A playback survey of the koala, *Phascolarctos cinereus*, and a review of its distribution in the Eden Region of south-eastern New South Wales

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Summary

A survey conducted by playing pre-recorded calls of a male koala and listening for responses was used to further assess the distribution of koalas in south-eastern New South Wales.

Fourteen koalas were recorded from 388 sample sites. This detection rate (4%) was low compared to detection rates in north-eastern New South Wales. Insufficient data were generated to allow analysis of koala distribution in relation to environmental variables. The koalas were scattered through the region on various land tenures. The results suggest that conclusions regarding the distribution of koalas, based on previous records, may reflect uneven survey effort. The data from this survey and from other contemporary sources show the continued presence of koalas at localities where they had previously been reported as extinct. It is concluded that a low density koala population persists in the regional forests and that purported evidence of decline in the population is unconvincing.

There were no significant differences in detection rates between different land tenures. The detection rate of koalas was highest in the north of the region, at lower altitudes. There were significant differences in detection rates between modelled vegetation types, but the small number of detections precluded analysis of habitat preferences.

Keywords: surveys, wildlife, conservation, ecology, *Phascolarctos cinereus*, New South Wales

Introduction

Most koala research has, for logistical reasons, studied dense populations (Melzer and Lamb 1994). Melzer and Lamb (1994) stated that almost nothing is known about the ecology or conservation significance of low-density populations even though they occupy most of the koala's range. Koalas occur at very low densities in the Eden region (Jurskis and Potter 1997) and they are rarely seen (Lunney *et al*. 1997). Fauna surveys using standardised techniques across the region have not generated enough data to statistically analyse koala distribution against environmental and historical variables. The low probability of detecting koalas living at low densities makes assessment of their distribution, and possible changes in distribution over time, very difficult. Nevertheless, even limited data from regional field surveys may complement other information and enable more informed assessments.

Lunney *et al*. (1997) reported that there were a few small, isolated populations of koalas scattered through the Eden region. From a questionnaire survey, they concluded that koalas were rare and were mostly in State Forests rather than in other tenures. They considered that dry forest was the preferred habitat and that koala numbers in the region had been constantly low over four decades. Reed and Lunney (1990) had earlier concluded that koalas in the region were rare, confined almost entirely to State Forests and isolated from all other populations in New South Wales and Victoria.

Lunney and Leary (1988) stated that koalas suffered a sharp and permanent decline early in the 20th Century due to loss of habitat in the Bega Valley to farmlands. Reed *et al*. (1990) stated that populations had been lost from 3 out of some 13 grid cells[1] in the region during the second half of the 20th century. Reed and Lunney (1990) suggested that koalas had been lost from 6 localities in the region over the same period.

Only 14 koala records had been obtained during a number of systematic regional field surveys conducted over two decades (Reed *et al.* 1990; Kavanagh and Peake 1993; Kavanagh and Bamkin 1995; Jurskis and Potter 1997). One of these surveys used koala call playback and detected four koalas. Some of the surveys reported anecdotal records of the presence of koalas (Best 1980; Recher *et al*. 1980; Braithwaite 1983). Ninety-two percent of nearly 1200 respondents to a questionnaire survey had never seen a koala in the region and only 2% had seen a koala more than once (Lunney *et al.* 1997). Lunney *et al.* (1997) analysed 185 koala records, mostly from their 1991 questionnaire survey, although Cork *et al*. (1995) stated that existing information on koala distribution in the region could not be satisfactorily analysed. They saw major problems of uneven search effort and data on presence but not absence of koalas.

Following the formation, in 1990, of a committee to investigate koala management in the region, community groups and government agencies advocated a regional koala survey of all land tenures involving all sections of the community (Cork *et al.* 1995; Jurskis and Potter 1997). Hence a systematic regional field survey using listening and playback techniques was conducted between September and November 1997 covering the Eden Management Area (State Forests of NSW 1994).

Methods

Study area and stratification

The survey covered the Eden region in far south-eastern NSW. This region comprises approximately 800 000 ha, of which 500 000 ha has forest cover (State Forests of NSW 1994). Due

[1]In this analysis the State was divided into gridcells encompassing 15'of latitude and 15' of longitude.

to the low density of koala populations and their wide-ranging behaviour (Jurskis and Potter 1997), stratification was based on broad geographic and environmental units (Fig. 1, Table 1). Fourteen strata were defined using altitude, topographic roughness, predominant forest league (State Forests of NSW 1994) and geographic criteria.

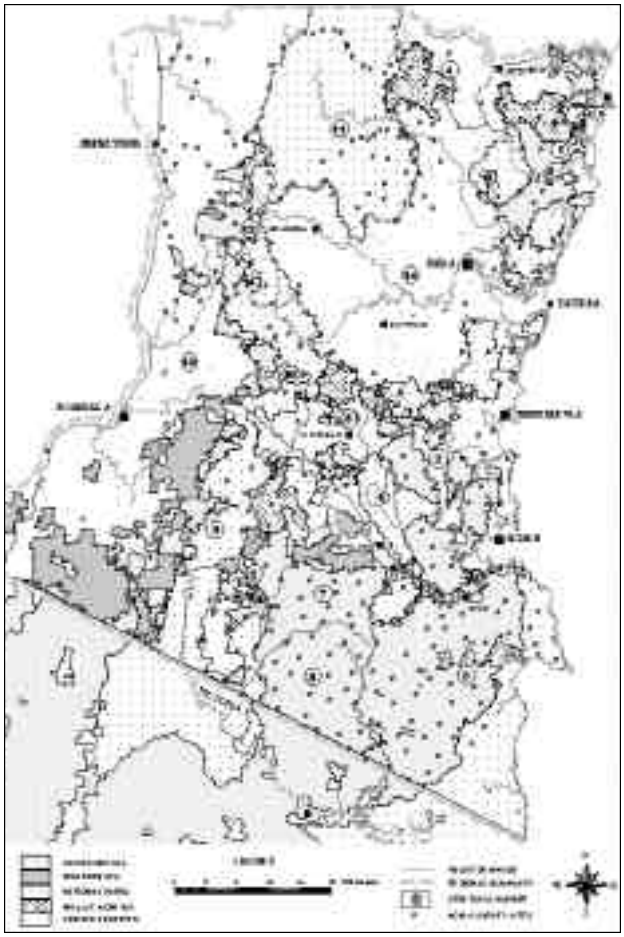

Figure 1. Survey sites and strata

Site selection

Based on expected low detection rates, it was planned to sample 400 sites with the aim of achieving 20 to 40 detections and possibly elucidating broad habitat preferences. The survey was confined to spring to limit seasonal variation and the choice of sites was restricted to areas accessible by four-wheel-drive vehicle. Sites were assigned to strata in proportion to the area of forest within the strata, as determined by a GIS analysis. This ensured a standard sampling intensity across the strata.

Cells, 1 km square, from the Australian Map Grid were randomly selected from within each stratum. Where 1:25 000 topographic mapping indicated that a cell was served by public vehicular access and the GIS vegetation layer indicated that it contained forest cover, a survey site in the cell was chosen for the best potential audio coverage (most extensive field of vision). To disperse sites within each stratum, a minimum distance between sites was specified. The minimum distance varied between 3 km and 1 km according to the density of roads and trails within each stratum.

Sample sites were fairly regularly distributed through State Forests but clumped along access routes in National Parks (Fig. 1). On private lands they were patchily distributed in remnants of native forest. Twelve sites in the Nadgee Wilderness Area were not sampled due to access restrictions.

Survey techniques

People from a wide cross section of the community carried out the survey, including staff of State Forests, National Parks and Wildlife Service, Harris Daishowa and logging contractors as well as other volunteers. Training sessions were held to familiarise the participants with nocturnal fauna sounds and survey techniques. Each two-person survey team included at least one experienced fauna surveyor. Surveys were conducted between dusk and midnight. Two surveyors listened for calls of koalas and other animals during an eight minute playback session as well as for about five minutes before and after the playback at each site. The playback session used standard taped copies of a recording of a male koala grunting and bellowing, broadcast at a moderate volume level from portable tape players.

When unfavourable weather conditions, such as strong winds, interfered with playback and listening at a survey site, the site was rescheduled for survey under better conditions. When problems such as lack of access or lack of forest cover prevented effective sampling at a site, the nearest suitable location within the same stratum was selected for sampling. The survey was conducted during spring 1997.

Date, time, weather conditions and animals heard at each site were noted as well as estimated distances and bearings to each koala call. When surveyors heard possible koala vocalisations that could not be positively identified, the site was rescheduled for another visit. If definite koala vocalisations were heard during the second visit, a koala record was assigned to the site.

Data analysis

The G-test (Zar 1984) was used to test the null hypothesis that koalas were detected in proportion to the area of forest and number of sites in each stratum. Also, due to the relatively large number of strata compared to koala detections, strata were pooled in various ways (see results) and the same test was applied. Detection rates according to land tenure and modelled vegetation type (Keith and Bedward 1999) were also tested this way.

Results

Fourteen koalas were detected from 14 of the 388 sample sites (Figs 1 and 2). Detection rates in strata varied from 0 to 16% of sites (Table 1). The overall detection rate was 4%. There was no statistically significant difference between the 14 individual strata in detection rates. Rates were higher in the north of the region (north of the Bega River) than in the south ($G = 11.5$, 1 d.f., $P<0.001$). Detection rates were higher in the low-altitude northern stratum than in the other 13 strata combined. ($G = 9.4$, 1 d.f., $P<0.01$). Six koalas were detected in State Forests (181 sites), six in National Parks (125 sites) and two in private property (81 sites). There was no statistically significant difference between land tenures in their detection rates.

Figure 2. Distribution of koala records from regional field surveys, showing a scatter of records extending across the region, without obvious clustering. Some records occur at localities where extinctions were previously reported.

Table 1. Distribution of survey sites and koala records by stratum

Stratum No.	Stratum name	Number of survey sites	Number of koalas detected	Detection rate (%)
1	Low altitude northern	32	5	16
2	Low altitude central	50	1	2
3	Low altitude southern	56	0	0
4	Intermediate altitude northern	8	1	13
5	Intermediate altitude central	13	0	0
6	Intermediate altitude southern	27	1	4
7	Flat hinterland	15	0	0
8	Hinterland dry shrubby forest	21	0	0
9	High altitude southern	29	0	0
10	High altitude central	21	0	0
11	Steeply dissected	44	3	7
12	Wet forests	12	0	0
13	Tablelands	39	1	3
14	Bega Valley	21	2	5

The koalas were detected in eight modelled vegetation types of which seven were dry forests and one was mesic forest (Keith and Bedward 1999, Table 2). There were no detections in 42 other vegetation types (Table 2). There were significant differences in the detection rate of koalas between modelled vegetation types ($G = 41.5$, 9 d.f., $P<0.001$).

Table 2. Distribution of survey sites and koala records by modelled vegetation type

Vegetation type No.[1]	Vegetation type name[1]	Number of survey sites	Number of koalas detected	Detection rate (%)
13	Southern Blue Gum	21	3	14
19	River Peppermint	11	2	18
20	Forest Red Gum	1	1	100
31	Stringybark-Gum	18	1	6
32	Woolybutt	25	3	12
34	Gum-Box-Stringybark	11	1	9
37	Rough-barked Apple	8	1	13
W2	White Ash	3	1	33
Not Typed	-	25	1	4
All other types	-	263	0	0

[1]Vegetation type numbers are according to Keith and Bedward (1997). Type names refer to the closest corresponding type according to Forestry Commission of NSW(1989).

The average estimated distance to a responding koala was about 400 m, suggesting that the effective survey area was about 50 ha per site. Thus 388 sites amounted to a total survey area of about 19 400 ha. Since there are in the order of 500 000 ha of forests in the region (State Forests of NSW 1994), the survey was estimated to have sampled about 4% of the region's forests.

Discussion

Survey technique

Call playback has been used extensively in the region to survey large forest owls (Kavanagh and Bamkin 1995). Only one previous regional survey used koala call playback, though the technique has been used in local surveys and to locate koalas for radiotracking studies (Jurskis and Potter 1997). Mitchell (1990) observed a 17% vocal response rate by males to playback experiments in a high-density koala population. Barrott (1999), however, achieved about a 50% detection rate of koalas using call playback in both low- and high-quality habitat. Listening was the most effective survey technique used by Barrott (1999) in low-quality habitat. Listening achieved a 79% detection rate compared to 50% for faecal pellet surveys. It is suggested that listening combined with call playback is likely to be the most effective method for extensive surveys of low-density koala populations.

Current distribution of koalas

This survey, previous field surveys and questionnaire surveys indicate that koalas are scattered through the region. Fourteen records of koala resulted from five previous regional fauna surveys (Fig. 2). One survey using call playback detected four koalas in East Boyd State Forest, Nullica State Forest, Nadgee State Forest and Mimosa Rocks National Park (Jurskis and Potter 1997). An owl playback and listening survey (Kavanagh and Peake 1993) detected a single koala in Yurammie State Forest. A similar survey detected four koalas in Murrah State Forest, Nadgee State Forest, Mumbulla State Forest and Tanja State Forest (Kavanagh and Bamkin 1995). Three koalas were detected by a similar survey (Jurskis and Potter 1997) in Waalimma National Park, Genoa National Park and Yowaka National Park. A predator scat survey detected koala remains in two scats from Yurammie State Forest (Reed *et al.* 1990). These previous surveys did not extend into Wallaga Lake National Park or Wadbilliga National Park. Only the predator scat survey (Reed *et al*. 1990) sampled Murrabrine State Forest. There were

koala records from each of these three areas in the current survey.

No regional field survey has suggested a concentration of koalas at any locality within the region, nor do combined data from all regional field surveys point to any concentration of koalas (Fig. 2). Consistently low detection rates and scattering of detections suggest a low-density distribution of koalas through the region. Intensive local surveys have produced multiple records of koalas in some localities but have not identified dense populations (Jurskis and Potter 1997). For example, intensive surveys and radiotracking in an area of about 70 ha in Tantawangalo State Forest, over more than two years, yielded evidence of only three koalas including the radiotracked female and a juvenile offspring (Jurskis *et al*. 1994; Jurskis and Potter 1997). Intensive local surveys that have detected koala faecal pellets have rarely produced koala sightings (Jurskis *et al*. 1994; Jurskis and Potter 1997). During sampling of 2043 trees on 76 sites containing koala faecal pellets (Phillips unpublished), no koalas were seen. Koalas living in forests at low densities are cryptic animals.

The data from regional field surveys (Fig. 2) show a quite different pattern than combined data from a range of sources (Fig. 3). The combined data include records from intensive local surveys as well as incidental observations from areas receiving high human visitation. Thus they reflect a very uneven 'survey effort'across the region (Cork *et al.* 1995). Lunney *et al*. (1997) considered that their questionnaire survey data showed that koalas were mainly in State Forests, especially in the Murrah-Bermagui and the Tantawangalo-Yurammie State Forests (Fig. 3). The results from the current survey and previous field surveys of the region (Fig. 2) do not support the conclusion (Lunney *et al*. 1997; Reed and Lunney 1990) that koalas were concentrated in or confined to State Forest lands. These conclusions appear to have been influenced by uneven 'survey effort'(Cork *et al.* 1995).The regional field surveys indicate that koala distribution is independent of land tenure.

Areas containing three of the six detections within State Forest from the current survey have since been reserved in the expanded National Park system (Fig. 2) under the Eden Regional Forest Agreement (Commonwealth of Australia and State of New South Wales 1999). The Comprehensive Adequate and Representative reserve system (Commonwealth of Australia and State of New South Wales 1999) established by the Eden Regional Forest Agreement includes most of the Tantawangalo-Yurammie and Bermagui-Murrah State Forest areas considered by Lunney *et al*. (1997) to contain most of the regional koala population (Fig. 3). Even if the regional surveys have failed to detect a real association of koalas with particular localities, there is no evidence that koalas are associated with existing State Forests.

The limited data from the current survey suggest that koalas may be associated with particular vegetation types (Keith and Bedward 1999) (Table 2). Most of the records (10) came from seven dry vegetation types. There was no difference, however, between wet and dry vegetation types in their detection rates as three of the records came from a modelled mesic type (Keith and Bedward 1999).

Figure 3. Distribution of incidental koala records since 1988, showing clusters of records at Tantawangalo–Yurramie and Murrah where public interest in koala management has concentrated. Records occur at each locality where extinctions were previously reported.

Changes in koala distribution

Lunney and Leary (1988) stated that koalas in the region suffered a sharp and permanent decline early in the 20th century due to loss of habitat in the Bega Valley (Fig. 3) to farmlands. Platts (1989) noted that koalas were prolific on the Cathcart Plateau (Fig. 3) in the late 19th Century. That area is now farmland with scattered trees, and koalas have not been reported there for many decades (Lunney *et al*. 1997; Fig. 3).

In the current survey, koalas were not detected in some localities where they are known to occur (Figs 2 and 3). For example, there have been several reports of koalas from Yurammie State Forest during the past decade (Fig. 3) and two koalas in that area have recently been studied by Jurskis and Potter (1997), but no koalas were detected by the current survey in that area. Since this survey, there have been additional records in the area (R. Harris *pers. comm.*). Thus extensive surveys are not able to identify localities from which koalas are absent.

Reed *et al*. (1990) and Reed and Lunney (1990) considered historical information and data from three questionnaire surveys in 1949, 1975 and 1987. Comparing the data from the 1987 questionnaire with all other data, Reed *et al*. (1990) concluded that koala populations had been lost from 3 of some 13 grid cells (areas encompassed by 15' of latitude and 15' of longitude) in

the region, whilst Reed and Lunney (1990) concluded that koala populations had been lost from 6 localities in the region. These grid cells and localities included Bondi, Cathcart, East Boyd, Nadgee and Tantawangalo State Forests as well as Wadbilliga National Park.

The recent regional field surveys (Fig. 2) have recorded koalas in some of the localities and grid cells from which losses were reported (Reed *et al*. 1990; Reed and Lunney 1990) including East Boyd and Nadgee State Forests and Wadbilliga National Park. Additional records have accumulated in all of the localities and cells since 1988 (Fig. 3). The reported contractions in koala distributions (Reed *et al*. 1990; Reed and Lunney 1990) were based on comparisons of information from a single survey with historical information gathered over many years. The assumption that a single survey can establish the absence of koalas from a particular locality appears to be inappropriate. A comparison of a number of regional field surveys and questionnaire surveys (e.g. Lunney *et al*. 1997) does not indicate any contraction in the regional distribution of koalas since the early 20th Century.

Reed and Lunney (1990) concluded that koalas in the region were isolated from all other populations in New South Wales and Victoria. There are, however, recent records of koalas from the far north and south of the region as well as from adjacent parts of the regions to the north and south (Figs 2 and 3; Lunney *et al*. 1997; State Forests unpublished records), indicating that the regional population is not isolated.

Koala densities

Kavanagh *et al*. (1995) reported a survey of nocturnal animals in north-eastern New South Wales that did not use playback of koala calls. Koalas were recorded at 12% of the 291 survey sites, suggesting that koala densities are substantially higher in north-eastern than in south-eastern New South Wales. Radiotracking studies at Eden estimated that the average home range size of individual mature koalas was more than 100 ha and contained in the order of 40 000 trees (Jurskis and Potter 1997). Thus it is very difficult to detect koalas in the region's forests. Phillips (unpublished) concluded that koala habitat at Bermagui-Murrah (Fig. 3) contained no 'primary'food trees and therefore had low carrying capacity for koalas.

Since koalas are rarely seen in the Eden region, there is little basis for estimating their population density. The current survey is estimated to have sampled about 4% of the region's forests, but the method is unlikely to detect female koalas since they rarely bellow, and vocal response rates of males may be as low as 17% (Mitchell 1990). Koala populations may have a slight female bias (Martin and Handasyde 1990). The detection rate of koalas in an extensive survey of this type is therefore likely to be considerably less than 50%. Assuming even a 50% response rate by male koalas present at survey sites and a 1:1 sex ratio, the detection rate in this survey translates to an estimated population density of around 0.003 koalas per hectare. This is comparable to the lowest densities reported elsewhere (Melzer and Lamb 1994) and to estimates based on radiotracking at Eden (Jurskis and Potter 1997). Melzer and Lamb (1994) reported a population density of 0.005 koalas per hectare at a 1700 ha clearing site. They suggested that viable low-density populations may be common in central Queensland.

Martin (1985) suggested that koala densities increased in Victorian coastal lowlands after European settlement and then were affected by wildfires, hunting for skins and clearing. Low-density populations probably persisted in inland forests (Martin 1985). In the Eden region, koala populations crashed early in the 20th Century following clearing for agriculture (Lunney and Leary 1988) and low-density populations have persisted in the remaining forests (Lunney *et al*. 1997; the current survey). This situation is similar to that postulated by Martin (1985) in southern Victoria.

Conclusions

Although the dense koala populations in the former woodlands of the coastal valleys and the tablelands near Eden were extinguished by agricultural clearing, a low density population of koalas persists in the forests.

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