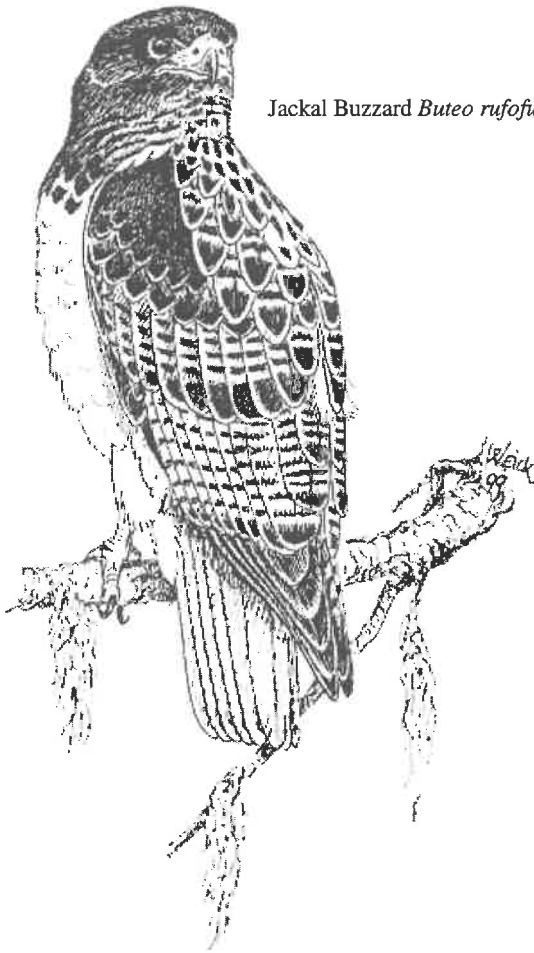


Part 6

Understanding Distribution - the Whys and Wherefores of Geographical Ranges of Raptors



Jackal Buzzard *Buteo rufofuscus* - light morph

Conveners:

Nick Mooney & David Pepler

Understanding the Distribution of Australia's Diurnal Raptors

William K. Steele and David J. Baker-Gabb

INTRODUCTION

Australia has a depauperate diurnal raptor community considering the size of the continent and the diversity of habitats it supports, with only 24 species of Falconiformes occurring regularly (Marchant & Higgins 1993). Of these, the Red Goshawk *Erythrotriorchis radiatus* is categorised as vulnerable, the Square-tailed Kite *Lophoictinia isura* and Grey Falcon *Falco hypoleucos* as rare (Endangered Species Protection Act 1992; Garnett 1993), and the Letter-winged Kite *Elanus scriptus* is uncommon. By way of contrast, southern Africa, which has a similar total number of bird species to Australia, supports 66 species of Falconiformes (Maclean 1993).

Nevertheless, the Australian Falconiformes form an important guild of native predators. Furthermore, as top-order predators with a high degree of mobility and because of their comparative conspicuousness, the more common diurnal raptors are ideal 'indicator species' for monitoring environmental change. But a knowledge of the present breeding and non-breeding distributions, relative abundances and movements of these birds is necessary before such monitoring studies can be initiated, or effective management policies implemented. Therefore, between 1986 and 1990 Birds Australia co-ordinated the first nation-wide survey of Australia's Falconiformes, using roadside counts to collect basic distribution and relative abundance data for all 24 species. A second national survey of diurnal raptors which repeated the methods of the first was initiated during 1996, ten years after the initial survey.

This paper presents and compares results of the two surveys and specifically addresses the questions:

1. Which areas of Australia support unusually high, or low, diversity and relative abundances of diurnal raptors, which might indicate a need for further study and appropriate management?
2. What changes to the large-scale distribution and abundance patterns of Australia's Falconiformes, if any, are evident from a comparison of results of two national surveys conducted ten years apart?

METHODS

Data Collection

The first national survey of Australian Falconiformes was conducted between 1986 and 1990. The second national survey commenced in July 1996, and is planned to continue until mid-2000.

During these surveys, roadside counts were conducted throughout Australia by knowledgeable volunteers from the birdwatching community while driving along rural roads at normal speeds. All birds of prey seen during counts were identified whenever possible and scored on a standard datasheet together with the date, time and duration of the journey, and the distance travelled. All road-killed raptors were identified and recorded.

After a review of relevant literature and consultation with a number of ecologists and biogeographers, Australia was divided into 61 biogeographic zones for the purposes of data collection (Fig. 1). Previously defined floral (Barlow 1984, 1985) and avian biogeographic regions (Blakers *et al.* 1984) were instrumental in devising these 61 zones, together with factors such as climate and altitude. In order to simplify data collection and to allow comparisons with other databases, boundaries between biogeographic zones follow 1° lines of latitude and longitude.

Figure 1. The 61 biogeographical zones used during the study.

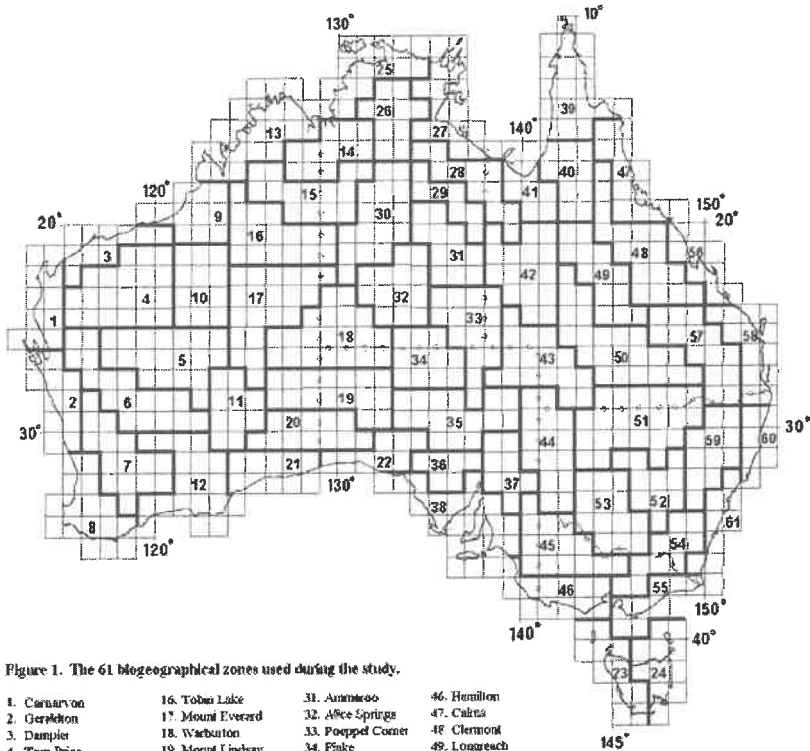


Figure 1. The 61 biogeographical zones used during the study.

- | | | | |
|-------------------------|-------------------|--------------------|-----------------|
| 1. Carnarvon | 16. Tobin Lake | 31. Ammeroo | 46. Hamilton |
| 2. Geraldton | 17. Mount Everest | 32. Alice Springs | 47. Calbra |
| 3. Dampier | 18. Warburton | 33. Poeppel Corner | 48. Clermont |
| 4. Tom Price | 19. Mount Lindsay | 34. Finke | 49. Longreach |
| 5. Wiluna | 20. Forrest | 35. Coober Pedy | 50. Chertville |
| 6. Mount Magnet | 21. Marbur | 36. Woomera | 51. Bourke |
| 7. Merredin | 22. Nullarbor | 37. Hawker | 52. Condonbabin |
| 8. Broome | 23. Queenstown | 38. Wallaroo | 53. Hay |
| 9. Lagrange | 24. Launceston | 39. Welpa | 54. Gundagai |
| 10. Lake Disappointment | 25. Darwin | 40. Croydon | 55. Sale |
| 11. Rason Lake | 26. Katherine | 41. Burketown | 56. Rockhampton |
| 12. Kalbarrie | 27. Borroloola | 42. Bourke | 57. Dalby |
| 13. Derby | 28. Watholow | 43. Inmanincka | 58. Oympe |
| 14. Lake Argyle | 29. Barkly | 44. Broken Hill | 59. Tanworth |
| 15. Hall's Creek | 30. Elliott | 45. Guyen | 60. Kempsey |
| | | | 61. Sydney |

Counts were conducted during daylight, or within half an hour of sunrise or sunset. All counts covered a minimum of 20 km, and few did not exceed 50 km. Counts with an average speed greater than 120 km/h were considered unreliable and excluded from the study. However, because of the continental scale of the study and the consequent need to involve a large number of volunteer observers it was not possible to establish too stringent rules governing the methods used to collect data. Therefore, unlike similar studies conducted elsewhere on a smaller scale (e.g. Tarboton & Allan 1984, Bunn *et al.* 1995), the speed at which vehicles travelled during counts, the timing of counts and the number of observers per vehicle were not standardised and the distance of each bird from the road was not measured or recorded.

Data collected during counts were used to calculate the relative abundance of Falconiformes within each zone, by season, in terms of the number of individuals recorded per 100 km. Following the *Atlas of Australian Birds* (Blakers *et al.* 1984), seasons were defined as: 'Summer' (December–February), 'Autumn' (March–May), 'Winter' (June–August) and 'Spring' (September–November).

The data also allow variation in Falconiformes species diversity across Australia to be determined. In general, the number of species recorded in any region will increase with the number of surveys conducted, and in an attempt to correct for this a simple index of species diversity was derived by dividing the number of species recorded in each zone by the logarithm of the number of counts conducted within that zone.

In order to assess how well lone drivers were able to detect raptors, when compared with counts conducted by more than one observer, 105 trial counts were carried out in southern New South Wales during the latter part of 1985. During these counts the number of raptors seen by the driver and by three additional observers in the same vehicle were recorded and compared. The same driver and observers were used in all counts.

Overall, the vehicle driver saw 2,963 (85%) of the 3,501 raptors recorded by the additional observers. The driver saw similar proportions of both large raptors, such as Wedge-tailed Eagles *Aquila audax*, and smaller ones, such as Nankeen Kestrels *Falco cenchroides*. In light of this result, a 'lone driver correction factor' was applied to the results of all counts carried out by a single person, whereby the total number of all birds of prey recorded during these counts was divided by 0.85.

The visibility of birds, and hence their detectability during roadside counts, is determined largely by three factors: the structure and density of local vegetation; local weather conditions; and the size, colouration and behaviour of the species. Although the biogeographic zones are differentiated largely on the basis of vegetation, it is difficult to determine a realistic correction factor for this variation which might be applied across the entire dataset. A simple test of the effectiveness of the methods used during the study produced equivocal results but indicated that roadside surveys recorded less than 60% of the raptors actually present, varying between species, habitat and land use types (Baker-Gabb 1986). Therefore, no attempt was made to estimate a correction factor for vegetation but rather the large-scale variations in vegetation between zones should be emphasised when interpreting results of the study.

The majority of Falconiformes are relatively conspicuous birds, which is why the roadside count methodology is generally considered appropriate for this group (e.g. Fuller & Mosher 1981, 1987; Diesel 1984; Tarboton & Allan 1984; Andersen *et al.* 1985; Taylor *et al.* 1985). Differences in conspicuousness or 'detectability' between species are not relevant in this study since no interspecific comparisons were considered. Only a few of the Australian species, such as the Red Goshawk, Collared Sparrowhawk *Accipiter cirrhocephalus* and Grey Falcon are difficult to observe from a motor vehicle (DJB-G pers. obs.; Mooney & Holdsworth 1988). In this study, both the observed distribution and the calculated relative abundance of these more secretive species are certain to be under-estimated.

RESULTS

Data Collection

Between 1986 and 1990, a total of 271 volunteer observers conducted 25,103 counts across Australia covering a distance of 3,818,471 km. Since 1996, 415 observers have submitted 23,611 completed datasheets. Of these, the results of 15,136 counts covering 1,971,787 km are used in this analysis. A further 94 roadside counts were conducted on an *ad hoc* basis during the 1990-1995 interim period between the two national surveys. Approximately 2% of datasheets submitted were considered unreliable, excluded from results and are not included in the totals given above.

As expected, there was great variation in the degree of coverage of the different zones, with those containing large cities having the greatest number of counts. In contrast, the arid central areas of Australia were not well covered, with fewer than 50 counts per season for some zones.

Species Diversity

Figures 2 and 3 show the Falconiformes species diversity recorded within each biogeographical zone during the course of the study, both as the number of species recorded and as a simple species diversity index which, to some extent, corrects for the varying number of counts conducted within zones.

As expected, species diversity generally increases from the temperate south of the country to the tropical north, with very low species diversity recorded in some particularly arid areas of central Australia (Fig. 3). The greatest number of species to be recorded within a zone was 20 in Zones 13 and 25, whereas the fewest species recorded was a mere four in Zone 19 in the Great Victoria Desert. The average number of species to be recorded in all zones was 14 ± 3.7 .

Figure 2. Falconiformes species richness across Australia.

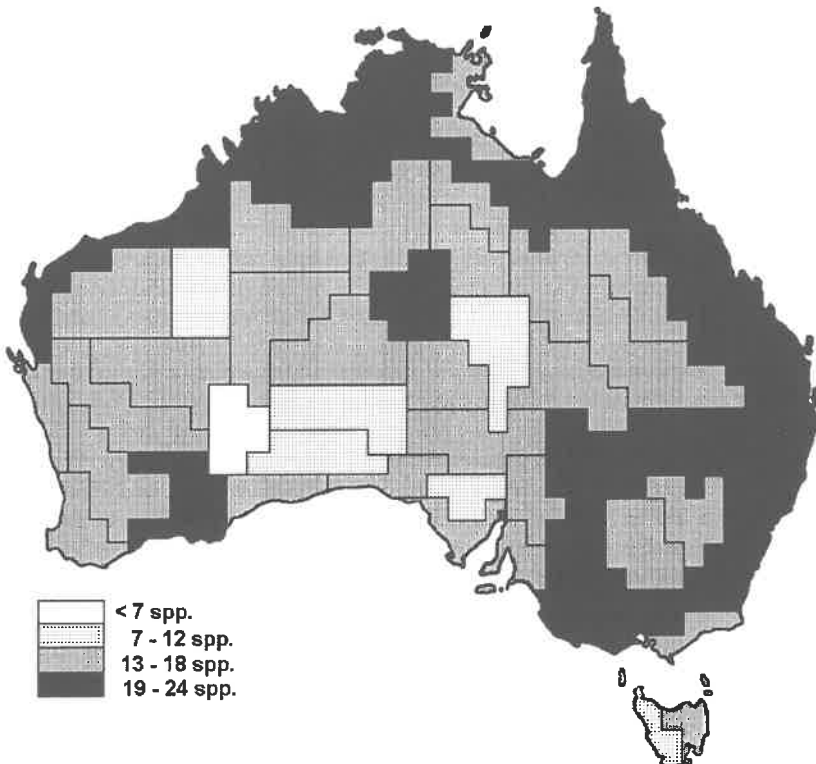
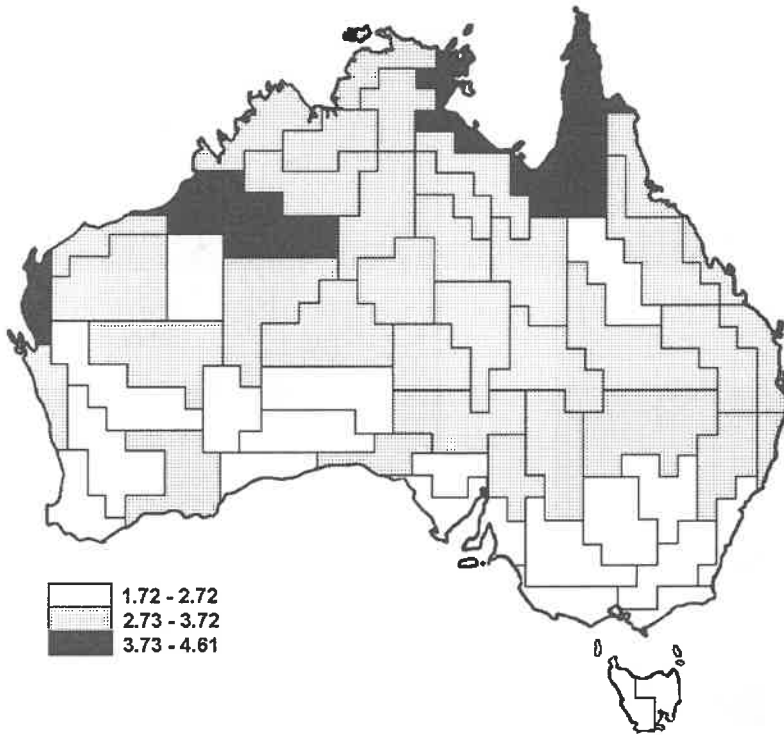


Figure 3. Index of Falconiformes species richness across Australia.



Distribution

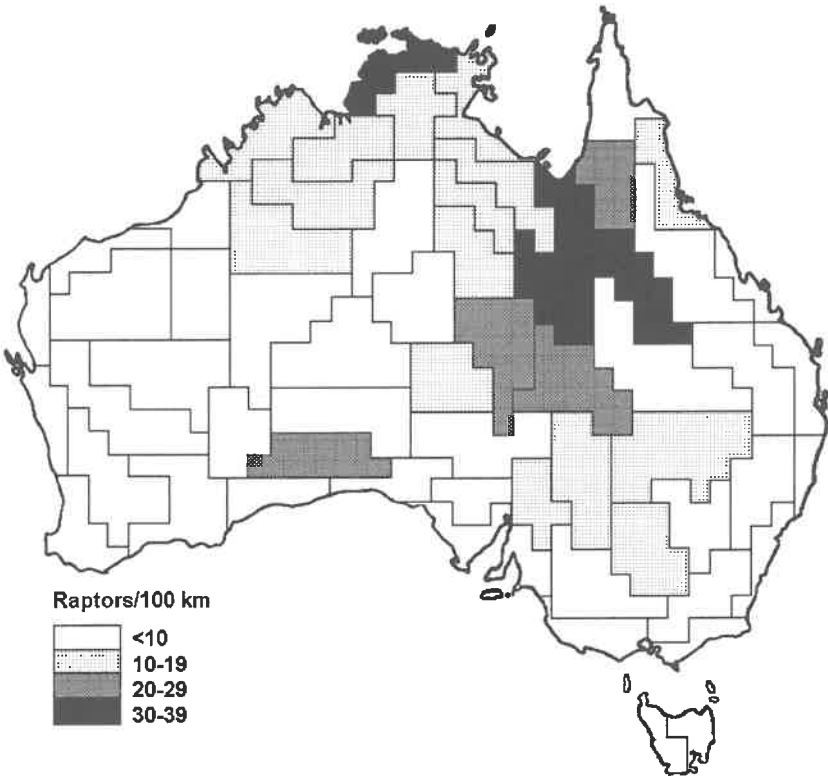
Figure 4 presents survey results showing the relative abundance (birds/100 km) for all 24 resident species of Falconiformes together. Figure 5 presents the relative abundance of Falconiformes by season.

These results indicate that the area of the Mitchell Grass Downs south to the Cooper’s Creek drainage basin (covering much of inland Queensland), and the Northwest coast of the Northern Territory are of major importance to Falconiformes. In contrast, Tasmania, the southeastern coastal region and much of Western Australia support comparatively low densities of raptors (Fig. 4).

Figure 5 illustrates a number of seasonal changes in the distribution of Falconiformes. The relative abundance of raptors in the Wet Tropics of northeastern Queensland (i.e. Zone 47) decreases markedly during the wet summer months from a winter peak. There is a similar decline during summer in the relative abundance of raptors in the Wet-Dry Tropics of northern Australia (e.g. Zones 13 and 25), which is least pronounced in the drier Gulf of Carpentaria (Zone 41). The summer decline in these areas is likely to be a result of wet weather leading to poor atmospheric conditions for soaring raptors. Simultaneously with the summer decrease in the relative abundance of raptors in northern and northwestern Australia there is an increase in numbers recorded to the south in the Riverina (Zone 53) and Nullarbor (Zone 22).

A large area from northern Western Australia extending through the Pilbara and Kimberley to the Arnhem Land coast assumes great importance during the dry autumn and winter but supports few raptors during the wet summer months. Also, there is an apparent overall decrease in the relative abundance of raptors throughout Australia during spring, which may be attributable to breeding birds at nests being less easy to detect from road-bound motor vehicles (Fig. 5).

Figure 4. Relative abundance (birds/100 km) of Falconiformes across Australia.



Inter-annual Variation

The number of diurnal raptors recorded per kilometre of survey varied significantly between years ($\chi^2 = 1,827.6$; d.f. = 4; $P < 0.01$), with 1987 having the lowest calculated relative abundance (Table 1).

Variation between Surveys

When the relative abundances of Falconiformes determined in each of the two national surveys, conducted 10 years apart, are compared, great differences become apparent. Those biogeographic zones where changes in the relative abundance of Falconiformes between the two surveys is 50% or greater (either an increase or decrease) are shown in Figure 6.

DISCUSSION

Data Collection

A potential criticism of this study is the simple methodology used to collect the data. In order to collect these data on a continent-wide scale a large number of competent volunteer observers was required, and this necessitated a simple data collection and recording procedure. Nevertheless, the unprecedented, continental database this study has produced provides useful information regarding the large-scale spatial distribution, movements and relative abundance of raptors throughout Australia. Such information could not have been collected in any other way without prohibitive cost to government research organisations.

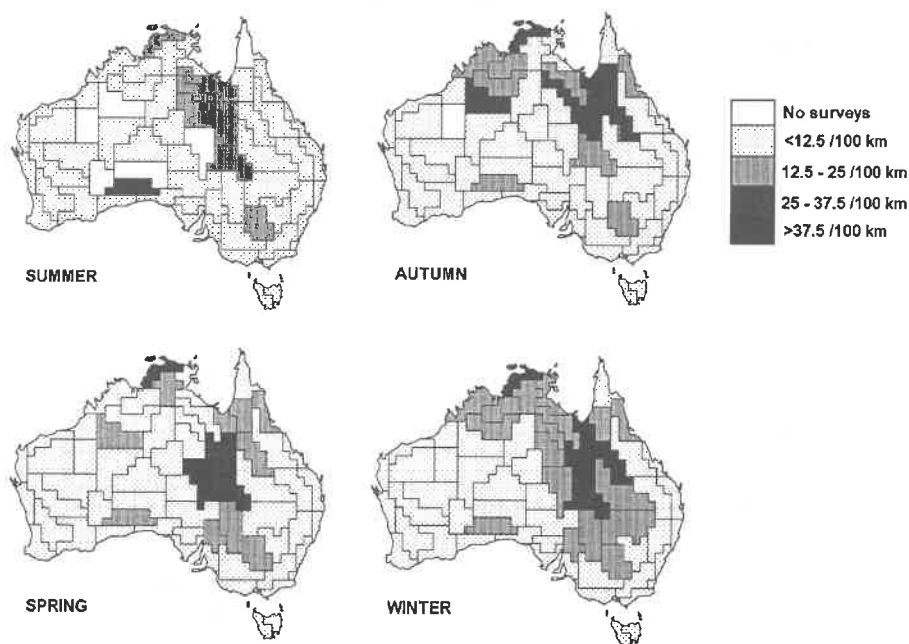
Species Diversity

It is generally true that species diversity increases as one moves from the higher to the lower latitudes, which is explained by the Stability-Time Hypothesis (Colinvaux 1973). To a certain extent this rule is evident in the species diversity index for Falconiformes across Australia (Fig. 3). However, it is apparent that, in Australia, this general pattern of variation in species diversity is overlaid by a second pattern. When measured simply in terms of the actual number of species recorded across Australia, it was found that arid areas of the interior support the fewest species (Fig. 2). This is also explained by the Stability-Time Hypothesis, as the interior is subject to an unpredictable and extreme climate. Furthermore, the arid interior lacks many of the habitats which are attractive to some Falconiformes, such as the woodlands preferred by some accipiters, and the coastlines and wetlands frequented by the Osprey *Pandion haliaetus*, White-bellied Sea-Eagle *Haliaeetus leucogaster*, Brahminy Kite *Haliastur indus*, Pacific Baza *Aviceda subcristata* and Swamp Harrier *Circus approximans*.

Distribution

Roadside counts of raptors have previously been conducted in Australia, although on a very much smaller scale (e.g. Genelly 1978; Brickhill 1992). This large-scale study has brought to light a number of previously unknown facts. Important concentration areas for Australia's Falconiformes occur in the northeast of the country, from the Gulf of Carpentaria through the Mitchell Grass Downs to the Cooper's Creek drainage area, and along the coast of Arnhem Land. The 10 most important concentration areas for Australian raptors throughout the year are Zones 41, 42, 25, 49, 33, 43, 40, 20, 47 and 53.

Figure 5. Relative abundance (birds/100 km) of Falconiformes across Australia by season.



It is notable that most of these zones lie in the north of Australia, and that these zones support the greatest density of raptors during autumn and winter. In contrast, only Zones 20 and 53 lie in southern Australia: Zone 20 having the greatest density of raptors over summer, and Zone 53 supporting large numbers of raptors throughout the year (Fig. 5). Many of these zones are characterised by flat

grasslands with few trees, which means raptors are easily seen and recorded. This result may be biased by the methods used and it is likely that some wooded zones are also of great importance to raptors, particularly accipiters.

The high relative abundance of raptors recorded in Zone 53 compared with surrounding zones (Figs 4 and 5) may be due to differences in land use as the Hay area is generally uncultivated grazing land whereas surrounding zones are important for crop production (Division of National Mapping 1979).

The importance of the Kimberley as a wintering ground for several species of Falconiformes (Fig. 5) has been noted previously (Aumann 1993; Olsen 1995). The MacDonnell Ranges in central Australia appear to be used as a migration corridor from the Murray-Darling and Cooper's Creek drainages to these northern wintering grounds and avoiding the arid Western Deserts (Fig. 5).

The 10 zones which display the lowest relative abundances of diurnal raptors are 23, 7, 55, 8, 11, 24, 10, 17, 6 and 12.

Thus the lowest relative abundance of Falconiformes occurs in Tasmania, southwestern Australia and the arid central areas of the Gibson and Great Victoria Deserts. However, the low numbers of raptors recorded in some of these zones may simply be related to their forested habitats (e.g. Zones 8, 23, 24 and 55). In contrast, the arid central zones are largely treeless, so vegetation cover is unlikely to have prevented birds from being seen and to have resulted in the low relative abundances observed.

Inter-annual Variation

Some variation in the number of Falconiformes recorded each year is normal, but there appears to be a trend towards decreased numbers in recent years (Table 1).

Table 1. Relative abundance of diurnal raptors throughout Australia between 1986 and 1998.

Year	No. of Surveys	Distance Covered (km)	No. of Survey Hours	No. of Falconiformes Recorded	Falconiformes / 100 km	Falconiformes / 100 h
1986	4,221	697,291	9,631.2	58,899.2	8.45	611.54
1987	5,222	836,067	11,131.8	57,030.8	6.82	512.33
1988	5,505	816,721	10,705.6	71,167.5	8.71	664.77
1989	5,509	813,815	10,581.4	70,391.1	8.65	665.24
1990	4,400	619,901	8,075.2	53,902.4	8.70	667.51
1996	3,241	446,589	6,071.2	33,242.5	7.44	547.55
1997	10,628	1,367,550	19,059.0	96,737.8	7.07	507.57
1998	1,267	157,648	2,080.1	10,151.5	6.44	488.04

The introduced European Rabbit *Oryctolagus cuniculus* is a major environmental pest in Australia, causing widespread habitat degradation and restricting new growth of vegetation. During 1995/96, Rabbit Calicivirus Disease (RCD), which can kill up to 95% of infected rabbits, was introduced to Australia as a pest-control mechanism. However, the rabbit is now also a significant component in the diets, at least over a part of their ranges, of several Australian raptors (Leopold & Wolfe 1970; Brooker & Ridpath 1980; Mooney 1983; Baker-Gabb 1984a, 1984b, 1985; Debus 1984; Hull 1986; Aumann 1988, 1989; Robertson 1987; Olsen *et al.* 1990; Marchant & Higgins 1993).

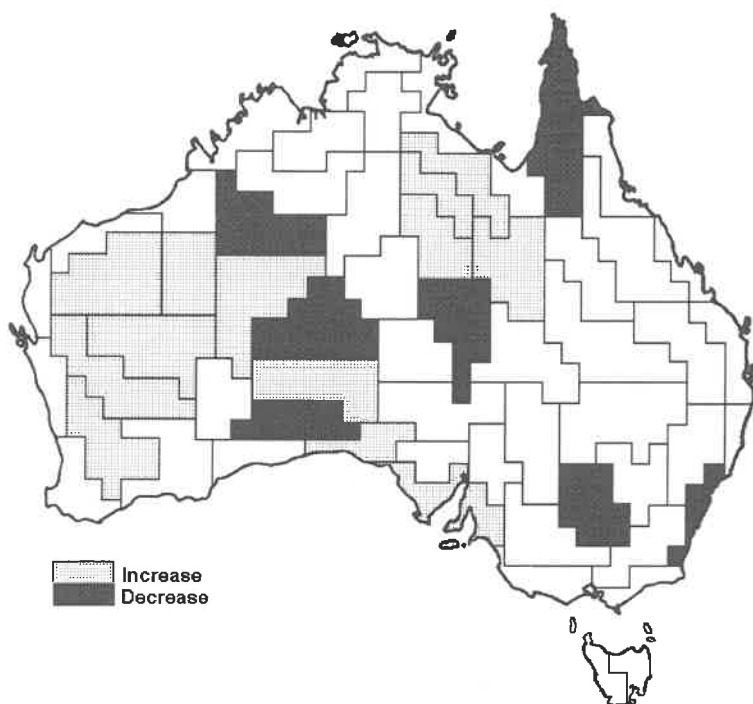
The effect of a wide-scale reduction in rabbit numbers following the introduction of RCD has apparently been detrimental to some populations of Australia's larger Falconiformes, although effects vary between species and geographical areas. The overall relative abundance of Falconiformes is known to have declined in rabbit-infested areas after the introduction of RCD. A notable exception was southwestern Australia (Steele 1998) but the effectiveness of RCD was patchy rather than widespread in this area (M. G. Brooker pers. comm.).

It is difficult to assess to what degree this reduction in abundance of Falconiformes over large areas of southeastern Australia is attributable to the impact of RCD on rabbit numbers as 1997 was unusually hot and dry in southeastern Australia and it is likely that this will have had some influence on the number of birds recorded. However, there apparently is not a linear relationship between seasonal rainfall and the numbers of raptors recorded during counts in southeastern Australia (Baker-Gabb & Steele 1998). Thus one cannot use lower than average seasonal rainfall to predict lower than average relative abundances of diurnal raptors in this region.

Variation between Surveys

A broad comparison between the results of the 1986–90 and 1996–98 national surveys indicates that there have been major changes in the distribution patterns of Falconiformes during the last 10 years (Fig. 6). Some of these apparent changes are explicable but many can only be the subject of conjecture at this stage.

Figure 6. Biogeographic zones showing 50% or greater change in the recorded relative abundance (birds/100 km) of Falconiformes between 1986–90 and 1996–98.



Major declines in the relative abundance of Falconiformes recorded in Zone 53 and Zone 61 reflect the increased intensity and extent of land use by Man over the past decade.

The decline recorded in Zone 33 is suspected to be due to two factors: the impact of reduced rabbit numbers following the introduction of RCD to this area (Steele 1998), and the very low number of counts conducted in this Zone during the 1986–90 survey, which lead to artificially high values for relative abundance (Baker-Gabb & Steele 1998).

Similarly, the decline observed in Zone 20 may be attributable to a combination of factors. During 1986–90 this zone was surveyed most often by a train driver. The Nullarbor is characterised

by a lack of trees and it is likely that some Falconiformes, particularly habitual pole-perchers such as the Nankeen Kestrel, were attracted to structures, such as telephone poles, alongside the railway line which meant that unnaturally high numbers were recorded from trains. With new technology, most telephone poles have been removed from this area and so it might be expected that fewer birds are now recorded during roadside counts.

Apparent increases in the relative abundance of Falconiformes over inland areas of Western Australia from 1986–90 to 1996–98 (Fig. 6) are difficult to explain. Although these areas have become more accessible, following the construction of new roads, the number of counts conducted there has not increased significantly.

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