# A 1986–1987 survey of the koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution

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A survey in 1986–87 of the distribution of koalas in New South Wales showed that they mainly occurred on the north coast, although they have an extensive but fragmented distribution west of the Great Divide and in the southern half of the State. Koalas were uncommon at the majority of localities. Healthy koalas were reported in 91.8% of their range and the conclusion was drawn that disease is not the primary determinant of the distribution of the koala in New South Wales. Koalas occurred mainly on rural lands rather than within either the National Parks and Wildlife Service or Forestry Commission estates. Historical records show that the koala distribution was more extensive and less fragmented prior to the first survey in 1949. The distribution of the koala is closely linked to tree species restricted to high nutrient soils, such as those of river valleys which have been extensively cleared for agriculture. Since koalas are now primarily found on farmland, long-term management plans need to include the protection of their habitat on rural land through co-operation with the rural community.

Key words: Koala, *Chlamydia, Eucalyptus,* Wildlife Management, Disease, Distribution.

## INTRODUCTION

IN 1984 there was little information available to predict the long-term security of the koala in New South Wales. The national status of the koala was raised as a public issue through a programme broadcast by the Australian Broadcasting Corporation ("A Big Country", Series 28, Programme 4, October 1984). This programme, and subsequent public debate, centred on the health of the koala and particularly the problems caused by *Chlamydia psittaci* (e.g., Brown and Carrick 1985; Strahan 1985). The most recent survey data, which were nine years old, were largely concerned with distribution within the National Parks and Wildlife Service and Forestry Commission Estates, and had been collected at a time when the koala's health was not an issue (Gall 1978; Gall and Rohan-Jones 1978).

The bacterium *Chlamydia psittaci* was first isolated as the causative agent of keratoconjunctivitus ("pink eye") in koalas from New South Wales (Cockram and Jackson 1974). However, only limited information, primarily from Lismore and Port Macquarie on the north coast of New South Wales, was available on the incidence of this and other diseases in wild koala populations (Cockram 1978; Cockram and Jackson 1976, 1981). Indeed, prior to the 1986–87 survey reported here, the national view of koalas was largely based on information from Victoria (Martin 1981, 1985a–c; Strahan and Martin 1982; Obendorf 1983; McColl *et al.* 1984) and Queensland (Brown *et al.* 1984; Brown and Grice 1984; Brown and Carrick 1985).

The present study, undertaken to redress the imbalance, aimed to:

1. Describe the distribution, relative abundance, health, habitat, tree species selection and the tenure of the land on which koalas occur in New South Wales.
2. Compare the current survey with surveys between 1949 and 1985.
3. Describe the environmental factors associated with the distribution of the koala.
4. Propose guidelines for a management plan for the koala in New South Wales.

## SURVEYS OF THE DISTRIBUTION OF THE KOALA

### Survey methods

The methods used to determine koala distribution are described separately for each survey.

#### *1949 Survey*

Letters asking for reports of koalas were distributed to 46 land inspectors, 277 field officers of the Department of Agriculture, 373 Forestry Commsission officers and 57 Pastures Protection Boards. Police stations were circularized by the Commissioner of Police, school teachers were notified through the Education Gazette and a media campaign

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was conducted to seek public assistance. (A previously unpublished account is reproduced in full in Appendix 1.) A total of 109 reports of koalas was received and their distribution was mapped.

*1967 Survey*

A questionnaire survey was conducted by the newly formed National Parks and Wildlife Service, through the Tree Wardens' League of New South Wales, now amalgamated with the Gould League of New South Wales. Background information and a survey form were published in the League's newsletter, "The Junior Tree Warden," No. 1, 1967, which was distributed to every government school in the State. A media campaign promoted the survey. Much of the raw data from the 1967 survey were lost (A. Fox, pers. comm.). The surviving data were included in the 1949–85 data set.

*1975 Survey*

The methods of the co-operative National Parks and Wildlife Service and Forestry Commission survey were published in Gall and Rohan-Jones (1978). In summary, a questionnaire was distributed to Service and Commission staff to determine the distribution of the koala, principally within Crown reserves. The 1975 survey received reports of 353 koala sightings between January 1, 1970 and March 1, 1976 (Gall and Rohan-Jones 1978). The distribution of 250 records with a sighting date after January 1, 1974 was mapped, and the remaining records were used in the 1949–85 data set.

*The present survey 1986–87*

The survey covered the land area of New South Wales (801 358 km$^2$). Current ownership and utilization is listed in Table 1. The survey was carried out by the following methods:

1. *Farmers and Special Interest Groups.* The majority (70%) of these groups were surveyed by the distribution of self-explanatory, freepost survey forms (Fig. 1) distributed as inserts in the newsletter of the members of the New South Wales Farmers' Association (formerly the Livestock and Grain Producers Association). This newsletter reaches about 44% of the 51 728 agricultural establishments listed in the 1985–86 Australian Bureau of Statistics agricultural census (Wilson 1987).

   Other forms (7.6%) were included as an insert in the newsletter of the Recreational Four-wheel Drive Clubs Association of New South Wales and the Australian Capital Territory quarterly newsletter *Horizons*. A further 7 000 cards were distributed through the offices of the National Parks and Wildlife Service to members of the public and offices of the Water Resources Commission, Soil Conservation Service, Pasture Protection Boards, Crown Lands Office, Western Lands Commission, Department of Main Roads, Electricity Commission and all Defence Department establishments within the State. Of the 32 500 survey cards, 1 979 (6.1%) were returned. Of these, 12% were not used in the analyses because localities could not be found.

2. *Department of Education of New South Wales.* A separate form, with the same questions and additional information, was distributed by the Department of Education to 2 119 of the 2 240 government schools. The remaining 121 schools, in the Lismore and Tweed inspectorates of the Department's north coast region, were surveyed through the inclusion of a koala survey form in the concurrent Richmond-Tweed Wildlife Survey (Big Scrub Environment Centre, Lismore), operated in conjunction with the Department of Education. Of the 11 000 forms distributed, 162 (1.5%) were returned and 102 used in the analyses. The Richmond-Tweed Wildlife Survey returned 256 survey forms and 126 were used in the analyses.

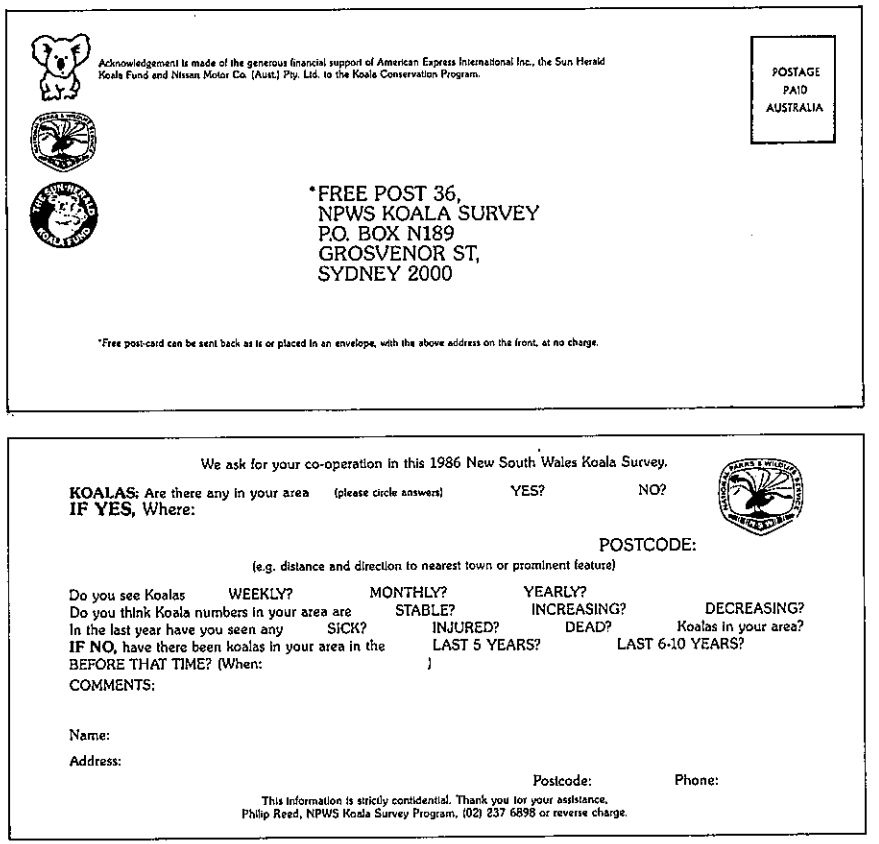
3. *Forestry Commission of New South Wales.* Owing to the difficulty of distinguishing among the species of *Eucalyptus*, only Forestry Commission staff were asked to identify the tree species occupied by koalas. The basic form, with additional questions, was distributed to Forestry Commission offices throughout the State. The additional questions were: Which state forests were koalas sighted in? If outside state forests, where? Which tree species were koalas seen in? Of the 250 survey forms, 187 (75%) were returned. Replies were received from all 47 forestry districts, 26 of which reported the presence of koalas in state forests.

4. *Media Campaign.* To promote the survey visits were made between July 1986 and June 1987, to locations where koalas were known to occur. Newspaper and radio interviews were undertaken in most rural areas known to have contained koalas. A media release, designed to draw attention to the survey, was sent in October 1986 to all newspapers, regional magazine supplements and radio stations. Articles requesting koala sighting records were published in late 1986 in a variety of magazines, including *Parks and Wildlife News*. *The Australasian Beekeeper* and the *Australian Veterinary Association Journal*, and newsletters including those of the Snowy Mountains Authority, the Federation of Bushwalking Clubs of New South Wales and the National Parks Association. Also, letters requesting assistance and koala sighting reports were distributed to all affiliated groups of the Nature Conservation Council of New South Wales, the members of the mammal section of the Royal Zoological Society and bird observer groups. A total of 143 letters reporting koala sightings resulted from the media coverage.

5. *Environmental Impact Statements.* Over 100 environmental impact statements in the library of the Department of Environment and Planning were checked in November 1986 for references to koalas in areas subject to development proposals. Four contained references to koalas.

6. *National Parks and Wildlife Service of New South Wales.*
   (a) Reports from districts. Apart from the distribution of survey forms, reports of all koala records were requested from the 62 National Parks and Wildlife Service offices, covering 27 districts, in September 1986. Responses were obtained from all 22 service districts and koalas occurred within 13 of these.
   (b) Field work. The Woodchip Agreement Area within the Eden Forestry Region was surveyed in 1987 for the presence of koalas using predator scat (dog and fox faeces) collected during a National Parks and Wildlife Service regional survey. The scats were analysed by B. Triggs using the methods in Triggs *et al.* (1984). Koala remains were found in only two of a total





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POSTAGE PAID AUSTRALIA

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NPWS KOALA SURVEY
P.O. BOX N189
GROSVENOR ST,
SYDNEY 2000

*Free post-card can be sent back as it or placed in an envelope, with the above address on the front, at no charge.

We ask for your co-operation in this 1986 New South Wales Koala Survey.

**KOALAS:** Are there any in your area (please circle answers) YES? NO?
**IF YES,** Where:

POSTCODE:

(e.g. distance and direction to nearest town or prominent feature)

Do you see Koalas WEEKLY? MONTHLY? YEARLY?
Do you think Koala numbers in your area are STABLE? INCREASING? DECREASING?
In the last year have you seen any SICK? INJURED? DEAD? Koalas in your area?
**IF NO,** have there been koalas in your area in the LAST 5 YEARS? LAST 6-10 YEARS?
BEFORE THAT TIME? (When: )
COMMENTS:

Name:
Address:
Postcode: Phone:

This information is strictly confidential. Thank you for your assistance.
Philip Reed, NPWS Koala Survey Program, (02) 237 6898 or reverse charge.

*Fig. 1.* The survey form used during the 1986–87 koala survey.

*Table 1.* Utilization of land within New South Wales.

| Authority/Land Manager | % of State | Area ($km^2$) | Land-use | Source | Date when determined |
|---|---|---|---|---|---|
| 51 728 Agricultural Establishments | 79.0 | 633 298 | Agricultural activities | Wilson 1987 | 31.03.1986 |
| Forestry Commission | 4.5 | 35 638[a] | 781 dedicated State Forests | Forestry Commission | 10.12.1986 |
| National Parks and Wildlife Service | 4.3 | 34 357 | 289 dedicated areas[b] | NPWS | 31.12.1986 |
| Department of Water Resources | 0.3 | 2 317 | Catchment areas for 21 dams | Crown Lands Office | 13.10.1987 |
| Department of Lands | 9.6 | 77 000[c] | Lands Department reserves and vacant Crown lands | Crown Lands Office | 30.06.1987 |
| Department of Main Roads | 1.0 | 8 200[d] | Public roads | DMR | 30.06.1987 |
| Other | 1.3 | 10 548[e] | Incl. Defence, SRA[f], Local Government, Water Board, towns and cities | | |
| Total | 100.0 | 801 358[g] | | | |

[a] An additional 2 230 $km^2$ are held as Timber Reserves (vacant Crown land, which may have been leasehold) which increases the percentage of the State under Forestry control to 4.7%. Conifer plantations cover 1 618 $km^2$ of the State Forest area.
[b] Comprising 66 National Parks, 177 Nature Reserves, 20 State Recreation Areas, 15 Historic Sites, nine Aboriginal Areas and two Wildlife Management Areas.
[c] Area held by Lands Department is not collated. This approximate figure excludes all lands leased, licensed, incompletely purchased or held by other government authorities.
[d] Area held by the Department of Main Roads is not collated. When the road is declared Public, the title becomes vested with the Local Council. The public road length is about 205 000 km and the maximum boundary width is 0.04 km = 8 200 $km^2$.
[e] Area only approximate as data not readily available.
[f] Area held by the State Rail Authority is not collated. The track length if 9 908 km and average width of land containing the track is 0.0402 km. This gives an estimated area of 398.3 $km^2$.
[g] Area excludes the Australian Capital Territory, including Jervis Bay Territory. Also excludes 70.55 $km^2$ comprising harbours, rivers, etc., not included within municipal or shire boundaries (Wilson 1987).

of 2 000 scats, both collected in Yurramie State Forest, near Merimbula.

## ANALYTICAL PROCEDURES

Of a total of 2 564 survey returns received from all sources in 1986–87, 816 reported seeing koalas. Of these, 697 were reports of sightings since January 1, 1985, and were used in the analyses. The remaining records reporting koala sightings prior to this date were used in the 1949–85 set.

Two databases were developed: one contained all data to 1985, and the other contained data from the 1986–87 survey. These databases were established as part of the Australian Resource Information System (ARIS), a computerized geographic information system developed by CSIRO (Cocks and Walker 1980).

### 1. 1949–85 Data Set

All data prior to the 1986–87 survey were contained in the National Parks and Wildlife Service Wildlife Inventory Programme database (Wildata). Individual Wildata records consist of a date of sighting, Australian Map Grid (AMG) reference, National Parks and Wildlife Service and Forestry Commission Estate code (if applicable), and general information. Koala sightings within an area of the Service or the Commission estates were assigned a standardized latitude and longitude if no specific location was provided. These were obtained from the Geographic Names Board, Department of Lands of New South Wales.

### 2. 1986–87 Survey

The database contains record number, postcode, AMG reference, National Parks and Wildlife Service and Forestry Commission Estate code (if applicable), indices of koala health, and date and frequency of sighting.

Postcodes were used for the initial classification of the locality data. A total of 282 postcode districts cover 783 539 $km^2$, or 97.8% of the land area of New South Wales. The remaining 17 819 $km^2$ comprises the Sydney statistical division (256 postcodes) and the Wollongong (24 postcodes) and Newcastle statistical subdivisions (42 postcodes) (as defined by the Australian Bureau of Statistics). These groups of postcodes were treated as three single units for analyses.

The koala sighting localities were derived from information returned on the completed survey cards, letters and incidental reports. AMG references were obtained from the 1:25 000 and 1:100 000 sheets of National Topographic Map Series, Division of National Mapping, Canberra, and were read to an accuracy of ±0.1 km for both the north and east components.

The index of frequency of sighting was determined from the survey returns. Sightings were categorized by the survey respondents as occurring weekly, monthly, yearly or longer (intermittent).



The health index was simplified from the four categories on the survey card to either healthy or unhealthy because of respondent confusion between the sick and injured categories and the unknown prior condition or fate of the koalas. Therefore, the unhealthy category covers sick, injured or dead koalas.

All analyses were performed using capabilities of the Australian Resources Information System (ARIS). Distribution maps were produced for each of the 1949, 1975 and 1986–87 surveys, where each record is represented by a single point on the map (Figs 2a,b,c). A further map, comparing the change in distribution between the 1986–87 survey data and the pooled data from the previous surveys was produced comparing the presence or absence of koala sightings for grid cells of a quarter degree in extent. The three categories produced: CONSTANT (when a grid cell contained koala sighting records from both the 1986–87 survey and the previous surveys); GAIN (when a grid cell contained records only during the 1986–87 survey); and LOSS (when a grid cell only contained records prior to the 1986–87 survey).

A map showing the distribution of koala sightings in National Parks and Wildlife Service and Forestry Commission estates during the 1986–87 survey was prepared. Data on the frequency of sighting and the health of koalas in the 1986–87 survey were mapped using quarter-degree grid cells.

Each record in the two databases (1949–85 and 1986–87) was compared with the following environmental variables in ARIS: vegetation type for upper stratum; grazing density of cattle and sheep; and presence of six *Eucalyptus* species and varieties. Apart from the *Eucalyptus* species, all derived data were available at a resolution of a quarter degree in extent of latitude and longitude. A total of 1 232 such grid cells, varying in area from 614 to 680 $km^2$, cover New South Wales. The vegetation and grazing density data originate from Series 2 and 3 respectively of the Atlas of Australian Resources, Division of National Mapping, Canberra. Data on eucalypt species were derived from EUCALIST, a database developed by the CSIRO Division of Forest Research (Chippendale and Wolf 1981), and modified by Gill, Belbin and Chippendale (1985).

Two other map-based approaches were undertaken to assist in the interpretation of the survey data. All available data from both

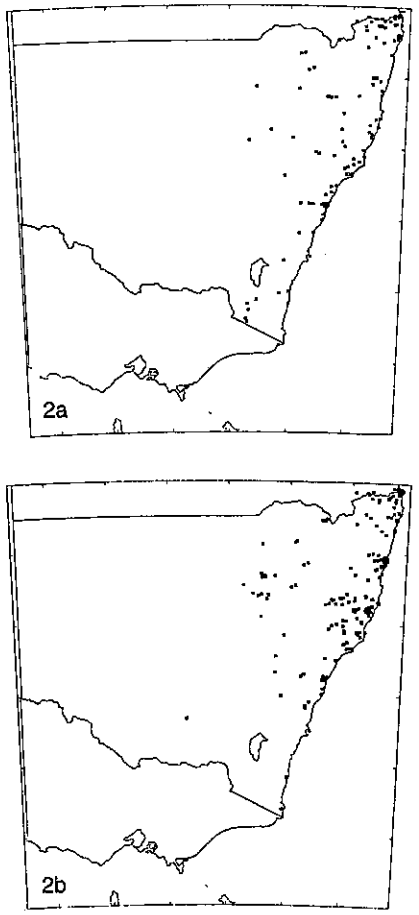



*Fig. 2.* The distribution of the koala as determined by (a) the 1949 survey, (b) the 1975 survey and (c) the 1986–87 survey. Each point represents a locality where a koala(s) was sighted.

*Table 2.* Forestry Commission Estate reported to contain koalas during the 1986–87 survey. State Forests, as of 10 December, 1986, supplied by the Forestry Commission.

| Forestry Region[a] | District | State forest(s) containing koalas 1985–87 | Pre-1985 | Additional Forests from Gall and Rohan-Jones (1978) |
|---|---|---|---|---|
| ALBURY | | | | |
| 166 state forests covering 4 189 km² | Batlow | Nil | Native Dog | |
| | Deniliquin | Nil | | |
| | Griffith | Nil | | |
| | Mildura | Nil | | |
| | Narrandera | Nil | | |
| | Tumbarumba | Nil | | |
| | Tumut | Nil | | |
| BATEMANS BAY | | | | |
| 49 state forests covering 3 761 km² | Batemans Bay | Nil | | |
| | Moss Vale | Nil | | |
| | Narooma | Nil | Bodalla[b] | |
| | Nowra | Nil | | |
| | Queanbeyan | Nil | | |
| BATHURST | | | | |
| 133 state forests covering 2 838 km² | Forbes | Nil | Bunberry | |
| | Lithgow | Nil | | |
| | Oberon | Nil | Vulcan[c] | |
| | Orange | Nil | | |
| COFFS HARBOUR | | | | |
| 94 state forests covering 5 307 km² | Casino | Braemar, Richmond Range, South Toonumbar | Washpool | |
| | Coffs Harbour | Bagawa, Boambee, Conglomerate, Kangaroo River, Lower Bucca, Nana Creek, Orara East, Orara West, Wedding Bells | | |
| | Dorrigo | Bielsdown, Moonpar, Wild Cattle Creek | Chaelundi | Ellis |
| | Grafton | Cangai, Clouds Creek | | Sheas Nob |
| | Murwillumbah | Mooball, Nullum, Whian Whian, Wollumbin | | Mebbin |
| | Urbenville | Beaury, Koreelah, Unumgar, Yabbra | | Donaldson, Toonumbar, Mount Lindesay |
| DUBBO | | | | |
| 114 state forests covering 6 000 km² | Baradine | Cumbil, Euligal, Pilliga East, Pilliga West | | Bobbiwaa, Coomore Ck |
| | Condobolin | Nil | | |
| | Gilgandra | Goonoo | | |
| | Mudgee | Avisford | | |
| EDEN | | | | |
| 31 state forests covering 3 262 km² | Bega | Bermagui, Glenbog, Mumbulla[b], Murrabrine[b], Murrah[b] | Tantawangalo[d] | |
| | Bombala | Nil | | |
| | Eden | Yurammie[d] | | Nadgee |
| GLEN INNES | | | | |
| 75 state forests covering 3 270 km² | Armidale | Styx River | | |
| | Glen Innes | Nil | Torrington | |
| | Inverell | Arthurs Seat, Bebo, Mehi | | Terry Hie Hie |
| | Tamworth | Black Jack Mountain[e], Breeza, Goran, Nundle, Wondoba | Tuggolo, Raimukka | Goran |
| | Tenterfield | Girard | Forest Land | Gilgurry |
| | Walcha | Nowendoc, Riamukka | Enfield | |



*Table 2* — continued

| Forestry Region[a] | District | State forest(s) containing koalas 1985–87 | Pre-1985 | Additional Forests from Gall and Rohan-Jones (1978) |
|---|---|---|---|---|
| NEWCASTLE | | | | |
| 44 state forests covering 2 882 km² | Bulahdelah | Batchelor, Bulahdelah, Myall River, Wallingat, Wang Wauk | | |
| | Cessnock | Corrabare, Mount Royal, Watagan | Pokolbin | |
| | Dungog | Chichester, Fosterton, Uffington, Wallaroo | | Avon River, Dungog, Trevor |
| | Gloucester | Barrington Tops, Copeland Tops, Craven, Giro | | Stewarts Brook |
| | Muswellbrook | Nil | | |
| | Wyong | McPherson[d], Olney[d], Ourimbah[d], Strickland[d], Wyong[d] | | |
| PORT MACQUARIE | | | | |
| 78 state forests covering 4 122 km² | Kempsey | Carrai, Nulla Five Day, Pee Dee, Tamban, Yessabah | Andersons | Maria River |
| | Kendall | Kendall, Kerewong | | Burrawan, Broken Bago, Comboyne, Kew, Lorne, North Branch, Queens Lake, Upsells Creek |
| | Taree | Bulga, Coopernook, Kiwarrak, Landsdowne, Middle Brother | | Dingo |
| | Urunga | Pine Creek | Bellinger River | Gladstone, Nambucca, Newry |
| | Wauchope | Doyles River | | |
| SYDNEY | | | | |
| 5 state forests covering 6 km² | Sydney | Nil | | |

[a] Eight state forests are shared by two different regions. The area per region is correct, however, and the total number of state forests is inflated by eight.
[b] Only one koala sighted in these forests.
[c] Forest cleared for Pine plantation.
[d] Intermittent sightings within these forests.
[e] Record received after database finalized for map production.

databases and the pre-1949 historical records were plotted on to a base map of the drainage system of the State obtained from the Central Mapping Authority, New South Wales, and on to a base map of the remnant native vegetation derived from Landsat imagery (after Benson 1987).

## RESULTS OF THE SURVEYS

### Analysis by Postcode

In the 1986–87 survey, returns were received from 251 (89%) of the 282 rural postcode districts including all the large postcode districts. The 31 postcode districts without returns were small and scattered. Of the 251 postcode districts, koala sightings were reported from 118 (47%), yet 87 of this 118 also had survey returns reporting no koala sightings. This tends to indicate that the koala has a patchy distribution within these 87 postcode districts. Koala sightings were received from the Sydney statistical division and the Newcastle subdivision, but not the Wollongong subdivision. Most sightings in the Sydney Statistical Division were from Avalon, Ku-ring-gai Chase National Park, Avon Dam and Campbelltown, and in the Newcastle statistical subdivision, from Port Stephens. Survey returns reporting no koala sightings were received from parts of all divisions and subdivisions.

### Reports from Service and Commisssion Estates

The 168 records of koalas in National Parks and Wildlife Service and Forestry Commission estates (Fig. 3) represent 24% of the 697 records from the 1986–87 survey. Koalas were reported from 84 (11%) of the 781 state forests comprising the Forestry Commission estate (Table 2). Four Forestry Regions (Coffs Harbour, Glen Innes, Port Macquarie and Newcastle) contained 72 of the 84 state forests with koalas and 21 of the 26 Forestry Districts with koalas (Table 2). The most frequent sightings of koalas (monthly) occurred in 12 of these state forests, which were primarily located in the Coffs Harbour region. The remaining 72 State Forests reported koala sightings on a yearly or intermittent basis. There were 29 state forests containing koala records during the 1975 survey (Gall and Rohan-Jones 1978), but none during the 1986–87 survey (Table 2).

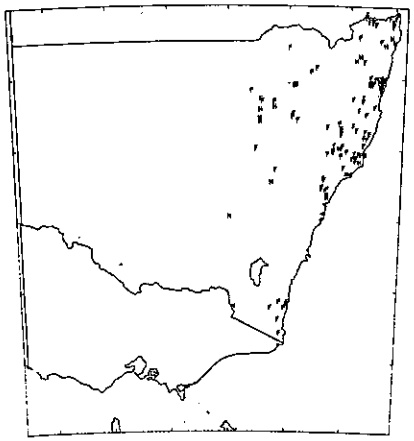


*Fig. 3.* The distribution of the koala within the National Parks and Wildlife Service (N) and Forestry Commission (F) estates, determined by the 1986–87 survey.

Of the 289 areas comprising the National Parks and Wildlife Service estate, 29 (10%) were reported to contain koalas. The majority (21) of these had regular (monthly or yearly) sightings (Table 3). An additional eight areas contained koala records during the 1975 survey (Gall and Rohan-Jones 1978), but none during the 1986–87 survey. Two service regions, northern and central, contained 24 of the 29 areas with koala sightings and nine of the 13 service districts with areas containing koalas (Table 3).

### Tree species identified by Forestry Commission Staff

Koalas were reported in 29 tree species, of which 25 were eucalypts. The species most frequently reported were *Eucalyptus saligna, E. tereticornis, E. punctata, E. pilularis, E. microcorys* and *E. grandis* (Table 4). There was some confusion over the identification of *E. punctata, E. punctata* var. *didyma* and *E. propinqua*, all commonly referred to as grey gum. The north coast and northern tablelands provided the greatest number of tree species in which koalas were seen. Within a postcode district, the largest number of species reported was eight. A much lower frequency of tree species was utilized on the north-west slopes, south coast and southern tablelands.

### Frequency of sighting

The sighting frequency data from the 1986–87 survey are summarized in Table 5. The modal category was "yearly" and the next most common category was "intermittent". The "weekly" and "monthly" categories made up only 27.6% of reports. The distribution of grid cells of these frequencies (Fig. 4a) were scattered over the range of the koala in New South Wales.

### Health status

Five hundred and thirty-eight (77.2%) of the reports categorized koalas as healthy. Checks with Service staff and other interested groups indicated that motor vehicles, dogs, fires and habitat clearing were important causes of injury and mortality. The category "healthy only" was most common, being reported in 111 of the 184 grid cells (60.3%). Both healthy and unhealthy categories were reported in 58 cells (31.5%). The unhealthy category occurred alone in 15 grid cells (8.2%). Thus, unhealthy koalas were reported in 73 grid cells (39.7%) and healthy koalas were in 169 grid cells (91.8%). There was no pattern to the distribution of health categories (Fig. 4b).



*Table 3.* National Parks and Wildlife Service estate[a] with koalas during the 1986–87 survey. Estate areas as of 31 December, 1986, supplied by the Service.

| Service Region (Number of each type of estate) | Service District | Estate containing koalas: Group 1 (Regular sightings) | Group 2 (Single or intermittent sightings) | Additional areas from Gall and Rohan-Jones (1978) |
|---|---|---|---|---|
| NORTHERN | | | | |
| 20 NP, 60 NR, 2 HS, 2 SRA, 2 WMA, 3 AA covering 3 498 km² | Armidale | Nil | | |
| | Dorrigo | Kororo NR[b] | Bowraville NR[b] | Dorrigo NP |
| | Glen Innes | Gibraltar Range NP, Washpool NP | | |
| | Grafton | Bundjalung NP, Illuka NR[b] | | Banyabba NR |
| | Lismore | Broadwater NP, Bungawalbin NR, Border Ranges NP, Tucki Tucki NR[b] | Stotts Island NR[b] | Mount Warning NP |
| | | | | Uralba NR |
| | Port Macquarie | Lake Innes NR, Macquarie NR[b] | Limeburners Creek NR, Werrikimbe NP, Yarravel NR | |
| CENTRAL | | | | |
| 21 NP, 48 NR, 9 HS, 13 SRA, 4 AA covering 10 543 km² | Bathurst | Hill End HS[b] | | Munghorn Gap NR |
| | Blue Mountains | Nil | | |
| | Hawkesbury | Brisbane Waters NP | | |
| | Hunter | Barrington Tops NP, Myall Lakes NP | Booti Booti SRA, Pulbah Island NR | |
| | Nth Metropolitan | Ku-ring-gai Chase NP, Marramarra NP | | Muogamarra NR |
| | Sth Metropolitan | Nil | | |
| | Sydney Harbour | Nil | | |
| | Upper Hunter | Nil | | |
| SOUTH-EASTERN | | | | |
| 16 NP, 34 NR, 2 HS, 5 SRA, 1 AA, covering 10 886 km² | Eden | Nil | | Mount Imlay NP |
| | Kosciusko | | Kosciusko NP[c] | |
| | Narooma | Nil | | Wallaga Lake NP |
| | Nowra | Nil | | |
| | Queanbeyan | Nil | | |
| WESTERN | | | | |
| 9 NP, 35 NR, 2 HS, 1 AA covering 9 430 km² | Cobar | Nil | | |
| | Coonabarabran | Pillaga NR, Warrumbungles NP | | |
| | Griffith | Narrandera NR[bd] | | |
| | Kinchega | Nil | | |
| | Lower Darling | Nil | | |
| | Mootwingee | Nil | | |
| | Narrabri | Mount Kaputar NP | | |
| | Tibooburra | Nil | | |

[a] NP=National Park, NR=Nature Reserve, HS=Historic Site, SRA=State Recreation Area, AA=Aboriginal Area, WMA=Wildlife Management Area.
[b] Area less than 150 hectares or 1.5 km².
[c] Only one koala sighted since 1973.
[d] Introduced population: Four koalas, from New South Wales central and north coast, were released on 16 December, 1972; a further 10 koalas, from French Island, Victoria, were released on 5 May, 1974.

### Changes in the distribution between 1949–85 and 1986–87

The changes in the distribution between the 1986–87 survey and the pooled data from 1949 to 1985 are shown in Figure 4c. Of the 299 grid cells shown, 113 (38%) show no change over time. Gains were identified in 72 (24%) of grid cells, but this could be due to a more thorough coverage of the State during the 1986–87 survey, particularly of the rural lands of the northern tablelands, northwestern slopes and plains. In contrast, the losses identified in 114 (38%) of grid cells are likely to have occurred, because the 1986–87 survey was more thorough than earlier surveys. Losses appear to outweigh gains in the southern half of the range and western fringe of the northern half.

### Environmental factors associated with koala distribution

Most records of koalas (77.1% of 1949–85 records; 68.6% of 1986–87 records) show that they occurred in grid cells that were characterized by medium to tall *Eucalyptus* with tree cover between 10% and 70% (Table 6). The other

*Table 4.* Numbers of koala sightings by Forestry Commission Staff during the 1986–87 survey for each tree species per postcode district.

| Postcode District | White mahogany (*E. acmenoides*) | White stringybark (*E. globoidea*) | Flooded gum (*E. grandis*) | Spotted gum (*E. maculata*) | Tallowwood (*E. microcorys*) | Blackbutt (*E. pilularis*) | Small-fruited grey gum (*E. propinqua*) | Grey gum (*E. punctata*) | White-topped box (*E. quadrangulata*) | Swamp mahogany (*E. robusta*) | Sydney blue gum (*E. saligna*) | Silvertop ash (*E. sieberi*) | Forest red gum (*E. tereticornis*) | Black wattle (*Acacia mearnsii*) | Blackwood (*Acacia melanoxylon*) | Forest oak (*Allocasuarina torulosa*) | Brush box (*Lophostemon confertus*) | Wattle-leafed peppermint (*E. accedens*) | New England Blackbutt (*E. andrewsii*) | Dieback stringybark (*E. cameronii*) | Silvertop stringybark (*E. laevopinea*) | Narrow-leaved black peppermint (*E. nicholii*) | Snow gum (*E. pauciflora*) | Narrow-leaved peppermint (*E. radiata*) | Scribbly gum (*E. rossii*) | Black sallee (*E. stellulata*) | Manna gum (*E. viminalis*) | White box (*E. albens*) | Blakely's red gum (*E. blakelyi*) | No. Species per district |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NORTH COAST | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Murwillumbah | | | 2 | | 3 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 6 |
| Mullumbimby | | | 2 | | 2 | 1 | | | | 1 | 1 | | 1 | | | | | | | | | | | | | | | | | | 5 |
| Urbenville | | | | | | | 1 | 1 | | | 1 | | 1 | | | | | | | | | | | | | | | | | | 5 |
| Kyogle | | | | 1 | | | 1 | 1 | | | 2 | | 1 | | | | | | | | | | | | | | | | | | 8 |
| Casino | | | | 1 | 1 | | 1 | 1 | | | 1 | | 1 | | | | | | | | | | | | | 1 | | | 1 | | | 1 |
| Grafton | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Dorrigo | | | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| Coffs Harbour | | | 2 | 1 | 2 | 4 | | | | | 2 | | 1 | | | 1 | | | | | | | | | | | | | | | 8 |
| Kempsey | | | 3 | | | 2 | | 2 | | | | | | | | | | | | | | | | | | | | | | | 8 |
| Kendall | | | | | | 1 | | | | | | | | | | 1 | | | | | | | | | | | | | | | 2 |
| Wingham | | | | | 2 | | 1 | | | | 2 | | | | | | | | | 1 | | 1 | | | | | | | | | 5 |
| Taree | | | | | | 2 | | | | | | | | | | | 1 | | | | | | | | | | | | | | 2 |
| Dungog | | | | 1 | | 1 | 1 | | | | 1 | | 1 | | | | | | | 1 | | | | | | | | | | | 6 |
| Gloucester | | | | 1 | | 4 | 1 | 3 | 1 | 2 | 1 | | | 1 | | | | | | | | | | | | | | | | | 7 |
| Buladelah | | | 2 | | 2 | | 1 | 3 | | 1 | 3 | | | | | | | | | | | | | | | | | | | | 8 |
| Forster | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Raymond Terrace | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | 2 |
| SOUTH COAST | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bodalla | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 1 |
| Cobargo | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| NORTHERN TABLELANDS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Armidale | | | | | | | 2 | | | | 4 | | | | | | | | | 1 | | | | | | | | 1 | | | 3 |
| Walcha | | | | | | | | | | | | | | | | | | | | 1 | | 1 | 2 | 2 | | 1 | 3 | | | | 9 |
| SOUTHERN TABLELANDS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cooma | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 |
| NORTH-WEST SLOPES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tamworth | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | 1 |
| Gunnedah | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 2 |
| No. districts per species | 2 | 1 | 6 | 5 | 8 | 8 | 8 | 8 | 2 | 2 | 11 | 1 | 7 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 5 | 1 | 1 | | |



*Table 5.* Number of reports of koalas in each frequency of sighting category in the 1986–87 survey.

| | Frequency | | | | |
|---|---|---|---|---|---|
| | Weekly | Monthly | Yearly | Infrequent | n |
| No. of reports | 64 | 128 | 292 | 213 | 697 |
| % Total | 9.2 | 18.4 | 41.9 | 30.6 | 100 |

*Table 6.* Upper stratum vegetation description[1] for localities with koala sightings.

| Description of upper vegetation | | | 1949–85 combined | | 1986–87 survey | |
|---|---|---|---|---|---|---|
| Genus | Tree height | % cover | Count | % | Count | % |
| *Eucalyptus* | tall | 30–70 | 232 | 22.6 | 131 | 18.8 |
| *Eucalyptus* | medium | 30–70 | 327 | 31.8 | 115 | 16.5 |
| *Eucalyptus* | medium | 10–30 | 233 | 22.7 | 232 | 33.3 |
| *Eucalyptus* | medium | <10 | 46 | 4.5 | 14 | 2.0 |
| *Eucalyptus* | low | 10–30 | 10 | 1.0 | 2 | 0.3 |
| Not specified | medium | >70 | 130 | 12.6 | 165 | 23.7 |
| *Callitris* | medium | 30–70 | 38 | 3.7 | 31 | 4.4 |
| *Acacia* | low | 10–30 | 3 | 0.3 | | |
| *Casuarina* | low | 10–30 | 6 | 0.6 | | |
| Total | | | 1 028 | 100.0 | 697 | 100.0 |

[1]After Carnahan (1976).

*Table 7.* Co-occurrence of koala sighting localities with the distribution of five species of *Eucalyptus* in New South Wales[a].

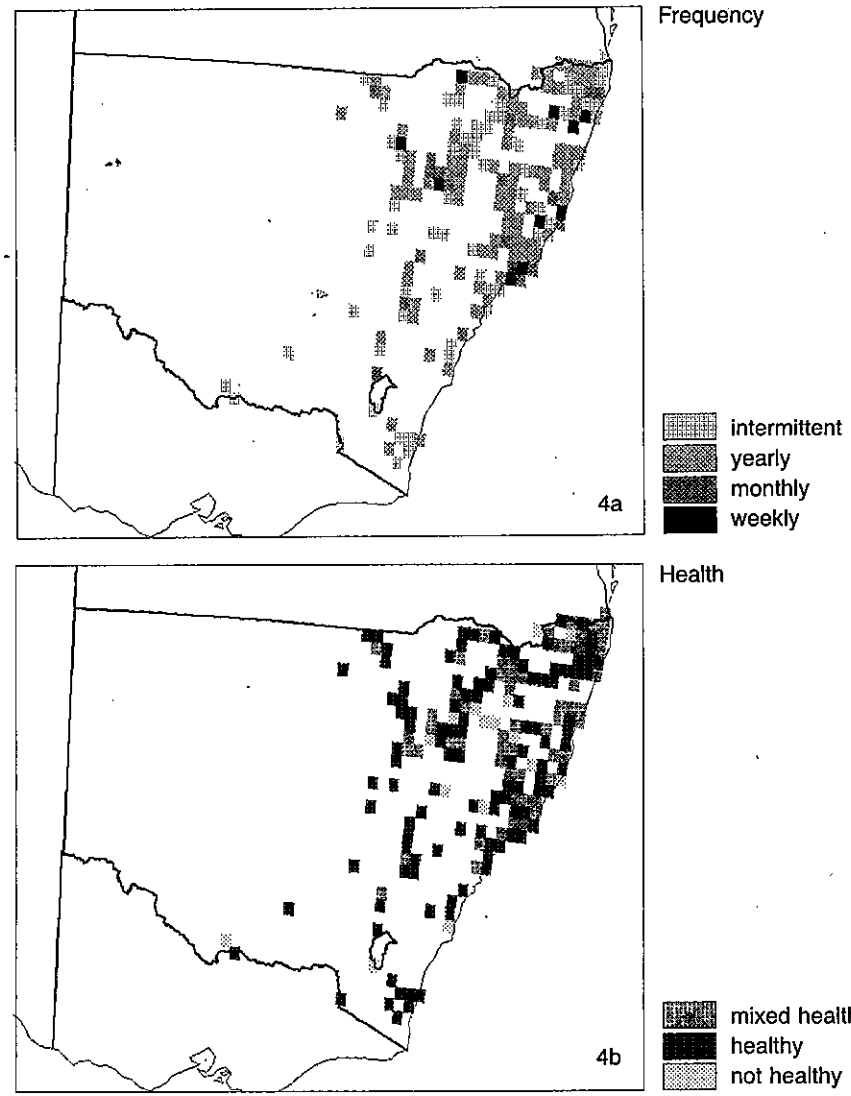
| | 1949–85 combined | | 1986–87 Survey | |
|---|---|---|---|---|
| *Eucalyptus* spp. | Count | % | Count | % |
| *E. camaldulensis* | 334 | 32.5 | 257 | 37.4 |
| *E. microcorys* | 684 | 66.5 | 456 | 65.4 |
| *E. punctata* var. *didyma* | 437 | 42.5 | 347 | 49.8 |
| *E. punctata* var. *punctata* | 307 | 29.9 | 171 | 24.5 |
| *E. tereticornis* | 888 | 86.4 | 626 | 89.8 |
| *E. viminalis* var. *viminalis* | 697 | 67.8 | 373 | 53.5 |
| Any of the above species | 987[b] | 96.0 | 687[c] | 98.6 |

[a]From Eucalist (Gill, Belbin and Chippendale 1985).
[b]987 of a possible 1 028 records.
[c]687 of a possible 697 records.

*Table 8.* Occurrence of koalas in relation to grazing density of sheep and cattle[a].

| Grazing density | | 1949–85 (combined) | | 1986–87 Survey | |
|---|---|---|---|---|---|
| Cattle (Animals/10 | Sheep hectares) | No. koala sightings | % | No. koala sightings | % |
| Nil | Nil | 361 | 35.1[b] | 40 | 20.1 |
| <0.2 | <1.3 | 14 | 1.4 | 24 | 3.4 |
| 0.2–0.6 | 1.3–5 | 202 | 19.6 | 132 | 18.9 |
| 0.6–2.5 | 5–20 | 112 | 10.9 | 69 | 9.9 |
| 2.5–10 | 20–80 | 239 | 23.2 | 175 | 25.1 |
| >10 | >80 | 100 | 9.7 | 157 | 22.5[c] |
| Total | | 1 028 | 100.0 | 697 | 100.0 |

[a] After 1983, Land-use. Atlas of Australian Resources, Series 3, NATMAP, Canberra.
[b] A reflection of emphasis of prior surveys on National Parks and Wildlife Service and Forestry Commission estates.
[c] A reflection of the comprehensive nature of the 1986–87 survey which included rural landholders.




important category was medium trees of unspecified genera with greater than 70% cover (12.6% of 1949–85 records; 23.7% of 1986–87 records). This category includes associations of *Eucalyptus* and rainforest genera, which occur on the north and central coast and are often associated with creek and river valleys.

The majority of koala records (63.4% of 1949–85 records; 76.4% of 1986–87 records) were associated with land which supported medium to high grazing densities of both sheep and cattle (Table 7). Koalas found in non-agricultural land largely occurred within the Forestry Commission and National Parks and Wildlife Service estates.

Koalas were associated with grid cells containing the following known food trees: *E. tereticornis*, *E. microcorys*, *E. viminalis* var. *viminalis*, *E. punctata*



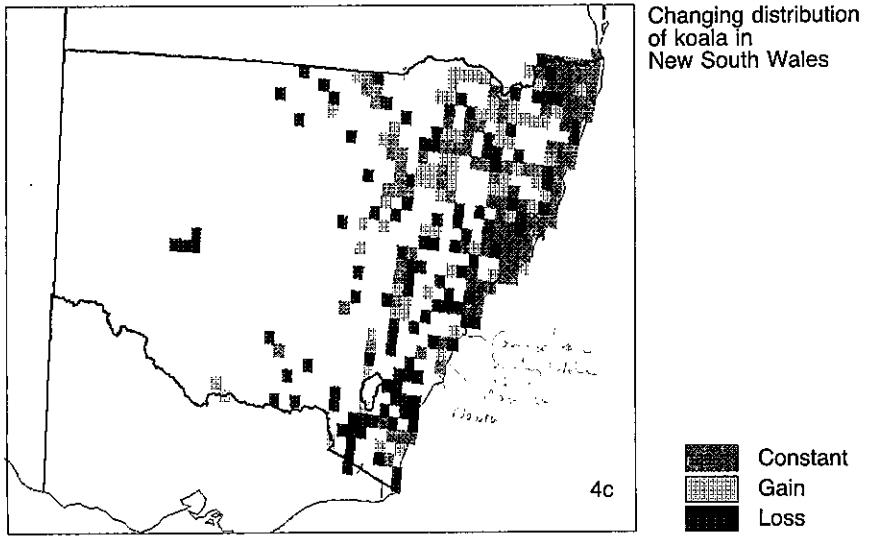



*Fig. 4.* The distribution of (a) top left, frequency of sightings and (b) bottom left, the health categories of koalas determined by the 1986–87 survey; and (c) above, the change in distribution of the koala determined from data gathered between 1949–85 and the 1986–87 survey.

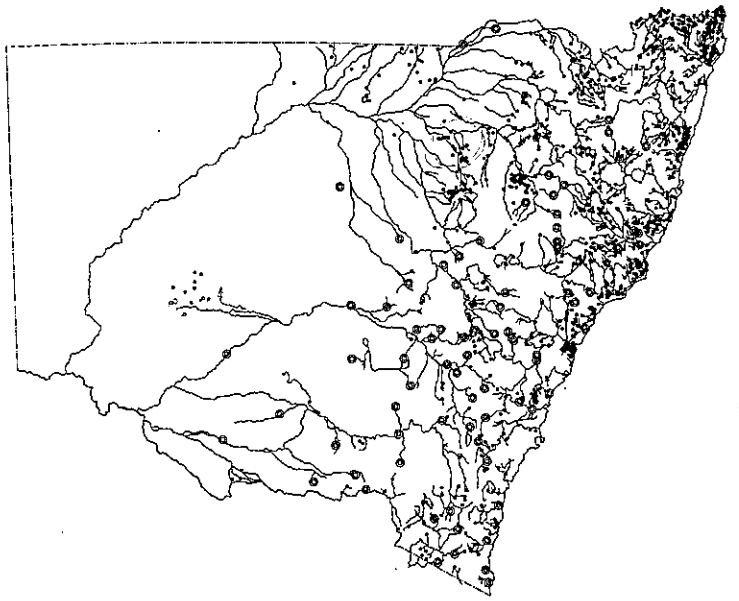


*Fig. 5.* Plot of all koala records 1949–87 (closed circles) and pre-1949 koala records (open circles) on the drainage system of New South Wales. (Drainage system supplied by Central Mapping Authority, New South Wales — Lambert's projection, 1:1 500 000.)

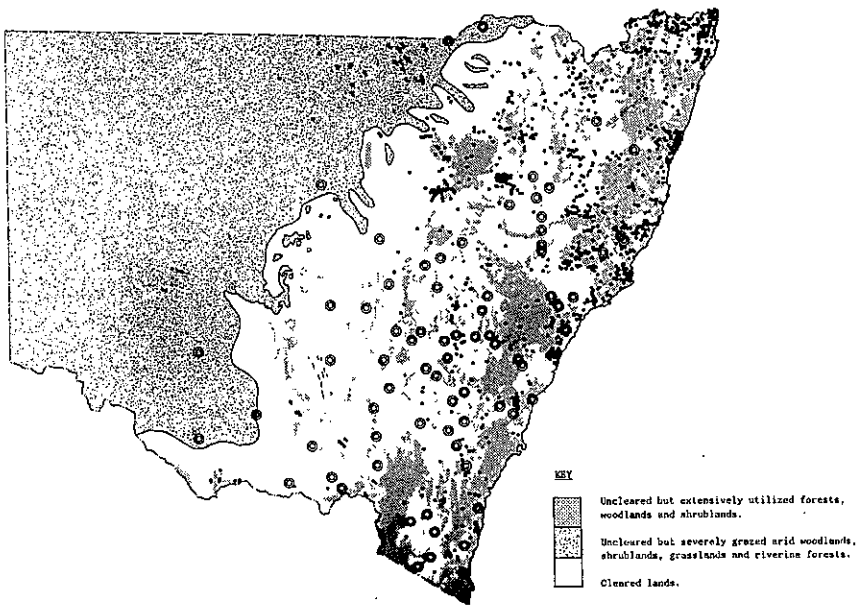



*Fig. 6.* Plot of all koala records 1949–87 (closed circles) and pre–1949 koala records (open circles) on the remnant native vegetation of New South Wales (after Benson 1987).

var. *didyma* and *E. camaldulensis* (Table 8). Apart from *E. camaldulensis,* the preceding species were all reported as important koala tree species during the contemporary survey.

Comparison of the records of koalas and the drainage system of the State (Fig. 5) shows that, with the exception of the north coast, records occurred principally near rivers and were frequently confined to their headwaters. Comparison of these records with remnant vegetation (Fig. 6) reveals that where the vegetation clearing has been greatest, on the western slopes and plains, the distribution of the koala is most scattered and the historical records predominate. The koala is sparsely distributed on the south coast compared with the north coast, despite a similar pattern of vegetation clearance on the north and south coasts. Comparatively few koala records occur in the largely continuous native vegetation of the Great Divide. The density of koala records is greatest on the north coast where much of the vegetation has been cleared. This is particularly noticeable in the Tweed and Richmond Valleys on the far north coast.

## DISCUSSION

### Distribution of the koala in New South Wales

The koala occurs principally on the central and north coast ranges and adjacent slopes. Concentrations of sightings occur on the north coast around Port Stephens, between Bulahdelah and Taree, at Port Macquarie and Coffs Harbour, and between Lismore and Tweed Heads. In addition, the 1975 and 1986–87 surveys show concentrations of sightings on the northern tablelands and the western slopes and plains. Its distribution is sparse and scattered on the north-west plains and the south coast.

Compared with previous surveys (1949 and 1975), the contemporary survey (1986–87) records a greater number of localities with koalas. The more extensive contemporary distribution suggests that the distribution of the koala was poorly known prior to the 1986–87 survey. However, the absence of koalas in areas where they were formerly present probably represents local extinction because the 1986–87 survey was more comprehensive. Thus, it may reasonably be concluded that since 1949 populations of koalas have been lost from many



localities throughout the State, particularly on the southern and western edges of their distribution.

On the south and central coast and ranges, koalas are rarely sighted even though much forest still remains (e.g., Braithwaite 1983; Lunney and Barker 1986; Newsome, Catling and Corbett 1983). For example, the extensive forests in and around Kosciusko National Park contain few post-war records of koalas. This suggests that this area was always, in historical terms, marginal koala habitat. Likewise, the rarity of koala records, recent or historical, from Royal, Morton, Blue Mountains and Wollemi National Parks and associated forests suggest that these forests contain only small areas of koala habitat. This points to a real north-south difference in the koala's distribution and suggests that in the southern part of its range in New South Wales, the koala was always more patchily distributed than in the north. This patchiness helps to explain why the koala population in the Bega valley during the nineteenth century (Lunney and Leary 1988) was vulnerable to land clearing.

### Koala abundance

Almost 73% of the frequency-of-sighting records in the 1986–87 survey were categorized as yearly or intermittent, suggesting that koalas occurred in low numbers in most areas. There were few areas with a large number of records and these were restricted to localities on the north coast, such as at Port Stephens, Port Macquarie, Coffs Harbour and Lismore. This suggests that these areas contain prime habitat. Since these localities are undergoing extensive rural or urban development, the numbers of koalas they support will decline. This has occurred elsewhere. For example, the koala population in the Sydney suburb of Avalon was noted as declining in the 1949 survey, and provided only infrequent sightings in the 1986–87 survey. This can be directly attributed to urban expansion.

### Tree species utilized

Koalas largely feed at night but the daytime occupancy of trees reliably predicts preference for food trees in free-ranging koalas (Hindell, Handasyde and Lee 1985). Thus the tree species in which koalas were recorded by Forestry Commission staff during the 1986–87 survey are assumed to be food trees utilized by the koala. This list of tree species, together with other lists for free-living koalas in New South Wales (Gall and Rohan-Jones 1978; Hawkes 1978; Clark 1983; Denny 1985) and unpublished data held by the National Parks and Wildlife Service, provides a summary of the tree species and forest types used by the koala (Table 9). Free-living koalas have been recorded in 55 of the 211 species and varieties of *Eucalyptus* listed by Chippendale and Wolf (1981) for New South Wales. Koalas have been recorded in 11 non-*Eucalyptus* species, which occur in association with some of the preferred *Eucalyptus.* The koala has not been recorded in *Eucalyptus* species of the mallee, shrublands, nor in strictly rainforest tree species.

Hindell (1984) found that the tree species in the Brisbane Ranges, Victoria, were not evenly distributed, and tended to occur in associations of two or three species whose distribution related to the fertility of soils. Also, the density of koalas was positively correlated with the *E. viminalis*-dominated associations. The most preferred species association, *E. viminalis-E. ovata,* generally occurred in the low-lying regions with deeper, more fertile soils, and especially along creek beds or gullies. In contrast, the less preferred *E. radiata, E. obliqua* and *E. macrorhyncha* were associated with shallow, poor soils on hilltops and steep slopes. Eberhard (1978) working on Kangaroo Island, South Australia, and Martin (1983) at Walkerville, Victoria, found an association between preferred tree species and water courses. Likewise, Gordon and McGreevy (1978) found that koalas in the dry country of central Queensland occurred most commonly along watercourses on *E. tereticornis* and *E. camaldulensis.*

The distribution of selected food trees was examined using the species groupings of Beadle (1981). The 55 *Eucalyptus* species can be divided geographically into those occurring principally on the coastal lowlands (27 species), highlands (17 species) and inland lowlands (11 species). Each division can be sub-divided into species groups or alliances (Beadle 1981) delimited by latitude, soil fertility and soil waterlogging on the coastal lowlands; by latitude, frost intensity, mean annual rainfall, soil fertility and moisture on the highlands; and by water availability on the inland lowlands. Braithwaite (1983) and Braithwaite, Turner and Kelly (1984) found that the arboreal marsupial fauna in the forests of the Eden Woodchip Agreement Area on the south coast of New South Wales was concentrated within minor portions of the forest that were rich in foliage nutrients. These portions in turn tended to occur only on geological formations recognized to produce higher nutrient soils. While an analysis of this association was not possible with the current data on koalas, the distribution of the selected food trees recorded in the present survey tends, in relation to the species grouping proposed by Beadle (1981), to suggest that this relationship is valid.

### Influence of land-use practices on koala food-tree distribution

Prior to the 1986–87 survey it was not possible to assess the variables influencing the distribution of the koala in New South Wales, either because

*Table 9.* Tree species recorded to have been utilized by free-living koalas within New South Wales. The grouping of tree species follows Beadle (1981) and within each of the coastal lowlands groupings, the soil fertility decreases from the top to the bottom of the list. Apart from the 1986–87 survey data, additional tree species data has been taken from Gall and Rohan-Jones (1978), Hawkes (1978), Clarke (1983), Denny (1985) and unpublished data held by National Parks and Wildlife Service.

| Region | Tree species | |
|---|---|---|
| | Alliance | Associated species |
| Coastal lowlands | *E. grandis* | |
| (High fertility soils) | *E. tereticornis* | *E. eugenioides, E. globoidea* |
| | *E. amplifolia* | *Angophora floribunda* |
| | *E. robusta* | *E. longifolia, Melaleuca quinquenervia, Casuarina glauca* |
| | *E. saligna* | *E. microcorys, E. dunnii, E. largeana, E. quadrangulata, Lophostemon confertus* |
| | *E. resinifera-E. acmenoides-E. propinqua* | *E. eugenoides, E. paniculata* |
| | *E. pilularis* | *E. microcorys, E. intermedia, E. pyrocarpa, E. saligna, E. paniculata, E. piperita, E. acmenoides, E. eugenioides, E. punctata, Angophora costata, Allocasuarina torulosa* |
| | *E. maculata* | *E. paniculata, E. agglomerata, E. globoidea* |
| | *E. moluccana* | *E. tereticornis* |
| (Low fertility soils) | *E. intermedia-E. acemenoides* | *Lophostemon suaveolens, Angophora costata* |
| | *E. sieberi-E. piperita-E. racemosa* | *E. agglomerata* |
| | *E. globoidea* | *E. sieberi* |
| Species typical of the sandstones | | *E. punctata, E. globoidea, E. sieberi, E. racemosa, E. piperita, E. eugenioides, E. haemastoma, Angophora costata* |
| Highlands | *E. pauciflora* | *E. acaciiformis, Acacia melanoxylon* |
| | *E. stellulata* | |
| | *E. obliqua-E. fastigata* | *Acacia melanoxylon* |
| | *E. viminalis-E. rubida* | |
| | *E. cypellocarpa* | |
| | *E. dalrympleana* | |
| | *E. radiata* | *E. acaciiformis, E. dalrympleana, E. piperita, E. sieberi, E. viminalis, E. cypellocarpa, Acacia melanoxylon, A. mearnsii* |
| | *E. macrorhyncha-E. rossii* | *Angophora floribunda, Brachychiton populneum* |
| | *E. andrewsii* | *E. caleyi, E. nicholli* |
| Inland lowlands | *E. melliodora-E. blakelyi* | |
| | *E. albens* | *Brachychiton populneum* |
| | *E. populnea* | *Callitris columellaris, Brachychiton populneum, Casuarina leuhmanii* |
| | *E. camaldulensis* | |
| | *E. microtheca* | *E. largiflorens* |
| | *E. largiflorens* | *E. microtheca, Casuarina leuhmanii* |
| | *E. creba* | *Callitris columellaris* |
| Additional species which occur over wider geographic range: | | *E. dealbata, E. bridgesiana, E. goniocalyx* |

of the inadequacy of records (e.g., Marlow 1958), or the coverage of the survey (Gall 1978; Gall and Rohan-Jones 1978). The 1986–87 survey remedied this lack of information by surveying all categories of land tenure and brought to light the importance of farmland for koalas since only 24% of koala sightings were in National Parks, Nature Reserves or State Forests.

At the time of European settlement the area of forest and woodland (tall and medium height trees shading 10% or more of the ground) was 447 820 km$^2$ or 56% of the land area of New South Wales (Wells, Wood and Laut 1984). Of this, at least 283 240 km$^2$ (63%) has since been cleared or severely modified and the remaining area partially modified by grazing, forestry and/or recreational activities (Wells, Wood and Laut 1984). Since most of the clearing of forests and woodlands for agriculture had occurred by 1949, the absence of the koala from many areas of the State may be due to historical land clearing of preferred food-trees. For example, the limited occurrence of koalas from the extensively cleared north coast river valleys and their persistence in the forested lands edging the valleys, suggest a distribution resulting from land clearing during early settlement.

Calaby (1966) found koalas to be uncommon in the upper Richmond and Clarence Rivers region where considerable areas of the tall *Eucalyptus* woodland had been cleared for both dairy and beef cattle grazing. The management plans for forests associated with the Tweed River (Anon. 1984), Bellinger River (Anon. 1982a), Camden-Haven River (Anon. 1982b) and Manning River (Anon. 1985) state that the forested lands considered unsuitable for agriculture, being the the poorest soil types, the least arable and/or having the most rugged topography, were left uncleared. These areas largely became state forests. The 1986–87 survey showed that koalas were recorded as uncommon in all these remaining forests. This suggests that the nutrient-rich forested valley country, which became the cleared rural lands, contained the prime koala habitat. Indeed, the persistence of koalas in areas with high levels of stock grazing supports this view.

Martin (1985c) suggested that prior to European settlement the lowland coastal forests of Victoria, with their milder climate and greater abundance of preferred food species, supported higher population densities of koalas than the tall, inland forests. Govatt (1836) reported that koalas were "numerous on the ranges leading to Cox's River, below the mountain precipices, and also in the ravines which open into the Hawkesbury River." Gould (1863) reported that "although nowhere very abundant . . . it is in the brushes which skirt the sea side of the mountain-ranges between the district of Illawarra and the River Clarence that it is most numerous; here among the branches of the great trees, the koala remains sleeping during the daytime." Warneke (1978) believes that Gould's comments should not be lightly dismissed, as Gould was dedicated to his work, a patient observer, and penetrated well beyond settlement into areas of unspoiled forest. A currently widely accepted view is that the koala was rare prior to 1800, then built up following the decline of Aborigines and dingoes, only to be sharply reduced by the fur trade (Lee and Martin 1988). In their study of the Bega Valley, Lunney and Leary (1988) drew the conclusion that, in addition to these factors, the major impact on koalas was the continued nineteenth century land clearing which took almost all of the arable land. These examples show the importance of including historical records when interpreting the distribution of the koala. Viewing koala distribution from an historical perspective allows the conclusion to be drawn that the koala population in New South Wales has suffered a major contraction of range since European settlement and will contract further as remaining localities continue to be modified by land clearing, fire, continued stocking and urban expansion. Isolation and habitat modification compounds the koala's natural hazards, such as drought (Le Souef and Burrell 1918; Braysher 1978; Gordon, Brown and Pulsford 1984), stormy wet weather (Gordon and McGreevy 1978), fire (Philpott 1965; Lunney and Leary 1988) and disease (Canfield 1987; Lee and Martin 1988).



### The health of koalas in New South Wales

Healthy koalas were reported over 91.8% of the koala's range. There was no systematic pattern in locations where sick or diseased koalas were recorded. The survey, accordingly, was unable to provide information on the relationship between the location of diseased koalas and their habitat. The much publicized issue of disease, however, may have less impact on koala numbers than the human-induced factors. The incidence of disease in free-living populations has been studied at only a few localities in New South Wales. During a survey of the incidence of keratoconjunctivitus (caused by *Chlamydia psittaci*) between December 1975 and June 1976, Cockram and Jackson (1981) found that 5% of koalas observed at Lismore and no koalas from Port Macquarie showed evidence of this disease. In contrast, Canfield (1987) reported that the mortality levels associated with motor vehicle accidents represented 30% of the overall mortality within koala populations in the vicinity of Port Macquarie. Likewise, Lee and Martin (1988) found motor vehicles and dogs accounted for 60% and 6% respectively of the mortality on Phillip Island. Furthermore, Canfield (1987) found that most of the koalas killed by motor vehicles had no underlying disease. This suggests that human-induced mortality is more important than disease in the mortality of koalas.

### Management implications

Analysis of data from the 1986–87 survey suggests that the distribution of the koala is related to the presence of preferred food trees, and that the koala primarily lives in trees growing on nutrient rich soils. Historically, forests with these soil types have been selected and cleared for agriculture. It is also clear that conservation of the koala cannot be achieved through further dedication of National Parks, Nature Reserves or State Forests on non-arable land. The area of National Parks and Wildlife Service estate has increased from 18 524 km$^2$ to 35 638 km$^2$ between the 1975 and 1986–87 surveys without an equivalent increase in the number of areas providing sightings of koalas. The key to managing the koala will be to conserve it within its preferred locations, namely the now largely degraded or cleared valleys of the east coast, ranges and tablelands and along the watercourses of the western slopes and plains. This requires adequate conservation of plant communities (alliances) containing the koala's preferred tree species where these alliances are poorly conserved or threatened (see Specht, Roe and Boughton 1974 and Benson, 1989). Thus, the conservation of the koala requires the support of the community, particularly the rural community which manages 79% of the area of New South Wales.

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# APPENDIX 1

## 1949 NEW SOUTH WALES KOALA SURVEY BY THE FAUNA PROTECTION PANEL

Only one copy of this report has been located and is held by V. Serventy (Wild Life Preservation Society of Australia). It was referred to in the report of the Fauna Protection Panel to the Parliament of New South Wales for the year ended June 30, 1950 (Anon. 1951) and is quoted in full below, with the kind permission of Vincent Serventy.

**'Koala Survey**

In October, 1949, the Panel decided to conduct a state-wide survey with the object of ascertaining the approximate koala population and distribution. As far as is known such a survey had never been made previously and estimates made during the past 20 years of the number of koalas in New South Wales ranged from 100 to 5 000.

**Method**

Press: The campaign began with a statement issued by the Chief Secretary. Following this, publicity was obtained whenever possible in the metropolitan press, periodicals and country newspapers.

Radio: Publicity for the campaign was given by the ABC News Service, in the Nature Speaks Session through 2GB, by Mr Kinghorn in his talks to schoolchildren and by Mr Colefax in the ABC Argonauts Session.

Official: All police stations were circularized by the Commissioner of Police who asked for reports of colonies of koalas.

Schoolteachers were notified of the survey by notice in the Education Gazette.

Circulars were sent to 46 Land Inspectors, 277 Field Officers of the Department of Agriculture, 373 Forestry Officers and 57 Pastures Protection Boards.

**Response**

One hundred and nine reports of the location of koala colonies were received from the following sources:

| | |
|---|---|
| Press reports | 6 |
| Nature Speaks Session | 20 |
| Argonauts Session | 8 |
| Mr Kinghorn's talks | 16 |
| Lands Department Officers | 3 |
| Police | 1 |
| Schools | 3 |
| Agriculture Department Officers | 20 |
| Forestry Officers | 22 |
| Origin unknown | 10 |
| Total | 109 |

In addition to the above replies which actually reported the whereabouts of koalas, a number of letters were received containing information of assistance in determining the previous distribution of the koala and the possible reasons for its decline.

**Distribution**

The accompanying map (now redrawn as Fig. 2a) shows the present distribution of the koala as indicated by the survey.

It can be seen that the koala is fairly well distributed along the North Coast and Tablelands from Newcastle to the Queensland border. Around Sydney there are a number of colonies, the most numerous being on the Barrenjoey Peninsula. There are also a few colonies on the South Coast and Tablelands and one apparently isolated colony in the Snowy River area.

The greatest density occurs on the far North Coast as there are reports from 26 localities north of the Clarence River.

**Population**

While the survey may have established fairly reliably the distribution of the koala it has not resulted in the acquisition of any accurate information as to the number of koalas in the State. This was to be expected as the koala is a forest dweller and a nocturnal animal, seldom seen during the daytime and difficult to locate by anyone unfamiliar with its habits.

Most of the reports merely stated that koalas were present in a certain locality and made no attempt to estimate the number. In some cases, however, colonies of considerable size were reported. The Stock Inspector at Lismore reported a colony of 50 at Bingel Creek, near Wardell, while the District Forester at Casino thinks there may be up to 40 in the Urballa State Forest, near Alstonville.

A letter from a resident of Nowendoc, near the headwaters of the tributaries of the Manning River, reported that there were probably 1 000 koalas within a radius of 10 miles of the village. However, a Forestry Officer estimated that the number in the same area was 15.

Summarizing the reports received, all that can be said is that there appear to be some thousands of koalas at present in the State.

**Previous Distribution**

Reports received during the survey have not given a great deal of information about the one-time distribution of the koala but do indicate that it was more widely distributed than it is today.

It would appear that koalas lived farther west than they are found now and were probably widely distributed east of a line drawn from Mungindi through Coonamble, Parkes and Cootamundra to Albury.

**Further Enquiries**

Although the survey has resulted in the acquisition of a good deal of useful information, it would be desirable to carry out a good deal of field work to supplement this.

For instance, we need to learn the varieties of eucalyptus trees used as food in each area and what variations there are in this respect.

If it is hoped to restore the koala to areas where it once lived, thorough inspection of those areas would be necessary to ascertain whether conditions are now suitable.'