REPORT ON THE 1987 AERIAL SURVEY OF KANGAROOS IN WESTERN AUSTRALIA.

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Summary

1. An aerial survey was conducted over 47% of Western Australia in May-August 1987, 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 and 1984.

2. The use of stratification was examined to determine whether increases in the precision of estimates and/or savings in total costs could be made.

3. Euros, Emus, Bustards and feral animals were also recorded.

4. There were estimated to be approximately 2 336 000 Red Kangaroos and 689 000 Western Grey Kangaroos in the area surveyed. Population change was estimated to be +16% and -1% for Reds and Western Greys respectively from 1984, and +123% and +55% respectively from 1981. The yearly finite rate of increase over the period 1981-87 was +0.134 for Reds and +0.071 for Western Greys.

5. Euro data are patchy and only presence/absence and observed density was reported here. No trends can be determined as data were not collected in 1984 or 1981.

6. Stratification resulted in an improvement of approximately 4% in the precision of the Red Kangaroo population estimate while reducing costs by approximately 10%. An equivalent or better improvement in the precision of the Western Grey Kangaroo estimate is possible, though this would effectively negate the 10% cost savings.

7. We recommend examination of ranger reports and/or harvest statistics from the areas experiencing significant increases and decreases in local Red Kangaroo populations, most notably the Gascoyne River catchment (increases) and the Nullarbor (decreases).

8. The Emu population in the survey area was estimated to be approximately 92 000 at an average density of 0.067 km^{-2}. Changes in distribution and abundance since 1981 are identified and discussed.

9. The Goat population in the survey area was estimated to be at least 368 000. This estimate is not corrected for visibility bias and so is a minimum value. Goats were the most widespread and frequently observed of the feral animals recorded on the survey.

10. Sightings of other feral animals were insufficient for population estimation, but gave a broad indication of distribution within the survey area.

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Introduction

In 1981 Short *et al.*(1983) aerially surveyed 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). Short *et al.*'s (1983) survey followed a drought of 2-4 years duration in Western Australia that broke in 1980. In 1984, after three seasons of moderate to good conditions in Western Australia, the Australian National Parks and Wildlife Service (ANPWS) conducted a similar survey of 47% of the state to determine the extent of change in the distribution and abundance of the two species. The results from this survey were again combined with those from aerial surveys conducted in other states in 1984 to derive an updated national estimate (Grigg *et al.* 1985).

A third survey was carried out over much the same area in the winter of 1987, maintaining a three year interval between surveys. In addition to resampling distribution and abundance it was decided that the possibility of reducing operating costs by stratifying the sampling would be investigated, and additional data on the Euro (*M. robustus erubescens*), Emu (*Dromaeus novaehollandiae*), Bustard (*Ardeotis australis*), Dingo (*Canis familiaris dingo*) and feral animals (Fox (*Vulpes vulpes*), Cat (*Felis catus*), Donkey (*Equus asinus*), Pig (*Sus scrofa*), Camel (*Camelus dromedarius*) and Goat (*Capra hircus*)) would be recorded.

This report presents the results of the 1987 survey and compares them with those from 1981 and 1984. Part I deals with the large kangaroos: the Red Kangaroo, the Western Grey Kangaroo and the Euro. It also examines the costs and benefits of stratification. The Emu, Bustard and feral animals are covered in Part II.

Methods

Survey areas

The 1987 survey covered 131 $1^{o}x1^{o}$ blocks ('degree blocks'). This represents an area of 1 370 239 km^2, or 47% of the state. A similar proportion of the state was surveyed in 1984. The 1984 and 1987 surveys were largely but not entirely coincident in area (Fig.1); all but three of the blocks surveyed in 1984 were resurveyed in 1987, and two additional blocks which were surveyed in 1981 but not in 1984 were included in the 1987 survey. The 1981 survey was larger in extent than the two latter surveys, covering 61% of the state (Fig. 1). The two most recent surveys were less extensive because some areas surveyed in 1981 (particularly the Great Sandy Desert in the north of the state) had negligible kangaroo densities.

Survey details

The 1987 survey was conducted in two sessions from 28 May to 11 June 1987 and 23 July to 11 August 1987. Technical details of the survey (speed, height, transect width, vegetation correction factors, observer standardisation and strip delineation) were as for the 1981 and 1984 surveys of Western Australia (Short *et al.* 1983, Fletcher and Southwell 1984) and surveys of other states (Caughley and Grigg 1981, Caughley and Grigg 1982, Short and Grigg 1982, Grigg *et al.* 1985).

The survey crew comprised five observers (B. Brown, M. Fletcher, T. Scotney, C. Southwell and G. Wyre) and two pilots (D. Bland and M. Dando). B. Brown was kindly provided by CSIRO Division of Wildlife and Ecology for part of the survey.

Stratification

Following discussions with the Western Australian Department of Conservation and Land Management (WA CALM) an attempt was made to stratify sampling effort on the basis of previously recorded densities of Red Kangaroos. Thirty-four degree blocks which recorded relatively high densities of Red Kangaroos (> 2 km^{-2} vegetation corrected) in either the 1981 or 1984 surveys were sampled at an intensity of approximately 0.6%. Rainfall records for Western Australia (Bureau of Meteorology) since 1983 were examined and 12 blocks with recorded densities of < 2 km^{-2} that had experienced above average rainfall were also sampled at 0.6% All other blocks were sampled at half this intensity*. The two strata are identified in Fig. 2a.

Two Western Grey Kangaroo strata were also selected; a low density stratum consisting of the 62 degree blocks north of 28°S and a high density stratum of the 69 degree blocks to the south of 28°S (Fig. 2b). Sampling intensities in these strata were not manipulated in response to expected Western Grey Kangaroo densities; instead the indicated Red Kangaroo sampling intensities were followed.

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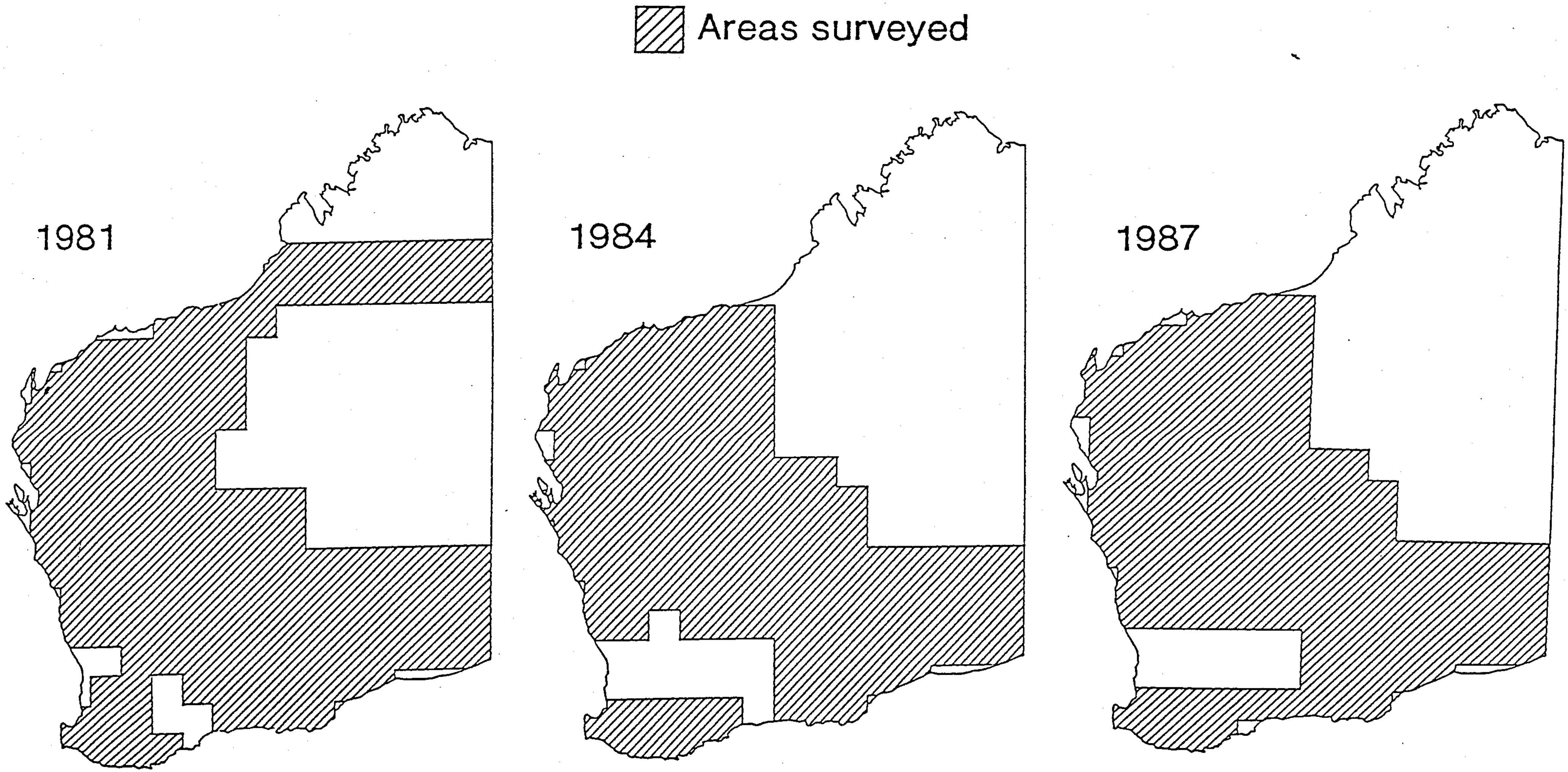
*Intensity depends upon the length of transect and area of degree block. Blocks with irregular boundaries and small areas (e.g. coastal blocks) may be sampled at non-standard intensities.

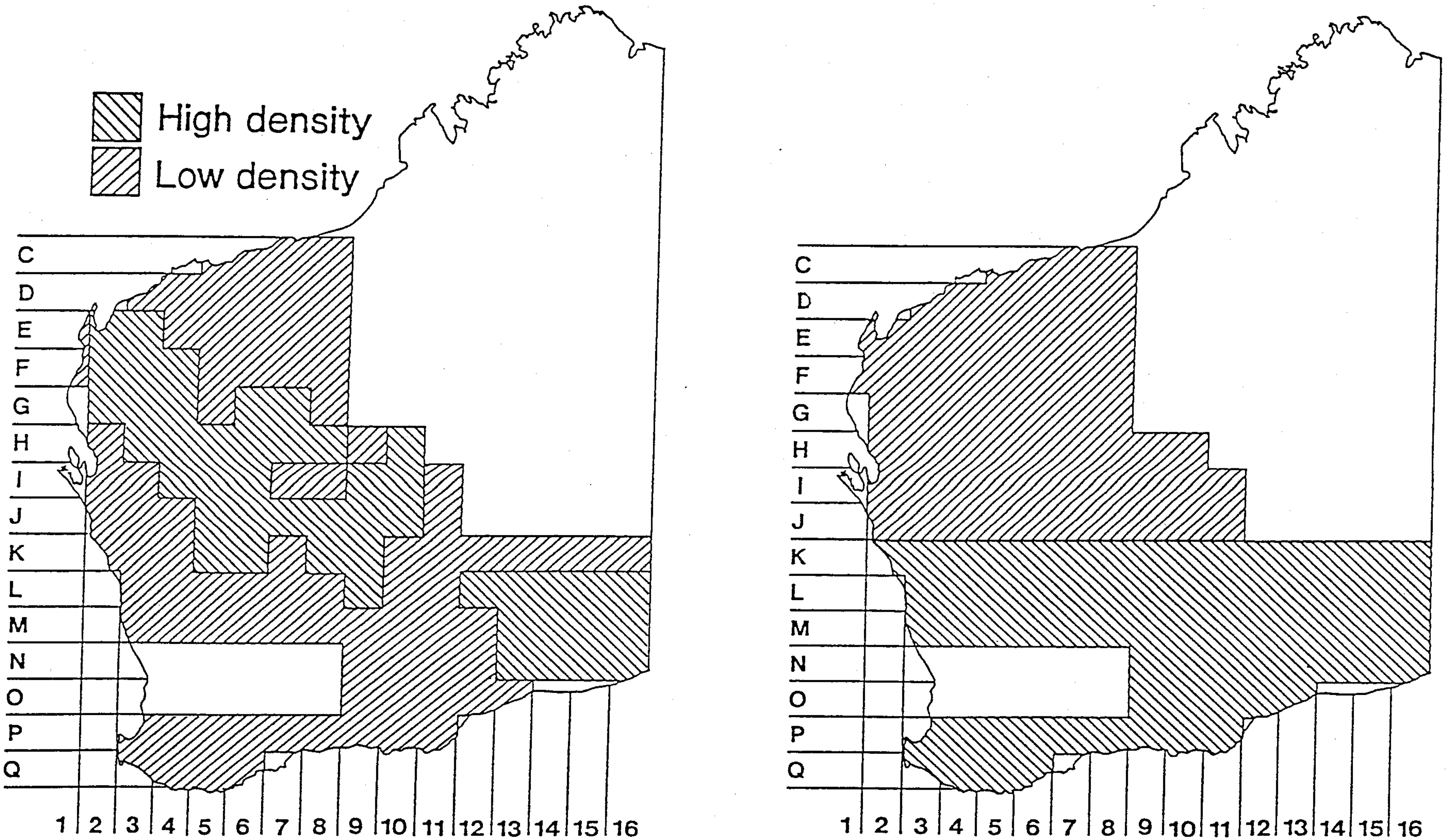
Fig. 1. Aerial survey zones in 1981*, 1984 and 1987



*Source Short *et al.* 1983

Fig. 2. Density strata for Red and Western Grey Kangaroos in 1987.

Block codes follow Short *et al.*(1983).



(a) Red Kangaroo (b) Western Grey Kangaroo

Correction for vegetation

Vegetation was recorded for each segment (200 m by 5 km, or 1 km^{-2}). The vegetation bias correction factors used in this report are those derived for Red Kangaroos by Caughley *et al.* (1976). There is now considerable evidence that these correction factors underestimate Western Grey Kangaroo populations by a factor somewhere in the range of 2.5 to 7 times (Short and Bayliss 1985, Short and Hone 1989). Further work is currently being conducted on Red Kangaroo correction factors, but the most recently available works of Short and Bayliss (1985) and Short and Hone (1989) do not contradict the original results of Caughley *et al.* (1976). Two studies have been conducted on correction factors for Euros. One, an aerial survey/drive count comparison at Kinchega National Park in western N.S.W., returned a correction factor of 11.1 in what was considered by the authors to be atypical Euro habitat (Short and Hone 1989). The second study in central southern Queensland, using an aerial survey/ground survey comparison, gave an average correction factor of 15 over a range of vegetation from open cover to high density shrubland, though the sample sizes were small (Southwell *et al.* 1986). Although no firm conclusions can be drawn from these studies, it would appear that correction factors for Euros are higher than those for Red or Grey Kangaroos. Only observed densities are used in this report.

Observed densities of Emus have been 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, so the correction factor should be applicable to conditions encountered during the 1984 and 1987 surveys.

Analysis

Kangaroo density data corrected for visibility bias were grouped by transect before being analysed separately for Red and Western Grey Kangaroos. The ratio method (Cochran 1953) was used to calculate standard errors as sampling units were of unequal size (Norton-Griffiths 1978).

$\hat{R}$ = ratio of animals counted to area searched
N = total number of sampling units in population
n = number of sample units in the sample
Z = area of the survey zone
z_i = area of the ith sample unit
y_i = number of animals counted in the ith sample unit

$$s_y^2 = \frac{1}{n-1}\sum\left(y_i^2 - \frac{(\sum y_i)^2}{n}\right)$$

$$s_z^2 = \frac{1}{n-1}\sum\left(z_i^2 - \frac{(\sum z_i)^2}{n}\right)$$

$$S_{zy} = \frac{1}{n-1} \cdot \sum\left((z_i \cdot y_i) - \frac{(\sum z_i) \cdot (\sum y_i)}{n}\right)$$

$$\text{Population total} = \hat{Y} = Z.\hat{R}$$

$$\text{Population variance} = \text{Var}(\hat{Y}) = \frac{N(N-n)}{n} \cdot (S_y^2 - 2.\hat{R}.S_{zy} + \hat{R}^2.S_z^2)$$

$$\text{Population standard error} = \text{SE}(\hat{Y}) = \sqrt{\text{Var}(\hat{Y})}$$

Average transect area was used to calculate N, the total number of transects.

Corrected density data for the three surveys were heteroscedastic with the standard deviations proportional to the means so the data were transformed to $X' = \log_{10}(X + 1)$. This transformation also reduced skew. Analysis of variance (ANOVA) was performed on the transformed densities. A Student-Newman-Keuls (SNK) test was used for multiple comparisons between years when ANOVA rejected the null hypothesis (Zar 1974). Average density (kangaroos km^{-2}) for the 119 degree blocks common to all three surveys were included in the analyses. Data for Red and Western Grey Kangaroos were analysed separately.

A population estimate and population variance were calculated separately for each stratum and combined to give a total estimate and variance (Norton-Griffiths 1978). In the text estimates are rounded to the nearest thousand, but unrounded figures are presented in the Appendices.

Trends between surveys were deduced from summed block totals for each year. Only blocks common to the years being compared were used in each case. Standard errors could not be calculated for these comparisons as many blocks contained only one sample. Standard errors are calculated for strata and combined total estimates only.

Density maps were prepared from data averaged over transects with reference to variation along transects. Contours were fitted by eye. Red Kangaroo, Western Grey Kangaroo and Emu densities were corrected for vegetation and observer bias, but not for temperature. Goat densities were corrected for observer bias only. Euro, Bustard and feral animal sightings are presented as presence/absence maps (numbers for these species were not recorded during the 1984 survey). Observed densities for each degree block for 1987 are given in the Appendices.

PART I. KANGAROOS

Results

Comparison of 1987 survey with 1981 and 1984 surveys

(i) Red Kangaroo

The estimated corrected numbers and densities of Red Kangaroos in each degree block surveyed in 1981, 1984 and 1987 are presented in Appendix 1. The Red Kangaroo population in the survey zone in 1987 is estimated to be approximately 2 336 000. A comparison of results for the degree blocks common to various combinations of the 1981, 1984 and 1987 surveys is given in Table 1.

Between 1984 and 1987 there was a 16 % increase in Red Kangaroo numbers, from 2 015 000 to 2 336 000 in the areas common to both surveys. This represents an average finite yearly rate of increase (r) of +0.049. From 1981 to 1987 the population has experienced an average r of +0.134.

ANOVA detected a significant difference between years (F = 4.2579, P = 0.0149). A SNK test revealed that densities in 1981 were significantly lower than in 1984 or 1987, while 1987 was not significantly different from 1984.

Maps of the corrected densities for 1981, 1984 and 1987 are displayed in Fig. 3. Densities have increased in the Carnarvon, Ashburton East, Ashburton West, Gascoyne, Murchison, North East Pastoral, Sandstone and Leonora-Eastern Goldfields management areas over the period 1981-87, while the Pilbara and Nullarbor management areas and the Great Victoria Desert have recorded density declines.

The broad pattern of density distribution in 1987 is similar to 1981 and 1984 with the exception of the Rawlinna/Nullarbor area where a prominent high density zone has shrunk over time.

The southern limit of distribution continues to approximate the line between Geraldton and Eyre, while the highest densities were recorded between North West Cape, Mount Newman and Leonora.

(ii) Western Grey Kangaroo

Appendix 2 presents the estimated corrected number and density of Western Grey Kangaroos for each degree block surveyed in 1981, 1984 and 1987. The total population in the survey zone in 1987 is estimated to be 689 000. Table 1 compares results for the degree blocks common to various combinations of the three surveys.

Western Grey Kangaroo populations remain essentially unchanged, having decreased by 1% from 683 000 to 675 000 in common areas between 1984 and 1987, an average annual r of -0.004. From 1981 to 1987 the average r has been +0.071.

ANOVA detected no significant differences between surveys (F = 0.9953, P = 0.3706).

Fig. 4 displays density distributions for the years 1981, 1984 and 1987. The pattern of distribution is very similar to that recorded in 1984. The highest densities were recorded along the southern coast near Albany, Balladonia and

Madura. Western Grey Kangaroos were sighted well up into the Nullarbor Plain/Great Victoria Desert region especially just east of Laverton.

(iii) Euro

Appendix 3 presents observed densities of Euros for those degree blocks in which they were recorded during the 1987 survey. Presence/absence of Euros in each degree block is given for the 1984 and 1987 surveys in Fig. 5 (Euros were not recorded in the 1981 survey).

The number of sightings in each survey is low and the distribution patchy though generally similar in appearance to that of the Red Kangaroo and Emu.

The highest observed densities were around Mount Magnet, between the Gascoyne and Lyons Rivers, and north of Laverton on the western edge of the Great Victoria Desert.

Stratification

(i) Red Kangaroo

The results of the stratified sample for Red Kangaroos are presented in Table 2.

The high density stratum (Fig. 2a) comprised 37% of the total survey area and contained 75% of the total estimated Red Kangaroo population.

The estimated Red Kangaroo population in the low density stratum was 576 000 with a standard error (S.E.) of 125 128 and a C.V. of 21.7%. In the high density stratum the estimated population was 1 759 000 (S.E. 181 276 and C.V. 10.3%). The total population was estimated to be 2 335 000 (S.E. 220 268 and C.V. 9.4%). This differs slightly from the unstratified estimate of 2 336 000 (0.004% lower) due to densities not being weighted by block area in the ANOVA.

(ii) Western Grey Kangaroo

Table 3 presents the results of the stratified analysis for Western Grey Kangaroos.

The high density stratum (Fig. 2b) comprised 51% of the total survey area and contained 99.6% of the total estimated Western Grey Kangaroo population.

The estimated Western Grey Kangaroo population in the low density stratum was 2000 with a S.E. of 1 745 and a C.V. of 71.3%. In the high density area the estimated population was 640 000 (S.E. 181 375 and C.V. 28.4%). The total population was estimated to be 642 000 (S.E. 181 383 and C.V. 28.2%). This estimate is 4.8% lower than the unstratified estimate of 675 000, reflecting the non-random distribution of animals and varying transect lengths, as was the case with Red Kangaroos.

Table 1. Population estimates, percentage change and annual *r* for Red and Western Grey Kangaroos from the 1981, 1984 and 1987 surveys for areas common to all three surveys.

SURVEY RESULTS*	3 YEAR TRENDS**	6 YEAR TREND**
1981 (148)	1981-1984 (119)	
Reds 981 000	Reds 1981 962 000	
Greys 436 000	1984 1 849 000	
	Percent change = +92%	
	r = +0.218	
	Greys 1981 424 000	
	1984 665 000	
	Percent change = +57%	1981-1987 (121)
	r = +0.150	
		Reds 1981 962 000
1984 (133)		1987 2 146 000
		Percent change = +123%
Reds 2 019 000		*r* = +0.134
Greys 683 000		
		Greys 1981 428 000
		1987 657 000
	1984-1987 (130)	Percent change = +55%
		r = +0.071
	Reds 1984 2 015 000	
	1987 2 336 000	
	Percent change = +16%	
	r = +0.049	
1987 (132)	Greys 1984 683 000	
	1987 675 000	
Reds 2 336 000	Percent change = -1%	
Greys 689 000	*r* = -0.004	

* The number of partial or complete degree blocks surveyed is given in brackets.

** The number of partial or complete degree blocks common to both surveys which were used in analysis is given in brackets.

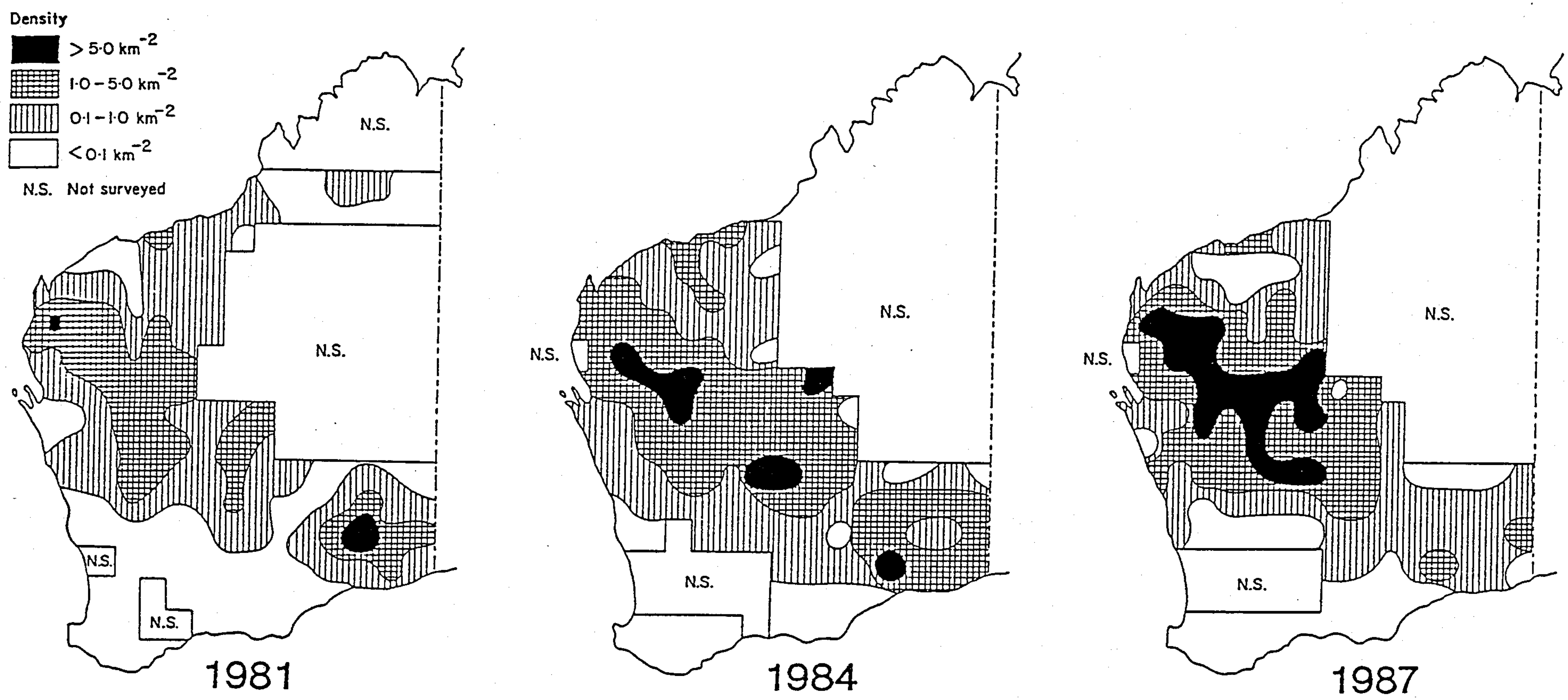
Table 2. Population estimates (Y), standard errors (S.E.) and coefficients of variation (C.V.) for 1987 stratified sample of Red Kangaroos. Number of blocks is given in brackets.

STRATA	*n*	*Y*	S.E.	C.V.(%)
Low density (85)	86	576 000	125 128	21.7
High density (46)	92	1 759 000	181 276	10.3
Total combined (131)	178	2 335 000	220 268	9.4

Table 3. Population estimates (Y), standard errors (S.E.) and coefficients of variation (C.V.) for 1987 stratified sample of Western Grey Kangaroos. Number of blocks is given in brackets.

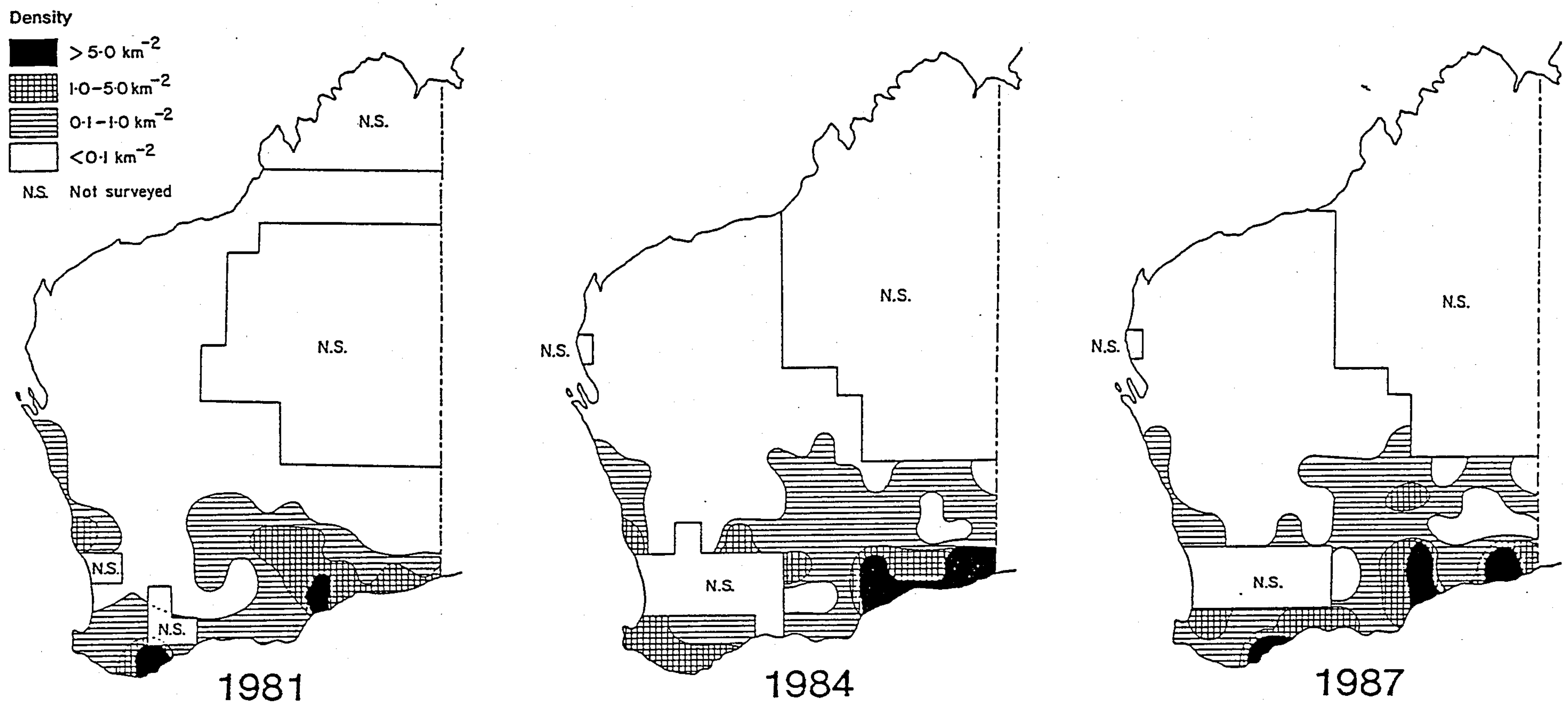
STRATA	*n*	*Y*	S.E.	C.V.(%)
Low density (62)	90	2 000	1 745	71.3
High density (69)	88	640 000	181 375	28.4
Total combined (131)	178	642 000	181 383	28.2

Fig. 3. Red Kangaroo densities in 1981*, 1984 and 1987.



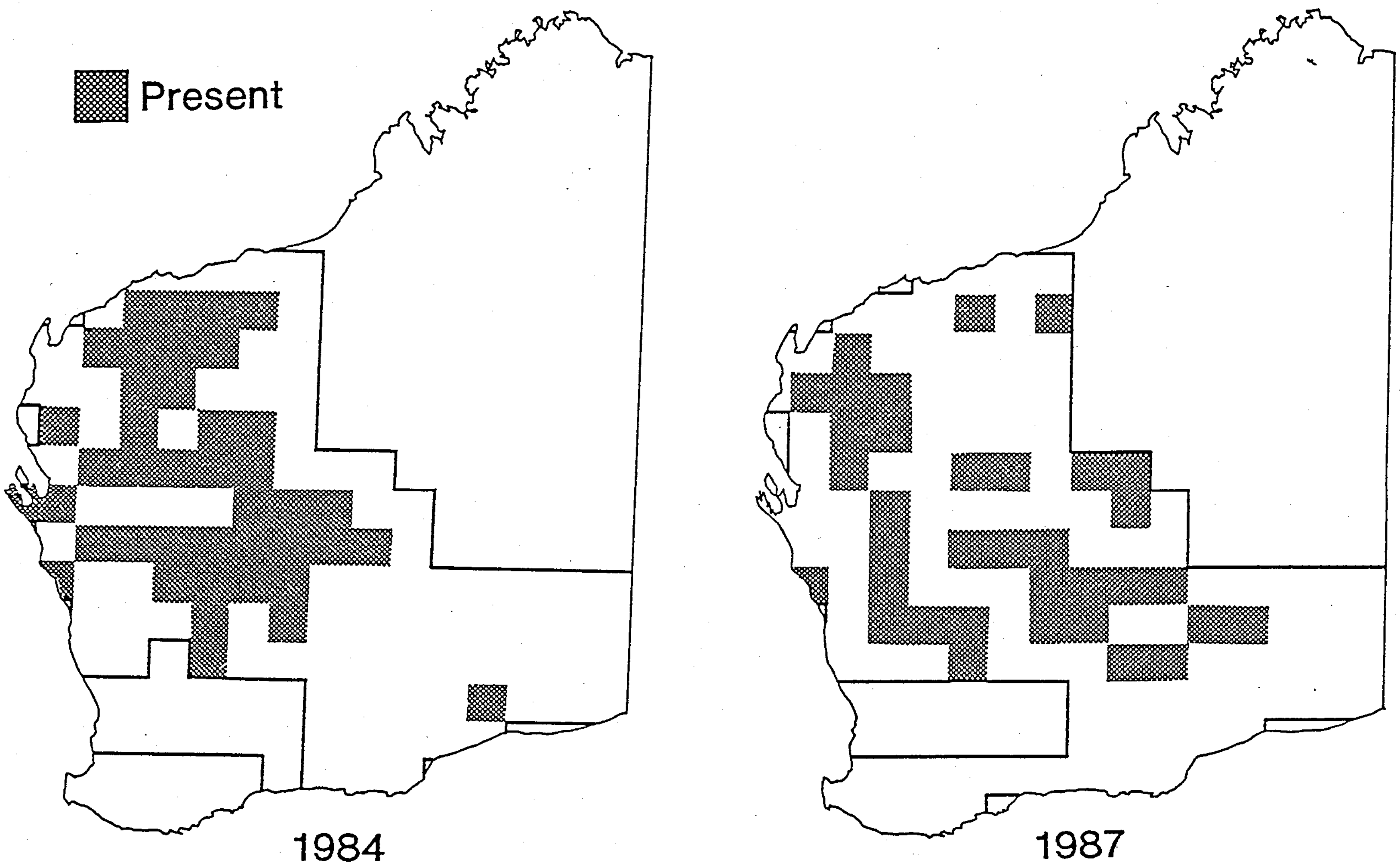
* Source Short *et al.* (1983)

Fig. 4. Western Grey Kangaroo densities in 1981*, 1984 and 1987.



* Source Short *et al.* (1983)

Fig. 5. Presence/absence of Euros in 1984 and 1987.



Discussion

Red and Western Grey Kangaroo

The 1987 survey recorded an increase of 16% in Red Kangaroo numbers and a decrease of 1% in Western Grey Kangaroo numbers since 1984. Neither was a statistically significant change from the 1984 results.

Fig. 3 highlights the continued increase in Red Kangaroo densities in the central west of the state around the Gascoyne River catchment and the continuing decrease in the Nullarbor region. We suggest that particular attention be paid to ranger reports and harvest statistics from the latter area.

Western Grey Kangaroo populations appear to be static with only minor variations in local density patterns being detected (Fig. 4). The rate of increase may well have been adversely affected by drought episodes in the south west of the state.

Rainfall has been good to average over most of the state in the 1984-87 period with the only significant rainfall deficiencies being seen in the south west tip and coast (17 months, 1 June 1984 to 31 October 1985, Geraldton-Southern Cross-Manjimup; 9 months, 1 March to 30 November 1986, Perth-Newdegate-Albany; 4 months, 1 December 1986 to 31 March 1987, Perth-Bencubbin-Lake Varley, Bureau of Meteorology 1984-1987).

Euro

Research into correction factors for this species is in a preliminary state and we felt it wise to report only observed densities. Although data are scarce it is certain that the species is difficult to observe from the air. From Fig. 5 we would venture to suggest that the distribution of the Euro is generally similar to that of the Red Kangaroo (Fig. 3) and Emu (see Fig. 6, Part II), i.e. distributed throughout the pastoral regions of the state.

We have not reported observed densities for the 1984 survey because Euros were not a primary target species in that survey and only presence/absence was recorded. For this reason we cannot comment on any apparent trends in the population up to 1987.

Stratification

Stratification on the basis of Red Kangaroo densities recorded in 1981 and 1984 appears to have succeeded with a C.V. of 9% being attained. The C.V. for the corresponding analysis of Western Grey Kangaroos was 28%, reflecting both the relatively inefficient allocation of sampling intensity for this species (due to its different distribution) and its lower numbers. Calculations suggest that identical effort expended in a non-stratified survey would have returned C.V.'s of around 13% and 27% for Red and Western Grey Kangaroos respectively. This emphasises the efficiency of this design with respect to Red Kangaroos and its relative inefficiency with respect to Western Greys.

Flight records indicate that through stratification in 1987 we reduced the number of hours surveying by 28%, increased the number of hours spent in transport flying by 17%, and reduced total flying hours by 7% when compared to 1984. This is consistent with expectation as a less systematic location of transects usually results in a lower coverage of sampled area per unit time (Caughley

1977). Total savings on plane and pilot hire, fuel, salaries and allowances is in the order of 10% when compared to an unstratified design of identical total effort.

Stratification has thus resulted in both a drop in expenditure and a gain in the precision of the Red Kangaroo estimate. It should be noted that not much more can be done to improve the precision for Red Kangaroos without dramatically increasing the intensity and hence cost of the survey. Costs could be held stable by reducing the effort put into sampling the Western Grey Kangaroo population. Conversely, the precision of the Western Grey Kangaroo estimate can be improved to some extent by surveying the areas of highest density at increased intensity, effectively negating the 10% savings on total expenditure.

Survey design

Aerial surveys have several possible objectives in biological work, each with their own requirements. Estimates of relative or absolute abundance require consideration of the area for which the estimate is required, the precision with which it is required and whether stratification is feasible. These three factors will determine the sampling intensity and ultimately the cost. If distributional information is required, transects may have to be flown systematically over the entire survey area to allow production of a density contour map. If both outcomes are expected then some combination of the above may be necessary, with the efficiency of the former compromised by the need for the latter.

In the case of Western Australia the two species of primary interest (the Red and Western Grey Kangaroo) have opposing distributions and impose conflicting requirements on survey design. No single design is optimal for both species. One must instead choose between a design that is directed toward both species and optimal for neither (as in the 1981 and 1984 surveys) or toward one species only (as for the Red Kangaroo in the 1987 survey). A comparison of the two options is presented in the results.

A related option may be to apply an unstratified systematic design with sampling intensity half that of the 1981 survey. This would involve flying a single transect across each block rather than two transects. The sampling intensity of two lines per block derives originally from developmental work in New South Wales (Caughley *et al*. 1977). This state is only half the size of Western Australia, and sampling at the same intensity in the latter state may be a case of sampling 'overkill' (halving the sampling intensity in Western Australia would result in a similar effort to that for New South Wales).

We hope to carry out further investigations of these and other options prior to the next survey in 1990.

PART II. OTHER ANIMALS

Results

Emu

The estimated corrected numbers and densities of Emus for each degree block in which they were sighted in 1984 and 1987 are presented in Appendix 4. Fig. 6 shows corrected densities of Emus for 1981, 1984 and 1987.

In 1981 population size was estimated to be 110 000 and average density 0.074 km^{-2} (Caughley and Grice 1982). Relatively high densities (>0.3 km^{-2}) were recorded in the middle reaches of the Ashburton River, a narrow band extending north from Jurien to Geraldton then up the Murchison River and three small pockets located east of Wiluna, south of Laverton and west of Albany (Caughley and Grice 1982).

Estimated population size in the 1984 survey area was 73 000 and average density was 0.053 km^{-2}. Fig. 6 shows the high density region on the west coast, up the Murchison and in the middle reaches of the Ashburton Rivers to have disappeared. There was one large area of high density extending through the lower reaches of the Minilya River, the middle reaches of the Gascoyne and the upper tributaries of the Murchison River, and a smaller high density region immediately west of Leonora.

Average density in 1987 was estimated to be 0.067 km^{-2}, giving an estimated population of 92 000. High densities were recorded along the south coast and near Leonora. In the central west of the state there has been a general expansion of the moderate density area while high densities were once again recorded near the Minilya and Gascoyne Rivers.

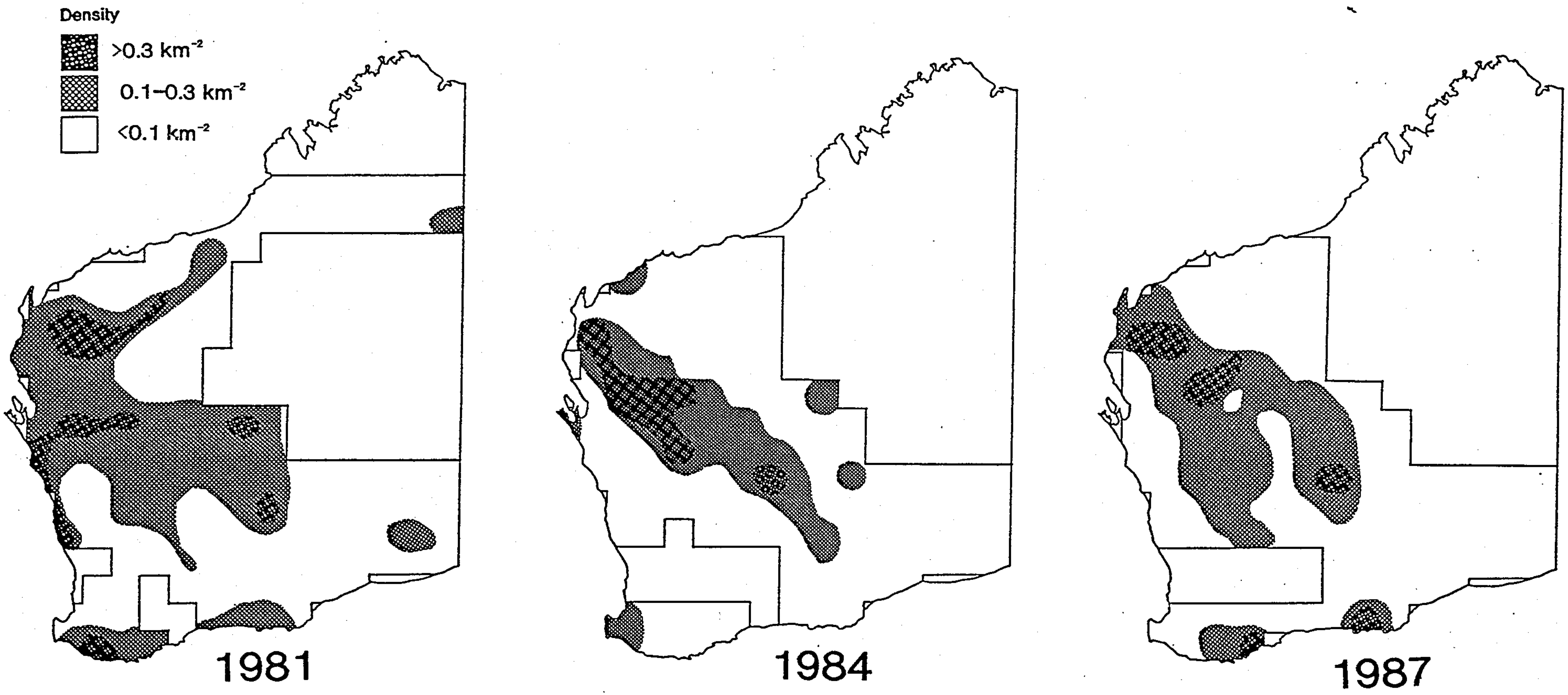
Distributions in all three years are generally consistent with that given in Blakers *et al.* (1984).

Bustard

Bustard sightings were not recorded during the 1981 or 1984 surveys so no comparison with the 1987 results is available. The patchy distribution of sightings in 1987 (Fig. 7) probably reflects the difficulty of surveying low density populations rather than the true distribution of the bird in Western Australia. Appendix 5 presents observed densities of Bustards for those degree blocks in which they were sighted.

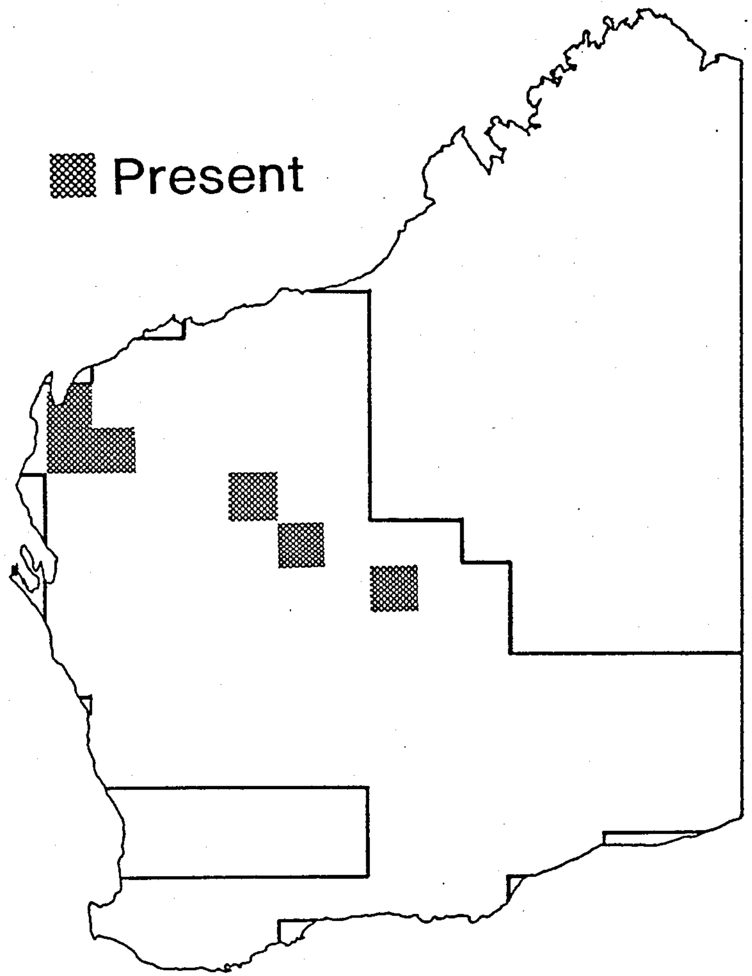
The sightings lie along the south-western edge of the 11-40% and 40% reporting rate areas identified by Blakers *et al.* (1984), or roughly the area bordered by Exmouth Gulf-Collier Range-Lake Disappiontment-Oakover River. Curiously, no Bustards were sighted inside this area, though Blakers *et al.* (1984) do note that this species is 'probably nomadic in response to increases in food supply after rain'. Average observed density was low at 0.03 km^{-2} in blocks where the Bustard was sighted.

Fig. 6 Emu densities in 1981*, 1984 and 1987.



*Source Caughley and Grice (1982)

Fig. 7. Presence/absence of Bustards in 1987.



Dingo

Fig. 8 displays degree blocks in which the Dingo was sighted in 1984 and 1987, while the raw data for 1987 are presented in Appendix 6. Sightings in 1987 were less extensive than in 1984, but this is more likely an artefact of low densities than a real decline in range. Sightings in 1984 were primarily in the Nullarbor region north of the rail link between Rawlinna and Deakin; in 1987 a single animal was sighted in the extreme south-east of the state between Mundrabilla and Eucla. Strahan (1983) considers the Dingo to be found all over mainland Australia.

Fox

As for the Dingo, Fox sightings were concentrated in the Nullarbor region, with scattered records elsewhere. All sightings were of individual animals (Fig. 9 and Appendix 7). Strahan (1983) considers the Fox to be distributed south of the line Oakover River- Lake Carnegie-Surveyor Generals Corner, except in years with favorable rainfall when they may range further north. All sightings fall within this distribution.

Cat

The Cat is certainly the smallest and hardest to spot of all animals recorded on the surveys. Fig. 10 displays the distribution of sightings on a degree block basis. Observed densities are listed in Appendix 8.

As with the other two predators (the Dingo and Fox), sightings of Cats were concentrated in the Nullarbor region. Strahan (1983) considers the Cat to be present across all of Australia.

Donkey

Donkey sightings were concentrated in the northern section of the survey areas, restricted to the isolated populations that Strahan (1983) identified in Western Australia (Fig. 11 and Appendix 9).

Pig

Only three Pigs have been recorded during the two surveys; all were in block K2 near Geraldton in 1987 (Fig 12 and Appendix 10). This is some 1 000 km from the closest population (near Port Headland) identified in Strahan (1983) and may represent a population introduced by humans for recreational hunting purposes.

Camel

The extent of Camel sightings in 1987 has contracted from that of 1984 (Fig. 13). Most sightings in 1987 were made on the central western edge of the survey zone around Lake Carnegie, while none were recorded north of 25^{o} south. A small population was once again sighted between Kambalda and Balladonia. All

Fig. 8. Presence/absence of Dingoes in 1984 and 1987.

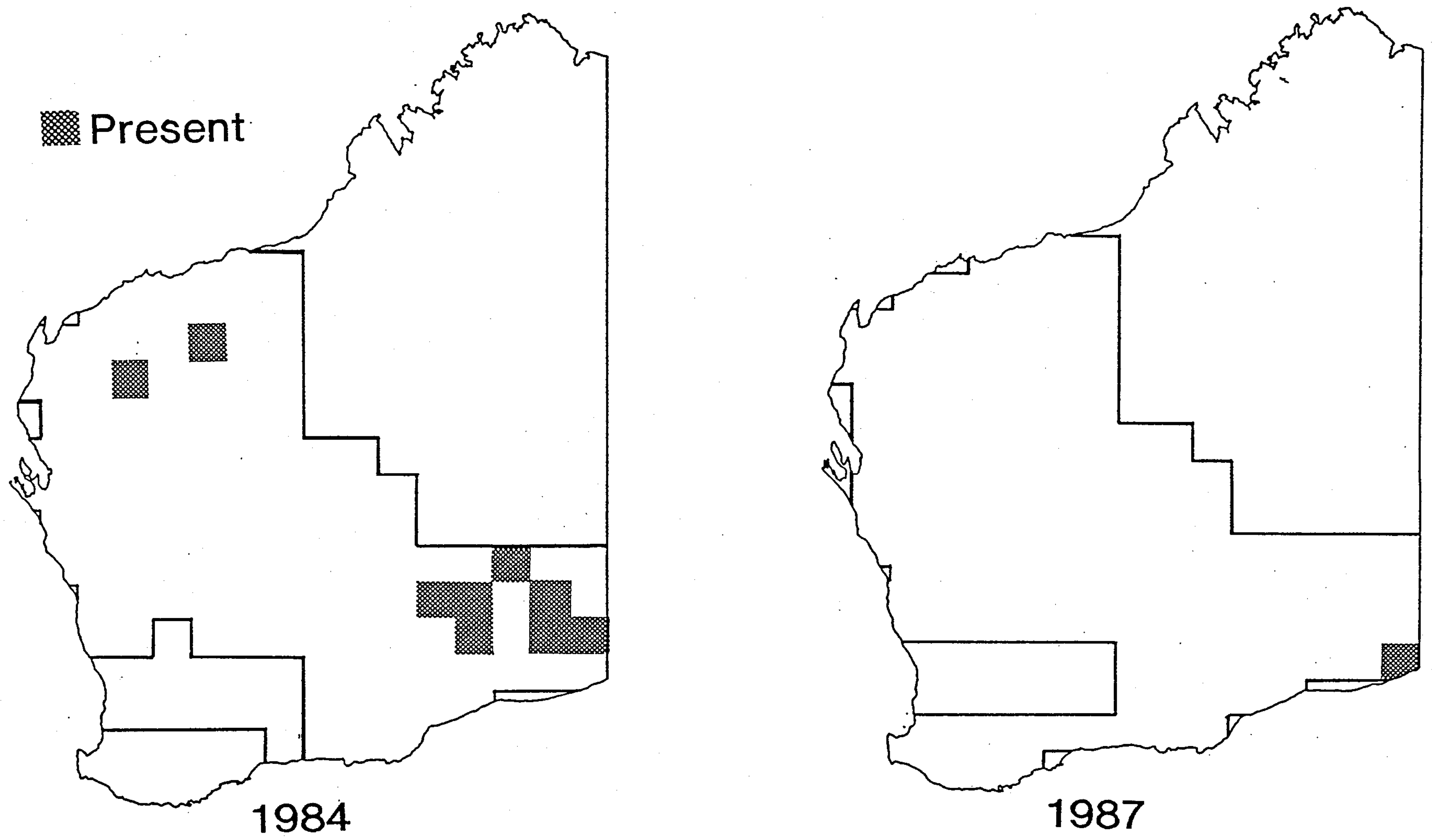


Fig. 9. Presence/absence of Foxes in 1984 and 1987.

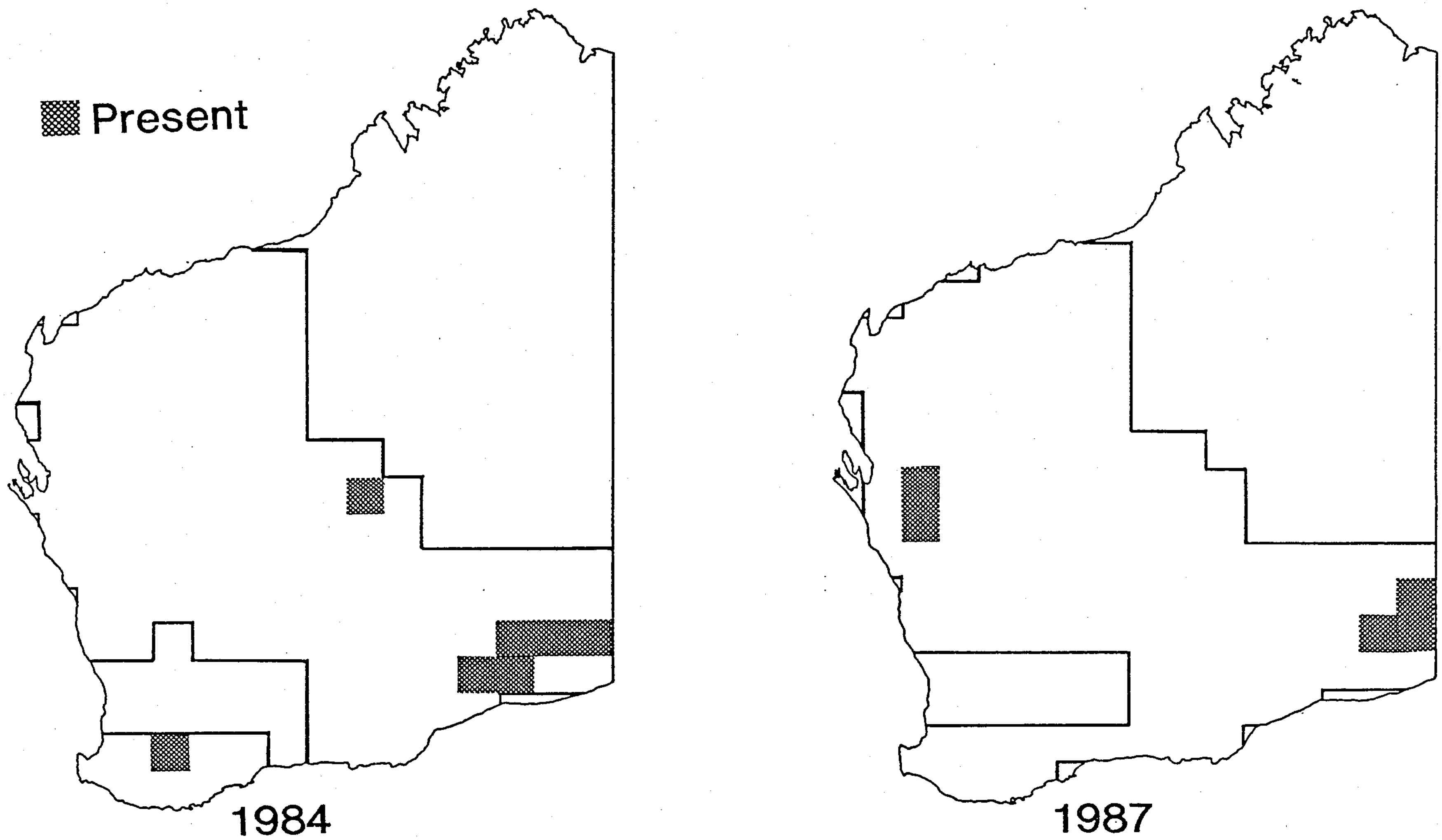


Fig. 10. Presence/absence of Cats in 1984 and 1987.

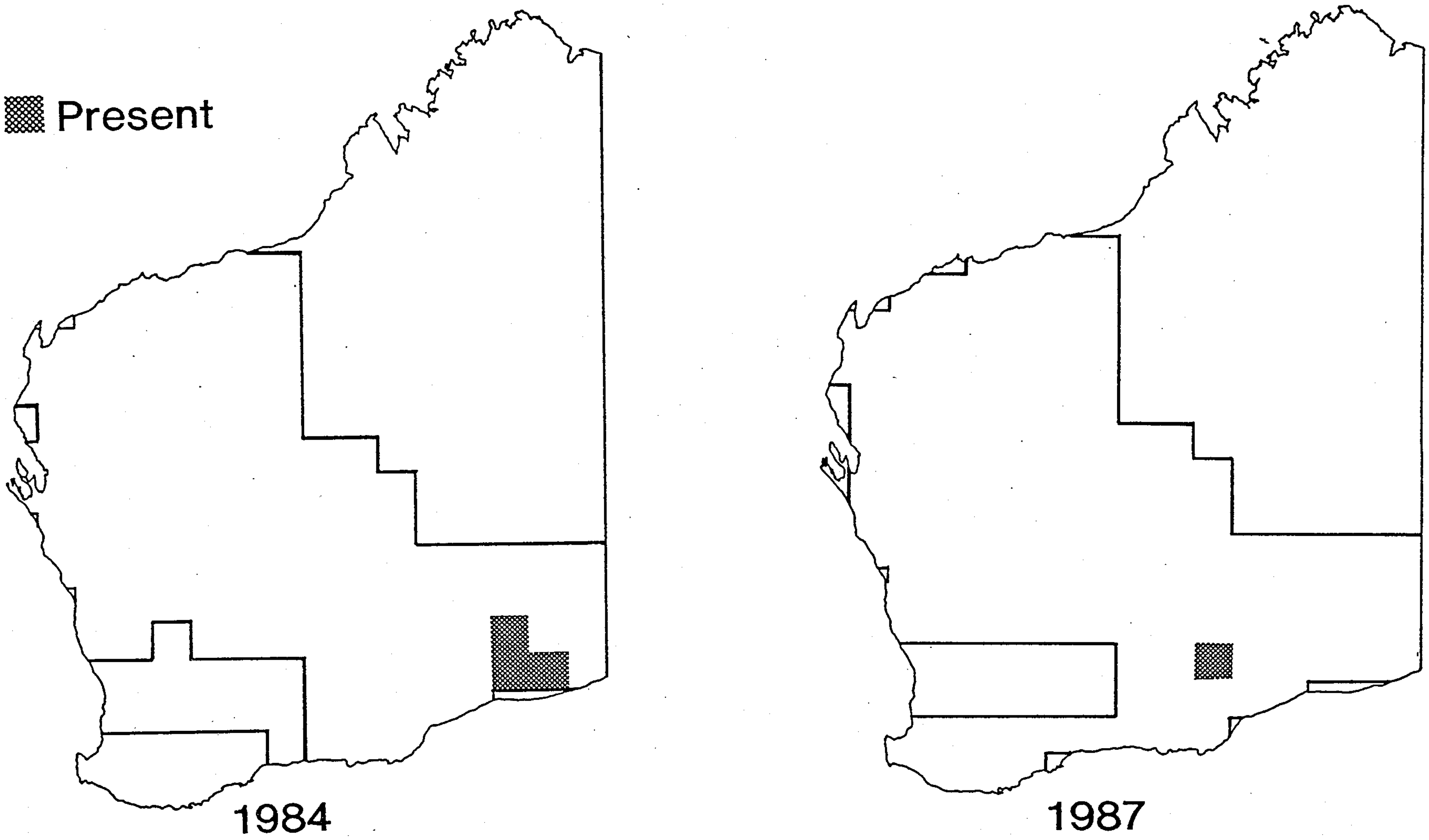


Fig. 11. Presence/absence of Donkeys in 1984 and 1987.

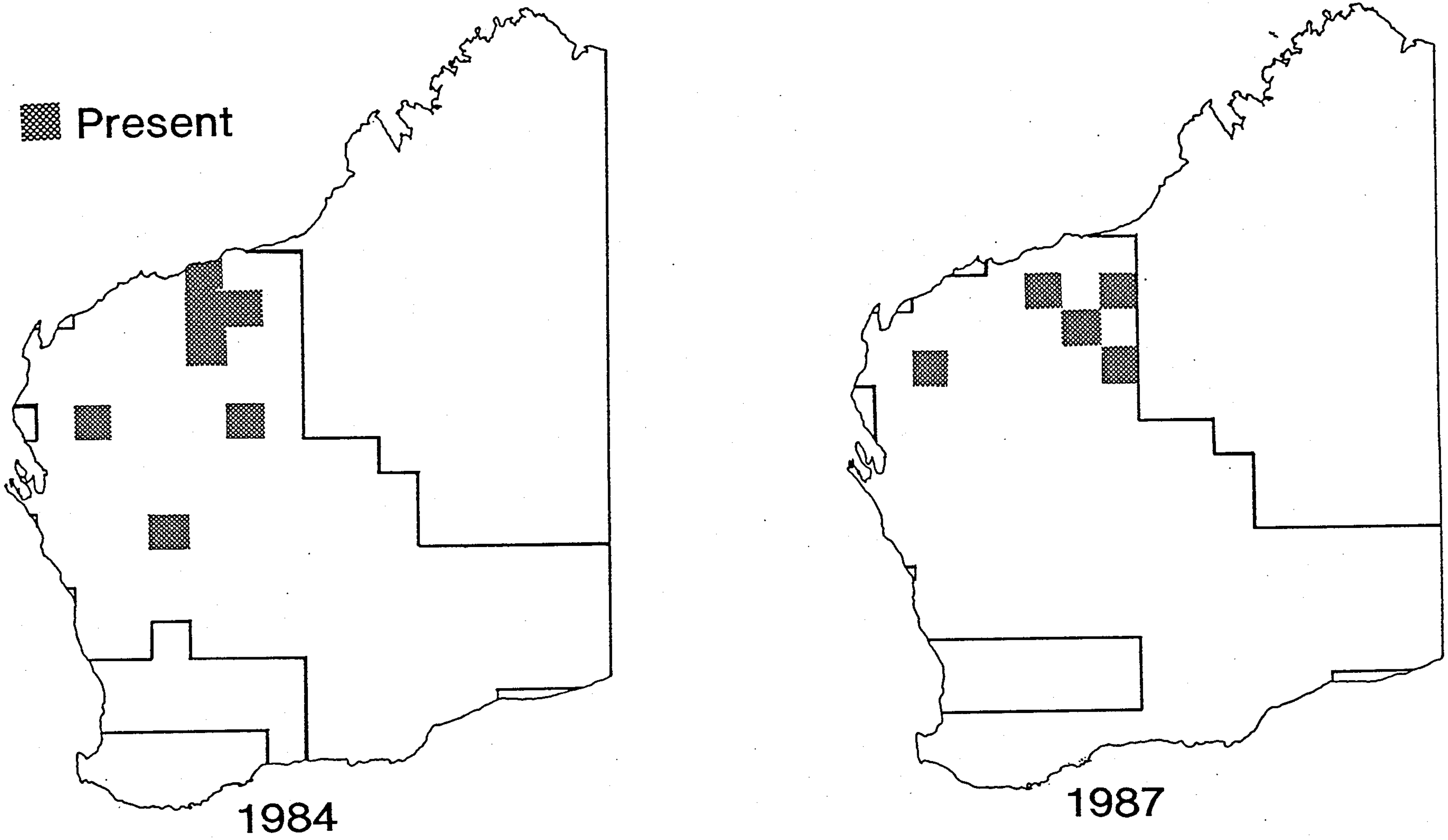


Fig. 12. Presence/absence of Pigs in 1984 and 1987.

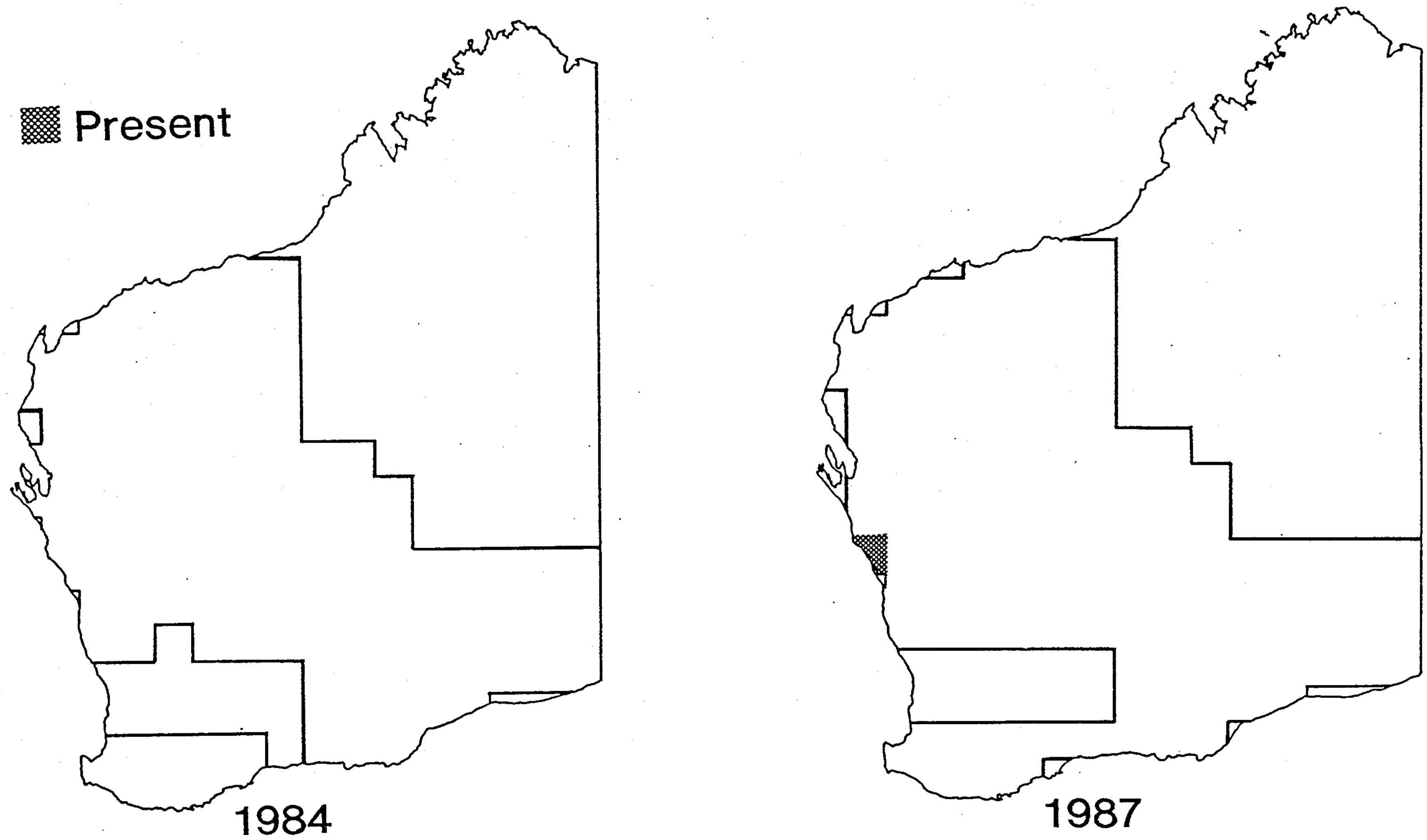
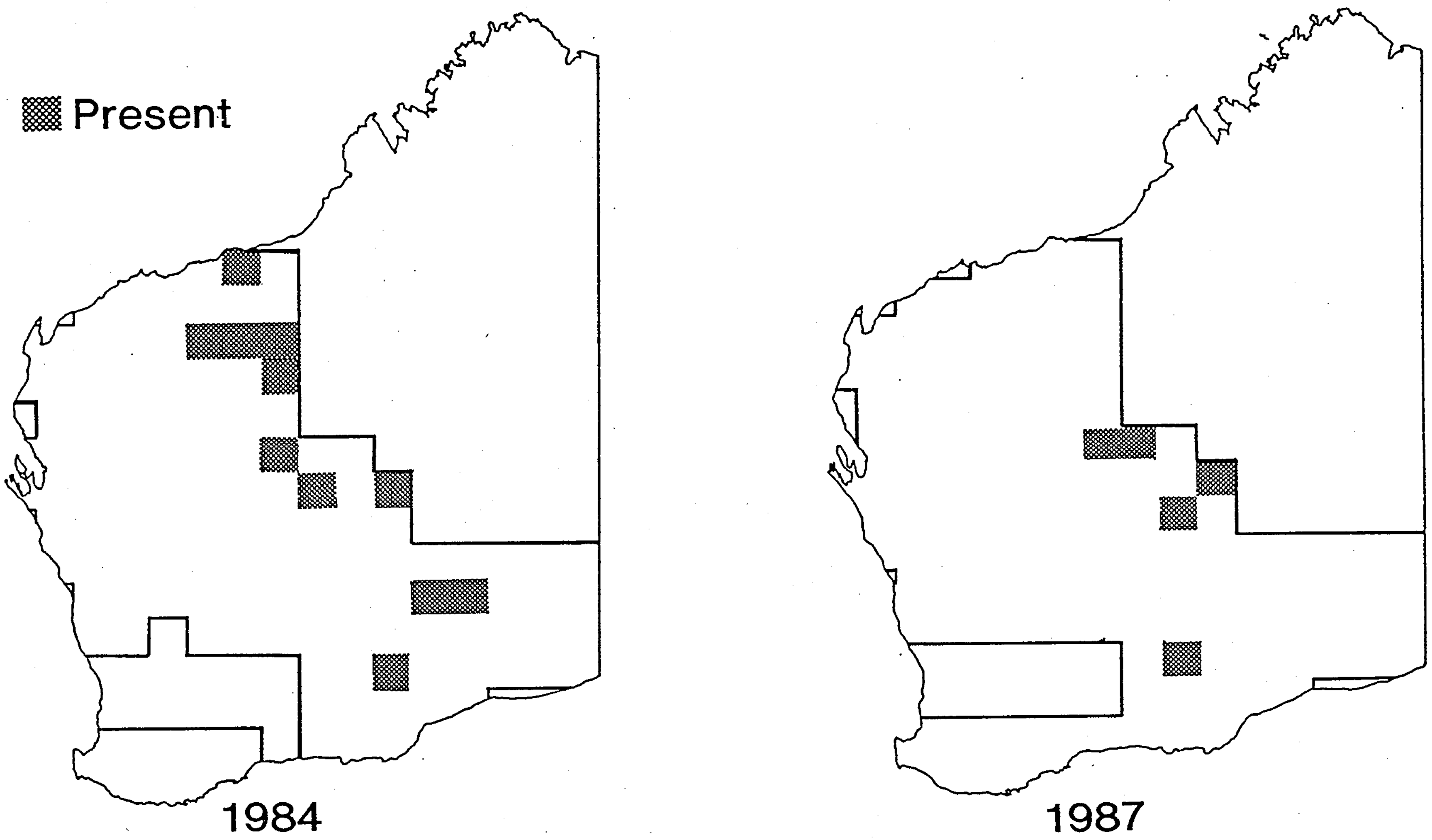


Fig. 13. Presence/absence of Camels in 1984 and 1987.

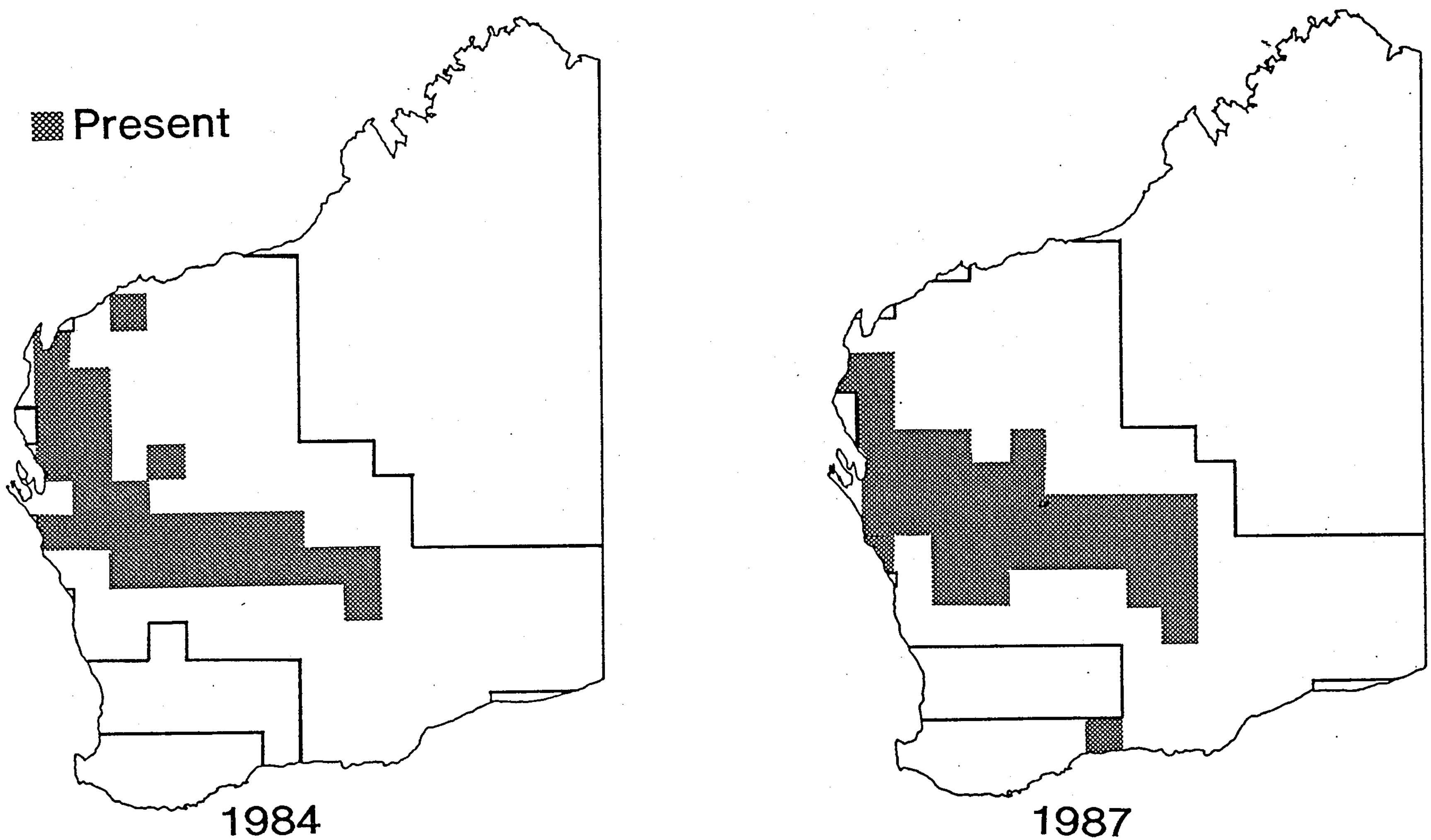


sightings conformed with Strahan (1983). Observed densities are given in Appendix 11.

Goat

Goats remain the most widespread and numerous of the large feral animals recorded during surveys. Observed densities are given in Appendix 12. Average observed density across the entire survey area in 1987 was 0.268 km^{-2}, giving an uncorrected (and hence minimum) population size of 368 000. The distribution is very heterogeneous, with the highest densities around the Gascoyne basin (approximately 1.8 km^{-2}) and between Sandstone, Lake Barlee and Laverton (approximately 3.2 km^{-2}), and no sightings over much of the survey area (Fig. 14). Distribution appears to have changed little between 1984 and 1987 (Fig. 14).

Fig. 14. Presence/absence of Goats in 1984 and 1987.



Discussion

Emu

Emus appear to be fairly conspicuous from the air; an observation supported by the low correction factor of 1.47 derived by Caughley and Grice (1982) for this species. We consider this correction factor to be applicable to our survey as it was derived from a survey operating under identical conditions in a nearly colinear survey area.

Counts since 1981 suggest a decline and contraction of Emu populations from 1981-84, and subsequent increase in populations from 1984-87. It is possible that this pattern may be an artefact of observer experience (two of the 1984 observers were experienced in sighting kangaroos but not Emus, and so may have been undercounting Emus relative to other surveys), hence we stress that the pattern should be considered with circumspection. The 1981 and 1987 surveys were more comparable in observer experience and returned similar population estimates.

The 1987 average density of 0.067 km^{-2} compares well with the Caughley and Grice (1982) estimate of 0.074 km^{-2} and with the medium-term average of 0.067 km^{-2} suggested for Western Australia by Davies (1976).

We concur with Caughley and Grice (1982) and Davies (1976) that Emus appear to be rare outside the pastoral zone either for reasons of insufficient water (the Emu must drink each day, Blakers *et al*. (1984)) or difficulty in breeding in disturbed areas of little or no cover.

Feral animals

A wide range of feral animals was sighted on the survey, although sighting frequencies were generally low. Because of these low frequencies, and a lack of information on correction factors, estimates of population size could not be calculated with confidence. Rather the data can be used only to give a broad indication of distribution.

An exception to the above is the Goat, which was seen in large numbers in some parts of the survey area. The uncorrected population estimate of 368 000 is a minimum estimate because no correction factors have been applied to the data. Our subjective opinion is that sightability of the Goat from the air is good, due to its strong herding tendency and striking pelage. We therefore consider that a corrected population estimate would not be dramatically different from the uncorrected one given here.

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Appendix 1. Corrected density (D_c) and estimated number (Y) of Red Kangaroos for each degree block surveyed in 1981, 1984 and 1987. Block codes and data for 1981 from Short *et al.*(1983). Data for 1984 from Fletcher and Southwell(1984). Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}. Areas not surveyed are indicated by -. Blocks in high density stratum are indicated by *.

Block code	1981 D_c	1981 Y	1984 D_c	1984 Y	1987 D_c	1987 Y
A9	0.66	1 329	-	-	-	-
A10	0	0	-	-	-	-
A11	0	0	-	-	-	-
A12	0.05	587	-	-	-	-
A13	0.25	2 934	-	-	-	-
A14	0.16	1 878	-	-	-	-
A15	0	0	-	-	-	-
A16	0	0	-	-	-	-
B8	0.46	1 048	-	-	-	-
B9	0	0	-	-	-	-
B10	0.27	3 152	-	-	-	-
B11	0	0	-	-	-	-
B12	0	0	-	-	-	-
B13	0	0	-	-	-	-
B14	0	0	-	-	-	-
B15	0	0	-	-	-	-
B16	0	0	-	-	-	-
C4	-	-	0.54	1 886	-	-
C5	-	-	2.35	10 349	1.28	5 642
C6	1.17	9 243	1.35	14 586	0.06	661
C7	0.95	10 884	1.11	12 922	0.12	1 421
C8	0.24	2 782	0.18	2 096	0.12	1 421
C9	0	0	-	-	-	-
D3	0	0	0.80	7 072	0.72	6 341
D4	0.12	1 374	0.30	3 499	0.06	694
D5	0	0	2.38	27 394	0	0
D6	0.25	2 877	0.54	6 242	0	0
D7	0.06	690	0.24	2 774	0	0
D8	0.12	1 381	0	0	0.24	2 774
E1	-	-	3.44	7 066	0.23	471
* E2	0.39	3 709	1.81	18 774	0.84	8 742
* E3	0.80	9 141	3.19	36 485	0.99	11 340
E4	0.74	8 455	0.74	8 401	0.92	10 491
E5	0	0	0.06	731	0	0
E6	0.24	2 714	1.34	15 264	0.70	7 965
E7	0.12	1 314	0.97	11 112	1.29	14 725
E8	0.55	6 284	0.31	3 506	0.06	701
F1	0.24	892	1.07	2 912	1.18	3 206
* F2	5.01	56 828	2.55	28 947	6.05	68 610
* F3	4.36	49 449	2.27	25 713	5.57	63 231
* F4	3.95	44 857	1.32	14 916	5.04	57 153
F5	0.36	4 083	0.80	9 128	1.68	19 000
F6	1.44	16 349	0.35	3 989	0.06	716
F7	0.35	3 989	0.78	8 806	1.13	12 806
F8	0.20	2 269	0.31	3 460	0.38	4 266
G1	1.35	7 517	-	-	-	-
* G2	0.52	5 877	2.58	29 090	1.60	18 034

*	G3	1.91	21 461	5.50	61 885	7.48	84 200
*	G4	1.64	18 515	3.26	36 670	9.38	105 650
	G5	0.93	10 445	1.19	13 437	1.87	21 103
*	G6	2.04	22 926	1.34	15 119	3.71	41 781
*	G7	1.03	11 649	0.74	8 303	1.31	14 789
	G8	-	-	0	0	5.34	60 107
	H1	-	-	0	0	-	-
	H2	0.18	2 003	1.03	11 080	2.26	24 244
*	H3	0.98	10 954	1.92	21 495	4.02	44 884
*	H4	1.48	16 508	4.42	49 428	6.30	70 471
*	H5	3.04	33 936	5.56	62 125	10.02	111 995
*	H6	1.20	13 461	4.69	52 380	6.84	76 466
*	H7	2.10	23 526	3.59	40 103	6.97	77 874
*	H8	-	-	2.17	24 247	6.11	68 251
	H9	-	-	1.25	13 923	0.06	706
*	H10	-	-	8.26	92 330	4.34	48 529
	I1	-	-	0.45	1 357	-	-
	I2	0.06	617	0.11	1 201	0.47	4 962
	I3	0.08	908	0.79	8 712	0.81	8 952
*	I4	0.33	3 682	3.18	35 255	8.00	88 646
*	I5	1.86	20 636	4.98	55 178	4.85	53 727
*	I6	1.62	17 895	4.43	49 007	6.48	71 821
	I7	0.51	5 607	0.95	10 506	2.81	31 084
	I8	0.30	3 342	1.23	13 675	5.82	64 435
*	I9	0.82	9 108	2.72	30 138	2.80	30 973
*	I10	1.86	20 583	2.22	24 534	2.16	23 876
	I11	-	-	0.46	5 082	0.33	3 630
	J2	0.03	310	0.46	4 934	0	0
	J3	0.38	4 132	0.56	6 113	3.25	35 698
	J4	0.42	4 565	1.05	11 507	4.78	52 493
*	J5	1.61	17 678	1.54	16 901	4.49	49 220
*	J6	1.33	14 579	1.41	15 463	4.23	46 381
*	J7	1.14	12 624	2.29	25 098	1.87	20 540
*	J8	0.37	4 073	4.34	47 663	3.88	42 560
*	J9	2.02	22 187	3.72	40 832	3.65	40 052
*	J10	0.51	5 579	1.70	18 622	1.52	16 624
	J11	-	-	1.18	12 946	0.20	2 158
	K2	0.37	2 179	0.26	2 043	1.03	8 036
	K3	0.24	2 609	0.25	2 719	0.27	2 935
	K4	0.39	4 239	0.62	6 734	1.08	11 696
*	K5	1.62	17 596	2.64	28 669	2.45	26 580
*	K6	1.24	13 435	1.18	12 825	2.35	25 504
	K7	0.82	8 929	0.52	5 658	5.56	60 465
*	K8	0.41	4 402	5.10	55 451	8.73	94 843
*	K9	1.11	12 105	8.26	89 778	2.86	31 099
	K10	0.30	3 301	0.88	9 562	2.62	28 468
	K11	0.34	3 695	1.25	13 543	0.40	4 329
	K12	0.07	761	0.37	4 060	0	0
	K13	0.07	761	0	0	0	0
	K14	0.43	4 674	0.07	754	0	0
	K15	0	0	0.03	366	0	0
	K16	0	0	0	0	0.20	2 138
	L3	0	0	0	0	0.46	4 940
	L4	0	0	0.61	6 593	0	0
	L5	1.08	11 627	0.38	4 110	0.68	7 295
	L6	0.46	4 970	0.52	5 605	0.27	2 871
	L7	0	0	0.21	2 253	0.13	1 412
	L8	0.19	2 016	0.57	6 186	0.13	1 435

*	L9	1.16	12 536	2.71	29 144	1.18	12 658
	L10	0.15	1 635	1.06	11 383	1.05	11 280
	L11	0	0	0.26	2 845	0.13	1 453
*	L12	0.06	646	1.99	21 391	0.33	3 529
*	L13	0.41	4 414	2.34	25 172	0.65	7 025
*	L14	1.89	20 348	1.67	17 944	0.51	5 539
*	L15	0	0	1.69	18 181	0.84	9 081
*	L16	0.45	4 845	2.29	24 654	0.52	5 646
	M3	0.65	6 237	0	0	0.21	2 060
	M4	0.11	1 173	0.26	2 796	0	0
	M5	0	0	-	-	0	0
	M6	0	0	0.07	709	0	0
	M7	0	0	0.16	1 747	0	0
	M8	0	0	0.23	2 447	0	0
	M9	0.37	3 959	0.69	7 357	0.13	1 431
	M10	0.20	2 159	0.47	5 060	0.71	7 606
	M11	0	0	0	0	0.20	2 097
	M12	0.36	3 845	1.34	14 339	0.46	4 905
*	M13	4.97	53 040	3.87	41 229	0.71	7 543
*	M14	7.18	76 600	0.18	1 878	0.61	6 497
*	M15	2.99	31 879	0.53	5 635	0.70	7 461
*	M16	1.39	14 856	3.89	41 511	2.55	27 149
	N5	0	0	-	-	-	-
	N6	0	0	-	-	-	-
	N7	0	0	-	-	-	-
	N8	0	0	-	-	-	-
	N9	0.03	356	0.16	1 684	0.13	1 384
	N10	0	0	0.20	2 136	0.13	1 384
	N11	0.07	713	0.13	1 406	0	0
	N12	0.10	1 038	0.64	6 717	0.52	5 450
*	N13	0.38	4 030	14.57	153 812	1.98	20 938
*	N14	0.45	4 774	3.45	36 475	0.41	4 366
*	N15	1.34	14 105	1.21	12 726	0.57	6 055
*	N16	0.30	2 767	1.79	16 261	0	0
	O4	0	0	-	-	-	-
	O5	0	0	-	-	-	-
	O7	0	0	-	-	-	-
	O8	0	0	-	-	-	-
	O9	0	0	0	0	0	0
	O10	0	0	0	0	0	0
	O11	0	0	0	0	0	0
	O12	0	0	0	0	0	0
	O13	0	0	0	0	0	0
	P3	0	0	0	0	0	0
	P4	0	0	0	0	0	0
	P5	0	0	0	0	0	0
	P6	-	-	0	0	0	0
	P7	-	-	0	0	0	0
	P8	0	0	-	-	0	0
	P9	0	0	0	0	0	0
	P10	0	0	0	0	0	0
	P11	0	0	0.07	604	0	0
	Q3	0	0	0	0	0	0
	Q4	0	0	0	0	0	0
	Q5	0	0	0	0	0	0
	Q6	0	0	0	0	0	0
	Q7	-	-	0	0	-	-

Appendix 2. Corrected density (D_C) and estimated number (Y) of Western Grey Kangaroos for each degree block surveyed in 1981, 1984 and 1987. Block codes and data for 1981 from Short *et al.*(1983). Data for 1984 from Fletcher and Southwell(1984). Values are corrected for vegetation bias but not for temperature. Densities are in animals km^{-2}. Areas not surveyed are indicated by -. Blocks in high density stratum are indicated by *.

Block	1981		1984		1987	
code	D_C	Y	D_C	Y	D_C	Y
A9	0	0	-	-	-	-
A10	0	0	-	-	-	-
A11	0	0	-	-	-	-
A12	0	0	-	-	-	-
A13	0	0	-	-	-	-
A14	0	0	-	-	-	-
A15	0	0	-	-	-	-
A16	0	0	-	-	-	-
B8	0	0	-	-	-	-
B9	0	0	-	-	-	-
B10	0	0	-	-	-	-
B11	0	0	-	-	-	-
B12	0	0	-	-	-	-
B13	0	0	-	-	-	-
B14	0	0	-	-	-	-
B15	0	0	-	-	-	-
B16	0	0	-	-	-	-
C4	-	-	0	0	-	-
C5	-	-	0	0	0	0
C6	0	0	0	0	0	0
C7	0	0	0	0	0	0
C8	0	0	0	0	0	0
C9	0	0	-	-	-	-
D3	0	0	0	0	0	0
D4	0	0	0	0	0	0
D5	0	0	0	0	0	0
D6	0	0	0	0	0	0
D7	0	0	0	0	0	0
D8	0	0	0	0	0	0
E1	-	-	0	0	0	0
E2	0	0	0	0	0	0
E3	0	0	0	0	0	0
E4	0	0	0	0	0	0
E5	0	0	0	0	0	0
E6	0	0	0	0	0	0
E7	0	0	0	0	0	0
E8	0	0	0	0	0	0
F1	0	0	0	0	0	0
F2	0	0	0	0	0	0
F3	0	0	0	0	0	0
F4	0	0	0	0	0	0
F5	0	0	0	0	0	0
F6	0	0	0	0	0	0
F7	0	0	0	0	0	0
F8	0	0	0	0	0	0
G1	0	0	-	-	-	-
G2	0	0	0	0	0	0

	G3	0	0	0	0	0	0
	G4	0	0	0	0	0	0
	G5	0	0	0	0	0	0
	G6	0	0	0	0	0	0
	G7	0	0	0	0	0	0
	G8	-	-	0	0	0	0
	H1	-	-	0	0	-	-
	H2	0	0	0	0	0	0
	H3	0	0	0	0	0	0
	H4	0	0	0	0	0	0
	H5	0	0	0	0	0	0
	H6	0	0	0	0	0	0
	H7	0	0	0	0	0	0
	H8	-	-	0	0	0	0
	H9	-	-	0	0	0	0
	H10	-	-	0	0	0	0
	I1	-	-	0.09	271	-	-
	I2	0.03	263	0	0	0	0
	I3	0	0	0	0	0	0
	I4	0	0	0.07	726	0	0
	I5	0	0	0	0	0	0
	I6	0	0	0	0	0	0
	I7	0	0	0	0	0	0
	I8	0	0	0	0	0	0
	I9	0	0	0.06	706	0	0
	I10	0	0	0	0	0	0
	I11	-	-	0.07	726	0	0
	J2	0.99	10 130	0.26	2 819	0.13	1 451
	J3	0	0	0	0	0	0
	J4	0	0	0.07	719	0	0
	J5	0	0	0	0	0	0
	J6	0	0	0.07	719	0	0
	J7	0	0	0	0	0	0
	J8	0	0	0.07	716	0	0
	J9	0	0	0	0	0	0
	J10	0	0	0.32	3 521	0	0
	J11	-	-	0	0	0.19	2 130
*	K2	0.56	3 298	1.11	8 697	0.29	2 279
*	K3	0	0	0.07	759	0	0
*	K4	0	0	0	0	0	0
*	K5	0	0	0.03	377	0	0
*	K6	0	0	0	0	0	0
*	K7	0	0	0	0	0	0
*	K8	0	0	0.03	377	0.13	1 458
*	K9	0	0	0.10	1 131	0.26	2 877
*	K10	0.06	660	0.10	1 108	0.39	4 275
*	K11	0	0	0.27	2 928	0.46	5 000
*	K12	0	0	0.03	372	0.78	8 523
*	K13	0	0	0.24	2 562	0	0
*	K14	0	0	0.44	4 775	0.13	1 425
*	K15	0	0	0.03	3 294	0.20	2 138
*	K16	0.05	543	0	0	0	0
*	L3	0	0	0.25	2 675	0	0
*	L4	0	0	0	0	0	0
*	L5	0	0	0.03	374	0	0
*	L6	0	0	0	0	0.07	727
*	L7	0.06	654	0	0	0	0
*	L8	0.23	2 524	0	0	0	0

*	L9	0.43	4 614	0.42	4 483	0.13	1 407
*	L10	0	0	0.37	4 024	0	0
*	L11	0.20	2 153	0.22	2 370	1.57	16 927
*	L12	0.06	646	0.30	3 263	1.68	18 091
*	L13	0	0	0.78	8 395	0.26	2 829
*	L14	0	0	0	0	0	0
*	L15	0	0	0.75	8 104	0.06	697
*	L16	0.10	1 077	0.09	924	0.13	1 422
*	M3	1.05	10 076	2.59	25 051	0.74	7 108
*	M4	0.24	2 559	0	0	0.39	4 141
*	M5	0	0	-	-	0	0
*	M6	0.07	746	0.03	355	0	0
*	M7	0	0	0.56	5 941	0.33	3 554
*	M8	0.34	3 599	0.60	6 390	0	0
*	M9	0.20	2 147	0.52	5 496	0.46	4 861
*	M10	1.15	12 236	0.27	2 915	0.32	3 391
*	M11	1.22	12 956	0.53	5 650	0.40	4 301
*	M12	2.57	27 376	0.91	9 701	0.07	711
*	M13	0.26	2 755	0.13	1 204	0.03	355
*	M14	0	0	0	0	0	0
*	M15	0	0	0	0	0	0
*	M16	0	0	0.06	610	0	0
*	N5	0	0	-	-	-	-
*	N6	0	0	-	-	-	-
*	N7	0	0	-	-	-	-
*	N8	0.24	2 495	-	-	-	-
*	N9	0.03	356	1.50	15 827	0	0
*	N10	0.14	1 425	0.44	4 628	0.85	8 987
*	N11	1.82	19 244	0.17	1 770	2.04	21 490
*	N12	4.56	48 108	9.96	105 169	9.66	102 035
*	N13	2.19	23 173	4.33	45 673	0.19	2 025
*	N14	0.56	5 884	3.31	33 078	0.25	2 687
*	N15	2.94	31 087	3.44	36 270	5.10	53 827
*	N16	0.29	2 749	5.05	47 059	3.82	34 664
*	O4	0.06	626	-	-	-	-
*	O5	0.40	4 174	-	-	-	-
*	O7	0	0	-	-	-	-
*	O8	0	0	-	-	-	-
*	O9	0	0	0	0	0	0
*	O10	0.14	1 461	0	0	0.14	1 449
*	O11	0.43	4 487	0.77	7 993	4.00	41 759
*	O12	7.36	72 739	5.96	56 949	15.20	145 257
*	O13	0.57	3 171	8.38	45 228	0.48	2 579
*	P3	0.25	1 639	5.69	35 799	0.46	2 866
*	P4	0.30	3 094	0.95	10 133	3.67	37 830
*	P5	0.47	4 847	0.81	8 574	0.54	5 605
*	P6	-	-	0.93	9 663	0.42	4 286
*	P7	-	-	0.79	8 107	2.44	25 161
*	P8	0.43	4 130	-	-	1.53	14 351
*	P9	0.88	7 888	0.27	2 352	2.26	19 705
*	P10	0.69	6 627	0.21	1 956	0.20	1 898
*	P11	0.15	1 311	0.07	609	0	0
*	Q3	3.08	13 866	0.29	1 274	0.74	3 171
*	Q4	0.62	6 062	1.90	18 822	0	0
*	Q5	1.96	19 968	3.42	35 604	0.48	4 905
*	Q6	5.66	43 995	2.07	15 837	6.60	50 443
*	Q7	-	-	0	0	-	-

Appendix 3. Observed density (D_O) of Euros for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.* (1983). Densities are in animals km^{-2}.

Block code	D_O	Block code	D_O	Block code	D_O
D6	0.03	H10	0.02	K11	0.17
D8	0.03	I4	0.02	L4	0.03
E3	0.02	I10	0.03	L5	0.19
F2	0.02	J4	0.03	L6	0.03
F3	0.03	J6	0.03	L8	0.08
F4	0.02	J7	0.03	L9	0.05
G3	0.06	J8	0.05	L12	0.04
G4	0.07	K3	0.06	L13	0.02
H3	0.03	K5	0.03	M4	0.06
H6	0.04	K8	0.04	M6	0.03
H7	0.02	K9	0.07	M10	0.03
H9	0.05	K10	0.11	M11	0.06

Appendix 4. Corrected density (D_C) and estimated number (Y) of Emus for each degree block in which individuals were observed in 1984 and 1987. Block codes follow Short *et al.* (1983). Densities are in animals km^{-2}. Values have been corrected for visibility bias.

	1984			1987	
Block code	D_C	Y	Block code	D_C	Y
C5	0	0	C5	0.16	705
C6	0.07	720	C6	0	0
C8	0.08	897	C8	0	0
D3	0.15	1 371	D3	0	0
E2	0	0	E2	0.16	1 664
E3	0.04	442	E3	0.15	1 714
F1	0.06	167	F1	0.16	436
F2	0.37	4 169	F2	0.39	4 424
F3	0.08	878	F3	0.31	3 516
F7	0.02	219	F7	0	0
G2	0.26	2 908	G2	0.02	225
G3	0.16	1 790	G3	0.29	3 266
G4	0.10	1 118	G4	0.19	2 140
G5	0	0	G5	0.31	3 491
G6	0	0	G6	0.14	1 577
H3	0.41	4 564	H3	0.27	3 018
H4	0.41	4 564	H4	0.31	3 465
H5	0.31	3 423	H5	0.04	447
H6	0.16	1 826	H6	0.19	2 124
H7	0	0	H7	0.15	1 677
H8	0.08	913	H8	0.25	2 795
H10	0.12	1 369	H10	0.08	894
I1	0.23	676	I1	0	0
I2	0.04	368	I2	0.08	842
I3	0.27	2 939	I3	0	0

I4	0.27	2 939	I4	0.12	1 329
I5	0.02	226	I5	0.12	1 329
I6	0.06	678	I6	0.08	886
I7	0.12	1 357	I7	0.08	886
I8	0	0	I8	0.19	2 104
I9	0.02	226	I9	0.21	2 326
I10	0.02	226	I10	0.04	443
J4	0.08	849	J4	0.12	1 317
J5	0.43	4 704	J5	0.12	1 317
J6	0.10	1 120	J6	0.18	1 975
J7	0.12	1 344	J7	0	0
J8	0.20	2 240	J8	0.22	2 414
J9	0.08	896	J9	0.16	1 755
J10	0.02	224	J10	0	0
K3	0	0	K3	0.04	435
K4	0	0	K4	0.12	1 304
K5	0.06	705	K5	0.14	1 522
K6	0	0	K6	0.10	1 087
K7	0.09	940	K7	0	0
K8	0.45	4 934	K8	0.27	2 935
K9	0.19	2 115	K9	0.53	5 761
K10	0	0	K10	0.08	870
K11	0.11	1 175	K11	0.04	435
L4	0.04	465	L4	0	0
L5	0.09	931	L5	0.14	1 507
L6	0.04	465	L6	0	0
L9	0.11	1 164	L9	0.16	1 723
L12	0.04	465	L12	0	0
M5	0	0	M5	0.04	427
M6	0	0	M6	0.16	1 706
M9	0.04	461	M9	0	0
M10	0.13	1 383	M10	0	0
M12	0	0	M12	0.08	853
N10	0.08	887	N10	0	0
P3	0.21	1 321	P3	0	0
P4	0	0	P4	0.09	928
P10	0	0	P10	0.48	4 509
Q3	0.21	2 166	Q3	0	0
Q5	0.09	881	Q5	0.22	2 241
Q6	0	0	Q6	0.90	6 877

Appendix 5 Observed density (D_O) of Bustards for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.* (1983). Densities are in animals km^{-2}.

Block code	D_O	Block code	D_O	Block code	D_O
E2	0.02	F3	0.04	H7	0.03
F2	0.04	G6	0.02	I9	0.03

Appendix 6. Observed density (D_o) of Dingoes for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.*(1983). Densities are in animals km^{-2}.

Block code	D_o
N16	0.02

Appendix 7. Observed density (D_o) of Foxes for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.*(1983). Densities are in animals km^{-2}.

Block code	D_o	Block code	D_o	Block code	D_o
I4	0.02	L16	0.02	M16	0.02
J4	0.03	M15	0.02		

Appendix 8. Observed density (D_o) of Cats for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.*(1983). Densities are in animals km^{-2}.

Block code	D_o
N11	0.03

Appendix 9. Observed density (D_o) of Donkeys for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.*(1983). Densities are in animals km^{-2}.

Block code	D_o	Block code	D_o	Block code	D_o
D6	0.24	E7	0.18	F8	0.39
D8	0.03	F3	0.04		

Appendix 10. Observed density (D_o) of Pigs for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.*(1983). Densities are in animals km^{-2}.

Block code	D_o
K2	0.19

Appendix 11. Observed density (D_o) of Camels for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.*(1983). Densities are in animals km^{-2}.

Block code	D_o	Block code	D_o	Block code	D_o
H8	0.09	I11	0.13	N10	0.14
H9	0.05	J10	0.03		

Appendix 12. Observed density (D_o) of Goats for degree blocks in which individuals were observed in 1987. Block codes follow Short *et al.* (1983). Densities are in animals km^{-2}. Block area (*a*) in km^2.

Block code	D_o	*a*	Block code	D_o	*a*	Block code	D_o	*a*
F1	2.28	2 722	J2	0.44	10 751	K6	1.70	10 869
F2	1.08	11 434	J3	0.75	10 971	K7	3.92	10 869
G2	1.42	11 261	J4	0.03	10 971	K8	2.58	10 869
H2	1.82	10 731	J5	0.32	10 971	K9	3.74	10 869
H3	2.23	11 178	J6	0.96	10 971	K10	0.42	10 869
H4	0.20	11 178	J7	0.09	10 971	L4	1.19	10 766
H6	0.06	11 178	J8	0.13	10 971	L5	0.37	10 766
I2	0.28	10 521	J9	1.56	10 971	L9	2.35	10 766
I3	0.28	11 075	J10	0.04	10 971	L10	0.64	10 766
I4	0.60	11 075	K2	0.19	7 826	M10	1.11	10 663
I5	0.90	11 075	K4	0.31	10 869	P8	0.29	9 605
I6	0.42	11 075	K5	0.76	10 869			