis* subsp. *viminalis*) (Manna Gum) open forest / woodland (69.5 ha). Occurs only on Newer Volcanics, most extensively at Mt Buninyong on generally southerly aspects, on reddish clay loam or loam soils with medium/heavy clay subsoils. A few small isolated remnants of this community also occur just west of Cardigan. *E. obliqua* is clearly dominant in this community.

**15.** *E. viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland on Newer Volcanics (43.4 ha). There are several pure stands of *E. viminalis* subsp. *viminalis* open forest on Newer Volcanics, for example the north-eastern side of Mt Buninyong. Most other stands of *E. viminalis* subsp. *viminalis* are small scattered woodland remnants with southerly aspect on farmland.

**16.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus dives* (Broad-leaf Peppermint) open forest / woodland on Newer Volcanics (4.7 ha). This is a very restricted community only found interspersed within a pine plantation east of Gong Gong and Kirks Reservoirs.

**17.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus obliqua* (Messmate) open forest / woodland (6.6 ha). On Mt Buninyong this community is generally on northern aspects with minor amounts of *E. obliqua*. On drainage lines running from Mts Buninyong and Warrenheip this community (with *E. viminalis* subsp. *viminalis* clearly dominant) also occurs, however in these areas the community has been mostly cleared. Two small isolated remnants of this community also occur just west of Cardigan on the volcanic plain.

**18.** *Eucalyptus aromaphloia* (Scentbark) / *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) open forest/scattered woodland (68.7 ha). *E. aromaphloia* is always clearly dominant in this community, which occurs only in the far south-west of the LGA, on two low rises with Ordovician geology. This community is mostly found as woodland or scattered trees due to clearing and thinning on farmland.

**<u>Group C: Vegetation Communities on Ordovician geology</u>**

**19.** *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (44.6 ha). This Ordovician geology community is found on lower-elevation upper slopes with drier northerly aspects. The forest canopy is very sparse. This community is often found in areas highly disturbed due to historical mining activity, for example Mt Clear and Sovereign Hill. There is usually abundant quartz on the soil surface.

**20.** *Eucalyptus aromaphloia* (Scentbark) with *Eucalyptus obliqua* (Messmate) open forest / woodland (70.1 ha). *E. aromaphloia* is clearly dominant in this community which is usually situated on footslopes with a southerly aspect. *E. radiata* is occasionally present.

**21.** *Eucalyptus aromaphloia* (Scentbark) / *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (42.1 ha). This community is found on the western slopes of the Creswick forest block, often on low rises which have not been cleared for farming. *E. obliqua* is occasionally present in this community.

**22.** *Eucalyptus dives* (Broad-leaved Peppermint) / *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (39.9 ha). *E. dives* dominates this community. *E. obliqua* may be present in minor amounts (less than 30%). *E. aromaphloia* is sub-dominant in this community.

**23.** *Eucalyptus dives* (Broad-leaved Peppermint) with *Eucalyptus aromaphloia* (Scentbark) and/or *Eucalyptus obliqua* (Messmate) open forest / woodland (509.7 ha). This community is clearly dominated by *E.dives* which often is the only species, *E. aromaphloia* (and *E. obliqua* if present) make up less than 40% of the community. This community is usually found on north-western aspects and crests and often shows mining disturbance. Where present, *E. obliqua* occurs on midslopes in minor amounts.

**24.** *Eucalyptus dives* (Broad-leaved Peppermint) / *Eucalyptus obliqua* (Messmate) open forest / woodland (628.4 ha). *E. dives* is usually dominant in this community. *E. aromaphloia* is a common associate of this community in minor amounts. *E. ovata* occasionally occurs on drainage lines. Soils are generally low in potassium, with abundant quartz fragments throughout the soil profile. This community is typically found on higher elevation northerly aspect slopes and crests north of the Western Freeway.

**25.** *Eucalyptus obliqua* (Messmate) woodland (68.4 ha). This community is found upslope of *E. ovata* woodland east of Bunkers Hill and also west of Creswick Forest block on gently-sloping low-lying Ordovician-derived soils, and has a woodland structure due to farm clearing.

**26.** *Eucalyptus obliqua* (Messmate) open forest / woodland (353.3 ha). This community is found amongst other forest communities on moderately-sloping Ordovician-derived soils north and south of Ballarat on southerly aspects or upper watercourses, and at higher elevations on gently-sloping northern aspects (for example northwest of White Swan). Woodlands and scattered woodlands are also found on footslopes adjoining cleared farming areas.

**27.** *Eucalyptus obliqua* (Messmate) / *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (474.5 ha). *E. obliqua* is usually clearly dominant in this community. *E. dives* or *E. radiata* are occasionally present in small amounts. This community is usually found on steeper areas near watercourses (where there may be minor occurrences of *E. viminalis* subsp. *viminalis*), and on toeslopes with a northerly aspect.

**28.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus dives* (Broad-leaved Peppermint) open forest / woodland (885.8 ha). *E. obliqua* is usually clearly dominant in this community, which is mostly found on southerly aspects. *E. aromaphloia* is absent. This community is rarely found on northerly aspects except at higher elevations (above 500 m) or on toeslopes near watercourses or broad valleys where there is more moisture in the soil.

**29.** *Eucalyptus obliqua* (Messmate) / *Eucalyptus dives* (Broad-leaf Peppermint) / *Eucalyptus baxteri* (Brown Stringybark) open forest / woodland (311.2 ha). *E. obliqua* and *E. baxteri* intergrade in two locations in the LGA, with *E. obliqua* usually dominant. NE of Mt Helen near Mt Clear Secondary College and in a small section of Canadian Forest on westerly aspects *E. dives* is present in varying amounts with *E. aromaphloia* occasionally present. In the area east of Durham Lead (Grenville Forest) this community is more widespread and variable in composition, and generally found on southerly aspects. *E. dives* may even be dominant, and *E. aromaphloia* is sometimes present. *E. ovata* may occur in damper areas.

**30.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus dives* (Broad-leaved Peppermint)and *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (598.7 ha). *E. obliqua* makes up 40% or more of the trees in this community and is often clearly dominant, *E. dives* and *E. aromaphloia* together make up less than half of the community, with *E. dives* dominant over *E. aromaphloia*. This community generally occurs on footslopes with a southerly aspect, broad flats, or on upper watercourses with occasional *E. ovata*.

**31.** *Eucalyptus rubida* (Scentbark) / *Eucalyptus melliodora* (Yellow Box) open forest / woodland (46.4 ha). This community is found on low rises adjacent to Gillies Road/Addington Road near Bald Hills and is disturbed by grazing. *E. melliodora* is replaced by *E. obliqua* towards the south, with occasional *E. dives* also gradually appearing.

**32.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus ovata* (Swamp Gum) open forest / woodland (106.7 ha). This community is found near the middle reaches (downstream from *E. obliqua/E. dives* communities) of watercourses draining to the west, or on upper reaches of drainage lines with a southerly aspect. *E. obliqua* is clearly dominant with *E. ovata* dominant over other occasional species including *E. dives*, *E. radiata* and *E. aromaphloia*.

**33.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus radiata* (Narrow-leaf Peppermint) and *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (754.7 ha). This community is clearly dominated by *E. obliqua*. *E. aromaphloia* is usually in smaller amounts where it occurs in this community. *E. viminalis* subsp. *viminalis* and *E. ovata* may occasionally be present on steep southerly aspects and near watercourses. Generally, this community is found on wetter and more fertile soils than those supporting *E. dives*, for example higher elevations north of The Western Freeway or around Buninyong. Near Sovereign Hill this community intergrades into a community of *E. dives* and *E. aromaphloia*. This community surrounds most of the *Pinus radiata* (Monterey Pine) plantations at higher elevations so it seems possible that this community was more widespread in the past. This community also occurs in a few places on the eastern and southern edges of the Grenville Forest block on gently-sloping areas bordering cleared land.

**34.** *Eucalyptus obliqua* (Messmate) with *Eucalyptus rubida* (Candlebark) open forest / woodland (97.0 ha). Usually with *E. obliqua* clearly dominant, this community occurs west of White Swan (occasionally with *E. viminalis* subsp. *viminalis*). In 3 locations east of the Nerrina-Creswick Road *E. rubida* or *E. radiata* are the dominant species.

**35.** *Eucalyptus obliqua* (Messmate) with *E. viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland (87.8 ha). *E. obliqua* is clearly dominant in this community, which is found north from Buninyong on larger watercourses (occasionally with *E. ovata*) and occasionally on steeper southerly aspects where *E. dives* or *E. radiata* or *E. aromaphloia* may be rarely present.

**36.** *Eucalyptus ovata* (Swamp Gum) open forest / woodland (30.7 ha). On Ordovician-derived soils south of White Swan some patches of pure *E. ovata* occur. This community is found near the middle reaches of watercourses, or on upper reaches of drainage lines with a southerly aspect. Soil moisture is presumably too high for other species in these locations.

**37.** *Eucalyptus ovata* (Swamp Gum) with *Eucalyptus obliqua* (Messmate) and Peppermint open forest / woodland (111.4 ha). This community is typically found in the eastern section of the LGA south of the Western Freeway. The typical landscape position is at the headwaters of creeks draining westward from Newer Volcanics through the Canadian and Grenville Forest blocks or eastwards through farmland. These areas have very gentle slopes prone to seasonal waterlogging. *E. ovata* is usually clearly dominant and there may be varying amounts of *E. dives*, *E. radiata* and sometimes *E. aromaphloia*. *E. viminalis* subsp. *viminalis* is very occasionally present in small amounts.

**38.** *Eucalyptus ovata* (Swamp Gum) with *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest / woodland on wetter drainage lines (4.7 ha). *E. ovata* is clearly dominant. This community is mainly found in the wetter eastern sections of the LGA around White Swan downstream from *E. ovata* and *E. ovata/E.obliqua* communities.

**39.** *Eucalyptus ovata* (Swamp Gum) / *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) open forest (37.6 ha). *E. viminalis* subsp. *viminalis* is sub-dominant in this community, occurring on two creeks north of Reid Park Rd at Mt Helen. On two large creeks north of Glenisla Rd at Brown Hill this community occurs with occasional *E. radiata*, *E. aromaphloia* and *E. obliqua*.

**40.** *Eucalyptus radiata* (Narrow-leaf Peppermint) with *Eucalyptus aromaphloia* (Scentbark) open forest / woodland (53.9 ha). *E. radiata* is clearly dominant in this community, *E. obliqua* is occasionally present. This community may be found on flatter more fertile areas with northerly aspect, for example around Sovereign Hill and between Grenville Hill and Durham Lead.

**41.** *Eucalyptus radiata* (Narrow-leaf Peppermint) with *Eucalyptus obliqua* (Messmate) open forest / woodland (75.8 ha). This community occurs on more gently-sloping Ordovician-derived soils and usually near watercourses, for example lower reaches of Union Jack Ck, northwest of Buninyong and near White Swan on various aspects. *E. aromaphloia* is a common associate of this community, with *E. viminalis* subsp. *viminalis* and *E. ovata* in wetter areas. *Eucalyptus macrorrhyncha* (Red Stringybark) occurs in one patch of this community between Buninyong and Mt Helen.

**42.** *Eucalyptus radiata* (Narrow-leaf Peppermint) / *Eucalyptus rubida* (Candlebark) scattered woodland/scattered trees (38.6 ha). This community occurs on farmland in two locations north and west of Grenville Hill adjacent to the road between Buninyong and Durham Lead on southerly aspects.

**43.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus obliqua* (Messmate) open forest (117.7 ha). The best examples of this community occur on larger creeks between Ballarat and Creswick. Occasional species include *E. radiata*, *E. ovata* and *E. aromaphloia*.

**44.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) with *Eucalyptus ovata* (Swamp Gum) open forest (70.4 ha). *E. viminalis* is usually clearly dominant over *E. ovata* in this community found mostly on larger creeks. Occasional species include *E. radiata*, *E. obliqua*, *E. dives* and *E. aromaphloia*.

**Group D: Vegetation Communities on Recent alluvial soils**

**45.** *Eucalyptus yarraensis* (Yarra Gum) woodland (5.5 ha). Degraded remnants of this community occur adjacent to Union Jack Creek on the north side of Gear Avenue at Mt Helen. The broader gullies in the south-east of the LGA once carried *E. yarraensis*. Little of this community remains due to landclearing.

**46.** *Eucalyptus camaldulensis* (River Red Gum) woodland (29.2 ha). This community at present is found only on the shores of Lake Burrumbeet and Burrumbeet Creek, and Winter Swamp (likely planted) south of Ballarat airport. Underlying geology is Newer Volcanics basalt, soils are predominately clay loams with a subsurface of mottled medium/heavy clay indicative of intermittent waterlogging. This community was likely more widespread before clearing, as there are anecdotal reports of scattered single *E. camaldulensis* trees nearer to the Ballarat urban area. Where it occurs this community is likely to have been thinned due to selective clearing or lack of recruitment because of grazing.

**Group E: Vegetation Communities on Pliocene/Pleistocene gravels**

**47.** *Eucalyptus viminalis* subsp. *cygnetensis* (Rough-barked Manna Gum) / *Eucalyptus aromaphloia* (Scentbark) / *Eucalyptus obliqua* (Messmate) open forest / woodland (115.5 ha) This community is found on Pliocene gravels/Ordovician low rises at Bunkers Hill. *E. viminalis* subsp. *cygnetensis* is dominant with some *E. obliqua* present.

**48.** *Eucalyptus ovata* (Swamp Gum) woodland (5.4 ha). This community occurs only on Pliocene gravel alluvial fan outwash derived from Bunkers Hill, areal extent has been reduced by gravel extraction.

**Group F: Vegetation Communities various geologies**

**49.** *Eucalyptus aromaphloia* (Scentbark) / *E. dives* (Broad-leaved Peppermint) open forest / woodland (134.0 ha). This community is found in similar locations to pure *E. aromaphloia* communities but at lower elevations and southerly aspects with more moisture, and occurs primarily on Pliocene and Pleistocene gravels and occasionally Ordovician geology. The forest canopy is sparse. *E. dives* is a subdominant species with *E. obliqua* sometimes present in minor amounts for example between Brown Hill and Invermay, or near watercourses elsewhere.

**50.** *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (33.2 ha). *E. radiata* is the only species in this community, which occurs on more fertile soils on several different geologies. Most patches of pure *E. radiata* are found as small remnants with woodland structure on gently-sloping farmland.

**51.** *Eucalyptus viminalis* subsp. *viminalis* (Manna Gum) / *Eucalyptus radiata* (Narrow-leaf Peppermint) open forest / woodland (50.9 ha). *E. viminalis* subsp. *viminalis* clearly dominates this community, which mainly occurs as remnant patches on Quaternary alluvial or Newer Volcanics soils generally and some Ordovician-derived alluvial soils in forests north of Brown Hill. Other species present may include *E. obliqua*, and *E. aromaphloia* in small amounts. *E. ovata* may be present adjacent to watercourses.

**Group G: Planted / non-indigenous Species**

**52.** Native forest regrowth (155.8 ha). Most regrowth areas are small, with the largest patches found on Mt Bolton. It was not possible to identify species in these 93 polygons from aerial photography.

**53.** *Eucalyptus globulus* subsp. *globulus* (Tasmanian Bluegum) plantation (595.9 ha). In recent years this species has been planted in many areas of the LGA. Large plantations are found around Mt Bolton, and plantings of this species appear to be replacing *Pinus radiata* plantations on Ordovician soils as they are harvested.

**54.** *Pinus radiata* (Monterey Pine) plantation (2046 ha). Blocks of *P. radiata* have been planted after clearing or logging of native vegetation on Ordovician-derived soils. Incursion of Pine seedlings into the adjacent native forest has occurred in most locations.

**55**. Native forest with a high proportion of mature *Pinus radiata* (51.6 ha). On farmland, remnant forest may be planted with *P. radiata* to enhance windbreaks. Forested areas adjacent to *P. radiata* plantations often contain juvenile and mature pine trees which have dominated native species in some locations.

**56.** Other planted *Eucalyptus* species (88.0 ha). This group includes species planted in urban areas and on farms as shelterbelts and windbreaks. Species may be planted with indigenous eucalypts and/or *Pinus radiata*. This Group also includes Landcare projects. Species information is included where known.

**57**. *Salix* spp. (Willow) woodland (25.9 ha). *Salix* spp. occur along many watercourses, sometimes with other exotic species.

**58**. Exotic tree species (233.5 ha). Includes urban and rural tree plantings, occasionally with some remnant native species interspersed. These plantings often include *Pinus radiata* as a secondary species.

**59.** Unknown communities (24.5 ha). These areas of forest or woodland have been mapped in areal extent from aerial photography but have not been identified due to access constraints.

**Acknowledgments**

Many people provided valuable input and data to this project. These people are listed in Table 1. Appreciation is also extended to Rick Pope of Land Victoria for his ongoing support for the project over more than 10 years, and to Adrian Bloch of DSE for access to the State Forest Resource Inventory data.

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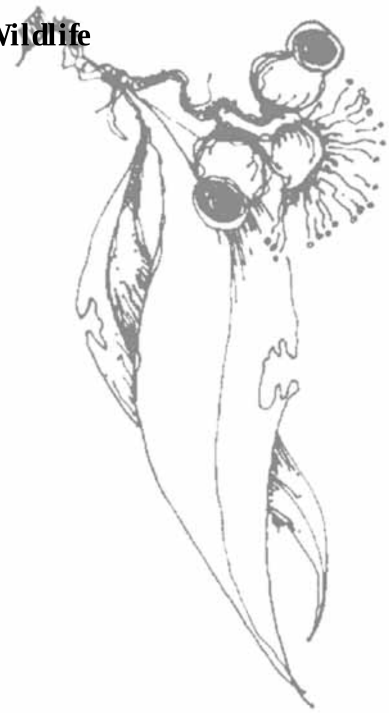
**APPENDIX 6**: **Contact Details for Trust for Nature and Land for Wildlife**



**Contact details for Trust for Nature:**

**Trust for Nature (Victoria)**
Level 2, 385 Little Lonsdale St.
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Tel: (03) 9670 9933
Fax: (03) 9670 9977
Freecall: 1800 99 9933
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Web site: www.tfn.org.au

**Contact details for Land for Wildlife:**

**Department of Sustainability & Environment**
State Government Offices
402-406 Mair St,
Ballarat, 3350

Tel: (03) 5333 6782
Web site: http://www.dse.vic.gov.au/plntanml/native/landfor/index.htm

**Statewide Coordinator**
Box 3100, Bendigo Delivery Centre
Bendigo, 3554

Tel: (03) 5430 4363

**Bird Observers' Club of Australia**
P O Box 185
Nunawading, 3131

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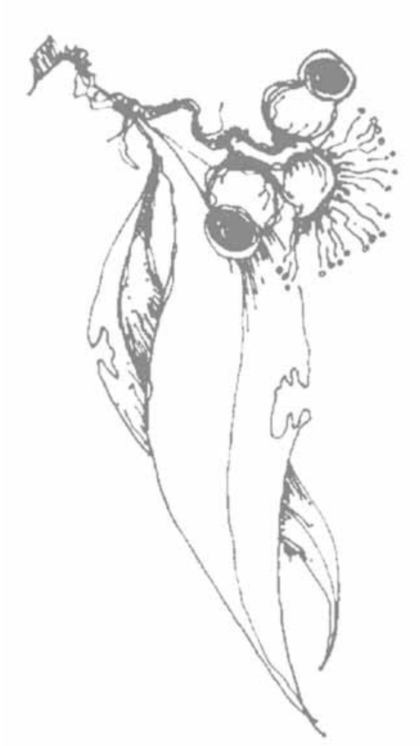
## APPENDIX 7: Spot Assessment Technique



# The *Spot Assessment Technique*: determining the importance of habitat utilisation by Koalas (*Phascolarctos cinereus*).

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Running Title: Spot Assessment Technique

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**Abstract**

In order to more effectively conserve Koalas, the National Koala Conservation Strategy recognises the need for development of reliable approaches to the assessment of Koala habitat. This paper describes a tree-based sampling methodology that utilises binary data derived from the presence/absence of Koala faecal pellets within a prescribed area beneath trees to determine whether the use of a given area of habitat by Koalas is important. Confidence intervals from a data set comprising 14,313 trees from 405 field plots have been utilised to assign threshold values for low, medium (normal) and high Koala activity for three population density/habitat biomes in eastern Australia. The approach is expected to assist field-based assessments by those interested in clarifying aspects of habitat utilisation by free-ranging Koalas, especially where identification of important areas for protection and management is required.

**Introduction**

The primary aim of the National Koala Conservation Strategy (NKCS) is to conserve Koalas by retaining viable populations throughout their natural range (ANZECC 1998). In order to develop a better understanding of the conservation biology of Koalas, Objective 3 of the NKCS further recognises the need for development of a consistent and repeatable approach to assessment of Koala populations, in addition to surveys to establish correlates of habitat quality at both broad geographic scales and the individual-tree scale within preferred habitats (ANZECC 1998).

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

In this paper we present a methodology for evaluation which we believe contributes to the need for a reliable approach to objectively assessing Koalas and their habitat. An unreviewed progenitor to this work (Phillips and Callaghan 1995) was originally circulated to a limited audience following the Australian Koala Foundation's 1995 conference on the status of Koalas. Its purpose at that time was to promulgate an approach that could potentially assist field-based assessments by ecologists, consultants, land managers and others interested in quantifying aspects of habitat utilisation by free-ranging Koalas. The purpose of this paper is to refine the earlier approach in the light of further field studies and in so doing, to formally supersede that work.

**Background to the approach**

Traditionally, knowledge relating to habitat utilisation by free-ranging Koalas has been reliant on opportunistic observations or radio-tracking data (Robbins and Russell 1978; Martin 1985; Hindell *et al*. 1985; Hindell and Lee 1987; 1988; White and Kunst 1990; Reed *et al*. 1990; Hasegawa 1995; Melzer and Lamb 1996; Pieters and Woodhall 1996). In other instances, emphasis has been placed on benign indicators such as accumulated faecal pellet counts (Moon 1990; Munks *et al.* 1996; Pahl 1996). However, each of these approaches are problematic; existing models for determining tree preferences by free-ranging Koalas (Hindell *et al*. 1985) require a number of assumptions to be met which do not appear to hold in heterogeneous forest communities (Phillips 1999). While accumulated faecal pellet counts can provide an indication of tree importance in some instances (Munks *et al.* 1996; Pahl 1996), the information is of limited value in contributing to a broader understanding of habitat use by Koalas. The ability to accurately survey and interpret faecal pellet deposits can also be influenced by other variables including visibility and tree morphometrics (Achurch 1989; Pahl 1996; Ellis *et al*. 1998). Scratch marks on trees are also an unreliable indicator of habitat use – they cannot be detected on some species whereas others retain them for long periods of time, nor is it always possible to confidently distinguish Koala scratches from those of other arboreal animals.

Studies of free-ranging Koalas have established that those in a stable breeding aggregation arrange themselves in a matrix of overlapping home range areas (Lee and

Martin 1988; Faulks 1990; Mitchell 1990). Home range areas vary in size depending upon the quality of the habitat (measurable in terms of the density of preferentially utilised food tree species) and the sex of the animal (males tend to have larger home range areas than females). Long-term (ie several years) fidelity to the home range area is generally maintained by adult Koalas in a stable population (Mitchell 1990; Phillips unpub. data). An additional feature of home range use is the repeated use of certain trees, some of which may also be utilised by other Koalas in the population (Faulks 1990; Mitchell 1990; Phillips 1999). Given these considerations, it follows that areas being utilised by stable Koala populations will be characterised by a higher rate of faecal pellet deposition. For the purposes of this paper, we propose the term "areas of major activity" to describe such localities, regarding them as a fundamental component of “Core Koala Habitat” as defined by the NSW Government’s *State Environmental Planning Policy No. 44 (Koala Habitat Protection).*

## The Spot Assessment Technique

The *Spot Assessment Technique* (SAT) is an abbreviated form of the methodology utilised by the Australian Koala Foundation for purposes of the Koala Habitat Atlas project (Sharp and Phillips 1997; Phillips 1999; Phillips *et al*. 2000; Phillips and Callaghan 2000). The Atlas approach is probability-based and utilises a binary variable (presence/absence of faecal pellets within a prescribed search area around the base of trees) to determine tree species preferences, along with a commensurate measure of Koala activity for each plot. The SAT approach arose from consideration of variations within larger (40m x 40m) Atlas field plots and is consequently the smallest tree-based unit of assessment that we consider will provide a reliable means of determining the importance of a given area of habitat from a Koala's perspective.

Table 1 details results from Atlas plots that have been undertaken across a variety of habitat types and landscapes utilised by Koalas in eastern Australia. In this context, while significant differences between mean activity levels from low and medium - high density Koala populations of the eastern seaboard are believed to reflect real differences in habitat quality (Table 1 - Southeast Forests/Campbelltown *vs* Port Stephens/Noosa: Levene’s test: $F = 0.086$, $P > 0.05$; $t = -7.877$, $P < 0.001$), we speculate that similar differences between medium - high density populations of the eastern seaboard and those from more western[#] areas (Port Stephens/Noosa *vs* Pilliga/Walgett – Levene's test: $F = 0.925$, $P > 0.05$; $t = -4.743$, $P < 0.001$), more likely reflect differences in faecal pellet longevity as a consequence of aridity than they do habitat quality *per se*.

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

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

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

## Applying the SAT

**1**. Locate and mark with flagging tape a tree that meets one or more of the criteria specified above;

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

**3**. undertake a systematic search for Koala faecal pellets beneath each of the marked trees based on a cursory inspection of the undisturbed ground surface within 100 centimetres from the base of each tree, followed (if no faecal pellets are initially

[#] areas generally receiving less than 600mm of rainfall annually.

detected) by a more thorough inspection involving disturbance of the leaf litter and ground cover within the prescribed search area.

A maximum of two person minutes/tree should be dedicated to the faecal pellet search. For assessment purposes, the search should be concluded once a single Koala faecal pellet has been detected or when the maximum search time has expired, whichever happens first. This process should be repeated until each tree in the site has been assessed. Where the location of faecal pellets falls within overlapping search areas brought about by two or more trees growing in close proximity to each other, both should be positively scored for the pellet(s). For more detailed reporting purposes, information relating to the site's location (UTM co-ordinates or Lat/Long), selection criteria and the tree species assessed should also be recorded. Faecal pellets should not be removed from the site unless some verification (*ie* that they are in fact Koala faecal pellets) is necessary.

**Calculation and interpretation of Koala activity levels**

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

From the pooled data sets of Table 1, we have adopted mean activity levels plus or minus 99 per cent confidence intervals as defining the limits of "normal" Koala activity. Based on these threshold values we propose three categories of Koala activity as detailed in Table 2. Thus, subject to qualifications regarding the need for a precautionary approach to low activity levels in some instances (see below), where the results of a SAT site returns an activity level within the range prescribed for low use, the current level of use by Koalas is likely to be transitory. Conversely, where a SAT site returns an activity level within the prescribed range for medium (normal) to high use - the current level of use by Koalas is indicative of more sedentary ranging patterns and thus within an area of major Koala activity.

Further assessments within areas of major Koala activity should be dependant upon the nature and extent of any proposed activity which has the potential to adversely affect Koalas or their habitat. Advice on the types of assessment required and various ameliorative measures that might be suitable should be sought from qualified and/or accredited Koala specialists.

**A precautionary approach to activity levels in low use areas.**

Ideally, activity levels derived from SAT sites should only be interpreted in the context of location-specific habitat utilisation data (Lunney *et al*. 1998; Phillips *et al*. 2000; Phillips and Callaghan 2000). Low activity levels recorded in what might otherwise be considered important Koala habitat may be a result of historical disturbances including logging, mining, fire frequency, agricultural activities and/or urban development. Such considerations should not necessarily detract from the potential importance of such habitat for longer-term Koala conservation, particularly if Koala food trees are present and Koalas are known to occur in the general area.

Low activity levels can also be associated with low-density Koala populations. Stable, low-density Koala populations are a natural phenomena in some areas (Melzer and Lamb 1994; Jurskis and Potter 1997; Phillips and Callaghan 2000). Koala density in such areas generally reflects the absence of “primary” food tree species and reliance by the population on “secondary” food tree species only (Phillips and Callaghan 2000). While secondary food tree species will return significantly higher levels of utilisation when compared to other *Eucalyptus* spp. in the area, their level of use (as determined by field survey) will tend to be both size-class and/or density dependent when compared to a primary food tree species (size-class and/or density independent) (Phillips *et al* 2000; Phillips and Callaghan 2000). Application of a "Koala Habitat Atlas" type methodology over the larger area in conjunction with historical research (eg Knott *et al* 1998) would be useful to clarify such issues.

**Recommended Applications**

The SAT is suitable for use in conjunction with land-use planning activities and/or policies that require Koalas and their habitat to be assessed, especially where identification of important areas for protection and management is required. For the purposes of preliminary survey work, SAT sites should be systematically applied throughout the area to be assessed and be representative of major forest types and soil landscapes. However, the design and detail of sampling protocols that could be developed using the SAT approach are essentially beyond the scope of this paper and should be developed in consultation with a biometrician.

Further information and advice regarding application and use of the SAT, interpretation of activity levels, and its application to the task of determining broad-scale tree species preferences, can be supplied if required. The authors would also be thankful for any feedback regarding application of SAT methodology for any of the purposes indicated in this paper.

**Acknowledgments**

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**Table 1.** Mean activity levels and related measures of central tendency (expressed as percentage equivalents) associated with habitat utilisation by Koalas from six areas in eastern Australia. Data has been pooled to reflect three major categories of Koala activity which correspond to low and med-high density Koala populations of the tablelands and areas east of the Great Dividing Range, and those of more western areas respectively. Koala densities for the low density category are arbitrarily defined at ≤ 0.1 Koalas/ha. (Data sources: [1] South-east Forests Conservation Council, unpub. data; [2] Phillips and Callaghan 1997; [3] Phillips and Callaghan 2000; [4] Phillips *et al*. 1996; [5] Phillips *et al*. 2000; [6] AKF, unpub.data; [7] Phillips 1999; [8] AKF unpub. data; [9] AKF unpub. data).

Table 1

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

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

Table 2

| ACTIVITY CATEGORY | LOW USE | MEDIUM (NORMAL) USE | HIGH USE |
|---|---|---|---|
| **Area (density)** | | | |
| East Coast (low) | < 9.47% | ≥ 9.47% but ≤ 12.59% | > 12.59% |
| East Coast (med – high) | < 22.52% | ≥ 22.52% but ≤ 32.84% | > 32.84% |
| Western areas (med – high) | < 35.84% | ≥ 35.84% but ≤ 46.72% | > 46.72% |