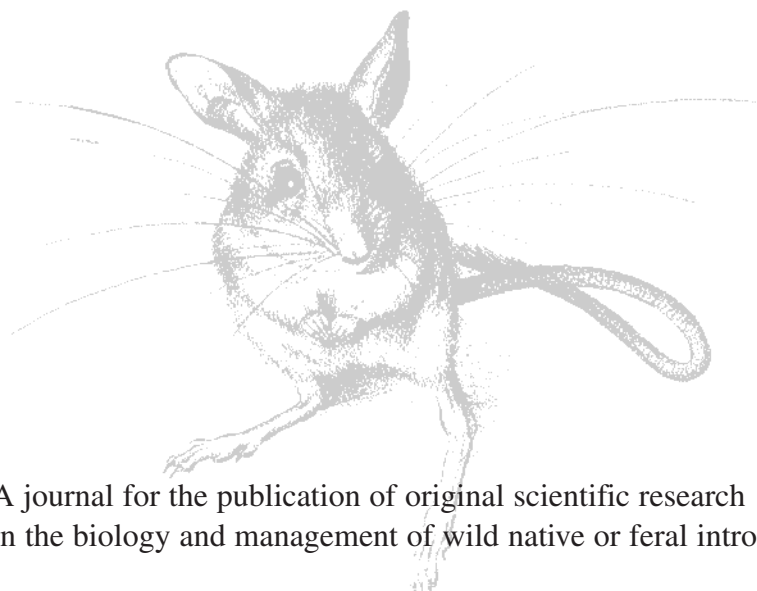

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A Community-based Survey of the Koala, *Phascolarctos cinereus*, in the Eden Region of South-eastern New South Wales

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Abstract

A community-based postal survey (questionnaire and map) was undertaken in the Eden region of south-eastern New South Wales in 1991–92 to help determine the local distribution of koalas and to obtain information on which to base a regional plan of management for koalas. The 1198 replies from the 11 600 households in the region represented all parts of the area surveyed. The survey responses suggest that koalas are rare in the Eden region, and that the number of koalas has been constantly low for the last four decades. The records are scattered both chronologically and geographically. National Parks and Nature Reserves have never been the stronghold of local koala populations, and freehold land, particularly farmland, is not a major reservoir of koalas. Most koalas reported were in, or adjacent to, State Forests, particularly Murrah–Bermagui and Tantawangalo–Glenbog–Yurammie. These areas appear to contain the core of the surviving koala population of the region. An assessment of the vegetation where koalas were sighted indicated that dry forest is the preferred habitat. The once abundant and widespread local koala population of late last century has been reduced by habitat loss and fragmentation to a few small, isolated populations. This regional survey, which was undertaken by use of a carefully constructed questionnaire, revealed an invaluable source of records and contributed 70% of the records in the database used for this study. This study also laid a basis for assessing koala management options in south-eastern New South Wales.

Introduction

Wildlife conservation in forests subject to intensive logging operations has been an enduring issue of the land-use debate that began with the advent of a woodchip industry in the Eden region on the far south coast of New South Wales (NSW) in 1969 (Lunney and Moon 1987). This debate intensified in 1990 and culminated with the confirmation of sightings of koalas in areas designated for logging (e.g. 'Koalas found at Devil's Creek', *Bega District News*, 6 November 1990). In early 1990, the then NSW Minister for the Environment and the NSW Minister for Natural Resources directed the National Parks and Wildlife Service (NPWS) and the Forestry Commission (now State Forests of NSW) to address the problem. The two departments resolved (1) to determine the distribution of koalas in the Eden region by a community-based survey and (2) to prepare a management plan for koalas in the context of current land-use activities. This paper reports on the first of these two activities.

A state-wide survey of koala distribution in NSW, carried out by the NPWS in 1986–87, described their current and former distribution (Reed *et al.* 1990). The survey found that, since European settlement, koala populations have declined in range and size throughout the State. A Koala Summit in 1988 identified koala populations that should be the focus of special study. The Eden population was one of these (Lunney *et al.* 1990; Lunney and Reed 1990). The export of koala skins from the south coast in the late 1800s accelerated the rate of population decline from abundant to near extinction early this century (Lunney and Leary 1988). Historical land-use patterns, particularly clearing for agriculture, virtually eliminated koalas from the fertile river valleys, leaving only remnant populations in the more inaccessible and non-arable forested hills of the region (Lunney and Leary 1988; Lunney and Moon 1988; Reed and Lunney 1990). The region's history of drought and repeated and severe wildfire (Lunney and Leary 1988; State

Forests of NSW 1994) has probably compounded the debilitating impact of hunting and clearing of koala populations (Lunney and Leary 1988). Koalas are still present in the region, although rare (Reed and Lunney 1990) and their future is thought to be precarious, requiring research to derive a conservation strategy for the area (State Forests of NSW 1994).

Koalas in this region have proven difficult to locate by standard field-survey techniques. By the time the study reported in this paper was complete, the Tantawangalo Catchment Protection Association (TCPA) had spent 310 person-days (C. Allen, TCPA unpublished report 1992), and State Forests had spent 160 person-days (D. Ridley, State Forests of NSW, unpublished report 1992) looking for koalas in Tantawangalo State Forest. The TCPA located seven koalas, and State Forests located three. This demonstrates the major search effort required to locate koalas by sight in this region. Cork (1994) also noted that koalas are much harder to locate in these forests than in higher-density populations elsewhere.

To obtain sufficient koala records to present a picture of their occurrence over the entire Eden region, a community-based postal survey (questionnaire and map) was considered a more effective method. This method was trialled at a local scale on the Iluka peninsula in northern NSW and proved successful (Lunney *et al.* 1996b). A further advantage of this method was to increase community awareness of koala conservation in the area. This was particularly important for the preparation of a management plan that would target areas of human activity that have contributed to the decline in the local population, including agriculture, grazing and forestry-related habitat destruction. This consideration of social factors is often overlooked but has been highlighted as an important factor in the management of wildlife (Kellert 1985).

Methods

Study Area

The study covered all land tenures in south-eastern NSW in the area bounded approximately by Bermagui, Nimmitabel, Bombala and the Victorian border (Fig. 1). The area included all parts of the Eden Native Forest Management Area and the 'Woodchip Agreement Area', including Bondi, Glenbog and Murrabrine State Forests. The total area of south-eastern NSW in this map is 1 205 689 ha. The area of State Forest is 314 277 ha, 26% of the total area; the area of national parks and nature reserves is 105 889 ha (9%); and the area of other land (almost entirely private freehold land but including some Crown land) is 785 523 ha (65%).

Householder Survey

On 16 August 1991, a koala-survey form was distributed by Australia Post's Householder Delivery Service to each of the 11 600 households in the Eden region (at a cost of \$A6-80 per 100 forms dispatched and \$A0-50 for each return). The survey included a covering letter, questionnaire and a large regional map (Fig. 2). The map was drawn with a number of familiar roads and towns to assist local residents to accurately locate and mark the location of all their koala records. Householders were asked to record, describe and date their koala sightings in the area, including whether the koala was dead or carrying young, and to provide historical and demographic information.

The respondents who had given a positive koala response were contacted, by either telephone, letter or interview, to verify the koala sightings. Each location was converted to an AMG (Australian Map Grid) reference, logged into the NPWS Atlas of NSW Wildlife (Ellis 1992), and the data analysed by the NPWS Geographic Information System called E-RMS (Environmental Resources Mapping System) (Ferrier 1991). These results augmented existing koala information from environmental impact statements, NPWS historical research, records from State Forests of NSW and other collected reports of koalas, which combined to form the basis of this study. The E-RMS for south-eastern NSW, which carries land-tenure classifications (State Forest, National Park or Nature Reserve, private land) and vegetation communities (Keith *et al.* 1995), was used to determine the type of land use and vegetation where koalas were sighted.

In addition, State Forests of NSW, with assistance from NPWS and interested members of the timber industry and local community, conducted eight 4-day field surveys for koalas between August and December 1991. The field surveys were undertaken in areas where koalas had been reported, and in areas considered likely to be koala habitat on the basis of the vegetation communities present. Vegetation communities considered unlikely habitat for koalas were not surveyed. The field surveys covered areas

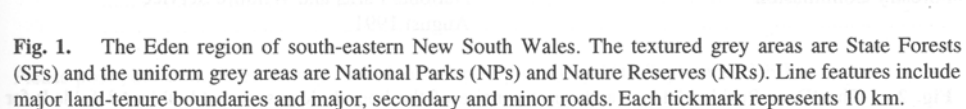


Fig. 1. The Eden region of south-eastern New South Wales. The textured grey areas are State Forests (SFs) and the uniform grey areas are National Parks (NPs) and Nature Reserves (NRs). Line features include major land-tenure boundaries and major, secondary and minor roads. Each tickmark represents 10 km.

KOALA SURVEY

No Postage stamp required if
posted in Australia



Please fold and return to:



South-east NSW Koala Survey
Reply Paid No. 2
P.O. BOX 186
EDEN NSW 2551



Dear Resident,

We are writing to ask for your co-operation in a koala survey which the New South Wales Government has asked the Forestry Commission and the National Parks and Wildlife Service to carry out in south-east NSW.

Harris Daishowa (Australia) P/L has provided funding for the survey.

The purpose of the survey is to locate any koala populations in the region, to study their habitat requirements and to produce a joint Forestry Commission/NPWS plan to conserve them.

To help us understand the present distribution of koalas, we are asking for any historical information you may have, such as your family's recollections, about koalas in the Eden region. We also want to use the opportunity provided by this survey to collect information on some other animals of interest.

We would like you to fill in this survey form **EVEN IF YOU HAVE NEVER SEEN ANY KOALAS**. A lack of sightings in any area is also important in building the picture of koala distribution in the region.

We believe that a comprehensive and objective survey is essential for planning koala management in the region. For this reason, we are asking all residents to provide detailed and accurate responses to the survey.

As the Premier Nick Greiner has said: "The koala is our diplomat for Australia's unique fauna, as well as for the Australian bush. It is also a symbol of community concern for our wildlife".

Thank you for taking the time to assist us.

Alf Sebire
Forestry Commission

Dan Lunney, Chris Moon and Carol Esson
National Parks and Wildlife Service
August 1991

Fig. 2. The 'Dear Resident' letter and questionnaire of the householder survey (double A3 folded) for koalas. The regional maps are not reproduced here because of their similarity to the location map in Fig. 1; the regional maps also included railway lines, extra roads, rivers and creeks, mountains and extra locality names to create a more 'user-friendly' map for respondents to plot records.

KOALA SURVEY: SOUTH-EAST NSW

Please circle the nearest answer, or give details as requested.

1.

How often do you see koalas in this region?
a) Monthly
b) Quarterly
c) Yearly
d) Occasionally
e) Once only
f) Never
2.

Please mark the locations of your koala sightings from question 1 on MAP 1, overleaf.
3.

Have you heard from a reliable source of a koala sighting?
Please describe where and when.....
.....
.....
4.

Where else have you seen koalas in southern NSW and/or East Gippsland in Victoria?
.....
.....
5.

Do you have any old records or historical information on koalas in this region? Please give details.....
.....
.....
6.

What is the main reason that you go into forests in this region?
Please circle the closest answer and give details.

a) Timber industry worker.....
b) Government employee.....
c) Recreation.....
d) Driving through.....
e) Agricultural work (e.g. beekeeping, grazing).....
f) Other (please specify)
7.

How many years have you lived in this region?
.....
8.

What is your local area or nearest town?
.....
9.

May we contact you for more details?Yes/No.....
10.

NAMEAGE
ADDRESS.....
.....PHONE No.....

(Respondents' identities will be kept strictly confidential, but if you prefer not to give your name and address, we would appreciate it if you could still fill in the other details on the survey form and maps.)
11.

Do you have any comments?
.....
.....

Please post your completed survey form (no stamp required) by 16th September 1991.

Please also return MAPS 2 and 3 with your Koala Survey form.

Fig. 2. continued

familiar to local NPWS and State Forests of NSW wildlife managers: Rock River; Wyndham Trig; private property near Boben Road, Chalkhills fire trail and Myrtle Mountain Road; Hayes Road; around Cow Bail Road; near Towamba; near Numeralla; Bermagui and Murrah State Forests; land adjoining Nutley's Creek Road, Dignam's Creek and Yurammie State Forest. The koala sightings from these surveys were included in the Wildlife Atlas and provided an extra source of information for the database of this study.

To ascertain how well the questionnaire covered the region, and to encourage a high response rate, records of other easily identified species, some of which are locally common, were also sought from the respondents. The list included feral predators (the cat, *Felis catus*, dog, *Canis familiaris*, and red fox, *Vulpes vulpes*), species listed as endangered in NSW (e.g. the brush-tailed phascogale, *Phascogale tapoatafa*, and spotted-tailed quoll, *Dasyurus maculatus*) and well-known species such as the emu, *Dromaius novaehollandiae*, and platypus, *Ornithorhynchus anatinus*. Their inclusion in the Eden koala survey was recognised as a broadly beneficial exercise, and the results of these surveys will be published separately.

Results

Answers to the Survey Questions

There were 1198 replies (10.3% return) to the questionnaire. Survey coverage across the region was widely distributed and representative. The respondents also represented a wide spectrum of the population in terms of their use of the forest (including the categories of timber-industry workers, government employees, recreation, 'driving through' and agricultural workers) and age. However, there was a bias towards older people, with only 30% of respondents being less than 40 years old.

At the outset it was recognised that koalas were locally rare, so every effort was made to elicit all the available information. A number of questions sought written answers and much useful information was obtained.

Not all questions were answered by each respondent. The results in each table are strictly from those people who answered the specific question, that is, respondents who did not answer a question were not included in the analysis of that particular question. The 2-way tables include only those people who answered both questions, which was always less than the number recorded for each of the 1-way tables.

The responses to the question 'How often do you see koalas in this region?' show that only 89 people (8%) had ever seen a koala locally (Table 1). In response to the question 'Have you heard from a reliable source of a koala sighting?', there were 263 items of information from 153 people. To the question 'Do you have any old records or historical information on koalas in this region? Please give details', 81 people stated that they had information. This was almost as many as had seen koalas. Similarly, there was a high written response rate to the question 'Where else have you seen koalas in southern NSW and/or East Gippsland in Victoria?' (Table 2). About four times as many people had seen koalas in East Gippsland as in southern NSW.

Responses showed that community knowledge about both historical and recent koala sightings is fragmented (Tables 3 and 4). There were 36 people who had both seen a koala and

Table 1. Number and percentage of people who responded to the question 'How often do you see koalas in this region?'

Frequency of sighting	<i>n</i>	%
Monthly	0	—
Quarterly	1	0
Yearly	4	0
Occasionally	21	2
Once only	63	6
Never	1059	92
Total	1148	

Table 2. Number and percentage of people who gave a written response to the question 'Where else have you seen koalas in southern NSW and/or East Gippsland in Victoria?'

Location	<i>n</i>	%
Southern New South Wales	26	3
Queensland	4	0
East Gippsland, Victoria	96	12
None seen	696	85
Total	822	

heard from a reliable source of a koala sighting. There were 39 people who had seen a koala but had not heard of a koala sighting (Table 3). Most people (77.5%) who had seen koalas did not have historical information (Table 4), which indicates that many of those who know something about local koalas know only a fragment of a larger and more complex picture.

Table 3. Number and percentage of people who answered the question 'How often do you see koalas in this region?' (i.e. frequency of sighting) cross-tabulated with the number who gave a written response to the question 'Have you heard from a reliable source of a koala sighting?', given in this table as yes or no

Frequency of sighting	Yes		No	
	<i>n</i>	%	<i>n</i>	%
Monthly	0	—	0	—
Quarterly	0	—	0	—
Yearly	1	1	3	0
Occasionally	11	7	6	1
Once only	24	16	30	3
Never	112	76	835	96
Total	148		874	

Table 4. Number and percentage of people who answered the question 'How often do you see koalas in this region?' (i.e. frequency of sighting) cross-tabulated with the number who gave a written response to the question 'Do you have any old records or historical information on koalas in this region? Please give details', listed in this table as yes or no

Frequency of sighting	Yes		No	
	<i>n</i>	%	<i>n</i>	%
Monthly	0	—	0	—
Quarterly	0	—	0	—
Yearly	1	1	3	3
Occasionally	4	5	11	1
Once only	11	14	41	5
Never	64	80	806	94
Total	80	861		

The responses to the question 'What is the main reason that you go into the forests in this region?' show that recreation (61%) was the main reason. Furthermore, householders that enter the forest for recreation and driving provided the most marked maps for koalas (67%), while timber-industry workers and government employees entering forests provided only 14% of marked maps for koalas (Table 5).

Of householders who answered the questionnaire, 49% had lived in the area for at least 12 years (Table 6). An examination of the relationship between the number of years of residency and frequency of sighting suggests that the number of koalas has not changed and has been low during the past 90 years. Ten people who had been in the region for less than two years had seen koalas. Newcomers (those who arrived in the 1980s or 1990s) constituted 49% of the respondents and saw 30% (27 of 89) of the koalas.

Of the 601 comments on the survey form, 410 (68%) did not express an opinion about koala conservation in south-eastern NSW. There were, however, 174 comments that supported koala conservation and 17 that opposed it. Differences of opinion were expressed about the worth of forests as a timber resource and their value as koala habitat.

Table 5. Reasons for being in the forests (first listed reason only) cross-tabulated with whether (yes or no) the koala map had location records entered on it

Reason for being in the forest	Yes		No		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Timber-industry worker	5	5	59	6	64	6
Government employee	8	9	18	2	26	2
Recreation	45	48	606	62	651	61
Driving through	18	19	221	23	239	22
Agricultural work	5	5	25	3	30	3
Other	13	14	42	4	55	5
Total	94		970		1064	

Table 6. Number of years of residency in the region cross-tabulated with the frequency of sighting a koala

Frequency of sighting	Parameter	No. of years in the region						Total
		0-2	3-6	7-11	12-20	21-40	41-90	
Monthly	<i>n</i>	0	0	0	0	0	0	0
	%	—	—	—	—	—	—	
Quarterly	<i>n</i>	0	0	0	1	0	0	1
	%	—	—	—	100	—	—	
Yearly	<i>n</i>	0	1	0	2	1	0	4
	%	—	25	—	50	25	—	
Occasionally	<i>n</i>	3	3	1	2	5	7	21
	%	14	14	5	10	24	33	
Once only	<i>n</i>	7	7	5	7	17	20	63
	%	11	11	8	11	27	32	
Never	<i>n</i>	141	207	192	181	185	152	1058
	%	13	20	18	17	17	14	
Total	<i>n</i>	151	218	198	193	208	179	1147
	%	13	19	17	17	18	16	

Analysis of the Map-based Information

Sufficient responses were provided to divide the records into decades to show the changes in location over time (Fig. 3).

Pre-1970. The locations show koalas around Cobargo, Bermagui, Tanja State Forest and south of Eden to the Princes Highway on the western edge of Nadgee State Forest. Records also stretch in an arc on the southern side of the Bega Valley from Bournda Nature Reserve west through Yurammie and Tantawangalo State Forests. There are also records in Bondi State Forest north of Nungatta National Park. The survey provided 33 of these 40 records.

1970s. The known range of the Tantawangalo koala population now includes Cathcart State Forest to the south-west, and into Glenbog State Forest to the north. Koala records have remained in Bournda Nature Reserve and around Bermagui and in a few locations scattered south-west of Eden. There is also a record just north of Bega. As with the pre-1970 records, the population is widespread and sparse. The survey provided 24 of these 34 records.

1980s. The major feature of this decade is the cluster of records, especially in farmland, around Bermagui on the coast to just east of the Princes Highway, south of Cobargo. Another feature is the arc of koala records south through Bournda Nature Reserve, across Yurammie State Forest, and through to Tantawangalo State Forest. There are also scattered records in Coolangubra and Glenbog State Forests and a few records south-west of Eden. The survey provided 51 of these 63 records.

1990s. These records cover the two years of 1990–91. There is a concentration of koala records in Tantawangalo State Forest, continued records in Murrah, Yurammie and Bondi State Forests, a persistence south of Eden in Nadgee and East Boyd State Forests, and also in Cathcart State Forest, and an expanded location of records that now includes Coolangubra State Forest. The survey provided 22 of these 48 records.

Total koala records. Of the total of 185 records, 125 (68%) were verified. The highest concentration of records was in and near Tantawangalo State Forest and around Bermagui, including Bermagui Nature Reserve, Murrah State Forest, Bodalla State Forest, Wallaga Lake National Park and in the adjacent freehold land that these forests encompass. There was also a scattering of records to the south-west of Eden and east of Tantawangalo State Forest in Yurammie State Forest and Bournda Nature Reserve.

The following areas describe koala records in greater detail because they appear to contain the core of the remaining koala population as determined by the number of records through the decades.

(i) Tantawangalo. The locations of all records in and around Tantawangalo State Forest show a broad distribution mostly in State Forest (Fig. 4). There is a concentration of observations along the Tantawangalo Mountain Road, that is, the road from Candelo to Bombala, and to the south-east of the point where this road enters the State Forest.

(ii) Murrah. There is a concentration of records on the western edge of Bermagui State Forest, with scattered records to the east, north and west, including on private land (Fig. 5). The line of records along the Bermagui to Cobargo Road indicates that koalas may regularly cross this road.

Geographical (E-RMS) Analysis of Map-based Data

Analyses identified the locations of koalas by land tenure, classified as State Forest (Table 7), National Parks and Nature Reserves (Table 8), and on other land, principally private land (Table 9), as well as by proximity to roads (Table 10) and by vegetation type (Table 11).

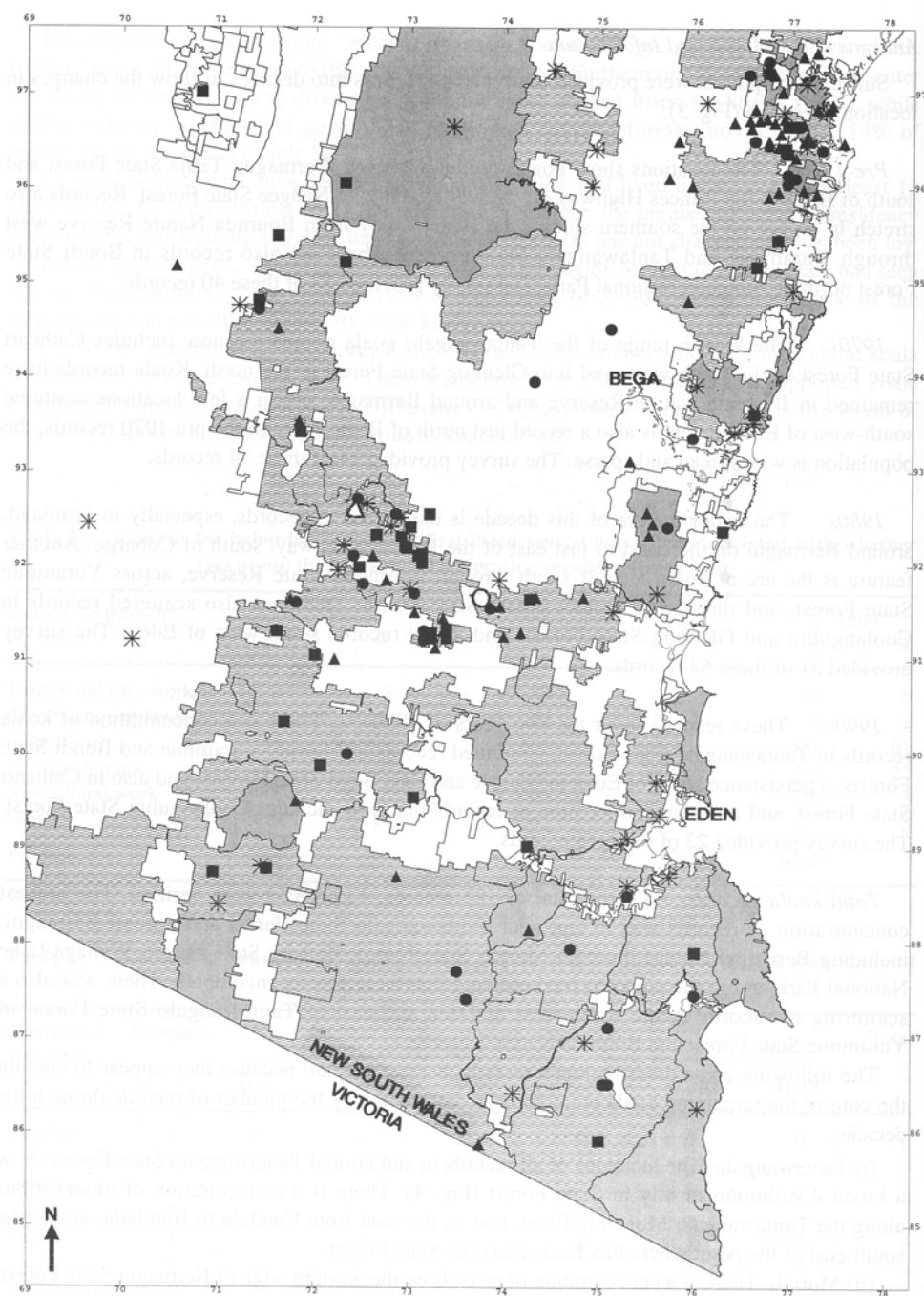


Fig. 3. Location of koala records from before 1970 (*), the 1970s (●), 1980s (▲) and 1990s (■). In two locations, koalas were recorded in the same location in different decades: before 1970 and in the 1970s (Δ); and in the 1970s and 1980s (○). Each symbol represents 1 ha within a 1-km² grid cell. The textured grey areas are State Forests and the uniform grey areas are National Parks and Nature Reserves. Each tickmark represents 10 km.

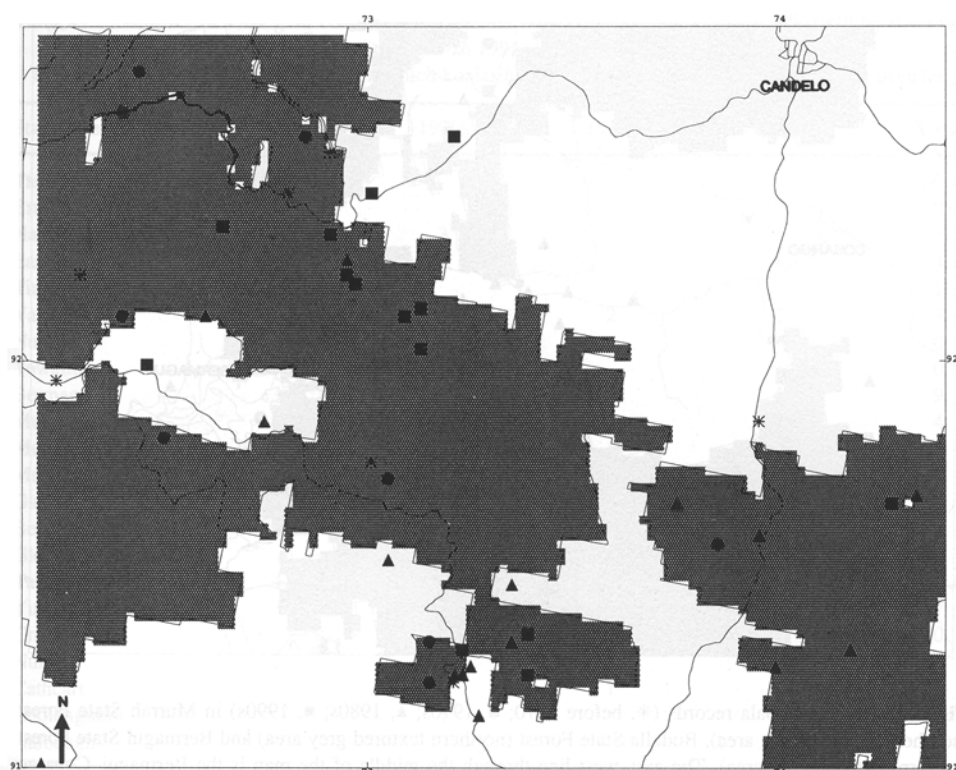


Fig. 4. Detail of koala records (*, before 1970; ●, 1970s; ▲, 1980s; ■, 1990s) in Tantawangalo State Forest (grey area). The line running west of Candelo is the Tantawangalo Mountain Road; the line running south of Candelo is the Myrtle Mountain Road. Each tickmark represents 10 km.

The 90 koala locations were scattered over 16 State Forests, 14 in 9 National Parks and Nature Reserves, and 62 on other (i.e. private) lands. Koalas were also recorded every decade in each of the land tenures. An examination of the records through the decades shows that the greatest number of locations (41) in the 1990s was in State Forests, with half of the records (22) being in Tantawangalo State Forest. The on-ground koala surveys by the TCPA during the 1990s contributed to this result. This number was higher than the records from previous decades, although before 1970 and in the 1970s there were more records in Tantawangalo than in any other State Forest. In the 1980s, there were more koala records in Yurammie State Forest, adjacent to Tantawangalo State Forest, than in any other. In three State Forests (Bermagui, Tantawangalo and Glenbog), there were records for every decade, and in five other State Forests (Nadgee, East Boyd, Yambulla, Yurammie and Bondi), there were records for all but one decade. The number of State Forests with koalas in each decade ranged between only 8 and 10.

The number of location records (1-ha grid cells) of koalas in National Parks and Nature Reserves was consistently low through the decades, with the peak of seven locations in five different areas occurring in the 1980s (Table 8). Only one area, Bournda Nature Reserve, had records (a total of five) for three decades. Wallaga Lake National Park had records in two decades, and the other seven areas had a record for only one decade (Table 8). On private land, the number of koala records ranged between 5 and 31 (Table 9). The 31 records in the 1980s are half of the records on private land; private land accounted for 38% of all records, State Forests 54% of all records, and National Parks and Nature Reserves 8% of all records.

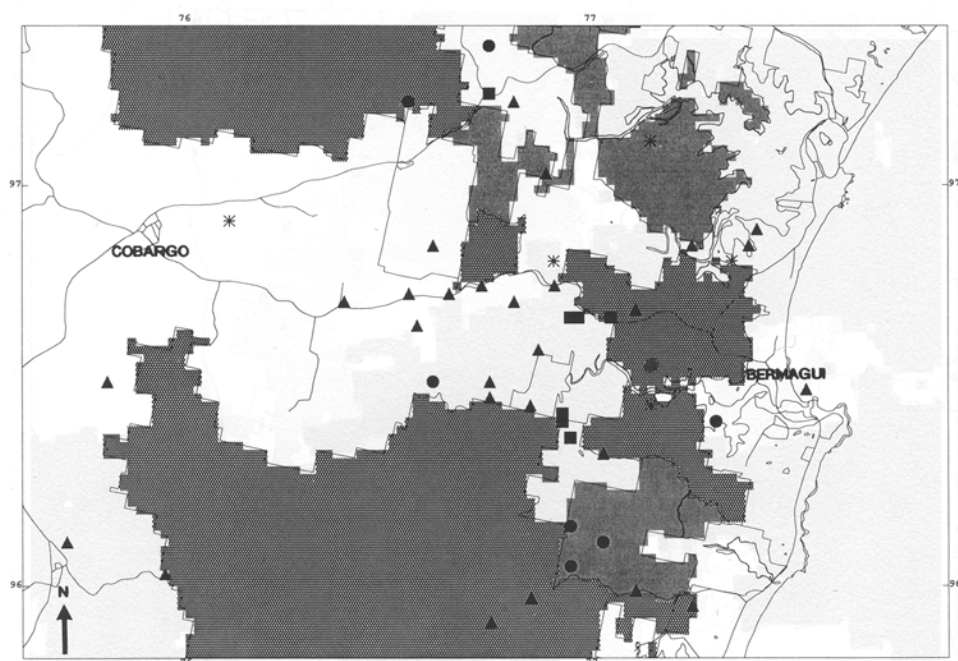


Fig. 5. Detail of koala records (*, before 1970; ●, 1970s; ▲, 1980s; ■, 1990s) in Murrah State Forest (southern textured grey area), Bodalla State Forest (northern textured grey area) and Bermagui State Forest (eastern textured grey area). The east-west line through the middle of the map is the Bermagui-Cobargo Road. Each tickmark represents 10 km.

Following the listing of nine new National Parks and Nature Reserves in the Eden region in November 1994, 15 koala records previously in State Forest estate were transferred to the National Parks estate: Tantawangalo National Park (eight records), Genoa National Park (three records) and Coolungubra National Park (four records).

Koalas were mapped in 1-ha grid cells overlapping with roads, mainly 2-wheel-drive rather than 4-wheel-drive roads or off the regular roads. The sighting of koalas on roads in three decades indicates that, although the frequency is low, it is a reasonably reliable index of koala presence (Table 10).

The greatest number of koala records in any one vegetation type occurred in dry forest types: Coastal dry shrub forest (*Eucalyptus longifolia*, *Acacia falciformis*) (17 records), Brogo dry shrub forest (*Eucalyptus globoidea*, *Eucalyptus cytellocarpa*, *Acacia floribunda*, *Pittosporum undulatum*, *Leucopogon juniperinus*) (17 records) and Escarpment dry grass forest (*Eucalyptus maidenii*, *Indigofera australis*) (14 records) (Table 11). However, koalas also occurred in wet forest types, with 10 records in Hinterland wet fern forest (*E. cytellocarpa*, *Calochlaena dubia*). Of the 15 vegetation types listed (where three or more koalas were sighted), five groups contained monkey gum, *E. cytellocarpa*.

Discussion

The total of 1198 replies received (10.3% of forms posted) highlights the value of this co-operative effort by the NPWS and the Forestry Commission (now State Forests of NSW) when this community-based survey was undertaken. Had either party attempted the project alone, the broad spectrum of responses, including responses from the timber industry or conservationists,

Table 7. Number of 1-ha grid cells in State Forests with a koala record, from pre-1970 by decades to 1991

Total is the total number of grid cells in which koalas had been recorded, not a total through the decades

State Forest	Pre-1970	1970s	1980s	1990s	Total
Tanja					0
Bruces Creek					0
Nadgee	1	3		1	5
East Boyd	1	2		1	4
Timbillica	1				1
Yambulla		1	2	2	3
Nungatta					0
Towamba					0
Bermagui	3	1	3	4	9
Murrah			3	1	4
Mumbulla	1		1		2
Murrabrine	1				1
Glenbog	3	4	1	2	7
Bemboka					0
Glen Allen					0
Tantawangalo	4	6	5	22	35
Yurammie		1	7	1	7
Gnupa					0
Nullica	2				2
Cathcart			1		1
Coolangubra		1		4	4
Nalbaugh					0
Bondi	2	1		3	4
Pine Plantations					0
Bombala					0
Broadwater					0
Bodalla		1			1
Wandella					0
Total No. of grid cells	19	21	23	41	90
Total No. of State Forests	10	10	8	10	16

may not have been elicited. It was clear from the survey response that no one person had a complete historical and present knowledge of koalas in the region; thus, this study was able to extract information from many sources to create a larger and more complex picture of local koala populations. One of the primary aims of this community-based survey was to determine the currently known locations of koala populations in the Eden region. Without such a regional picture, planning and management decisions lack the certainty that they are relevant and appropriate. The results of this detailed survey provide much of this certainty and have shifted the koala-conservation debate into a more manageable level than that provided by either Reed and Lunney (1990) or Richards *et al.* (1990).

The community postal survey provided an economical and broadscale method of obtaining information from an invaluable source of records that would otherwise be unavailable. The study provided records over all land tenures, including the largely forested lands of State Forests and National Parks and Nature Reserves, as well as providing records in remnant forests on private lands. It also provided a more than 3-fold increase in data (from 55 to 185 records) that were previously available from sources such as environmental impact statements, NPWS

Table 8. Number of 1-ha grid cells in National Parks, Nature Reserves and the former Bournda State Recreation Area (now part of Bournda Nature Reserve) containing a koala record, from pre-1970 by decades to 1991

Park or Reserve	Pre-1970	1970s	1980s	1990s	Total
Goura					0
Wallaga Lake	1		1		2
Mimosa Rocks	1				1
Wadbilliga	1				1
Ben Boyd					0
Mount Imlay			1		1
Nalbaugh			1		1
Nungatta					0
Bell Bird Creek					0
Bournda Nature Reserve	1	1	3		5
Eagles Claw					0
Egan Peaks					0
Nadgee	1				1
Bournda (former State Recreation Area)				1	1
Bermagui			1		1
Total No. grid cells	5	1	7	1	14
Total No. of Parks and Reserves	5	1	5	1	9

Table 9. Number of 1-ha grid cells on private land (with a very small proportion of Crown land) containing a koala record, from pre-1970 by decades to 1991

	Pre-1970	1970s	1980s	1990s	Total
No. of grid cells	15	5	31	11	62

Table 10. Number of 1-ha grid cells covered by 2- and 4-wheel-drive roads containing a koala record, from pre-1970 by decades to 1991

Road type	Pre-1970	1970s	1980s	1990s	Total
2-wheel drive	2		11	7	20
4-wheel drive			1	1	2

historical research and State Forests of NSW records. However, this approach to regional survey also presented a number of inherent problems, such as a lack of information from areas that were not frequented by people. There was also a potential for respondents to carelessly mark, create or omit koala records due to a fading memory, a careless mistake or dishonesty. This was partially addressed by a rigorous follow-up of positive responses for verification and clarification. Responses were also checked for potential biases from a self-selecting sample of the community, including biases arising from age, occupation and location. By obtaining records of other species it showed that the extent of coverage of the region was high and that few areas remained unfrequented by respondents.

Table 11. Number of 1-ha grid cells with a koala record from those vegetation types (Keith *et al.* 1995) that contained three or more koala records, from pre-1970 by decades to 1991

The total percentage of vegetation is 71.6%; the remainder consists of vegetation types where fewer than three koalas were sighted. Total area of the vegetation is 461 141 ha

Vegetation type	Area (ha)	% of total area	Pre-1970	1970s	1980s	1990s	Total
Coastal dry shrub forest (stringybark–silvertop) (<i>Eucalyptus agglomerata</i> , <i>Eucalyptus sieberi</i> , <i>Cooperhooikia barbata</i>)	37890	8.2	2	1	1	1	5
Lowland dry shrub forest (bloodwood) (<i>Eucalyptus gummifera</i> , <i>Banksia spinulosa</i>)	32912	7.1	2	2	2		6
Eden dry shrub forest (silvertop–apple) (<i>Eucalyptus sieberi</i> , <i>Angophora floribunda</i> , <i>Dillwynia glaberrima</i>)	20538	4.5	1	1	1		3
Coastal dry shrub forest (messmate) (<i>Eucalyptus obliqua</i> , <i>Pultenaea benthamii</i>)	21381	4.6		2	3		5
Coastal dry shrub forest (woolybutt) (<i>Eucalyptus longifolia</i> , <i>Acacia falciformis</i>)	20880	4.5	3	3	8	3	17
Brogo dry shrub forest (<i>Eucalyptus globoides</i> , <i>Eucalyptus</i> <i>cypellocarpa</i> , <i>Angophora floribunda</i> , <i>Pittosporum undulatum</i> , <i>Leucopogon</i> <i>juniperinus</i>)	20543	4.5	5	2	7	3	17
Escarpment dry shrub forest (maiden's gum) (<i>Eucalyptus maidenii</i> , <i>Indigofera australis</i>)	23030	5.0	4	4	4	2	14
Hinterland dry grass forest (stringybark) (<i>Eucalyptus globoides</i> , <i>Dichelachne rara</i> , <i>Plantago varia</i>)	37026	8.0	1	1	4	5	11
Wallagaraugh dry grass forest (gum) (<i>Eucalyptus cypellocarpa</i> , <i>Eucalyptus</i> <i>globoides</i> , <i>Epacris impressa</i>)	9472	2.1			1	2	3
Subalpine dry shrub forest (peppermint) (<i>Eucalyptus radiata</i> , <i>Eucalyptus pauciflora</i> , <i>Bossiaea foliosa</i>)	15392	3.3	2	2	1	5	10
Hinterland wet fern forest (gum) (<i>Eucalyptus cypellocarpa</i> , <i>Calochlaena</i> <i>dubia</i>)	32056	7.0	3	5	2		10
Hinterland wet shrub forest (stringybark) (<i>Eucalyptus muellerana</i> , <i>Eucalyptus</i> <i>cypellocarpa</i> , <i>Acacia cognata</i>)	19003	4.1	2	1	1	1	5
Mountain wet herb forest (messmate–gum) (<i>Eucalyptus obliqua</i> , <i>Eucalyptus</i> <i>cypellocarpa</i> , <i>Hieracium rariflorum</i>)	22764	4.9	1	1	1	4	7
Flats wet herb forest (ribbon gum) (<i>Eucalyptus viminalis</i> , <i>Stellaria pungens</i>)	7696	1.7	1			2	3
Bega wet shrub forest (peppermint–blue box) (<i>Eucalyptus elata</i> , <i>Eucalyptus baueriana</i> , <i>Carex longibrachiatata</i>)	9879	2.1	1		2		3
Total No. of grid cells			28	26	38	28	120

Koalas have existed in the Eden region during the past 90 years. The region now contains a number of populations, which appear to be small and scattered. The most obvious continuity of populations through the decades can be seen around Bermagui State Forest and the adjacent

private lands down to the north-east corner of Murrah State Forest, and Tantawangalo State Forest, including the western half of Yurammie State Forest and Glenbog State Forest to the north. There is a smaller, scattered population south and south-west of Twofold Bay in Nadgee State Forest. Koala population centres do not appear to occur on National Parks and Nature Reserves, except for Bournda Nature Reserve. However, three of the nine National Parks and Nature Reserves listed in 1994 now hold koala records. Koala records in the region are largely confined to State Forests, in conjunction with the immediately adjacent private land, principally between Bermagui and Cobargo on the northern side of Murrah State Forest. Following the recent listing of additional National Parks and Nature Reserves in the Eden region, the number of koala records in State Forests and on private land still greatly outnumbers that in National Parks and Nature Reserves. Thus, the major responsibility for their local conservation falls on State Forests of NSW and the few neighbours on private lands. Most of the area of National Parks and Nature Reserves does not appear ever to have held koalas, so the management of koalas is not as important an issue in these areas. Conversely, the two principal areas with koalas (Bermagui–Murrah area and Tantawangalo–Yurammie–Glenbog State Forests) need particular attention as they carry the core of the remaining koala population of the region. A report to the NPWS and State Forests of NSW concurred with this position, noting that 'While there might be other areas just as important for koalas, as suggested by State Forests of NSW, Tantawangalo–Yurammie and Bermagui–Murrah State Forests are logical high priorities because there is better evidence of substantial populations there than elsewhere' (Cork 1994).

Freehold land, particularly farmland, is not a major reservoir of koalas across most of the region. Since the historical record shows that koalas were once widespread and common through the Bega Valley (Lunney and Leary 1988), their general absence on farmland demonstrates that koala populations have been pushed to local extinction throughout most of the area of what was prime koala habitat last century. However, the farmland near some State Forests, particularly between Bermagui and Cobargo, is an important part of the habitat of local populations of koalas. Koalas were once abundant in the nutrient-rich valleys containing forest red gums, *Eucalyptus tereticornis*, prior to land clearance (Lunney and Leary 1988). The Eden koala population may then have been contiguous with the Bermagui population along the coast, as well as linked across the Bega Valley to the population now isolated in the Tantawangalo area, and down the Towamba Valley to Eden. One consequence of the agricultural development phase in the 1800s and early 1900s was to diminish and fragment the region's koala population by habitat clearance.

The assessment of the vegetation, in relation to koalas, points to particular dry-forest vegetation types as being the preferred habitat, although koalas were also sighted in wet forest types. Monkey gum, *Eucalyptus cypellocarpa*, was listed in a number of the vegetation types where koalas occurred, but the importance of this and other tree species to koalas has yet to be identified. Field survey (scat search and radio-tracking) by State Forests of NSW in Tantawangalo–Yurammie and Nullica State Forests also indicated that koalas prefer *E. cypellocarpa* (Jurskis *et al.* 1994). Cork (1994) recognised that conclusions drawn about habitat requirements from chance locations of koalas may be biased from whatever made the animal apparent, such as their visibility in different forest types or the visitation rate. However, these results provide an essential basis upon which to implement stratified field surveys, based on environmental grounds and in areas known to contain koalas and in those without records, to determine tree preferences of koalas as part of a detailed assessment of koala habitat. It may then be possible to predict the distribution of koalas on the basis of the distribution of these preferred vegetation types and/or tree species.

Since the initiation of this research programme, the passage in December 1991 of the Endangered Fauna (Interim Protection) Act 1991, and the subsequent inclusion of the koala as an endangered species (Schedule 12, National Parks Wildlife Act 1974) (see Lunney *et al.* 1996a for details), has provided further impetus for seeking a properly researched framework for conserving koalas. An aim of this study was to present a basis for managing the koala population

of south-eastern NSW. This study applied to land of all tenures and the results of the survey indicate that koala conservation will be of particular relevance to managers of State Forests in the Eden region. The results also apply to the local council (Bega Valley Shire) through the recent State Environmental Planning Policy No. 44, 1995 (SEPP 44), detailing koala habitat protection, issued by the NSW Department of Urban Affairs and Planning. In essence, this policy requires councils to consider all development applications on land larger than 1 ha for potential koala habitat, the only exception being for those shires with a Shire-wide Plan of Management for koalas. This survey, therefore, provides the basis for the implementation of formal procedures to address the issue of koala conservation in south-eastern NSW.

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