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1988

## INTRODUCTION

There has been considerable public opposition to the implementation of Development and Subdivision Consents Nos. S109 and S110 for the development of Lot 505 in DP 775431 and Portion 9, Parish of Wedderburn, Victoria Road, Wedderburn, because of the presence of koalas on and near the development site and concern that the effects of development on them will be detrimental. On 12th July, 1988, the developers, Yap Yap Pin Pty. Limited, entered into a conservation agreement with the Minister for Environment in N.S.W., which contained conditions limiting land clearing and vehicular access to the developed site and requiring control of domestic dogs. As adverse public opinion continued, CSIRO was engaged on 18th August 1988 to provide an expert and impartial assessment of the situation. Our brief was:

- a. to establish the extent of koala habitat on the land covered by Development and Subdivision Consents S109 and S110;
- b. to prepare a Management Plan to protect the koala habitat on this land;
- c. to make expert comment on the potential effects, on koala populations or habitat, of the proposed development if carried out in accordance with -
  - i. the conditions of Development and Subdivision Consents S109 and S110;
  - ii. the conservation agreement between the Minister for Environment in N.S.W. and Yap Yap Pin Pty Limited; and
  - iii. the engineering plans 67426/3 and 67426/6 for the construction of subdivisional roads, and Campbelltown Local Environmental Plan No. 32, Development Control Plan No. 6.

To fulfil this brief in the limited time allowed, we surveyed the trees on the site, using an environmentally stratified sampling strategy, and analysed our data using pattern analysis to identify the tree communities present and their distributions. During this survey we recorded all sightings or signs of koalas to establish the relationship between these animals and the trees, but for longer term observations we have relied on data passed on to us from other sources. Justification for this approach follows.

Previous research has shown that koalas are highly selective in their choice of food, and that stable populations only persist when one or more of a small number of species of eucalypt suitable as a staple diet are present as a major component of the habitat (Bergin 1978; Eberhard 1978). At least two of these staple species, the grey gum, *Eucalyptus punctata*, and the forest red gum, *E. tereticornis*, occur in the vicinity of Campbelltown, and koalas appear to be associated with the former at Wedderburn.

Digestive utilisation of the foliage of *E. punctata* by koalas has been studied in detail (Cork and Hume 1983; Cork, Hume, and Dawson 1983; Cork and Warner 1983; Cork 1984, 1986). Less detailed data are available on the utilisation of a mixture of 3 other species of eucalypt (*E. melliodora*, *E. robusta*, and *E. sideroxylon*) by koalas in San Diego zoo (Ullrey, Robinson, and Whetter 1981). These studies have provided information on the nutritional requirements of koalas and suggest that koalas have a precarious energy balance which can only be maintained if acceptable food is abundant and accessible daily. However, studies on captive koalas, or other leaf-eating marsupials (e.g., Cork and Pahl 1984), have so far failed

to identify the components of eucalypt foliage responsible for diet selectivity by koalas and possums (Cork 1984; Cork and Sanson in press). Therefore, there is at present no definitive chemical analysis which can be performed on eucalypt foliage to assess its nutritional quality for koalas.

In the eucalypt forests of south-eastern New South Wales, leaf-eating marsupials like the greater glider are in high abundance in less than 10% of the present forest, and koalas appear to be restricted to an even smaller proportion (Braithwaite, Dudzinski, and Turner 1983; Braithwaite, Turner, and Kelly 1984; Braithwaite 1986). These high quality areas of forest occur mainly on soils containing high levels of nutrients, such as potassium (K) and nitrogen (N) (Braithwaite, Turner, and Kelly 1984; Braithwaite 1986), which are necessary to support high rates of growth and leaf production in trees and which might influence the production of other leaf components of nutritional importance to mammals.

Because of the influence of soil fertility (and probably other environmental factors) on the quality of food for leaf-eating marsupials, it is unlikely that a description of prime koala habitat in terms of the presence of individual preferred species alone, as has been the practice in the past, is adequate. Individual tree species can grow over a wide range of nutritional and climatic conditions but their physiology and abundance relative to other species can differ greatly between sites depending on how much present or past conditions differ from the optimum for the species (Austin, Cunningham, and Fleming 1984). Also, although it is important for koalas to have access to a staple food species, they often feed and rest in other eucalypt species and may even move seasonally into adjacent habitat containing a relatively low frequency of trees of the staple species (Eberhard 1978; Hindell 1984; Hindell, Handasyde, and Lee 1985).

For these reasons we consider that the most reliable way to assess the extent and distribution of habitat for koalas at Wedderburn (or any other place) is by relating direct observations of koala locations to tree communities and mapping the distribution of preferred tree communities.

Our brief also included liaison with the NSW National Parks and Wildlife Service, the National Parks Association of NSW (Macarthur branch), and representatives of the developers, Yap Yap Pin Pty. Limited. We informed all parties of our brief and progress in conducting the study and solicited from them whatever input they wished to have to the preparation of our report. The brief was extended during the course of the study to include liaison with Ms Sue Dobson, the chairperson of the Campbelltown Committee to Save the Wedderburn Koala Colony. We have included in this report our brief summary of concerns and opinions relating to koalas and their habitat expressed by these parties but we have restricted our comments only to those concerns which fall within our areas of expertise and which the data we have collected allow us to comment on objectively. We reiterate that our brief was to assess the extent of koala habitat and the possible effects of one proposed development at one site; we were not commissioned to assess the range of alternative options for use of this land nor the significance of the land on a regional or broader scale, and our conclusions should be taken only in this context.

## METHODS

### Study area

The study area was Lot 505 in DP 775431 and Portion 9, Parish of Wedderburn, Victoria Road, Wedderburn, and some crown land to the north which was expected to be an important refuge for koalas (Fig. 1). Much of the flat country at the centre of Lot 505 was cleared in the past for cattle grazing and is now covered by thick heath. Extensive forest is restricted to slopes leading to creeks and streams surrounding the central plateau.

### Tree survey

In this region *Eucalyptus punctata*, grey gum, appears to be the food species favoured by koalas. It would be impossible to locate all individual trees of *E. punctata* without a complete inventory of the study area, which was not feasible given the time and financial constraints on this study. In any case, the distribution of koalas is related to the distribution of tree communities as koalas do utilise eucalypts other than their staple species for occasional change of diet and resting. We would expect that favourable koala habitat on the study site is represented by communities with a high proportion of *E. punctata* and that poor habitat consists of communities with no *E. punctata*. Therefore, a survey was conducted to determine patterns in the distribution of tree communities.

The survey used a stratified sampling design. The stratification was based on environmental variables identified in a reconnaissance survey as those most likely to affect the distribution of tree species on the study site, i.e., aspect and topographic position. Eleven transects were placed on a contour map in such a way that all aspects and topographic positions were covered more than once and there was an even geographic distribution across the study area (Fig. 2). Within each transect, the topographic positions ridge, top slope, mid slope, bottom slope, and creek flat were sampled (Fig. 3).

In the field, 0.1 ha quadrats (50 x 20 m) were placed at each of these topographic positions. The tree species present, their basal area, the aspect of the site, the angle to the nearest facing ridge, and the angle of slope were recorded from each quadrat. Altogether, 58 quadrats were sampled.

### Data analysis

A numerical hierarchical agglomerative clustering algorithm was used to derive five groups, referred to hereafter as tree communities. The algorithm used the Bray-Curtis measure of association (Bray and Curtis, 1957) and a pair-group arithmetic averaging sorting strategy with Beta = -0.1 (Sneath and Sokal 1973). It was run on the PATN software package (Belbin, 1987) at CSIRO Division of Wildlife and Ecology.

This clustering method uses a measure of association between quadrats which is determined by the species they have in common. The two quadrats most closely associated according to shared species are fused, and associations between this new group (two most similar quadrats) and all other quadrats are re-calculated and the next two most similar ones fused, and so on until only one large group is left. The analysis results in a clustering tree, or dendrogram (Fig. 4).

### Koala sightings

The designated period of the study precluded an exhaustive census of koalas. At each sample quadrat on the tree transects and during movement between sites we looked for koalas in all visible canopy and for scratches on trees and fresh faeces which would indicate the presence of koalas in the vicinity. The tree in which a koala was sited or under which droppings were found or on which scratches were observed was recorded. All such observations were made in daylight. In this way we looked for the presence of koalas in all major tree communities. In addition, we had the services of Mr D. Homer for one day, who showed us most sites at which he has observed koalas over several years of observation. We found him to be an extremely reliable source of information and in all cases we were able to verify his observations by observing presence or signs of koalas. Finally, we were given access to data on koala sightings obtained by members of the National Parks Association of NSW (Macarthur branch) over the period June 1986 - October 1988; details of the methods used to make these sightings are included in the Appendix.

## RESULTS

### Tree communities and their distributions

Figure 4 shows the dendrogram resulting from the pattern analysis of tree survey data. A line has been drawn through at the six-group level, where there is a large change in the coefficient of association. One of these six groups (i.e., no. 6) consists of a single quadrat which was not similar enough to any of the other five groups to be fused with them until higher up in the dendrogram. It does not contain *E. punctata* but does have an unusual combination of trees, with *E. pilularis* (blackbutt) and *E. sclerophylla* (scribbly gum) occurring together. Although it might be of academic interest, for the purposes of this study that singleton can be ignored.

The species compositions of the five tree communities are summarised in Table 1. Community 2, *E. punctata* - *Angophora costata*, contains *E. punctata* as a constant species (i.e., in all 13 quadrats), so this community represents the most favourable koala habitat. In this study area, community 2 occurs on slopes with aspects between 25° and 80° (Table 2) or, if on other aspects, close to drainage lines adjacent to slopes with those aspects. It occurs predominantly on mid or bottom slopes, with only one record coming from a top slope. Figure 5 maps top, mid, and lower slopes between 25 and 80° and the lower slopes of adjacent drainage lines. These represent the limits to the distribution of community 2 on the study site. The map units in Figure 5 are not composed exclusively of community 2 (communities 1, 3, and 4 occur as minor components also) but their boundaries represent the limits outside which community 2 is not found.

*Eucalyptus punctata* was a minor component of communities 3 and 4, being found on only 4 of the 20 quadrats comprising these communities, which probably represent marginal habitat for koalas. Figure 6 maps the limits of the distribution of *E. punctata* (which includes the distribution of communities 2, 3, and 4) in the study area. No sightings of *E. punctata* were made outside these limits, and our analysis predicts that if it occurs there at all it is at a very low frequency.

### Koala distribution

Figure 7 shows the distribution of sightings made by the National Parks Association of NSW (Macarthur branch) in the Wedderburn area over the period June 1986 - October 1988. Sightings of koalas have been made also by Mr D. Homer at each of the general localities recorded in Figure 7 (personal communication). Our own observations at or near each of these general locations confirmed that koalas were present or had been present recently. We saw no signs of koalas at other locations on the study site. The records supplied by the National Parks Association indicate numerous sightings of koalas in the crown land to the north of the study site, along the O'Hare's Creek gorge leading into the George's River. No sightings have been made immediately to the south of the study site, but little effort has been made to search this area (Julie Sheppard, National Parks Association of NSW, personal communication).

Our observations of which tree species koalas or their signs were associated with are summarised in Figure 8. Most records were in *E. punctata*, and all records were close to one or more *E. punctata* trees bearing signs of koalas. These observations strongly support all other evidence that koalas have a high preference for *E. punctata* and that it forms the basis for high quality koala habitat in the Sydney region.

## CONCLUSIONS AND RECOMMENDATIONS

### Extent of koala habitat

**1. Koalas at the Wedderburn site are associated strongly with *Eucalyptus punctata*.**

This conclusion is consistent with other studies of diet preferences of koalas which have shown *E. punctata* to be a staple diet. *Eucalyptus punctata* appears to be one of the few eucalypts which will support koalas nutritionally even if other species are unavailable (Cork et al. 1983).

**2. *Eucalyptus punctata* was found primarily in one tree community (*E. punctata* - *A. costata*) on the study site, and this we consider to be prime habitat for koalas.**

Community 2 (*E. punctata* - *A. costata*) is the only tree community on the study site which is likely to support long-term populations of koalas, because of the high frequency of *E. punctata* in this community and its very low frequency in other communities. Reports of mother koalas with young in or near the *E. punctata* - *A. costata* community (National Parks Association of NSW, Macarthur branch, and Mr D. Homer, personal communications) suggest that koala populations therein are relatively stable, but further study is needed to confirm this.

**3. Prime koala habitat is confined to the slopes of the O'Hare's Creek gorge and some of the tributaries of O'Hare's Creek.**

The *E. punctata* - *A. costata* community occurs on north-easterly slopes with aspects between 25 and 80° or, if on other aspects, close to drainage lines adjacent to north-easterly slopes, in the north and north-east of the study site and in the adjacent crown land to the north (Fig. 5). All previous sightings of koalas have been in or near community 2 (Fig. 7).

**4. *Eucalyptus punctata* occurs as a minor component of 2 other tree communities on the study site, and we consider that these communities represent marginal habitat for koalas.**

Koalas have been sighted only rarely in communities 3 and 4, and these were probably transient animals. These communities were found mostly on south-west to north-west slopes with aspects between 160 and 325° in the north and north-east of the study site. Therefore, they are intermingled with community 2, and we suggest that these communities are important routes and sources of temporary food for koalas moving from one area of prime habitat to another. These communities might be important seasonally if koalas in this area change their diet away from the staple for brief periods as has been reported in some other habitats (Eberhard 1978; Hindell 1984).

**5. We consider that tree communities which do not include *Eucalyptus punctata* are poor quality habitat for koalas.**

There have been few sightings of koalas in tree communities on the study site which do not include *E. punctata* (i.e., communities 1 and 5), and these were never far from a community containing *E. punctata*, nor did we find any signs of recent or past koala activity therein. None of the tree species occurring in communities 1 and 5 have been reported previously to be staple food species for koalas.

Communities not containing *E. punctata* were found intermingled with other communities at a wide range of aspects throughout the study site, but they appeared to be the only communities on the steep slopes leading to O'Hare's Creek in the south-east of the study site, in the gullies in the west of the site, and the flat country at the centre of the proposed development site.

**6. We suggest that the koalas on the study site represent a remnant of a larger population which once ranged over a wider area, now cleared, which had high nutrient soils in the Wedderburn district, and form part of a present population stretching along the O'Hare's Creek gorge to the north of the study site in remaining prime habitat.**

We have not been able to survey the country surrounding the study site, but casual observations suggest that much of the country now cleared for housing and agriculture was once covered by forest containing *E. punctata* and *E. tereticornis*, which would have provided prime food for koalas. The military reserve to the east of the study site also may contain areas of prime koala habitat. The observations of the National Parks Association of NSW indicate that koalas and their habitat occur along the O'Hare's Creek gorge to the north of the study site. The extent of koala habitat and numbers of koalas to the south of the study area remain to be investigated.

We point out that currently the numbers of koalas present in and around the study site are not known nor are their movements and home ranges recorded. Therefore there are no base-line data with which to assess the on-going stability of the koala populations in the area.

#### **Recommendations for management**

Given the short term of our study and the fact that detailed information is not available on feeding behaviour, feeding preferences, and annual and daily movements of koalas in the area, our recommendations for management can be general only. Nevertheless, there are some clear and definite steps which must be taken to conserve koalas in the immediate area of the study site.

**7. Persistence of koalas on the study site will, in our opinion, depend on;**

- i. the koalas being protected from undue disturbance;**
- ii. the koalas being assured of continuous access to the areas of prime habitat in the reserve to the north of the site;**
- iii. the areas of prime koala habitat on the site being protected from undue disturbance or influences which would affect the ecology and physiology of the trees.**

Undue disturbance to the koalas could result from harassment by feral or domestic animals, especially dogs, or excessive or insensitive use of the areas by humans. Bushfires, the incidence of which could be influenced by human activity (see discussion below), are an extreme form of potential disturbance and threat. Steps should be taken to minimise all of these effects.

We recommend no active management of the areas of prime koala habitat at present, although future research might indicate the need for some form of manipulative management for the benefit of koalas and other wildlife. Judging from the extent of undergrowth, the main areas of prime koala habitat on the slopes of the O'Hare's Creek gorge have not been burnt for some time and, therefore, the threat of bushfire in the gorge might be high. We would expect bushfires in the



gorge to be hot and to move quickly, and, therefore, to have severe effects on the local koala population. We recommend that experts on fire behaviour and management be asked to recommend ways of minimising the risk of fire without destroying prime koala habitat. As a minimum we recommend restriction of access to the gorge by people who are unfamiliar with the fire risk or are unlikely to observe due care in preventing fires.

To provide access for koalas between patches of prime habitat, intermediate areas of marginal habitat should be maintained also undisturbed. Provision of these access routes, especially to the crown land to the north, is important because koala populations have been observed to overutilise their food supplies when confined to an island of good habitat and to crash as a result (Lee and Martin 1988).

The ecology and physiology of the trees in the prime habitat could be affected by human activity that greatly alters the flow of water and nutrients down the slopes on which *E. punctata* is found. Excessive clearing of land, or application of fertilizers for intensive agriculture, at sites near the prime habitat (e.g., on the plateau at the centre of the site or near the tops of the gullies) could affect the flow of water and nutrient detrimentally. Therefore we recommend that permission for any activities which could affect water or nutrient flows into the gullies should not be granted unless their potential effects are thoroughly investigated first; in this regard, expert hydrologists and/or geologists should be consulted to assess the likely extent of nutrient and water flows and plant physiologists/ecologists should be asked to assess the likely effects on tree communities.

**8. Effective long-term management of the koala population on the study site would require the setting-up of a monitoring program to assess the continuing size, distribution, and viability of the population.**

For long-term management of wildlife populations to proceed successfully, managers must be aware of the effects of the measures taken. In the case of koalas, data on numbers, age, sex and social structure, movements (including "home ranges" and seasonal changes in habitat use and diet), and fecundity/mortality of the population at the site and in surrounding areas are needed. We believe that the precautions that we recommend in this report would be adequate to ensure the continuance of koala habitation at Wedderburn if development were to proceed, but a monitoring programme would be a good check on the success of management measures and would allow procedures to be modified if necessary in the future.

**Potential effects of the proposed development**

In accordance with our brief, we comment here specifically on the effects of the proposed development by Yap Yap Pin Pty. Limited. We are aware of other proposals for the use of this land but we have received no brief, nor have we had the opportunity, to assess these alternatives thoroughly.

**9. The development as proposed in engineering plans 67426/3 and 67426/6 will result in no direct loss of prime koala food trees or habitat.**

All areas of prime habitat for koalas lie outside the boundaries of proposed residential lots (Fig. 5) and either inside the area designated for public reserve or in the crown land to the north. The residential lots either have few or no eucalypt trees on them, having been cleared in the past for grazing and being covered now by heath, or contain eucalypt communities which we judge to be of poor quality for koalas. A few lots adjoin marginal or prime koala habitat and these are discussed specifically below.

**10. The conditions of consents S109 and S110, the agreement between the Minister for Environment and Yap Yap Pin Pty. Limited, and Campbelltown Local Environmental Plan No. 32, Development Control Plan No. 6, which limit the extent of development, clearing of vegetation, erection of fences, and agricultural use of the land, and require that access roads to the area be private, are necessary to minimise the impact of the proposed development of lots 301-311, 402-404, and 407-409 on koalas on the study site, and are sufficient only if strictly adhered to and enforced.**

Although the tree communities on the proposed residential lots are poor quality habitat for koalas, it is important that they be preserved as far as is possible in their present state to act as a buffer between residential development and koala habitat. Clearing of the understorey should be minimised as the presently dense shrubs in these areas probably minimise the activity of feral and domestic animals and would deter future incursions of such into the koala habitat. Retention of buffer zones between the koala habitat and human habitation will minimise the effects that the clearing necessary for construction of dwellings will have on drainage and nutrient flow patterns from the plateau into the gullies.

The Development and Subdivision Consents prohibit clearing of undergrowth on the lots. The agreement between the Minister for Environment and the developers prohibits clearing except for suppression of bushfires or provision of essential services, restricts agricultural practices on the lots, and limits clearing on each lot to 2 hectares. We are concerned at the generality of the provision relating to clearing for suppression of bushfires. We recommend that expert opinion be sought on the minimum extent of clearing necessary for suppression of bushfires, that it be established that this will not substantially reduce the extent of the presently proposed buffer zones, and that enforceable conditions preventing more extensive clearing than the established minimum be introduced.

Development Control Plan No. 6 defines the areas (called homesite areas; Fig. 1b) which may be cleared for a dwelling. We agree with the positioning of these areas because they provide for a buffer between human habitation and the nearest koala habitat.

We have indicated above the importance of buffer zones and the possible effects on koala habitat of relaxation of restrictions on agricultural use or land clearing. At present there is evidence (in the form of dumped cars) of irresponsible use of the area and access to the site should be strictly limited to prevent this from continuing if the site is settled. Provision of educational material on the site and elsewhere, as indicated in the agreement, should aid koala conservation by raising the ecological consciousness of people using the public reserve. Care should be taken to minimise the number of access tracks into the public reserve, especially where there is prime koala habitat, so that human traffic and movement of dogs is kept to a manageable level. Any precautions which can be taken specifically to limit access by dogs, evidence of which we observed during our survey, would be beneficial. We see the limitation of access to the O'Hare's Creek gorge as being of paramount importance, because of the bushfire risk, which we consider to be one of the greatest threats to the koalas.

**11. Lots 312-314, 401, 405, 406, and 410-412 are in particularly sensitive positions and their development should only proceed if all conditions discussed above can be enforced and if the vegetation buffer zones between the lots and the gorge or adjacent koala habitat can be guaranteed.**

Lots 312-314 and lot 401 have relatively narrow strips of bush separating the areas designated for dwellings from the edge of the gully. There will be a strong temptation for residents to clear at least part of this strip to gain access to the

exceptional views and to the public reserve below. We emphasise that these vegetation buffer zones are barely adequate at present and must be retained undisturbed for the benefit of the koala populations below. Our understanding of the engineering plans is that the proposed fire control easement crossing these lots will follow the existing track. It is important that construction of this easement does not result in loss of any of the present buffer zones and that no further clearing of trees between the existing track and the gorge is required or permitted for fire control or other purposes. Clearing of the buffer zone on lots 312 and 401, at least, would result in loss of some marginal habitat used by koalas (Fig. 7).

As for all other lots, it is important that any use of these lots does not affect water and nutrient flows into the gorge, increase access by feral or domestic animals to the gorge, or encourage the dumping of rubbish into the gorge; however for these lots the likelihood of human habitation leading to these detrimental effects is much greater. Development should not proceed at any point this close to the gorge unless adherence to all of the conditions discussed above can be guaranteed.

The areas designated for dwellings on lots 405 and 406, and 410-412 are not as close to the gorge, but are close to prime koala habitat. In these cases we consider that the proposed buffer zone is sufficient, if and only if retained in its planned form and extent, to minimise the impact of human habitation on the koalas. However, relaxation of any of the conditions discussed above or failure to comply with the conditions could threaten koalas and/or their habitat in the immediate area.

**12. Although most of the lots to the west of the main access road do not impinge on, nor are adjacent to, koala habitat, we recommend that the requirements for preservation of buffer zones applied to other lots be applied also to these, for the benefit of other wildlife living in the gullies.**

**13. It appears that subdivisional roads detailed in engineering plans 67426/3 and 67426/6 will have no direct effect on koala habitat or movements, but it is important that access to these roads should be restricted to minimise indirect effects.**

The position of the roads detailed in plans 67426/3 and 67426/6 does not traverse any prime or marginal koala habitat. We advise that disturbance of vegetation beyond the immediate border of the roads be avoided. In some places roads pass close to prime koala habitat (especially around lots 405-406 and 410-412) and special care should be taken here to avoid removal of *E. punctata* trees or disturbance to the habitat. It is important that access to, and traffic along, the access roads leading to lots 405-406 and 410-412 be strictly limited and controlled. Koalas come to the top of the gorge at times, so the presence of a rough track with limited traffic has not deterred them from using the edge of their habitat in this way, at least until recently when the rate of visitation appears to have increased (opinion from National Parks Association of NSW, Macarthur branch; see Appendix). The koalas have considerable habitat in the gullies and gorge into which they can retreat to avoid contact with people; we expect that if the road is used only by residents the koalas will continue to use the top of the gully, but greater use may cause koalas to retreat further into the gullies and, in the extreme, to leave the area all together.

**14. Failure of owners to comply with, or of authorities to enforce, the conditions of Development and Subdivision Consents S109 and S110, the conservation agreement between the Minister for Environment and Yap Yap Pty. Limited, and Campbelltown Local Environmental Plan No. 32, Development Control Plan No. 6, could result in the short term in koalas retreating deeper into their present habitat on the site (i.e., not using the fringes as they do at present), leaving their present habitat on the site, or having their survival threatened either**

**due to direct injury from dogs or people, or disturbance of feeding habits because of harassment by dogs or people. In the long term these effects could threaten koalas in areas adjacent to the development site.**

We consider that disturbance to natural water, and nutrient flows into areas of prime and marginal habitat for koalas, increased access to these areas by dogs, and increased human activity which is insensitive to the environment could pose a threat to koalas and their habitat in both short and long terms. Disturbance to water and nutrient flows might take years to reduce the extent of koala habitat significantly, depending on the extent of the disturbance, but even moderate access by uncontrolled dogs and insensitive people could result in koalas abandoning the site within one year. These animals would face the risk of being excluded from adjacent areas of prime habitat by koalas already established there and could have difficulty meeting their nutritional requirements in marginal or poor habitat alone. There is also a risk that uncontrolled dogs will kill koalas as wild dogs are known to take koalas as prey. The potential fire risk due to increased access of people to the gorge has been discussed above. We consider that development and subdivision under the conditions laid down in Consents S109 and S110, the agreement between the Minister for Environment and Yap Yap Pin Pty. Limited, and Development Control Plan No. 6, and taking our recommendations above into consideration, will pose no long-term threat to the koalas, so long as these conditions are adhered to and enforced when necessary.

#### **Regional significance of the study site**

We cannot draw firm conclusions about the regional significance of the study site. If the koala population at this site represents the south-western extreme of a much larger population existing in the crown land to the north and military reserve to the east, then loss of koala habitat at the study site would not threaten the viability of koalas in the region. If, on the other hand, the population at the site is a large part of the regional population, or the koala population stretches south along the O'Hare's Creek gorge, then conservation of koala habitat at the study site might be important to prevent fragmentation of existing populations and to ensure the viability of koalas in the region. Further assessment of koala habitat and movements regionally and locally is needed to resolve these questions.

#### **Concerns/ opinions expressed by interested parties**

The National Parks Association of NSW (Macarthur branch) provided us with written comments for consideration in the preparation of our report and a copy of their previous report to Campbelltown City Council. We have appended their comments to our report (see Appendix). We considered these comments only after we had assessed the results of our own study and found close agreement on the areas of greatest sensitivity within the study site. We accept the comment of the National Parks Association that our report should not be seen as a definitive study of the ecology of koalas at Wedderburn or a detailed management plan because of the short time over which it was performed. However, we have endeavoured to take this constraint into account in the formulation of our recommendations, which in some cases have been necessarily general and conservative. We agree that formulation of a more detailed long term management plan would require intensive study of the ecology of the koalas over several seasons. The National Parks Association expressed concern also about whether restrictions on clearing of vegetation and keeping of dogs can or will be enforced. It is beyond our expertise to comment on these possibilities, but our report emphasises at several points the necessity for the conditions and restrictions to be adhered to and enforced if koalas are to survive and prosper on the study site.

The National Parks Association has suggested, as an alternative to the proposed development, the designation of the study site as a nature reserve. Clearly, creation of a nature reserve on the site, with strictly limited access by people and domestic or feral animals, would mean a wider buffer zone between human habitation and koalas. However, the specific advantages and the degree of advantage to koalas would depend on the conditions of management of the reserve. To assess such alternatives thoroughly and objectively would require much more time and resources than were allocated to the present study. Therefore, we have confined our comments necessarily to the questions that we were engaged to address; what is the extent and distribution of koala habitat on the study site and what are the likely effects of the proposed development?

Ms Sue Dobson expressed similar concerns about the enforceability of the restrictions on development and voiced additional concerns about the possible effects of increased access to the O'Hare's Creek gorge on sites of historical and anthropological significance. We record these opinions here but cannot comment objectively because the subject falls outside our professional expertise.

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**TABLE 1**

Species composition of the five tree communities recognized in the study area.

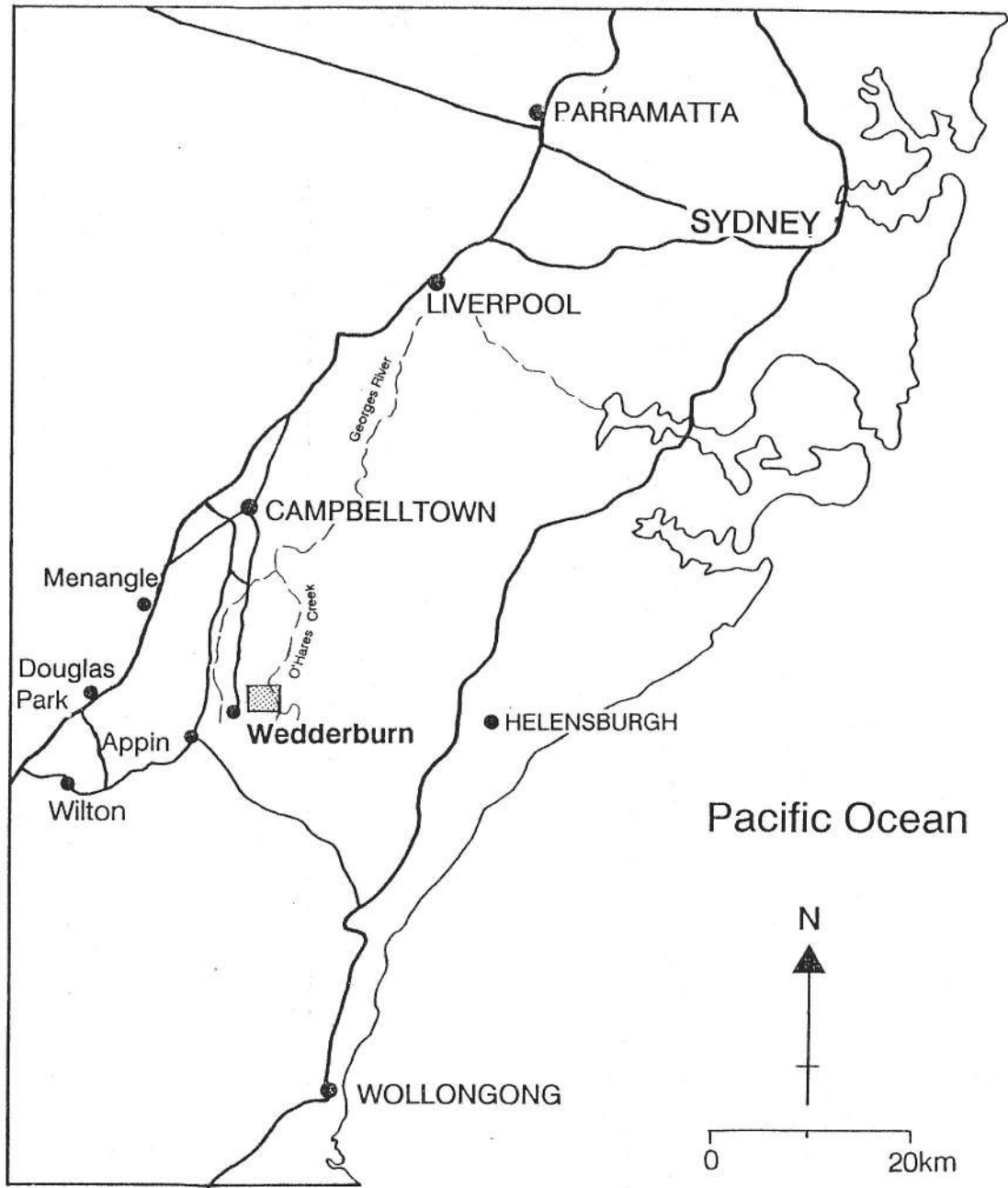
No.	Community Name	No. of quadrats	Species frequency
1	<i>Angophora costata</i> - <i>Eucalyptus agglomerata</i>	14	<i>A. costata</i> 1.0
			<i>E. agglomerata</i> 1.0
			<i>E. gummifera</i> 0.93
			<i>E. piperita</i> 0.93
			<i>Banksia serrata</i> 0.36
			<i>Casuarina littoralis</i> 0.36
			<i>E. pilularis</i> 0.14
			<i>E. consideniana</i> 0.14
<i>E. sieberi</i> 0.07			
2	<i>E. punctata</i> - <i>A. costata</i>	13	<i>E. punctata</i> 1.0
			<i>A. costata</i> 1.0
			<i>E. gummifera</i> 0.85
			<i>E. agglomerata</i> 0.77
			<i>E. piperita</i> 0.62
			<i>C. littoralis</i> 0.23
			<i>B. serrata</i> 0.08
3	<i>E. gummifera</i> - <i>E. piperita</i> - <i>A. costata</i>	10	<i>E. gummifera</i> 1.0
			<i>E. piperita</i> 1.0
			<i>A. costata</i> 1.0
			<i>B. serrata</i> 0.56
			<i>E. oblonga</i> 0.40
			<i>E. sieberi</i> 0.20
			<i>E. pilularis</i> 0.20
			<i>Callitris sp.</i> 0.10
			<i>E. sclerophylla</i> 0.10
			<i>E. punctata</i> 0.10
4	<i>E. consideniana</i> - <i>A. costata</i> - <i>E. gummifera</i>	11	<i>E. consideniana</i> 1.0
			<i>A. costata</i> 1.0
			<i>E. gummifera</i> 1.0
			<i>E. oblonga</i> 0.73
			<i>E. punctata</i> 0.36
			<i>E. sieberi</i> 0.09
			<i>B. serrata</i> 0.09
			<i>E. multicaulis</i> 0.09
5	<i>E. consideniana</i> - <i>E. gummifera</i>	10	<i>E. consideniana</i> 1.0
			<i>E. gummifera</i> 1.0
			<i>E. oblonga</i> 0.9
			<i>B. serrata</i> 0.6
			<i>E. sclerophylla</i> 0.5
			<i>E. sieberi</i> 0.3
			<i>A. hispida</i> 0.3
			<i>E. multicaulis</i> 0.1
			<i>A. costata</i> 0.1



**TABLE 2**

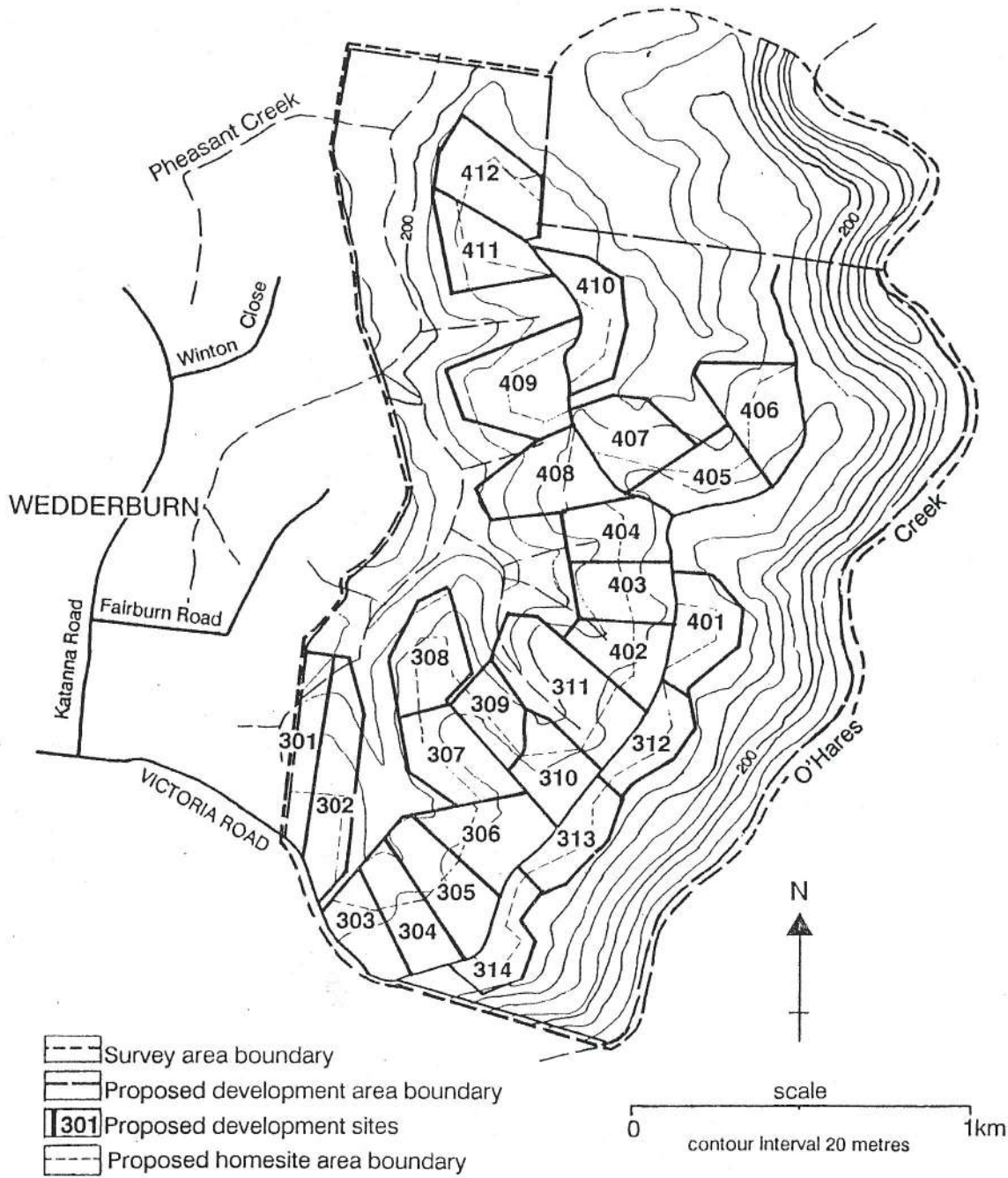
Number of sample sites from each community recorded in each of four aspect classes. The classes are: NE, 0-90°; SE, 91-180°; SW, 181-270°; and NW, 271-360°.

Community	Aspect				Total
	NE	SE	SW	NW	
1	2	1	4	7	14
2	9	-	2	2	13
3	3	1	2	4	10
4	3	-	3	5	11
5	3	-	2	5	10
Total	20	2	13	23	58



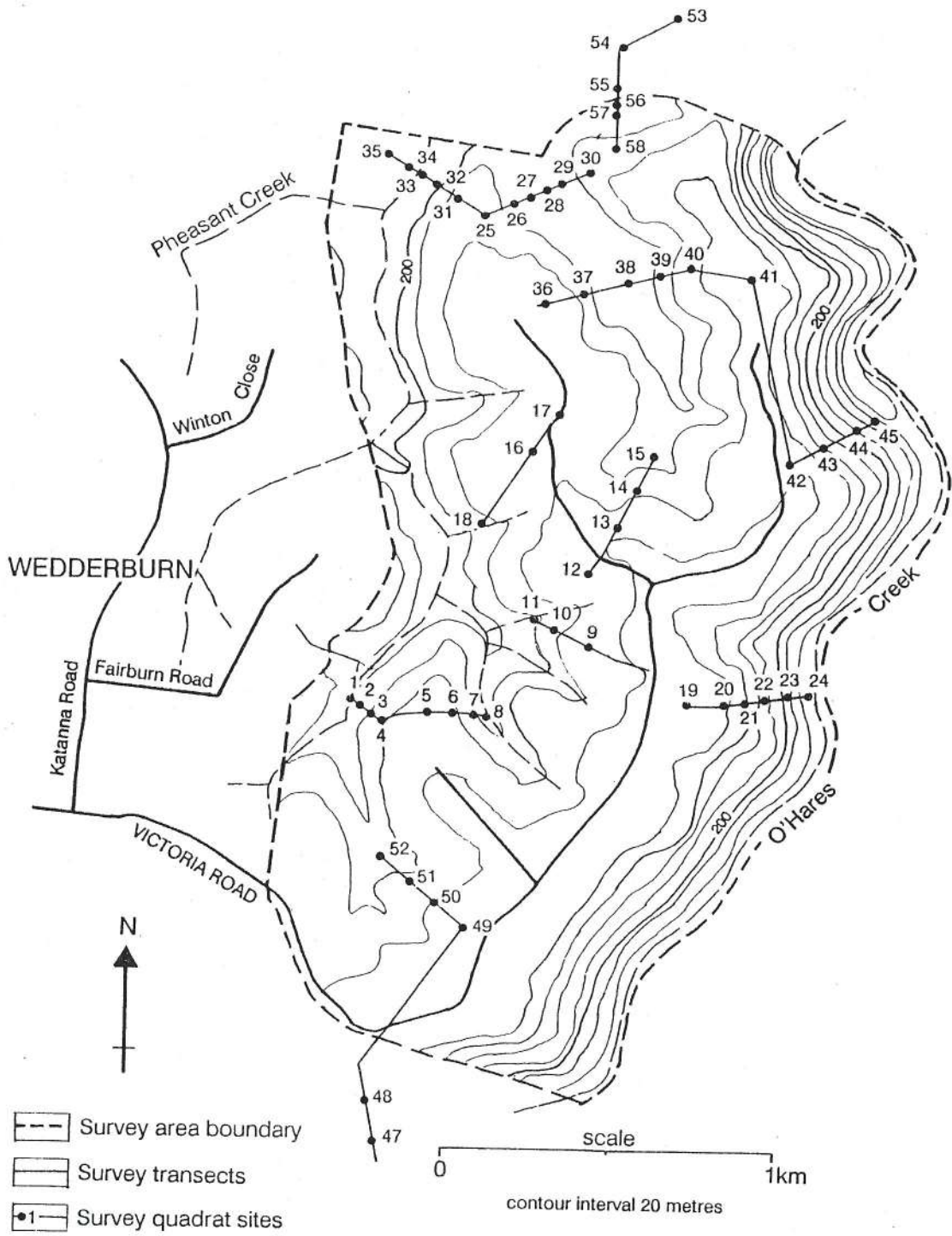
**FIGURE 1A**

The study site shown in relation to Campbelltown and Sydney.



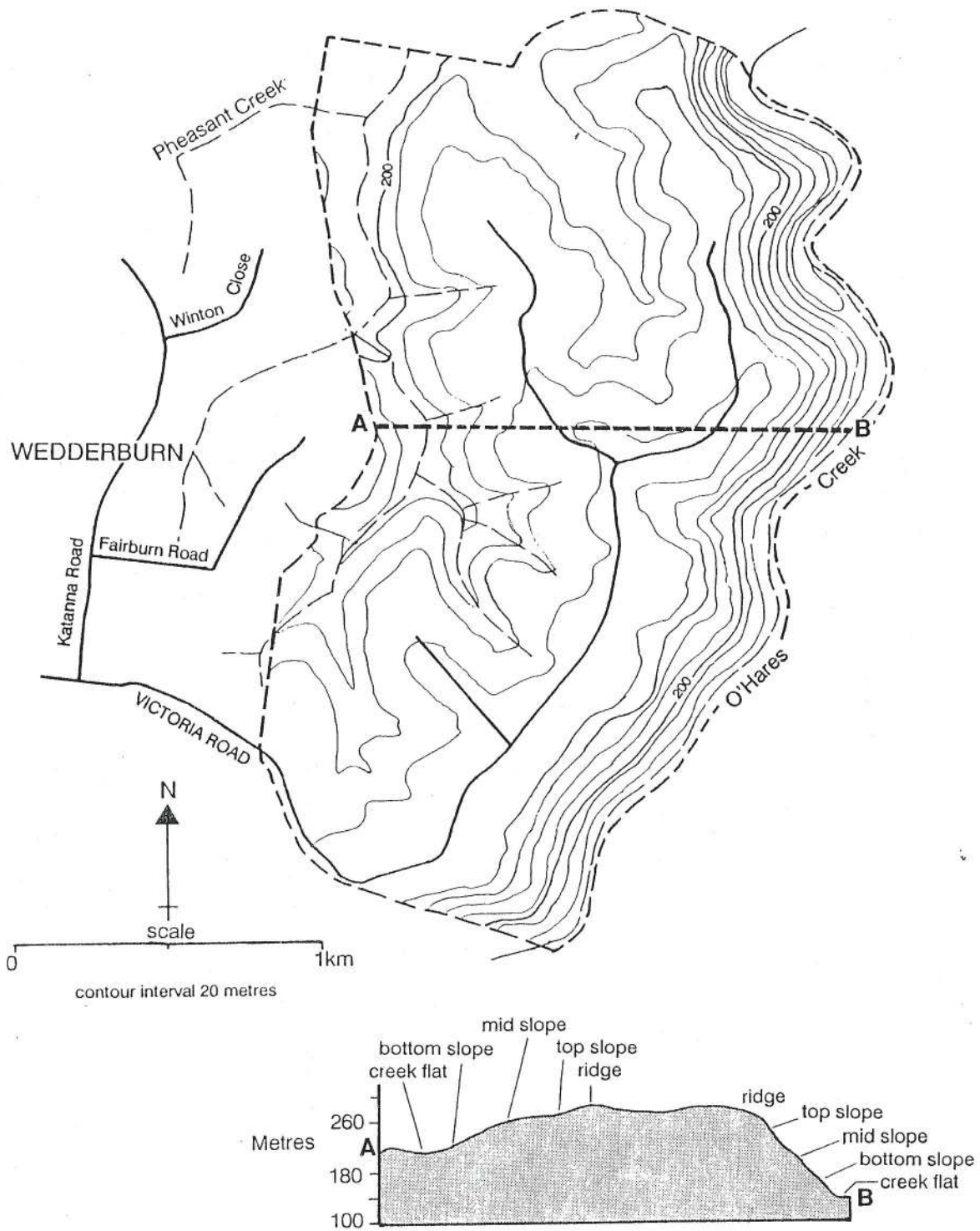
**FIGURE 1B**

The study site in detail with the proposed 4-ha environmental lots indicated and numbered according to engineering plan 67426/6. All areas within the proposed development area boundary other than the numbered lots are designated for public reserve.



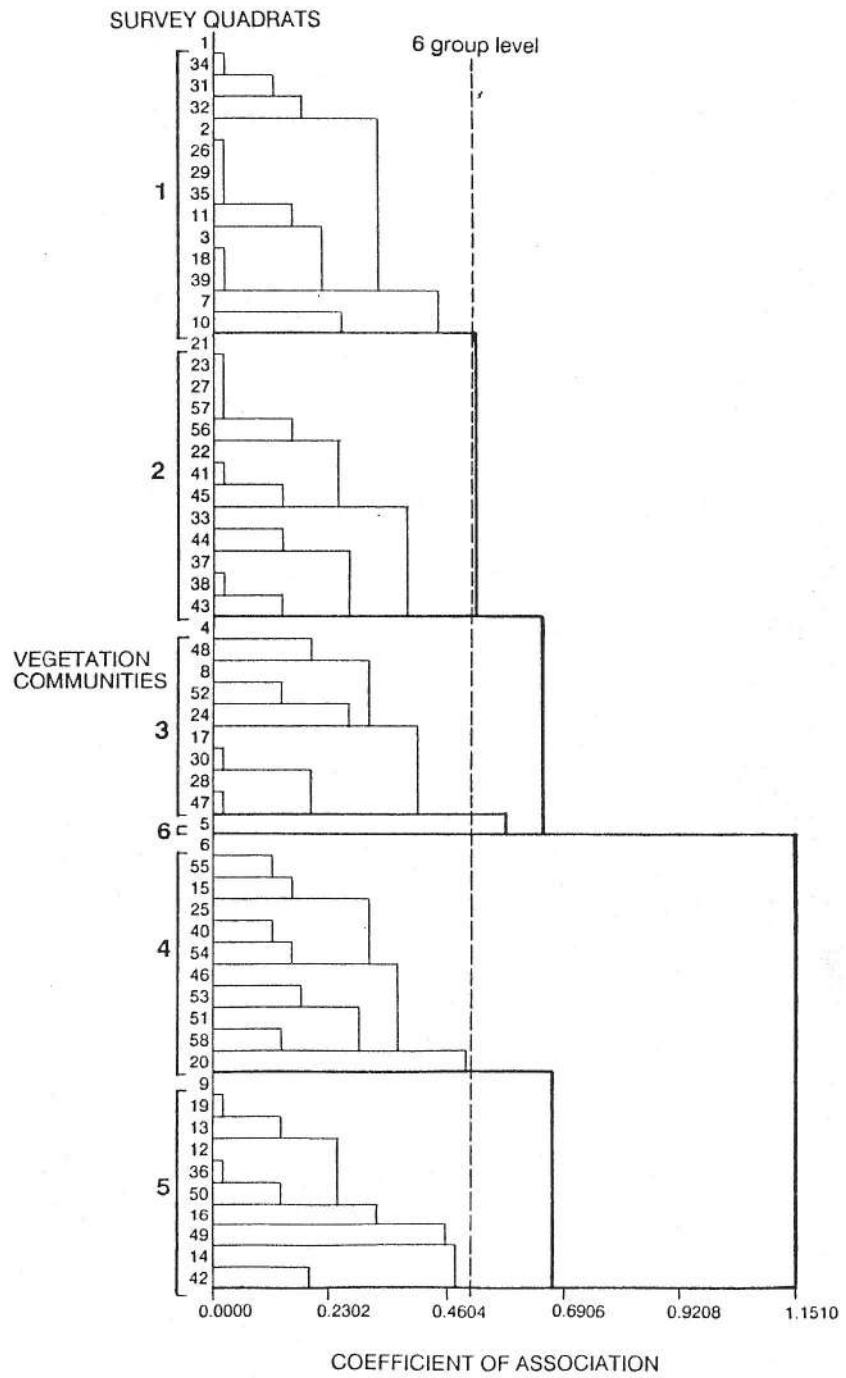
**FIGURE 2**

The location of survey transects showing the sites (numbered) at which 0.1-ha quadrats were placed.



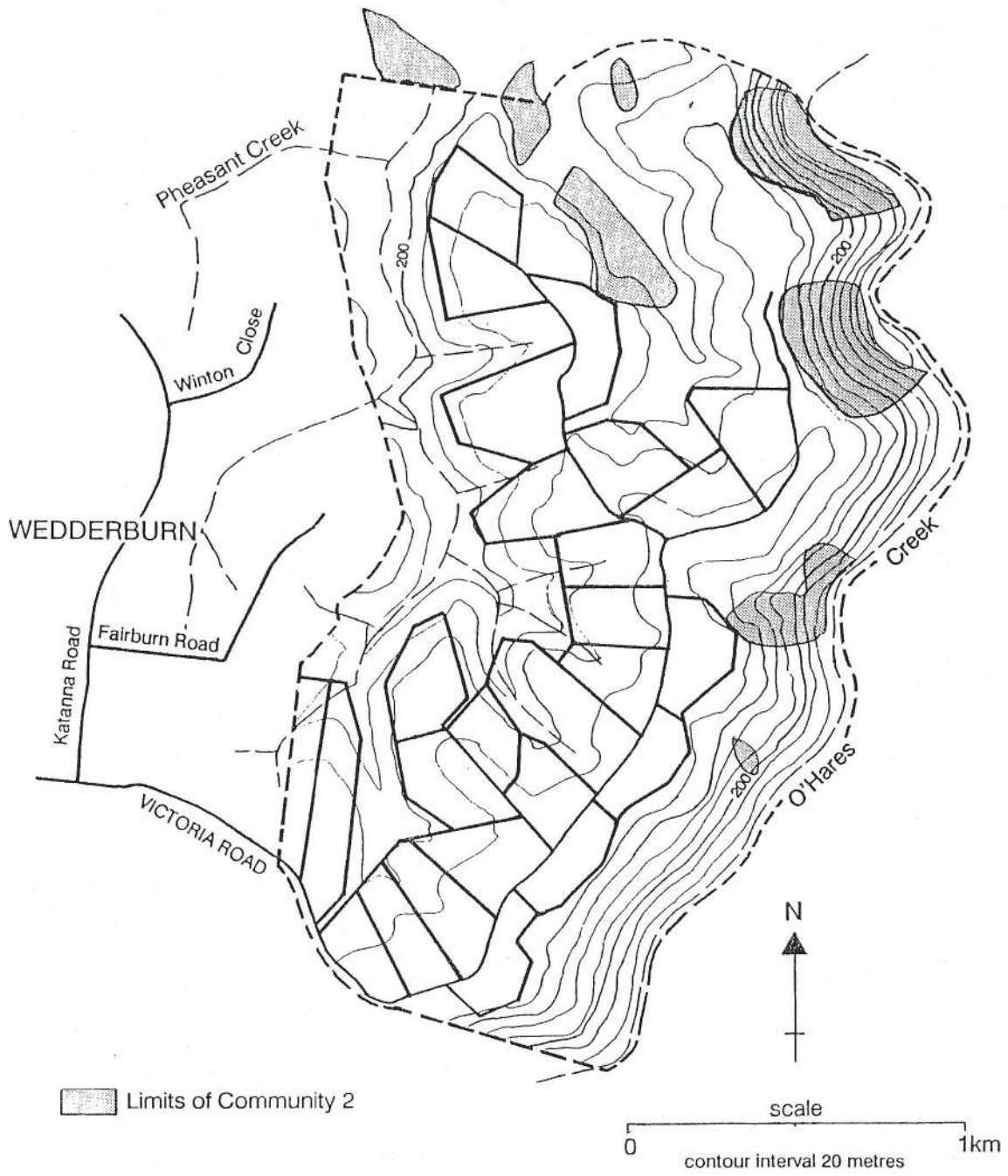
**FIGURE 3**

A cross-section of the study site illustrating the topographic positions sampled for vegetation and koalas.



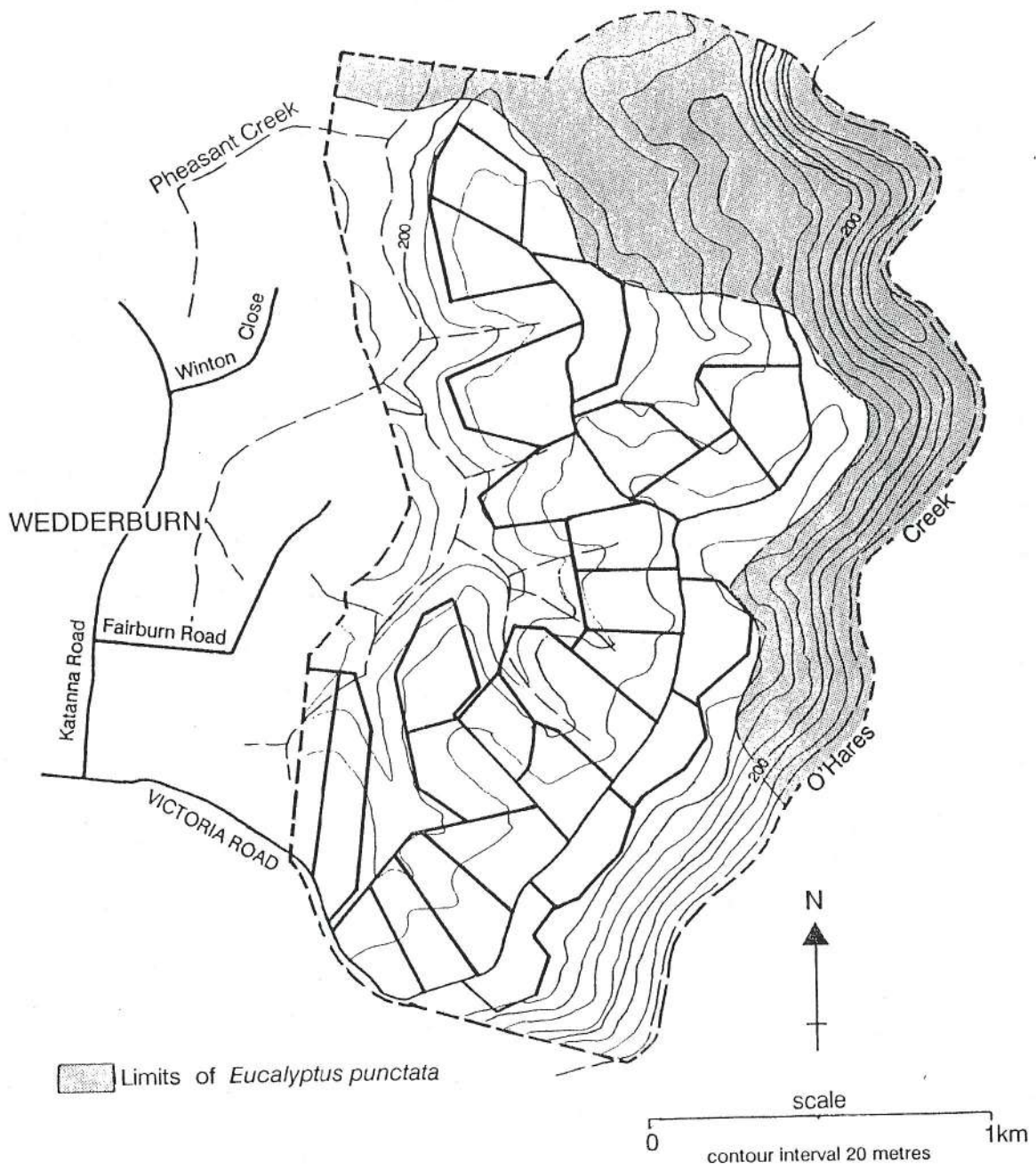
**FIGURE 4**

Clustering tree (dendrogram) showing the degree of association, revealed by pattern analysis, between survey quadrats, and the grouping of quadrats into tree communities. Further details of this process are given in the text. For details of the tree species included in each community see Table 1.



**FIGURE 5**

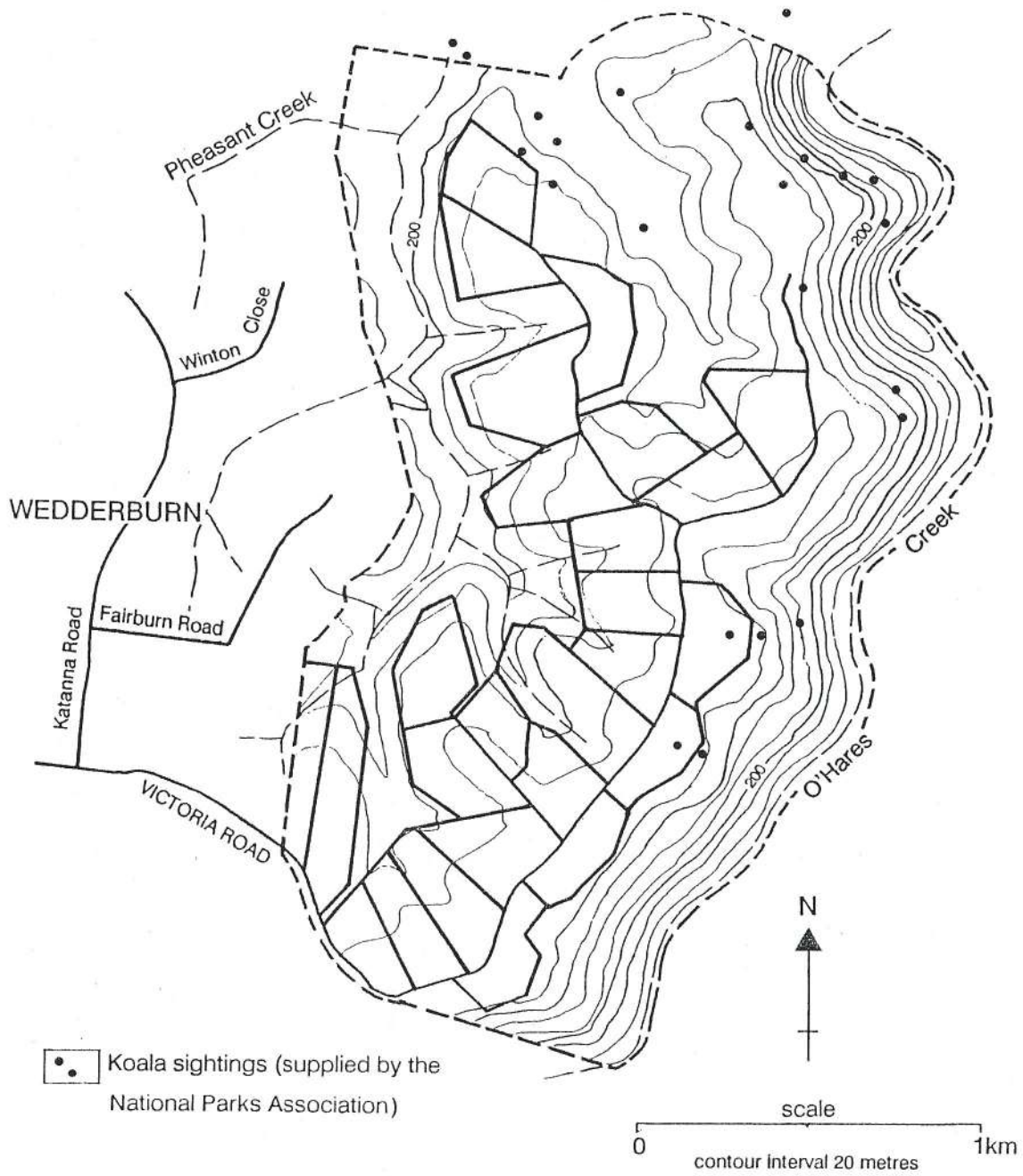
The limits to the distribution of community 2, which we consider to be prime koala habitat.



**FIGURE 6**

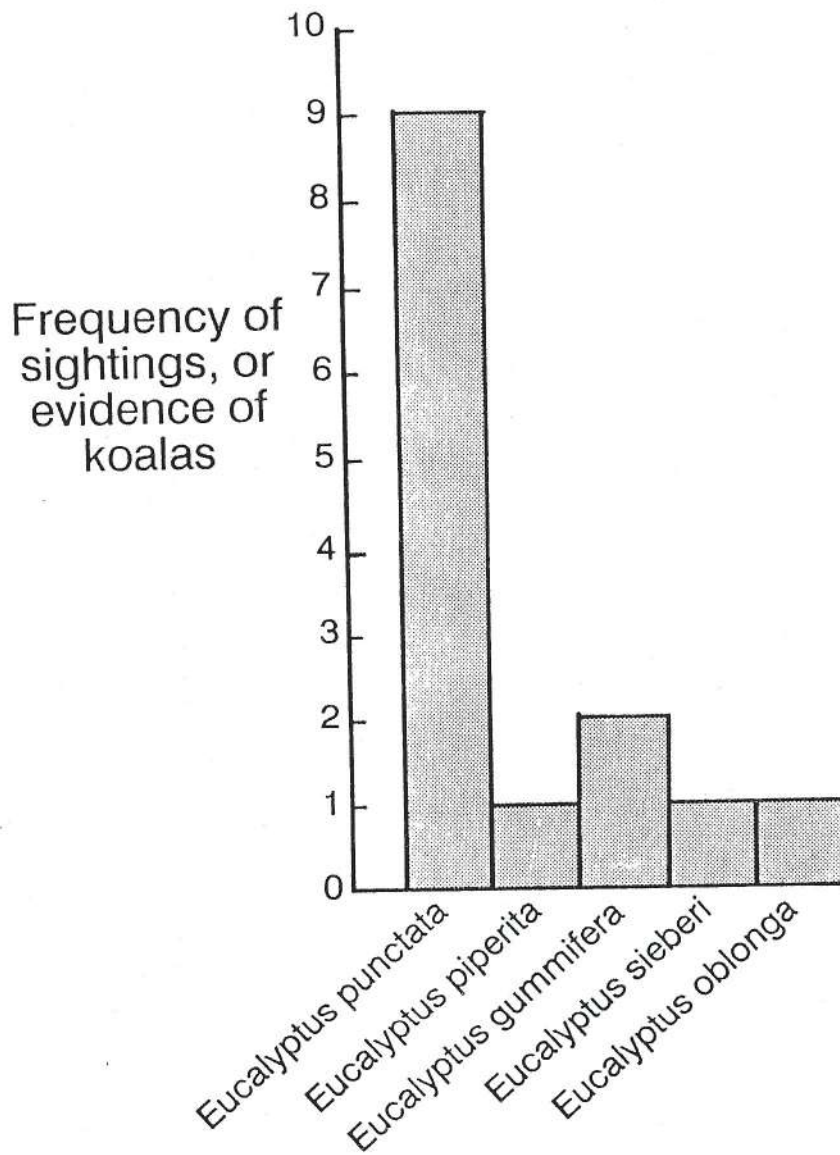
The limits to the distribution of *E. punctata* on the study site.





**FIGURE 7**

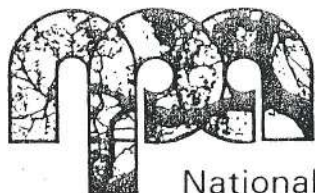
Locations of koala sightings by the National Parks Association of NSW (Macarthur branch) on the study site. Data on the frequency of sightings at each locality are not presented.



**FIGURE 8**

The frequency of sightings of koalas or their signs with respect to tree species on the study site during our tree survey.

**APPENDIX : Report submitted by the National Parks Association of  
NSW, Macarthur branch, for our consideration.**



National Parks Association of NSW

Macarthur  
Campbelltown Sub-Branch  
P.O. Box 792,  
Campbelltown, 2560

REPORT TO CSIRO FOR INCLUSION IN THEIR  
KOALA HABITAT STUDY AND MANAGEMENT PLAN

Julie Sheppard,  
Secretary Macarthur Branch,  
NPA of NSW.

7.10.88

## A. COMMENTS ON CSIRO STUDY

It must be stated that we have serious reservations about the worth of such a study, as it has been taken over a very short time period. There is a danger of this being seen as the definitive study (both by Council and the developer) and we feel it needs to be stressed that there is much more research to be done to have a real understanding of the koalas' needs and to draw up an effective management plan for the future. There is a need to look at the colony over a number of seasons to see the change in their feed tree preferences, for instance.

## B. COMPILATION OF DATA

Our data has been compiled only by volunteers on a random basis, with no specific expertise. Advice was given for setting out the data from the Mammal Dept. of the Australian Museum. There was no assistance, support or encouragement forthcoming from the NPWS.

Sheets were only filled out if an animal was sighted (with 2 exceptions).

Increased visitation since May 1988 due to the publicising of the sub-division has led to a decrease in the number of sightings as the koalas have been driven further away from people.

## C. SIZE AND VIABILITY OF COLONY

In the 28 month period (June '86-Oct '88) that sightings have been made, approx. 85 animals have been sighted. This includes babies and also what is presumed to be a number of sightings of the same animal. What this means in terms of total numbers is beyond our expertise to guess.

Their range, as we have so far determined, is in an area approx. 8kms long by 4kms wide. The sub-division intrudes into the southern end of their habitat.

They appear to be a healthy and obviously breeding colony. Of the 85 sightings, approx. 11 have been juveniles of various ages, from one with an arm protruding from the pouch, to another climbing on the back of its mother, to others in close proximity to the mother (adjacent tree). Dates of these sightings correlate directly to the growth chart in The Koala - A Natural History, p.59 by Lee and Martin.

## D. HISTORY of KOALAS IN THE AREA

Koalas were known to have been found throughout the Campbelltown district at the turn of the century. They were shot for their pelts by early residents Mick and Kerb Rixon in the vicinity of the sub-division. Until the discovery of their presence in June 1986, however, koalas had

not been seen in the area for about 50 years.



#### E. SPECIFIC THREATS FROM SUB-DIVISION

##### 1. FIRE HAZARD

When considering the original application, in 1982, Council acknowledged that "the topography of the subject <sup>land</sup> renders any development in great danger from wildfire". ( P.&B. Committee Minutes 13/7/82). Special provisions were to be made for fire control, including strategically situated water tanks and fire trails down the side of each block. The voluntary covenants placed on the blocks restrict clearing of vegetation, however it is obvious that landowners, perceiving the very real threat of fire, will clear extensively for fire hazard reduction, with or without approval.

##### 2. DOMESTIC ANIMALS

The voluntary covenants require dogs to be restrained on a leash outside the fenced ha.yard of a dwelling. We consider this to be quite unenforceable as neither the Council nor the NPWS have the manpower to police it, and also, many people let their dogs out to roam at night and this is when the damage is done to largely nocturnal animals like the koala.

#### F. ALTERNATIVES TO THE SUB-DIVISION AS PROPOSED

##### 1. ACQUISITION OF THE WHOLE AREA AND ITS INCLUSION WITHIN THE PROPOSED NATURE RESERVE

This is the ideal solution to the protection of the koalas and the other natural features of this area. Instead of the Nature Reserve as proposed being almost bisected by the sub-division, it would add immeasurably to the viability of the Reserve, by providing a sizeable corridor from the northern to the southern management areas. The river gorge and the koala habitat to the north would then have an adequate buffer zone of protection from development to the west.

\* NOTE \_ Although the area affected by the sub-division was originally not included in the Dharawal Nature Reserve proposal, it is now NPA's view that this area should be included.

##### 2. A COMPROMISE PLAN

This would involve acquisition of the most sensitive areas, to the north and east and development of part of the sub-division only. This position is outlined in the attached Report to Campbelltown City Council.

It is our view that alternative #2 will have serious detrimental effects on the whole area, particularly the koalas, in the long-term, as the necessary bufferzone will not exist and they will be at the mercy of domestic animals, inquisitive humans, increased <sup>incidence</sup> of fire, clearing of their habitat etc.