REPORT ON THE 1993 AERIAL SURVEY OF KANGAROOS IN WESTERN AUSTRALIA

by

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November 1993

Jointly funded by the Australian Nature Conservation Agency and the Western Australian Department of Conservation and Land Management.

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Summary

1. An aerial survey was conducted over 35% of Western Australia in June-August 1993, with the aim of estimating the distribution and abundance of Red and Western Grey Kangaroos and comparing the results with similar surveys undertaken in 1981, 1984, 1987 and 1990.

2. Data on Euros, Emus and Goats were also recorded and analysed.

3. Standardised methodology used over the period 1981-90 was again employed in the 1993 survey, but additional data enabling line transect analysis of sighting data were recorded in the northern regions of the survey area for comparison against standard analytical methods.

4. As in previous years, overall population estimates and degree block estimates are presented. In addition, analysis of data by management zone over the period 1984-93 are presented.

5. In previous reports no estimates of precision for the overall population estimates have been provided because transect lines were not always replicated within degree blocks. Approximate sampling errors have been calculated in these instances using pseudoreplication by splitting single lines into pairs of half-lines. Sampling errors for the 1987-93 surveys are presented in this report.

6. There were estimated to be 1,362,700±90,200 Red Kangaroos in the area surveyed in 1993. Red Kangaroo population estimates are relatively precise (CV's 6-7%) enabling changes in the order of >20% to be detected with confidence. Red Kangaroo populations have declined by approximately 40% since 1990, following increases over the period 1981-87.

7. There were estimated to be 433,800±170,900 Western Grey Kangaroos in the area surveyed in 1993. This estimate would be conservative, considering current knowledge on sightability of Grey Kangaroos. Low precision in Western Grey Kangaroo population estimates hinders confidence in inferences about long-term trends. Over the period 1981-93 Western Grey Kangaroos appear to have been present in roughly similar numbers.

8. Uncorrected aerial survey counts of Euros are extremely negatively biased due to low sightability of the species from the air. Sighting data indicate that Euros remain broadly distributed throughout the survey area.

9. The population of Emus in the survey area for 1993 was estimated to be 219,700±24,200. Emu populations have increased steadily since 1984.

10. The minimum number of Goats estimated to be in the survey area in 1993 was 447,500±39,400. Following population increases over the period 1987-90, Goat populations have declined by 25% from 1990 to 1993.

11. Recommendations for the design of future aerial surveys in Western Australia are given.

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INTRODUCTION

In 1981 Short *et al.*(1983) conducted an aerial survey of 61% of Western Australia to assess the distribution and abundance of the Red Kangaroo (*Macropus rufus*) and Western Grey Kangaroo (*M. fuliginosus*). The data also contributed to a national census of kangaroo populations (Caughley *et al.* 1983).

Similar broad-scale surveys have subsequently been carried out, on a slightly reduced scale and on a tri-ennial frequency, by ANCA in collaboration with CALM. Surveys in 1984, 1987, 1990 and 1993 have each covered approximately 40% of the state (some areas originally surveyed in 1981 have not been repeated because kangaroo abundance and harvesting there was zero or negligible (mostly the Great Sandy and Gibson Desert areas) or because the density and height of trees made aerial survey inappropriate (the south west)).

The 1984, 1987 and 1990 surveys have been reported in Fletcher and Southwell (1984), Fletcher and Southwell (1989) and Southwell *et al.* (1990) respectively.

In the 1981 and 1984 surveys only data on Red and Western Grey Kangaroos were reported, although information on other visible species were recorded. In the 1987 and 1990 surveys additional data on the Euro (*M. robustus erubescens*), Emu (*Dromaeus novaehollandiae*), Dingo (*Canis familiaris dingo*) Bustard (*Ardeotis australis*) and feral animals ((Donkey (*Equus asinus*), Camel (*Camelus dromedarius*), Goat (*Capra hircus*, Fox (*Vulpes vulpes*), Cat (*Felis catus*) and Pig (*Sus scrofa*))) were collected. Data for all these species were analysed and reported for the 1987 survey (Fletcher and Southwell 1989), but the report on the 1990 survey presented data for only two auxiliary species (the Emu and Goat) because sightings of other species were too low to justify detailed analysis. Data on Euro sightings, although sparse, were also included in the 1990 report as this species is also subject to commercial harvesting in Western Australia.

In this report on the 1993 survey, data for Red Kangaroos, Western Grey Kangaroos, Emus, Goats and Euros are presented as in the 1990 report. In addition to the 1993 data, long-term trends over the period 1981-93 in the area common to all five surveys, and 1984-93 trends in management zones, are analysed and presented.

METHODS

Survey area

The 1993 survey covered 102 1°x1° blocks ('degree blocks'). This represents an area of 1,041,958 km^2, or 35% of the state. A slightly larger proportion of the state (45%) was surveyed in 1984, 1987 and 1990. The 1984, 1987, 1990 and 1993 surveys were largely but not entirely coincident with each other in area (Fig.1). The 1981 survey was larger in extent than the later surveys, covering 61% of the state (Fig. 1). The more recent surveys were less extensive than in 1981 because some areas surveyed in 1981 had negligible kangaroo and harvest densities (the Great Sandy Desert to the north of the state), or because some areas had tree densities or heights which rendered aerial survey inappropriate (the south west).

Survey details

The 1993 survey was conducted in two sessions from 4 May-18 June 1993 and 13-23 August 1993. The survey crew comprised four observers (T. Scotney, C. Southwell, K. Weaver and G. Wyre) and one pilot (T. Olsen).

As in previous surveys a light aircraft (Cessna 206) was flown at height 250 ft and speed 100 knots along transects placed systematically within degree blocks. A total of 188 transect lines were flown within the 102 sampled degree blocks; two lines were flown in 86 blocks and one line in 16 blocks.

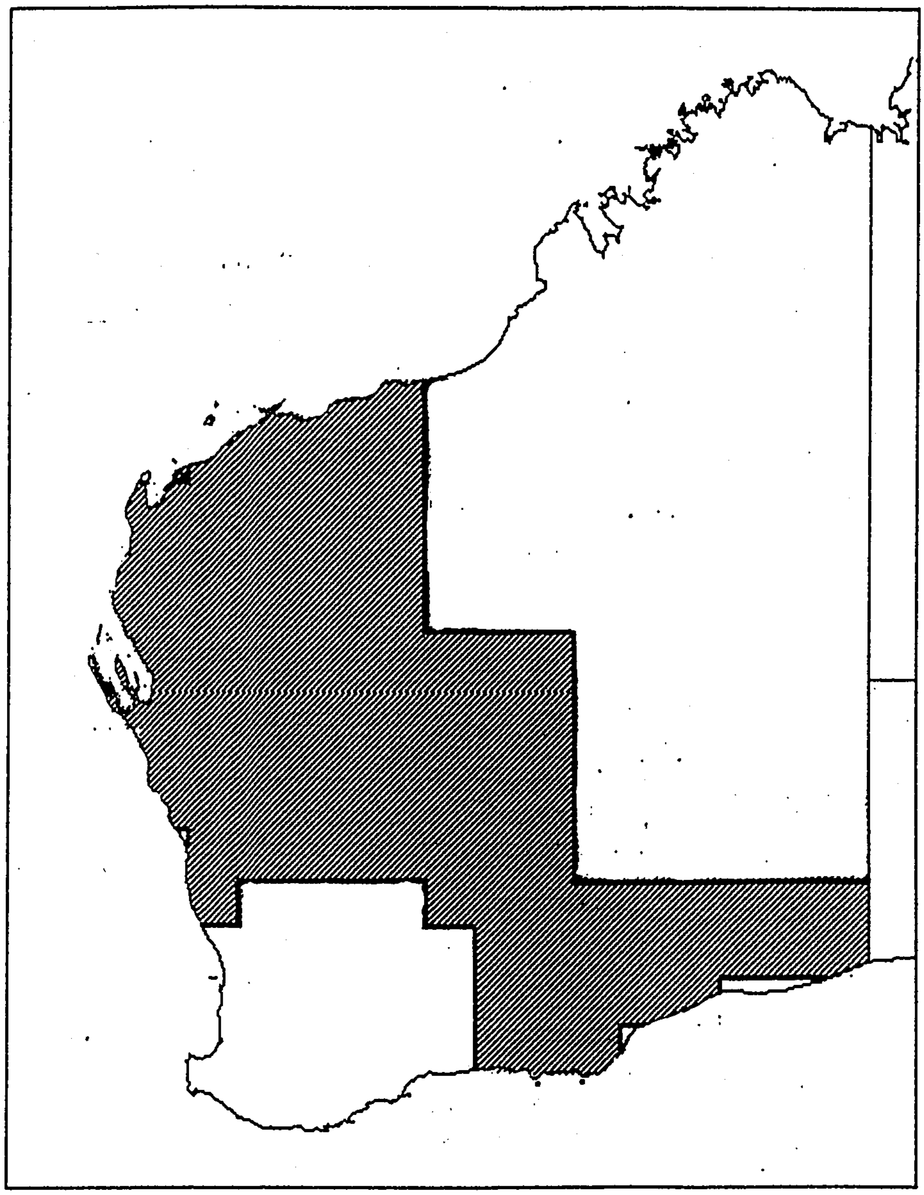
In previous surveys a strip transect methodology was used for data collection and analysis. This method was again applied throughout the 1993 survey, but during the second survey session in August additional data enabling line transect analysis were recorded.

In the strip transect method the transect is divided into 97 second 'segments' (5 km lengths), and the numbers of animals seen within a 200 m strip on either side of the plane are recorded for each segment. Vegetation within the segment is recorded on a 4-point scale (open, light, medium and dense), and the auxiliary variables of temperature, cloud cover and time of day are recorded at the beginning and end of each transect. In past years the strip has been delineated by a streamer attached to the wing strut. In 1993 a fibreglass rod was attached to the strut, providing a more stable border to the strip.

Collection of line transect data was achieved by placing two additional rods on the strut to delineate 0-50 m, 51-100 m, and 101-200 m sub-strips. Whereas in the strip transect method an animal was simply recorded as in or out of the 200 m strip, in the line transect method its position within the 200 m strip, as one of the three sub-strips, was recorded. This required use of a microcassette recorder to call sightings as they occurred, as the additional data recording overloaded the traditional recording procedure of tallying in the head throughout a segment. Apart from the use of a cassette recorder, and the pattern of scanning the sub-strips (see below), other data recording procedures did not vary from strip to line transect methods.

The scanning pattern was important to line transect data collection. In the strip transect method there was no attempt to standardise the scanning pattern, but generally the observer would repeatedly scan across the strip from inner to outer to inner borders. In the line transect method it is important that each sub-strip receives equal attention so that the probablility of sighting an animal is a function only of its distance (i.e. sub-strip) from the observer. From timing the passage of objects past the observer in each of the sub-strips, it was found that objects in the inner-most strip passed by almost twice as quickly as objects in the outer-most strip. To ensure equal attention (time scanned/unit area) to each sub-strip, it was necessary for the time spent scanning each strip to be approximately inversely proportional to the time they are available for sighting. The scanning pattern therefore adopted was to scan along the inner strip from forward to back, return back

Figure 1. Area surveyed in 1993.



along this strip to a forward viewing position, scan back along the middle strip, forward along the outer strip, and then repeat the process.

Data analysis

'Standard' analysis

The strip transect data have been analysed using 'standard' analytical procedures as in previous surveys and reports. Counts of Red and Western Grey Kangaroos were corrected for vegetation visibility bias using the correction factors derived for Red Kangaroos by Caughley *et al.* (1976) (in the appendices these are referred to as 'Caughley' correction factors). While there is now considerable evidence that these correction factors substantially underestimate Western Grey Kangaroo populations (Short and Bayliss 1985, Short and Hone 1989), continued use of the correction factors ensures comparability of survey results from present to earlier surveys until alternative analytical methods are finalised.

A single study on sightability of Euros (Short and Hone 1989) confirmed the subjective opinion that Euros are very difficult to see during aerial survey. In the relatively open habitat of their study area Short and Hone found that less than 1 in 10 Euros were sighted during standard kangaroo surveys. In this report only observed (uncorrected) densities of Euros are given.

Observed densities of Emus were multiplied by 1.47 to correct for visibility bias. This correction factor was originally calculated for groups of Emus (Caughley and Grice 1982) but can be applied to individuals if it is assumed that all individuals within a sighted group are tallied. Caughley and Grice (1982) estimated this correction factor during the 1981 aerial survey of Western Australia.

No work on correction factors for Goats has been conducted. Population estimates presented in this report are uncorrected and therefore represent minimum estimates.

Following correction (for some species) for vegetation visibility bias, degree block estimates of population density and size, and their standard errors, were obtained using the simple method (Caughley 1977) for equal length transects and the ratio method (Cochran 1953) when transects were of unequal length. For the 16 transects in which only a single transect was flown, density and standard error were calculated using pseudoreplication by splitting each single line into a pair of half-lines. An overall estimate of population size and its variance for the survey area was then calculated by summing estimates and variances across degree blocks.

The overall estimates of population density and size, and the individual degree block estimates, are of limited use for management. Of greater use are estimates for management zones (Fig. 2). To allow such estimation ANCA contracted a consultant to write a program for management zone estimation (Cairns 1991). By providing the locations of management zone boundaries, this program identifies all the transect segments to a management zone and calculates estimates of population size and density using the same methods as described above. Thus in this report both degree block and management zone estimates of population density and size are given.

Additional analyses

Two forms of additional analyses are presented in this report.

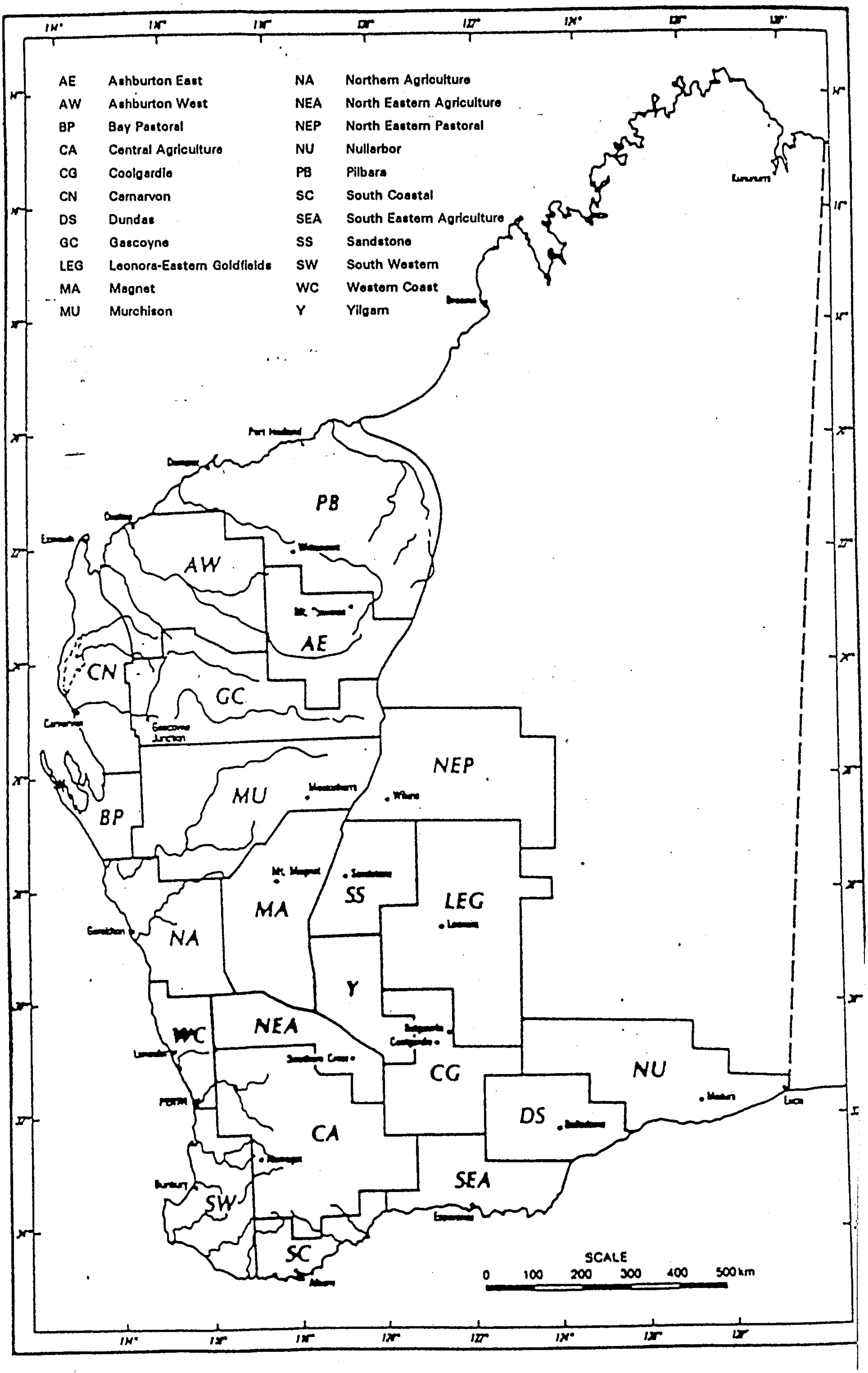
One is a comparison population estimation in relation to the side of the plane, not as left or right side, but in relation to 'good' and 'poor' visibility. Standard aerial survey uses two observers, one on each side of the plane. In sunny conditions, when aerial survey is generally conducted, visibility is invariably better for one observer than the other, and this is related to the position of the sun relative to the observer. Visibility is better when the sun is behind the observer and shining onto the animals than when it is in front of the observer. Thus for east-west transects the south side of the plane will generally have better visibility than the north side. For north-south transects the west side would have better visibility than the east side in the morning, but the reverse would be true for the afternoon. For each transect the visibility conditions for each of the two observers were classified as 'good' or 'poor' according to the side of the plane they were on, the direction of the transect, and the time of day (Table 1). Estimates of population density and size were then calculated separately for the 'good' and 'poor' sides of the plane using the standard analytical methods descibed above for those areas common to all surveys for the years 1990 and 1993 .

Table 1. Categorising visibility according to side of plane, direction of flight and time of day.

Side of plane	Direction of travel	Time of day	Visibility category
Left	East-west	Morning or afternoon	Good
Right	East-west	Morning or afternoon	Poor
Left	West-east	Morning or afternoon	Poor
Right	West-east	Morning or afternoon	Good
Left	South-north	Morning	Good
Right	South-north	Morning	Poor
Left	South-north	Afternoon	Poor
Right	South-north	Afternoon	Good
Left	North-south	Morning	Poor
Right	North-south	Morning	Good
Left	North-south	Afternoon	Good
Right	North-south	Afternoon	Poor

The second additional analysis used the line transect data to calculate population density. The program DISTANCE (Laake et al. 1993) was used to estimate population density from line transect data. The number of animal clusters (or social groups) in each of the 3 distance categories was tallied and used as 'grouped' data in the program. Density of clusters was first estimated, then individual density was calculated as the product of estimated cluster density and mean cluster size. Cluster data were analysed in preference to individual data because Red Kangaroos, Emus and Goats are gregarious, and there is less dependence between cluster sightings than individual sightings (Buckland et al. 1993). If DISTANCE detected significant size-bias in the estimation of mean cluster size, an estimate of expected (unbiased) cluster size was computed and used for calculating individual density; otherwise the observed mean cluster size was used. The Akaike Information Criterion was used to select the 'best' model. Most surveying in the second session occurred in areas with open or light vegetation, hence the line transect analyses are relevant to these vegetation covers only.

Figure 2. Map of management zones in Western Australia.



RESULTS

Population estimates and trends using 'standard' analysis

Red Kangaroo

The estimated densities and numbers of Red Kangaroos in each degree block surveyed in 1993 are presented in Appendix 2. For 1981, 1984, 1987 and 1990 data readers are referred to Short *et al* (1983), Fletcher and Southwell (1984), Fletcher and Southwell (1989) and Southwell *et al.* (1990). Table 2 gives population estimates for the entire area surveyed in each of the five surveys and for the area common to all surveys. Estimated densities and numbers of Red Kangaroos by management zone are given in Appendices 7-10, and population trends over the period 1984-93 for the area common to all surveys and for management zones are illustrated in Figs. 3-19.

The Red Kangaroo population in the survey area in 1993 was estimated to be 1,362,700±90,200. The small coefficient of variation (CV) for this estimate (6.6%), which is of similar magnitude to CV's of previous years (7.6% for 1987, 7.0% for 1990), should enable changes in the order of >20% to be detected as significant with 95% confidence. The estimated population in the 93 blocks common to all 5 surveys declined by 41% from 1990 to 1993. The long-term trend in these common blocks shows an increasing population from 1981-87, a stable population from 1987-90, and a declining population from 1990-93. The current population is now approximately 40% higher than in 1981 when the first aerial survey was conducted.

When the data are broken down by management zone there is a substantial loss of precision on population estimates, which could to some extent mask the real trends. Averaged across the years 1984-93, only 2 management zones have CV's of <15% (North East Pastoral and Leonora-Eastern Goldfields). The majority of zones have average CV's of 20-30%, and two zones (Bay Pastoral and Yilgarn) have average CV's of >40%. The overall decline from 1990-93 is evident in several of the management zones (notably Ashburton West, Gascoyne, Leonora-Eastern Goldfields, Magnet, Murchison, North East Pastoral and Sandstone), but other zones were relatively stable over this period (Ashburton East, Bay Pastoral, Carnarvon, Coolgardie and Yilgarn) or had increasing populations (Pilbara).

Western Grey Kangaroo

The estimated densities and numbers of Western Grey Kangaroos in each degree block surveyed in 1993 are presented in Appendix 3. For 1981, 1984, 1987 and 1990 data readers are referred to Short *et al* (1983), Fletcher and Southwell (1984), Fletcher and Southwell (1989) and Southwell *et al.* (1990). Table 2 gives population estimates for the entire area surveyed in each of the five surveys and for the area common to all surveys. Estimated densities and numbers of Western Grey Kangaroos by management zone are given in Appendices 11-14, and population trends over the period 1984-93 for the area common to all surveys and for management zones are illustrated in Figs. 3-19.

The Western Grey Kangaroo population in the survey area in 1993 was estimated to be 433,800±170,900. The large CV for this estimate (39.4%) is higher than for previous years (24.6% for 1987, 13.6% for 1990), but even these smaller CV's are such that small changes in populations could not be detected with confidence. The long-term trend could be strongly masked by the large sampling errors. The apparent increase then decline over the period 1987-93 may be an artefact of a spurious result in 1990, where two blocks in which only a single line was flown accounted for nearly half the estimated population for the entire survey (Southwell *et al.* 1990). Taking into account this result, and the large sampling errors, the best inference that can be drawn from the long-term

Table 2. Population estimates for the Red Kangaroo, Western Grey Kangaroo, Emu and Goat in 1981, 1984, 1987, 1990 and 1993 in entire survey areas and in areas common to all surveys.

	1981	1984	1987	1990	1993
All areas surveyed					
Red Kangaroo	969,000	1,731,300	2,335,900±177,500	2,365,500±165,600	1,362,700±90,200
Western Grey Kangaroo	458,700	523,000	691,000±167,500	1,069,100±145,600	433,800±170,900
Emu	-	63,200	96,000±12,900	172,200±35,600	219,700±24,200
Goat	-	-	365,900±44,100	651,300±42,200	447,500±39,400
Commonly surveyed areas					
Red Kangaroo	902,200	1,462,200	2,097,900±161,800	2,095,100±148,300	1,246,300±87,900
Western Grey Kangaroo	354,100	376,500	473,100±153,900	985,800±145,000	432,200±170,900
Emu	-	54,900	76,900±10,300	160,300±34,900	198,700±23,400
Goat	-	-	363,100±44,000	591,100±40,600	443,200±39,000

data is that Western Grey Kangaroos have been present in roughly similar numbers over the period 1981-93.

The population estimates for management zones have very low precision (average CV across years 1984-93 >50% for most zones) making inferences about trends within zones very difficult.

Euro

Appendix 4 gives observed densities and mimimum numbers of Euros for each degree block surveyed in 1993. Observed densities by management zone are given in Appendices 15-17.

Because of the low number of sightings, density and population estimates are very imprecise. As stated in the methods section, density and population estimates are extremely conservative due to very low sightability of the species and the fact that no correction factors have been applied to raw counts. As in previous years, Euro sightings were widely distributed throughout the survey area.

Emu

The estimated densities and numbers of Emus in each degree block surveyed in 1993 are presented in Appendix 5. For 1981, 1984, 1987 and 1990 data readers are referred to Short *et al* (1983), Fletcher and Southwell (1984), Fletcher and Southwell (1989) and Southwell *et al.* (1990). Table 2 gives population estimates for the entire area surveyed in each of the five surveys and for the area common to all surveys. Estimated densities and numbers of Emus by management zone are given in Appendices 18-21, and populations trends over the period 1984-93 by management zone are illustrated in Figs. 3-19.

The Emu population in the survey zone in 1993 was estimated to be 219,700±24,200 (CV 11.0%). The long-term trend shows a steady increase throughout the period 1981-93. Current populations are estimated to be 262% higher than in 1984.

Goat

The estimated observed densities and minimum numbers of Goats in each degree block surveyed in 1993 are presented in Appendix 6. For 1981, 1984, 1987 and 1990 data readers are referred to Short *et al* (1983), Fletcher and Southwell (1984), Fletcher and Southwell (1989) and Southwell *et al.* (1990). Table 2 gives population estimates for the entire area surveyed in each of the five surveys and for the area common to all surveys. Estimated observed densities and minimum numbers of Goats by management zone are given in Appendices 19-21, and populations trends over the period 1984-93 for the area common to all surveys and for management zones are illustrated in Figs. 3-19.

The minimum number of Goats in the survey zone in 1993 was estimated to be 447,500±39,400 (CV 8.8%). The CV for this estimate is close to that for Red Kangaroos, and the precision for previous estimates is similarly low (12.1% for 1987, 6.5%for 1990). The long-term trend throughout the survey area indicates an increase in populations from 1987-90, followed by a decline from 1990-93. Current populations levels are estimated to be 22% higher than in 1987.

Figure 3. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in areas common to all surveys.

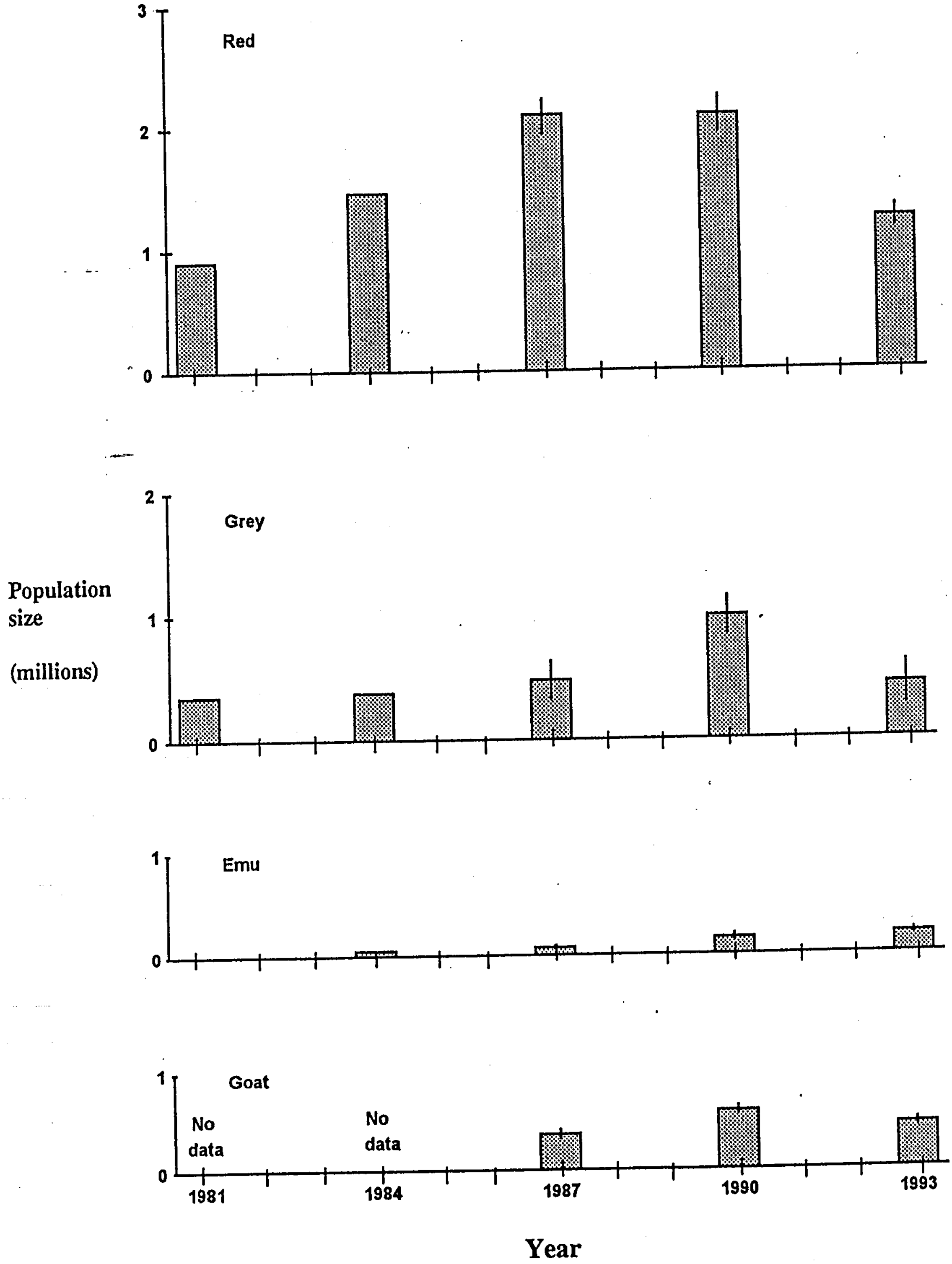


Figure 4. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat Populations in the Ashburton East management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

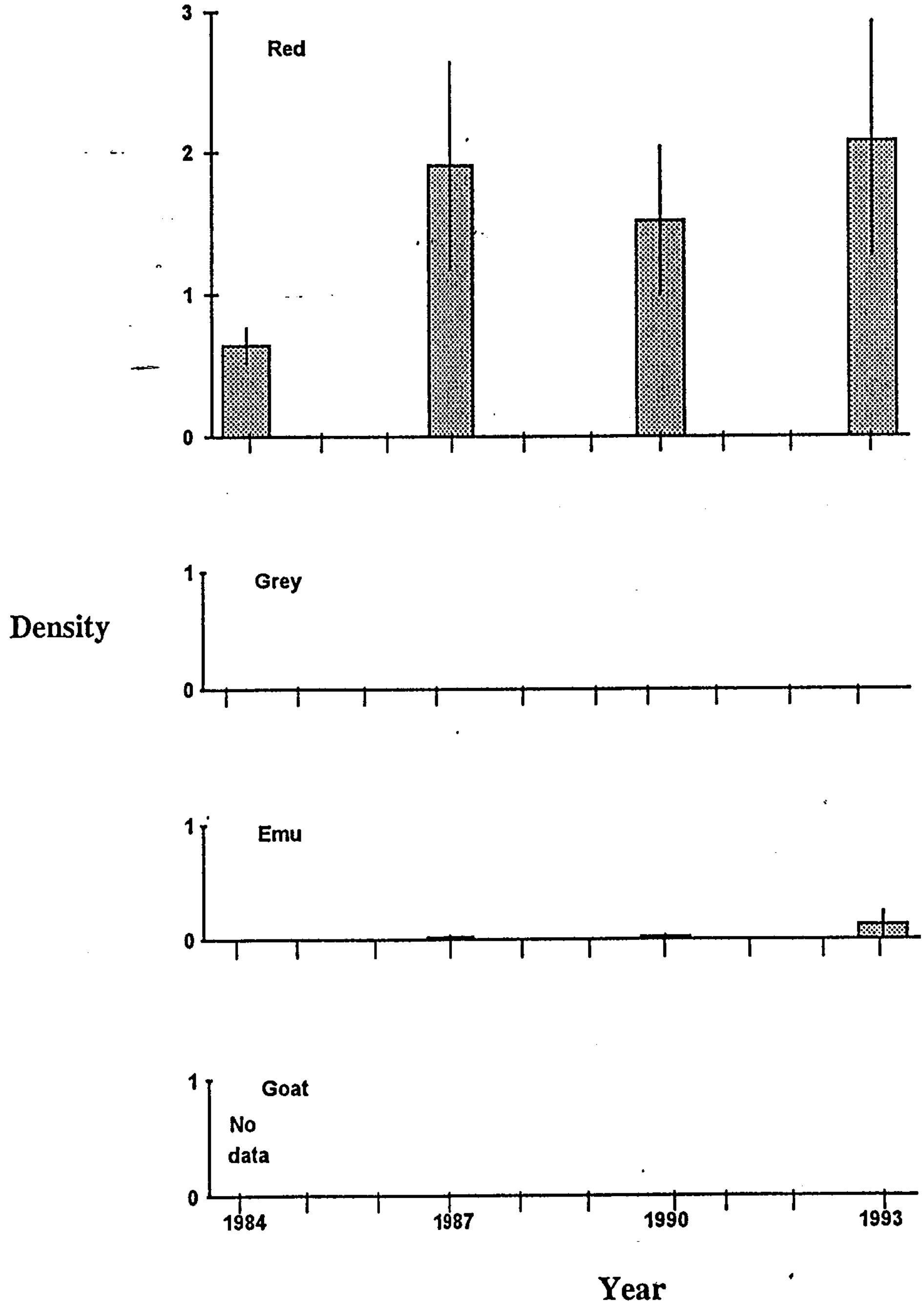


Figure 5. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Ashburton West management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

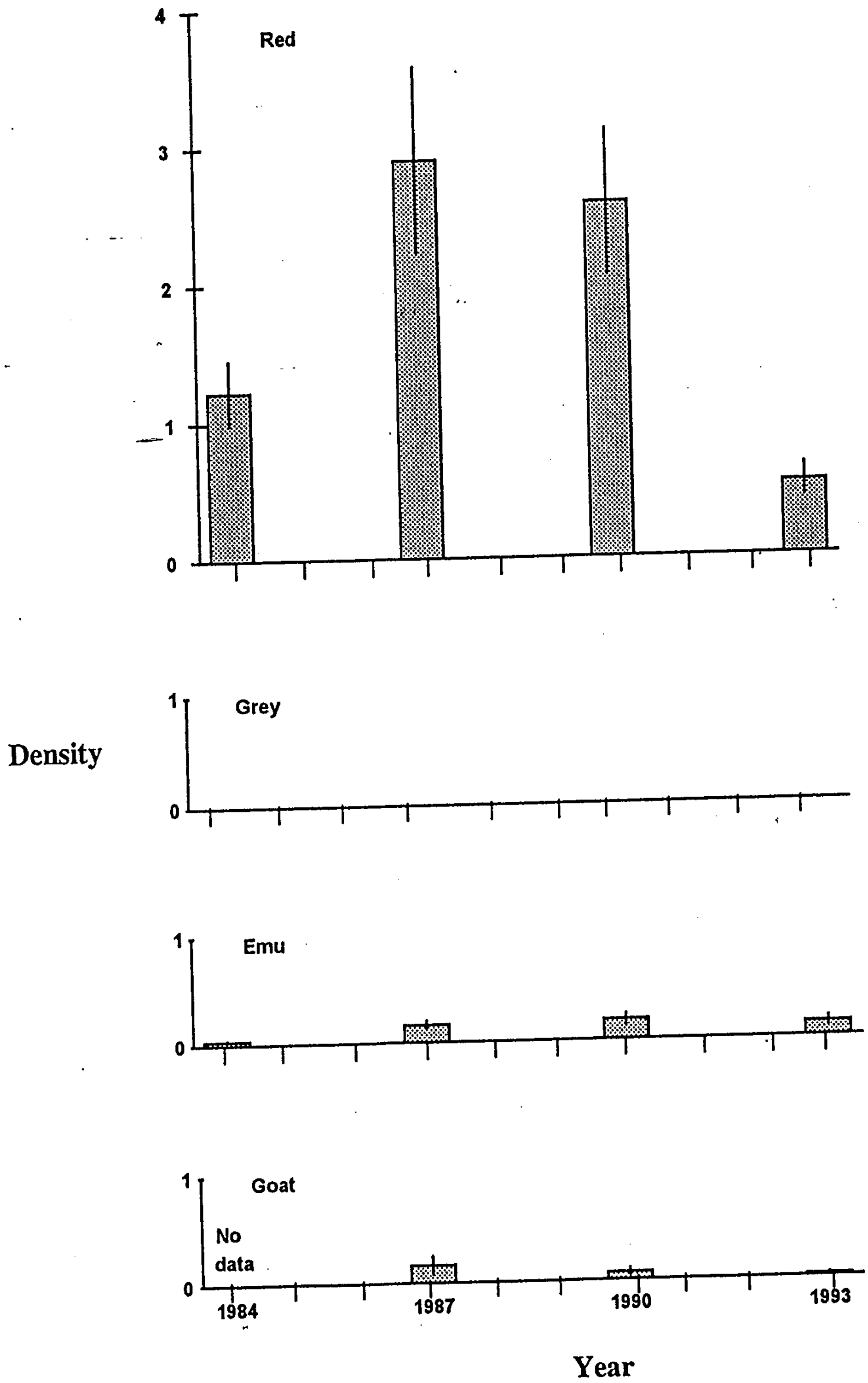


Figure 6. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Bay Pastoral management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

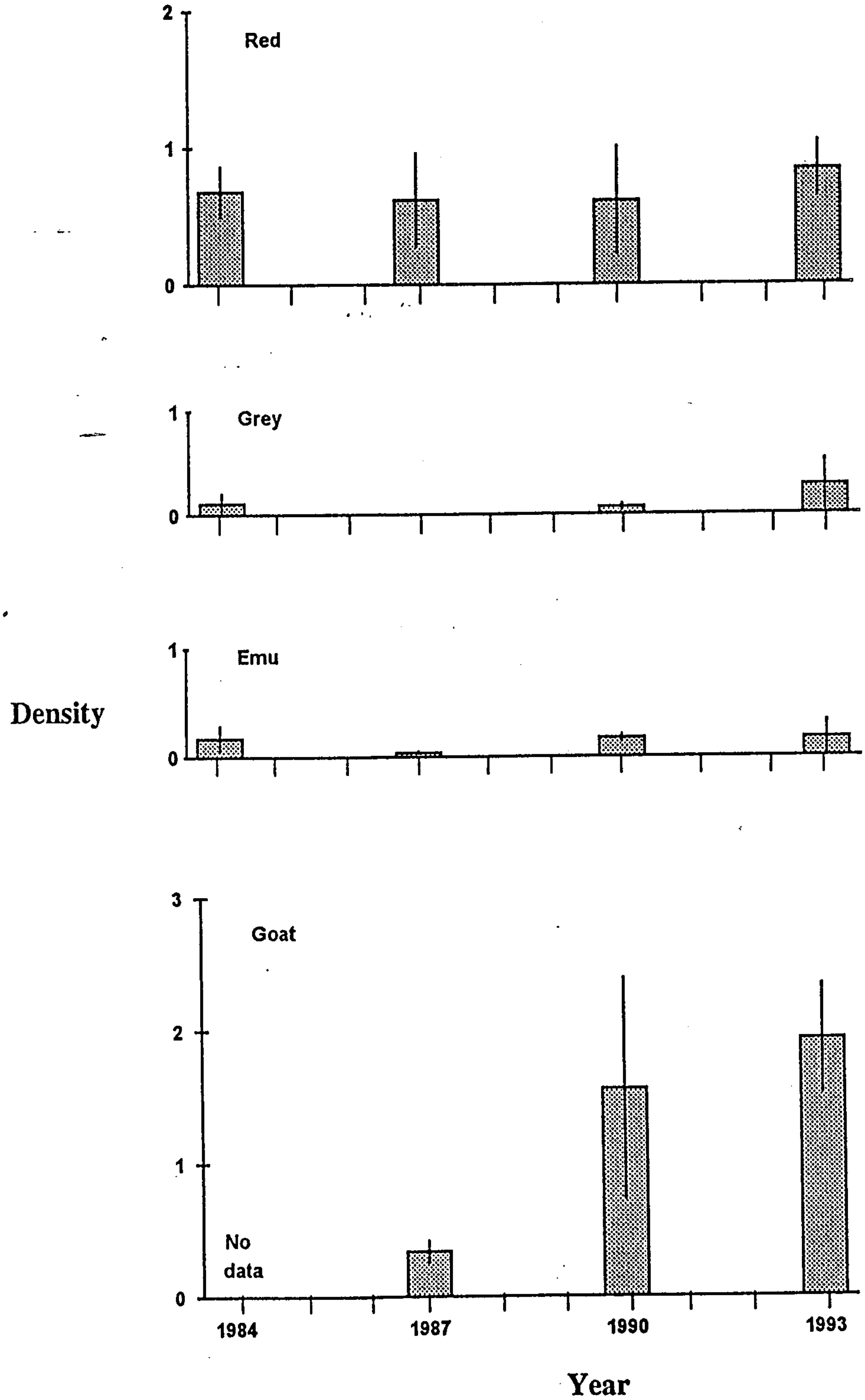


Figure 7. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Carnarvon management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

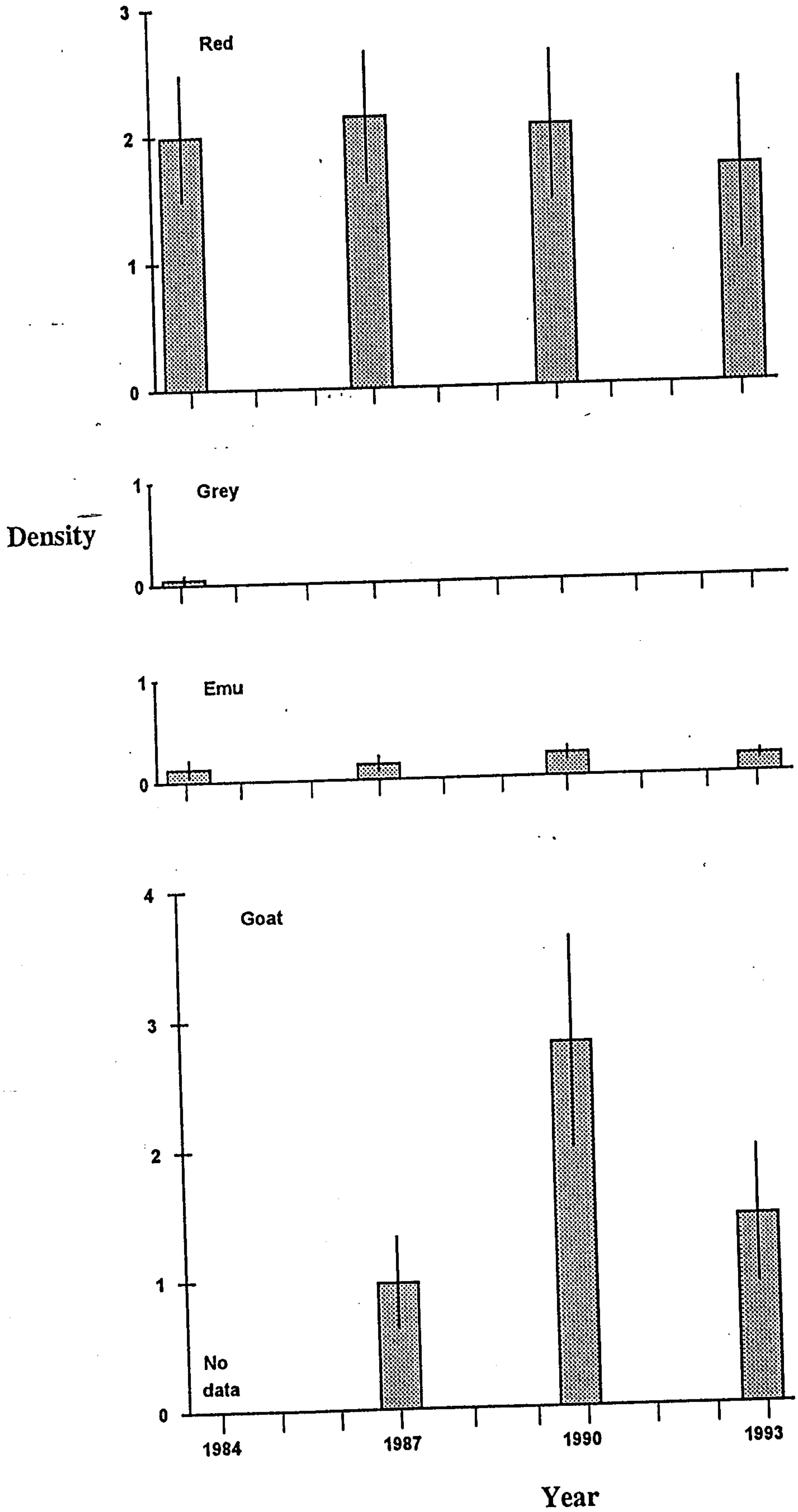


Figure 8. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Coolgardie management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

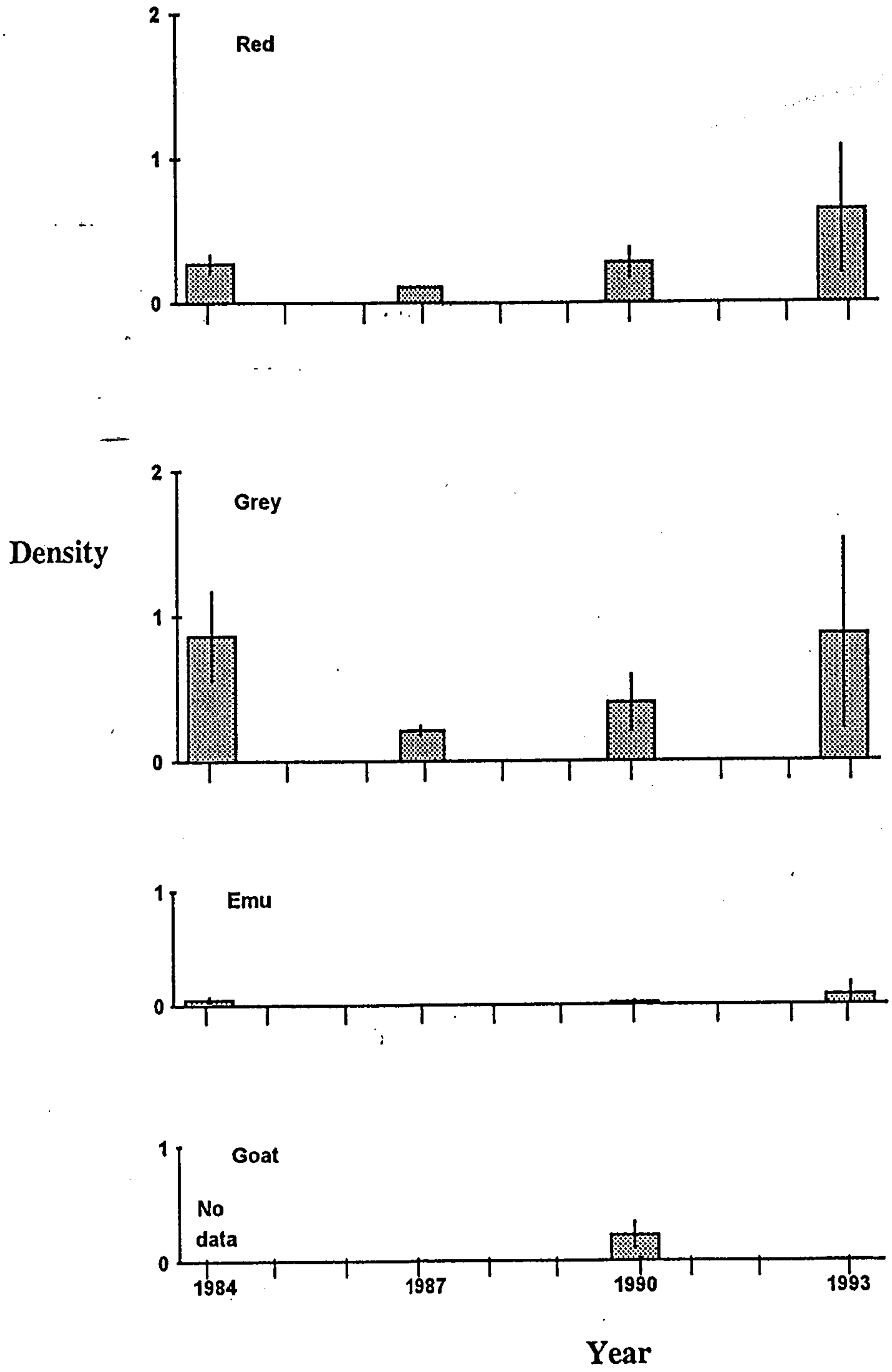


Figure 9. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Dundas management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

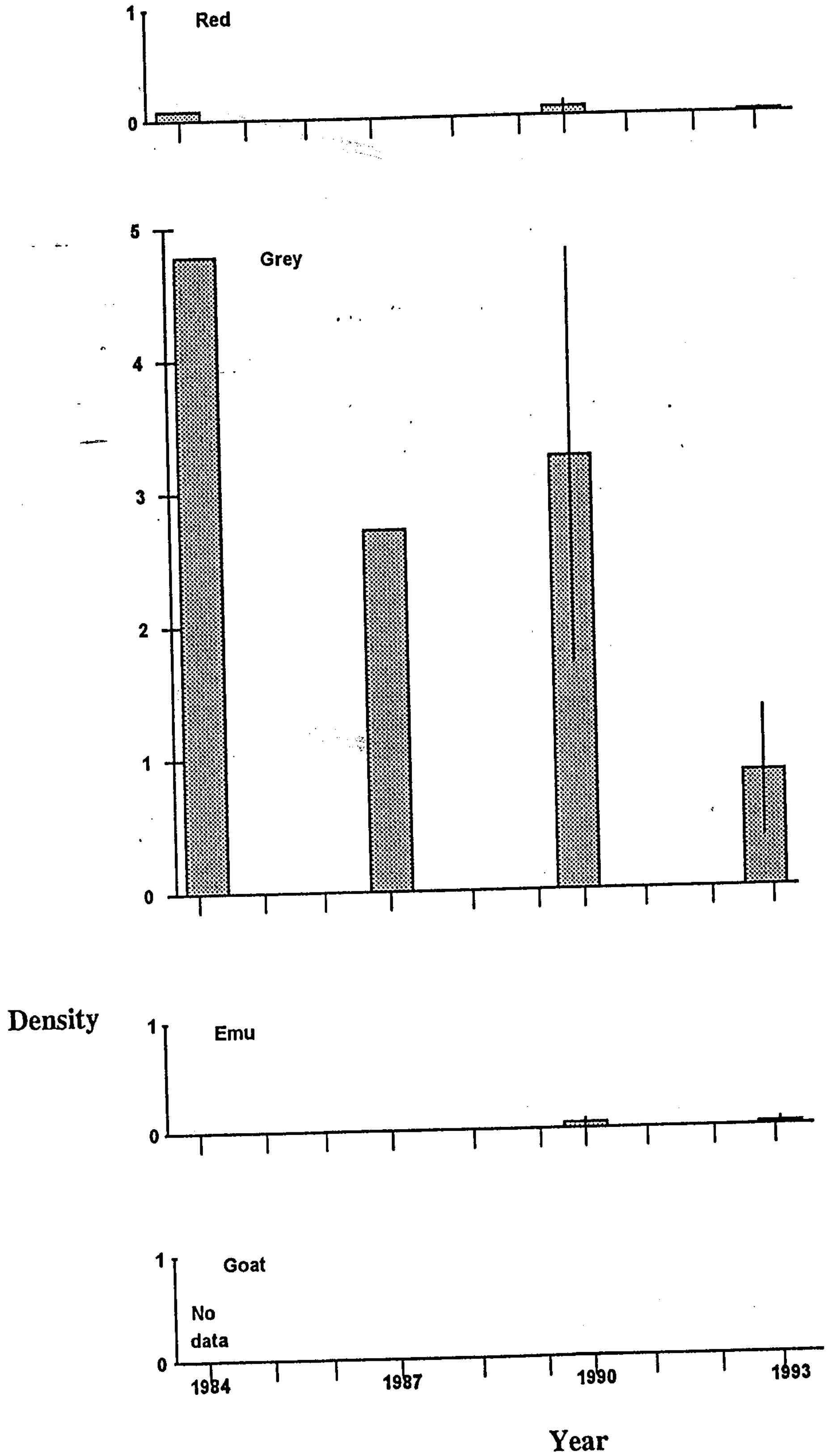


Figure 10. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Gascoyne management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

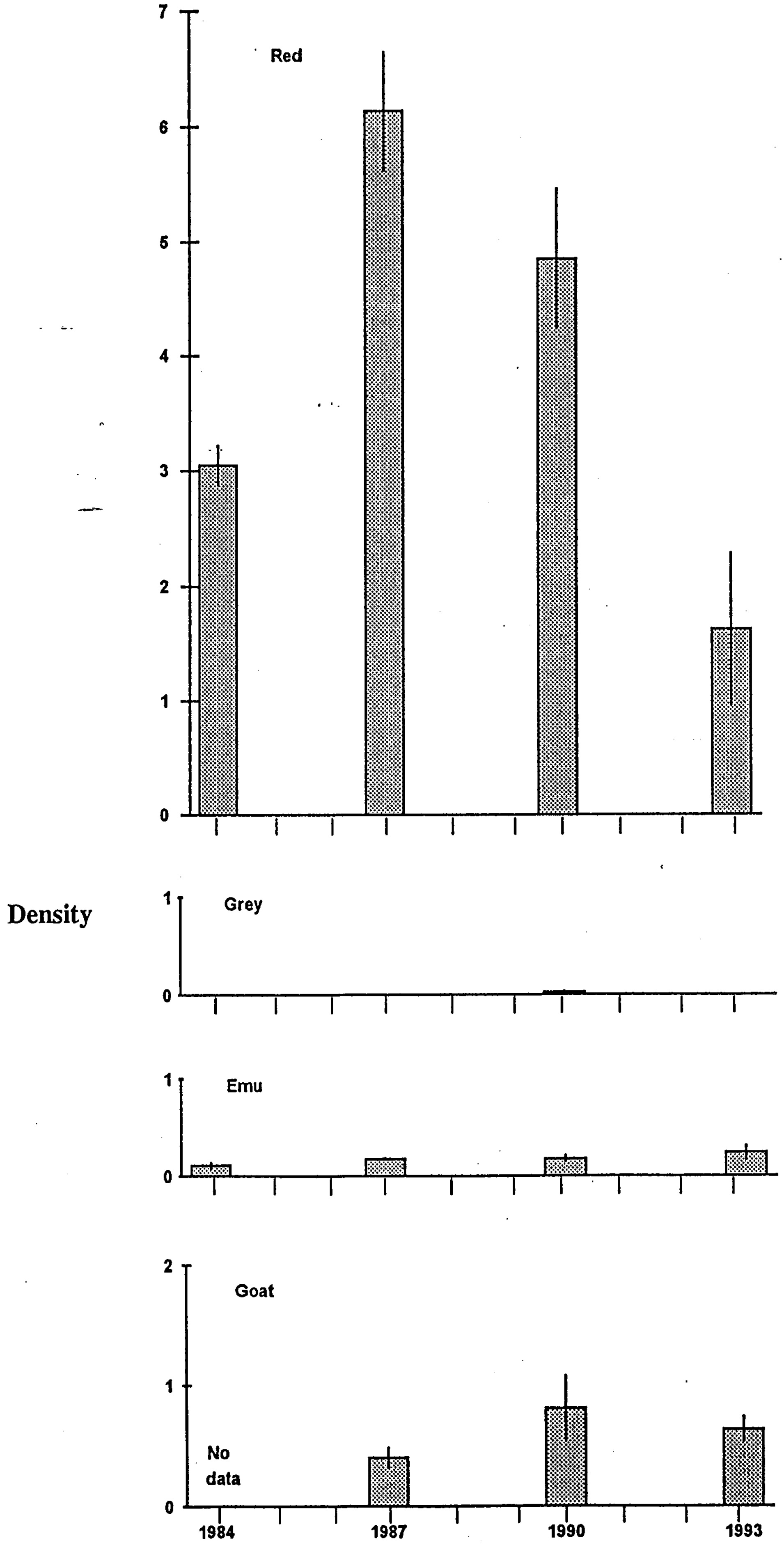


Figure 11. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Leonora-Eastern Goldfields management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

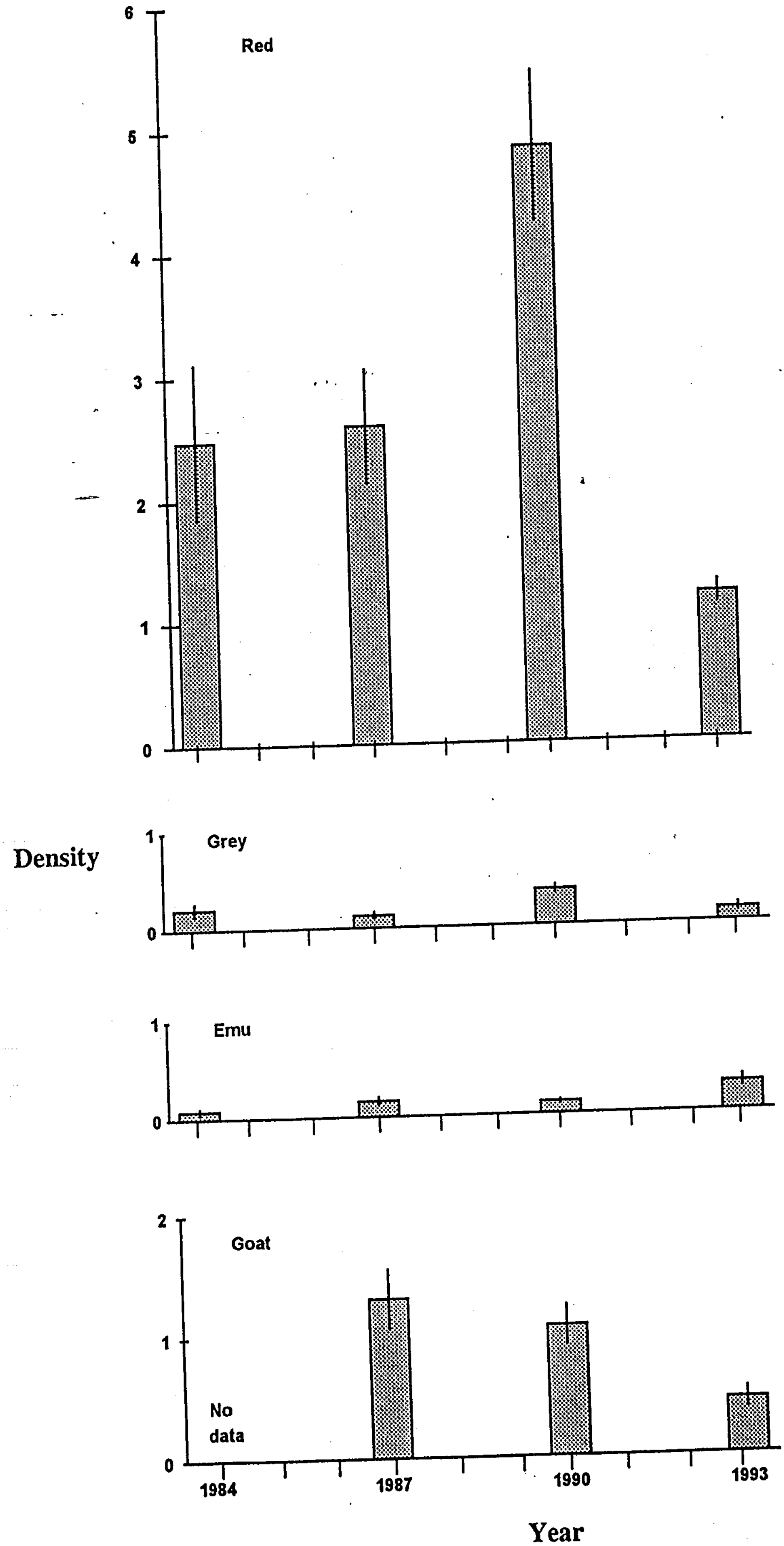


Figure 12. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Magnet management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

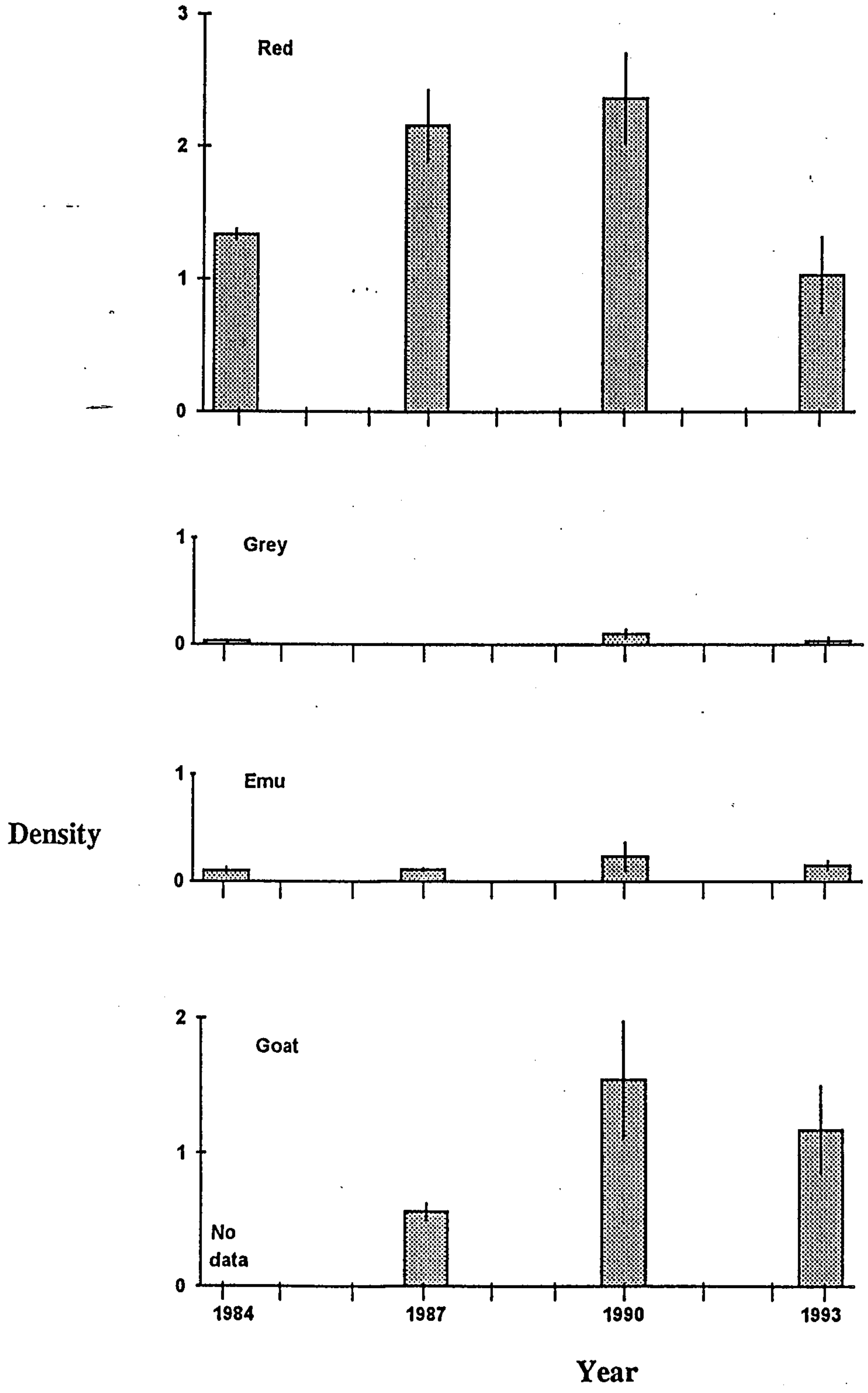


Figure 13. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Murchison management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

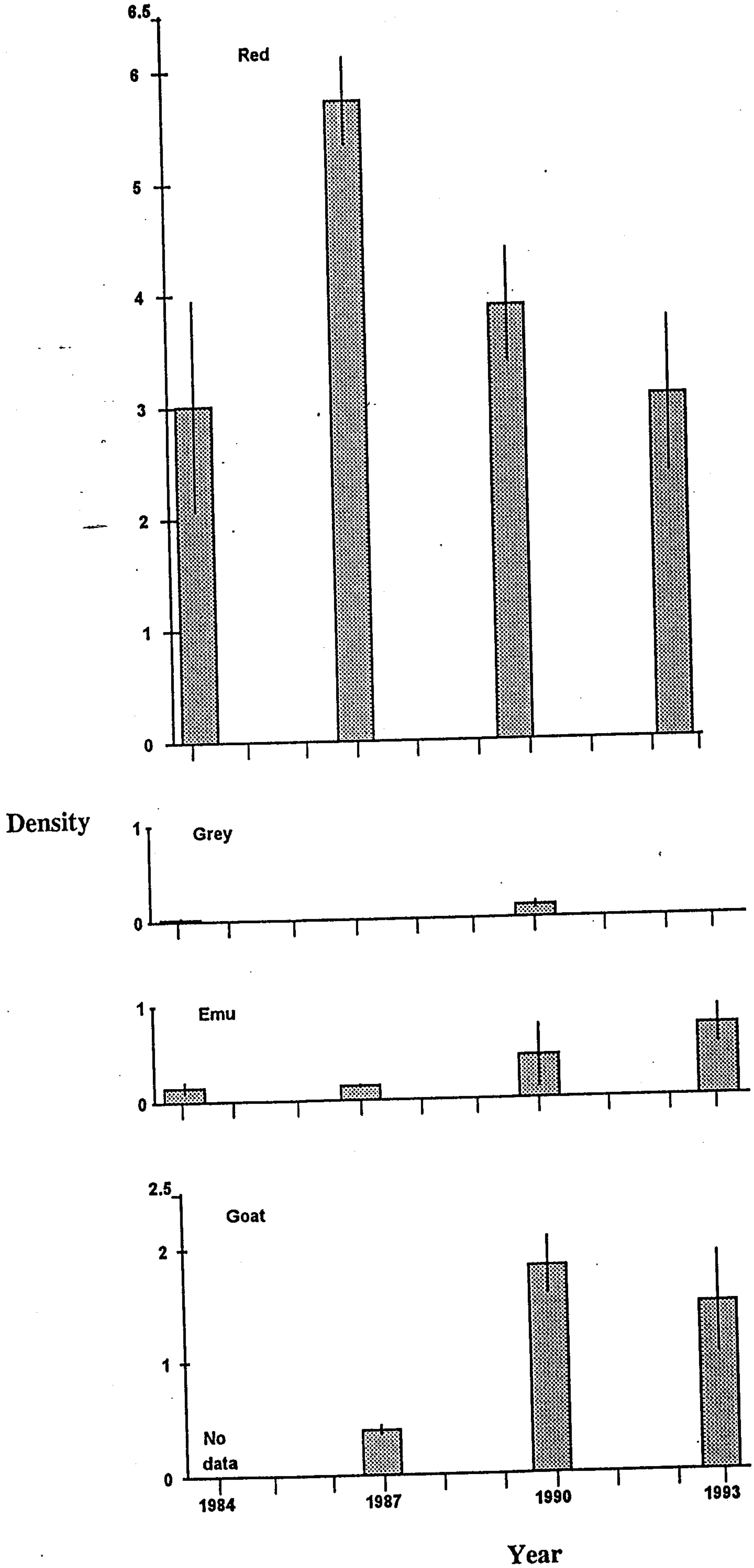


Figure 14. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the North-East Pastoral management zone. Densities are in animals km^{-2}. No data are available for Goats in 1984.

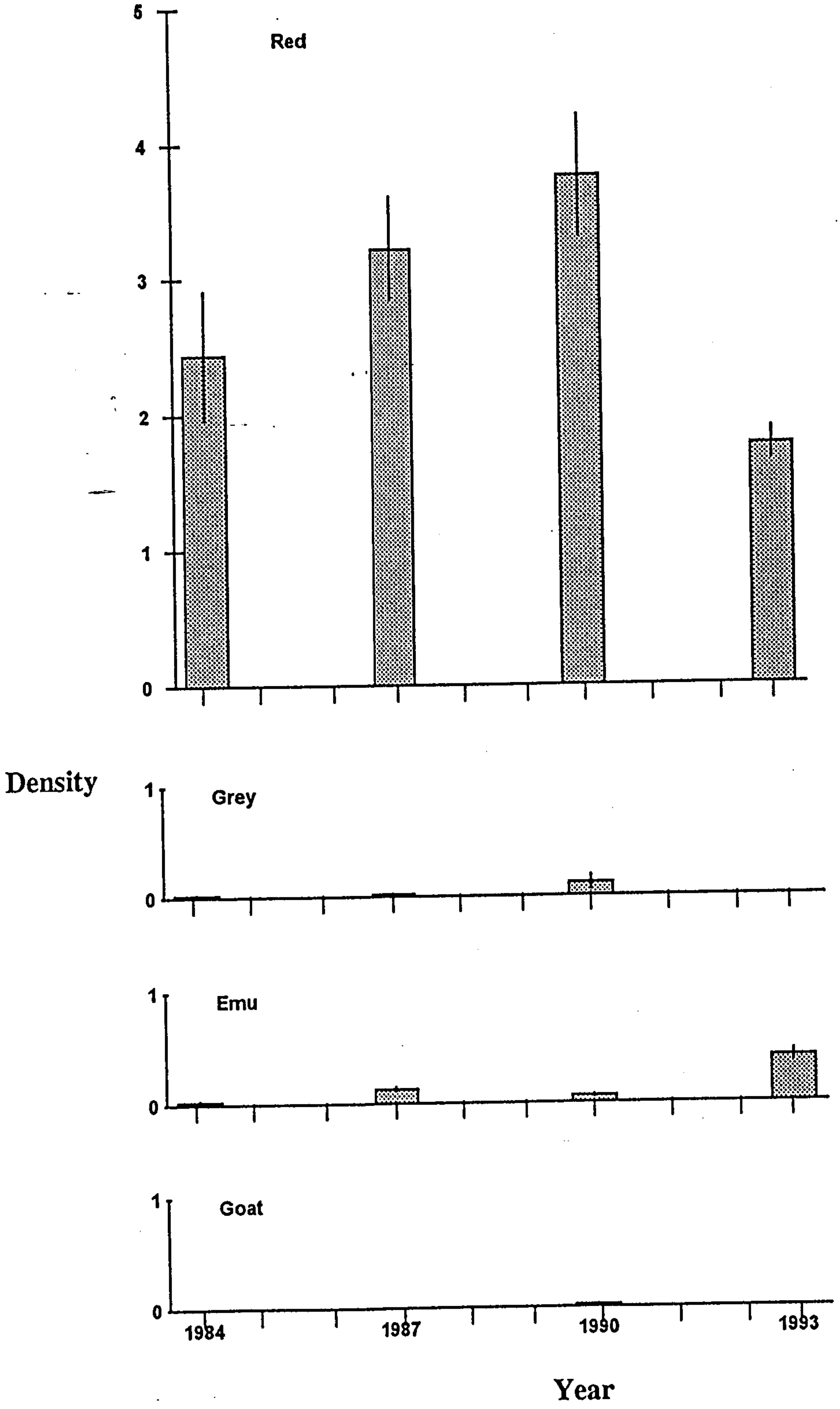


Figure 15. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Northern Agriculture management zone. Densities are in animals km^{-2}. No data are available for Goats in 1984.

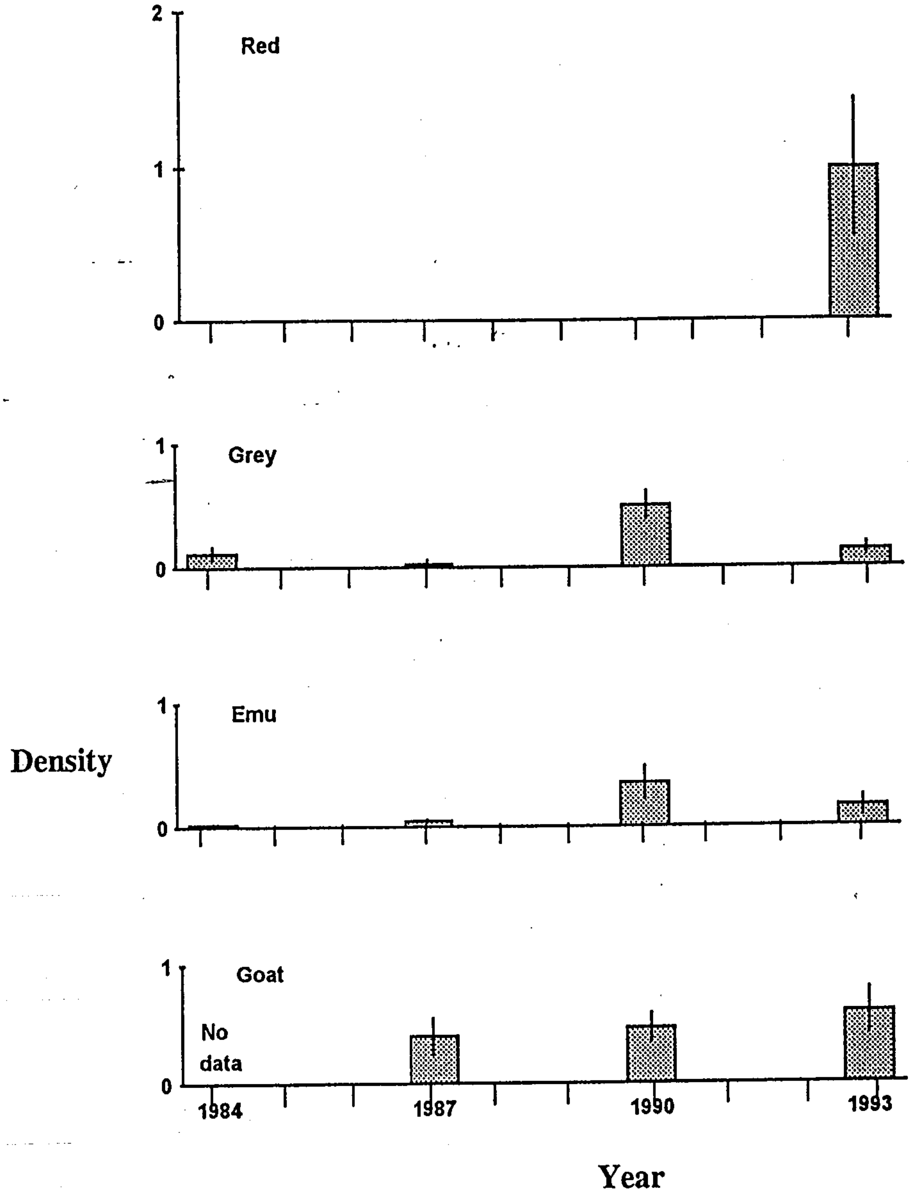
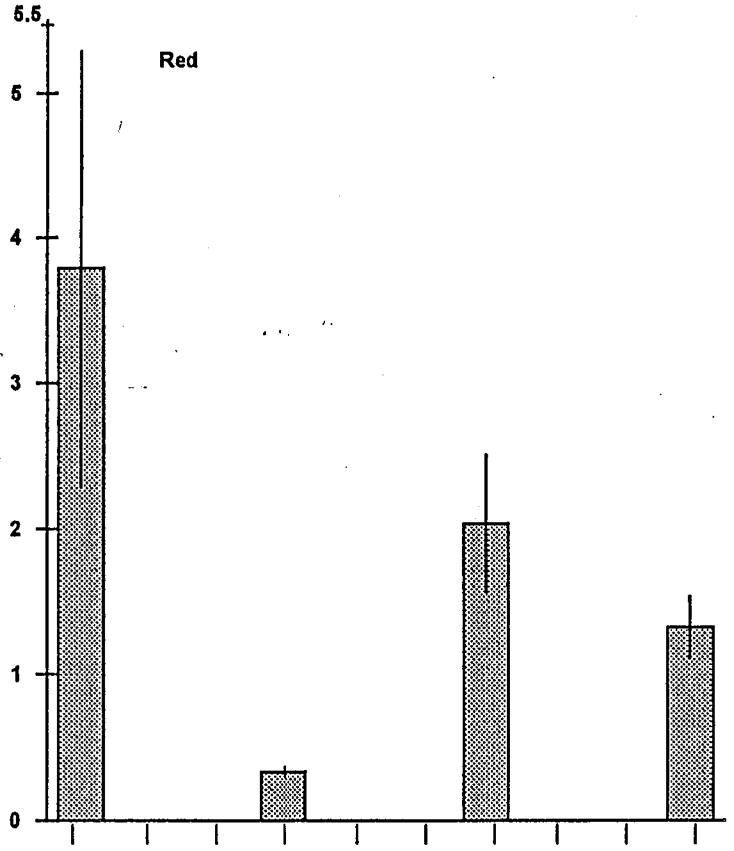
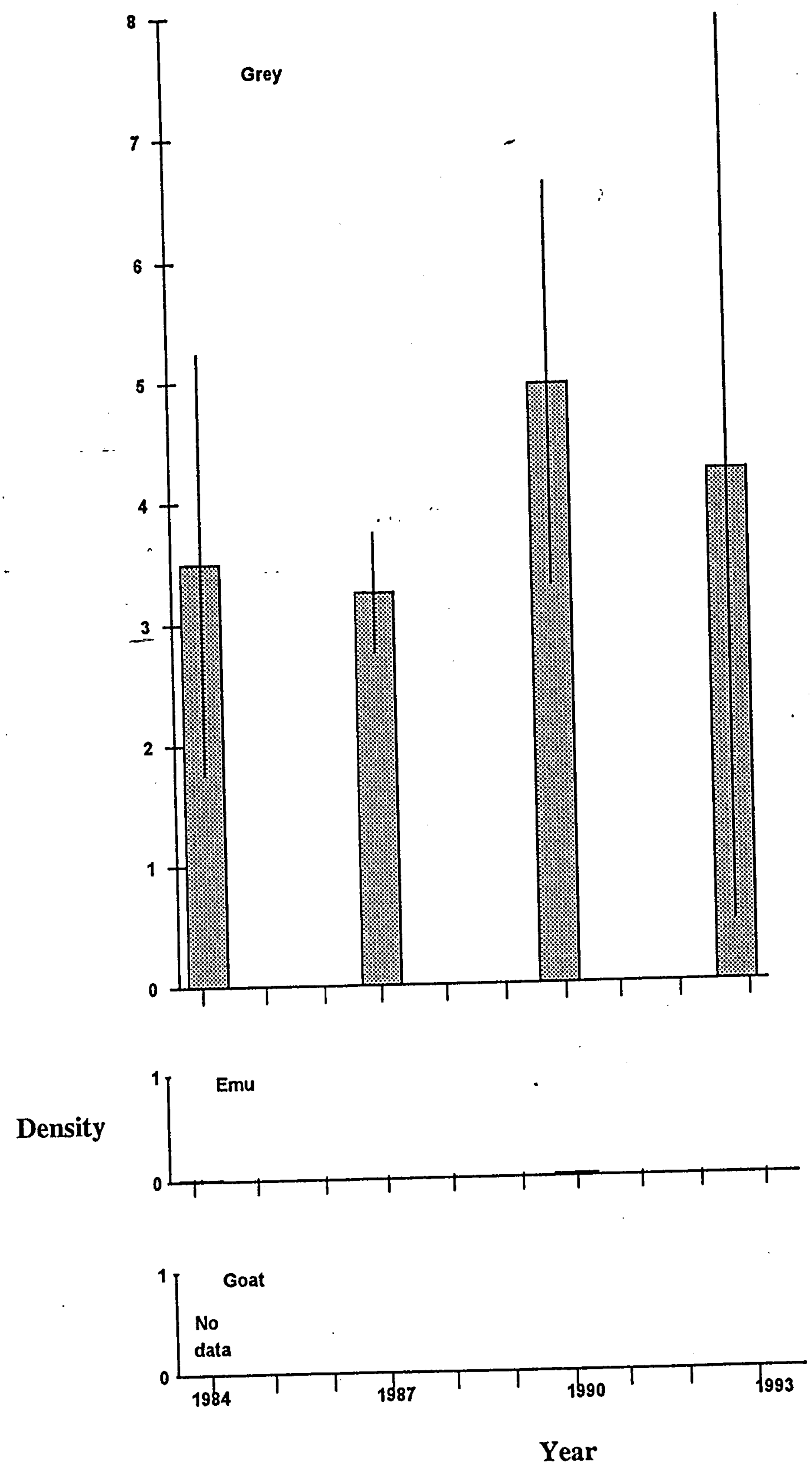


Figure 16. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Nullarbor management zone. Densities are in animals km^{-2}. No data are available for Goats in 1984.





Grey
8
7
6
5
4
3
2
1
0
Emu
1
0
Goat
No
data
1
0
Density
1984
1987
1990
1993
Year

Figure 17. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Pilbara management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

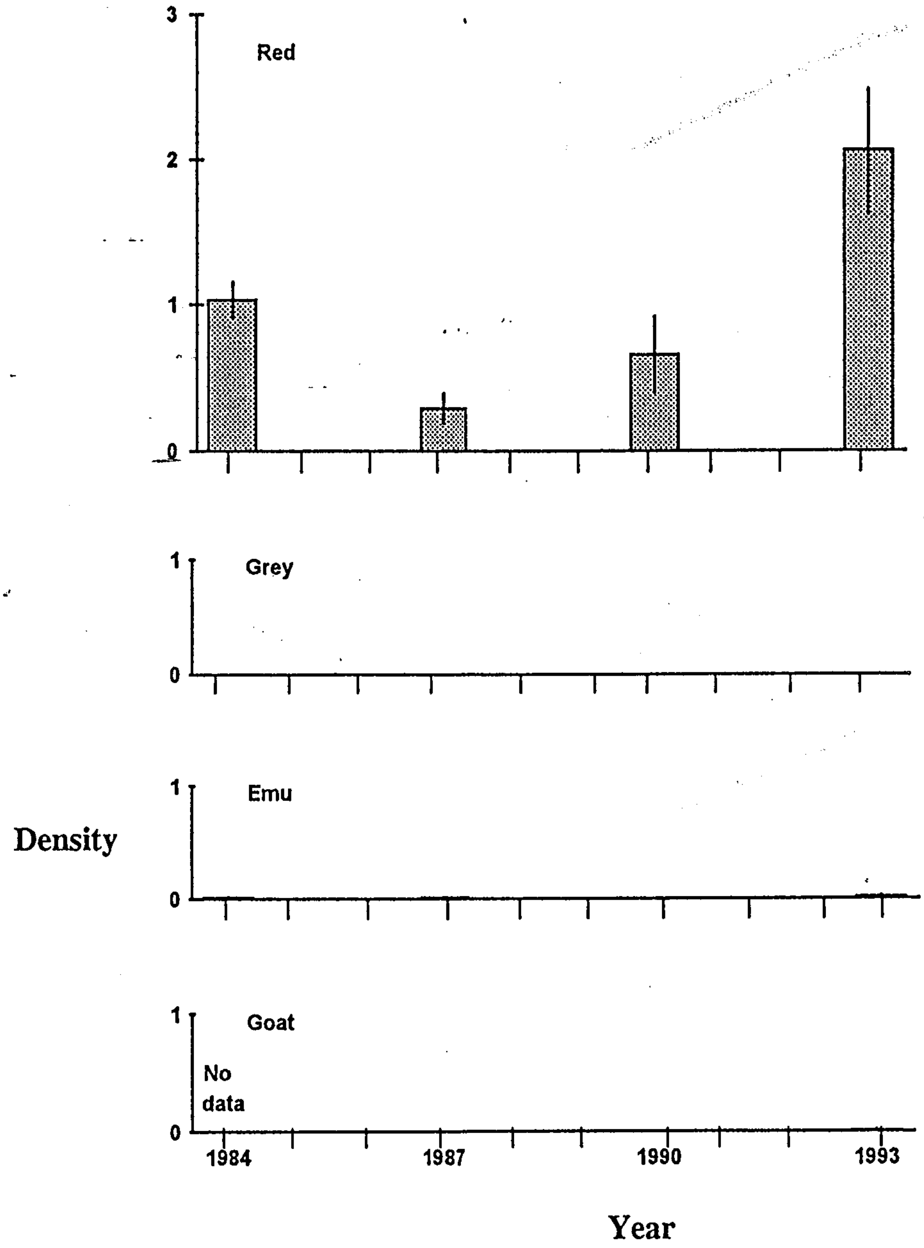


Figure 18. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Sandstone management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.

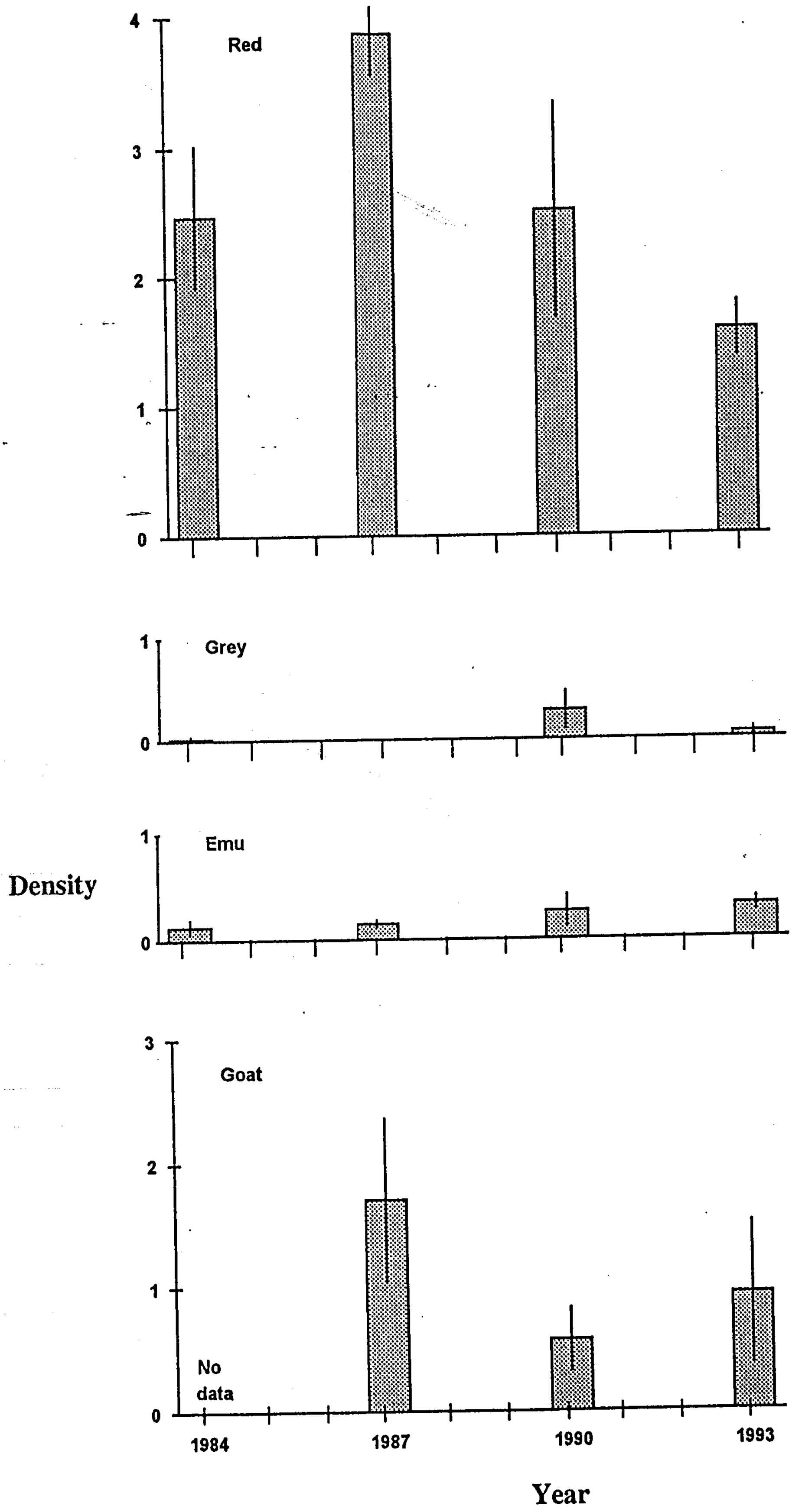
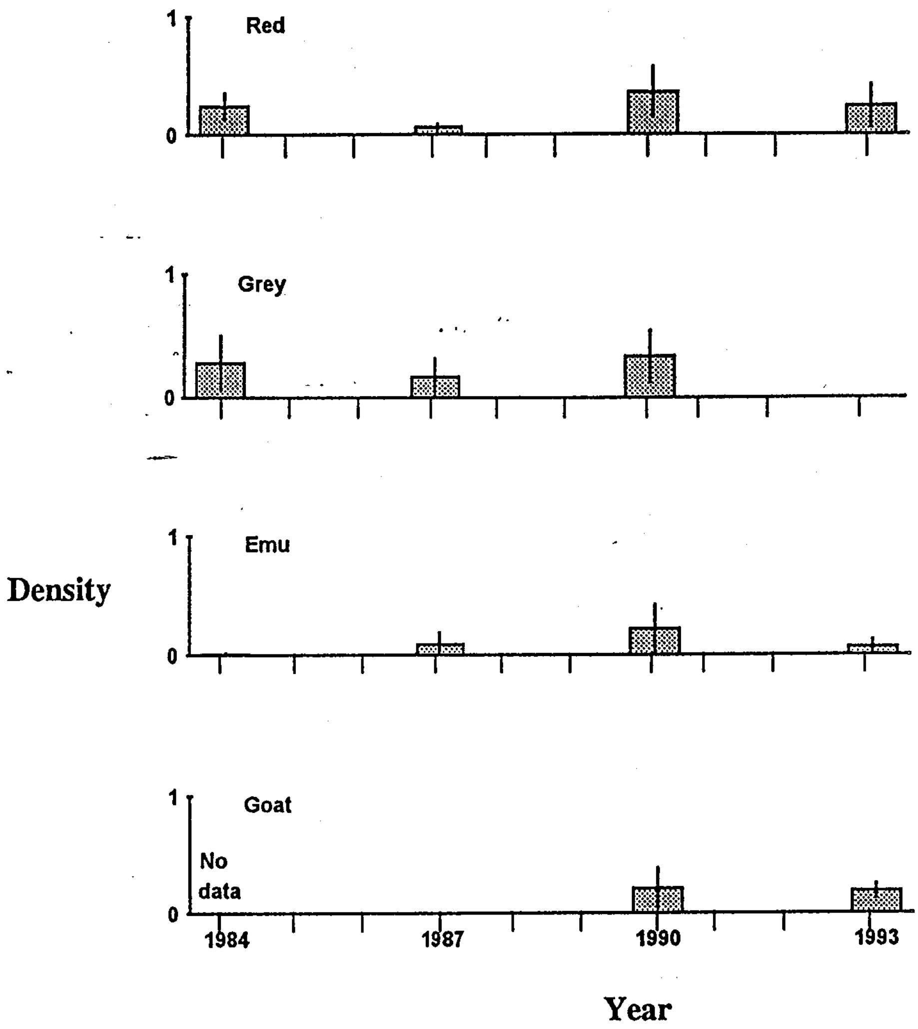


Figure 19. Trends in Red Kangaroo, Western Grey Kangaroo, Emu and Goat populations in the Yilgarn management zone, 1984-1993. Densities are in animals km^{-2}. No data are available for Goats in 1984.



Additional analyses

Comparison of side-of-plane

Results for analyses in relation to side-of-plane are presented in Table 3. The very low precisions on estimates for the Western Grey Kangaroo rule out confident assessment of the effect of side of plane for this species. For the Red Kangaroo the estimates of population size are substantially larger for the 'good'-side than the 'poor'-side in both years (39% larger in 1990, 62% in 1993). Judging from the magnitude of the estimates and standard errors, these differences would be significant for 1993 and close to significant for 1990. For Emus and Goats in both years a strong overlap in confidence intervals for 'good' and 'poor' estimates indicates no significant difference in side-of-plane estimates. For the Red Kangaroo, Emu and Goat 'poor'-side CV's were larger than 'good'-side CV's, and 'good'-side CV's were generally larger than 'both'-side CV's, but in all cases the differences were relatively small.

Table 3. Comparison of population estimates (Y), standard errors (SE) and coefficients of variation (CV) for good, poor and both sides of the plane for areas common to all surveys.

Species	Year	Side-of-plane	Y	SE	CV
Red	90	Good	2,438,200	178,400	7.3
Red	90	Poor	1,753,400	151,200	8.6
Red	90	Both	2,095,100	148,300	7.1
Red	93	Good	1,539,400	105,900	6.9
Red	93	Poor	952,400	92,500	9.7
Red	93	Both	1,246,300	87,900	7.1
Grey	90	Good	1,064,000	238,700	22.4
Grey	90	Poor	906,200	144,200	15.9
Grey	90	Both	985,800	145,000	14.7
Grey	93	Good	577,600	243,800	42.2
Grey	93	Poor	286,600	105,400	36.8
Grey	93	Both	432,200	170,900	39.5
Emu	90	Good	179,000	42,900	23.9
Emu	90	Poor	137,000	33,600	24.5
Emu	90	Both	160,300	34,900	21.8
Emu	93	Good	197,200	24,700	12.5
Emu	93	Poor	200,400	31,600	15.8
Emu	93	Both	198,700	23,400	11.8
Goat	90	Good	540,400	52,600	9.7
Goat	90	Poor	641,400	67,000	10.5
Goat	90	Both	591,100	40,600	6.9
Goat	93	Good	478,000	27,300	5.7
Goat	93	Poor	408,600	40,800	10.0
Goat	93	Both	443,200	39,000	8.8

Line transect density estimation

Line transect data were obtained along 5415 km of transect. The number of Red Kangaroo, Emu and Goat groups sighted in the three distance intervals along this length of transect is shown in Table 4 (there were insufficient sightings of Western Grey Kangaroos and Euros for line transect analysis). Taking into account the results of side-of-plane analyses in the previous section, Red Kangaroo data were treated separately in relation to side of plane, but Emu and Goat data were not.

Table 4. Number of sightings of groups by distance class intervals

	0-50 m	51-100 m	101-200 m	Total
Red Kangaroo, good side	218	157	77	452
Red Kangaroo, poor side	165	75	32	273
Red Kangaroo, both sides	383	232	109	725
Emu, both sides	37	27	13	77
Goat, both sides	43	36	33	112

The data in Table 4 show clearly that sightability of Red Kangaroo and Emu groups declines with distance from the transect line. This is less obvious for Goats. However, it must be remembered that the outer strip is twice as wide as the two inner strips and therefore twice the area, so a constant number of sightings across the strips would still indicate a decline in sightability. This is clear in the detection histograms in Figs. 20-22, where the number of sightings is scaled by the width of the strip.

Program DISTANCE used the half normal key function with hermite polynomial expansion for modelling the Red Kangaroo (both-sides and poor-side) and Goat sighting data, and the uniform key function with cosine expansion for modelling the Red Kangaroo (good-side) and Emu data. Size-bias in estimation of mean cluster size was detected for the Goat only.

Table 5 shows line transect density estimates and compares them with uncorrected strip transect density estimates.

Of interest for Red Kangaroos is the difference in side-of-plane estimates. Uncorrected strip transect estimates are 48% higher for the 'good'-side than the 'poor'-side. However the difference for line transect estimates is much smaller, with the 'good'-side estimate only 15% higher than the 'poor'-side estimate. The detection histograms in Fig. 20 show that the decline in sightability is greater on the 'poor'-side than the 'good'-side. The line transect method has taken this differential decline in sightability into account and largely corrected for it.

Figure 20. Detection histograms for the Red Kangaroo

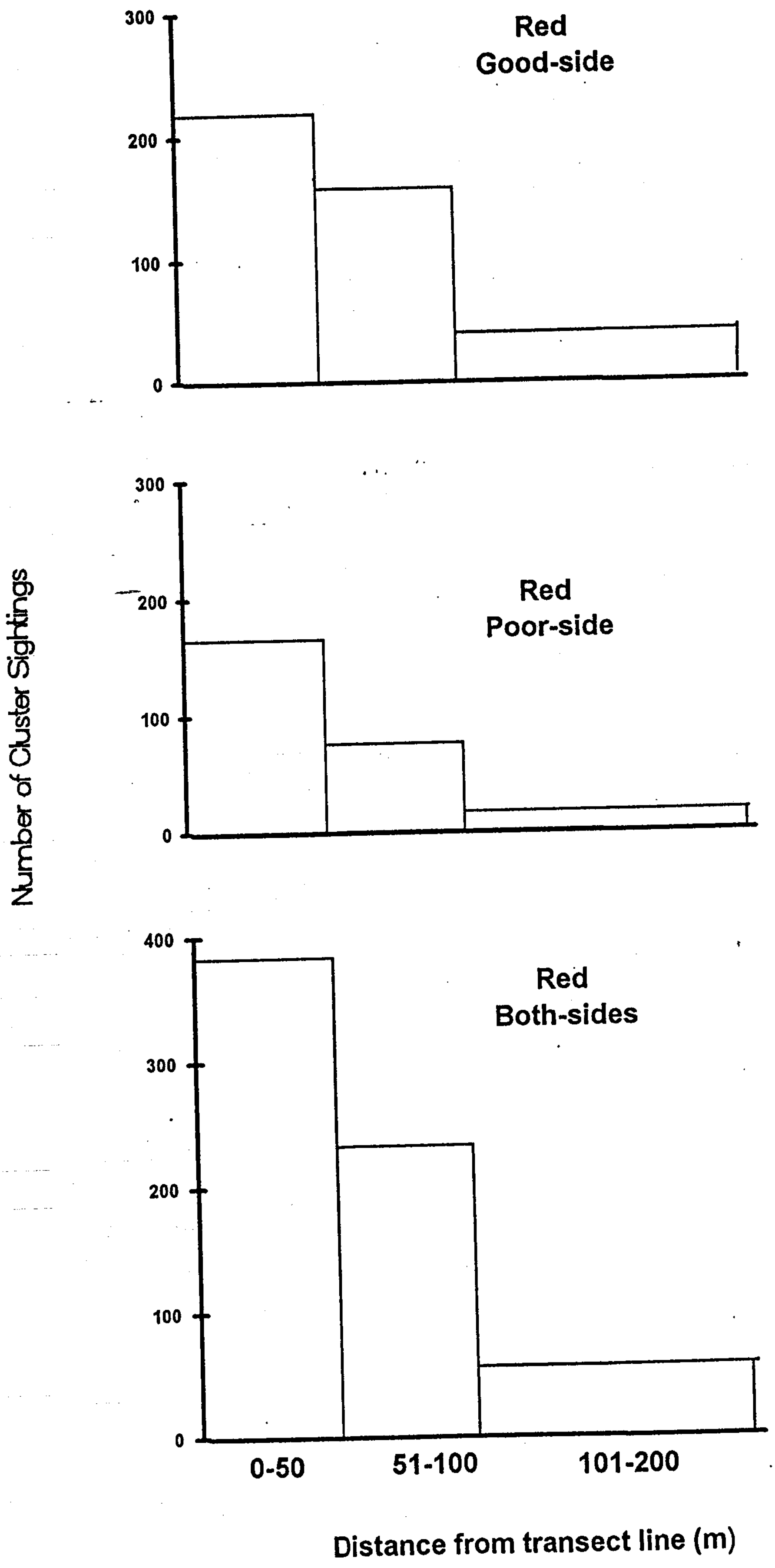


Figure 21. Detection histogram for Emus

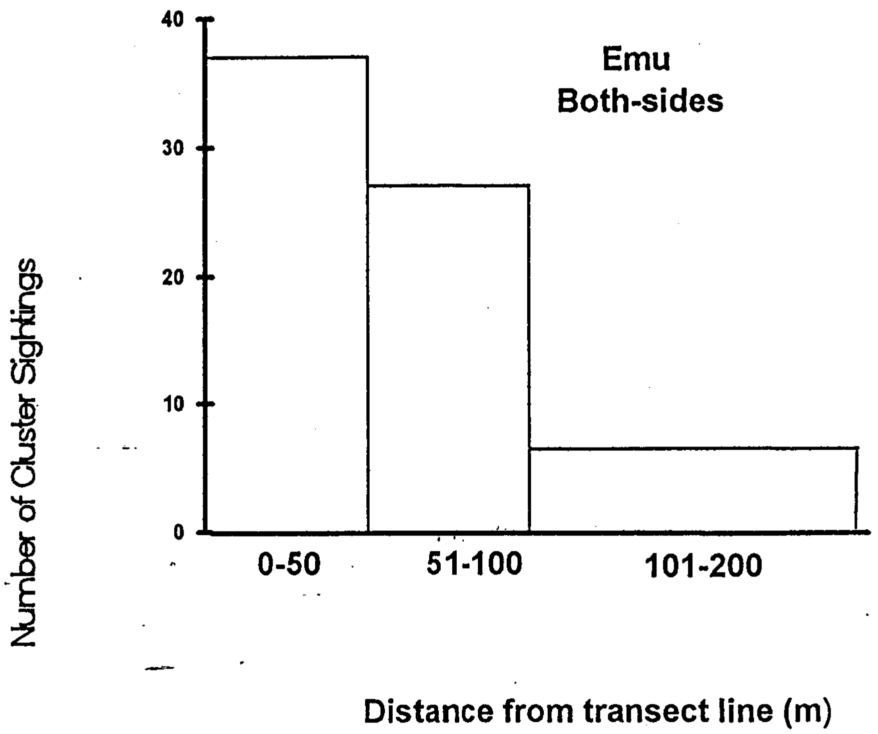


Figure 22. Detection histogram for the Goat

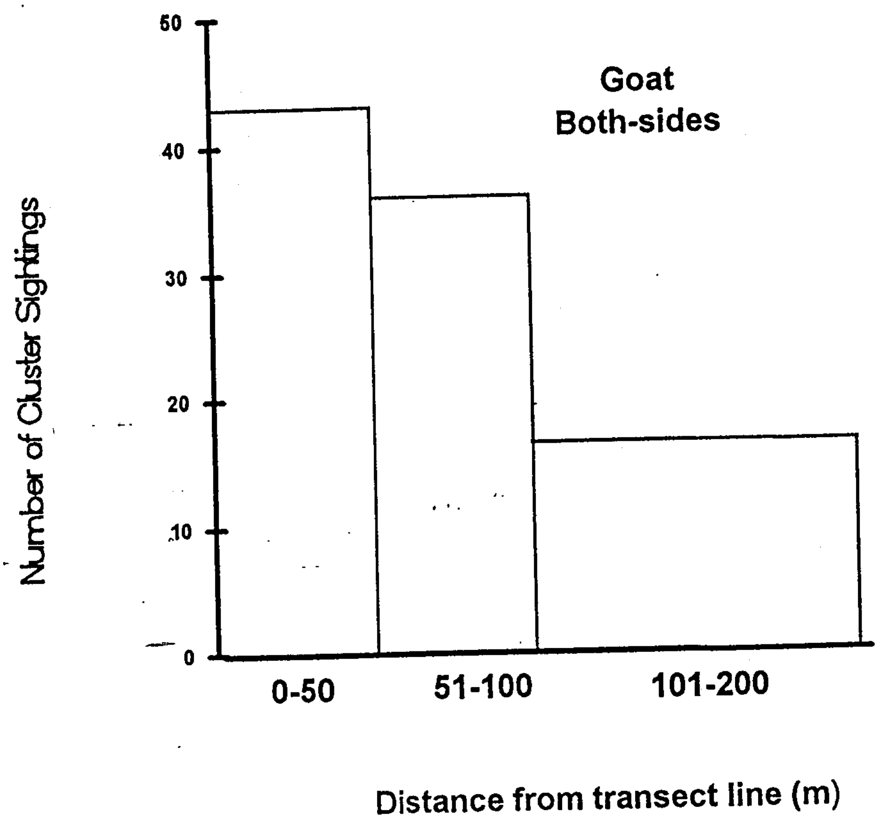


Table 5. Comparison of line transect (D_{LT}) and uncorrected strip transect(D_{ST}) density estimates.

	D_{LT}	D_{ST}	D_{LT}/D_{ST}
Red Kangaroo, good side	1.404	0.702	2.00
Red Kangaroo, poor side	1.218	0.473	2.58
Red Kangaroo, both sides	1.345	0.587	2.29
Emu	0.215	0.108	2.00
Goat	0.364	0.282	1.29

If the essential assumption of the line transect method is fulfilled (i.e. all animals on the line are seen), the ratio of line transect to uncorrected strip transect density estimates gives an accurate estimate of a 'correction factor' for the strip transect survey. If this assumption is violated (i.e. some animals on the line are missed), the estimated correction factor would be negatively biased to an unknown degree. The ratio for the Red Kangaroo, 2.29, is identical to the 'Caughley' correction factor for open vegetation. The ratio for the Emu, 2.00, is considerably higher than the 1.47 correction factor developed by Caughley and Grice (1982). No work on sightability of Goats has been conducted to date. These results indicate a correction factor of at least 1.29 is necessary to convert raw counts to accurate estimates under the conditions of this survey.

DISCUSSION

Aerial surveys in Western Australia and other states have employed the same methodology since their instigation some 12-15 years ago. The methodology is based on the strip transect method, with correction for sightability using results from separate experiments (in the case of kangaroos), sightability estimation from previous surveys (in the case of Emus), or use of uncorrected counts as an index or minimum estimate (in the case of Euros and Goats). The methodology relies on standardisation of survey variables such as height, speed, strip width, time of day, season, and calibration of observers to ensure repeatability from one survey to another.

Since instigation of the surveys there have been considerable improvements in knowledge on sightability of animals from the air and in the theoretical basis for estimating sightability.

Studies by Short and Bayliss (1985), Short and Hone (1988), and Caughley (1990) have shown that factors other than the standardised survey variables of height, speed and strip width influence sightability of kangaroos. In particular, environmental variables such as cloud cover and temperature are important. These environmental variables cannot be standardised by the surveyor, and as such pose potential problems with regard to repeatability of surveys from year to year. If temperatures were generally higher in one year than another, or one year was cloudier than another, repeatability may suffer. We now know that the assumption by Caughley et al. (1976) of equal sightability for Red and Grey Kangaroos was unrealistic.

Paralleling these improvements in knowledge on sightability have been improvements in the theoretical basis for estimating sightability. The use of independent observers to estimate sightability of Emus by Caughley and Grice (1982) was one of the first adaptations of mark-recapture theory to aerial surveys. Line transect theory has developed from an infant stage in the mid 1970's when kangaroo aerial survey methodology was developed to its current state-of-art stage as outlined in a new book by Buckland et al. (1993). Following these theoretical developments have been increased use of the line transect method in the field. A feature of these latest methods is that sightability is estimated for each survey during the survey, rather than in a separate experiment with the associated assumption that sightability will be the same in the experiment and the survey, or from survey to survey. Estimating sightability during the survey requires some amendments to the data collection procedures; either the use of paired observers for independent counts, or counting in sub-strips and using a specific scanning pattern for line transects. Neither amendment requires much change from the standard strip transect procedure.

The additional data collection and analyses undertaken in the 1993 survey were aimed at re-assessing the standard strip transect methodology which has been used for the Western Australian surveys since 1981.

The comparison between sides of the plane indicated there was a strong effect for the Red Kangaroo, but not for the Emu or Goat, in density estimation. Clearly for Red Kangaroos sightability is much worse on the 'poor'-side than on the 'good'-side. This begs the question of whether it is worth counting on the 'poor'-side at all, when sightability is much lower for some species and no different for others. The strongest argument for counting on both sides is that it increases the number of objects counted, and therefore results in better precision. However, the results from the side-of-plane analysis indicate that the benefit in terms of precision, from 'good'-side to 'both'-sides, is very small. One could count on only the 'good'-side, thus saving on observers (rotate two observers instead of three), but get uncorrected estimates closer or as close to true density, and in practical terms no less precise, than on 'both'-sides. It is recommended that serious consideration be given to changing the aerial survey procedure from the current one where observers count on both sides of the plane, with three observers rotating in the observing task, to counting only on the 'good'-side, with two observers rotating. This would not lead to incomparability with all previous data, because the data can be analysed retrospectively in relation to side-of-plane back to at least 1987 (and has been done for 1990 and 1993 in this report).

Independent observers and line transects are two ways of estimating survey-specific sightability. The former method breaks down at high animal densities, and while appropriate to some areas, would not be appropriate for all species and areas of interest in Western Australia. The line transect method is more generally applicable. Use of line transect data collection procedures caused no problems during the survey. Ease in allocation of sightings to sub-strips was facilitated by the sighting frame of fibreglass rods. Use of the traditional streamers would have compromised data quality. Use of microcassette recorders was also essential to success. Changing the scanning pattern required some practise but was not difficult. From an analytical view it would be desirable to use more sub-strips, but this could 'clutter' the broad 200 m strip. Four sub-strips is probably the maximum number that could be used. Analysis of the line transect data collected indicated that the method was sensitive to differences in sightability between species, and could largely account or correct for side-of-plane differences in sightability, suggesting that it would be generally responsive to changes in sightability from survey to survey. It was not possible during the survey to test the main assumption of the line transect method, that all animals on the line would be seen. This would require a separate experiment with a known population, or use an independent observer together with line transect data collection. The greatest potential in the method is that it could provide a means of estimating survey-specific sightability, thus negating the need to assume that sightability is constant from survey to survey, as is currently done. It is recommended that consideration be given to use of line transect methods in future aerial surveys in Western Australia, preferably with some testing of the method's main assumption.

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ACKNOWLEDGEMENTS

I thank Tom Scotney, Karen Weaver and Gordon Wyre for acting as observers, and Tony Olsen for pilotting the aircraft. Cindy Steensby assisted in data analysis and report preparation.

Appendix 1. Degree block codes (BKCD), locations (latitude (LATD) and longitude (LONG) of the block's south west corner) and areas (in km^{-2}), and the number of lines flown in each block in 1981, 1984, 1987, 1990 and 1993.

BKCD	LATD	LONG	AREA	1981	1984	1987	1990	1993
A9	19	121	2204	1	0	0	0	0
A10	19	122	11020	1	0	0	0	0
A11	19	123	11755	1	0	0	0	0
A12	19	124	11755	1	0	0	0	0
A13	19	125	11755	1	0	0	0	0
A14	19	126	11755	1	0	0	0	0
A15	19	127	11755	1	0	0	0	0
A16	19	128	11755	0	0	0	0	0
B8	20	120	2553	1	0	0	0	0
B9	20	121	9484	1	0	0	0	0
B10	20	122	11673	1	0	0	0	0
B11	20	123	11673	1	0	0	0	0
B12	20	124	11673	1	0	0	0	0
B13	20	125	11673	1	0	0	0	0
B14	20	126	11673	1	0	0	0	0
B15	20	127	11673	1	0	0	0	0
B16	20	128	11673	0	0	0	0	0
C4	21	116	3477	0	1	0	1	1
C5	21	117	4404	0	1	1	1	1
C6	21	118	10779	1	2	1	1	1
C7	21	119	11591	1	2	1	1	2
C8	21	120	11591	1	1	1	1	0
C9	21	121	11591	1	0	0	0	0
C10	21	122	11591	0	0	0	0	0
C11	21	123	11591	0	0	0	0	0
C12	21	124	11591	0	0	0	0	0
C13	21	125	11591	0	0	0	0	0
C14	21	126	11591	0	0	0	0	0
C15	21	127	11591	0	0	0	0	0
C16	21	128	11591	0	0	0	0	0
D2	22	114	720	0	0	0	0	1
D3	22	115	8861	1	2	1	1	2
D4	22	116	11508	1	2	1	1	2
D5	22	117	11508	1	2	1	1	2
D6	22	118	11508	1	2	1	1	2
D7	22	119	11508	1	2	1	1	2
D8	22	120	11508	1	1	1	1	0
D9	22	121	11508	0	0	0	0	0
D10	22	122	11508	0	0	0	0	0
D11	22	123	11508	0	0	0	0	0
D12	22	124	11508	0	0	0	0	0
D13	22	125	11508	0	0	0	0	0
D14	22	126	11508	0	0	0	0	0
D15	22	127	11508	0	0	0	0	0
D16	22	128	11508	0	0	0	0	0
E1	23	113	2057	0	1	1	2	1
E2	23	114	10398	1	2	2	2	2
E3	23	115	11426	1	2	2	2	2

E4	23	116	11426	1	2	1	2	2
E5	23	117	11426	1	2	1	1	2
E6	23	118	11426	2	2	1	1	2
E7	23	119	11426	2	2	1	1	2
E8	23	120	11426	1	1	1	1	0
E9	23	121	11426	0	0	0	0	0
E10	23	122	11426	0	0	0	0	0
E11	23	123	11426	0	0	0	0	0
E12	23	124	11426	0	0	0	0	0
E13	23	125	11426	0	0	0	0	0
E14	23	126	11426	0	0	0	0	0
E15	23	127	11426	0	0	0	0	0
E16	23	128	11426	0	0	0	0	0
F1	24	113	2722	1	2	1	2	2
F2	24	114	11343	1	2	2	2	2
F3	24	115	11343	1	2	2	2	2
F4	24	116	11343	1	2	2	2	2
F5	24	117	11343	1	2	1	2	2
F6	24	118	11343	2	2	1	2	2
F7	24	119	11343	2	2	1	2	2
F8	24	120	11343	1	1	1	1	0
F9	24	121	11343	0	0	0	0	0
F10	24	122	11343	0	0	0	0	0
F11	24	123	11343	0	0	0	0	0
F12	24	124	11343	0	0	0	0	0
F13	24	125	11343	0	0	0	0	0
F14	24	126	11343	0	0	0	0	0
F15	24	127	11343	0	0	0	0	0
F16	24	128	11343	0	0	0	0	0
G1	25	113	4997	1	0	0	2	2
G2	25	114	11261	2	2	2	2	2
G3	25	115	11261	2	2	2	2	2
G4	25	116	11261	2	2	2	2	2
G5	25	117	11261	2	2	1	2	2
G6	25	118	11261	1	2	2	2	2
G7	25	119	11261	1	2	2	2	2
G8	25	120	11261	0	1	1	1	0
G9	25	121	11261	0	0	0	0	0
G10	25	122	11261	0	0	0	0	0
G11	25	123	11261	0	0	0	0	0
G12	25	124	11261	0	0	0	0	0
G13	25	125	11261	0	0	0	0	0
G14	25	126	11261	0	0	0	0	0
G15	25	127	11261	0	0	0	0	0
G16	25	128	11261	0	0	0	0	0
H1	26	113	2990	0	1	0	1	0
H2	26	114	10731	2	2	1	2	2
H3	26	115	11178	2	2	2	2	2
H4	26	116	11178	2	2	2	2	2
H5	26	117	11178	2	2	2	2	2
H6	26	118	11178	2	2	2	2	2
H7	26	119	11178	2	2	2	2	1
H8	26	120	11178	0	1	2	1	1
H9	26	121	11178	0	1	1	1	1
H10	26	122	11178	0	1	2	1	1
H11	26	123	11178	0	0	0	0	0
H12	26	124	11178	0	0	0	0	0
H13	26	125	11178	0	0	0	0	0

H14	26	126	11178	0	0	0	0	0
H15	26	127	11178	0	0	0	0	0
H16	26	128	11178	0	0	0	0	0
I1	27	113	2990	0	1	0	1	1
I2	27	114	10521	2	2	1	2	2
I3	27	115	11075	2	2	1	2	2
I4	27	116	11075	2	2	2	2	2
I5	27	117	11075	2	2	2	2	2
I6	27	118	11075	2	2	2	2	2
I7	27	119	11075	2	2	1	2	2
I8	27	120	11075	2	2	1	2	2
I9	27	121	11075	2	2	2	2	2
I10	27	122	11075	2	2	2	2	1
I11	27	123	11075	0	1	1	1	0
I12	27	124	11075	0	0	0	0	0
I13	27	125	11075	0	0	0	0	0
I14	27	126	11075	0	0	0	0	0
I15	27	127	11075	0	0	0	0	0
I16	27	128	11075	0	0	0	0	0
J2	28	114	10751	2	2	1	2	2
J3	28	115	10971	2	2	1	2	2
J4	28	116	10971	2	2	1	2	2
J5	28	117	10971	2	2	2	2	2
J6	28	118	10971	2	2	2	2	2
J7	28	119	10971	2	2	2	2	2
J8	28	120	10971	2	2	2	2	2
J9	28	121	10971	2	2	2	2	2
J10	28	122	10971	2	2	2	2	1
J11	28	123	10971	0	1	1	1	0
J12	28	124	10971	0	0	0	0	0
J13	28	125	10971	0	0	0	0	0
J14	28	126	10971	0	0	0	0	0
J15	28	127	10971	0	0	0	0	0
J16	28	128	10971	0	0	0	0	0
K2	29	114	7826	1	2	1	2	2
K3	29	115	10869	1	2	1	2	2
K4	29	116	10869	1	2	1	2	2
K5	29	117	10869	2	2	2	2	2
K6	29	118	10869	2	2	2	2	2
K7	29	119	10869	2	2	1	2	2
K8	29	120	10869	2	2	2	2	2
K9	29	121	10869	2	2	2	2	2
K10	29	122	10869	2	2	1	2	2
K11	29	123	10869	1	2	1	2	0
K12	29	124	10869	1	2	1	1	0
K13	29	125	10869	1	2	1	1	0
K14	29	126	10869	1	2	1	1	0
K15	29	127	10869	1	2	1	1	0
K16	29	128	10869	0	2	1	1	0
L2	30	114	430	0	0	0	0	0
L3	30	115	10766	1	1	1	2	2
L4	30	116	10766	1	2	1	2	2
L5	30	117	10766	1	2	1	2	2
L6	30	118	10766	2	2	1	2	2
L7	30	119	10766	2	2	1	2	2
L8	30	120	10766	2	2	1	2	2
L9	30	121	10766	2	2	2	2	2
L10	30	122	10766	2	2	1	2	2

L11	30	123	10766	1	2	1	2	0
L12	30	124	10766	1	2	2	2	0
L13	30	125	10766	1	2	2	2	0
L14	30	126	10766	1	2	2	2	0
L15	30	127	10766	1	2	2	2	0
L16	30	128	10766	0	2	2	2	0
M3	31	115	9597	1	1	1	1	2
M4	31	116	10663	1	1	1	2	0
M5	31	117	10663	1	0	1	2	0
M6	31	118	10663	1	2	1	2	0
M7	31	119	10663	1	2	1	2	0
M8	31	120	10663	2	2	1	2	2
M9	31	121	10663	2	2	1	2	2
M10	31	122	10663	2	2	1	2	2
M11	31	123	10663	2	2	1	2	2
M12	31	124	10663	2	2	1	2	2
M13	31	125	10663	2	2	2	2	2
M14	31	126	10663	2	2	2	2	2
M15	31	127	10663	2	2	2	2	2
M16	31	128	10663	2	2	2	2	2
N3	32	115	4620	0	0	0	0	0
N4	32	116	10559	0	0	0	0	0
N5	32	117	10559	1	0	0	0	0
N6	32	118	10559	1	0	0	0	0
N7	32	119	10559	1	0	0	0	0
N8	32	120	10559	2	0	0	0	0
N9	32	121	10559	2	2	1	2	2
N10	32	122	10559	2	2	1	2	1
N11	32	123	10559	2	2	1	2	2
N12	32	124	10559	2	2	1	2	2
N13	32	125	10559	2	2	2	2	2
N14	32	126	10559	2	2	2	2	2
N15	32	127	10559	2	2	2	2	2
N16	32	128	9080	2	2	2	2	2
O3	33	115	2935	0	0	0	0	0
O4	33	116	10436	1	0	0	0	0
O5	33	117	10436	1	0	0	0	0
O6	33	118	10436	0	0	0	0	0
O7	33	119	10436	1	0	0	0	0
O8	33	120	10436	1	0	0	0	0
O9	33	121	10436	1	1	1	1	1
O10	33	122	10436	1	1	1	1	2
O11	33	123	10436	1	1	1	1	2
O12	33	124	9559	1	1	1	1	2
O13	33	125	5395	1	1	1	1	1
O14	33	126	3260	0	0	0	0	0
O15	33	127	2609	0	0	0	0	0
P3	34	115	6290	2	1	1	0	0
P4	34	116	10312	1	1	1	0	0
P5	34	117	10312	1	1	1	0	0
P6	34	118	10312	0	1	1	0	0
P7	34	119	10312	0	1	1	0	0
P8	34	120	9605	1	0	1	0	0
P9	34	121	8703	1	1	1	1	1
P10	34	122	9394	1	1	1	1	2
P11	34	123	8559	1	1	1	1	2
P12	34	124	410	0	0	0	0	0
Q3	35	115	4279	2	1	1	0	0

Q4	35	116	9577	1	1	1	0	0
Q5	35	117	10188	1	1	1	0	0
Q6	35	118	7641	1	1	1	0	0
Q7	35	119	2955	0	1	0	0	0

Appendix 2. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Red Kangaroos for each degree block surveyed in 1993. Block codes (BKCD) are from Short *et al.*(1983). Values are corrected for vegetation bias using 'Caughley' correction factors, but there has been no correction for temperature. Densities are in animals km^{-2}. Areas not surveyed are indicated by -.

BKCD	D	SED	Y	SEY
A9	-	-	-	-
A10	-	-	-	-
A11	-	-	-	-
A12	-	-	-	-
A13	-	-	-	-
A14	-	-	-	-
A15	-	-	-	-
A16	-	-	-	-
B8	-	-	-	-
B9	-	-	-	-
B10	-	-	-	-
B11	-	-	-	-
B12	-	-	-	-
B13	-	-	-	-
B14	-	-	-	-
B15	-	-	-	-
B16	-	-	-	-
C4	10.80	4.76	37500	16600
C5	1.57	1.10	6900	4800
C6	1.27	0.12	13600	1300
C7	3.74	2.19	43300	25400
C8	-	-	-	-
C9	-	-	-	-
C10	-	-	-	-
C11	-	-	-	-
C12	-	-	-	-
C13	-	-	-	-
C14	-	-	-	-
C15	-	-	-	-
C16	-	-	-	-
D2	0.00	0.00	0	0
D3	0.10	0.03	900	200
D4	0.33	0.32	3800	3700
D5	1.96	1.25	22500	14400
D6	0.99	0.61	11400	7000
D7	0.54	0.52	6200	6000
D8	-	-	-	-
D9	-	-	-	-
D10	-	-	-	-
D11	-	-	-	-
D12	-	-	-	-
D13	-	-	-	-
D14	-	-	-	-
D15	-	-	-	-
D16	-	-	-	-

E1	0.69	0.69	1400	1400
E2	0.99	0.48	10300	5000
E3	0.36	0.35	4100	4000
E4	0.16	0.09	1800	1000
E5	1.39	1.06	15900	12100
E6	2.79	1.87	31900	21400
E7	2.02	1.72	23100	19700
E8	-	-	-	-
E9	-	-	-	-
E10	-	-	-	-
E11	-	-	-	-
E12	-	-	-	-
E13	-	-	-	-
E14	-	-	-	-
E15	-	-	-	-
E16	-	-	-	-
F1	0.71	0.46	1900	1200
F2	1.71	0.03	19400	300
F3	0.27	0.03	3100	300
F4	0.16	0.09	1800	1000
F5	0.19	0.00	2100	0
E6	0.99	0.30	11300	3400
F7	1.93	1.88	21800	21400
F8	-	-	-	-
F9	-	-	-	-
F10	-	-	-	-
F11	-	-	-	-
F12	-	-	-	-
F13	-	-	-	-
F14	-	-	-	-
F15	-	-	-	-
F16	-	-	-	-
G1	1.67	0.40	8300	2000
G2	0.28	0.21	3100	2400
G3	0.27	0.09	3100	1000
G4	0.16	0.09	1700	1000
G5	0.37	0.00	4200	0
G6	2.52	1.50	28300	16900
G7	4.01	2.60	45100	29300
G8	-	-	-	-
G9	-	-	-	-
G10	-	-	-	-
G11	-	-	-	-
G12	-	-	-	-
G13	-	-	-	-
G14	-	-	-	-
G15	-	-	-	-
G16	-	-	-	-
H1	-	-	-	-
H2	3.08	1.31	33100	14100
H3	2.16	1.53	24100	17100
H4	1.95	1.03	21700	11500
H5	3.38	1.45	37800	16200
H6	3.74	2.34	41800	26200
H7	1.11	0.06	12500	700
H8	0.72	0.28	8100	3100
H9	2.62	0.78	29300	8700
H10	2.23	0.46	24900	5100

H11	-	-	-	-
H12	-	-	-	-
H13	-	-	-	-
H14	-	-	-	-
H15	-	-	-	-
H16	-	-	-	-
I1	0.00	0.00	0	0
I2	0.76	0.70	8000	7300
I3	1.79	0.42	19800	4600
I4	3.34	0.62	37000	6900
I5	6.29	1.49	69700	16500
I6	6.33	1.71	70100	19000
I7	2.17	0.31	24000	3500
I8	2.69	0.31	29800	3400
I9	1.18	0.62	13100	6900
I10	0.85	0.28	9400	3100
I11	-	-	-	-
I12	-	-	-	-
I13	-	-	-	-
I14	-	-	-	-
I15	-	-	-	-
I16	-	-	-	-
J2	0.43	0.17	4700	1800
J3	1.03	0.05	11300	500
J4	2.07	0.35	22700	3800
J5	2.67	1.40	29300	15300
J6	1.25	0.50	13700	5500
J7	1.17	0.37	12800	4000
J8	2.29	0.06	25200	700
J9	1.05	0.44	11500	4800
J10	0.46	0.46	5000	5000
J11	-	-	-	-
J12	-	-	-	-
J13	-	-	-	-
J14	-	-	-	-
J15	-	-	-	-
J16	-	-	-	-
K2	1.31	0.79	10200	6200
K3	1.01	0.73	11000	8000
K4	2.33	1.86	25400	20300
K5	1.52	0.81	16500	8900
K6	0.81	0.33	8800	3500
K7	0.84	0.03	9200	400
K8	2.56	0.00	27800	0
K9	1.21	0.54	13200	5900
K10	1.64	0.89	17800	9600
K11	-	-	-	-
K12	-	-	-	-
K13	-	-	-	-
K14	-	-	-	-
K15	-	-	-	-
K16	-	-	-	-
L2	-	-	-	-
L3	0.25	0.25	2700	2700
L4	0.17	0.16	1800	1800
L5	0.56	0.28	6000	3100
L6	0.14	0.13	1500	1400
L7	0.39	0.32	4200	3400

L8	1.08	0.59	11600	6300
L9	1.47	0.67	15900	7200
L10	0.64	0.28	6800	3000
L11	-	-	-	-
L12	-	-	-	-
L13	-	-	-	-
L14	-	-	-	-
L15	-	-	-	-
L16	-	-	-	-
M3	0.03	0.04	300	300
M4	-	-	-	-
M5	-	-	-	-
M6	-	-	-	-
M7	-	-	-	-
M8	0.54	0.53	5800	5700
M9	1.16	0.34	12400	3700
M10	0.95	0.16	10100	1700
M11	0.20	0.06	2100	700
M12	0.23	0.23	2400	2400
M13	1.15	1.07	12200	11400
M14	0.47	0.44	5000	4700
~~M15~~	0.00	0.00	0	0
M16	0.03	0.03	400	300
N3	-	-	-	-
N4	-	-	-	-
N5	-	-	-	-
N6	-	-	-	-
N7	-	-	-	-
N8	-	-	-	-
N9	0.07	0.07	800	700
N10	0.00	0.00	0	0
N11	0.00	0.00	0	0
N12	1.99	0.48	21000	5000
N13	1.28	0.82	13500	8700
N14	1.55	0.95	16400	10000
N15	2.09	0.82	22000	8700
N16	0.14	0.08	1300	700
O3	-	-	-	-
O4	-	-	-	-
O5	-	-	-	-
O6	-	-	-	-
O7	-	-	-	-
O8	-	-	-	-
O9	0.42	0.28	4300	2900
O10	0.00	0.00	0	0
O11	0.07	0.00	700	0
O12	0.04	0.04	300	400
O13	0.07	0.07	400	400
O14	-	-	-	-
O15	-	-	-	-
P3	-	-	-	-
P4	-	-	-	-
P5	-	-	-	-
P6	-	-	-	-
P7	-	-	-	-
P8	-	-	-	-
P9	0.00	0.00	0	0
P10	0.07	0.07	700	700

P11	0.00	0.00	0	0
P12	-	-	-	-
Q3	-	-	-	-
Q4	-	-	-	-
Q5	-	-	-	-
Q6	-	-	-	-
Q7	-	-	-	-

Appendix 3. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Western Grey Kangaroos for each degree block surveyed in 1993. Block codes (BKCD) are from Short *et al.*(1983). Values are corrected for vegetation bias using 'Caughley' correction factors, but there has been no correction for temperature. Densities are in animals km^{-2}. Areas not surveyed are indicated by -.

BKCD	D	SED	Y	SEY
A9	-	-	-	-
A10	-	-	-	-
A11	-	-	-	-
A12	-	-	-	-
A13	-	-	-	-
A14	-	-	-	-
A15	-	-	-	-
A16	-	-	-	-
B8	-	-	-	-
B9	-	-	-	-
B10	-	-	-	-
B11	-	-	-	-
B12	-	-	-	-
B13	-	-	-	-
B14	-	-	-	-
B15	-	-	-	-
B16	-	-	-	-
C4	0.00	0.00	0	0
C5	0.00	0.00	0	0
C6	0.00	0.00	0	0
C7	0.00	0.00	0	0
C8	-	-	-	-
C9	-	-	-	-
C10	-	-	-	-
C11	-	-	-	-
C12	-	-	-	-
C13	-	-	-	-
C14	-	-	-	-
C15	-	-	-	-
C16	-	-	-	-
D2	0.00	0.00	0	0
D3	0.00	0.00	0	0
D4	0.00	0.00	0	0
D5	0.00	0.00	0	0
D6	0.00	0.00	0	0
D7	0.00	0.00	0	0
D8	-	-	-	-
D9	-	-	-	-
D10	-	-	-	-
D11	-	-	-	-
D12	-	-	-	-
D13	-	-	-	-
D14	-	-	-	-
D15	-	-	-	-

D16	-	-	-	-
E1	0.00	0.00	0	0
E2	0.00	0.00	0	0
E3	0.00	0.00	0	0
E4	0.00	0.00	0	0
E5	0.00	0.00	0	0
E6	0.00	0.00	0	0
E7	0.00	0.00	0	0
E8	-	-	-	-
E9	-	-	-	-
E10	-	-	-	-
E11	-	-	-	-
E12	-	-	-	-
E13	-	-	-	-
E14	-	-	-	-
E15	-	-	-	-
E16	-	-	-	-
F1	0.00	0.00	0	0
F2	0.00	0.00	0	0
F3	0.00	0.00	0	0
F4	0.00	0.00	0	0
F5	0.00	0.00	0	0
F6	0.00	0.00	0	0
F7	0.00	0.00	0	0
F8	-	-	-	-
F9	-	-	-	-
F10	-	-	-	-
F11	-	-	-	-
F12	-	-	-	-
F13	-	-	-	-
F14	-	-	-	-
F15	-	-	-	-
F16	-	-	-	-
G1	0.00	0.00	0	0
G2	0.00	0.00	0	0
G3	0.00	0.00	0	0
G4	0.00	0.00	0	0
G5	0.00	0.00	0	0
G6	0.00	0.00	0	0
G7	0.00	0.00	0	0
G8	-	-	-	-
G9	-	-	-	-
G10	-	-	-	-
G11	-	-	-	-
G12	-	-	-	-
G13	-	-	-	-
G14	-	-	-	-
G15	-	-	-	-
G16	-	-	-	-
H1	-	-	-	-
H2	0.00	0.00	0	0
H3	0.00	0.00	0	0
H4	0.00	0.00	0	0
H5	0.00	0.00	0	0
H6	0.00	0.00	0	0
H7	0.00	0.00	0	0
H8	0.00	0.00	0	0
H9	0.00	0.00	0	0

H10	0.00	0.00	0	0
H11	-	-	-	-
H12	-	-	-	-
H13	-	-	-	-
H14	-	-	-	-
H15	-	-	-	-
H16	-	-	-	-
I1	0.52	0.08	1600	200
I2	0.00	0.00	0	0
I3	0.00	0.00	0	0
I4	0.00	0.00	0	0
I5	0.00	0.00	0	0
I6	0.03	0.03	400	300
I7	0.00	0.00	0	0
I8	0.00	0.00	0	0
I9	0.00	0.00	0	0
I10	0.00	0.00	0	0
I11	-	-	-	-
I12	-	-	-	-
I13	-	-	-	-
I14	-	-	-	-
I15	-	-	-	-
I16	-	-	-	-
J2	0.60	0.27	6500	2900
J3	0.00	0.00	0	0
J4	0.00	0.00	0	0
J5	0.00	0.00	0	0
J6	0.00	0.00	0	0
J7	0.00	0.00	0	0
J8	0.00	0.00	0	0
J9	0.00	0.00	0	0
J10	0.00	0.00	0	0
J11	-	-	-	-
J12	-	-	-	-
J13	-	-	-	-
J14	-	-	-	-
J15	-	-	-	-
J16	-	-	-	-
K2	0.00	0.00	0	0
K3	0.10	0.09	1000	1000
K4	0.00	0.00	0	0
K5	0.00	0.00	0	0
K6	0.00	0.00	0	0
K7	0.00	0.00	0	0
K8	0.26	0.25	2900	2800
K9	0.03	0.03	400	300
K10	0.10	0.03	1100	300
K11	-	-	-	-
K12	-	-	-	-
K13	-	-	-	-
K14	-	-	-	-
K15	-	-	-	-
K16	-	-	-	-
L2	-	-	-	-
L3	0.29	0.09	3100	1000
L4	0.13	0.00	1400	0
L5	0.00	0.00	0	0
L6	0.17	0.16	1800	1800

L7	0.00	0.00	0	0
L8	0.07	0.07	700	700
L9	0.20	0.00	2100	0
L10	0.09	0.02	1000	300
L11	-	-	-	-
L12	-	-	-	-
L13	-	-	-	-
L14	-	-	-	-
L15	-	-	-	-
L16	-	-	-	-
M3	2.46	1.55	23700	14900
M4	-	-	-	-
M5	-	-	-	-
M6	-	-	-	-
M7	-	-	-	-
M8	1.01	0.20	10800	2100
M9	0.46	0.32	4900	3400
M10	0.13	0.13	1400	1400
M11	0.46	0.45	4900	4800
M12	0.16	0.10	1700	1000
M13	0.00	0.00	0	0
M14	0.00	0.00	0	0
M15	0.00	0.00	0	0
M16	0.00	0.00	0	0
N3	-	-	-	-
N4	-	-	-	-
N5	-	-	-	-
N6	-	-	-	-
N7	-	-	-	-
N8	-	-	-	-
N9	0.07	0.07	800	700
N10	0.00	0.00	0	0
N11	0.28	0.00	3000	0
N12	1.61	0.05	17000	600
N13	0.88	0.51	9200	5300
N14	1.25	0.66	13200	7000
N15	13.81	12.98	145800	137100
N16	9.90	10.83	89900	98300
O3	-	-	-	-
O4	-	-	-	-
O5	-	-	-	-
O6	-	-	-	-
O7	-	-	-	-
O8	-	-	-	-
O9	1.74	0.92	18100	9600
O10	1.22	0.34	12700	3500
O11	1.04	0.86	10900	9000
O12	0.81	0.32	7700	3000
O13	3.40	2.36	18300	12700
O14	-	-	-	-
O15	-	-	-	-
P3	-	-	-	-
P4	-	-	-	-
P5	-	-	-	-
P6	-	-	-	-
P7	-	-	-	-
P8	-	-	-	-
P9	1.01	0.26	8800	2300

P10	0.27	0.00	2600	0
P11	0.51	0.59	4400	5100
P12	-	-	-	-
Q3	-	-	-	-
Q4	-	-	-	-
Q5	-	-	-	-
Q6	-	-	-	-
Q7	-	-	-	-

Appendix 4. Observed (uncorrected) density (D_O) and mimimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Euros for for each degree block surveyed in 1993. Block codes (BKCD) are from Short *et al.*(1983). Observed densities are in animals km^{-2}. Areas not surveyed are indicated by -.

BKCD	D_O	SED_O	Y_M	SEY_M
A9	-	-	-	-
A10	-	-	-	-
A11	-	-	-	-
A12	-	-	-	-
A13	-	-	-	-
A14	-	-	-	-
A15	-	-	-	-
A16	-	-	-	-
B8	-	-	-	-
B9	-	-	-	-
B10	-	-	-	-
B11	-	-	-	-
B12	-	-	-	-
B13	-	-	-	-
B14	-	-	-	-
B15	-	-	-	-
B16	-	-	-	-
C4	0.00	0.00	0	0
C5	0.11	0.11	500	500
C6	0.00	0.00	0	0
C7	0.01	0.00	200	100
C8	-	-	-	-
C9	-	-	-	-
C10	-	-	-	-
C11	-	-	-	-
C12	-	-	-	-
C13	-	-	-	-
C14	-	-	-	-
C15	-	-	-	-
C16	-	-	-	-
D2	0.25	0.25	200	200
D3	0.04	0.05	400	500
D4	0.04	0.01	500	100
D5	0.01	0.01	200	100
D6	0.14	0.04	1700	400
D7	0.00	0.00	0	0
D8	-	-	-	-
D9	-	-	-	-
D10	-	-	-	-
D11	-	-	-	-
D12	-	-	-	-
D13	-	-	-	-
D14	-	-	-	-
D15	-	-	-	-
D16	-	-	-	-
E1	0.10	0.10	200	200
E2	0.05	0.05	500	600

E3	0.01	0.01	200	100
E4	0.01	0.01	200	100
E5	0.05	0.03	600	300
E6	0.12	0.09	1400	1000
E7	0.04	0.04	500	400
E8	-	-	-	-
E9	-	-	-	-
E10	-	-	-	-
E11	-	-	-	-
E12	-	-	-	-
E13	-	-	-	-
E14	-	-	-	-
E15	-	-	-	-
E16	-	-	-	-
F1	0.00	0.00	0	0
F2	0.04	0.04	400	400
F3	0.07	0.06	700	700
F4	0.09	0.04	1000	400
F5	0.03	0.03	300	300
F6	0.01	0.01	100	100
F7	0.08	0.05	900	600
F8	-	-	-	-
F9	-	-	-	-
F10	-	-	-	-
F11	-	-	-	-
F12	-	-	-	-
F13	-	-	-	-
F14	-	-	-	-
F15	-	-	-	-
F16	-	-	-	-
G1	0.06	0.07	300	400
G2	0.03	0.03	300	300
G3	0.05	0.03	600	300
G4	0.05	0.00	600	0
G5	0.00	0.00	0	0
G6	0.01	0.01	100	100
G7	0.04	0.01	400	100
G8	-	-	-	-
G9	-	-	-	-
G10	-	-	-	-
G11	-	-	-	-
G12	-	-	-	-
G13	-	-	-	-
G14	-	-	-	-
G15	-	-	-	-
G16	-	-	-	-
H1	-	-	-	-
H2	0.10	0.01	1000	100
H3	0.18	0.12	2000	1400
H4	0.04	0.01	500	100
H5	0.22	0.18	2400	2000
H6	0.00	0.00	0	0
H7	0.00	0.00	0	0
H8	0.00	0.00	0	0
H9	0.00	0.00	0	0
H10	0.00	0.00	0	0
H11	-	-	-	-
H12	-	-	-	-

H13	-	-	-	-
H14	-	-	-	-
H15	-	-	-	-
H16	-	-	-	-
I1	0.00	0.00	0	0
I2	0.01	0.01	200	200
I3	0.00	0.00	0	0
I4	0.06	0.05	600	600
I5	0.06	0.05	600	600
I6	0.00	0.00	0	0
I7	0.06	0.03	600	300
I8	0.01	0.01	200	100
I9	0.00	0.00	0	0
I10	0.00	0.00	0	0
I11	-	-	-	-
I12	-	-	-	-
I13	-	-	-	-
I14	-	-	-	-
I15	-	-	-	-
I16	-	-	-	-
J2	0.00	0.00	0	0
J3	0.00	0.00	0	0
J4	0.00	0.00	0	0
J5	0.00	0.00	0	0
J6	0.01	0.01	200	100
J7	0.08	0.08	900	900
J8	0.08	0.05	900	600
J9	0.00	0.00	0	0
J10	0.00	0.00	0	0
J11	-	-	-	-
J12	-	-	-	-
J13	-	-	-	-
J14	-	-	-	-
J15	-	-	-	-
J16	-	-	-	-
K2	0.04	0.02	300	200
K3	0.00	0.00	0	0
K4	0.01	0.01	200	100
K5	0.01	0.01	200	100
K6	0.03	0.03	300	300
K7	0.00	0.00	0	0
K8	0.00	0.00	0	0
K9	0.00	0.00	0	0
K10	0.03	0.03	300	300
K11	-	-	-	-
K12	-	-	-	-
K13	-	-	-	-
K14	-	-	-	-
K15	-	-	-	-
K16	-	-	-	-
L2	-	-	-	-
L3	0.00	0.00	0	0
L4	0.01	0.01	100	100
L5	0.00	0.00	0	0
L6	0.00	0.00	0	0
L7	0.01	0.01	100	100
L8	0.01	0.01	200	100
L9	0.00	0.00	0	0

L10	0.02	0.01	200	100
L11	-	-	-	-
L12	-	-	-	-
L13	-	-	-	-
L14	-	-	-	-
L15	-	-	-	-
L16	-	-	-	-
M3	0.00	0.00	0	0
M4	-	-	-	-
M5	-	-	-	-
M6	-	-	-	-
M7	-	-	-	-
M8	0.03	0.03	300	300
M9	0.00	0.00	0	0
M10	0.03	0.03	300	300
M11	0.00	0.00	0	0
M12	0.00	0.00	0	0
M13	0.00	0.00	0	0
M14	0.00	0.00	0	0
M15	0.00	0.00	0	0
M16	0.00	0.00	0	0
N3	-	-	-	-
N4	-	-	-	-
N5	-	-	-	-
N6	-	-	-	-
N7	-	-	-	-
N8	-	-	-	-
N9	0.03	0.03	300	300
N10	0.00	0.00	0	0
N11	0.00	0.00	0	0
N12	0.00	0.00	0	0
N13	0.00	0.00	0	0
N14	0.00	0.00	0	0
N15	0.00	0.00	0	0
N16	0.00	0.00	0	0
O3	-	-	-	-
O4	-	-	-	-
O5	-	-	-	-
O6	-	-	-	-
O7	-	-	-	-
O8	-	-	-	-
O9	0.00	0.00	0	0
O10	0.00	0.00	0	0
O11	0.00	0.00	0	0
O12	0.00	0.00	0	0
O13	0.00	0.00	0	0
O14	-	-	-	-
O15	-	-	-	-
P3	-	-	-	-
P4	-	-	-	-
P5	-	-	-	-
P6	-	-	-	-
P7	-	-	-	-
P8	-	-	-	-
P9	0.00	0.00	0	0
P10	0.00	0.00	0	0
P11	0.00	0.00	0	0
P12	-	-	-	-

Q3	-	-	-	-
Q4	-	-	-	-
Q5	-	-	-	-
Q6	-	-	-	-
Q7	-	-	-	-

Appendix 5. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Emus for each degree block surveyed in 1993. Block codes (BKCD) are from Short *et al.*(1983). Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}. Areas not surveyed are indicated by -.

BKCD	D	SED	Y	SEY
A9	-	-	-	-
A10	-	-	-	-
A11	-	-	-	-
A12	-	-	-	-
A13	-	-	-	-
A14	-	-	-	-
A15	-	-	-	-
A16	-	-	-	-
B8	-	-	-	-
B9	-	-	-	-
B10	-	-	-	-
B11	-	-	-	-
B12	-	-	-	-
B13	-	-	-	-
B14	-	-	-	-
B15	-	-	-	-
B16	-	-	-	-
C4	0.00	0.00	0	0
C5	0.00	0.00	0	0
C6	0.00	0.00	0	0
C7	0.00	0.00	0	0
C8	-	-	-	-
C9	-	-	-	-
C10	-	-	-	-
C11	-	-	-	-
C12	-	-	-	-
C13	-	-	-	-
C14	-	-	-	-
C15	-	-	-	-
C16	-	-	-	-
D2	0.00	0.00	0	0
D3	0.10	0.03	800	200
D4	0.00	0.00	0	0
D5	0.10	0.09	1100	1100
D6	0.00	0.00	0	0
D7	0.00	0.00	0	0
D8	-	-	-	-
D9	-	-	-	-
D10	-	-	-	-
D11	-	-	-	-
D12	-	-	-	-
D13	-	-	-	-
D14	-	-	-	-
D15	-	-	-	-
D16	-	-	-	-
E1	1.18	1.18	2400	2400
E2	0.15	0.09	1500	900

E3	0.25	0.13	2900	1500
E4	0.00	0.00	0	0
E5	0.06	0.06	700	600
E6	0.00	0.00	0	0
E7	0.00	0.00	0	0
E8	-	-	-	-
E9	-	-	-	-
E10	-	-	-	-
E11	-	-	-	-
E12	-	-	-	-
E13	-	-	-	-
E14	-	-	-	-
E15	-	-	-	-
E16	-	-	-	-
F1	0.10	0.01	300	0
F2	0.17	0.02	2000	200
F3	0.43	0.04	4800	400
F4	0.04	0.04	400	400
F5	0.21	0.21	2400	2400
F6	0.00	0.00	0	0
F7	0.00	0.00	0	0
F8	-	-	-	-
~~F9~~	-	-	-	-
F10	-	-	-	-
F11	-	-	-	-
F12	-	-	-	-
F13	-	-	-	-
F14	-	-	-	-
F15	-	-	-	-
F16	-	-	-	-
G1	0.16	0.21	800	1000
G2	0.02	0.02	200	200
G3	0.60	0.59	6800	6700
G4	0.02	0.02	200	200
G5	0.27	0.11	3000	1300
G6	0.54	0.50	6100	5600
G7	0.00	0.00	0	0
G8	-	-	-	-
G9	-	-	-	-
G10	-	-	-	-
G11	-	-	-	-
G12	-	-	-	-
G13	-	-	-	-
G14	-	-	-	-
G15	-	-	-	-
G16	-	-	-	-
H1	-	-	-	-
H2	0.22	0.13	2400	1400
H3	0.18	0.18	2000	2000
H4	0.04	0.00	400	0
H5	0.72	0.40	8000	4500
H6	0.45	0.27	5000	3000
H7	0.65	0.31	7300	3500
H8	0.04	0.04	500	500
H9	0.82	0.45	9100	5000
H10	0.74	0.22	8200	2500
H11	-	-	-	-
H12	-	-	-	-

H13	-	-	-	-
H14	-	-	-	-
H15	-	-	-	-
H16	-	-	-	-
I1	0.00	0.00	0	0
I2	0.26	0.26	2700	2700
I3	0.51	0.33	5700	3600
I4	1.23	0.35	13600	3900
I5	1.12	0.60	12400	6700
I6	0.92	0.56	10200	6200
I7	0.29	0.16	3200	1700
I8	0.20	0.04	2300	400
I9	0.47	0.45	5200	4900
I10	0.37	0.37	4100	4100
I11	-	-	-	-
I12	-	-	-	-
I13	-	-	-	-
I14	-	-	-	-
I15	-	-	-	-
I16	-	-	-	-
J2	0.00	0.00	0	0
J3	0.12	0.12	1300	1300
J4	0.55	0.49	6000	5400
J5	0.82	0.55	9000	6000
J6	0.22	0.02	2500	200
J7	0.02	0.02	200	200
J8	0.59	0.14	6500	1500
J9	0.04	0.04	400	400
J10	0.00	0.00	0	0
J11	-	-	-	-
J12	-	-	-	-
J13	-	-	-	-
J14	-	-	-	-
J15	-	-	-	-
J16	-	-	-	-
K2	0.00	0.00	0	0
K3	0.06	0.06	700	600
K4	0.39	0.34	4200	3600
K5	0.06	0.06	700	600
K6	0.31	0.30	3300	3200
K7	0.10	0.10	1100	1100
K8	0.88	0.61	9500	6700
K9	0.22	0.22	2400	2400
K10	0.06	0.06	700	600
K11	-	-	-	-
K12	-	-	-	-
K13	-	-	-	-
K14	-	-	-	-
K15	-	-	-	-
K16	-	-	-	-
L2	-	-	-	-
L3	0.10	0.10	1100	1100
L4	0.06	0.06	700	600
L5	0.25	0.08	2600	900
L6	0.00	0.00	0	0
L7	0.14	0.14	1500	1500
L8	0.50	0.49	5400	5300
L9	0.35	0.30	3700	3200

L10	0.14	0.06	1500	700
L11	-	-	-	-
L12	-	-	-	-
L13	-	-	-	-
L14	-	-	-	-
L15	-	-	-	-
L16	-	-	-	-
M3	0.41	0.40	3900	3900
M4	-	-	-	-
M5	-	-	-	-
M6	-	-	-	-
M7	-	-	-	-
M8	0.43	0.42	4600	4500
M9	0.41	0.40	4400	4300
M10	0.00	0.00	0	0
M11	0.00	0.00	0	0
M12	0.00	0.00	0	0
M13	0.00	0.00	0	0
M14	0.00	0.00	0	0
M15	0.00	0.00	0	0
M16	0.00	0.00	0	0
N3	-	-	-	-
N4	-	-	-	-
N5	-	-	-	-
N6	-	-	-	-
N7	-	-	-	-
N8	-	-	-	-
N9	0.00	0.00	0	0
N10	0.00	0.00	0	0
N11	0.00	0.00	0	0
N12	0.00	0.00	0	0
N13	0.00	0.00	0	0
N14	0.00	0.00	0	0
N15	0.00	0.00	0	0
N16	0.00	0.00	0	0
O3	-	-	-	-
O4	-	-	-	-
O5	-	-	-	-
O6	-	-	-	-
O7	-	-	-	-
O8	-	-	-	-
O9	0.00	0.00	0	0
O10	0.11	0.10	1100	1100
O11	0.00	0.00	0	0
O12	0.00	0.00	0	0
O13	0.00	0.00	0	0
O14	-	-	-	-
O15	-	-	-	-
P3	-	-	-	-
P4	-	-	-	-
P5	-	-	-	-
P6	-	-	-	-
P7	-	-	-	-
P8	-	-	-	-
P9	0.00	0.00	0	0
P10	0.19	0.21	1800	1900
P11	0.02	0.03	200	200
P12	-	-	-	-

Q3	-	-	-	-
Q4	-	-	-	-
Q5	-	-	-	-
Q6	-	-	-	-
Q7	-	-	-	-

Appendix 6. Observed (uncorrected) density (D_O) and minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Goats for for each degree block surveyed in 1993. Block codes (BKCD) are from Short *et al.*(1983). Observed densities are in animals km^{-2}. Areas not surveyed are indicated by -.

BKCD	D_O	SED_O	Y_M	SEY_M
A9	-	-	-	-
A10	-	-	-	-
A11	-	-	-	-
A12	-	-	-	-
A13	-	-	-	-
A14	-	-	-	-
A15	-	-	-	-
A16	-	-	-	-
B8	-	-	-	-
B9	-	-	-	-
B10	-	-	-	-
B11	-	-	-	-
B12	-	-	-	-
B13	-	-	-	-
B14	-	-	-	-
B15	-	-	-	-
B16	-	-	-	-
C4	0.00	0.00	0	0
C5	0.00	0.00	0	0
C6	0.00	0.00	0	0
C7	0.00	0.00	0	0
C8	-	-	-	-
C9	-	-	-	-
C10	-	-	-	-
C11	-	-	-	-
C12	-	-	-	-
C13	-	-	-	-
C14	-	-	-	-
C15	-	-	-	-
C16	-	-	-	-
D2	0.00	0.00	0	0
D3	0.00	0.00	0	0
D4	0.00	0.00	0	0
D5	0.00	0.00	0	0
D6	0.00	0.00	0	0
D7	0.00	0.00	0	0
D8	-	-	-	-
D9	-	-	-	-
D10	-	-	-	-
D11	-	-	-	-
D12	-	-	-	-
D13	-	-	-	-
D14	-	-	-	-
D15	-	-	-	-
D16	-	-	-	-
E1	0.00	0.00	0	0
E2	0.25	0.15	2600	1600

E3	0.00	0.00	0	0
E4	0.00	0.00	0	0
E5	0.00	0.00	0	0
E6	0.00	0.00	0	0
E7	0.00	0.00	0	0
E8	-	-	-	-
E9	-	-	-	-
E10	-	-	-	-
E11	-	-	-	-
E12	-	-	-	-
E13	-	-	-	-
E14	-	-	-	-
E15	-	-	-	-
E16	-	-	-	-
F1	1.40	1.78	3800	4800
F2	0.30	0.04	3400	400
F3	0.00	0.00	0	0
F4	0.00	0.00	0	0
F5	0.00	0.00	0	0
F6	0.00	0.00	0	0
F7	0.00	0.00	0	0
F8	-	-	-	-
F9	-	-	-	-
F10	-	-	-	-
F11	-	-	-	-
F12	-	-	-	-
F13	-	-	-	-
F14	-	-	-	-
F15	-	-	-	-
F16	-	-	-	-
G1	0.86	1.11	4300	5500
G2	2.18	0.93	24600	10500
G3	1.08	0.54	12200	6100
G4	0.00	0.00	0	0
G5	0.01	0.01	100	100
G6	0.00	0.00	0	0
G7	0.00	0.00	0	0
G8	-	-	-	-
G9	-	-	-	-
G10	-	-	-	-
G11	-	-	-	-
G12	-	-	-	-
G13	-	-	-	-
G14	-	-	-	-
G15	-	-	-	-
G16	-	-	-	-
H1	-	-	-	-
H2	3.18	0.44	34100	4700
H3	0.41	0.02	4500	200
H4	0.73	0.16	8200	1800
H5	0.58	0.58	6500	6400
H6	0.25	0.24	2800	2600
H7	0.00	0.00	0	0
H8	0.00	0.00	0	0
H9	0.00	0.00	0	0
H10	0.00	0.00	0	0
H11	-	-	-	-
H12	-	-	-	-

H13	-	-	-	-
H14	-	-	-	-
H15	-	-	-	-
H16	-	-	-	-
I1	0.00	0.00	0	0
I2	1.78	1.64	18700	17200
I3	2.79	0.94	30900	10400
I4	4.56	1.24	50500	13700
I5	1.24	1.17	13700	13000
I6	1.94	0.18	21500	2000
I7	0.60	0.51	6600	5700
I8	0.00	0.00	0	0
I9	0.00	0.00	0	0
I10	0.00	0.00	0	0
I11	-	-	-	-
I12	-	-	-	-
I13	-	-	-	-
I14	-	-	-	-
I15	-	-	-	-
I16	-	-	-	-
J2	0.17	0.16	1800	1800
J3	1.26	0.47	13900	5100
J4	1.13	0.47	12300	5100
J5	0.99	0.79	10800	8600
J6	0.71	0.20	7800	2200
J7	0.42	0.40	4600	4400
J8	0.43	0.20	4700	2200
J9	0.22	0.21	2400	2300
J10	0.42	0.42	4600	4600
J11	-	-	-	-
J12	-	-	-	-
J13	-	-	-	-
J14	-	-	-	-
J15	-	-	-	-
J16	-	-	-	-
K2	0.00	0.00	0	0
K3	0.88	0.04	9500	400
K4	1.10	0.36	11900	3900
K5	2.88	0.85	31200	9200
K6	1.39	0.73	15100	7900
K7	1.92	0.83	20800	9100
K8	0.00	0.00	0	0
K9	0.82	0.04	8900	400
K10	0.24	0.15	2600	1600
K11	-	-	-	-
K12	-	-	-	-
K13	-	-	-	-
K14	-	-	-	-
K15	-	-	-	-
K16	-	-	-	-
L2	-	-	-	-
L3	0.00	0.00	0	0
L4	0.00	0.00	0	0
L5	0.38	0.37	4000	3900
L6	0.33	0.08	3600	900
L7	0.15	0.15	1600	1600
L8	0.10	0.09	1100	1000
L9	1.65	0.39	17800	4200

L10	0.56	0.24	6000	2600
L11	-	-	-	-
L12	-	-	-	-
L13	-	-	-	-
L14	-	-	-	-
L15	-	-	-	-
L16	-	-	-	-
M3	0.00	0.00	0	0
M4	-	-	-	-
M5	-	-	-	-
M6	-	-	-	-
M7	-	-	-	-
M8	0.00	0.00	0	0
M9	0.14	0.05	1500	600
M10	0.00	0.00	0	0
M11	0.00	0.00	0	0
M12	0.00	0.00	0	0
M13	0.00	0.00	0	0
M14	0.00	0.00	0	0
M15	0.00	0.00	0	0
M16	0.00	0.00	0	0
N3	-	-	-	-
N4	-	-	-	-
N5	-	-	-	-
N6	-	-	-	-
N7	-	-	-	-
N8	-	-	-	-
N9	0.00	0.00	0	0
N10	0.00	0.00	0	0
N11	0.00	0.00	0	0
N12	0.00	0.00	0	0
N13	0.00	0.00	0	0
N14	0.00	0.00	0	0
N15	0.00	0.00	0	0
N16	0.00	0.00	0	0
O3	-	-	-	-
O4	-	-	-	-
O5	-	-	-	-
O6	-	-	-	-
O7	-	-	-	-
O8	-	-	-	-
O9	0.00	0.00	0	0
O10	0.00	0.00	0	0
O11	0.00	0.00	0	0
O12	0.00	0.00	0	0
O13	0.00	0.00	0	0
O14	-	-	-	-
O15	-	-	-	-
P3	-	-	-	-
P4	-	-	-	-
P5	-	-	-	-
P6	-	-	-	-
P7	-	-	-	-
P8	-	-	-	-
P9	0.00	0.00	0	0
P10	0.00	0.00	0	0
P11	0.00	0.00	0	0
P12	-	-	-	-

Q3	-	-	-	-
Q4	-	-	-	-
Q5	-	-	-	-
Q6	-	-	-	-
Q7	-	-	-	-

Appendix 7. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Red Kangaroos for management zones, 1984. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.64	0.12	32,700	6,100
Ashburton West	1.22	0.23	100,300	18,800
Bay Pastoral	0.68	0.18	15,700	4,000
Carnarvon	1.99	0.49	67,300	16,600
Coolgardie	0.27	0.06	12,900	2,900
Dundas	0.09	0.00	3,200	0
Gascoyne	3.05	0.17	261,300	14,300
Leonora-Eastern Goldfields	2.48	0.63	262,200	66,200
Magnet	1.33	0.4	70,600	21,400
Murchison	3.01	0.94	287,900	89,600
North-east Pastoral	2.44	0.47	203,400	38,800
Northern Agriculture	0.42	0.09	23,900	5,100
Nullarbor	3.79	1.50	284,000	112,500
Pilbara	1.03	0.12	142,200	16,700
Sandstone	2.47	0.55	101,400	22,400
Yilgarn	0.24	0.11	8,700	4,000

Appendix 8. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Red Kangaroos for management zones, 1987. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	1.91	0.73	97,400	37,000
Ashburton West	2.90	0.68	237,800	56,200
Bay Pastoral	0.62	0.34	14,300	7,800
Carnarvon	2.14	0.51	72,700	17,200
Coolgardie	0.11	0.00	5,000	0
Dundas	0.00	0.00	0	0
Gascoyne	6.14	0.57	525,700	49,000
Leonora-Eastern Goldfields	2.60	0.46	274,800	48,300
Magnet	2.16	0.27	114,500	14,400
Murchison	5.73	0.39	546,900	37,500
North-east Pastoral	3.22	0.39	268,600	32,400
Northern Agriculture	0.56	0.09	31,900	5,300
Nullarbor	0.33	0.03	24,400	2,300
Pilbara	0.29	0.10	39,800	13,900
Sandstone	3.87	0.31	158,700	12,700
Yilgarn	0.06	0.03	2,100	1,100

Appendix 9. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Red Kangaroos for management zones, 1990. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	1.52	0.52	77,500	26,600
Ashburton West	2.58	0.53	212,100	43,800
Bay Pastoral	0.61	0.39	14,000	9,000
Carnarvon	2.05	0.58	69,500	19,600
Coolgardie	0.28	0.10	13,200	4,900
Dundas	0.08	0.05	2,900	1,900
Gascoyne	4.85	0.61	415,000	51,900
Leonora-Eastern Goldfields	2.22	0.17	234,400	18,400
Magnet	2.36	0.34	125,300	18,100
Murchison	3.89	0.50	371,500	47,800
North-east Pastoral	3.76	0.45	313,400	37,400
Northern Agriculture	1.23	0.22	70,000	12,400
Nullarbor	2.04	0.47	153,400	35,300
Pilbara	0.66	0.26	90,400	35,700
Sandstone	2.51	0.83	102,800	33,900
Yilgarn	0.36	0.21	13,100	7,500

Appendix 10. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Red Kangaroos for management zones, 1993. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	2.08	0.85	105800	43300
Ashburton West	0.53	0.12	43800	10200
Bay Pastoral	0.84	0.20	19300	4700
Carnarvon	1.71	0.67	58000	22800
Coolgardie	0.64	0.44	30,600	20,800
Dundas	0.02	0.01	700	400
Gascoyne	1.62	0.66	138,600	56,600
Leonora-Eastern Goldfields	1.19	0.09	125,600	9,300
Magnet	1.03	0.28	54,800	15,000
Murchison	3.07	0.69	293,600	66,300
North-east Pastoral	1.77	0.12	147,600	10,100
Northern Agriculture	0.99	0.44	55,900	24,800
Nullarbor	1.32	0.21	98,700	16,100
Pilbara	2.06	0.42	283,500	57,300
Sandstone	1.58	0.21	64,600	8,700
Yilgarn	0.24	0.18	8,700	6,500

Appendix 11. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Western Grey Kangaroos for management zones, 1984. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.00	0.00	0	0
Ashburton West	0.00	0.00	0	0
Bay Pastoral	0.11	0.09	2,400	2,200
Carnarvon	0.05	0.04	1,700	1,300
Coolgardie	0.86	0.31	40,800	14,900
Dundas	4.78	0.00	169,000	0
Gascoyne	0.00	0.00	0	0
Leonora-Eastern Goldfields	0.21	0.06	22,100	6,000
Magnet	0.03	0.01	1,500	600
Murchison	0.02	0.01	1,400	1,000
North-east Pastoral	0.02	0.01	1,600	700
Northern Agriculture	0.12	0.05	6,500	2,900
Nullarbor	3.50	1.74	262,400	130,300
Pilbara	0.00	0.00	0	0
Sandstone	0.02	0.02	700	700
Yilgarn	0.28	0.22	10,000	8,100

Appendix 12. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Western Grey Kangaroos for management zones, 1987. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.00	0.00	0	0
Ashburton West	0.00	0.00	0	0
Bay Pastoral	0.00	0.00	0	0
Carnarvon	0.00	0.00	0	0
Coolgardie	0.21	0.03	10,000	1,300
Dundas	2.72	0.00	96,300	0
Gascoyne	0.00	0.00	0	0
Leonora-Eastern Goldfields	0.13	0.03	13,700	2,700
Magnet	0.00	0.00	0	0
Murchison	0.00	0.00	0	0
North-east Pastoral	0.02	0.01	1,400	700
Northern Agriculture	0.03	0.03	1,800	1,500
Nullarbor	3.25	0.49	243,700	37,000
Pilbara	0.00	0.00	0	0
Sandstone	0.00	0.00	0	0
Yilgarn	0.17	0.15	6,300	5,400

Appendix 13. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Western Grey Kangaroos for management zones, 1990. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.00	0.00	0	0
Ashburton West	0.00	0.00	0	0
Bay Pastoral	0.07	0.03	1,600	600
Carnarvon	0.00	0.00	0	0
Coolgardie	0.40	0.19	19,100	8,800
Dundas	3.25	1.55	114,800	54,800
Gascoyne	0.03	0.01	2,200	1,100
Leonora-Eastern Goldfields	0.36	0.04	37,600	4,200
Magnet	0.10	0.04	5,500	2,400
Murchison	0.13	0.03	12,000	3,300
North-east Pastoral	0.12	0.06	10,200	5,400
Northern Agriculture	0.50	0.11	28,100	6,300
Nullarbor	4.96	1.66	372,400	124,700
Pilbara	0.00	0.00	0	0
Sandstone	0.28	0.18	11,600	7,300
Yilgarn	0.34	0.21	12,400	7,700

Appendix 14. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Western Grey Kangaroos for management zones, 1993. Values are corrected for vegetation bias using 'Caughley' correction factors, but there is no correction for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.00	0.00	0	0
Ashburton West	0.00	0.00	0	0
Bay Pastoral	0.28	0.24	6,400	5,500
Carnarvon	0.00	0.00	0	0
Coolgardie	0.87	0.65	41,300	30,900
Dundas	0.86	0.48	30,500	17,000
Gascoyne	0.00	0.00	0	0
Leonora-Eastern Goldfields	0.13	0.04	13,400	4,100
Magnet	0.03	0.03	1,800	1,800
Murchison	0.00	0.00	0	0
North-east Pastoral	0.00	0.00	0	0
Northern Agriculture	0.14	0.05	8,000	2,800
Nullarbor	4.23	3.13	317,600	234,600
Pilbara	0.00	0.00	0	0
Sandstone	0.05	0.04	2,100	1,800
Yilgarn	0.14	0.16	5,000	5,700

Appendix 15. Observed (uncorrected) density (D_O) and estimated minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Euros for management zones, 1987. Observed densities are in animals km^{-2}.

Management zone	D_O	SED_O	Y_M	SEY_M
Ashburton East	0.00	0.00	0	0
Ashburton West	0.02	0.00	1300	400
Bay Pastoral	0.00	0.00	0	0
Carnarvon	0.00	0.00	0	0
Coolgardie	0.00	0.00	0	0
Dundas	0.00	0.00	0	0
Gascoyne	0.03	0.00	2200	300
Leonora-Eastern Goldfields	0.03	0.01	3500	700
Magnet	0.03	0.01	1700	400
Murchison	0.01	0.00	600	100
North-east Pastoral	0.01	0.00	1000	300
Northern Agriculture	0.02	0.00	1200	300
Nullarbor	0.00	0.00	0	0
Pilbara	0.01	0.00	700	400
Sandstone	0.03	0.01	1300	300
Yilgarn	0.00	0.00	0	0

Appendix 16. Observed (uncorrected) density (D_O) and estimated minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Euros for management zones, 1990. Observed densities are in animals km^{-2}.

Management zone	D_O	SED_O	Y_M	SEY_M
Ashburton East	0.00	0.00	0	0
Ashburton West	0.01	0.00	600	300
Bay Pastoral	0.10	0.11	2300	2600
Carnarvon	0.00	0.00	0	0
Coolgardie	0.01	0.00	500	200
Dundas	0.00	0.00	0	0
Gascoyne	0.01	0.00	900	300
Leonora-Eastern Goldfields	0.02	0.00	2200	300
Magnet	0.03	0.02	1700	1000
Murchison	0.01	0.00	1400	500
North-east Pastoral	0.00	0.00	0	0
Northern Agriculture	0.07	0.04	3900	2500
Nullarbor	0.00	0.00	0	0
Pilbara	0.00	0.00	0	0
Sandstone	0.04	0.00	1700	100
Yilgarn	0.06	0.03	2000	1300

Appendix 17. Observed (uncorrected) density (D_O) and estimated minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Euros for management zones, 1993. Observed densities are in animals km^{-2}.

Management zone	D_O	SED_O	Y_M	SEY_M
Ashburton East	0.03	0.01	1500	700
Ashburton West	0.05	0.01	3800	800
Bay Pastoral	0.01	0.01	200	200
Carnarvon	0.06	0.02	2000	800
Coolgardie	0.01	0.01	400	500
Dundas	0.00	0.00	0	0
Gascoyne	0.07	0.02	6000	1600
Leonora-Eastern Goldfields	0.01	0.00	1200	300
Magnet	0.01	0.01	600	300
Murchison	0.02	0.01	1600	1000
North-east Pastoral	0.00	0.00	0	0
Northern Agriculture	0.02	0.01	1000	500
Nullarbor	0.00	0.00	0	0
Pilbara	0.05	0.01	7600	1500
Sandstone	0.04	0.02	1800	900
Yilgarn	0.01	0.01	300	200

Appendix 18. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Emus for management zones, 1984. Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.00	0.00	0	0
Ashburton West	0.04	0.01	3,000	1,100
Bay Pastoral	0.17	0.11	3,900	2,500
Carnarvon	0.13	0.08	4,300	2,800
Coolgardie	0.05	0.02	2,300	900
Dundas	0.00	0.00	0	0
Gascoyne	0.11	0.03	9,300	2,800
Leonora-Eastern Goldfields	0.08	0.03	8,700	3,100
Magnet	0.10	0.03	5,300	1,500
Murchison	0.15	0.05	14,400	4,700
North-east Pastoral	0.03	0.01	2,600	1,000
Northern Agriculture	0.02	0.01	1,200	500
Nullarbor	0.01	0.01	500	500
Pilbara	0.01	0.01	1,200	900
Sandstone	0.13	0.06	5,500	1,900
Yilgarn	0.01	0.01	500	500

Appendix 19. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Emus for management zones, 1987. Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.02	0.01	800	700
Ashburton West	0.16	0.04	12,900	3,700
Bay Pastoral	0.04	0.01	900	300
Carnarvon	0.15	0.07	5,000	2,500
Coolgardie	0.00	0.00	0	0
Dundas	0.00	0.00	0	0
Gascoyne	0.18	0.01	15,500	1,200
Leonora-Eastern Goldfields	0.16	0.04	16,400	4,300
Magnet	0.11	0.01	5,700	700
Murchison	0.15	0.01	14,600	1,200
North-east Pastoral	0.13	0.02	10,900	1,300
Northern Agriculture	0.05	0.01	2,900	800
Nullarbor	0.00	0.00	0	0
Pilbara	0.01	0.01	1,000	700
Sandstone	0.15	0.03	6,300	1,200
Yilgarn	0.09	0.10	3,200	3,700

Appendix 20. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Emus for management zones, 1990. Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.02	0.01	1,000	400
Ashburton West	0.18	0.05	14,600	3,800
Bay Pastoral	0.17	0.03	3,900	800
Carnarvon	0.22	0.06	7,400	2,100
Coolgardie	0.02	0.01	800	500
Dundas	0.05	0.03	1,800	1,200
Gascoyne	0.18	0.03	15,100	2,300
Leonora-Eastern Goldfields	0.12	0.02	12,600	2,000
Magnet	0.23	0.13	12,000	7,000
Murchison	0.44	0.32	42,200	30,600
North-east Pastoral	0.06	0.01	4,900	800
Northern Agriculture	0.35	0.13	19,800	7,600
Nullarbor	0.02	0.01	1,200	900
Pilbara	0.00	0.00	0	0
Sandstone	0.26	0.15	10,600	6,000
Yilgarn	0.22	0.19	7,900	6,800

Appendix 21. Corrected density (D) and estimated number (Y) (with standard errors, SED and SEY respectively) of Emus for management zones, 1993. Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}.

Management zone	D	SED	Y	SEY
Ashburton East	0.13	0.11	6,700	5,400
Ashburton West	0.13	0.04	10,800	2,900
Bay Pastoral	0.17	0.15	3,900	3,400
Carnarvon	0.17	0.04	5,800	1,300
Coolgardie	0.08	0.11	3,700	5,400
Dundas	0.03	0.03	1,100	900
Gascoyne	0.24	0.07	20,600	6,200
Leonora-Eastern Goldfields	0.29	0.06	30,100	5,900
Magnet	0.15	0.04	7,700	1,900
Murchison	0.74	0.19	71,200	18,600
North-east Pastoral	0.41	0.05	34,500	3,900
Northern Agriculture	0.16	0.08	9,100	4,500
Nullarbor	0.00	0.00	0	0
Pilbara	0.02	0.01	2,100	1,300
Sandstone	0.31	0.06	12,800	2,700
Yilgarn	0.07	0.06	2,700	2,300

Appendix 22. Observed (uncorrected) density (D_O) and estimated minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Goats for management zones, 1987. Observed densities are in animals km^{-2}.

Management zone	D_O	SED_O	Y_M	SEY_M
Ashburton East	0.00	0.00	0	0
Ashburton West	0.16	0.08	13,400	6,900
Bay Pastoral	0.34	0.08	7,800	1,700
Carnarvon	0.97	0.34	32,900	11,600
Coolgardie	0.00	0.00	0	0
Dundas	0.00	0.00	0	0
Gascoyne	0.40	0.08	34,500	6,500
Leonora-Eastern Goldfields	1.30	0.24	137,100	24,800
Magnet	0.56	0.06	29,900	3,200
Murchison	0.40	0.04	37,800	3,600
North-east Pastoral	0.00	0.00	0	0
Northern Agriculture	0.40	0.15	22,800	8,400
Nullarbor	0.00	0.00	0	0
Pilbara	0.00	0.00	0	0
Sandstone	1.70	0.66	69,600	27,000
Yilgarn	0.00	0.00	0	0

Appendix 23. Observed (uncorrected) density (D_O) and estimated minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Goats for management zones, 1990. Observed densities are in animals km^{-2}.

Management zone	D_O	SED_O	Y_M	SEY_M
Ashburton East	0.00	0.00	0	0
Ashburton West	0.07	0.03	5300	2100
Bay Pastoral	1.56	0.83	36100	19100
Carnarvon	2.80	0.81	94900	27500
Coolgardie	0.22	0.11	10700	5400
Dundas	0.01	0.01	300	200
Gascoyne	0.80	0.27	68400	23100
Leonora-Eastern Goldfields	1.06	0.16	111700	16500
Magnet	1.54	0.43	81800	22800
Murchison	1.82	0.25	174100	23800
North-east Pastoral	0.02	0.01	1300	800
Northern Agriculture	0.47	0.12	26600	6800
Nullarbor	0.00	0.00	0	0
Pilbara	0.00	0.00	0	0
Sandstone	0.57	0.25	23200	10200
Yilgarn	0.21	0.17	7600	6100

Appendix 24. Observed (uncorrected) density (D_O) and estimated minimum number (Y_M) (with standard errors, SED_O and SEY_M respectively) of Goats for management zones, 1993. Observed densities are in animals km^{-2}.

Management zone	D_O	SED_O	Y_M	SEY_M
Ashburton East	0.00	0.00	0	0
Ashburton West	0.02	0.01	1,800	1,000
Bay Pastoral	1.93	0.41	44,400	9,500
Carnarvon	1.45	0.52	49,300	17,700
Coolgardie	0.01	0.03	700	1,200
Dundas	0.00	0.00	0	0
Gascoyne	0.63	0.10	53,600	8,700
Leonora-Eastern Goldfields	0.44	0.08	46,500	8,400
Magnet	1.17	0.32	62,300	17,000
Murchison	1.47	0.44	140,300	42,000
North-east Pastoral	0.00	0.00	0	0
Northern Agriculture	0.60	0.19	34,000	11,100
Nullarbor	0.00	0.00	0	0
Pilbara	0.01	0.01	1,200	800
Sandstone	0.94	0.57	38,600	23,300
Yilgarn	0.19	0.06	6,800	2,000