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Corrigenda

Abbott, I. (1999). The avifauna of the forests of southwest Western Australia: Changes in species composition, distribution and abundance following anthropogenic disturbance. *CALMScience Supplement* No. **5**, 1-175.

The following corrections should be noted:

TEXT

PAGE	COLUMN	LINE	ACTION
2	2	4-5*	Delete reference to Keartland collecting in forests in 1895 near King George Sound
6	1	31**	Change ?1905 to 1907
6	1	32**	Change ?1906 to 1907
31	1	18**	Change Figure 3 to Figure 4
44	2	20*	Change Storr 199 to Storr 1991
67	1	13*	Change 1829 to 1830
97	2	5*	Change *Zoologishe* to *Zoologische*

* counting from bottom of page, ** from top

TABLES

PAGE	ACTION
140	The rows *Leipoa ocellata, Coturnix novaezelandiae* and *Coturnix ypsilophora* are out of sequence. Place them after *Dromaius novaehollandiae*, as is the case elsewhere in Table 2.
148 (No. 41)	Change 102 to 10 and 500 to 2 500
149 (No. 45)	Change 201 to 20 and 750 to 1 750
152 *(Meliphaga virescens)*	'Brown' in column 1 belongs in column 3
156	The dots in rows *Merops ornatus* through to *Smicrornis brevirostris* should commence immediately from under the column headed W

CALMScience Supplement 5: 1–176 (1999)

The avifauna of the forests of south-west Western Australia: changes in species composition, distribution, and abundance following anthropogenic disturbance

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SUMMARY

The avifauna (land and waterbirds) of the forests of south-west Western Australia is circumscribed by reference to information recorded in the period 1840 to 1998. A database was assembled from 272 published and unpublished bird lists, and this was supplemented with records extracted from a systematic search of the primary ornithological literature. In excess of 7 000 records were located. The original forest avifauna (just before the impact of European settlers became pronounced) consisted of 112 breeding species (81 land, 31 water). Salient characteristics of this avifauna include: only 1 species is confined (as a breeding species) to the primaeval forest ecosystem; 53 species occur throughout the forests; 32 and 13 species are restricted to its eastern or southern portions respectively; most species occur extensively outside of the forests (66 species to the west, north, east and south; 33 species to the west, north and east); 52 per cent of landbird species are insectivores; about 20 per cent of the landbird fauna migrates from the forest in varying degrees in winter; 67 per cent of landbird species nest in the overstorey or understorey; and landbirds in streamside forests occur at higher densities than in upland forests.

The distribution of 5 species – *Leipoa ocellata* (Malleefowl), *Cacatua pastinator* (Western long-billed corella), *Atrichornis clamosus* (Noisy scrub-bird), *Falcunculus frontatus* (Crested shrike-tit) and *Rallus pectoralis* (Lewin's rail) – is discussed in detail, with new or neglected information being provided.

The landbird fauna of the primaeval forest is impoverished relative to elsewhere in the South West Land Division, particularly the region now known as the wheatbelt. The forests of south-west Western Australia have only about half of the number of bird species present in a similar-sized, comparable area in south-east Australia. The south-west forest avifauna is more similar to that present in the Mount Lofty Ranges (South Australia) than to the forest avifaunas of New South Wales or Tasmania. At local scales (1–100 ha), however, the number of landbird species present is similar in all forests in southern mainland Australia (20–25 breeding species). Overall density of bird populations in jarrah and karri forests is about one half of that in comparable forests in south-east Australia.

Disturbances caused by European settlement have resulted in 4 species present in the primal forests contracting in geographical range, 2 species becoming extinct, and more than 90 species benefiting from provision of new habitats. Forest management has had limited impact on biodiversity and total abundance of birds. Prescribed burning under moist soil conditions has no impact on bird species richness in jarrah forest, but increases bird species richness in karri forest for 3–6 years. Total abundance of birds increases in both types of forest after prescribed burning. Planned burning under dry soil conditions increases both bird species richness and total abundance of birds. Wildfire reduces bird species richness. All of these changes are temporary.

Thinning of jarrah forest does not change bird species richness, whereas cutting to gaps increases bird species richness. Clearfelling of karri forest initially reduces bird species richness; 12 years later about 85 per cent of the avifauna in mature stands is present in regrowth karri forest. Those species dependent on large hollows for nesting are unlikely to nest in unthinned regrowth forest younger than about 120 years.

Open-cut mining for bauxite has a severe initial impact on bird species richness, but following rehabilitation there is a rapid return of bird species, with 85 per cent of species present before mining being recorded after 5 years. Species requiring large hollows for nesting cannot, however, nest in rehabilitated sites for many decades. The most severe, long term reduction in local bird species richness and total abundance is caused by dieback disease and by permanent removal of forest as in agriculture, urbanization, damming of rivers, and plantations of pine. However, an additional 75 species (51 land, 24 water) have been recorded within the forests following clearing for farming and towns. Of these species, 23 (17 land, 6 water) now breed, but only two of them (*Aquila morphnoides* Little eagle, *Dacelo novaeguineae* Laughing kookaburra) breed in forest.

The policies and procedures in place to mitigate the impact of humans on the forest bird fauna and to promote

the conservation of bird species are summarized. These include an extensive mosaic of protected areas (national parks, nature reserves, forest along roads, rivers and streams), a structural goal of 40 per cent of the forest being maintained at the mature or senescent stage, the retention of habitat trees for species dependent on hollows for nesting, and spatially and temporally diversified use of fire.

Much of the ornithological literature about forest management impacts in the south-west forests was found to be based on misconceptions about, or lack of awareness of, silvicultural and fire science, policies and prescriptions. The erroneous impressions thus created are discussed. Available empirical data and other information synthesized in this review present a strong challenge to the proponents of fire and logging as causes of long term detrimental change in the forest avifauna.

Several bird species are proposed for consideration as suitable indicators of ecologically sustainable forest management. The paper concludes with numerous suggestions for further research.

INTRODUCTION

When I was researching the literature relating to this paper (which frequently involved discussion with other scientists), one knowledgeable ornithologist felt that I was wasting my time on the project, as there was little new to discover about the bird fauna of the forests of south-west Western Australia (WA).

While it is true that there is considerable knowledge available, much of it is fragmented and its historical context is deficient. Previous compilations and syntheses concerning the forest avifauna have either been telegraphically brief (Anon. nd; Kimber and Christensen 1977), regional in scope (Christensen *et al.* 1985a; Nichols and Muir 1989; Christensen 1992), based on very large rasters (Busby and Davies 1977; Blakers *et al.* 1984), or considered as a small portion of a larger geographical area, such as the South West Land Division (Storr 1991), the south-west broadly conceived (Saunders and Ingram 1995), or even most or all of WA (Serventy and Whittell 1976; Johnstone and Storr 1998). Apart from Storr (1991), there has been insufficient attention to locating all published material relating to the composition of the forest avifauna. However, Storr (1991) did not provide complete referencing of his conclusions, so it is difficult to verify some of his statements.

Many bird books and field guides tend to over-generalize the occurrence of bird species in the south-west forests of WA. They also fail to distinguish records of vagrants from the more or less stable breeding range of species. Moreover, they overlook the fact that current distributions of some species differ from distributions 100–150 years ago. Secondary sources are frequently relied on instead of primary literature.

This work is an attempt to overcome these shortcomings. Its aims are to assemble and make available the raw distributional data; to collate, interpret and synthesize these records; to enlarge, consolidate and advance knowledge particularly through unexpected alignments of previously unassociated data, thus creating novel insights and fresh perceptions of the familiar; and to provide a definitive list of the bird species occurring in the primordial[1] forests of south-west WA at the time of their discovery by Europeans, i.e. the period from 1826 to the 1880s. In order to document those species which have changed in distribution, i.e. extinctions in, and colonizations of, the forest as a single entity during the past 150 years, it is first necessary to provide a definitive listing of the bird species present in the forests when Europeans settled in WA. An attempt is also made in this review to integrate silvicultural knowledge and practice with ornithological information in a more systematic way than has been done in the past.

Historical information on the occurrence of certain conspicuous species, management of fire, and the gross appearance of the forest was sought from 47 residents in south-west WA born in the period 1901–1928.

Birds are the best studied and most completely known of all organisms. They live in all available habitats and being primary, secondary and tertiary consumers depend on the existence of plant species, many invertebrate species, and other vertebrate species. They therefore integrate at a high level key ecosystem processes such as carbon, water, and nutrient cycling. Birds provide early indication of how adequately land in south-west WA has been, and is being, managed. If their habitat requirements are not met, they will be unable to feed or successfully reproduce. This will translate into changes in abundance and distribution.

METHODS

In order to establish which bird species occurred in the forests of south-west WA, it is first necessary to map the original extent of forest (prior to conversion to agriculture or urbanization). In Figure 1, the original extent of jarrah forest is derived from Beard (1981) and the original extent of karri forest is taken from Bradshaw and Lush (1981).

Next, a thorough search of the ornithological literature was undertaken and lists of all bird species recorded were compiled. Early records tend to be less specific than demanded by modern scientific standards, presumably reflecting the rudimentary infrastructure that existed in the forests until timber harvesting commenced in the 1870s. Several problematic records are discussed below.

Attempts to locate lists of bird specimens collected by Quoy and Gaimard in 1826 (in forests adjoining the King and Kalgan Rivers), Preiss in 1838–1841, Cockerell in 1879, White in 1872 and 1889, Carter in 1887, Keartland in 1895, and Le Soeuf in 1899 were unsuccessful (see Carter 1888; Campbell 1900, p.1076; Mathews 1910–1927; Alexander 1916; White 1920; Whittell 1938a, 1954; Glauert 1948a; Meise 1951; Schifter 1973;

[1] Also referred to throughout this paper as original, primaeval, or primal; all are used interchangeably to indicate the forest as it was prior to European settlement, without any implication of environmental value.

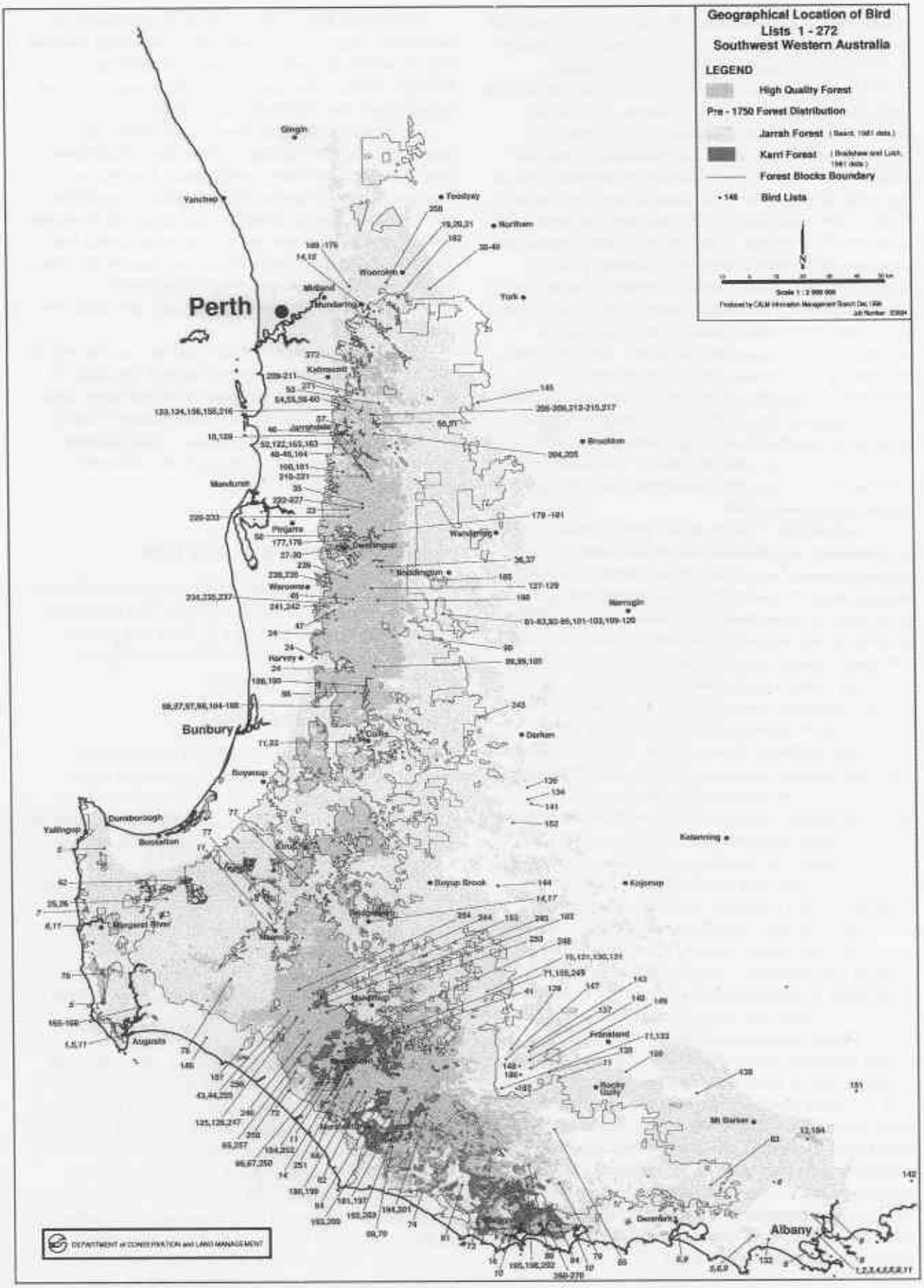

Figure 1. Map showing the extent of the original distribution of forests in south-west Western Australia and the geographical location of each bird list (1–272). The term 'pre-1750' is a convention used by the Commonwealth of Australia.

McGillivray 1975; Marchant 1990; also Horton[2], personal communication). Other active workers such as Conigrave (*fl.* 1901–1910), Whitlock (*fl.* 1905–1925), Lipfert (*fl.* 1911) and Alexander (*fl.* 1912–1920) published nothing about their observations made in forests. Nor did the important compendium of Jackson (1907) reveal any information of significance. The potentially significant notebooks (1915–) of W.H. Loaring are presumed lost, as they were not deposited in the State Library (see Serventy 1968). Label information from specimens and eggs lodged in the world's principal collections of Western Australian birds, *viz.* the Western Australian Museum of Natural Science (Perth), Natural History Museum (London) and American Museum of Natural History (New York) could not be readily accessed because little or none of this information is on a searchable database. However, most bird species in the south-west forests are poorly represented in museum collections (Johnstone[3], personal communication). The Museum of Victoria completed databasing its specimen and egg collections in 1998 (O'Brien[4], personal communication). I accessed this information after this paper was drafted; interestingly it yielded no major surprises.

A comprehensive search of the 'grey literature' (reports by consultants, unpublished field books, theses etc) also turned up further lists of bird species recorded in forests. Because much of this literature is in private hands, it is never possible to discover its full extent – e.g. it is highly unlikely but not impossible that some resident recorded the bird species present in part of the forest between Gilbert's visit in the 1840s and Campbell's visit in 1889.

The vegetation types present in the primordial forests of south-west WA can be distinguished using various criteria and mapped at diverse scales. Examples include 10 vegetation systems and minor portions of 8 others (Beard 1981); 17 forest associations (Bradshaw *et al.* 1997); 25 forest ecosystems (Commonwealth and Western Australian Regional Forest Agreement Steering Group 1998); and about 150 vegetation complexes (Mattiske and Havel 1998). Within the outer boundary of the forest as designated (Fig. 1), areas of woodland, heath, swamp, shrubland, sedgeland, and lithic complex occur. These vegetation types usually relate to substrate type and drainage characteristics. For photographs or descriptions of the range of vegetation types present, see Smith (1972, 1973, 1974), Havel (1975a, b), Beard (1979a, b, c; 1981; 1990), Strelein (1988), and Churchward *et al.* (1988). The eastern boundary of the original distribution of forest is vague, as cells of forest occur in a matrix of woodland (Fig. 1). Some woodland bird species may penetrate to some degree westwards between these forest cells, but unless these species actually live in forest they are not considered to be part of the forest avifauna. Thus, woodland and swamp at Lake Muir (being almost completely surrounded by forest) are considered to be part of the forest ecosystem, whereas woodland at Julimar and swamps on the south coast are not.

Because the focus of this study is documentation of occurrence of species in forests, I have separately itemized lists of species for localities or particular habitats. Multiple studies at the same locality have been combined, unless a particular disturbance intervened.

Bird species visiting the forested part of WA in the austral summer but breeding in the northern hemisphere have been excluded from consideration. The species involved belong to families Scolopacidae, Charadriidae and Apodidae. Species breeding occasionally in forest but feeding outside the forest (as in estuaries or coastal waters) are not treated here as forest birds. Such species have been listed separately. Because of their distinct habitat requirements, waterbirds have been listed separately from landbirds.

Throughout this paper forest blocks are used to refer to occurrences of species. This partly reflects the dearth of precise locality names in the sparsely settled forest. State forest is divided into 418 forest blocks, each of roughly 5000 ha. Their names are shown on a 1: 650 000 map produced by, and available from, CALM's Information Management Branch at Como.

Source and Location of Bird Lists

All of the lists discovered have been numbered and placed in more-or-less chronological sequence. The location of each has been marked on Figure 1. Latin and English names of bird species follow the Western Australian Museum list (Johnstone, in press).

1. Gilbert 1840, 1842–1843

Gilbert visited WA twice, in 1839–40 and 1842–43, collecting mainly bird and mammal specimens for the English taxonomist John Gould – 'a masterly stroke of forward planning' (Tree 1991). Of the 1 031 days spent in the colony, the only time spent collecting in forests was:

- 16 days in the King George Sound area from 14 to 29 February 1840
- about 4 days in the Murray River–Mt William area, 2 to 5 November 1842
- 20 days at Augusta, 2 to 21 December 1842
- 28 days in the King George Sound area, 19 May to 15 June 1843 (Fisher 1992)

Collectively, this is only about 7 per cent of his total time in the colony. It would be fair to say that Gilbert did not penetrate the heart of the jarrah forests or karri forests, an example of how reliant collectors are on the presence of a road network and extensive settlement. In the 1840s the only roads traversing the forests were the routes from Mundaring to Northam, from Armadale to Williams, from Mt Barker to Albany, and from Busselton to Augusta. In addition, the aim of early collectors was to discover biodiversity. Gilbert would have quickly realized that forest is relatively poor in bird species and hence an unrewarding place to search for novelties.

[2] Dr P.H. Horton, South Australian Museum, Adelaide.
[3] R.E. Johnstone, Western Australian Museum of Natural History, Perth.
[4] R. O'Brien, Museum of Victoria, Melbourne.

Gilbert, accompanied by the botanist James Drummond, did attempt to cross overland from Augusta to King George Sound in December 1842 but they were defeated by the swamps of the Scott River plain (see Whittell 1942a; Bolton *et al.* 1992). If they had succeeded, they would have passed through the largest tract of karri forest. The existence of 'heavily timbered' land and 'close forest' north-east of Broke Inlet was depicted on Arrowsmith's 1833 map of south-west WA.

I have assumed that specimens collected by Gilbert and labelled from Augusta or King George Sound were from forest. This information (Table 1) has been extracted from Gilbert (MS), Gould (1848–1869), Gould (1865) and Fisher[5] (1992 and personal communication).

2. Masters 1866

Masters visited 'King George Sound' from January to April 1866. The list of specimens collected was published by Krefft (1867). Although no itinerary or notes on the specimens were published, it is clear from several of the specimens of bird and mammal collected that Masters ventured well into the hinterland of Albany. North (1901–04, 1906–09, 1911–12, 1913–14) several times mentions the locality 'Mongup' which according to Rohan (1979) lies in Peenebup Creek, a tributary of the Pallinup River, south-east of Borden. This area was first settled by Europeans in 1852, was an important source of sandalwood for export, and would have been linked with the port of Albany by cart tracks. Masters is also known to have collected in the Stirling Range (Britton and Stanbury 1981).

Mongup (= the present day Mungerup) and the Stirling Range are well outside the limit of forest, being part of eucalypt woodland and mallee (Beard 1979a) (Fig. 1). Two ways of handling Masters' data are possible. First, one could assume that all specimens (unless labelled otherwise) came from near Albany. On this assumption, failure of later collectors and observers to record the species near Albany could be interpreted to signify local extinction. The second method would involve presuming that species which no subsequent person collected or noted near Albany were collected by Masters well to the inland. This second method is more parsimonious. Thus, with the aid of Storr (1991) and North (1901–1914) I have presumed that various species could not have been collected in the forests close to Albany. In doing so, I am conscious that such species collected by Masters cannot then be used as a baseline with which to detect later changes in distribution of forest bird species. This disclaimer applies also to collections made by Masters in 1868–1869 and by Webb in 1874 (see 3 and 4 below).

3. Masters 1868–1869

Masters returned to the King George Sound region in September 1868 and remained until April 1869. North (1901–1914) occasionally provides details relating to specimens collected at Mongup in January and February 1869. However, even after setting aside such specimens, there remain other species which could not have been collected in forests near Albany (see list of specimens collected in Krefft 1869). I agree with the sentiment expressed by Carter (1933): "It is a disaster in our natural history that Masters's collecting experiences and first-hand observations were never committed to writing, for he made notable contributions to knowledge...".

4. Webb 1874

Webb arrived in Albany in 1862 and obtained work as a shepherd and sandalwood cutter in the Albany, Kojonup and Cape Riche areas (Green 1989a, p.198). Little is known about Webb's collecting efforts, except that he sent a large number of specimens to Macleay in February 1875 (see Fletcher 1929, p. 235). Further material was purchased by Macleay in 1876 (pp. 241, 261) and 1879 (p. 267). The Macleay Museum kindly provided me with a list of specimens collected from 'King George Sound', presumably by Webb (no original labels remain on the bird specimens).

The provenance of these specimens is not assured, as he is known to have collected botanical specimens widely in south-west WA. For example, CALM's WAHERB database records the following localities where plants were collected: south coast in 1881, King George Sound 1879, 1880, 1882, 1888 and 1892, Bremer River 1884, Yarrabin-upper Blackwood River 1893, Mt Lindesay 1882, Cape Le Grand, Salt River 1885, foot of Stirling Range 1886, between Albany and the Williams River 1882 (Marchant[6], personal communication).

5. Campbell 1889

Campbell, a prominent amateur ornithologist, arrived in Albany on 28 September 1889 from Melbourne. He spent 10 days at Torbay based at Millar's karri timber mill, then travelled by steamer to Hamelin Bay where he spent three weeks mainly at Karridale, also visiting Augusta and Ellis' farm on the Blackwood River (16 October – 4 November). Next he spent one day at Wallcliffe on the Margaret River and then proceeded to the timber mill at Quindalup in jarrah forest. Subsequent travel was to Perth and Geraldton, before he returned to Albany on 30 December.

Although his three months in WA yielded 105 bird skins and 600 eggs, he apparently did not collect much in the forests. Details have been taken from Campbell (1890, 1900, 1913) and the Museum of Victoria database (O'Brien, personal communication). Campbell's visit represents the first localized observations of birds from forest; the existence of infrastructure connected with the nascent timber industry facilitated his access to the forests.

6. Hall 1899

Hall arrived in Albany on 23 September 1899 and spent the next 11 days collecting near Albany, Torbay and Denmark, making use of infrastructure provided by the

[5] Dr C. Fisher, Liverpool Museum, U.K.

[6] Dr N.G. Marchant, Department of Conservation and Land Management, Perth.

timber industry. Although he made 'two visits into the heart of the magnificent karri country' (Hall 1902b, p.164), he noted that in Denmark he 'did not meet with sufficient success to compensate me for some three days spent in that vast area, the timber of which seemed to me too heavy for any other purpose with regard to bird-life than to hide its representatives. I was slightly more fortunate at Tor Bay [*sic*], which is midway between Albany and Denmark and less heavily wooded' (Hall 1902a, pp.121–122).

7. Milligan 1900, Carter 1902–1903

Milligan seems to have been the first Western Australian resident to become interested in documenting the avifauna in forests. He worked the area between Cowaramup and Margaret River in October (14 days) and December (five days) 1900 (Milligan 1902), and discovered *Dasyornis broadbenti* in coastal vegetation. He did not, however, consistently specify the habitats of all birds observed. I have also included here several relevant records made by Carter between October 1902 and January 1903 in the same area (Carter 1903).

8. Shortridge 1904–1906

Shortridge apparently arrived in Albany on 1 December 1904 and collected on and near the property of W. E. Balston at King River until 28 February 1905 (Thomas 1906; Ogilvie-Grant 1909). We know that bird specimens were also collected at Chorkerup 22–28 January 1905, at Big Grove 3 March–2 May 1905, Little Grove (10 April 1905) and at Kalgan River on 7–10 February, 28 February and 3 March 1905.

Bird specimens were also collected at Margaret River on 16–18 February (?1905), 1 March, 23 March and 1 April (?1906). The localities involved presumably were Burnside and Ellenbrook (see Thomas 1906).

9. Nicholls 1905

Nicholls visited Albany, Torbay and Denmark (including Wilson Inlet) from February to June, apparently in 1905 (he read his paper to the Bird Observers' Club in Melbourne in August 1905 and it was published in October 1905). His list is obviously not a complete record of the bird species present in the areas visited.

10. Jackson 1912–1913

The visit of Jackson to the Bow River -Nornalup Inlet - Mt Frankland region – the heart of the tingle, karri and jarrah forests of the deep south-west – is highly significant. At the time, the area visited was very sparsely settled and the railway line from Albany did not extend west of Denmark (Jackson 1913). Jackson was an experienced observer and collector of birds, as well as an oologist; indeed, his patron H.L. White considered him 'the best scrub collector I know' (White 1991, p. 28).

His itinerary was Bow River from 14 October 1912 to 19 February 1913, with visits to Nornalup Inlet and the Frankland River in November, Deep and Walpole Rivers in December, and Mt Frankland in February (Jackson 1913; Whittell 1952). Jackson (1913) stated that during his five months' stay 'the country was thoroughly explored on foot by me from Denmark westwards to the edge of Brookes [sic] Inlet, a distance of nearly 70 miles, and for a range of from 10–20 miles inland from the ocean'. His main camp, at Bow River, was 'about three miles from the ocean in a direct line'.

Jackson never published his observations, probably because he failed in his principal objective – to locate and secure the nest and eggs of *Atrichornis clamosus*. Whittell (1952) provided only a partial list of nine species out of the more than 60 species mentioned. I therefore located Jackson's field diaries in the National Library of Australia, thanks to advice from library staff at the Australian Museum and the State Library of New South Wales. A copy of these diaries has been lodged in the CALM library. Jackson's observations have been extracted, collated and summarized by Abbott (1998a).

11. Carter 1905–1919

Although Carter arrived in WA in 1887, and in that year visited the heart of the karri forest, he left no records of the birds encountered (Carter, V. 1987). It was not until he settled at Broome Hill in 1905 that he began to publish his observations. Localities visited included Albany 1905; Albany 1907; Blackwood and Warren River, Albany 1910; Lake Muir and Frankland River 1911, Albany 1914, Lake Muir, upper and lower Blackwood, Margaret River, Collie 1916; Lake Muir, Warren River 1919. These records were published in Carter (1903, 1920, 1921, 1923, 1924a, b) with some duplication in North (1901–1914) and Mathews (1910–1927).

12. White 1920

White was a member of a party of ornithologists visiting WA via rail from eastern Australia in October 1920. This was the first visit to WA by the Royal Australasian Ornithologists Union (RAOU), which had been formed in 1901. One week was spent about the south-west capes, with Yallingup, Canal Rocks, Cape Mentelle, Ellenbrook, Karridale, Cape Leeuwin and Cape Naturaliste being visited (White 1921).

13. Le Soeuf 1920

Le Soeuf (an ornithologist from New South Wales) travelled largely independently of the RAOU excursion mentioned under list 12 above. He visited the Porongurup Range which has jarrah forest and an outlier of karri forest. No details were provided of how long he spent in this locality (Le Soeuf 1921).

14. Parsons 1922

Parsons was a South Australian ornithologist who recorded bird species near Mundaring, Pemberton and Bridgetown (and other non-forest localities) in a 37–day period in September and October (Parsons 1923).

15. Carnaby 1927

Carnaby lived at Parkerville in 1926–27 and published breeding records for bird species (Carnaby 1954a).

16. Ashby and Le Soeuf 1927

The RAOU visited WA for the second time in October 1927, being based at F.S. Thompson's rather isolated property 'Tinglewood' (established in 1911), on the Deep River (Ashby and Le Soeuf 1928).

17. Whittell 1925 onwards

Whittell settled on a farm 'within a mile of Bridgetown township' in 1925 and published (Whittell 1933a, 1938b) an annotated list of bird species in the surrounding area, which was then sparsely settled but was being rapidly cleared. He also contributed brief records of vagrants or colonizing species (Whittell 1935, 1936, 1941, 1942a, 1944). Whittell (1933a, p. 182) noted that '...practically nothing has appeared in...any...publication on the birds frequenting the western escarpment or 'Darling Range' of south-west Australia'.

These 17 contributions, when considered together, can be regarded as embodying the corpus of baseline knowledge of the forest avifauna (Table 1).

The next set of records, from 1950 to the present day, comes from a period in which closer settlement of the south-west occurred, parts of the jarrah forest were logged a second, third or fourth time, a more intensive method was introduced for logging of karri forests, deliberate low intensity burning of forest was introduced to lessen the probability of destructive wildfires, and removal of forest occurred to allow mining of bauxite.

18. Serventy 1950

This brief list of birds (recorded in October) comes from the valley of Gooralong Brook, about 3 km south-east of Jarrahdale, probably jarrah forest in Mundlimup and Serpentine forest blocks (Serventy 1950).

19. Sedgwick 1952–1953

This study is based on 36 lists of species recorded in the same ('almost pure') jarrah forest near Wooroloo (Sedgwick 1955). It appears to be the first repeated census of birds along a fixed transect made in the forest.

20. Sedgwick 1951–1953

Sedgwick also repeatedly counted birds along a fixed transect along a forested watercourse near Wooroloo Brook (Sedgwick 1955). The type of vegetation was not indicated; however, the name of the area (White Gum Gully) suggests that it was principally wandoo.

21. Sedgwick 1951–1953

This is a list of the bird species recorded within *c.* 6 km ['4 miles'] of Wooroloo townsite (Sedgwick 1956).

22. Sedgwick 1956–1962

This is a list of birds recorded in Collie, the jarrah forest around it, farmland, the valley of the Collie River and Wellington Dam (Sedgwick 1968). Sedgwick himself considered the list to be incomplete and justified its publication on the 'paucity of district bird lists relating to the jarrah forest'.

23. McCormick 1972

This is a list of species recorded in jarrah forest in January and February 1972 after prescribed fires in November 1971 in Myara, Wilson, Turner, Urbrae and Scott blocks (McCormick 1972).

24. Sedgwick 1962–1972

Although the scope of this study (Sedgwick 1973) was large, I have included only records from the Darling Plateau, i.e. from Harvey Reservoir east to Stirling Dam and Tallanalla and north to Logue Brook dam (jarrah forest).

25. Forests Department 1974

This is a February 1974 bird list from jarrah forest in Rapids, Treeton, Molloy, Whicher, Punch, Kingia and Quilergup forest blocks (Forests Department nd = 1975). This list was based on field work by P. Skinner.

26. Forests Department 1974

This is an October 1974 list of bird species from jarrah forest in Molloy, McGregor, Whicher, Bovell, Kingia, Rosa, McCorkhill, Butler, Cambray, Barrabup and St John forest blocks. It is based on field work by P. Kimber, K. Pentony and P. Skinner (Forests Department nd = 1975).

27–30. Kimber 1963–1970

This is a list (Kimber 1972) of bird species recorded in State forest within 24 km [15 miles] of Dwellingup in:

27. jarrah forest;
28. swamp and riverside forest;
29. clearings and forest edges;
30. rivers and dams.

31–34. Forests Department 1968–1973

This is a list of bird species occurring in the proposed woodchipping area in the southern forests, as follows:

31. jarrah forest;
32. karri forest (including tingle forest);
33. wandoo woodland;
34. waterways and wetlands (creeks, rivers and lakes throughout forest areas) (Forests Department nd = ?1973).

35–37. Kimber 1971–1973

This is a list of jarrah forest birds seen in spring on marked transects established in 16 ha plots in White and Amphion forest blocks with differing recent fire histories. Only breeding resident species present in 'reasonably large numbers' were reported on (Kimber 1974). These results were also published in Christensen and Kimber (1975).

35. White forest block, burned November 1971 (low intensity fire covering 6 500 ha);
36. Amphion forest block, compartment 4, 182 ha burned December 1971 (some crown scorching);
37. Amphion forest block, compartment 6, unburned since 1933.

38–40. Masters and Milhinch 1930–1973

The relevant (forested) part of this paper relates roughly to the area bounded by Wooroloo, State forest and Clackline (see Fig. 1 of Masters and Milhinch 1974).

38. jarrah forest;
39. wandoo forest;
40. streams, swamps and rivers in the forest.

41. Brown and Brown 1977–1980

This list comes from observational and banding studies carried out in Smith Brook Reserve between Diamond and Dingup forest blocks (Brown and Brown 1980). This nature reserve is 96 ha of karri, marri, yarri and jarrah forest.

42. Hussey 1976

This is a list of bird species recorded over 3 days in October in the jarrah forest, mainly in Whicher and McGregor forest blocks but also including Bovell and Hopkins forest blocks (Hussey 1977).

43–44. J. C. Serventy 1976

43. I have extracted bird lists for virgin jarrah forest in a 10.4 ha plot in Iffley forest block, in September-October 1976 (Serventy[7] unpublished MS nd = 1982);
44. this list refers to the same plot, but for the period 1978–1982 after the plot and surrounding forest were logged (in the summer of 1977–78).

45–47. Nichols, Glossop and Smurthwaite 1979–1981

This study included lists of species recorded in jarrah forest, as follows:

45. Federal and Keats forest blocks (May, August 1979; January, May, August 1980);
46. near Jarrahdale (January 1981);
47. near Willowdale (January 1980).

Species primarily found inhabiting stream zones were indicated (Nichols *et al.* 1981).

48–52. Wardell-Johnson 1981

A short-term (7 day) study of birds in the jarrah forest was based on transects stratified on the basis of position in the landscape and fire history. As Wardell-Johnson (1982) does not present a clear tabulation of the birds recorded in each transect, I have had to follow his arrangement, except where I was able to locate raw data (incomplete) held in the Archives in the CALM Library, Woodvale.

48. valleys (Chandler [1 transect], Serpentine [1 transect] and Karnet [3 transects] forest blocks);
49. uplands (Chandler [1 transect], Serpentine [2 transects] and Karnet [2 transects] forest blocks);
50. ridge in Chandler forest block, unburned since 1937;
51. gully in Chandler forest block, unburned since 1937;
52. ridge in Serpentine forest block, last burned 1979.

53. Abbott 1979–1982

This list is based on bird species noted in virgin jarrah forest in Ashendon forest block, on 70 days at all times of the year.

54–60. Nichols and Watkins 1979–1981

These lists are based on transects in jarrah forest in the Jarrahdale-Dwellingup area (Nichols and Watkins 1984; Nichols[8], personal communication):

54. Gordon forest block (plot 20)) Dec. 1979–
55. Gordon forest block (plot 21)) Jan. 1980
56. Marrinup forest block (plot 22))
57. Mundlimup forest block – healthy forest)
58. Chandler forest block – healthy forest) Jan. 1981
59. Chandler forest block – severe dieback)
60. Chandler forest block – dieback.)

61–63. Nichols and Nichols 1978–1980

The area covered was Saddleback forest block, in all months (Nichols and Nichols 1984). Stratification was as follows:

61. jarrah forest;
62. creek;
63. dams.

64–71. Tingay and Tingay 1981–1982

This was a space-for-time study of the recovery of the karri forest avifauna following clearfelling (Tingay and Tingay 1984). It consisted of 7.9 ha transects, based on 4 consecutive seasonal censuses:

[7] J.C. Serventy, formerly Department of Conservation and Land Management, Manjimup.

[8] Dr O. Nichols, environmental consultant, Perth.

64. Lane forest block, 0 years since fire, virgin karri forest;
65. Giblett forest block, 3 years since fire, virgin karri forest;
66. Hawke forest block, 6 years since fire, virgin karri forest;
67. Hawke forest block, 11 years since fire, virgin karri forest;
68. Dombakup forest block, 0 years since fire, regrowth karri forest 0 years old;
69. Boorara forest block, 6 years since fire, regrowth karri forest 6 years old;
70. Boorara forest block, 12 years since fire, regrowth karri forest 12 years old;
71. Big Brook forest block, 3 years since fire, regrowth karri forest 51 years old.

72–85. Christensen and Liddelow 1972–1983

These lists came from an extensive, area-based biological survey of the southern forests (Christensen *et al.* 1985a):

72. Yeagerup area 1972;
73. Woolbales area 1972;
74. Dombakup area 1972;
75. Perup area 1972, 1983;
76. Boranup area 1973;
77. 'Pines' (Blackwood Valley) 1974;
78. Milyeannup area 1976;
79. Soho area 1975;
80. Mitchell area 1977;
81. Shannon area 1979;
82. 'Karri' area [Crowea forest block] 1974;
83. Mitchell River area 1980;
84. Giants area 1981;
85. Frankland area 1981.

Their survey named 'Sunklands' is omitted here, as it is identical with lists 25 and 26 above.

86–103. Worsley Alumina 1980

These bird lists are of two kinds (Worsley Alumina 1981). Numbers 86–96 were done in July and November 1980 in so-called 'Principal Investigation Locations', each of 400 m^2 area. The remainder (numbers 97–103) represent studies done over 38 days in March, July, August, October and November 1980 in particular 'communities' though not confined to particular plots. Communities in which no bird species were recorded are omitted here:

86. Hamilton forest block – yarri/marri (plot A);
87. Hamilton forest block – jarrah/marri (plot B);
88. Ernest forest block – yarri/bullich (plot C);
89. Ross forest block – jarrah/marri (plot D);
90. Bell forest block – wandoo/marri/jarrah (plot E);
91. cancelled;
92. Saddleback forest block – jarrah (plot G);
93. Saddleback forest block – heath (plot H);
94. Saddleback forest block – jarrah (plot I);
95. Saddleback forest block – wandoo (plot J);
96. Saddleback forest block – jarrah (plot K);
97. Hamilton forest block – jarrah/marri (vegetation community 1);
98. Hamilton forest block – yarri/jarrah/marri (vegetation community 2);
99. Ross forest block – *Melaleuca*/bullich (vegetation community 7);
100. 'northern corridor' – jarrah/marri (vegetation community 10);
101. Saddleback forest block – wandoo/marri (vegetation community 11);
102. Saddleback forest block – jarrah/marri (vegetation community 19);
103. Saddleback forest block – heath (vegetation community 23).

104–120. Worsley Alumina 1982

These bird lists (Worsley Alumina 1985) pertain to 4 ha plots in Hamilton forest block censused over 6 days in April 1982 and 2 days in October 1982 (numbers 104–108) and 4 ha plots in Saddleback forest block studied in February, April, July, August and October 1982 (39 days total) (numbers 109–120):

104. jarrah forest, midslope (plot 16);
105. jarrah forest, midslope (plot 18);
106. bullich forest, gully plot (17);
107. yarri forest, gully (plot 15);
108. dam in the refinery lease area at Worsley;
109. dam;
110. heath, valley (plot 7);
111. heath, valley (plot 8);
112. heath, upper slope (plot 10);
113. wandoo, valley (plot 6);
114. wandoo, ridge (plot 9);
115. jarrah, lower slope (plot 3);
116. jarrah, midslope (plot 5);
117. jarrah, midslope (plot 2);
118. jarrah, midslope (plot 4);
119. jarrah, upper slope (plot 1);
120. jarrah, ridge (plot 11).

121. Christensen, Wardell-Johnson and Kimber 1979–1983

Bird lists (incomplete) from two sites in jarrah forest in Yendicup and Yackelup forest blocks are provided, based on 5 counts made along transect lines in each site in spring over 5 years (Christensen *et al.* 1985b).

122–124. Wykes 1981–1982

Three bird lists refer to jarrah forest near Jarrahdale (Wykes nd = 1985; Collins *et al.* 1985):

122. Serpentine forest block – 14.6 km of transect lines totalling 53 ha, censused bimonthly (10 times) from spring 1981 to winter 1982;
123. ?Gordon/Chandler forest blocks – 'healthy' jarrah forest, visited 6 times between June 1981 and August 1982 (3.2 ha area);

124. as for 123, but severely disturbed ('dieback') jarrah forest (1.8 ha).

125–126. Wardell-Johnson et al. *1982–1989*

These two lists refer to the same study in Gray forest block (Wardell-Johnson 1983, 1985, unpublished MS[9] 1994):

125. four sites (each with a 9 ha plot) bulked, spring 1982, 1983, summer 1983, 1984 – all virgin karri forest;
126. the same sites as 125 after logging (spring 1985, 1986, 1987, 1988, 1989, summer 1986, 1987, 1988, 1989).

Unexplained discrepancies between Wardell-Johnson (1983, 1985) and Wardell-Johnson (unpublished MS 1994) in the identification of several species have been resolved by assuming the names used in Wardell-Johnson (unpublished MS 1994) are the correct ones.

127–129. Abbott and Van Heurck 1981–1983

These 3 lists are from jarrah forest in Yarragil forest block south-east of Dwellingup (Abbott and Van Heurck 1985b). All are based on transects:

127. jarrah forest, untreated 1981, 1982 and 1983 bulked;
128. jarrah forest, logged 1983;
129. yarri forest, unlogged 1981, 1982 and 1983 bulked.

130–131. Wooller and Calver 1983–1985

This study was conducted in jarrah forest 'near Tone River east of Manjimup', presumably in the area known as the Perup. Birds were mist-netted in October 1982, February, July and October 1983, October 1984, and October 1985 (Wooller and Calver 1988). The data have been grouped as follows:

130. pre-burning data (October 1982);
131. all (5) post-fire data.

132–153. Jaensch et al. *1981–1985*

These bird lists come from a major study of waterbirds in nature reserves in south-west WA (Jaensch *et al.* 1988). Numbers 142 and 151 are not strictly within the original boundary of forest, but are included so as to help characterize the bird species present in these sectors.

132. Grasmere Lake (Lake Powell) Nature Reserve;
133. Lake Muir Nature Reserve [includes Lake Muir, Byenup Lagoon, Tordit-Gurrup Lagoon, Neeranup Lagoon and other wetlands];
134. Towerrining Lake Nature Reserve;
135. Cobertup Swamp Nature Reserve;
136. Deadmans Swamp Nature Reserve;
137. Kulunilup Lake Nature Reserve;
138. Kwornicup Lake Nature Reserve;
139. Unicup Lake Nature Reserve [includes Little Unicup Lake and small lakes near north and south ends of Unicup Lake];
140. Yarnup Lagoon Nature Reserve;
141. Moodiarrup Swamps;
142. Albany 27157 (about 22 km E of the forest boundary);
143. Bokarup Swamp;
144. Boyup Brook 18239 (near Kulikup);
145. Dobaderry Swamp;
146. Gingilup Swamp;
147. Kodjinup Swamp;
148. Noobijup Swamp;
149. Pinticup Swamp;
150. Plantagenet 22442;
151. Plantagenet 25386 (about 12 km NE of the forest boundary);
152. Wild Horse Swamp;
153. Donnelly River [no waterbirds recorded].

154. Wooller and Brooker 1978–1979

This is a bird list based on mistnetting in Treen Brook forest block in May 1978 and May 1979. This is forest dominated by karri (Wooller and Brooker 1980). The area was burned in spring 1978. A paper of all the bird species observed (cited as 'Milewski in prep.') evidently was never published, as I could not locate it.

155. Wooller and Calver 1979–1980

This is a list of birds mistnetted in May 1979, May 1980 and September 1980 in karri forest in Big Brook forest block, unburned since the 1930s (Wooller and Calver 1981; Calver and Wooller 1981).

156. Curry and Nichols 1981

This is a pooled listing of breeding species from six 1 ha plots in jarrah forest near Jarrahdale No. 2 minesite. Bird counts took place between October and November 1981 (Curry and Nichols 1986).

157. Cable Sands 1988

Birds were listed from jarrah forest/woodland near Central forest block and National Park in August 1987, November 1987, February 1988 and May 1988 (Cable Sands 1989).

158–164. Ninox Wildlife Consulting 1989

The data tabulated here are the species *actually* recorded by Ninox Wildlife Consultancy (1989) on the seven localities (areas 17–100 ha) studied. A minimum of 6 man-hours was spent in February 1989 on the smaller areas and 10 hours within larger areas:

158. yarri/jarrah/marri woodland, Gordon forest block;
159. bullich/yarri/jarrah/marri, Mundlimup forest block;
160. yarri/jarrah, Myara forest block;
161. bullich/yarri/swamp/jarrah/marri, Myara forest block;
162. yarri/stream/jarrah/marri, Serpentine forest block;
163. yarri/stream/jarrah/marri, Serpentine forest block;
164. bullich/yarri/stream/jarrah/marri, Karnet forest block.

[9] G. Wardell-Johnson, formerly Department of Conservation and Land Management, Manjimup.

165–168. BHP – Utah Minerals International 1989

Birds were recorded within several transects within 'Intensive Sampling Areas' on remnant native vegetation on farmland 17 km north-east of Augusta, adjacent to Scott National Park (BHP–Utah Minerals International 1990). Actual sampling dates were June 1989 (2 days), September–October 1989 (12 days) and December 1989 (6 days):

165. jarrah forests with admixtures of yarri or *Agonis flexuosa/Banksia grandis*;
166. wetlands (swamps, creeks, temporary pools);
167. low woodlands dominated by *Banksia* spp. and/or *Agonis flexuosa*;
168. heathlands.

169–176. CALM 1990–1991

I have bulked records for 8 vegetation types in John Forrest National Park, taken in winter 1990, spring 1990 and autumn 1991 (CALM 1991):

169. powderbark/wandoo woodland over heath (vegetation type Q1);
170. jarrah/casuarina forest (vegetation type Q2);
171. jarrah/marri forest (vegetation type Q3);
172. wandoo/powderbark woodland (vegetation type Q4);
173. heath (vegetation type Q5);
174. *Agonis linearifolia* creekline (vegetation type Q7);
175. granite outcrop (vegetation type Q8);
176. yarri woodland (vegetation type Q16).

177–178. Norwood 1991

These are counts of birds recorded in four 0.9 ha plots in jarrah forest near Dwellingup. Records were made over 11 days from April to September 1991:

177. unthinned forest, Holyoake and Holmes forest blocks;
178. thinned forest, Holyoake and Holmes forest blocks.

Note that several of the species listed in Norwood (1991) are most unlikely to occur in this area: *Microeca fascinans, Petroica goodenovii, P. cucullata, Smicrornis brevirostris, Melithreptus brevirostris* and *Meliphaga virescens* probably are misidentifications and have therefore been excluded from Table 2.

179–181. Norwood 1992

The three lists provided here represent data from jarrah forest in Kennedy forest block east of Dwellingup, collected between April and September 1992 (Norwood 1992; Norwood *et al.* 1995):

179. gap (5–15 ha in size from logging in 1989);
180. edge;
181. untreated forest.

182. Barrett 1985–1990

This list has been compiled from 30 visits to wandoo woodland, wandoo/jarrah/marri forest and heathland along Flynn Road in Gorrie forest block (Barrett 1990; Pegler 1991). Lists for the separate habitats have not been published.

183. Craig 1994–1996

This is a list based on 43 plots within jarrah forest in Warrup, Walcott, Winnejup and Kingston forest blocks (Craig[10], personal communication).

184. Abbott 1974–1993

This species list is founded on records made on 146 days over 14 years in the Porongurup Range. Emphasis was given to the karri and jarrah forests in the south-west sector of the National Park (Abbott 1981, 1995).

185. Marston 1995

This is a list of the species seen in a 4-ha patch of wandoo woodland during the period June – December 1995 in Marradong forest block (Marston 1996).

186–187. Jaensch and Vervest 1986–1987

These lists are of waterbirds recorded from September 1986 to July 1987 (Jaensch and Vervest 1988a), as follows:

186. Byenup Lagoon;
187. Tordit-Gurrup Lagoon (no December 1986 census).

188. Western Australian Naturalists' Club 1985–1992

Although this study recorded birds on three sites (upland jarrah forest; valley slope including riparian vegetation of Murray River; seasonally inundated wetland near Yarragil Brook) in the Lane Poole Reserve south of Dwellingup, the data available do not differentiate between these sites and also include opportunistic observations (O. Mueller *in litt.* 1997).

189–190. Harold 1983

This list is based on sampling over 15 days (October, December 1983) of nine habitat types within the catchment area of the proposed Harris River dam near Collie (Arklow, Ernest, Ross and Edward forest blocks). However, the data obtained were not reported against these habitat types; two broad habitat types have been used instead (Water Authority of Western Australia 1985):

189. jarrah forest;
190. aquatic habitats, including streamside vegetation.

191–203. Burbidge and Boscacci 1985

Observations of birds were made opportunistically during a reconnaissance trip and a floristic survey in September

[10] M. Craig, Zoology Department, University of Western Australia.

1985. The birds recorded were reported against four vegetation types, each with 2 to 4 replications (Burbidge and Boscacci 1986).

191. jarrah forest over dense *Agonis parviceps/Acacia lateriticola* heath (Northcliffe forest block);
192. jarrah forest over dense *Agonis parviceps/Acacia* sp. thicket (Poole forest block);
193. karri/marri forest over dense *Acacia pentadenia* thicket (Jane forest block);
194. jarrah/karri forest over dense *Agonis parviceps* heath (Westcliffe forest block);
195. jarrah/karri/marri forest over dense *Agonis parviceps/Acacia pentadenia* heath (Frankland forest block);
196. karri/marri forest (Crowea forest block);
197. dense low heath of *Podocarpus*, with thickets of *Agonis parviceps* and *Acacia extensa* (Northcliffe forest block);
198. *Agonis parviceps* heath (Frankland forest block);
199. *Acacia* spp./*Agonis parviceps* heath (Crowea forest block);
200. sedgeland (Jane forest block);
201. sedgeland (Westcliffe forest block);
202. dense heath/sedgeland (Frankland forest block);
203. sedgeland (Poole forest block).

204–242. Alcoa of Australia Ltd 1992–1996

These lists derive from Alcoa's ongoing environmental monitoring program at its Jarrahdale, Huntly and Willowdale operations. Each list is based on transects covering an area of 2 ha (Nichols, personal communication).

204. jarrah forest (Cobiac forest block, 1992, winter, plot PW1);
205. jarrah forest (Cobiac forest block, 1992, winter, plot D1);
206. exposed rock in jarrah forest (Chandler forest block 1994 winter and summer, plot G1);
207. exposed rock in jarrah forest (Chandler forest block 1994 winter and summer, plot G2);
208. jarrah forest (Chandler forest block 1994, winter and summer, plot P2);
209. jarrah forest (Churchman forest block 1994, winter and summer, plot P1);
210. riparian zone (Churchman forest block 1994, winter and summer, plot S1);
211. riparian zone (Churchman forest block 1994, winter and summer, plot S2);
212. jarrah forest (Chandler forest block 1995 summer and winter, plot JF1);
213. jarrah forest (Chandler forest block 1995 summer and winter, plot JF2);
214. riparian zone (Chandler forest block 1995 summer and winter, plot JS1);
215. riparian zone (Chandler forest block 1995 summer and winter, plot JS2);
216. jarrah forest affected by dieback disease (Gordon forest block 1995, summer and winter, plot JD1);
217. jarrah forest affected by dieback disease (Chandler forest block, 1995 summer and winter, JD2);
218. jarrah forest (Clinton forest block 1995, winter and summer, plot FC1);
219. jarrah forest (Clinton forest block 1995, winter and summer, plot FC2);
220. riparian zone (Clinton forest block 1995, winter and summer, plot FS1);
221. riparian zone (Clinton forest block 1995, winter and summer, plot FS2);
222. riparian zone (White forest block 1996, winter and summer, plot RS1);
223. riparian zone (White forest block 1996, winter and summer, plot RS2);
224. riparian zone (White forest block 1996, winter and summer, plot RS3);
225. jarrah forest (White forest block 1996, winter and summer, plot RF1);
226. jarrah forest (White forest block 1996, winter and summer, plot RF2);
227. jarrah forest (White forest block 1996, winter and summer, plot RF3);
228. jarrah forest (Urbrae forest block, 1995, winter and summer, plot HF1);
229. jarrah forest (Urbrae forest block, 1995, winter and summer, plot HF2);
230. riparian zone (Urbrae forest block, 1995, winter and summer, plot HS1);
231. riparian zone (Urbrae forest block, 1995, winter and summer, plot HS2);
232. jarrah forest affected by dieback disease (Urbrae forest block, 1995, winter and summer, plot HD1);
233. jarrah forest affected by dieback disease (Urbrae forest block, 1995, winter and summer, plot HD2);
234. jarrah forest (Federal forest block 1994, winter and summer, plot F1);
235. jarrah forest (Federal forest block 1994, winter and summer, plot F2);
236. jarrah forest (Nanga forest block 1994, winter and summer, plot F3);
237. jarrah forest (Federal forest block 1994, winter and summer, plot F4);
238. jarrah forest (Waroona forest block 1994, winter and summer, plot F5);
239. riparian zone (Waroona forest block 1994, winter and summer, plot S1A);
240. riparian zone (Waroona forest block 1994, winter and summer, plot S1B);
241. riparian zone (Samson forest block 1994, winter and summer, plot S2A);
242. riparian zone (Samson forest block 1994, winter and summer, plot S2B).

243. RAOU per W. McRoberts (unpublished data) 1994.

This list is a composite of lists for jarrah forest, wandoo forest and associated farmland collected on 4–6 November by participants in an excursion to Maxon Farm, adjacent to Hillman forest block (Burbidge[11], personal

[11] Dr A.H. Burbidge, Department of Conservation and Land Management, Woodvale.

communication). Highlights were published in *WA Bird Notes* **72**, 12–13.

244–258. Wardell-Johnson et al. *1988–1989*

Birds were recorded in November 1988 and August 1989 in karri forest ('type 10'), in and around 0.16 ha plots (Wheeler[12], personal communication).

244. Gordon forest block (6 plots amalgamated);
245. Graphite forest block (9 plots amalgamated);
246. Beavis forest block (4 plots amalgamated);
247. Gray forest block (6 plots amalgamated);
248. Channybearup forest block (4 plots amalgamated);
249. Big Brook forest block (4 plots amalgamated);
250. Hawke forest block (2 plots amalgamated);
251. Brockman forest block (1 plot);
252. Treen Brook forest block (5 plots amalgamated);
253. Lindsay forest block (3 plots amalgamated);
254. Lewin forest block (1 plot);
255. Iffley forest block (2 plots amalgamated);
256. Strickland forest block (2 plots amalgamated);
257. Giblett forest block (1 plot);
258. Fly Brook forest block (2 plots amalgamated).

259. Karakamia Sanctuary 1991–1997

This list comes from jarrah forest and associated wandoo woodland and granite outcrops in a 180 ha property at Lots 196 and 197, Lilydale Rd, some 5 km NW of Chidlow (Karakamia Sanctuary Pty Ltd, nd; Schmitz[13], personal communication). There is also a lake present, resulting from damming of a creek (Crookes Bk).

260–270. Wardell-Johnson 1985–1987

These lists have been derived from quarterly 0.16–ha plot-based surveys in forest east of Walpole, in Walpole-Nornalup National Park and Giants forest block. Various forest types, often in close proximity, were sampled from spring 1985 to spring 1987 (Wardell-Johnson unpublished).

260. jarrah-marri forest (40 plots amalgamated);
261. red tingle-marri forest (5 plots amalgamated);
262. yarri forest (1 plot);
263. karri forest (9 plots amalgamated);
264. karri-red tingle-marri forest (12 plots amalgamated);
265. karri-red tingle-yellow tingle-marri forest (3 plots amalgamated);
266. yellow tingle-marri forest (1 plot);
267. yellow tingle-red tingle-jarrah forest (1 plot);
268. karri-yellow tingle-jarrah forest (1 plot);
269. red tingle-jarrah forest (1 plot);
270. yarri-jarrah forest (1 plot).

271. Johnstone 1992–1996

This list (Johnstone 1996), based mainly on 81 visits to Bungendore Park near Churchman forest block, does not consistently specify the occurrence of all bird species against the six habitats recognized (jarrah-marri forest, wandoo woodland, sheoak woodland, riparian vegetation, heath, and granite outcrops).

272. RAOU per J. Start (unpublished data) 1998

This list is based on four counts (June 1992, May 1994, May 1996 and June 1998) along a 4 km route in Stinton Cascade Nature Reserve, near Illawarra forest block. Vegetation is jarrah forest with a small seasonal stream, dam and open grass field in the centre. Highlights were published in *WA Bird Notes* **87**, pp. 11–12.

All occurrences of bird species in lists 18–272 have been recorded in Table 2.

Knowledge of the avifauna of the forests of south-west WA was gained only slowly from the 1840s to the 1950s (Fig. 2). Table 1 contains only 755 records, in contrast to 6 671 records in Table 2. Half of the bird lists used to compile this review come from the 1980s.

SPECIES COMMENTARY

The following is a *catalogue raisonné* intended to summarize information available for each of the species listed in Tables 1 and 2. Where necessary, this is supplemented with data published in *Western Australian Bird Notes*, Serventy and Whittell (1976), Storr (1991), and elsewhere, and personal observations or personal communications. These commentaries include pertinent details of biology or ecology.

Species Present in the Primaeval Forest

Landbirds

Dromaius novaehollandiae EMU

Emus occurred throughout the primordial forest in all major habitats – jarrah forest, wandoo forest, karri forest (?casual), wetlands and heaths – usually in ones or twos. The colour of emus in the lower south-west is very dark, almost black (lists 10, 11 in Table 1) instead of greyish-brown. This is presumably an expression of Gloger's rule (emus in the northern Kimberley also have very dark plumage, Johnstone and Smith 1981). Mathews (1912, p. 175) used a specimen collected from Gracefield as the basis of a new subspecies, *rothschildi*. Breeding has been reported (Campbell 1900; Serventy 1948; Worsley Alumina 1985; *WABN* **84**, p. 22). The high mobility of emus is evidenced by pronounced fluctuation in numbers recorded on set transects (P. Christensen *et al.* 1985a). For example, emus were twice as abundant in October 1990 as in October 1970 (1.6 vs 0.7 birds recorded/ 100 km of transect, N = 2900 km of transect over the whole of State forest, Christensen[14], personal communication). Judged also by the distribution and abundance of their scats

[12] I. Wheeler, Department of Conservation and Land Management, Manjimup.
[13] A. Schmitz, Environmental Manager, Karakamia Sanctuary Pty Ltd, Chidlow.
[14] Dr P. Christensen, formerly Department of Conservation and Land Management, Manjimup (now retired).

(personal observation), emus appear to use forest roads and tracks freely and hence probably now have better access to denser parts of the karri forest.

Scats have been observed to contain macrofungi (Robinson[15], personal communication) and epacrid, *Macrozamia*, *Persoonia* and *Podocarpus* seeds. Emus often congregate to feed in recently burnt areas, and also apparently spread blackberries from farms into forests (Christensen *et al.* 1985a). Occasionally this species is reported as feeding on lupin and cereal crops near Collie, McAlinden, Donnybrook, Greenbushes, Bridgetown and Nannup (Riggert 1975). On Peron Peninsula, Shark Bay emus have increased in abundance following removal of foxes (CALM's Project Eden, P. Christensen personal communication). A similar response is to be expected in the south-west forests (CALM's Western Shield Project, see Bailey 1996).

Leipoa ocellata MALLEEFOWL

None of the early chroniclers list the Malleefowl as occurring in forest (consistent with its extensive range in the arid and semi-arid parts of WA, South Australia, Northern Territory, Victoria and New South Wales). This species was recorded (lists 5, 7, 11) as particularly associated with stinkwood *Jacksonia furcellata* thickets along the coast between Quindalup, Cape Naturaliste and Cape Mentelle, and between Augusta and the mouth of the Warren River (Fig. 3). Nests were recorded early this century within the forest near Yelverton (reported to W. Forrest, personal communication). Later, in 1963, a mound was noted under *Agonis flexuosa* trees at Ringbolt Bay, south of Augusta (Smith[16], personal communication). This species was also recorded as nesting near Lake Muir (list 11), presumably in adjacent woodland. These populations appear to have been isolated[17] from the major inland population which reached its western limit from Wongan Hills-Woyaline-Dryandra-Dumbleyung-Broome Hill to Stirling Range (Storr 1991). Ashby (1921) thought that the lower south-west population may prove to be a distinct subspecies but specimens collected do not appear to support this suggestion.

Malleefowl became extinct between Quindalup and Yallingup between 1932 and 1954 (Whittell 1933b; Storr 1954) but remained plentiful around Gingilup swamp in 1948 (Storr 1954). They became extinct around Scott River in the 1930s (V. Roberts, personal communication) and south of Lake Jasper before 1937 (Lionel Scott, personal communication). Lew Scott (personal communication) saw one bird in 1927 near Quannup (between Lake Jasper and the mouth of the Donnelly River) and blamed the advent of the fox in 1929 for their subsequent extinction. Eggs were also collected and eaten by the local cattle farmers. Birds were reported inland as far as where Cleave and Carey forest blocks are presently situated. One bird was seen near Big Brook forest block in the 1920s (reported to F. Bamess, personal communication). The population at Lake Muir was still present, though scarce, before 1939 (R. Muir, personal communication) but was extinct by 1948 (B. Hanekamp, personal communication).

Jarrah forest between Bussell Highway and the Great North Road (Bramley and Forest Grove) was traversed on horseback by D. Perry (personal communication) in the early 1920s without Malleefowl being seen. He also did not record this species in forest between Pemberton and

[15] Dr R. Robinson, Department of Conservation and Land Management, Manjimup.
[16] R. Smith, Department of Conservation and Land Management, Bunbury.

[17] The localities Gnowergerup and Gnowergerup Brook near Mayanup are suggestive of the Noongar name *(Gnow)* for the Malleefowl and may indicate that the western edge of its geographical range continued south-west of Dryandra through Darkan, Mayanup, Lake Muir and then east to the Stirling Range. A mound and birds were recorded by R. Schinzig in *c.* 1930 on 'Hillman Downs', on the east side of Buller Rd south of Darkan (J. Schinzig, personal communication).

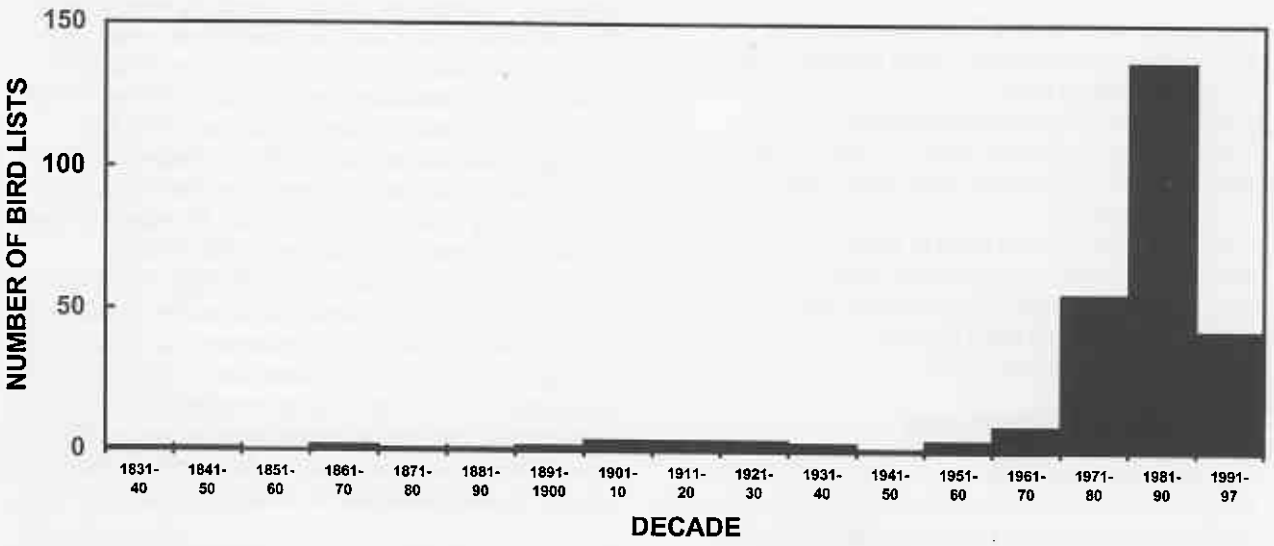

Figure 2. Chronological increase in knowledge of the distribution of bird species in forests in south-west Western Australia, based on lists 1–272.

Broke Inlet or north of Denmark in the 1920s.

Since 1971 there have been several records of Malleefowl in State forest where the species was never previously known to occur. In July 1971 Forests Department personnel discovered a nest in the table drain of Western Road (Surprise/Crossing forest blocks). Another nest was discovered in 1972 east of Frankland River on the edge of a disused forest track in an extensive area of dense heath (Christensen *et al.* 1985a). In 1977 an aerial survey revealed no other nests in the area, though 2 young birds were sighted. Also, one bird was recorded (without further comment) near Northcliffe in December 1982 (*WA Bird Report* 1982, p. 15). The actual location of this record was on Middleton Road in Westcliffe forest block (Langfield[18], personal communication).

In February 1993 logging road contractors reported one bird on Johnston Road in 10-year-old karri regeneration in Lochart forest block, attracted by the noise of a 2-stroke electric pump. This sound apparently resembled the call of this species (B. Elwin, personal communication). Another bird was sighted on Roe Road east of Deep River in 14-year-old karri regeneration in Lochart forest block (month not recorded). One bird was seen on a road in 7-year-old karri regrowth in Thomson forest block in February 1996 and another was sighted on Johnston Road on the western edge of the Deep River in 13-year-old karri regrowth in Lochart forest block in April 1996. All of these records in Thomson and Lochart forest blocks were in or near regrowth karri forest, in which foxes rarely occur (Christensen, personal communication). These forest blocks are also remote from farmland where fox numbers are greatest (*cf.* Catling and Burt 1995).

It is unlikely that litter supply limits nest construction in these forests. This contrasts with low rainfall mallee vegetation which does not support Malleefowl until 10–15 years after fire (Benshemesh 1990). The fuel accumulated in this period would not exceed *c.* 12 t/ ha (McCaw[19], personal communication). In karri regrowth forest, 12 t/ ha of litter is accumulated in about 12 years (McCaw, personal communication). Because of the sensitivity of young karri to fire, fire is excluded from regrowth for *c.* 15 years after clearfelling. Mature karri forest accumulates 12 t/ ha of litter in only 2–5 years after fire (Sneeuwjagt and Peet 1985).

In the northern jarrah forest there have been occasional reports of apparent vagrants. W. P. Clifton in 1878 noted single birds 'high up on the Harvey and the Preston [Rivers]' (Glauert 1948b). A disused nest was discovered in the 1970s by Forests Department officer G. Lapinski at Windmill Gully between Grimwade and Noggerup

[18] G. Langfield, Fitzroy North, Melbourne.

[19] Dr L. McCaw, Department of Conservation and Land Management, Manjimup.

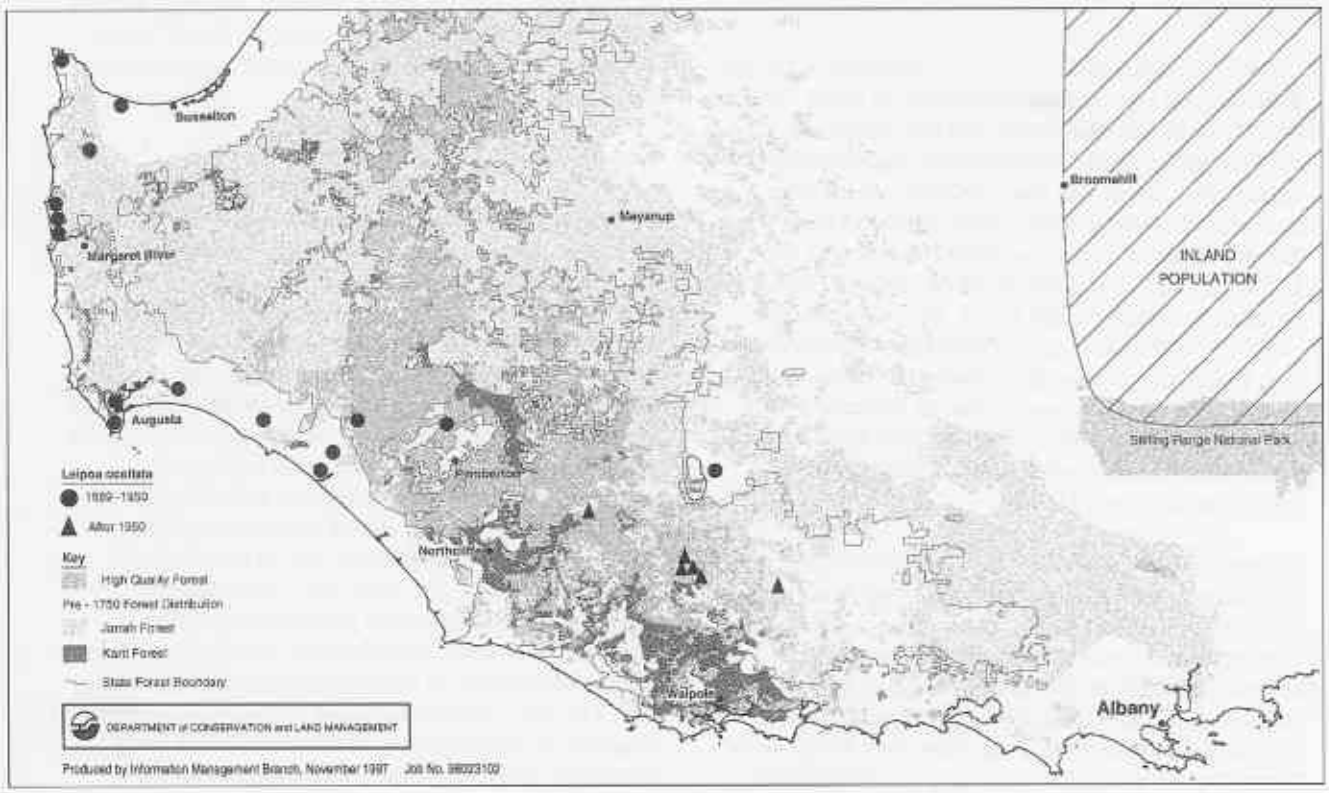

Figure 3. Distribution of Leipoa ocellata *(Malleefowl) in the lower south-west of Western Australia. Limits of the inland population are from Storr (1991). The term 'pre-1750' is a convention used by the Commonwealth of Australia.*

(J. Dearle, personal communication). C. Elvard shot one bird west of Kojonup towards Collie early this century (R. Garstone, personal communication). This species was reported in the 1920s from wandoo forest near Bowelling (A. Wood, personal communication). Mees [20](personal communication) found a fresh road-killed specimen in September 1961 between the 33 and 34 mile pegs on the Perth-York Road just east of the Lakes. The reference by Kimber (list 27) is to a single bird observed by Forests Department officer F. Pridham on a treeless flat on North East Road (Windsor/Boonering forest blocks) in late summer 1965. One bird was present in summer and autumn in *c.* 1975 at Warinegaring north of Bakers Hill (W. Chitty, personal communication). Two birds were seen in *c.* 1986 along Talbot West Road in wandoo (reported to L. Talbot, personal communication). About 5 birds were seen near Cooke pine plantation (near Mt Cooke) in the early 1980s (K. Jones, personal communication). There is also a record of a bird in a 'forested backyard in Canning Valley at Roleystone' and of a roadkill on Brookton Highway about 50 km from Perth (*WABN* **59**, 4). As noted by Carter (list 11), this species is prone to wandering at the end of the breeding season in summer.

The lower south-west population of the Malleefowl was only discovered in 1889. Its occurrence near the coast between Capes Naturaliste and Leeuwin must have been patchy for it to have gone undetected by Gilbert. It may also indicate that in the 1840s the track linking Busselton to Augusta passed well inland (Horwitz and Wardell-Johnson 1996), and that Gilbert did not collect very far from Augusta.

Coturnix novaezelandiae STUBBLE QUAIL

Stubble quail are recorded infrequently in forest. Whittell (list 17) noted that this species was the commonest quail in the Bridgetown district (where nesting was recorded in crops). This species has been positively identified in several parts of the southern jarrah and karri forests (usually on forest tracks) and heaths (see lists 80, 81, 83, 157 in Table 2). It was also noted on partially cleared farmland at Metricup (Hall 1974). There are only four published records from the northern jarrah forest (lists 46, 232, 259; Bickley – breeding reported, Serventy 1948).

The claim that this species was not recorded in WA before 1901 (Blakers *et al.* 1984; see also Anon. 1900 and Anon. 1902) is disproved by the fact that Gilbert (MS) listed it, as did Gould (1865).

Coturnix ypsilophora BROWN QUAIL

According to Storr (1991), Brown quail occur south of a line joining Cape Naturaliste, Bridgetown, Lake Muir and Cheyne Beach. Quail attributed to this species were, however, recorded in lists 28 (Dwellingup), 47 (Willowdale), 182 (Gorrie forest block), and 243 (east of Hillman forest block); these may have been *Turnix varia* Painted button-quail. The remaining records of Brown quail come from coastal heath (lists 5, 168), low lying or swampy country (lists11, 17, 184), open sedgeland (list 85), dense karri regeneration after clearfelling (lists 68, 126), low jarrah forest (list 260), and karri-red tingle forest (lists 263–264). The factor in common between these habitat types is dense undergrowth. This species has not been recorded in mature karri forest (lists 64–67, 125–126).

Haliastur sphenurus WHISTLING KITE

Whistling kites occur sparsely in the forest (jarrah, karri), being usually recorded singly or in pairs, and are most common near large areas of water (e.g. Lake Muir). This species also scavenges freshly-killed carrion. With the increase in rabbit populations in the 1930s, this raptor showed a similar numerical response until the introduction of myxomatosis in the 1950s reversed the situation (Masters and Milhinch 1974; Serventy and Whittell 1976). According to Christensen *et al.* (1985), this species occurs about equally in forest and farmland in southern regions. On farmland near Diamond forest block it was the commonest raptor species present (Brown and Brown 1976–1991).

Accipiter fasciatus BROWN GOSHAWK

Brown goshawks occur throughout the forest – in jarrah, wandoo, karri, tingle and heath habitats. They occur at a low density and are usually recorded as single birds. Breeding has been reported (lists 21, 156, 182). This species is migratory, as nearly all records are from spring and summer (one bird was recorded in the very dry winter of 1986 in jarrah forest east of Walpole, list 260). In karri it occurs either about equally in unlogged (list 67) and regrowth (lists 68, 71) forest, or is present only in mature forest (lists 125–126).

Accipiter cirrhocephalus COLLARED SPARROWHAWK

Collared sparrowhawks (the smallest raptor species) have been recorded at all times of the year in all types of forested habitats – jarrah, wandoo, karri, tingle – as well as heath. Christensen *et al.* (1985a) noted that this species in the southern forests was not as common as the Brown goshawk whereas in jarrah forest around Dwellingup the reverse was thought to apply (Kimber 1972). In one study of karri forest both species were recorded equally (4 birds each, lists 64–71), whereas in another only one sparrowhawk was recorded compared with 14 goshawks (lists 125–126). In forest east of Walpole only one sparrowhawk was recorded (list 261) in contrast to 13 goshawks (lists 260–261, 263–264). It is uncertain whether these differences are genuine or represent confusion in correctly identifying the two species. There are several instances of birds being captured in mistnets (lists 131, 155, Brown and Brown 1976–1991), perhaps suggestive of foraging close to the ground or of being attracted by mistnetted birds. This species is recorded about twice as abundantly in mature than in regrowth karri forest (lists 65, 68, 125–126).

[20] Dr G. F. Mees, Busselton (formerly Curator of Birds, WA Museum).

Aquila audax WEDGE-TAILED EAGLE

Wedge-tailed eagles originally seem to have been found only in the extreme northern and eastern sectors of the forest – in jarrah, wandoo and heath habitats (see also *WABN* **43**, p. 8; **58**, p. 10; **60**, p. 12; **72**, p. 13; **81**, p. 14). Indeed, it is difficult to envisage how such a large predator could have foraged effectively in the primaeval karri and high quality jarrah forests. According to F. Bamess (personal communication), the jarrah and karri forest up to the 1930s was burnt regularly so that there was little understorey; he recalls observing this species chasing kangaroo within the forest. One bird was recorded in mature karri forest in 1982 (list 125), the species was listed for karri forest (without further detail) by Tingay and Tingay (1984), and the WA Museum of Natural Science holds numerous specimens collected from the forest (Johnstone, personal communication). This species also scavenges freshly-killed carrion. It almost always occurs singly or in pairs. Nesting has been recorded in 'rugged country near the junction of the Avon River and the Wooroloo Brook' (Serventy 1948), presumably south-west of Moondyne forest block, at Mandalup on the Blackwood River south of Boyup Brook (*WABN* **64**, p. 10), and in Wungong Gorge (list 271).

Circus approximans SWAMP HARRIER

Swamp harriers usually occur singly (maximum 4) in and near swamps with breeding waterfowl. Not surprisingly, most records in Table 2 come from the wetland bird surveys of Jaensch *et al.* (1988) and Jaensch and Vervest (1988a). This species was also recorded frequently on farmland near Diamond forest block (Brown and Brown 1976–1991), where it also breeds.

Falco berigora BROWN FALCON

Several early observers (lists 8, 11, 17) record the Brown falcon as the commonest (?most conspicuous) bird of prey in the southern forests, which is still the case (Christensen *et al.* 1985a). There it occurs in jarrah, karri, wandoo and tingle, as well as heath. In the northern forest, at least since 1951, it is seldom recorded although it does breed there (lists 21, 182).

Falco peregrinus PEREGRINE FALCON

The Peregrine falcon, the most widely distributed bird species in the world, is rarely recorded in forest, and then usually as single birds. To the ten records in Tables 1 and 2 may be added observations from Bickley (Serventy 1948), Julimar (*WABN* **67**, p. 2), Mt Cooke (*WABN* **70**, p. 2), near Diamond forest block (Brown and Brown 1976–1991), Wilgarup Lake (*WABN* **82**, p. 16), Lake Muir (*WABN* **86**, p. 22), and in yate woodland in Giants forest block in December 1985 (Wardell-Johnson, formerly Department of Conservation and Land Management, Manjimup unpublished). Habitats within the forest ecosystem in which Peregrine falcons have been recorded are jarrah, wandoo, karri, yarri, yate, and heath. Early this century Carter (list 11) noted preference by this species for open country where waterfowl are abundant, as at Lake Muir. Although there are no published records of breeding, the species is known to nest within the forest (Johnstone, personal communication) in the vicinity of mountains (cliffs and gorges).

Turnix varia PAINTED BUTTON-QUAIL

Painted button-quail are widespread in jarrah and wandoo forests (and associated heath). Records additional to those in Tables 1 and 2 come from near Jarrahwood (*WABN* **25**, p. 9), Kalamunda forest block (Dell 1963), Kalamunda (McEvey and Middleton 1968; *WABN* **71**, 9), Julimar (*WABN* **84**, 22), and Molloy Island (*WA Bird Report* 1982, 15). There is one published nesting record from near Diamond forest block (Brown and Brown 1976–1991) and others unpublished from jarrah forest (Johnstone, personal communication).

Phaps chalcoptera COMMON BRONZEWING

Common bronzewings occur throughout the forest, having been recorded in jarrah, yarri, wandoo, heath, karri and tingle. This species is recorded more often in karri regenerating after clearfelling than in mature stands (lists 68, 69, 125–126). Median density in jarrah forest is 0.13 birds/ ha (lists 122, 165), range 0.1–0.25, N = 3. This pigeon is also seen frequently on roads, farms and in towns situated within the forest. Its numbers appear to fluctuate noticeably over several years (lists 17, 184). In forest east of Walpole, this and the next species were more often recorded in jarrah than karri forest (lists 260–270).

Phaps elegans BRUSH BRONZEWING

Brush bronzewings occur extensively in the southern forests (jarrah, karri, red tingle), being most abundant closer to the coast (lists 5, 8, 11). They seem to occur as vagrants in the northern jarrah forest, near Jarrahdale (lists 46, 214) and Dwellingup (lists 27, 224; *WABN* **54**, p, 2). It is possible that several of these northern records may be of Common bronzewings. The Brush bronzewing is recorded more often in karri regenerating after clearfelling than in mature stands (lists 125–126). Both species of bronzewing were recorded in similar numbers in one study of karri forest (lists 125–126), whereas in another this species was absent (lists 64–71).

Calyptorhynchus banksii RED-TAILED BLACK COCKATOO

Red-tailed black cockatoos[21] occur throughout the forest. They appear to be more common in jarrah than in karri or tingle forest (contrast lists 89–120 with 64–71 and 125–126). Indeed this species could be described as primarily a jarrah forest cockatoo, whereas Baudin's and Carnaby's cockatoos are primarily karri forest and woodland species respectively. For example, only 5 red-tails were recorded in karri forest in lists 125–126, as against 110 white-tails; numbers recorded in lists 64–71 were 0 : 41. Forest red-tailed black cockatoos have been recorded nesting mainly in marri trees (R. Johnstone, personal communication); however, jarrah and wandoo are

[21] See Appendix 1 for a list of suitable aboriginal names which could be used for species and subspecies endemic to south-west Western Australia.

also used. This species rarely forms mixed flocks with the other cockatoos, even though it subsists largely on marri seed (list 17). Near Margaret River it was noted that breeding took place in forests farther inland, followed by movement to the coast in December (list 7).

The distribution of the Forest red-tailed black cockatoo has changed since European settlement (Storr 1991 *contra* Saunders *et al.* 1985). It originally extended slightly east of the forest to Toodyay–Wandering–Kojonup/Broomehill, occasionally to Jerramungup (Hasssell 1975). This subspecies was not located during surveys in 1995–1997 in forest north-east of a line between Chidlow and North Bannister (Abbott 1998b, c). This species was last recorded near Julimar and Bakers Hill in *c.* 1940 (H. and S. Cook, W. Chitty, personal communication).

The actual or potential impact of clearfelling of karri forest on this species was overstated by Garnett (1992a, p. 101), Saunders and Ingram (1995) and Rice (1995). Garnett (1992b) subsequently summarized these impacts more objectively: '[D]estruction of nest sites may be reducing recruitment'; 'Decline [in density] not confirmed'; 'Threats include destruction of nest sites by logging (speculative) and prevention of development of new nest sites by short rotation times in wood production forests (speculative)'. The proportion of existing eucalypt forest available for clearfelling is only 7.5 per cent (Commonwealth and Western Australian Regional Forest Agreement Steering Committee 1998, p. 41), not 25 per cent (as implied in Garnett 1992a). Cutting rotations are not 80 years but 'at least 100 years' (CALM 1994a). Moreover, more than 20 per cent of pre-1940 regrowth karri forest is to be deferred from clearfelling and grown on to develop mature/senescent characteristics (CALM 1994a). Over 30 per cent of the total area of regrowth karri forest regenerated between 1940 and 1975 will also be deferred from clearfelling. Similarly, 10 per cent of stands regenerated between 1975 and 1990 will be grown on to the senescent stage (CALM 1994a). Surveys co-ordinated by Abbott (1998b, c) found no difference in the number of sightings of this species over a 2-year period between forest regions with contrasting proportions of logged and unlogged forest. A large surplus of appropriately-sized trees (diameter at breast height over bark [d.b.h.o.b.] > 60 cm) was also demonstrated to be available throughout the forest.

Calyptorhynchus latirostris CARNABY'S COCKATOO

Carnaby's cockatoo was recognized as early as 1933, but was not formally described (as a subspecies) until 1948 and designated as a full species until 1991. It is thus difficult to be certain of the identity of early sight or aural records. More recent records come from the western sector of the northern forest (lists 158, 160, 271) between John Forrest National Park and Collie (jarrah, yarri, wandoo forest), and the eastern sector at Wooroloo, Karakamia Sanctuary and Mt Saddleback (jarrah, wandoo and associated heath). Storr (1991) states that this species breeds in the forest only in the eastern sector. Carnaby's cockatoo is well known as a consumer of seed in pine plantations (Saunders 1974). This species has declined dramatically in the main part of its range (the wheatbelt), owing to clearing of native vegetation for agriculture, a mismatch between the location of its major food supplies and the location of suitable nesting habitat, and the activities of aviculturists (Saunders *et al.* 1985).

Calyptorhynchus baudinii WHITE-TAILED BLACK COCKATOO

Carter (list 11) regarded the white-tailed black cockatoo as the commonest cockatoo in the south-west, and Le Soeuf (list 13) thought that it was the commonest (= most conspicuous?) bird species in the south-west. Baudin's cockatoo occurs throughout the forest (jarrah, wandoo, yarri, karri, tingle), with nesting recorded in the southern forest (in karri trees, lists 5, 6, 14, 16). In karri forest this species was recorded in spring and summer (lists 64–70) but not in autumn or winter, perhaps indicating post-breeding movement away from these nesting grounds. This species has been recorded as far east as Mt Saddleback but only in summer, autumn and winter, suggesting that it may not nest there. Other nesting records (Johnstone, personal communication) come from near Kojonup (in wandoo), Pemberton (in marri) and Serpentine (in marri). Thus, the view that this species breeds solely or mainly in karri forest (Saunders 1974, 1979) is not correct and seems to have been founded on a belief, not substantiated, that 'there is a general lack of suitable nesting hollows' in jarrah forest (S. Davies, quoted in Forshaw 1969; *cf.* Saunders 1974 and 1979). The fact that most nesting takes place in the southern forest does not appear to be connected with forest management.

This species has often been recorded feeding on marri seed (lists 13, 14, 16, 72–85, 271) and also seed of *Banksia* sp. (lists 12, 271), nectar of *B. grandis* (list 189) and bardis (cerambycids) in ringbarked jarrah trees (list 17). These cockatoos also damage apple crops (Serventy and Whittell 1976; Long 1985; Halse 1986). Whittell (1950) recorded that 34 birds were shot as orchard pests. Later bounty data for Bridgetown district indicate that 1 634 birds were shot in the years 1960–1965, and 828 birds were shot in 1984 (Halse 1986). This is of concern as many of these birds are likely to be adults. The open season notice was revoked in 1989 and this species was first listed in 1996 as threatened (Mawson and Johnstone 1997).

Although Baudin's cockatoo is recorded in karri regenerating after clearfelling, it is much commoner in mature forest (lists 64–71, 125–126). Garnett (1992a, p. 105) exaggerated the impact of clearfelling of karri forest on the nesting of this species, and also overlooked the existence of prescriptions (current at the time) to leave 15 marked habitat trees/ 5 ha in logged coupes in jarrah forest (CALM 1989c). Later, Garnett (1992b) noted that 'Threats include destruction of nest sites by logging (speculative), prevention of development of new nest sites by short rotation times in wood production forests (speculative)'...'though there is no evidence of a decline in range or density, destruction of nest sites is likely to be reducing recruitment'.

Cacatua pastinator

WESTERN LONG-BILLED CORELLA

Western long-billed corellas (subspecies *pastinator*) in the primaeval forest would have been found only in the larger areas of un- or sparsely-forested habitat, such as sedgelands on the margins of lakes. Actual records come from near Albany (Barker 1830; Nind 1831; last reported in 1834, near Kalgan River at Oyster Harbour [Clark 1994]), Augusta (birds flying over the Blackwood River, list 11), Lake Muir (list 11), Wilgarup (list 17), and west of Nannup (lists 72–85). Outside the forest this species was recorded from New Norcia, Victoria Plains, Toodyay, York, Mt Stirling, Broome Hill, Kojonup, Mongup, Mt Barker, and country east of Albany and the Stirling and Porongurup Ranges, possibly as far east as Esperance (lists 2, 3, 11; Curr 1886). This species was also recorded in the 1830s at Upper Swan and up to the 1880s near Perth, Pinjarra, Harvey, Bunbury, Picton and Busselton to the west of the forest (Curr 1886, Bolton *et al.* 1991, 1992)[22]. Evidently this species is prone to wandering in large flocks, particularly outside the breeding season (Saunders *et al.* 1985).

The long culmen of this species is an adaptation to extract corms, bulbs and rhizomes from the topsoil. Consequently, these corellas were quick to take up new opportunities with European settlement in 1826 – they began to dig up sown grain as well as consume ripening grain (Moore 1884; list 11; Schorer 1968, p. 262). Farmers responded by laying poison baits (Carter 1912), which were so effective that the Western long-billed corella became locally extinct as a breeding species in all but the Lake Muir area by about 1900. According to Garnett (1992b) it may then have numbered as few as 100 birds. This species was also recorded in large flocks (up to 500 birds) visiting the 'bottom plains' on Scott River, after burning in summer (V. Roberts, personal communication). They would dig for rushes and tubers. They were last observed (5 birds) in 1936. They also visited a farm near Cleave/Strickland/Carey forest blocks to feed on oats (Lew Scott, personal communication). Farmers poisoned birds and shot and ate others for soup. This species was last recorded there in the 1930s. The Western long-billed corella was also recorded on a farm south of Walcott forest block in flocks of *c.* 40 for several weeks in summer in two years in the late 1930s (K. Smith, personal communication), at Deeside before 1914 (H. Green, personal communication), in the Dunsborough/Yallingup area in small numbers up to the late 1920s (W. Forrest, personal communication), about 100 birds at Five Mile Brook near Pemberton in the 1930s (L. Court, personal communication), near Carlotta in about 1933 (L. Talbot, personal communication), near Nannup (20–30 birds, ?1940s, B. Tame, personal communication), at Smith Brook (hundreds, before 1934, A. Dawson, personal communication), and near Pemberton (flock of *c.* 400 reported in 1930s; *c.* 16 seen several times in period 1946–1950, A. Kern, personal communication).

[22] These records indicate that this subspecies had a much wider and less patchy range in south-west Western Australia than described by Storr (1991). Alexander (1918) and Serventy and Whittell (1976) provide additional records.

Since then and with official protection this subspecies is thriving on agricultural lands around Lake Muir, Tone River and Rocky Gully, where it subsists on seeds and bulbs of weeds (Smith and Moore 1991). Massam and Long (1992) noted flocks of about 300 birds at Tonebridge and Chowerup, and M. Craig (*WABN* **71**, p. 2) recorded a flock of 250 birds in December 1993 3 km north-west of Tonebridge. Other recent records include south of Dinninup, Mayanup and near Dwalganup (H. Whistler, B. Trigwell and R. Korn, personal communication). Several pairs have been recorded since 1996 (November–December) on the south coast 1–2 km west and north of Parry Inlet (P. Wells, personal communication). These birds behaved like wild birds and one pair was observed to inspect nest hollows in karri trees. One pair was also sighted on a farm west of Redmond (R. Walker, personal communication). It is estimated that there are 100–200 breeding pairs present at Lake Muir out of a total population of about 2 000 birds (Johnstone, personal communication). Nesting has been recorded in jarrah, marri, wandoo and flooded gum (Smith 1991; Johnstone, personal communication), in trees with d.b.h.o.b. > 68 cm (Mawson and Long 1994). This species will probably gradually re-invade its former haunts, e.g. records at Manjimup in the 1980s (G. Gardner, personal communication) and 2 birds 3 km west of Manjimup in October 1994 (*WABN* **72**, p. 2). However, vigilance is still required – in 1994 157 birds were poisoned with strychnine-baited wheat (CALM Wildlife Offence database).

Western long-billed corellas feed also on nectar from flowers of marri (Moore, quoted by Alexander 1918, p. 41) and yate (presumably *Eucalyptus occidentalis*) [list 11], berries in kwongan (Carter 1912) and marri seed (Smith and Moore 1991).

Glossopsitta porphyrocephala

PURPLE-CROWNED LORIKEET

Purple-crowned lorikeets occur throughout the forest (jarrah, wandoo, yarri, karri, tingle), but are highly nomadic, following the flowering of karri, marri, wandoo, jarrah and other eucalypts. They are the commonest species present in karri forest (lists 64–71, 125–126) and are most frequently recorded in the southern forest (with one record of a flock of > 5000 birds at Byenup Lagoon in February 1987, moving north-west – *WABN* **41**, p. 3). Northern forest records come from Kalamunda, Karakamia Sanctuary, Wooroloo, Gorrie forest block, Bungendore Park, Jarrahdale, Myara, Dwellingup, Willowdale, Collie, Mt Saddleback and Marradong. As noted by Serventy (1948), this species may be absent for many months at a time. In karri forest it was commonest in spring and least abundant in autumn (lists 65–71), and was recorded in enormous numbers in November 1988 and February 1989 (lists 125–126). Purple-crowned lorikeets breed in the extreme eastern sector of the forest and in the karri forest (Storr 1991). This species occurs infrequently in 51-year-old karri regrowth forest (lists 125–126), probably because pollen and nectar are scarce relative to mature forest. Even in mature karri forest abundant flowering occurs only once

in 4–12 years (Loneragan 1979), although individual trees may flower each year and some may flower for 6 months.

Platycercus zonarius AUSTRALIAN RINGNECK

Australian ringnecks are common and widespread in the forest, occurring in jarrah, karri, tingle, yarri, bullich, wandoo and heath. Estimates of density in forest vary from 0.07 to 1.75/ ha (median = 0.12, N = 9). This species also frequents orchards, bluegum plantations, and farms within the forest. Its diet comprises mainly seeds and nectar of native species and seeds and fruits of many introduced plant species (Halse 1986), as well as larvae of jarrah leafminer (Mazanec 1988). Bellanger (1980) made the interesting observation that it took 6 birds of this species to make a parrot pie. Australian ringnecks have been recorded in small numbers in karri regenerating soon after clearfelling (lists 68, 125–126) but do not equal their abundance in mature forest until at least 51 years after clearfelling (list 71). Their abundance is reduced in dieback affected jarrah forest (lists 57–60, 123–124). This species is a pest in bluegum plantations (Ritson 1995) and is also causing mortality of *Xanthorrhoea preissii* in the eastern portion of the jarrah forest now cleared for agriculture (McNee 1997). Nesting has been recorded in trees with d.b.h.o.b. > 32 cm (Mawson and Long 1994).

Platycercus spurius RED-CAPPED PARROT

Red-capped parrots are ubiquitous and common in forest, especially jarrah, karri, flooded gum, wandoo, yarri, bullich and heath. Density in forest varies from 0.4 to 5.0/ ha (median = 1.3, N = 10). This species also occurs in jarrah forest severely affected by dieback disease (list 59) and on farmland, particularly orchards, within the forest where it can be a pest in some years (Halse 1986). Red-capped parrots have a broad diet, comprised mainly of seeds and nectar of native species and seeds and fruits of introduced species (Halse 1986). This species is rarely recorded in young regrowth karri (lists 71, 125–126), and is the least numerous parrot species of the karri forest (lists 64–71, 125–126). Its abundance is usually reduced in dieback affected jarrah forest (lists 57–60, 123–124). Nesting has been recorded in trees with d.b.h.o.b. > 32 cm (wandoo) and > 52 cm (jarrah) (Mawson and Long 1994). Abbott and Van Heurck (1985a) suggested that this species may be disadvantaged by a program of removing the understorey tree *Banksia grandis*; this program (CALM 1992a, p.126) has not been implemented.

Platycercus icterotis WESTERN ROSELLA

Western rosellas occur throughout the forest (jarrah, yarri, bullich, karri, tingle). Most records are west of a line joining Wooroloo and Gorrie, Illawarra, Churchman, Chandler, Clinton, White, Kennedy, Yarragil, Ross, and Edward forest blocks. Other records in the forest come from Bannister (Johnstone, personal communication), south of Gyngoorda forest block (Biddiscombe 1985), and Marradong, Saddleback and Hillman forest blocks (the eastern edge of the forest, mostly heath and wandoo).

Median density of this species is 0.6/ ha (range 0.04–25.0, N = 8). Christensen *et al.* (1985a) considered the Western rosella to be the commonest parrot species in karri forest (as was also the case in lists 64–71 and 125–126). Western rosellas have been recorded in jarrah forest affected by dieback disease (lists 123–124) and also frequent farmland within the forest (sometimes damaging stone fruit). They occur in large numbers after fire in mature karri forest (list 64) but do not re-invade clearfelled karri forest until regrowth is 6 or more years old (lists 68–71) or 1–3 years old (lists 125–126). Overall they remain more abundant in mature karri forest. Western rosellas eat seeds of native trees and shrubs, as well as those of introduced pasture weeds (Halse 1986).

The statement in Blakers *et al.* (1984) that the 'absence of records from the jarrah forest...may be correlated with the scarcity of hollows in trees for nesting' is unfounded. Nesting has been recorded in trees with d.b.h.o.b. > 32 cm (Mawson and Long 1994). Moreover, Mawson and Long (1995) noted that declines and local extinctions of the three *Platycercus* parrots had occurred in the wheatbelt, in contrast to the forest.

Keast (1961) considered that variation in this species was only clinal. The latest analysis (Johnstone, personal communication) supports this in that 'subspecies' *icterotis* (rump green, central tail feathers green, cheeks dark yellow, feathers on back green and black) is confined to the area between Pemberton, Manjimup and Denmark. All other localities show varying combinations of *xanthogenys* traits (rump greyish-olive, central tail feathers blue, cheeks pale yellow, feathers on back red and black). There is no abrupt intergradation from Bannister to Mt Barker as stated by Schodde and Mason (1997).

Cuculus pallidus PALLID CUCKOO

Pallid cuckoos are sparsely recorded in forest (jarrah, yarri, wandoo, karri [?casual], tingle) mostly between March and December, though some birds remain all year (list 260). On farmland near Manjimup birds were present from July to February (Brown and Brown 1986–1987). The only estimate of density in forest (jarrah) is 0.05 birds/ ha (list 165). This species was probably restricted to the less dense eastern sector of the primal forest and the south coast. Pallid cuckoos appear indifferent to age of karri forest (lists 66, 69).

Cacomantis flabelliformis FAN-TAILED CUCKOO

Fan-tailed cuckoos are recorded considerably more often in forest (jarrah, yarri, wandoo, karri, tingle) than the preceding species (lists 17, 31–33, 72–85, 260–272). This species arrives in the northern forest in March and departs by December, whereas some birds are present throughout the year in the southern forests (lists 72–85, 260–270). These cuckoos are recorded either singly or in twos at a median density in jarrah forests of 0.06 birds/ ha (range 0.03–1.1/ ha, N = 3; lists 122, 165). This species is less abundant in regrowth karri up to about 12 years old than in mature forest (lists 64–67, 70–71). However, in some years it is commoner in young regrowth karri than in mature karri forest (lists 125–126). The incidence of this species in forests east of Walpole was 12 times that of the preceding species (lists 260–270), whereas on farmland near Manjimup the reverse applied (Brown and Brown 1986–1987).

Chrysococcyx basalis HORSFIELD'S BRONZE CUCKOO

Horsfield's bronze cuckoo was probably restricted in the primaeval forest to the extreme north (wandoo and heath, lists 172–173, 182) and the eastern sector (where it occurs in jarrah, wandoo and associated heath as at Mt Saddleback, lists 110–120), and in jarrah forest/ woodland on the southcoast (lists 157, 165, 167). Elsewhere in the forest (as in karri and tingle in the southern forest) it is recorded singly and appears to be vagrant. This species is a migrant and is present in the forest from July to November; however, in forest east of Walpole a few birds are present all year (lists 260–270). There is an egg of this species collected by Whitlock in November 1916 from a nest of *Stipiturus malachurus* near Denmark (H.L. White collection, Museum of Victoria).

Chrysococcyx lucidus SHINING BRONZE CUCKOO

Shining bronze cuckoos are the common bronze cuckoo species of the jarrah, yarri, karri and tingle forests (lists 7, 11, 22, 27, 64–71, 125–126, 183) and are present between August and January. In some years in forest east of Walpole a few birds remain all year (lists 260–270). In the extreme northern and eastern jarrah and wandoo forests this species is recorded about as commonly as the preceding species (lists 114–120, 182). Density estimates range from 0.02 to 0.25 birds/ ha (N = 5), with a median of 0.06/ ha. This species is not recorded often in young karri regrowth (lists 125–126) but becomes as abundant as in mature karri forest 6 years after clearfelling (list 69). The incidence of this species in forests east of Walpole was about six times that of the preceding species. From 1840 to 1920 the identification of bronze cuckoos in the forested part of south-west WA was a matter of confusion, with only Masters and Carter recording both species.

Ninox connivens BARKING OWL

Barking owls in the primaeval forest seem to have been restricted to the extreme northern and eastern sectors. Actual records are from jarrah forest near Lake Muir (April 1911, list 11); Mandalup 14 km south of Boyup Brook on the Blackwood River, January 1963 (Mees 1963, 1964a); garden in Walliston (July 1984, *WABN* **32**, p. 9); Avon Valley National Park (wandoo woodland, October 1994, *WABN* **76**, p. 7); near Karakamia Sanctuary (259); Lake Kulunilup Nature Reserve (July 1988, *WABN* **47**, p. 2); heard or seen several times in 1998 in jarrah forest on farmland west of Redmond and next to Redmond forest block (R. Walker, personal communication); Westlington Brook (marri/yarri woodland) on farmland east of Balingup (P. Christensen, personal communication); and Mundaring Weir hall (R. Johnstone, personal communication). The only records from well within the forest are from Pemberton and Middlesex (R. Johnstone, personal communication).

Other records from farther afield include Bindoon Army Training area, Pinnaroo Valley Memorial Park, Sugarloaf Rock near Cape Naturaliste, Pt Dalling near Dunsborough, Avon River west of Toodyay (all from *WA Bird Notes*), Herdsman Lake, Katanning, Stirling Range and Chillinup near Borden (Mees 1964a), near Wubin (Ford 1965), and near Woodanilling (Garstone nd). All of these localities are woodland, not forest. The Barking owl has also been reported at Two Peoples Bay east of Albany (Smith[23], unpublished). The apparent preference for woodland or partially cleared dry sclerophyll forest is similar to that shown by this species in NSW (Kavanagh *et al.* 1995a; Debus 1997). However, R. Johnstone (personal communication) regards this species in south-west WA as favouring swamps and edges of rivers.

Ninox novaeseelandiae BOOBOOK OWL

Boobook owls are the common owls of the forest, more often heard than seen. They occur in jarrah, wandoo and karri forest. The only density estimate available is 0.03 birds/ha (list 122). This species also occurs on farmland within the forest and is capable of long distance movement in a short period, e.g. 111 km in 53 days (Baker *et al.* 1997).

Tyto novaehollandiae MASKED OWL

The status of the Masked owl is uncertain, as it has been infrequently recorded in the forest (karri, *Casuarina* woodland, caught in rabbit traps near Manjimup; Bridgetown, Boyup Brook, near Mt Barker [Mees 1964a]; karri-red tingle (list 264); all in southern forest). Although this species occurs in woodland west, north and east of the northern forest (Mees 1964a; Ford 1968; Garstone nd), there have been no reports from within the northern forest. This species has sometimes been collected in south-west WA as road-kills (Debus 1993), indicating that it makes use of ecotones created by roads through forest. In eastern Australia, this species includes ecotones such as the forest/ farmland and woodland/farmland interface, as well as mosaics of logged forest, unlogged forest, woodland, and open country, within its habitat (Debus 1993; Debus and Rose 1994; Kavanagh and Bamkin 1995; Kavanagh *et al.* 1995b).

It will be interesting to note whether this species becomes more frequently recorded in the future, once CALM's Western Shield project has been operational for several years. Fox numbers are being reduced, resulting in increased abundance of possums, quenda and numbat (Morris *et al.* 1995), and thus compensating for reductions caused by myxomatosis in numbers of rabbits (a source of food for Masked owls).

Tyto alba BARN OWL

Although one of the most widely distributed bird species in the world, the Barn owl probably occurred in the primordial forest mainly along the major rivers in flooded gum (*Eucalyptus rudis*) woodlands, as well as in the more lightly wooded eastern sector. The species seems to have benefited since European settlement with the creation of foraging ecotones at the edges of farms and forest (list 77), along major roads through the forest (list 17), around towns (list 77) and pine plantations (Christensen *et al.* 1981), together with the introduction of the house mouse

[23] Dr G.T. Smith, CSIRO, Wildlife and Ecology, Perth.

Mus domesticus. Mees (1964a) is of the view that south-west WA was recently colonized by this species, probably the result of habitat changes from settlement by Europeans. Evidence against this is that Gilbert (MS) recorded an aboriginal name for this species, distinct from that for the Masked owl. Bones of small bird species accumulated up to *c.* 2 100 years ago in Skull Cave 10 km WNW of Augusta were attributed to this species (Baird 1991).

Podargus strigoides TAWNY FROGMOUTH
Tawny frogmouths occur throughout the forest, apparently most common in jarrah and associated heath and sedgelands, and least abundant in karri and tingle. The only density estimate available comes from *Banksia* woodland – 0.75 birds/ ha (list 167).

Eurostopodus argus SPOTTED NIGHTJAR
Spotted nightjars have been very infrequently noted in forest – in dense wattle scrub in karri forest (list 10), in karri forest (Tingay and Tingay 1984, no details provided), in heathland/*Banksia* woodland north of Walpole (list 79), in jarrah forest at Bickley (Serventy 1948) and in red tingle (list 261). According to Storr (1991) this species does not breed in the forest, but only visits it from February to July. However, one of the records cited above (list 10) was made in November and another (list 261) was made in December. This species has been listed for the forest because it is both cryptic and nocturnal and likely to have been under-recorded. Its status requires further investigation.

Aegotheles cristatus AUSTRALIAN OWLET-NIGHTJAR
Australian owlet-nightjars are mostly recorded from jarrah forest but also occur in wandoo, yarri and karri forests and associated heath.

Todiramphus sanctus SACRED KINGFISHER
Sacred kingfishers occur throughout the forest, being recorded in jarrah, karri, tingle, yarri, bullich, wandoo and associated woodland and heath, karri stands regenerating after clearfelling (lists 64–71, 125–126), jarrah forest severely affected by dieback disease (list 59), and farmland and towns within the forest. This species is a migrant, arriving in September and departing in January, and is usually sighted near water. Two density estimates are available: 0.34 and 0.03 birds/ ha (lists 59, 165).

Merops ornatus RAINBOW BEE-EATER
Rainbow bee-eaters probably occurred in the primaeval northern forest wherever there were open vegetation types (heathlands in jarrah forest with occasional trees offering perches, wandoo forest, monadnocks, recently burnt jarrah forest [list 23]) with suitable soils (usually sandy for excavation of nesting burrow). With European settlement, the creation of road and railway cuttings and farmland within the forest has enormously expanded the availability of suitable habitat. The provision of powerlines has also provided valuable perching sites. This species also occurs abundantly in jarrah forest affected by dieback disease (lists 59–60). It is unlikely that it occurred in karri forest or regularly in the southern jarrah forest.

Rainbow bee-eaters migrate south to the forest in October and depart in March. Although usually recorded in pairs, this species sometimes is noted in large flocks, e.g. 19 birds 2–3 months after prescribed burning (list 23), 40 birds in Blackwood Valley (list 77), and 63 birds roosting in trees near Kalamunda in February 1987 (*WABN* **42**, p. 3). Foxes have been recorded digging out nesting burrows and eating nestlings (R. Garstone, personal communication).

Atrichornis clamosus NOISY SCRUB-BIRD
Discovered by naturalists in 1842, the Noisy scrub-bird lost ground so rapidly to European settlement that its original distribution cannot be circumscribed with much certainty. Storr (1991) noted that it was perhaps originally widespread in the humid south-west. Indeed, Smith and Robinson (1976) suggested that the original range of the Noisy scrub-bird may have been as extensive as that of the forest tree species bullich (*Eucalyptus megacarpa*), and that its primary habitat was the wetter areas of jarrah forest where there is some break in the canopy, as along streams and on the margins of swamps (Robinson and Smith 1976). Danks[24] (personal communication) believes that its range may have matched that of the White-breasted robin *Eopsaltria georgiana*.

This species was recorded by Europeans over a 50–year period in riparian vegetation east of (what is now) Waroona (specimen), near Augusta (specimen), near Albany (specimens), south from Mt Barker (reliable aural record[25]), karri forest near Torbay (specimen), and Boodjidup Brook near Margaret River (reliable aural record). According to Gilbert, this species seemed 'more numerous' in the Albany area than at Augusta or Drakes Brook. Only about 20 specimens[26] were collected (Mees 1964b); all existing labelled specimens (except the type) held in museums come from the Albany area (Whittell 1943, p. 233).

The original descriptions of habitat (by Gilbert, Masters, Webb and Campbell) emphasized dense vegetation, and (apart from Campbell) do not explicitly mention forest. In September 1997 I read the field diaries of S.W. Jackson, who unsuccessfully searched for the species in 1912–1913 in the Walpole area. His diaries reveal that he conferred with Campbell about the habitat in which the Noisy scrub-bird was collected in 1889. Jackson's records of these conversations serve to expand on the meagre notes published by Campbell (1890, 1900) and justify the inclusion of the Noisy scrub-bird in the avifauna of the primal forests of south-west WA.

Various ornithologists searched for it sedulously but unsuccessfully in the period 1899–1925: Hall in karri forest along the Denmark River, 1899 [list 6]; Milligan in

[24] A. Danks, Department of Conservation and Land Management, Two Peoples Bay Nature Reserve, Albany.
[25] The loud territorial song may carry for 1.5 km on calm days (Smith 1976).
[26] Excavations in Skull Cave, 10 km WNW of Augusta, have revealed the remains of 13 individuals of this species (Baird 1991). Radiocarbon dates of charcoal associated with the excavations range from 2 100 to 8 000 years BP. Skull Cave is currently surrounded by karri forest, scrub and low open woodland.

the Margaret River district, 1900 [list 7]; Shortridge near Albany and Margaret River, 1905–1906 [list 8]; Nicholls in karri forest near Torbay where Campbell collected a specimen in 1889 [list 9]; Jackson in karri, tingle and jarrah forests and associated coastal thickets and swamps, 1912–1913 [list 10]; Whitlock, resident at Wilson Inlet, 1905–1925; and Campbell in the Barrabup district north-east of Nannup, 1920 [list 12].

The ornithologist Webb, who probably collected more specimens than anyone else, explicitly stated that the species was known to him only close to the coast (cited in Whittell 1954). Many of the above-cited authorities blamed extensive fires for the decline of the species; however, to the extent that these ornithologists were visitors from New South Wales, Victoria, or England, they may not have fully appreciated the fire-prone nature of south-west WA and the role of aborigines in managing fire until the 1860s.

My view is that it is unlikely that a widespread species could have retreated so quickly, as several other fire sensitive species such as *Pezoporus wallicus* (Ground parrot), *Dasyornis longirostris* (Western bristlebird), *Dasyornis broadbenti* (Rufous bristlebird) and *Psophodes nigrogularis* (Western whipbird) (all occurring outside the primaeval forest) persisted at least until the first decade of this century along the western, southern or south-eastern boundaries of the forest. I think that the Noisy scrub-bird was not widespread throughout the forest, occurring only locally in certain core habitats specified below.

The Noisy scrub-bird probably occurred in *Nothofagus* rainforests during the Tertiary (Smith 1977). Subsequently *Nothofagus* became extinct in WA. It therefore seems likely that the geographical range of the Noisy scrub-bird then contracted (Smith 1978). With increasing aridity, its range should have become even smaller. Lightning strikes are a regular occurrence in the south-west; hence fires started by such strikes in summer should have caused the distribution of the Noisy scrub-bird to have become still more disjunct.

The arrival of aborigines 50 millennia BP probably had further adverse impacts on the extent of habitat actually occupied by Noisy scrub-birds. Nonetheless, an equilibrium would have been reached between the extent, frequency and season of aboriginal fires and the occurrence of sufficient areas of core habitat to support viable populations of Noisy scrub-birds. If the view of Bowler (1982) is correct, this species should have contracted to its core habitat at the height of the last glacial period (20 ka BP). There is evidence that south-west WA was virtually depopulated of aborigines from *c.* 6–4 ka BP (Ferguson 1985). Fires would once again have been started by lightning, and were probably of higher intensity. If so, they should have put more pressure on the extent and quality of core habitat.

South-facing slopes in very dissected country are likely to have been the least burned parts of the south-west because they remain moist longer than other areas (Walker[27], personal communication; compare also the heat index equation given by Enright *et al.* 1994). Even in the wettest parts of the forest, as at Dwellingup, there were 5 and 10 years in a period of 45 years in which no rain fell in the two hottest months of January and February (Gentilli 1989). In such years fires could be extensive and intense. Localities where the Noisy scrub-bird may have occurred (based on the criterion of south aspect in dissected landscapes) have been listed in Table 3 and mapped in Figure 4.

The hypothesized core geographical distribution of the Noisy scrub-bird has some interesting implications:

- It is greatly insularized, with 106 separate core populations; half of these appear strongly associated with portions of the Helena and Murray landform units (Churchward and McArthur 1980).
- 44 per cent of this core distribution was on land taken up later for agriculture.
- 30 per cent of the core distribution occurred in what later (between 1924 and 1930, Jarvis 1979) became State forest.
- 13 per cent of the core distribution occurred along rivers subsequently dammed in the period 1902–1994.
- Given that the core home range (where 80 per cent of time is spent) is 1.25 ha (Smith 1985a), most of the fragmented populations mapped each could only have supported low numbers of birds. It is possible that the minimum viable population size is 20–30 pairs, which was probably the size of the population at Two Peoples Bay in the 1940s (Smith 1985b). About 60 per cent of the 106 core populations are estimated to have consisted of 20 pairs or less (Table 3).
- Most of the northern populations (numbers 1–23, 32–39 in Table 3) probably became extinct soon after settlement in 1829, as much of the land along rivers draining the Darling Scarp was taken up for farming in the period 1830–1865 (Staples 1979; Statham 1979; Udell 1979; Popham 1980; Coy 1984). Early settlers quickly appreciated the infertility of the Swan Coastal Plain (Cameron 1979) and favoured the alluvial soils of the Swan, Helena and Canning Rivers and the valleys in the foothills of the Darling Scarp and their alluvial outwash areas for farming (Burvill 1979).
- Settlement had not intruded into Noisy scrub-bird habitat south of the Murray River by the early 1840s, when Gilbert discovered the species.
- Most of the inland southern populations probably became extinct after the 1850s, as settlement spread to strategic locations (permanent water, pastoral lands e.g. Garden 1977; Glover 1979) and altered natural fire regimes.
- The karri forest near Torbay consisted of several large isolated patches (Bradshaw *et al.* 1997), which after logging in the 1890s were cleared for agriculture.
- The karri forest near Augusta and at Boodjidup Brook was never part of State forest; much of it was cleared for agriculture.

[27] A. Walker, Department of Conservation and Land Management, Crawley.

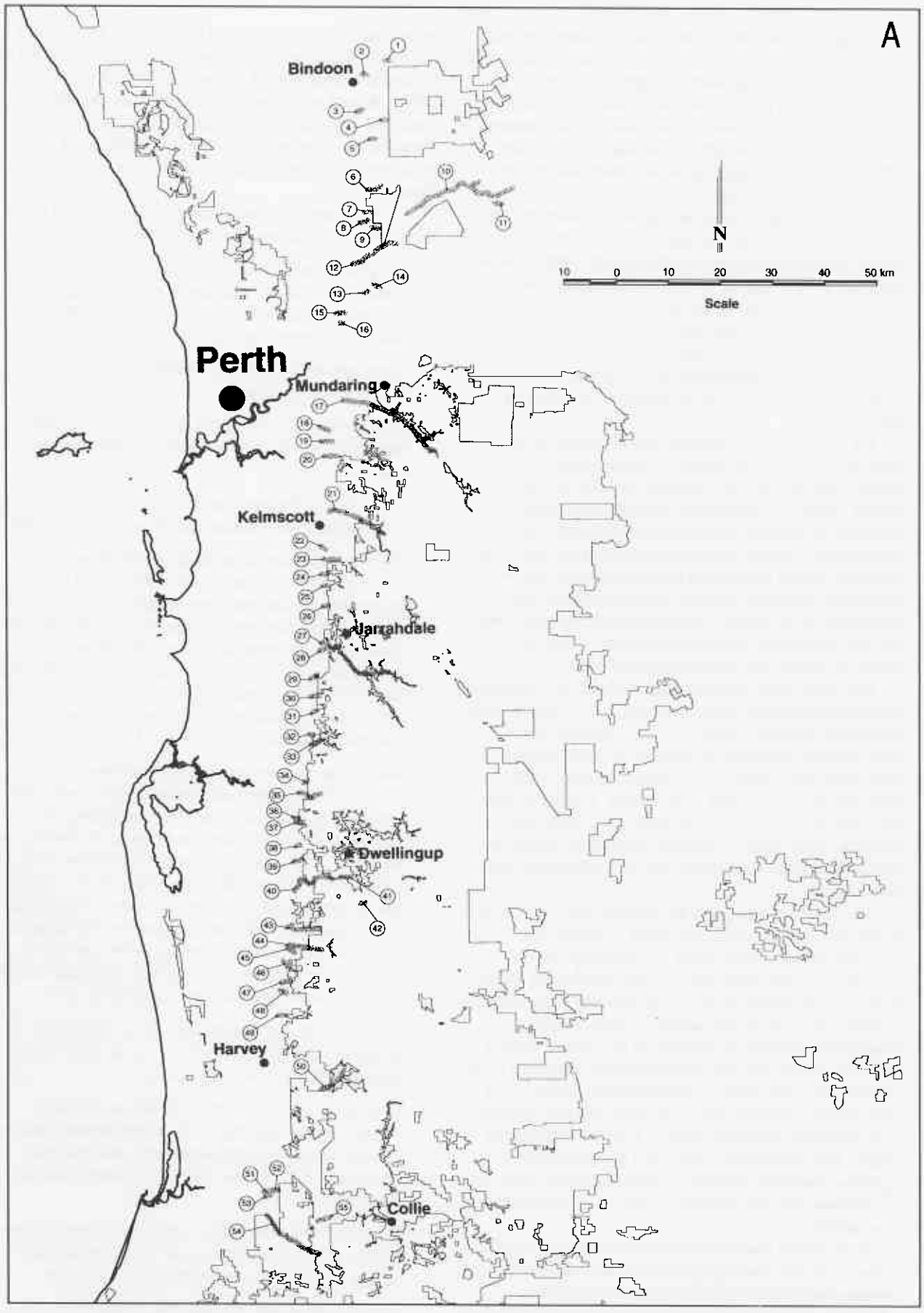

Figure 4A. Hypothetical core geographical distribution of Atrichornis clamosus *(Noisy scrub-bird) (see Table 3 for details).*

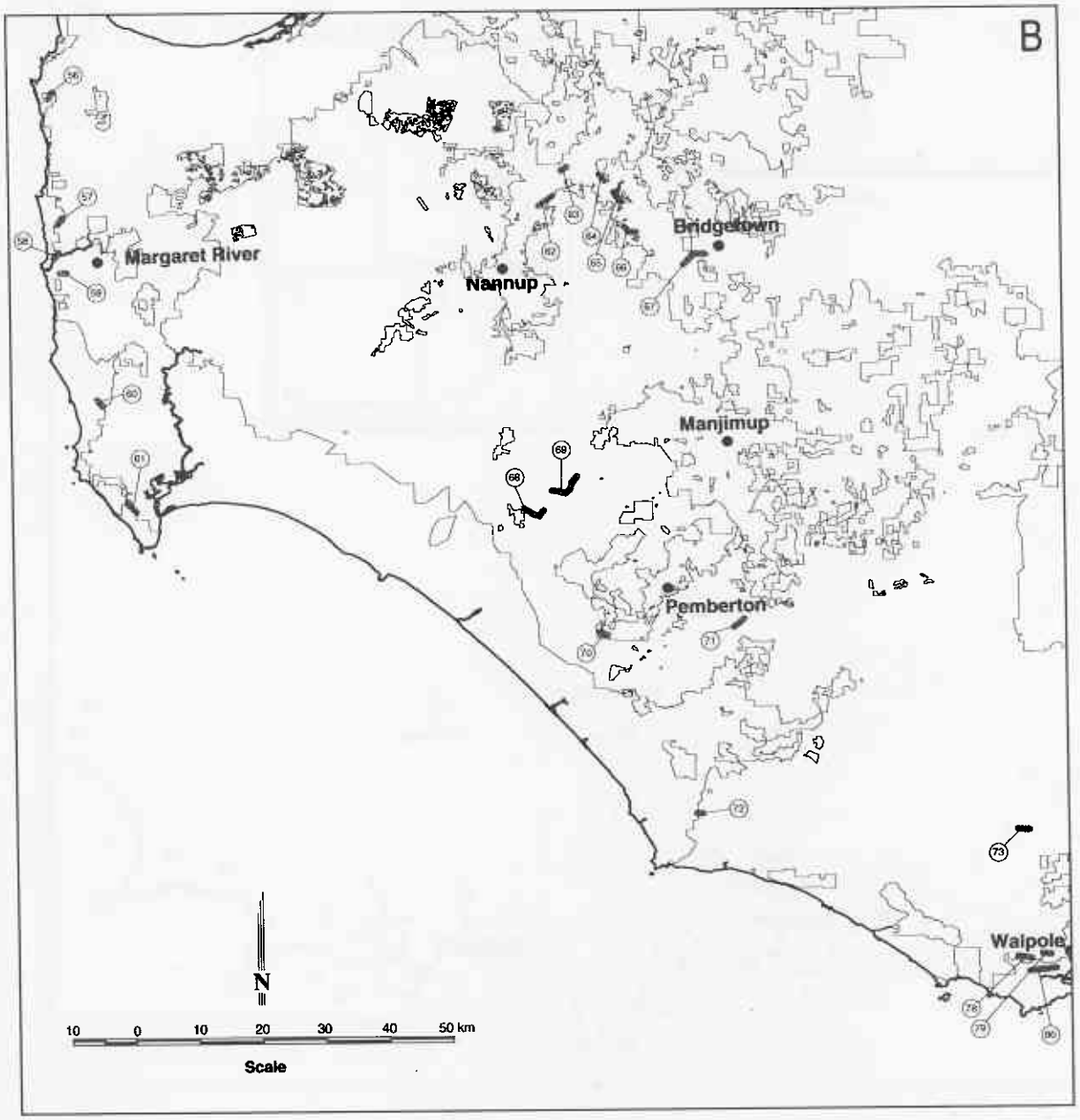

Figure 4B. Hypothetical core geographical distribution of Atrichornis clamosus *(Noisy scrub-bird) (see Table 3 for details).*

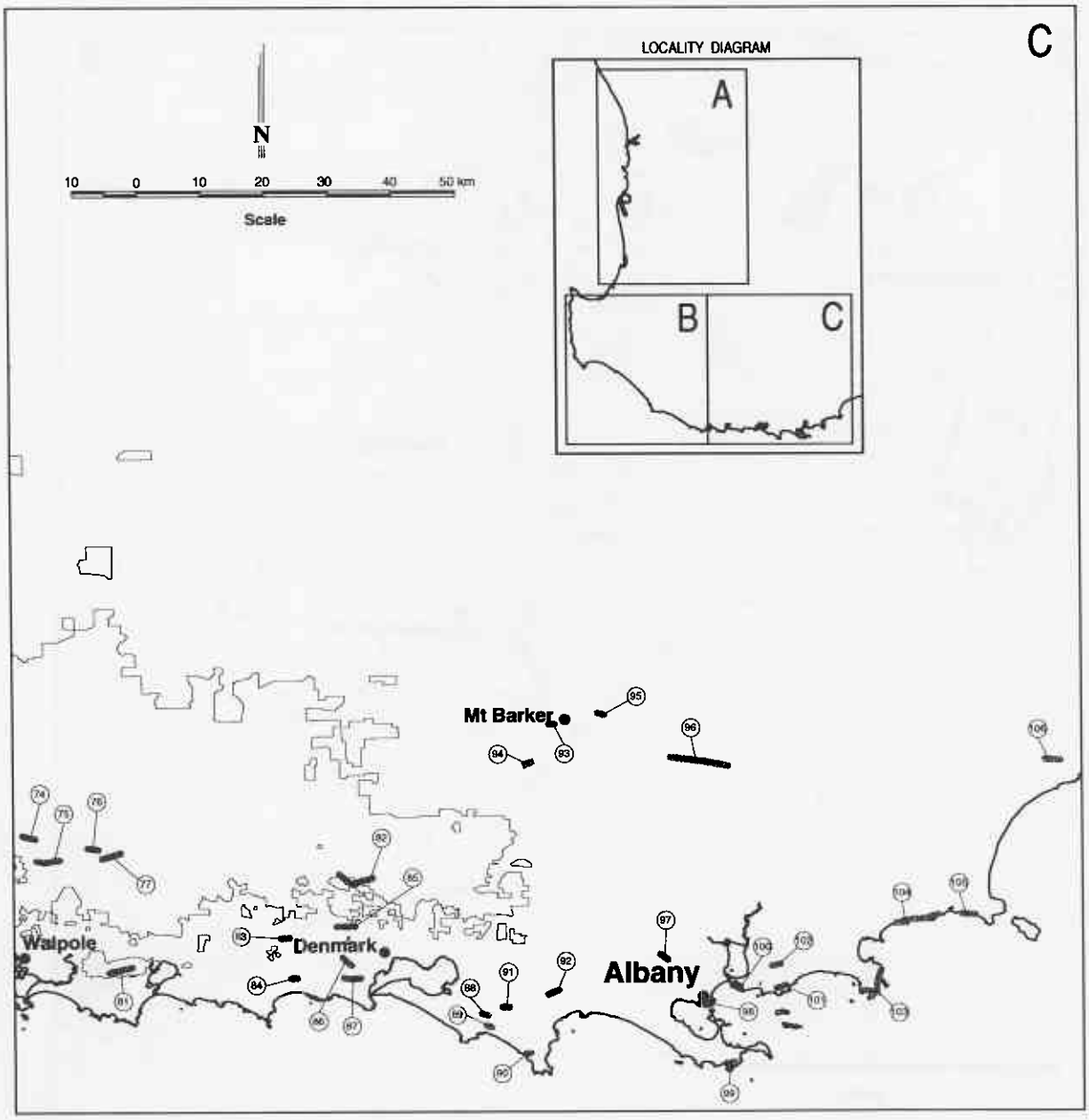

Figure 4C. Hypothetical core geographical distribution of Atrichornis clamosus *(Noisy scrub-bird) (see Table 3 for details).*

- These hypothetical core occurrences would have been the source of birds re-colonizing adjacent burned habitat, once it regenerated to a density, cover and height suitable for this species (Smith 1985a; Danks 1991).

This hypothetical distribution differs considerably from a distribution map published by CALM (1995c). The original range is shown there as consisting of 3 cells: a large one (*c.* 300 000 ha) bounded by Torbay, Mt Barker and Two Peoples Bay, and 2 smaller ones, between Margaret River and Augusta (*c.* 50 000 ha), and near Waroona (*c.* 60 000 ha).

Another criterion that may indicate areas likely to have escaped frequent burning is onshore drizzle along the south coast east of Pt D'Entrecasteaux in summer. For example, the probability of a totally dry summer at Denmark is less than once per century, some 50 times less than in the northern jarrah forest (Gentilli 1989). This factor may account for the occurrence of this species around swamps in coastal areas such as near Albany (Whitlock 1928, p. 184; Webb in Whittell 1954).

Steep south-facing slopes in middle latitudes receive the least incident radiation (Holland and Steyn 1975). However, in the two hottest months of December and January, incident radiation is not appreciably reduced on south-facing slopes < 15° . These months are also when differences in incident radiation between north- and south-facing slopes are least (Pryor[28], personal communication). Steep slopes in parts of the south-west with the greatest average annual rainfall are also most likely to experience rain during December and January, particularly slopes near the western edge of the Darling Plateau and near the south coast. Thus, the population of Noisy scrub-birds along the Darling scarp may have been even more insularized than indicated in Figure 4.

Given the vociferous and strident song of this species, it was probably well known to Noongars. The demise of south-west aborigines and their land management practices after the 1860s resulted in a rapid build up of litter, which compounded with lightning strikes, led to unprecedented extensive and moderate to high intensity fires in the period 1860 to 1900 (Smith 1985b). Fires of this scale and intensity may have degraded most of the preferred habitat at the same time. In addition, settlement by Europeans gradually advanced in the period 1839–1888. The 1890s saw the opening of the Perth-Bunbury railway and an influx of gold prospectors. The pace of land alienation then accelerated (Fig. 5). Fires set to clear natural vegetation for farming would have increased concomitantly. Because of this species' limited powers of flight, dispersal to regenerating habitats was likely to have been too slow (Smith 1985c) to re-establish a population and then increase in abundance before the next fire. (The Noisy scrub-bird has a clutch of only one egg and a low breeding success, Smith 1985b). The special conditions on the Mt Gardner promontory (near-isolation, extensive natural firebreaks in the form of granite sheets) acted as the final refuge of the species (Smith 1985a).

The type locality of the Noisy scrub-bird east of Waroona is not known with certainty. Danks *et al.* (1996)

[28] T. Pryor, Energy Research Institute, Murdoch University.

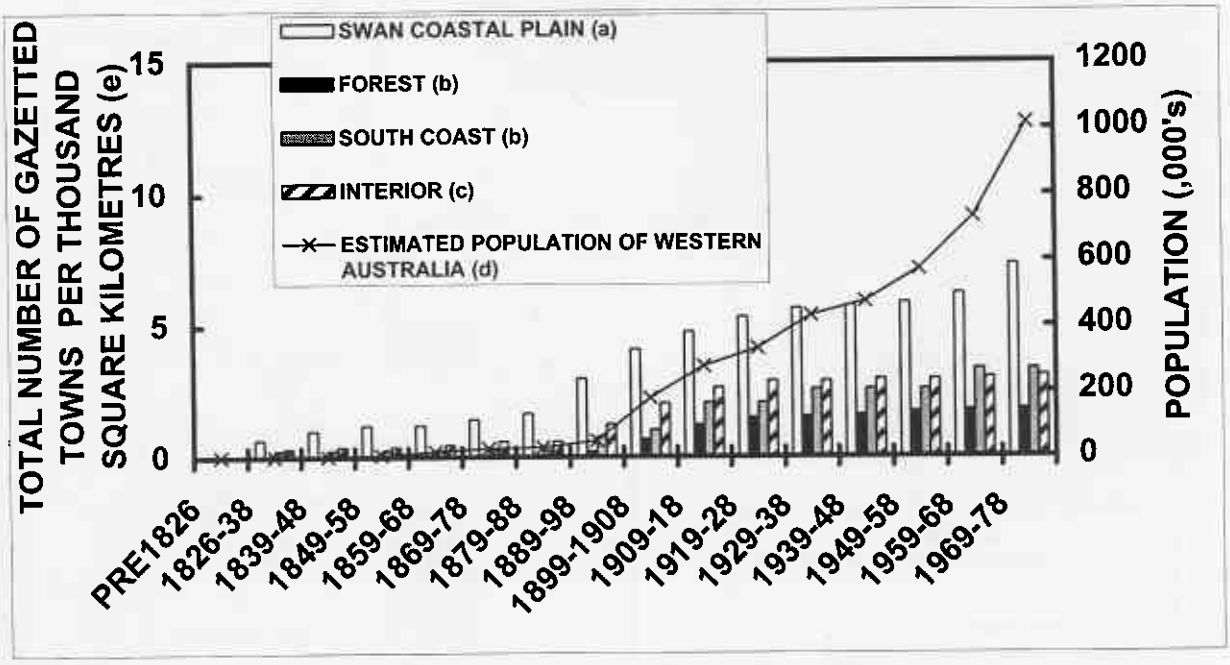

Figure 5. Population growth and development of towns in south-west Western Australia. Note: South coast (b) refers to the area south of the forest from Cape Leeuwin to near Albany; Western interior (c) is the area east of the forest to the Great Southern Railway; population data (d) are from Kelly (1997) and exclude aborigines before 1960; data on towns have been taken from Jarvis (1979) and include cancelled townsites.

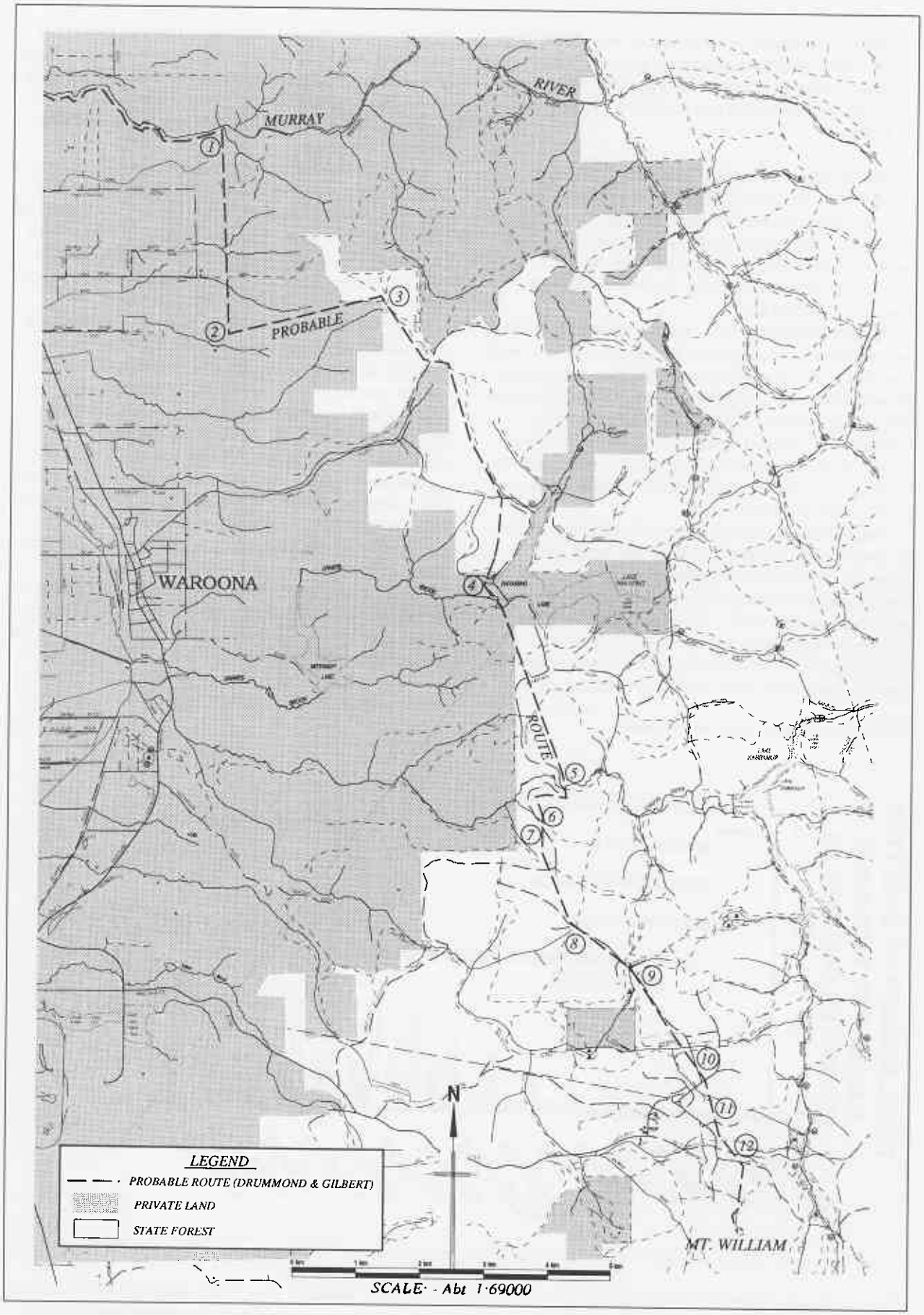

Figure 6. Probable route of J. Drummond and J. Gilbert, based on Drummond (1843). 4 indicates the probable type locality of Atrichornis clamosus.

indicated (their Fig. 1) that the species occurred at Mt William, though no substantiation was provided. In Figure 6 I have attempted to clarify and ascertain these matters by mapping the route of Gilbert (and James Drummond) in 1842 from the Murray River to Mt William, based on the narrative published by Drummond (1843). The chief difficulty with this account is that the distances supplied are inconsistent with the narrative. I have therefore relied more on the geographic notes recorded by Drummond.

Stages 1 to 12 shown in Figure 6 relate to the following points:

1. '...attempting to cross a tributary brook which falls into the Murray about a mile below the rapids [= Marrarup]'. 'On the 2nd [November]...we examined the Rapids where the Murray makes its way through the Darling Range ...'
2. 'On the 3rd...we set out for Mount William; about 2 miles to the south of the Murray, keeping just clear of the before-mentioned brook, which is the only tributary we found to fall into the river from the south and to the west of the Darling Range, we found an excellent ascent to the hills at a place where the mahogany [= jarrah] forest...comes much lower than usual.'
3. 'On reaching the top, we proceeded along a ridge of hills [?watershed], with an extensive valley to the left...'
4. 'in about 5 miles we came to a valley with a considerable brook, with swampy banks, running to the west [Drakes Brook]'...'On the banks of this brook Mr Gilbert got the first specimen of a new bird [= *Atrichornis clamosus*]...hiding itself among the rushes, and singing sweetly with loud, clear notes'.

5–12. 'We took the direction for Mount William from Arrowsmith's latest maps of Western Australia [published 1833], and in going to it we had to cross a series of hills and valleys, in 8 [here numbered 5–12] of which we found running streams, several of them so large we were obliged to take the packs off our ponies to get them over'. [This was a year which Drummond noted was 'unusually wet'.]

5. 'We slept on the night of the 3rd on what we supposed to be the River Meares [= Samson Brook]...It was on the banks of this brook...Mr. Gilbert...got a new species of the robin family [= *Eopsaltria georgiana*].'
6. Tributary of Samson Brook.
7. Tributary of Samson Brook.
8. Tributary of McKnoe Brook.
9. Tributary of McKnoe Brook.
10. 'On the 4th, after travelling 5 or 6 miles, we got from the top of a hill which lay a little to the left of our course, an excellent view of Mount William to the south...Soon after leaving the top of this hill, we crossed a stream of water running to the east [= tributary of Samson Brook] – the only one we met with between the Murray and Mount William which did not run in a westerly direction.'
11. 'We stopped for the night on the 4th on the banks of a brook which we thought must be near the foot of the mountain, but on the 5th we found that we had two considerable brooks to cross before we reached it...'
12. '...on the banks of one of those we left our horses, & returned there to sleep.'

After ascending Mt William they returned to Pinjarra.

From this narrative, I deduce the following:

- Only one specimen of the Noisy scrub-bird was collected.
- The type locality is Drakes Brook on what is now known as Location 27 (Fig. 6), approximately just below the Waroona dam wall holding back Lake Navarino. According to Beard (1979b, c), the original vegetation on the slopes of deeply excavated small valleys was marri/wandoo woodland and fringing woodland of *Eucalyptus rudis* and *Melaleuca preissiana* along streams. This area is the foothills west of the Darling Plateau (conventionally but inaccurately referred to as the Darling Range). Whittell (1942b) placed the type locality 3 km too far south-west (This site, near Drakes Brook Weir, has a plaque erected in 1948 celebrating the discovery of this species.)
- It is significant that Drummond makes no mention of other occurrences of the Noisy scrub-bird on this journey. If Gilbert had encountered it again, it is difficult to imagine him passing up the opportunity of collecting further specimens. This should have resulted (given the wariness of the species) in much time having been wasted, just the sort of information I would expect Drummond to record in a general narrative. In addition, Gilbert should have been both exasperated and disappointed – just the kind of information worthy of record in his notes.
- Noisy scrub-birds apparently did not occur on the Murray River (at least in 1842 east to Marrarup), as Gilbert spent a day there waiting for the return of a horse, and so had ample time to detect the species if it were present. In 1839 George Grey noted that this area was 'a favourite resort of the wild cattle, and we saw everywhere numerous recent traces of them' (Grey 1841, pp. 313–314).
- There is no evidence that the Noisy scrub-bird occurred at or close to Mt William (*contra* Danks *et al.* 1996). These authors appear to have taken Gilbert's comment [in Whittell 1951] that the species is found '...in the vicinity of Mount William where I first observed it' too literally. Gilbert was writing generally

about the geographical extent of the species as observed by him. He referred to Mt William simply because it was the nearest prominent geographical feature to the type locality and was marked on Arrowsmith's map. Drakes Brook was of course as yet unnamed. Whittell (1943) accepted that the type locality of the Noisy scrub-bird was in the 'vicinity of Drakesbrook'. Gilbert also wrote broadly (and incorrectly) when he stated that *Eopsaltria georgiana* was first collected by him 'in the immediate vicinity of Mount William...'. 'Immediate vicinity' should not be read as on the slopes or around the base of Mt William; rather we know from Drummond (1843) that this species was collected at Samson Brook (site 5, Fig. 6), some 7 km north-west of Mt William.

East of Waroona nearly all riparian habitat occurs on land taken up for agriculture between 1848 and 1891 (Fig. 7; Snell 1986). Before the 1890s pastoralism was practised as fencing of properties was minimal and thus sheep needed to be shepherded whereas cattle grazed unhindered, even into the western portion of the Darling Plateau (Popham 1980, p. 27). Cattle are more efficient feeders than sheep and will wander until they locate nutritious herbage on fertile river flats (Staples 1979, p. 185). Clearing of vegetation was minor but trees were ring-barked and fire was used to thin out vegetation and provide more suitable forage for stock (Cameron 1979, *cf.* Ashby 1921). In addition, riparian vegetation would have been burned frequently in order to improve access of stock to water. It is probable that inappropriate burning from 1850 resulted in the demise of the Noisy scrub-bird in whatever was its limited range east of Waroona. The first logging took place in the area in 1895 (Heberle 1997) and was of course directed at the uplands where the prime jarrah forest occurs. If any Noisy scrub-birds had persisted to the 1890s, the installation of logging tramways – generally low in the landscape – and the lack of spark arresters on locomotives at that time should have resulted in frequent burning.

Blakers *et al.* (1984) claimed that forest managers, through frequent use of fire, have contributed to the

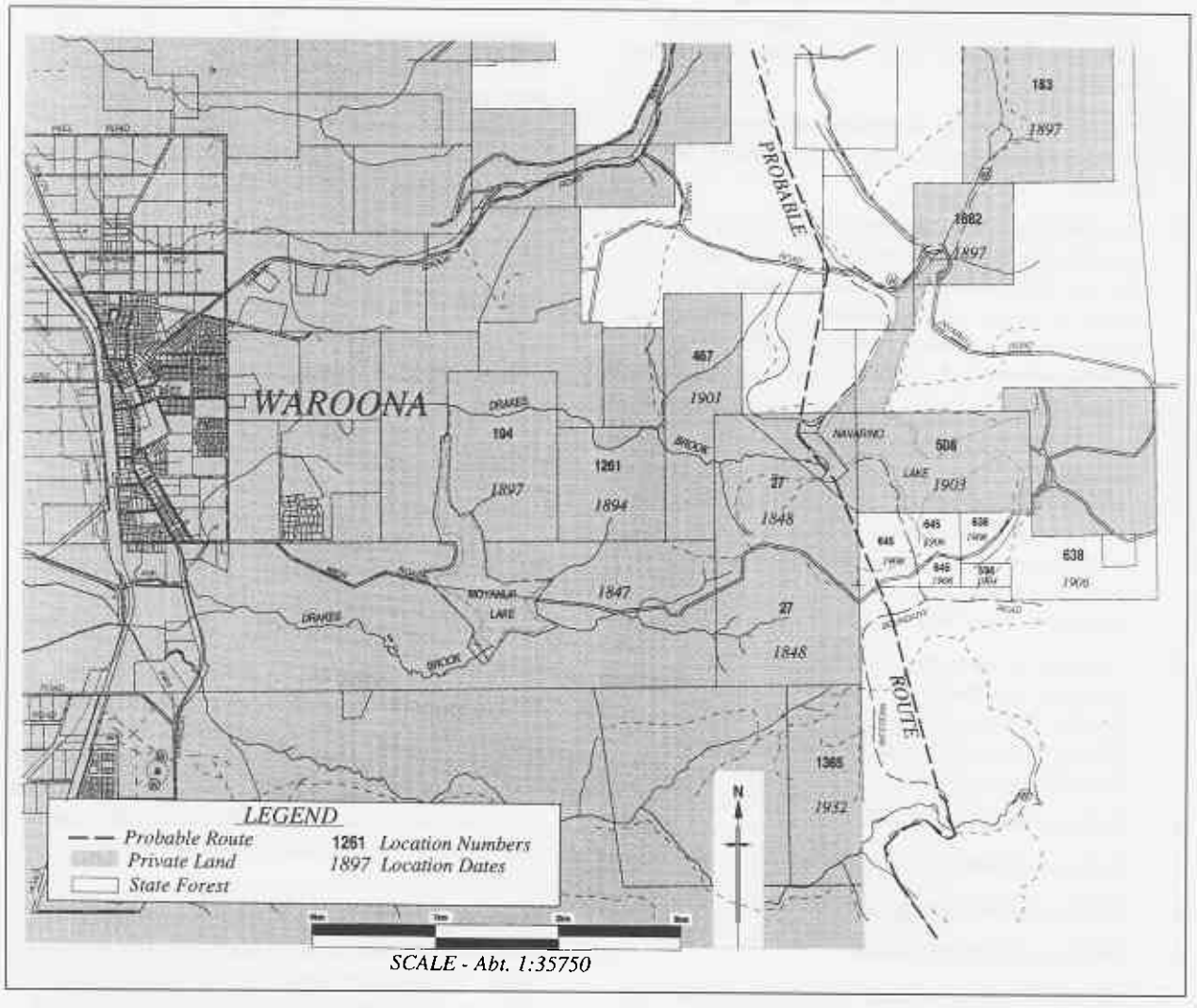

Figure 7. Enlarged portion of Figure 6, showing the probable type locality of Atrichornis clamosus *(Noisy scrub-bird) and when nearby land was taken up for agricultural development*

reduction of the geographical range of the Noisy scrub-bird. Not only does this beg the question of how widely the species was originally present in forest, it presupposes that fire in the south-west forests was managed before 1954 (when prescribed burning was introduced). Claims (*WABN* **86**, p. 16) that the type locality was searched 'around 1890' and that this species 'probably succumbed to increased frequency of fires resulting from timber extraction last century' are respectively incorrect and inconsistent with the historical facts and interpretation provided above.

The Noisy scrub-bird is in the process of being introduced into suitable long-unburned habitat in jarrah forest south of Dwellingup, in Waroona/Federal/Nanga, Driver, and Clarke forest blocks (Danks 1997). This introduction program should be progressively expanded where possible to test the hypothesized refugial distribution shown in Figure 3.

Climacteris rufa RUFOUS TREECREEPER

Rufous treecreepers occur singly or in pairs throughout the forest in jarrah, karri, tingle, yarri, bullich, wandoo and associated heath. This species occurs at a median density of 0.67 birds/ ha (range 0.1–6.7, N = 5). Birds feed from bark on branches and trunks, as well as on logs, with occasional feeding on nectar from conflorescences of *Banksia grandis* (*WABN* **72**, p. 4).

Rufous treecreepers were not recorded near Dwellingup in long unburned jarrah forest but occurred in jarrah forest subject to regular prescribed burning (lists 35–37, *contra* Storr 1991 and Johnstone 1996). A summer wildfire caused the destruction of two nesting hollows in active use (Johnstone 1996). Rufous treecreepers are unaffected by prescribed fire in karri (lists 64–67). Logging in jarrah forest appears to have minimal impact (lists 43–44, 177–178) and sometimes favours them (lists 127–128). However, clearfelling in karri forest removes their habitat. This species re-appears within 100 m of the forest/coupe edge 9 months after logging (lists 125–126), foraging over the debris on the ground. It returns to its abundance in unlogged forest by 51 years after clearfelling (list 71). This species has not been recorded in dieback affected jarrah forest (lists 57–60).

This species has become extinct in most of the Swan Coastal Plain and Wheatbelt but remains widespread in the forest. Speculation that Rufous treecreepers were declining in the 1920s in the northern jarrah forest near Bickley (Serventy 1948) remains unsubstantiated. This species is currently widespread but patchy and uncommon in the northern jarrah forest (Nichols, personal communication).

Malurus splendens SPLENDID FAIRY-WREN

Splendid fairy-wrens occur commonly (median density = 0.41 birds/ ha, range 0.13–11.7, N = 10) throughout the forest in jarrah, bullich, yarri, wandoo, and associated heath and sedgeland, but are either only vagrant in karri and tingle forests (list 10, not recorded in lists 64–71) or very rare (only 22 detections in lists 125–126, 154, 184, 244–258, 261, 263). Brown and Brown (1980) noted that this species nested only in the interface between karri forest and farmland. This species occurs in groups of up to about 4 birds and prefers dense shrubs. Hence, in much of the drier jarrah forest it is restricted to riparian habitats (e.g. lists 20, 28, 48–49, 127–129, 190) but will occur elsewhere wherever extensive thickets are present, especially in the high rainfall western sector of the northern jarrah forest (e.g. list 271).

Logging of jarrah forest causes an increase in density of the undergrowth; Splendid fairy-wrens invaded such forest 1 year after logging (lists 43–44) and 3 years later were three times as abundant as in the unlogged forest (lists 179–181). They (together with Red-winged fairy-wrens) were also recorded more often in thinned jarrah forest than untreated forest (lists 177–178). Splendid fairy-wrens were recorded 2 years after a fire to be as abundant as before the fire (lists 130–131). In karri forest this species is recorded very infrequently in mature stands relative to regrowth (lists125–126). Its abundance is reduced in dieback affected jarrah forest (lists 57–60, 123–124).

Malurus elegans RED-WINGED FAIRY-WREN

Red-winged fairy-wrens occur commonly (median density = 0.19 birds/ ha, range 0.18–1.88, N = 5) in groups of up to about 5 birds in suitable habitat in jarrah, karri, tingle, yarri and bullich forests and associated heath and sedgeland. They occur north to Stony Brook (*WABN* **78**, p. 28) and Zamia forest block (Chapman and Rowley 1978), and east to Reservoir (Serventy 1948), Ashendon, Chandler, Boonering (Buller 1954), Kennedy, Yarragil, Ross, Edward and Kingston forest blocks, the Perup and the Porongurup Range. They require dense scrub of no great height. In the karri forests this species is ubiquitous, is one of the dominant bird species of the understorey, and is not restricted to riparian habitat for breeding (Webster 1948). In jarrah forests it tends to be restricted to riparian situations (lists 11, 13, 17, 24, 28, 47, 48, 190) but will venture onto ridges if extensive thickets are present (list 53).

This species benefits from logging of southern jarrah forest (lists 43–44) and jarrah forest in the high rainfall part of the northern forest (lists 177–178, 179–181), as thickets of vegetation develop. These wrens invade clearfelled karri soon after logging (lists 125–126) and are as abundant as in unlogged forest by at least 6 years after the disturbance (lists 68–71). Recently burnt karri forest also favours this species (lists 64–67). Its abundance is reduced in dieback affected jarrah forest (lists 123–124).

The claim by Rowley *et al.* (1988) that prescribed burning 'must have severe effects on populations of *M. elegans* because our study has shown that nearly half the nest sites were in Dead Brush, the very 'fuel' that controlled burning is designed to reduce' is not supported by empirical information presented by Tingay and Tingay (1984). The reasoning of Rowley *et al.* (1988) that 'one can expect colonization of new (or recovering) areas to be slow if it occurs at all' is also not supported by data presented in Tingay and Tingay (1984). Moreover, Rowley *et al.* (1988) did not include a control in their study.

Stipiturus malachurus SOUTHERN EMU-WREN

Southern emu-wrens occur sporadically in low, dense vegetation in parts of the southern forests: in suitable heaths in the sunklands (probably 48[29] forest blocks from Dardanup block in the north, south-east to Cleave and west to Treeton and Chapman blocks [lists 25–26]; also reported by Liddelow[30], personal communication); soon (1–4 years) after logging (Dombakup forest block, list 68; Gray forest block, lists 125–126); in creek vegetation in karri forest on Tin Mines Road (Netic forest block); in *Melalueca* swamp on private property next to Alco forest block; at Granite Peak (Peak forest block); in riparian vegetation in jarrah forest, about 48 km north-west of Walpole [?Shannon forest block] (Ford 1965); in tingle, yarri and low jarrah forest east of Walpole (lists 260, 262, 269–270); near Nannup (Ford 1970); and at Chorkerup and Big Grove near Albany. This species is also recorded in dense regrowth in recently cleared forest on farmland (Harrison 1969). I saw 2 birds in such a situation on 11 March 1978 on a farm on Gold Gully Road adjacent to an isolated patch of jarrah forest (itself part of Beaton forest block).

This species approaches closely to the western edge of the northern jarrah forest at Bickley Brook and Ellis Brook (Kneebone 1952; *WABN* **38**, p. 8; **68**, p. 4; **85**, p. 3). It is very common in coastal heaths south of Busselton to Albany and beyond, where it has been recorded at densities of 0.13–0.25 birds/ ha.

Either this species occurs more widely in the southern forests but is overlooked, or it is genuinely patchy in distribution but can disperse readily as habitats become available (forming a metapopulation).

Pardalotus punctatus SPOTTED PARDALOTE

Spotted pardalotes are widespread in forest, occurring in jarrah, karri, yarri, tingle, bullich, flooded gum, wandoo and associated heath and sedgeland, and are usually recorded singly or in pairs. This species feeds in the mid- and upper canopy, though it does feed in shrubs in spring and summer (Wykes 1985). It has been recorded feeding on larvae of jarrah leafminer (Mazanec 1988). Its median density is 0.12 birds/ ha (range 0.06–5.0, N = 5).

This species appears to be a partial migrant, with most records in the northern forest coming from autumn or winter (lists 21, 22, 24, 90, 98, 109–111, 113–117, 119–120, 170, 178–180), perhaps indicating that most breeding occurs in the southern forests. Nonetheless, as these pardalotes are recorded in spring in wetter parts of the northern forest (e.g. Dwellingup area, lists 36–37, 127–129; Jarrahdale area, lists 53, 57; Bickley, Serventy 1948; Bungendore Park, list 271), some breeding presumably occurs there. During winter Spotted pardalotes are either absent from, or very rarely recorded in, karri and tingle forests relative to the other seasons (lists 64–71, 260–265); this may reflect lack of vocalization in winter by this species (Johnstone, personal communication).

In jarrah forest this species is abundant after fire relative to forest long unburned (lists 36–37) but is unaffected by fire in unlogged karri forest (lists 64–67). Spotted pardalotes re-appeared in clearfelled karri coupes 2 years after logging (list 126) but did not attain a level of abundance similar to that in unlogged karri until 51 years had elapsed (list 71). This species was unaffected by logging in jarrah forest (lists 127–128). Its abundance is reduced in dieback affected jarrah forest (lists 57–60, 123–124). Spotted pardalotes have benefited from the provision of banks of soil along railway and road cuttings in the forest, as this species makes a nesting burrow in the soil.

Pardalotus striatus STRIATED PARDALOTE

Striated pardalotes occur singly or in pairs (or occasionally in groups of up to 6) throughout the jarrah, karri, tingle, yarri, bullich and wandoo forests, and associated heath. Available estimates of density are 3.0 birds/ ha (median), ranging from 0.08 to 21.7/ ha (N = 14). In some forests this species is commoner in valleys than on ridges (lists 48–51) but not in others (lists 127–129). In karri forest it occurs at about the same abundance, or half the abundance, as the preceding species (lists 64–71, 125–126). It nests in small hollows in jarrah (lists 17, 18), marri (list 7), wandoo (lists 113–114) and karri (Christensen *et al.* 1985a) trees. It feeds mainly in the mid- and upper canopy but does feed low enough to be mistnetted occasionally (lists 130–131, 185). Striated pardalotes have been recorded as consuming large numbers of larvae of jarrah leafminer (Mazanec 1988).

The Striated pardalote vacates the southern forests and parts of the wetter forests of the north in winter (lists 22, 38–39, 64–71, 104–107, 260–270), as well as the drier north-east forests (list 21) but not the central eastern forests near Mt Saddleback (lists 110–120). Movements of this species are discussed in lists 35–37, 64–67). They appear to decrease in abundance after logging in jarrah forest (lists 43–44). Their abundance in clearfelled karri forest does not return to that in unlogged forest until 12–51 years after logging (lists 70–71). However, these pardalotes will forage in regrowth karri 2 or more years old (lists 69, 126). Although they can occur commonly in jarrah forest affected by dieback disease (lists 59–60), their abundance is usually reduced (lists 123–124).

Sericornis frontalis WHITE-BROWED SCRUBWREN

White-browed scrubwrens occur wherever there are dense thickets in jarrah, karri, tingle, yarri, bullich and wandoo forest and associated heath. This species occurs usually in pairs, at a median density of 0.28 birds/ ha (range 0.03–1.0, N = 8), in dense understorey within a few metres of the ground. In karri forest it is one of the dominant species of the understorey. In jarrah forest it tends to be restricted to densely vegetated riparian habitats, though it does occur upslope if extensive thickets are present. In the northern jarrah forest it is known to occur east to Gorrie, Kennedy, Marradong, Saddleback and Hillman forest blocks. It occurs throughout the southern forests.

[29] Extrapolated from the distribution of the *Kingia* heath vegetation complex as mapped by Mattiske and Havel (1998).

[30] G. Liddelow, Department of Conservation and Land Management, Manjimup.

Scrubwrens, being dependent on a dense shrub layer, do not re-invade burnt areas until this redevelops – 2 years in jarrah forest (list 121) and several months in karri forest (lists 64–67). This species apparently increases in abundance after logging or thinning of jarrah forest (lists 43–44, 177–178), probably reflecting the development of denser understorey with removal of part of the overstorey. It has not been recorded in dieback affected jarrah forest (lists 57–60, 123–124). When karri forest is clearfelled scrubwrens reach their maximum abundance by 3 years after logging (lists 68–71, 125–126).

Smicrornis brevirostris WEEBILL

Weebills occur most abundantly (in flocks up to 7 birds) in the more open forests of the northern and eastern sectors. They also are recorded sporadically in the western sector of the northern jarrah forest south to Hamilton and Arklow forest blocks near Collie. In the southern forest weebills have been recorded in small numbers west to 23 km north of Manjimup (*WABN* **76**, p. 4), the Perup forest (list 75) and near the Porongurup Range. They also occur in the sunklands (lists 25–26, 42, 78), Scott River and Margaret River (Hall 1974), and appear to be vagrant in Soho forest block, east of the Frankland River (list 79), and in jarrah forest east of Walpole (list 260).

The vegetation types in which weebills have been recorded comprise jarrah, yarri, flooded gum, wandoo and associated heath and *Casuarina* woodland. This species has never been recorded in karri forest. Weebills seem originally to have been confined to the extreme northern and eastern sectors of the primaeval forest and were not recorded in early lists (lists 5–13, 15–18, 22, 23, 24; the record in list 27, 'common in jarrah forest' has been withdrawn by Kimber [personal communication]). The opening up of the wetter, western jarrah forest north of Collie and south of Busselton through farming, logging, mining and dieback disease may have allowed this species to have spread westwards. Against this hypothesis, however, is the fact that it did not appear in Yarragil forest block when this was heavily logged (lists 127–129). This species was first recorded near Jarrahdale in 1981 (list 46). Weebills can occur as abundantly in dieback affected as in healthy jarrah forest (lists 57–60).

The only density estimates available come from jarrah forest near Jarrahdale (median 0.25 birds/ ha, range 0.01–0.34, N = 4).

Gerygone fusca WESTERN GERYGONE

Western gerygones are widespread in the forest, occurring in jarrah, karri, tingle, yarri, bullich, wandoo and associated heath, usually singly or in pairs. They mostly feed in the lower canopy and mid canopy by gleaning insects from foliage and snatching flying insects. Their median density is 0.33 birds/ ha (range 0.17–2.0, N = 13). In the karri, tingle, and wetter jarrah forests this species emigrates partially in autumn and almost totally in winter. In the extreme northern and eastern parts of the forest it is present all year; some of these birds may be from farther south (Johnstone, personal communication).

After fire in jarrah forest, Western gerygones avoided highly scorched crowns (Kimber 1974). This species reaches its greatest abundance in jarrah forest 2 years after typical prescribed fire in spring, and in unlogged karri forest between 6 and 11 years after burning. After clearfelling of karri forest, this species reaches its maximum abundance when the regrowth is 12 years old. Abundance then reduces by half once the regrowth is 51 years old. When jarrah forest is logged there may or may not be a decline in abundance (lists 47–44, 127–128). This species is also common in dieback-affected jarrah forest (lists 59–60). Abbott and Van Heurck (1985a) suggested that the Western gerygone may be disadvantaged by thinning of jarrah forest.

Acanthiza apicalis BROAD-TAILED THORNBILL

Broad-tailed thornbills occur throughout the forest, in jarrah, karri, tingle, bullich, yarri, wandoo and associated heath and are abundant (median = 0.58 birds/ ha, range = 0.17–6.7, N = 16). In the jarrah forest this species forages mainly in the understorey, and in the karri forest it is one of the dominant bird species in the shrub layer. It usually occurs singly, in pairs, or in small flocks. This species has been recorded eating larvae of jarrah leafminer (Mazanec 1988).

These thornbills are either unaffected by logging of jarrah forest (lists 127–128, 179, 181) or apparently increase in numbers after one year (lists 43–44). Thinning of jarrah forest did not impact on the abundance of this species (lists 177–178). In karri forest that is clearfelled, they are only temporarily displaced and become very plentiful by 6 years after logging (lists 68–71, 125–126). Thornbills (Broad-tailed and Western species combined) also become common 1–2 years after burning in jarrah and karri forests (lists 35–37, 64–67, 121). Kimber (1974) noted that the Broad-tailed thornbill foraged in a higher stratum of vegetation after its more usual foraging zone was burned. This species is less abundant in dieback affected than healthy jarrah forest (lists 57–60, 123–124).

Acanthiza inornata WESTERN THORNBILL

Western thornbills are found in jarrah, yarri, bullich, wandoo and associated heath, and sedgeland throughout the forest. Median density is 1.3 birds/ ha (range 0.14–21.7, N = 16). They are vagrant in karri and tingle forests (not recorded in lists 64–72 and 244–258; 7 detections in summer 1986 and 1987 in lists 125–126; 8 detections of 12 birds mostly in summer and autumn in lists 261, 263–264). This species feeds in shrubs and the lower understorey and has been recorded eating larvae of jarrah leafminer (Mazanec 1988). This species increases in abundance after fire (lists 121, 131) and after logging (lists 43–44, 179, 181) and can be common in dieback-affected jarrah forest (lists 59–60). It appears to decrease marginally in abundance in thinned jarrah forest (lists 177–178).

Acanthiza chrysorrhoa YELLOW-RUMPED THORNBILL

Yellow-rumped thornbills were probably restricted in the primaeval forest to the extreme northern and eastern

sectors, with possible limited occurrence on monadnocks in the western sector. With opening up of parts of the forest through farming, logging, spread of dieback and mining, this species appears to have spread rapidly from nearby non-forest habitat such as coastal heath (lists 7, 16) and woodland (Swan Coastal Plain, western portion of the wheatbelt). For example, Whittell (1933a) remarked that this species is the 'commonest small bird of the district'. It usually occurs in small groups and forages on the ground, in bushes, and in trees; feeding on larvae of jarrah leafminer has been recorded (Mazanec 1988). Yellow-rumped thornbills have a median density of 0.28 birds/ ha (range 0.17–7.25, N = 4).

In the wetter western sector of the northern jarrah forest this species has been recorded from Bungendore Park, Stinton Cascade Nature Reserve, and Gordon, Mundlimup, Chandler, Urbrae, Marrinup, Keats, Federal and Waroona forest blocks. However, all of these areas have extensive farmland and/or dams nearby, providing the ecotone preferred by this species, as well as presumably being the source of birds recorded in the forest (Matthiessen 1973). Brown and Brown (1976-91) recorded nesting by this species only at the interface between karri forest and farmland.

Little is known about the response of this species to fire and logging. A group of 4 birds moved into jarrah forest 6 years after it was logged (lists 43–44) and 3 birds were recorded in a logged gap in jarrah forest but not elsewhere (lists 179–181). On the other hand the species was not recorded after a heavy logging in jarrah forest (lists 127–129). Yellow-rumped thornbills were recorded (10 birds) within 1 year of clearfelling of karri forest but not in older regrowth (lists 68–71), whereas in another karri forest this species did not appear after clearfelling (lists 125–126). These different responses may relate to the presence or absence of nearby source populations.

Lichmera indistincta BROWN HONEYEATER

Brown honeyeaters in the primaeval forest appear to have been restricted as a breeding species to the extreme northern and eastern sector, in jarrah, wandoo and associated heath (*cf.* lists 19, 38–39, 109–120, 182). This species is vagrant in karri forest (lists 66, 125–126, 184, 244–258, 263), when karri is flowering (Serventy and Whittell 1976) but only in small numbers. In the southern forests it is only recorded in *Banksia* woodlands and where the forest has been cleared for farming or for settlement in towns (Serventy and Whittell 1976; Christensen *et al.* 1985a); otherwise it is vagrant (lists 41, 183, 260).

In the western sector of the northern jarrah forest Brown honeyeaters have been recorded in jarrah, yarri and bullich forest in a number of forest blocks, namely Churchman, Gordon, Chandler, Ashendon, Mundlimup, Myara, Clinton, White, Urbrae, Marrinup, Waroona, Yarragil, Samson and Federal (though not always consistently present – the species was not recorded in lists 46–52, 122–124, 156, 158, 160, 162–164, 177–181, 188). In Ashendon forest block it was recorded only from November 1979 to January 1980, and in April, October and November 1980 (list 53). In list 189 it was specifically noted that it was recorded only in December in Edward forest block adjacent to an isolated farm. None of the above records suggest that this species is a permanent resident in these areas.

Brown honeyeaters tend to forage in the upper understorey-lower canopy, taking nectar from *Banksia grandis, Dryandra sessilis, Xanthorrhoea preissii, Nuytsia floribunda, Melaleuca rhaphiophylla*, jarrah, wandoo, karri, flooded gum, and marri. Brown *et al.* (1997) also record feeding at flowers of *Adenanthos barbigera* and *Anigozanthus manglesii*. They usually occur in small groups (up to 10, occasionally 20). Median density is 0.42 birds/ ha (range 0.03–0.8, N = 4). This species appears to benefit from low intensity fire (lists 35–37) and from partial clearance of forest for farming.

Meliphaga ornata

YELLOW-PLUMED HONEYEATER

Yellow-plumed honeyeaters in the primaeval forest were restricted to the very extreme northern and eastern sectors, where the jarrah and wandoo forest is less tall and more open. This species has been frequently recorded at Julimar (lists 38–39, *WABN* **43**, p. 8), Gorrie forest block (list 182, nesting) and in the Perup (*WABN* **26**, p. 4); elsewhere it is vagrant: near Bailup (list 21); Karakamia Sanctuary (list 259); Kalamunda National Park (*WABN* **47**, p. 2); Lesmurdie (*WABN* **63**, p. 9); Yarra Road (*WABN* **58**, p. 10); West Talbot Road (*WABN* **83**, p. 21); Dobaderry Nature Reserve (*WABN* **23**, p. 2); Mandalup on the Blackwood River between Bridgetown and Boyup Brook (Serventy and Whittell 1976; *WABN* **64**, p. 10); Kingston area (27.5 and 30 km north-east of Manjimup, *WABN* **78**, p. 4); near Diamond forest block (list 41); and Shannon National Park (*WABN*, **54**, p. 3). Even in the northern and eastern forests it seems to be patchily distributed – e.g. it was not recorded in jarrah forest at or near Mt Saddleback (lists 61, 92–96, 101–103, 109–120, 185) or in John Forrest National Park (lists 169–176). According to Serventy (1977), this species has penetrated the forest as a result of extensive clearing for settlement.

Melithreptus chloropsis

WESTERN WHITE-NAPED HONEYEATER

Western white-naped honeyeaters occur singly or in pairs throughout the forest, in jarrah, karri, tingle, yarri, bullich, wandoo and associated heath. Early this century ornithologists remarked on this species' great abundance (lists 8, 11, 14, 17; Serventy 1948), which is still the case (e.g. in karri forest it was the second most abundant species of honeyeater, lists 64–71, 125–126). It occurs at a median density of 0.5 birds/ ha (range = 0.06–11.7, N = 10). Although these honeyeaters feed mainly among foliage and bark of the upper and mid-canopy of the forest, they are readily mistnetted (Wardell-Johnson 1985). They also feed on nectar from *Banksia grandis* (personal observation), marri (list 184), wandoo (list 271), jarrah (list 271), *Anigozanthus viridis (?= flavidus)* (Sedgwick 1969), *Chorilaena quercifolia* and karri (Brown *et al.* 1997). Larvae of jarrah leafminer are also eaten (Mazanec 1988).

This species increased in abundance immediately after a fire in jarrah forest in spring (list 35), and occurred at similar abundance to that in long-unburned forest. In unlogged karri forest it occurred in recently burned forest at similar abundance to forest not burned for 11 years (lists 64–67). Abbott and Van Heurck (1985a) speculated that this species may have been impacted by the removal of large jarrah trees. Logging in jarrah forest appears to reduce the abundance of these honeyeaters (lists 43–44, 127–129, 179–181). They reappear less than 1 year after clearfelling of karri (list 126) and steadily increase in numbers as the regrowth becomes taller, and become as abundant as in unlogged karri forest by 51 years after clearfelling (lists 69–71). They occur less abundantly in dieback affected than healthy jarrah forest (lists 57–60, 123–124).

Western white-naped honeyeaters do not appear to be very nomadic, but there is some local dispersal. For example, in karri and tingle forests this species is more often recorded in spring and autumn than in winter or summer (lists 64–67, 260–270). In jarrah forest north-west of Collie it was not recorded in winter (lists 104–107) whereas in the same forest type at Mt Saddleback it seemed most abundant in autumn and winter (lists 115–120).

Phylidonyris novaehollandiae

NEW HOLLAND HONEYEATER

New Holland honeyeaters occur (in small parties of up to *c.* 6 birds) throughout forest wherever there is suitable habitat: thickets. This species has been recorded in jarrah, karri, tingle, bullich, yarri and wandoo forests and associated heath and sedgeland. In the northern jarrah forest it tends to be restricted to riparian habitats (e.g. lists 22, 28, 86, 88, 129) but will occur on uplands if extensive thickets are present; otherwise it is vagrant in upland forests.

It is the most abundant species of honeyeater in karri forest (lists 64–71, 125–126) and is one of the most abundant species in karri and tingle forests, where as well as feeding in the shrub layer it forages in the canopy. In the southern jarrah forests it is uncommon where thickets are sparse or absent (list 183). This species occurs also in remnant forests on farms, and in gardens on farms and in towns (e.g. Manjimup) within the forest. Available density estimates are 1.25 birds/ ha (median, ranging from 0.18–5.75, N = 5).

New Holland honeyeaters appear to increase in numbers 3 years after prescribed burning in spring in jarrah forest (lists 130–131). In unlogged karri forest they re-appear soon after fire and attain their peak abundance by 6 years after fire (lists 64–67). This species does not appear to be affected by logging of jarrah forest (lists 43–44), whereas in karri forest it does not fully recover until *c.* 50 years after clearfelling (even though it is present within 12 months of clearfelling and is resident 6 years after logging, lists 68–72).

This species has been recorded feeding on insects, nectar from *Adenanthos barbigera, Anigozanthus flavidus, A. manglesii, A. viridis (?= flavidus), Calothamnus rupestris, Chorilaena quercifolia, Dryandra formosa, D. sessilis, Banksia grandis, B. littoralis, Grevillea wilsonii, Paraserianthes lophantha,* bullich, marri, yarri, jarrah, yate, and sap from *Agonis linearifolia* (list 61, Sedgwick 1969; Rooke 1979; Christensen *et al.* 1985a; Brown *et al.* 1997). New Holland honeyeaters become particularly numerous when karri and marri flower profusely, as in November 1988 and February 1989 (lists 125–126).

Phylidonyris nigra

WHITE-CHEEKED HONEYEATER

White-cheeked honeyeaters in the primaeval forest were probably distributed in the extreme north and east, occurring singly or in pairs in heath associated with jarrah and wandoo forest (e.g. *WABN* **56**, p. 10; **72**, p. 11; **61**, pp. 111–112; Biddiscombe 1985). Clearing of forests for farmland and bauxite mining has evidently permitted this species to penetrate suitable heath and riparian habitats in the western sector (Gorrie, Gordon, Serpentine, Waroona and Ross forest blocks; also near Mumballup [Keighery 1996]) and southern forest (Diamond forest block) adjacent to farmland. Two birds were recorded in karri forest in autumn 1986 (list 263) – the only record from karri forest. This species is common on the Swan Coastal Plain and south coast. In the forest it has been recorded feeding on nectar of *Dryandra sessilis,* as well as *Astroloma drummondii* and *Chorilaena quercifolia* (Brown *et al.* 1997).

Phylidonyris melanops

TAWNY-CROWNED HONEYEATER

Tawny-crowned honeyeaters were doubtless confined in the primaeval forest to the extreme northern and eastern sectors, in jarrah and wandoo and associated heath (lists 38, 93, 102–103, 110–111, 182; *WABN* **23**, p. 2; **43**, p. 8; **46**, p. 11; **58**, p. 10), and to the Kingia suite of soils (heath) occurring uniquely in the sunklands (lists 25–26, Liddelow [personal communication], probably in 48 forest blocks, from Dardanup in the north to Cleave in the south-east and Treeton and Chapman blocks in the west). Elsewhere in the forest this species is vagrant: it was recorded near Willowdale (list 47); 1 bird was detected in karri regrowth 2 years after clearfelling (list 126); 4 birds were netted 2 months after fire in jarrah forest (list 131); there was an irruption into karri forest/partly cleared farmland near Diamond forest block in autumn 1945 following flowering of marri and karri (Webster 1947); an influx in autumn 1954 near Wooroloo during flowering of marri (Carnaby 1954b); and 1–4 birds were recorded regularly in autumn and occasionally in winter in jarrah forest east of Walpole (list 260). This species has been recorded occurring at densities of 0.67 and 0.69 birds/ ha (list 167).

The Tawny-crowned honeyeater occurs commonly in coastal habitats south and west of the forest (lists 5, 7, 10, 11), sometimes approaching the forest very closely, as on the Darling Scarp near Lesmurdie (*WABN* **63**, p. 9) and Gooseberry Hill (*WA Bird Report* 1982, p. 32).

Acanthorhynchus superciliosus WESTERN SPINEBILL
Western spinebills are ubiquitous (singly, pairs or in groups up to 4) in the forest and occur in jarrah, karri, tingle, yarri, bullich, wandoo and associated heath and sedgeland. Spinebills occur at a median density of 0.65 birds/ ha (range 0.21–8.4, N = 14). They are rarest in the karri forest (lists 241–258), where they were not recorded at all in winter, only occasionally in spring and summer (lists 125–126), and most consistently in autumn (lists 64–70). This species feeds at all levels in the forest, mainly on nectar from jarrah, marri, *Banksia grandis*, *Adenanthos barbigera*, *Dryandra* spp., *Petrophile* sp., *Grevillea wilsonii*, *Anigozanthus* spp., *Paraserianthes lophantha*, *Kunzea recurva*, *Melaleuca densa*, *Xanthorrhoea preissii* and *Calothamnus* sp. Brown *et al.* (1997) also record feeding on flowers of *Astroloma ciliatum*, *Chorilaena quercifolia* and *Darwinia citriodora*.

Spinebills in jarrah forest respond variably to low to moderate intensity fire but are scarce in long unburnt forest (list 37). They also show variable responses to logging, being unaffected (lists 127–128), recovering within 3 years (lists 43–44, 125–126), or favouring logged gaps over unlogged forest (lists 179–181). They recolonize karri regrowth soon after clearfelling and are as abundant as in mature forest by 2 years (lists 125–126). This species also occurs in jarrah forest affected by dieback disease (list 60), farm gardens and towns situated in the forest (e.g. Manjimup), and rehabilitated bauxite minesites (Kabay and Nichols 1980). Abbott and Van Heurck (1985a) suggested that this species may be disadvantaged by a program of removing the understorey tree *Banksia grandis*; this program (CALM 1992a, p. 126) has not been implemented.

Anthochaera chrysoptera LITTLE WATTLEBIRD
Little wattlebirds occur throughout the forest (in groups of up to 17 birds) in jarrah, bullich, yarri, karri, tingle, wandoo and associated heath, woodland and sedgeland. They tend to occur in the upper storey and have been recorded feeding at flowers of karri, marri, *Banksia grandis* and *Dryandra sessilis*. Consequently, this species is a blossom nomad and may not be found in the same area all year (e.g. lists 21, 53, 61, 64–71, 110–111, 115–120). In the jarrah forest Little wattlebirds tend to occur mostly in riparian areas, heath, and forest affected by dieback disease. The only available estimate of density is 0.17 birds/ ha (list 60). Abbott and Van Heurck (1985a) suggested that this species may be disadvantaged by a program of removing the understorey tree *Banksia grandis*; this program (CALM 1992a, p. 126) was not implemented.

There have been no studies of the impact of fire on this species in jarrah forest. However, in unlogged karri forest Little wattlebirds are most abundant 3 years after fire (lists 64–71). Logging is unlikely to impact on this species in jarrah forest, given its preference for non-commercial forest. In karri forest, clearfelling removes its habitat and the species is recorded in small numbers up to 6 years later (lists 69, 125–126), mostly in autumn. This species appears to take several decades to recover fully after clearfelling. It has been recorded in dieback affected jarrah forest (list 60).

Anthochaera carunculata RED WATTLEBIRD
Red wattlebirds in the primaeval forest probably occurred as a breeding species only in the southern forests (jarrah, yarri, karri, tingle) and associated heaths and sedgelands. Evidently this species occurred patchily there, as Jackson (list 10) did not record it. By the 1980s the incidence of this species in forest east of Walpole was about six times that of the preceding species (lists 260–270). In one study of karri forest it was twice as abundant as the preceding species (lists 64–71), whereas in another karri forest the Little wattlebird was five times as abundant as this species (lists 125–126). This species tends to follow the flowering eucalypts, banksias and dryandras, and may occur in groups of up to 19 birds in red tingle forest.

Median density is 1.8 birds/ ha (range 0.33–3.33, N = 4). In the northern forests this species is reported as a visitor (e.g. lists 53 [November and December 1979, 1980 and 1981], 113 and 116 [autumn visitor mainly]), vagrant (lists 61, 127, 178, 179–180, 188) or more generally associated with partial clearing of forest as on farms and in towns (Christensen *et al.* 1985a; lists 22, 168, 182; *cf.* Anon. 1902).

Red wattlebirds feed mostly in the upper storey of the forest and have been noted feeding upon larvae of jarrah leafminer (Mazanec 1988). Logging appears to reduce their numbers for about 4 years (lists 43–44) in jarrah forest and for about 50 years in karri forest. Burning in forests appears to favour flowering of the species preferred by Red wattlebirds: in unlogged and recently burnt karri forest this species appears to be mainly an autumn visitor, feeding on marri flowers (list 64), whereas 3 years after fire Red wattlebirds are recorded in large numbers in all seasons (lists 65–67).

Petroica multicolor SCARLET ROBIN
Scarlet robins were described by early observers as fairly numerous in forest country (list 7), plentiful in the south-west (list 8), and common throughout the whole of the south-west, being most abundant in forests (list 11). All of these impressions remain true. This species occurs in jarrah, yarri, bullich, wandoo and associated heath, karri and tingle. In unlogged karri forest it is absent or scarce, but becomes temporarily common immediately after fire (lists 64–66). It is common in autumn and winter after clearfelling, becoming scarce again once areas of bare ground become overgrown by the regenerating forest (lists 68–71, 125–126; Christensen *et al.* 1985a). In jarrah forest it moves into recently burned areas (Christensen *et al.* 1985a, lists 121, 131) and areas severely affected by dieback disease (list 59). Scarlet robins also occur on farms and in towns within the forest.

This species is usually recorded singly or in pairs at any time of the year. Available density estimates range from 0.07 to 0.34 birds/ ha (all from jarrah forest), with a median of 0.22 birds/ ha (N = 6). Scarlet robins feed mainly on the ground and then return to a perch. In summer and autumn they forage also on bark and foliage of trees (Wykes 1985).

Petroica cucullata HOODED ROBIN

In the primaeval forests, Hooded robins would have been restricted to the extreme northern and eastern sectors – where the jarrah forest becomes less tall and more open and wandoo forest appears. Records are, however, sparse: Avon Valley National Park (*WABN* **46**, p. 11; **64**, p. 9); Gorrie forest block (list 182, breeding); Wooroloo (list 21, breeding); West Talbot Rd (*WABN* **83**, p. 21); Yarra Rd (*WABN* **58**, p. 10); east of Bridgetown (list 17); Perup area (list 31); and Narrikup (Storr 1991). More notable perhaps are its abs ces – it has not been recorded at Marradong forest block, Mt Saddleback or Hillman forest block. Equally interesting are records from near King George Sound (Gilbert [list 1] provides an aboriginal name for the species, probably from Kojonup), Whicher Range (list 42, perhaps a misidentified female White-winged Triller), and Wilgarup (Brown and Brown 1976–1991). Dr Per Christensen (personal communication) has advised me that he has never seen this species in 30 years of working in the southern forests.

Eopsaltria australis YELLOW ROBIN

Yellow robins were listed by earlier ornithologists as common in forest, particularly more open forests. This species has been recorded in jarrah, wandoo, powderbark and associated heath. It was either not, or only rarely, recorded in karri and tingle forest (lists 64–71, 125–126, 244–258, 264, 270) or in yarri or bullich forest (lists 86, 88, 98, 106, 107, 129). These robins usually occur singly or in pairs at a median density of 0.34 birds/ ha (range 0.16–3.4 birds/ ha, N = 7).

This species is recorded more often 1–2 years after fire (lists 35–37, 121, 130–131) and in thinned forest (lists 177–178). It was not recorded in forest affected by dieback (lists 59, 60, 124). The remark by Blakers *et al.* (1984) that the 'decline of winter visitors near Perth has been attributed to a decline in the quality of the forest on the adjacent Darling Scarp' is ill-founded. Yellow robins are widespread in the northern jarrah forest.

This species shows geographical variation in the coloration of the rump, being greenish-yellow over much of the forest and more green east of Boyup Brook–Denmark (Ford 1963).

Eopsaltria georgiana WHITE-BREASTED ROBIN

White-breasted robins are most widespread and common in the southern forests (jarrah, yarri, karri, tingle), wherever the understorey consists of dense thickets. This species is ubiquitous in karri forest where it is one of the dominant bird species of the understorey and is most abundant up to about 5 years after fire (lists 64–67). It also benefits from clearfelling, reaching its greatest abundance up to 6–12 years after logging (lists 69–71, 125–126). The ensuing dense regeneration provides its most preferred habitat.

In jarrah forest towards the eastern sector of the southern forest and in the northern forest, white-breasted robins are confined to dense riverside thickets, irrespective of whether the overstorey is yarri, bullich or wandoo. In the northern jarrah forest this species occurs as far north (and west) as Kalamunda National Park, Bickley Brook, Stony Brook and Wungong Brook, not having been recorded farther north, as at Avon Valley National Park, John Forrest National Park or Mundaring Weir (*WABN* **76**, p. 3). Its eastern recorded limits there are Illawarra, Canning, Ashendon, Chandler, Cobiac, Balmoral, Cameron, Yarragil, Keats and Ross forest blocks (see also Notley 1951; Bamford 1989).

The median density of this species is 0.13 birds/ ha (range 0.01–0.13, N = 3). The White-breasted robin is capable of dispersing far in a short period e.g. 13 km in 11 months (Baker *et al.* 1995). This species will nest in pine plantations (Christensen *et al.* 1981).

Pomatostomus superciliosus WHITE-BROWED BABBLER

White-browed babblers occur (in groups of 6–12 birds) in the southern forest (karri forest with *Acacia pentadenia* understorey, tingle forest, and jarrah forest over dense *Agonis parviceps* heath) west to Iffley forest block, north to Gordon, Diamond, Lane Poole and Shannon forest blocks, and east to Denmark. Although Ford (1971) thought that this population was connected to that in wandoo woodland to the north-east, it is isolated from the main range of this species by about 70 km. This species is not affected by fire in karri forest (lists 64–71) but is scarce in regrowth forest even as old as 51 years (lists 71, 125–126).

There is an old (extra-limital) record from near Busselton (list 11) as well as a record from *Kingia* dominated heath in the sunklands (list 26, at Lawson Road in McCorkhill forest block), some 40 km north-west of the nearest record in the karri forest. Liddelow (personal communication) has reported observing this species in the sunklands. It should be expected to occur patchily in 47 other forest blocks (see Mattiske and Havel 1998 for maps showing the distribution of the Kingia vegetation complex). Whether this population connects with that in the karri forest is not known.

The karri forest population of the White-browed babbler was only discovered in 1899. This indicates that Gilbert did not collect very far west of Albany.

Daphoenositta chrysoptera VARIED SITTELLA

Varied sittellas are widespread in the forest, having been recorded in jarrah, yarri (rarely), tingle, wandoo and associated heath. They are recorded in small flocks of 2–10 birds, usually feeding on bark in the midstorey. They occur at a median density of 0.83 birds/ ha (range 0.09–1.5, N = 7). This species is absent from karri forest (lists 64–71, 125–126, 244–258). Sittellas appear to be unaffected by logging (lists 43–44, 177–178) except where gaps are formed (lists 179–181). They are unlikely to be affected by low intensity prescribed fires in spring because they glean invertebrates from bark on branches and the upper trunk of trees. Although this species has been recorded in dieback-affected jarrah forest (list 60), it is more abundant in healthy forest (lists 58, 123).

Falcunculus frontatus CRESTED SHRIKE-TIT

Crested shrike-tits are widespread in the southern forests (jarrah, karri, tingle, flat-topped yate, flooded gum) but are

apparently uncommon (given that competent ornithologists such as Hall, Shortridge, Carter, White and Ashby failed to record the species in forest; perhaps it is just overlooked because it has a soft song and is unobtrusive). This species is usually recorded singly or in pairs. In the northern jarrah forest this species is found only at the northern and eastern extremes in wandoo forests (Julimar *WABN* **32**, p. 9; **36**, p. 8; **43**, p. 8; Yarrah Road **64**, p. 3; Gorrie forest block [list 182]; near Christmas Tree Well, **75**, p. 2; near Mt Saddleback **20**, p. 1; near Hillman forest block **72**, p. 2).

Both Serventy and Whittell (1976) and Storr (1991) provide an incorrect impression of this species' geographical range. The former regarded records at Wanneroo (1907) and Karridale (1889, 1961[31]) as vagrants and emphasized this species' occurrence along the south coast as a penetration from the west. Serventy, Whittell and Storr also overlooked its occurrence in the southern forests. The early account of Jackson (list 10) indicates that this species was widespread in the karri forests traversed by him around Bow River. The south coast 'corridor' should be more correctly viewed as a southern extension of the southern forest distribution (Christensen *et al.* 1985a, list 32). Shrike-tits have never been recorded immediately east of Torbay (as at Albany or Two Peoples Bay), but do occur at the Pallinup River and Fitzgerald River National Park. As this species is unknown in the sunklands, it appears that the population between Capes Naturaliste and Leeuwin is the southern extension of that on the Swan Coastal Plain.

This species was until the 1930s a resident of the Swan Coastal Plain (Whitlock 1939) and also ranged east of the forest into what is now the wheatbelt, extending south to the Porongurup Range (list 184). In order to dispel the above confusion I have provided a map depicting all records (Fig. 8).

In unlogged karri forest this species is most abundant 6–11 years after fire (lists 64–67). It is recorded only occasionally in older regrowth karri forest (Christensen 1972; list 71), as well as in 4-year-old regrowth (lists 125–126), which is not consistent with the suggestion (Serventy 1977; Christensen *et al.* 1985a, p. 45) that this species has extended its range from lighter timber country to heavier forested areas following clearing for farms and opening of forest after logging. This species will also use and nest in trees planted on farmland near forest (Brown and Brown 1976–91 and personal communication). This flexibility does not appear to support the suggestion that fragmentation of forest hinders redevelopment of the bark fauna (Garnett 1992a, p. 165). Shrike-tits feed on insects under loose bark from close to the ground to the highest branches and can be mist-netted (Wardell-Johnson 1985).

Pachycephala pectoralis GOLDEN WHISTLER

Golden whistlers occur commonly (usually singly or in pairs) throughout the forest in jarrah, karri, tingle, yarri, bullich, wandoo and associated heath. They occur at a median density of 0.32 birds/ ha (range 0.16–1.7, N = 8). In jarrah forest they tend to occur mainly in the mid-storey to lower canopy, whereas in karri they predominate in the understorey. Studies of fire-effects on this species are contradictory: Kimber (lists 35–37) found that Golden whistlers were more common by 2 years after fire and remained scarce in long unburned jarrah forest; Christensen *et al.* (list 121) and Wooller and Calver (lists 130–131) found a decline after burning. In unlogged karri forest this species was as abundant in spring after fire as before the fire (lists 64–67).

Logging of jarrah forest apparently resulted in either decreased numbers of Golden Whistlers (lists 43–44, 177–178, 179–181) or no change (lists 127–128). After clearfelling of karri forest numbers had either returned to levels comparable with unlogged forest by 6 years (lists 68–71) or remained lower than in uncut karri forest (lists 125–126). This species has not been recorded in dieback affected jarrah forest (lists 57–60, 123–124).

Pachycephala rufiventris RUFOUS WHISTLER

Rufous whistlers are likely to have been restricted in the primaeval forest to the extreme northern and eastern jarrah forest and wandoo forest. Christensen *et al.* (1985a) did not record this species from the denser southern forests, only from the Blackwood Valley, Perup, Boranup and Hay River forests. In Wardell-Johnson's comprehensive study in forest east of Walpole, it was only recorded once (one bird), in karri forest in spring 1987 (list 263). Similarly, in the Kingston forests it was recorded only 4 times (list 183). With clearing for farms and spread of dieback disease, even the denser northern jarrah forests between Churchman and Samson forest blocks have become partially suitable for this species. Rufous whistlers occur at a median density of 0.13 birds/ ha (range 0.1–0.5, N = 3). This species does not appear to have been a migrant in its limited range in the primal forests (*cf.* lists 38–39).

Colluricincla harmonica GREY SHRIKE-THRUSH

Grey shrike-thrushes are generally distributed and common throughout the forests. Median density is 0.17 birds/ ha (range 0.03–5.0, N = 9). They are usually recorded in ones or twos in jarrah, karri, tingle, yarri, bullich, wandoo and associated heath, feeding in the lower canopy and mid-storey of the forest. This species recovers quickly after fire (within 1–3 years) in jarrah and karri forests (lists 35–37, 64–67), but takes longer to recover after logging (lists 43–44, 69–71, 125–126), perhaps several decades. This species has not been recorded in dieback affected jarrah forest (lists 57–60, 123–124).

Myiagra inquieta RESTLESS FLYCATCHER

Restless flycatchers occur singly or in pairs (or occasionally up to 6 birds) mainly in karri and tingle forest, in flooded gums along rivers, and in open jarrah forest and wandoo forest in the extreme northern and eastern sectors of the forest. This species seems to be a vagrant elsewhere: bullich/yarri/jarrah in Myara forest block (list 61); jarrah forest near Logue Brook Dam (list 24) and in and near Kingston block (list 183); karri forest in the

[31] The actual record was made by G. F. Mees (personal communication) in November 1960 and was of one pair in karri forest.

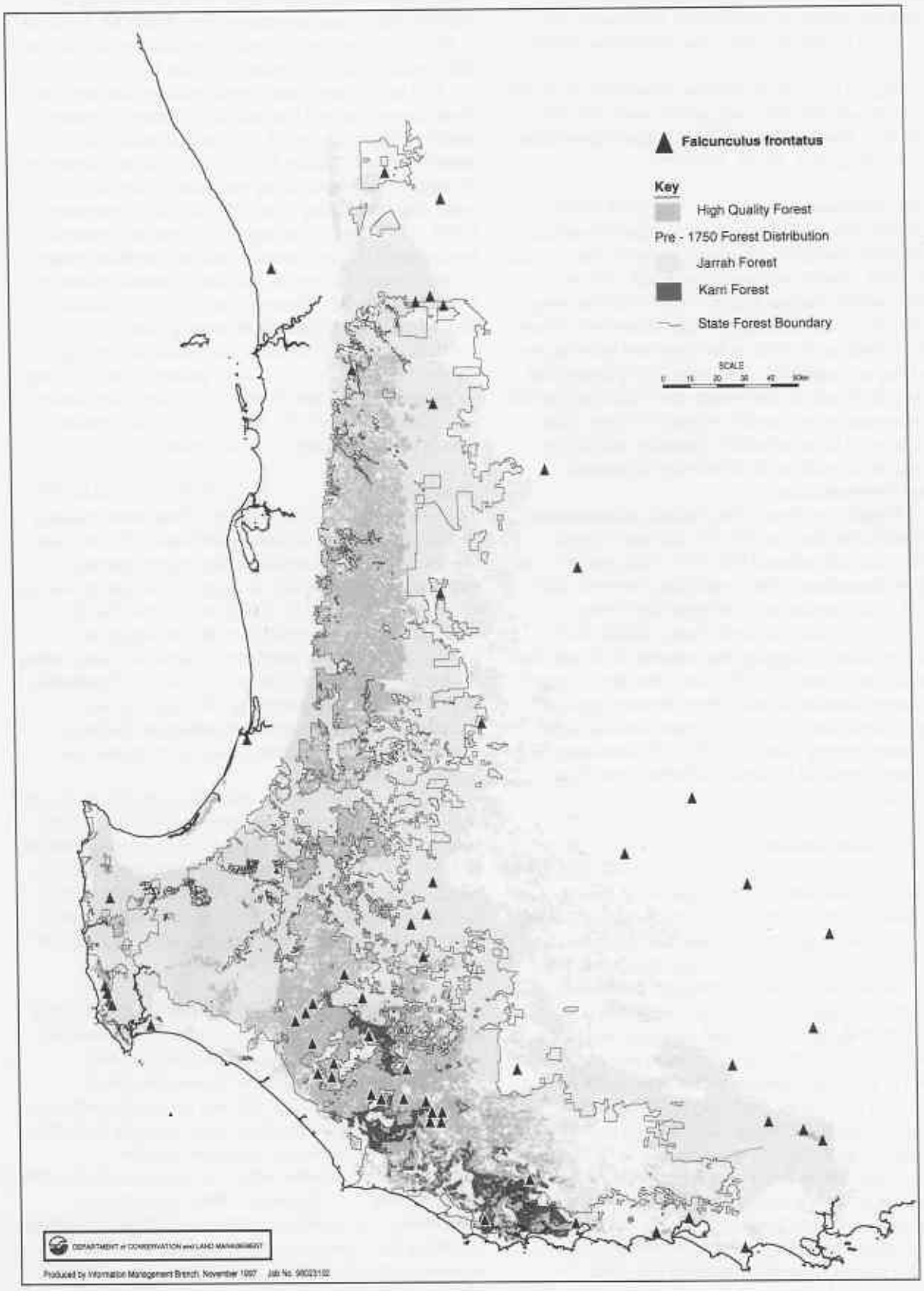

Figure 8. Distribution of Falcunculus frontatus *(Crested shrike-tit) in the forest and surrounding areas.*

Porongurup Range (list 184); in flat-topped yate woodland around Byenup Lagoon (*WABN* **26**, p. 4); and at Wilgarup (*WABN* **82**, p. 16). Masters and Milhinch (lists 38–39) noted that this species is seldom seen, is nomadic, and is usually in one locality for only a few days before moving on.

In unlogged karri forest, Restless flycatchers are mostly recorded immediately after, and up to 6 years after, fire (lists 64–67). This species is vagrant in karri regenerating after clearfelling (lists 68–71, 125–126).

Rhipidura fuliginosa GREY FANTAIL

Grey fantails occur usually singly or in pairs (occasionally up to 18 birds) throughout the forest, in jarrah, karri, tingle, bullich, yarri, wandoo and associated heath. It is an abundant species (median density = 0.84 birds/ ha, range 0.03–10.0, N = 15), particularly in the understorey of karri forests. It feeds in all strata in the forest and takes its prey by hawking and snatching. It is probably the tamest bird species in the forest. In the wettest and coldest parts of the forest it appears to be a partial emigrant in winter (lists 64–71), moving to the wheatbelt (Saunders and Ingram 1995) and as far north as the Kimberley (Johnstone, personal communication).

In unlogged karri forest, Grey fantails are commonest immediately after fire (lists 64–67), whereas in jarrah forest they are little affected (list 121). This species is infrequent immediately after clearfelling; however, after 6 years it is as abundant as in unlogged karri forest (lists 68–71, 125–126). In jarrah forest, fantails have variable responses to logging: less common in thinned than unthinned forest (lists 177–178); least abundant in logged gaps (though abundant in the ecotone between gaps and unlogged forest, lists 179–181); or more abundant after more intense logging (lists 127–128). The abundance of this species is reduced in dieback affected jarrah forest (lists 57–60, 123–124).

Coracina novaehollandiae

BLACK-FACED CUCKOO-SHRIKE

Black-faced cuckoo-shrikes are ubiquitous in forests, having been recorded from jarrah, karri (including recently clearfelled areas), tingle, bullich, wandoo and associated heath. This species is usually recorded singly or in pairs. Density has been estimated as 0.09 birds/ ha (median, range 0.06–0.17 birds/ ha, N = 4) in forest and 0.33 birds/ ha (0.25–0.38, N = 3) in low woodland and heath. It is a partial migrant in the southern forests, being mostly observed in spring and autumn, and near the north-east margin of the forest large flocks (up to 30) have been recorded in autumn. This species is recorded in jarrah forest affected by dieback disease (list 60) and wherever trees have been left on farms or in towns within the forest. Nonetheless, it remains less common in regrowth karri forest than in unlogged forest (lists 64–71, 125–126). Although normally feeding in the upper foliage of the forest, this species is readily mistnetted (list 154).

Artamus cyanopterus DUSKY WOODSWALLOW

Dusky woodswallows in the primaeval forest were probably only common in the karri and tingle forests and the extreme northern and eastern sectors of the jarrah forest, penetrating westwards to some extent along the flooded gums lining the major rivers (*WABN* **64**, p. 10; **76**, p. 19). With clearing of forest for agriculture, this species then expanded its distribution (e.g. lists 16, 22).

To a large extent Dusky woodswallows feed over the forest canopy but will feed within the canopy of mature stands of karri (lists 64–67, 125) and are readily mist-netted (Wardell-Johnson 1985). They also take advantage of logged karri stands, being particularly common 1–3 years after clearfelling (lists 125–126); see Christensen (1981, p. 22) for a photograph of this species nesting in a broken marri tree on a recently burned clearfelled coupe. In jarrah forest this species will feed in stands opened up by logging (list 44), thinning (lists 177–181), dieback disease (list 59) and prescribed burning (lists 23, 121).

In some parts of the forest this species is a spring-summer visitor (lists 11, 17, 263), whereas in others it may be present all year (lists 65–66, 157). Its median density is 0.25 birds/ ha (range 0.01–1.38, N = 7). This species usually occurs in groups of up to 6 birds.

Cracticus tibicen AUSTRALIAN MAGPIE

Australian magpies in the primaeval forest were probably restricted to wandoo and associated heath in the extreme northern and eastern sectors, as they require sparsely vegetated ground on which to forage. This species was not observed by Campbell in 1889 in karri forest (list 5). Clearing of forest for agriculture and settlement has allowed this species to penetrate the jarrah and karri forests (Serventy 1948), as at Collie in 1916 (list 11), Pemberton in 1922 (list 14), Bridgetown by 1925 (list 17), and Nornalup in 1930, 20 years after settlement (Bellanger 1980). This expansion should have led to greater nest predation of small birds.

Magpies do not colonize clearfelled karri forest (list 68, only 1 vagrant, recorded in summer), logged jarrah forest (lists 44, 128, 178–180) or dieback affected forest (lists 59, 60, 124) but will temporarily invade burnt forest (list 121; also Loaring, cited in Robinson 1956). The only density estimates available are 0.13 birds/ ha in forest and heath, respectively (lists 165, 168). Magpies occur in groups of up to 6 birds.

Strepera versicolor GREY CURRAWONG

Grey currawongs occur (usually in pairs) throughout the forest, including jarrah, yarri, bullich, wandoo and associated heath. In some karri forests (lists 64–71, 125–126, 184, 244–258; *cf.* 14) they are vagrant, whereas in others (including tingle) they occur regularly (lists 261, 263–266). This species has benefited from the establishment of orchards within the forest, in which it eats ripe fruit (lists 7, 17; Bellanger 1980). According to Christensen *et al.* (1985a), currawongs increase in numbers following fire. Their response to logging is unclear: no apparent impact in southern jarrah forest (lists 43–44); 7 birds recorded in karri regrowth (lists 64–71); 3 birds recorded in mature karri forest but none in regrowth (lists 125–126); not recorded in northern jarrah forest 6 months

after logging (lists 127–128). The only estimates available of density are 0.03 birds/ ha in forest (list 11) and in low woodland (list 167). In the period of active rabbit poisoning after 1945, this species apparently became very scarce (Ashcroft, personal communication).

Corvus coronoides AUSTRALIAN RAVEN

Australian ravens occur throughout the forest (in groups of up to 10 birds but usually singly or in pairs) in jarrah, karri, tingle, yarri, bullich, wandoo and adjoining heath and sedgeland. They occur at a median density of 0.25 birds/ ha (range 0.01–1.3, N = 9). In the primaeval forests ravens were probably only abundant locally (lists 7, 10, 11, vs 12, 17, 53, 64–66, 125). This species does not appear to be affected by logging of jarrah forest (lists 43–44, 127–128) or clearfelling of karri forest (lists 64–71, 125–126), though it has benefited from clearing of forest for farming (Christensen *et al.* 1985). Ravens are also recorded as colonizing recently burned forest (list 121). This species has benefited from roading, as it feeds on road-killed carrion such as kangaroos, birds and insects. This expansion should have led to greater nest predation of small birds.

Stagonopleura oculata RED-EARED FIRETAIL

Red-eared firetails are recorded in jarrah, karri, tingle, yarri, and bullich forests wherever dense thickets occur (along streams, on monadnocks). In the northern forests this species is largely restricted to riparian habitat (e.g. lists 17, 18, 22, 24, 28, 159, 164, 190), breeding north to Glen Forrest (*WABN* **25**, p. 9) and occurring east to Reservoir (Serventy 1948; Russell and Lisle 1955), Lesley, Canning and Boonering forest blocks (*WABN* **52**, p. 2; Buller 1954) and Mt Saddleback (list 119). There is also a record north to John Forrest National Park (*WABN* **65**, p. 2), which is presumably of vagrants as this species was not recorded in a comprehensive survey of the park (lists 169–176). This species undergoes marked seasonal movements, with post-breeding dispersal of immature birds and some post-breeding movements of adult birds (Bamford 1989).

In the southern forests Red-eared firetails are similarly restricted to dense vegetation (e.g. lists 44, 183), though there is evidence of local dispersal in summer and autumn into karri forest (lists 64, 66, 67, 69).

It is unlikely that logging or dieback disease would permanently impact on the habitat of this species. After clearfelling, firetails return to regrowth within 1 year but do not become as common as in unlogged karri forest until 3 years after clearfelling (lists 125–126). Similarly, the potential for conflict between the conservation of this species and bauxite mining appears low (Nichols *et al.* 1982). Provided that streamside vegetation is not burned out completely, fire should not be a problem for this species. In mature karri forest, firetails were most common shortly after fire (list 64). As noted by Christensen *et al.* (1981, 1985), firetails will nest in pine plantations if their habitat needs are met. This species frequently nests up to 15 m above ground level (Immelmann 1960). As well as eating grass and sedge *Lepidosperma angustatum* and *L. tetraquetrum* seeds, firetails eat seed of sheoak (Tarr 1948; Worsley Alumina 1985).

Dicaeum hirundinaceum MISTLETOEBIRD

Mistletoebirds were probably restricted in the primaeval forest to the extreme northern and eastern sectors of the northern forest, wherever mistletoe *Amyema miquelii, A. miraculosa* and *A. preissii* is present (usually on wandoo and flooded gum, occasionally marri and acacia). This species does not feed on the fruit of *Nuytsia floribunda*, which unlike other mistletoe species has a dry and inedible pericarp (Marchant, personal communication). Recent records in the forest include Kalamunda National Park (*WABN* **37**, p. 5), Avon Valley National Park (**46**, p. 11) and Murray River near Nanga Bridge (**76**, p. 18). It has also been seen near Bickley Brook Reservoir, just to the west of Victoria forest block (**83**, p. 20) and at Piesse Brook (**84**, p. 22). This species has been recorded at all times of the year and does not appear to be a migrant. Storr (1991) did not list this species for the forest, except in towns where exotic vegetation is available (e.g. *Solanum nigrum* – Griffiths 1977). Whittell (1933a) noted that this species was predated by cats.

Hirundo neoxena WELCOME SWALLOW

Welcome swallows in the primaeval forest probably occurred only along the major river valleys, around wetlands, and in heathlands and monadnocks with caves near water. This species has benefited considerably from European settlement, as it occurs on farmland, in towns, and near dams within the forest. It is now most unusual to find this species nesting in natural situations (Brown and Brown 1976–1991).

Hirundo nigricans TREE MARTIN

The Tree martin is the common swallow of the forest, being recorded in jarrah, yarri, bullich, wandoo, karri (including regrowth after clearfelling), tingle, and associated heath and wetland. It usually feeds by hawking above the forest canopy, but can be mistnetted (Wardell-Johnson 1985). This species is migratory, arriving in September and departing in March. It usually occurs in flocks up to about 20 (occasionally 70) in size, and tends to favour the vicinity of water. It nests in hollow spouts in tall trees, and if necessary several pairs will nest in the same tree. The species has a median density of 1.3 birds/ ha (range 0.1–18.4, N = 11).

Tree martins have benefited from partial clearing of forests to create farmland and towns, and in the latter make extensive use of power lines for perching. However, nesting rarely takes place in buildings (list 8). This species is very common immediately after karri forest is clearfelled (lists 68, 125–126). After about 6 years it is more common in mature karri forest (lists 69, 125–126). Tree martins have been recorded as less abundant in dieback jarrah forest relative to healthy forest (lists 57–60, 123–124).

Acrocephalus stentoreus
CLAMOROUS REED WARBLER
Clamorous reed warblers occur only in tall rushes bordering sizeable bodies of water. Such habitats are scarce in the northern forests, with the only records from near Wooroloo (list 21) and the Collie River (list 22). In the southern forest it occurs in many of the lakes between Darkan and Rocky Gully, as well as lakes on the south coast, from Gingilup Swamp east to Grasmere Lake. Breeding has also been reported at Wilgarup and on farm dams near Diamond forest block (Brown and Brown 1976–1991). This species is a migrant.

Megalurus gramineus LITTLE GRASSBIRD
Little grassbirds are restricted to rushes growing around the perimeter of freshwater lakes, mainly along the eastern edge of the southern forest between Darkan and Albany, and the southern edge of the forest between Augusta and Albany. This species is also recorded from Wilgarup, dams (breeding) on farmland near Diamond forest block (Brown and Brown 1976–1991), and sedgeland in Jane forest block (list 200). Brown and Brown (1990–1991) noted that 43 birds of this species had been banded by them, in marked contrast to 1 203 birds of the preceding species. The only mention of its occurrence in the northern forests is in list 28, which stated that the species is rare and occurs in densely vegetated swamps and riverside forest in the Dwellingup district, in particular Davis Brook (Kimber[32], personal communication). Although this species was not listed by Anon. (1900), it was recorded by Gilbert (MS).

Zosterops lateralis GREY-BREASTED WHITE-EYE
Grey-breasted white-eyes are generally distributed throughout the forest, including jarrah, karri, tingle, yarri, bullich, wandoo and associated heath and sedgeland. They occur in groups of up to *c.* 70 birds (median density = 0.5 birds/ ha, range = 0.15–1.17, N = 11), and tend to feed in the shrub layer. Consequently in the northern jarrah forest they may be more abundant in riparian thickets than elsewhere (lists 21, 28, 48–49).

White-eyes appear to be partial migrants – they were not recorded in winter or summer in the wetter jarrah forests near Collie (lists 104–107) or in summer in the drier forests at Mt Saddleback (lists 110–120). In unlogged karri forests they are least abundant in winter and spring (lists 64–67). Perhaps these observations indicate movement west towards the coast or onto nearby farms (list 61) in winter, west into the wetter jarrah forests in spring, and south into the southern forests in summer. Some of these movements appear to be long term (Brown and Brown 1976–1991).

This species commonly occurs in towns, orchards, potato crops and farm gardens within the forest, where it feeds on insects, nectar and soft fruits (Sargent 1928; Loaring 1952; Mees 1969; Matthiessen 1973; Griffiths 1977; Rooke 1984), and disperses blackberry (Sargent 1928; Gannon 1936). It appears to benefit from the abundant regrowth developing soon after logging in jarrah forest (lists 43–44, 179–181) and after clearfelling of karri forest (lists 68–71). Although Grey-breasted white-eyes have been recorded in large numbers in jarrah forest affected by dieback disease (list 60), they are more abundant in healthy jarrah forest (lists 123–124). This species appears to be an important predator of larvae of jarrah leafminer (Mazanec 1988).

Waterbirds

Oxyura australis BLUE-BILLED DUCK
Blue-billed ducks are most often recorded in suitable habitat (wetlands) towards the eastern margin of the forest between Darkan and Albany. In these lakes this species occurs in numbers up to 370. Breeding has been reported from Towerrining Lake (list 134). This species has also been recorded near Bridgetown (in 1933), breeding on a small lake.

Biziura lobata MUSK DUCK
Musk ducks are recorded (usually in pairs) throughout the forest south of about Dwellingup in suitable habitat (swamps, lakes, river pools). However, this species is most abundant (up to 160 birds) and breeds on the large lakes near the eastern margin of the forest between Darkan and Albany. These ducks also utilize farm dams, reservoirs and estuaries and will nest on farm dams (Brown and Brown 1976–1991). They have been recorded occasionally on Logue Brook and Samson Brook dams (Dames and Moore 1978).

Cygnus atratus BLACK SWAN
Black swans occur on extensive open stretches of water throughout the forest, with the largest numbers (and breeding) on wetlands in the eastern sector, e.g. Lake Muir complex, Deadmans Swamp, Kwornicup Lake, and Moodiarrup Swamps. There is also a record of breeding at Wilgarup Lake north of Manjimup (Brown and Brown 1976–1991). This species is also able to use reservoirs (e.g. Logue Brook and Samson Brook dams, Dames and Moore 1978), farm dams, seasonal swamps on pasture, and estuaries. Nesting has been reported on a farm dam (Brown and Brown 1976–1991).

Tadorna tadornoides
AUSTRALIAN SHELDUCK (MOUNTAIN DUCK)
Australian shelducks (Mountain ducks) occur throughout the forest in suitable habitats (lakes, rivers, swamps, sedgelands), usually as pairs on small waterbodies but ranging up to 12 000 birds on large lakes (list 133). Most breeding takes place on wetlands in the eastern sector of the forest. The provision of dams following the opening up of the forest for farms and mining has provided opportunities for this species, e.g. it has been recorded on lakes near Hamilton forest block and reported breeding at Mt Saddleback (Worsley Alumina 1985).

[32] P. Kimber, formerly Department of Conservation and Land Management, Como.

Anas gracilis GREY TEAL
Grey teal occur throughout the forest wherever suitable habitat (rivers, wetlands) occur, usually in small groups of up to 5 birds. On larger waterbodies near the eastern margin of the forest, hundreds or even thousands of breeding pairs of this species may be present. This species is also recorded on coastal lakes, reservoirs and farm dams, e.g. single birds noted on lakes near Hamilton forest block (Worsley Alumina 1985).

Anas castanea CHESTNUT TEAL
Chestnut teal occur in the eastern sector of the forest in suitable habitat, mainly brackish waters. Breeding has been recorded at Towerrining Lake (list 134). This bird is scarce in the forest and is recorded singly or in groups of up to 8 birds.

Anas superciliosa PACIFIC BLACK DUCK
Pacific black ducks are the commonest species of duck in the forest, occurring in pairs on rivers and swamps and in hundreds on large waterbodies in the eastern sector (Grasmere Lake, Lake Muir complex, Kwornicup Lake). This species has been favoured by clearing and the provision of farm dams, reservoirs and watering points, and will nest on farm dams (Brown and Brown 1976–1991). It was recorded as common on Logue Brook and Samson Brook dams (Dames and Moore 1978).

Anas rhynchotis AUSTRALASIAN SHOVELER
Australasian shovelers occur in suitable habitat (wetlands) in the eastern sector of the forest between Boddington and Albany. Generally this species occurs singly, but on large waterbodies numbers can range up to 69. Breeding has been reported at Deadmans Swamp (list 136) and Moodiarrup Swamps (list 141).

Aythya australis HARDHEAD
Hardheads occur in large numbers (up to 500) in suitable habitat (wetlands) in the eastern sector of the forest between Darkan and Albany. The only other records in forest are at Harvey Dam (7 birds, list 24) and a swamp near Bridgetown (list 17). This species has also nested on a farm dam near Diamond forest block (Brown and Brown 1976–1991).

Tachybaptus novaehollandiae AUSTRALASIAN GREBE
Australasian grebes occur (usually in pairs) throughout the forest wherever suitable habitat (open water) occurs. This species has also benefited from settlement as it uses dams (earth tanks) on farmland (lists 21, 40, 63, 86–103, 108) and tolerates brackish water. It will breed on farm dams (Brown and Brown 1976–1991). It also makes occasional use of reservoirs e.g. Logue Brook and Samson Brook dams (Dames and Moore 1978).

Poliocephalus poliocephalus HOARY-HEADED GREBE
Hoary-headed grebes appear to be most common on lakes in the eastern sector of the forest, including a breeding report at Boscabel (*WA Bird Report* 1982, p. 9). Elsewhere in the forest they are local in distribution, as at Wilgarup (list 17, small lake; see also *WABN* **82**, p. 16), Hamilton forest block (list 108 lakes, dam), Shannon area (list 81), and Molloy Island (*WA Bird Report* 1982, p. 9). This species will nest on farm dams (Brown and Brown 1976–1991).

Anhinga melanogaster DARTER
Darters occur in small numbers (often singly or up to 3 birds) in suitable habitat (lakes, swamps, rivers) in the forest mainly south of about Dwellingup. It is only on the large lakes in the eastern sector that up to 20 birds may be recorded. Nesting has been noted on the Blackwood River east of Bridgetown (*WABN* **64**, p. 10), Kent River south of Thames forest block (*WABN* **64**, p. 3), and Wilgarup Lake (*WABN* **82**, p. 17). This species was listed without comment (no locality or aboriginal name) by Gilbert (MS), was observed only once in lower south-west WA by Carter (list 11), and was regarded as rare by Whittell (list 17).

Phalacrocorax carbo GREAT CORMORANT
Great cormorants are recorded in suitable habitat (lakes, swamps, rivers, dams – e.g. common at Logue Brook and Samson Brook dams, Dames and Moore 1978) in the forest mainly south of about Dwellingup. They attain their greatest abundance in several lakes south of Darkan at the eastern margin of the forest.

Phalacrocorax sulcirostris LITTLE BLACK CORMORANT
Little black cormorants occur in suitable habitat (lakes, swamps, rivers) throughout the forest. This species is most abundant on lakes in the eastern sector of the forest, although it can occur abundantly elsewhere (Molloy Island, *WA Bird Report* 1982, p. 10). It was also recorded as common at Logue Brook and Samson Brook dams (Dames and Moore 1978). This species was first listed as occurring in south-west WA by Gould (1865), though not on the basis of any observation by Gilbert (MS).

Phalacrocorax melanoleucos LITTLE PIED CORMORANT
Little pied cormorants are the most frequently recorded species of cormorant in the forest, occurring wherever suitable habitat (lakes, swamps, rivers etc) is present. They were noted as common at Logue Brook and Samson Brook dams (Dames and Moore 1978). Normally this species occurs singly, and only in large lakes in the eastern sector of the forest does it occur abundantly. Nesting has been reported at Wilgarup Lake (Brown and Brown 1976–1991).

Ardea novaehollandiae WHITE-FACED HERON
White-faced herons occur throughout forest wherever suitable habitat (shallow standing water) is found. They mostly are recorded singly, but large numbers (up to 120) occur in some of the extensive lakes in the eastern sector of the forest. This species has benefited from the creation of suitable habitat by settlement: farm dams, low lying pastures, roadside ditches, and reservoirs – e.g. common at Logue Brook and Samson Brook dams (Dames and Moore

1978). The only available estimate of (foraging) density is 0.13 birds/ ha (list 168). Breeding has been reported at Wilga[illegible] Lake (Brown and Brown 1976–1991).

Nycticorax caledonicus RUFOUS NIGHT HERON

Rufous night herons are rarely noted in the forest, with most records coming from the southern forests (lists 17, 72, 75, 79; Wilgarup Lake, Brown and Brown 1976–1991). The only other records are from Avon Valley National Park (*WABN* **46**, p. 11), Towerrining Lake Nature Reserve (list 134), and Karakamia Sanctuary (list 259). All records are of single birds. These meagre records appear to contradict the remark by Carter (list 11) that this species occurs along all rivers in the south-west. Whittell (1933a) noted that his record was of an immature; this may indicate local breeding, though Storr (1991) drew attention to a record of an immature bird moving 1 000 km in 25 days. Later, Whittell implied that this species is a resident, but he did not personally know of its breeding in the region around Bridgetown (Whittell 1938b).

Ixobrychus minutus LITTLE BITTERN

Little bitterns occur in suitable habitat only in the southern forests, but seem to be very localized, e.g. swamp near Wilgarup (list 17); west of Northcliffe (*WABN* **86**, p. 3). Most records (some breeding) come from lakes near Lake Muir and wetlands along the south coast between Lake Gingilup and Grasmere Lake. This species was missed by all of the early observers and appears to have been first collected in south-west WA in the late 1890s (Anon. 1900).

Ixobrychus flavicollis BLACK BITTERN

Black bitterns occur in suitable habitat (riparian thickets) apparently only in parts of the forest: Murray River (at Nanga, *WABN* **22**, p. 9; **38**, p. 7; also list 30); Blackwood River (at Bridgetown, list 17; east of Bridgetown *WABN* **22**, p. 9; Mayanup, *WABN* **34**, p. 7; Sue's Bridge, *WABN* **34**, p. 7); Donnelly River (One Tree Bridge, *WABN* **60**, p. 1); Tone River (list 75); Frankland River (list 80); Warren River (*WABN* **79**, p. 3); near Northcliffe (*WABN* **60**, p. 5); and King River (list 8). The comprehensive survey by Jaensch *et al.* (1988) in the period 1981 to 1985 failed to locate this species.

Being secretive and nocturnal, however, this species is likely to occur singly or as pairs more widely in forest than indicated in the above reports. Black bitterns roost by day in trees overhanging water and are not easy to detect. Whether this species was originally rare cannot now be ascertained, as early chroniclers provided contradictory opinions (Shortridge thought that Black bitterns were 'not uncommon', Carter noted that they were 'not common', Whittell wrote that they probably were not really rare, and Whitlock stated that he had met with them sparingly).

Botaurus poiciloptilus AUSTRALASIAN BITTERN

Australasian bitterns occur in suitable habitat (swamps) in the southern forests, mostly in the sunklands (lists 25–26) and Lake Muir wetlands, as well as swamps on the south coast (between Yeagerup and Albany). Johnstone and Storr (1998) mention a nesting record from Narrikup. These bitterns are recorded singly or in groups of up to 5 birds.

Rallus pectoralis LEWIN'S RAIL

Lewin's rail has seldom been observed in the forest. It was first collected by Gilbert in the 1840s (one male, locality unknown, presumably near Perth as Gilbert (MS) provides the name used by aborigines at Perth). Moore (1884) also provided a very similar aboriginal name from the Perth area. The next collections or observations were by Masters in March 1866 near Albany (one male), Webb in 1874 near Albany (two birds, sex unknown), Shortridge in 1907 near Margaret River, presumably Ellenbrook and/or Burnside (one male, one female), and Whittell in December 1931 and September 1932 in a swamp 24 km south-west of Bridgetown. This species is now believed to be extinct in WA.

Shortridge also collected around Albany but did not record it there. He believed the species to be 'fairly plentiful' but 'shy and easily overlooked'. It does seem, however, that the species was always patchily distributed, as Preiss, Campbell, Tunney, Hall, Milligan, Jackson, Whitlock and Carter failed to observe it in the period 1838 to 1919. More recently, Christensen *et al.* (1985a) and Jaensch *et al.* (1988) did not locate the species.

In 1997 G. Lodge informed me that Whittell's swamp 24 km south-west of Bridgetown actually lies more south, at Wilgarup. This area is close to the watershed of the Wilgarup and Donnelly rivers and represents an extensive series of peat swamps. Although Whittell's observations were made on farmland currently owned by E. Phillips (*WABN* **81**, p. 19), extensive swamps on adjacent Wilgarup Nature Reserve and Alco forest block should also have harboured Lewin's rail.

The taxonomic status of Lewin's rail in WA is not clear. Mathews (1911, pp.189–190) assigned it the rank of endemic subspecies (*clelandi*) on the basis of larger size. Some modern authorities accept this (Harrison 1975; Storr 199; Johnstone, personal communication), some do not (Keast 1961; Condon 1975; Ripley 1977), and others express uncertainty (Greenway 1973, p. 303).

Porzana pusilla BAILLON'S CRAKE

Baillon's crake has only been recorded four times in the forest: Bridgetown, presumably Wilgarup Lake (list 17, *WABN* **82**, p. 16); Grasmere Lake (list 132); Moodiarrup Swamps (list 141); and nesting near Diamond forest block (Brown and Brown 1976–1991). Presumably it occurs more widely in suitable habitat (swamps and lake edges). This species was overlooked by all of the early observers and was first listed for south-west WA by Anon. (1900).

Porzana fluminea AUSTRALIAN SPOTTED CRAKE

Australian spotted crakes have been recorded from only two localities in the forest: Grasmere Lake (list 132) and Wilgarup swamp (*WABN* **33**, p. 9). Presumably this species occurs more widely in suitable habitat (swamps and lake edges). It was first collected in south-west WA by Masters in 1868, a fact overlooked by Ramsay (1888), Anon. (1900, 1902) and Alexander (1915).

Porzana fluminea SPOTLESS CRAKE
Spotless crakes are the most widely distributed species of crake in suitable habitat (swamps and riparian thickets) in the forest, having been recorded near Jarrahdale and Dwellingup, the sunklands, Wilgarup Lake south of Bridgetown (see also *WABN* **82**, p. 16), between Pemberton and Northcliffe, in the vicinity of the Lake Muir wetland complex, and around Albany. Whittell (1938b) stated that this species was 'undoubtedly the commonest Crake of the district'. Near Wilson Inlet, this species was in the breeding season most frequently recorded on flooded ground rather than around the edge of large permanent swamps (Whitlock 1914). This species probably occurs more widely but is easily overlooked. Christensen *et al.* (1985a) described how it was only detected after it entered traps set for small mammals. Predation of Spotless crakes by cats was recorded by Whitlock (1914) and Whittell (1933a).

Porphyrio porphyrio PURPLE SWAMPHEN
Purple swamphens occur (singly or up to 24 birds) throughout forest wherever suitable habitat (swamps, lakes, streams) is present. However, this species appears to be very localized in the northern forests (lists 21, 40, 62, 108). In the southern forests swamphens occur on pastures close to uncleared streams or swamps and will nest on farm dams (Brown and Brown 1980).

Gallinula ventralis BLACK-TAILED NATIVE-HEN
Black-tailed native-hens are irregular visitors to suitable habitat (swamps, lakes, streams) in the extreme eastern sector of the forest between Wooroloo and Albany. Mostly they are recorded singly or in pairs (lists 9, 21, 132, 142). The largest populations (*c.* 50 birds) have been recorded at Towerrining Lake and Moodiarrup swamps. This species is unknown from the Lake Muir wetlands complex. There is one record of a vagrant at Nornalup (Serventy 1952)

Fulica atra EURASIAN COOT
Although Eurasian coots occur in forest wherever suitable habitat (open waterbodies) is present, they are most abundant (and breed) in the wetlands on the eastern fringe of the forest between Darkan and Albany. This species also utilizes dams on farmland and reservoirs, and will nest on farm dams (Brown and Brown 1980). Carter (list 11) regarded the Eurasian coot as both uncommon and local in distribution early this century. Indeed, none of the other lists in Table 1 mention this species.

Himantopus himantopus BLACK-WINGED STILT
Black-winged stilts occur in suitable habitat (wetlands) at the eastern margin of the forest, between Darkan, Lake Muir and Albany. Breeding has been recorded only at Deadmans Swamp (list 136). These stilts occur in numbers up to 100.

Charadrius ruficapillus RED-CAPPED PLOVER
Red-capped plovers mostly occur on flats in and around estuaries to the south of the forest. However, they occur in large numbers (up to 500 birds) on edges of swamps and lakes at the eastern margin of the forest between Darkan and Albany.

Charadrius melanops BLACK-FRONTED DOTTEREL
Black-fronted dotterels occur in suitable habitat (river pools, swamp and lake margins) in the forest south to Collie–Mandalup (east of Bridgetown, *WABN*, **66**, p. 9) – Lake Muir– Grasmere Lake. They are usually present in pairs, though they may occur in groups up to *c.* 40 birds. This species also utilizes the edges of farm dams and reservoirs (e.g. near Hamilton forest block, Worsley Alumina 1985), and will nest on farm dams (Brown and Brown 1976–1991).

Erythrogonys cinctus RED-KNEED DOTTEREL
Red-kneed dotterels appear to occur only in the forest at the extreme eastern edge near Darkan. There they have been recorded in three wetlands, breeding in two of them.

Species not considered to have been present in the primaeval forest

The following commentary is intended to substantiate information presented in Table 4.

Landbirds

Pandion haliaetus OSPREY
Ospreys would not normally be regarded as a forest species as they feed on fish caught in coastal waters. Nevertheless there are several records of breeding in karri forest near Walpole and Torbay (list 81; *WABN* **30**, p. 3).

Elanus caeruleus BLACK-SHOULDERED KITE
Black-shouldered kites were first reported from the forest in 1943, when single birds were noted at King River, Kojonup, and Boyup Brook (Whittell 1944), and subsequently at Mt Barker and Nornalup (Serventy 1952), and in Collie townsite (list 22). Since then this species has been reported as rarely present in the Dwellingup district in clearings and forest edges (list 29) and extending into the forest as clearing for farmland proceeded (list 38). A single bird was reported in jarrah forest near Mt Saddleback (list 61) and several birds were noted near Walpole (in coastal habitats) and Manjimup (in farmland, list 84). This species has been commonly recorded on farmland near Diamond forest block (Brown and Brown 1976–1991). The most recent report is from partially cleared land near Torbay Inlet (*WABN* **30**, p. 3). In the primaeval forest there would not have been sufficient areas of open country to support a population of this species. The first record of breeding within the forest area was on a farm near Bridgetown in November 1943 (Whittell 1944).

Hamirostra isura SQUARE-TAILED KITE
Square-tailed kites have been recorded in 22 forest (jarrah, karri, yarri, wandoo) localities, mostly between October and February, almost all in the period 1980–1997, and nearly always as single birds. Regular breeding has not been proved, although one pair colonized and bred at

Bickley in 1928–1930 (Serventy 1948). However, this species was never recorded (over a 16-year period) on farmland near Diamond forest block (Brown and Brown 1976–1991). It is a specialized predator of the eggs and nestlings of birds in passerine-rich woodland and adjacent heathland (Debus and Czechura 1989; Olsen 1995).

Many records for the period 1983–1997 have been published in *WA Bird Notes* from the Swan Coastal Plain, Darling Scarp, south-west coasts and western wheatbelt, including nesting records in woodland near Frankland and Kojonup and in the Stirling Range. Consequently, this species is not considered to have been a member of the breeding avifauna of the primal forest. It should be noted that three valleys dissecting the Darling Scarp each supported one pair of Square-tailed kites (Jaensch 1987). In one valley (5–10 km long x 1 km wide) three pairs were present (Jaensch quoted in Debus and Czechura 1989). Breeding, however, was not reported.

Hamirostra melanosternon
BLACK-BREASTED BUZZARD
The only record of Black-breasted buzzards, in the Perup area (list 31), is undoubtedly an error for *H. isura* (*q.v*).

Milvus migrans BLACK KITE
The only record of the Black kite in the forest is of one pair at Glen Mervyn dam [Sherwood forest block] in March 1983 (*WABN* **26**, p. 10). None was noted during the irruption of 1952 (Serventy 1952).

Aquila morphnoides LITTLE EAGLE
Little eagles were first reported within the forest in 1936, at Pickering Brook (Serventy 1948) and then in the early 1950s (list 20), feeding on the rabbit. They are usually recorded singly, in jarrah, wandoo and karri, and do not seem to be influenced by logging or burning (lists 66–67, 71, 125–126). Their median density is 0.03 birds/ ha (range 0.01–0.05, N = 3). Dell (1971) noted that this species was the most frequently recorded large raptor in jarrah forest between Mundaring Weir and the Darling Scarp, where it is present throughout the year and breeding (at least in 1963). Johnstone (1996), however, noted this species only twice at Bungendore Park. Brown and Brown (1976–1991) recorded it commonly on farmland near Diamond forest block. Little eagles have been recorded in dieback affected jarrah forest (list 124).

Haliaeetus leucogaster WHITE-BELLIED SEA-EAGLE
White-bellied sea-eagles are not normally regarded as forest birds as they feed mainly in coastal waters. However, this species has been recorded as nesting in forest (lists 6, 11) near Denmark.

Circus assimilis SPOTTED HARRIER
Spotted harriers are vagrants in the forest, with only three records (lists 2, 73, and at Bridgetown [Serventy 1952]). Records published by Blakers *et al.* (1984) and Saunders and Ingram (1995) require substantiation.

Falco cenchroides AUSTRALIAN KESTREL
Australian kestrels are unlikely to have occurred in the primaeval forest. Evidence for this conclusion is (1) Gilbert in the 1840s noted that it was confined to the interior (sandplains) and was not known to settlers even as far west as at York and Toodyay; (2) early lists (1–17) usually do not mention the species as occurring in forest at all; (3) lists since 1951 mention the occurrence of the species in clearings or forest edges (lists 29, 73–85, 179). This species is nearly always recorded singly. It is particularly common on the coastal heaths south of the forest.

Falco longipennis AUSTRALIAN HOBBY
The Australian hobby visits the forest from the semi-arid interior in autumn and winter (Storr 1991). Early this century, Carter noted that it was more numerous than the Peregrine falcon, being generally distributed in low numbers in the south-west, although most abundant around Lake Muir (list 11). In the last few decades this species continues to be very localized in jarrah and karri forest and is usually recorded singly. It has bred at least once in the forest (list 41). Recent sightings come from 20 km north of Walpole on the south-west highway (*WABN* **61**, p. 31), Broke Inlet (**78**, p. 22), Yarra road (**80**, p. 21), in jarrah forest east of Walpole (single birds in spring 1985 and 1986, list 260), and Bungendore Park (list 271 – one in May 1990).

Otis australis AUSTRALIAN BUSTARD
Australian bustards are unlikely to have occurred in the primal forests. Since European settlement this species has been noted as a rare vagrant: one shot on farmland near Nannup in 1938 (L. Talbot, personal communication); at Bridgetown in 1949 (Serventy and Whittell 1976); hearsay south of the forest at Scott River (L. Talbot, personal communication); one near Collie in 1950s (E. Riley, personal communication); twice near Northcliffe in 1980s (G. Gardner, personal communication); and occasionally on farmland west of Redmond (R. Walker, personal communication).

Burhinus grallarius BUSH STONE-CURLEW
Bush stone-curlew are unlikely to have inhabited the primaeval forests. Deforestation this century has favoured this species, as it has been recorded widely throughout the south-west but only in partially cleared forest near Margaret River (lists 11, 12), Bridgetown (list 17), Wooroloo (lists 21, 39), Collie (list 22), near Julimar, north of Bakers Hill, Dwellingup, Harvey Weir pine plantation, Newlands, Kirup, Grimwade, Wilga, Boyup Brook, Dinnimup, Brookhampton, Dunsborough, Nannup, Channybearup, Northcliffe and Kin Kin. Breeding has been reported (lists 17, 39). Senior landholders informed me that this species declined after the arrival of the fox and disappeared in the late 1940s/early 1950s. This species was recorded in 1991 on abandoned farmland at Wellbucket pine plantation south of Gorrie forest block (L. Talbot, personal communication).

Columba livia DOMESTIC PIGEON
Domestic pigeons (introduced to WA) do not occur in forest stands but have been recorded in towns within the forest (lists 31–33; also Bridgetown, Chidlow, Collie, Margaret River , Long 1988) or near the forest (recreation ground near Bungendore Park, list 271; at Bedfordale adjacent to Churchman forest block, personal observation).

Streptopelia senegalensis LAUGHING TURTLE-DOVE
Laughing turtle-doves, introduced into South Perth in the late 1890s (Sedgwick 1958), now occur in small numbers in settled parts of the forest (gardens, farms) at Bickley (Serventy 1948), Glen Forrest (Sedgwick 1958), Wooroloo, Bungendore Park (list 271), Jarrahdale and Collie. The forest itself is shunned (Sedgwick 1958).

Streptopelia chinensis SPOTTED TURTLE-DOVE
Spotted turtle-doves (introduced to WA) do not occur in forest stands except as rare vagrants, being usually associated with cleared forest (roadsides and townsites) in or near Gidgegannup, Mundaring, John Forrest National Park, Wooroloo, Bickley, Parkerville, Chidlow, Hovea and Bedfordale (lists 20, 21, 176; Serventy 1948; Sedgwick 1958, 1965; Storr 1991).

Ocyphaps lophotes CRESTED PIGEON
Crested pigeons have been reported from settled areas in the forest at Collie (1950s, list 22), Manjimup (1982, *WABN* **24**, p. 3) and Torbay (1998, Johnstone, personal communication). This species is gradually spreading from the semi-arid interior (Storr 1991); it is unlikely that it could utilize forest stands as habitat.

Geopelia cuneata DIAMOND DOVE
Diamond doves have been reported near Wooroloo (list 21) and Kalamunda (Storr 1991) as vagrants.

Cacatua roseicapilla GALAH
Although Galahs were present in the 1920s just to the west of the jarrah forest at Maddington, they did not begin to colonize the north-west extremity of the forest (largely cleared) until the 1940s (list 39), penetrating west (lists 169–174, 176). According to Storr (1991) this species now occurs south to about Lupton forest block. Galahs are now common in Busselton and regular, probably resident, in Nannup (Mees, personal communication). They have also been reported from Manjimup (Christensen *et al.* 1985) and Denmark (*WABN* **84**, p. 17).

Cacatua sanguinea LITTLE CORELLA
Little corellas have only been recorded in the forest at Collie (one bird in the town, assumed to be an escaped cage bird, list 22). This species is not a forest bird and originally was not likely to have even occurred in the South West Land Division (Storr 1991).

Cacatua galerita SULPHUR-CRESTED COCKATOO
Sulphur-crested cockatoos occur as vagrants in the western sector of the jarrah forest between Darlington and Kalamunda (Storr 1991). This species was introduced to south-western Australia about 60 years ago (Long 1988).

Nymphicus hollandicus COCKATIEL
Cockatiels have been recorded as vagrant at Bridgetown (1 pair, Whittell 1935) and just west of Victoria forest block (1 male, *WABN* **37**, p. 8). This is not a forest species.

Polytelis anthopeplus REGENT PARROT
Regent parrots were first recorded in the jarrah forest at Mundaring in 1924 and at Bickley in 1946 (Serventy 1948), and subsequently near Wooroloo, Collie and Dwellingup in orchards and partly cleared farmland, and in an open area in Bungendore Park (list 271). Although not a forest species, the Regent parrot was recorded widely throughout the lower south-west in the period 1970–1990, apparently as nomadic post-breeding flocks (Mawson and Long 1995).

Platycercus elegans CRIMSON ROSELLA
One Crimson rosella, probably an escaped cage bird, was recorded in Bungendore Park in June 1993 (Johnstone 1996).

Neophema elegans ELEGANT PARROT
The Elegant parrot is not a forest species. Clearing of jarrah forest for orchards, pasture and bauxite mining has allowed this species to penetrate west and establish. It was first recorded in 1928 at Kulikup (Foley 1928), at Boyup Brook in 1937 (list 17), at Bedfordale in 1946 (Serventy 1948), and at Wooroloo and Collie in the 1950s (lists 21–22). Since then it has spread to the Bridgetown, Manjimup and Donnybrook Sunklands areas in the southern forest (lists 17, 26, 41–42, 73–75, 83, 130, 165, 167–168, 183; *WABN* **72**, p. 2; **76**, p. 4) and the Jarrahdale, Dwellingup and Mundaring areas in the northern forest (lists 27, 46–47, 49, 104–120, 156, 160, 173, 182, 272; *WABN* **76**, p. 18; Dell 1964). Median density has been estimated as 0.11 birds/ ha (N = 2).

Melopsittacus undulatus BUDGERIGAR
Budgerigars have occasionally been recorded near Wooroloo (list 21), Collie (list 22) and Gorrie forest block (*WABN* **57**, p. 10). This is not a forest species.

Dacelo novaeguineae LAUGHING KOOKABURRA
Laughing kookaburras were introduced from eastern Australia and released in large numbers from the zoo in South Perth in 1897 (Long 1988), Warren River in 1909 (1 pair, one of which was shot a few days after release, list 11), and elsewhere (Long 1988). Supposed Noongar names for this species from Pinjarra and Harvey (Curr 1886) refer to *Cracticus tibicen*, the Australian magpie.

Carter (list 11) noted the species as present in forest east of Cape Naturaliste in 1922. One pair was present at Denmark in 1927 (list 16) and the species reached Nornalup in 1930 (Bellanger 1980). It was recorded as very numerous at Bridgetown in the 1930s (list 17). Since then it has become ubiquitous in the forest, including jarrah, karri, tingle, yarri, bullich, wandoo and associated

heath, sedgeland and low woodlands. It occurs singly or in small groups of up to about 5 birds, at a median density of 0.13 birds/ ha (0.02–1.0, N = 7). This species is capable of moving far in a relatively short period e.g. 25 km in *c.* 20 months (Baker *et al.* 1997). Kookaburras are very rarely recorded in regrowth karri forest (lists 71, 125–126) and appear to be absent from dieback affected jarrah forest (lists 59–60, 124).

The addition of the Laughing kookaburra to the forest avifauna should have resulted in increased nest predation of small birds.

Malurus leucopterus WHITE-WINGED FAIRY-WREN
White-winged fairy-wrens were recorded at several localities along the Murray River between Plavins and Park forest blocks (*WABN* **54**, p. 6). As both Splendid and Red-winged wrens were also noted, it seems unlikely that a misidentification occurred. This species has been extending its range on the Swan Coastal Plain (Storr 1991), so these records of apparent vagrant birds may be valid.

Certhionyx niger BLACK HONEYEATER
Black honeyeaters have been recorded as vagrant near Wooroloo (list 21). This species is not a forest bird.

Meliphaga virescens SINGING HONEYEATER
Singing honeyeaters are unlikely to have occurred in the primaeval forest as they prefer woodland, shrubland (gardens) and heaths. With settlement and partial clearing in the forest (farmland, towns, mines), this species now occurs sparsely to commonly in such habitats, as at Gorrie forest block (list 182), Wooroloo (lists 19–21), Bungendore Park (list 271), Jarrahdale (list 46), Chandler (list 213), south of Gyngoorda forest block (Biddiscombe 1985), Federal (list 234), Waroona (list 239) and Saddleback forest blocks (lists 95, 101), Collie (list 22), Bridgetown (list 17), and near Diamond forest block (Brown and Brown 1976–1991).

This species tends to occur singly (when vagrant) or in small groups (3–4 birds) where resident. Overall, Singing honeyeaters have been recorded by local ornithologists and birdwatchers in 1 per cent of Darling Plateau surveys in contrast to 71 per cent of surveys on the adjacent Swan Coastal Plain (*WABN* **34**, p. 5).

Melithreptus brevirostris BROWN-HEADED HONEYEATER
Although present in wandoo woodland along the edge of the Darling Scarp from Helena River south to Harvey (Storr 1991), Brown-headed honeyeaters are unlikely to have been present in the primaeval forest. With clearing for settlement this species has been recorded as a vagrant at Wooroloo (lists 20–21), Karakamia Sanctuary (list 259), Gorrie forest block (list 182), Bungendore Park (list 271), Mt Saddleback (list 61), and Boyup Brook and Bridgetown (Serventy and Whittell 1976).

This species is easily confused with immatures of *M. chloropsis*. Records from the Dwellingup area ('common' in lists 27, 35–37; 1.3 birds/ ha, list 56; 177, with no listing of *M. chloropsis*) are not accepted as valid. Those from lists 27 and 35–37 have been withdrawn (Kimber, personal communication).

Phylidonyris albifrons WHITE-FRONTED HONEYEATER
White-fronted honeyeaters are vagrant to the extreme eastern sector of the forest, at Dobaderry Nature Reserve (*WABN* **74**, p. 5). There one bird was netted in wandoo forest.

Manorina flavigula YELLOW-THROATED MINER
Yellow-throated miners were recorded in lists 12 ("only one bird was seen") and 73 (Christensen *et al.* 1985a p. 96, though not mentioned on pp. 45–46). Storr (1991) also lists this species as present 50 and 55 km WNW of Brookton, which would lie just within the eastern margin of the original forest. This species is not a forest species, so all of these records should be regarded as questionable.

Epthianura albifrons WHITE-FRONTED CHAT
White-fronted chats are unlikely to have occurred in the primaeval forest, though it is possible that they bred occasionally around some granite outcrops (list 39). Most records are associated with coastal habitats (lists 11, 165), farms (lists 8, 17, 22, 31–33, 39; Biddiscombe 1985), lakes (list 11), dams (list 108), woodland (lists 157, 167) or heath (list 168). Otherwise this species is vagrant in forest (list 20; 126, where 5 birds were recorded in regrowth 3–4 years after clearfelling of karri forest; list 265).

Epthianura tricolor CRIMSON CHAT
Crimson chats have been recorded once in the forest (7 birds, May 1972), on the southern edge of Gakaling forest block at the extreme north-east edge of the wandoo forest (Milhinch 1983a).

Microeca fascinans JACKY WINTER
The Jacky winter has been recorded as vagrant in wandoo forest east of Collie (list 243) and 12 km south-east of Mundaring Weir (Storr 1991). The other two records (lists 13, 16) were considered by Storr (1991) to represent misidentified *Eopsaltria georgiana*; this concept seems applicable also to 3 records in coastal habitat near Walpole in autumn 1989 (Wardell-Johnson unpublished). The Jacky winter is not a forest species.

Petroica goodenovii RED-CAPPED ROBIN
Red-capped robins are unlikely to have lived in the primaeval forest, as they prefer more open woodlands and heaths. Gilbert (MS) recorded the species at Kojonup and Shortridge (list 8) thought that the south-west boundary of its range was Kojonup. Since the 1930s and probably because of the development of farmland within the forest, this species has been recorded frequently as single birds or pairs, mostly in autumn or winter, occasionally in spring, from near Bridgetown (list 17), Wooroloo (list 21), Collie (list 22), Pemberton (list 41), Nannup (list 77), Gray forest block 30 km south-west of Manjimup (Liddlelow, personal communication), Saddleback forest block (list 111), John Forrest National Park (list 170), Gorrie forest block (list

182), Hillman forest block (list 243), Bungendore Park (list 271), Avon Valley National Park (*WABN* **46**, p. 11; **64**, p. 9), Julimar (**60**, p. 11) Piesse Brook (**35**, p. 8), Bickley (Serventy 1948), 32 km west of Northam (McEvey and Middleton 1968), 19 and 27 km north-east of Manjimup (**72**, p. 2; **76**, p. 4), and Kalamunda National Park and Lake Muir Nature Reserve (**76**, p. 2; **78**, p. 17). Near Kalamunda one pair was observed to arrive in May 1985 and remain 8 days; in other years (1981–1996) one pair was recorded between March and May over a period of 2–4 weeks (*WABN* **35**, p. 8; **78**, p. 17).

There is only one (probable) instance of nesting recorded: Gorrie forest block (list 182, immatures in October 1989 and one sub-adult in February 1990). Just to the west of the forest, at Ellis Brook, this species was recorded mainly in burnt areas (*WABN* **74**, p. 8). This species has been recorded farther south than indicated by Storr (1991).

Oreoica gutturalis CRESTED BELLBIRD

Crested bellbirds have been recorded (without critical comment) as occurring in the Kingia heaths (stunted jarrah and marri to 6 m, with scrub to 1.5 m) of Rosa and McCorkhill forest blocks (list 26) and in Shannon National Park (*WABN* **54**, p. 2). The validity of these records – well to the south-west of the range of this species – seems questionable. G. Liddelow (personal communication) has never observed this species in the sunklands.

Rhipidura leucophrys WILLIE WAGTAIL

Willie wagtails are unlikely to have occurred in the primaeval forest, as they require treeless or sparsely wooded country. Serventy (1948) and Serventy and Whittell (1976) stated that this species did not occur in forest except where it had been opened up by settlement. For example, this species was absent from Walpole until forest was cleared for farming (list 16, recorded 16 years after settlement). This species was recorded as a vagrant (usually single birds) in jarrah and wandoo forest and heath near Saddleback forest block (lists 61, 109–120), in jarrah forest north-east of Manjimup (list 183), in open streams in jarrah forest in the extreme north-east sector of the forest (list 39), and in karri–red tingle forest (list 264). The only estimates of density are 0.88 birds/ ha in open jarrah forest and 0.08 birds/ ha in low woodland.

Grallina cyanoleuca MAGPIE-LARK

Magpie-larks are unlikely to have been an original inhabitant of the forest (lists 6, 8, 11). Following clearing for agriculture and towns they rapidly penetrated the south-west, reaching Albany in 1910 (list 11), Lake Muir in 1919 (list 11), Bickley in 1920 (Serventy 1948), Bridgetown in 1925 (Serventy and Whittell 1976) and Karridale in 1954 (Storr 1954). This species does not invade – even temporarily – forest when burned or logged, including clearfelled coupes. It has nonetheless been noted as vagrant (single birds) in jarrah (4 records), yarri (1 record) and red tingle (1 record) forest east of Walpole (lists 260–262). This species requires sparsely vegetated damp lands which are now plentiful as pastures, lawns and recreation grounds (e.g. list 271). Median density is 0.08 birds/ ha (range 0.04–0.13, N = 3, for woodland and heath areas near forest: lists 167–168).

Pteropodocys maximus GROUND CUCKOO-SHRIKE

Ground cuckoo-shrikes are vagrant in the forest at Bridgetown (farmland, list 17) and John Forrest National Park (jarrah forest, list 171). This species is not a forest bird.

Lalage tricolor WHITE-WINGED TRILLER

White-winged trillers are not likely to have occurred in the primaeval forests, for several reasons: (1) they were first recorded within the forest region of the south-west by Whittell (list 17) in the late 1920s; (2) they are usually recorded in partially cleared areas such as farms, towns, and road verges (lists 17, 22, 41, 75; Biddiscombe 1985).

This migratory species visits (and breeds in) the south-west in spring and summer but is uncommon and does not occur every year. For example, it was only recorded breeding once in Bungendore Park, in November 1995. It has been recorded in jarrah, yarri, karri and wandoo, especially after moderate to high intensity fires which scorch the forest canopy. The ensuing defoliation temporarily opens up the forest and thus provides suitable habitat (lists 75, 121, 182; personal observation in Proprietary forest block east of Collie). Trillers have also been observed in dieback-affected jarrah forest (density of 0.83 birds/ ha), which resembles woodland, the true habitat of this species. Brown and Brown (1976–1990) recorded that this species prefers roadside trees for nesting.

The records near Central and Chester forest blocks (lists 157, 165) together with two records 20 km south of Margaret River (*WABN* **79**, p. 3), one record near Augusta (*WABN* **85**, p. 25), and one record of one bird in spring 1985 in jarrah forest near Walpole (list 260) are well south of the southern limit given by Storr (1991).

Artamus personatus MASKED WOODSWALLOW

Masked woodswallows are not a forest species but have been recorded as vagrant near Wooroloo (several hundreds in one flock, list 21), Pickering Brook and south of Avon Valley National Park (Milhinch 1983b), and near Bannister (Serventy 1948).

Artamus cinereus BLACK-FACED WOODSWALLOW

Black-faced woodswallows are vagrant to the forest, having been recorded in jarrah or wandoo at Julimar (*WABN* **60**, p. 11), extreme north-east sector (list 40), near Mt Saddleback (list 61), pasture west of Churchman forest block (Slater 1962), Bungendore Park (list 271), near Willowdale (list 47), Federal forest block (list 234), east of Collie (list 243), and north-east of Augusta (list 165). Storr (1991) provides other records: 52 km ESE of Karragullen; Bannister; Quindanning; Kojonup; and specimens collected at the turn of the century from Wandering and Williams. Note that some of these records may be of misidentified Dusky woodswallows.

Cracticus torquatus GREY BUTCHERBIRD
Grey butcherbirds were not an original inhabitant of the forest because their habitat is woodland (coastal and inland). With clearing of forests for agriculture this species has spread into the forest block since the 1930s (Storr 1991). However, it rarely occurs in forest away from farms and towns and does not even colonize forest that has been logged. The only available estimate of density is 0.06 birds/ ha (list 165).

Cracticus nigrogularis PIED BUTCHERBIRD
Pied butcherbirds were recorded at Carmel (2 birds, Serventy 1948) and once (1 bird) in jarrah forest near Mt Saddleback (list 61). Possibly this latter record was of a Grey butcherbird, which was not listed. A record published by Saunders and Ingram (1995), apparently near Nannup, requires substantiation.

Corvus bennetti LITTLE CROW
Little crows were listed for jarrah and karri forest either without comment (lists 31–32) or with the remark that this species is a bird of passage in early summer and midsummer/autumn (lists 38–39). Storr (1991) recorded this species as occurring south to Harvey and Boyup Brook. This is not a forest species, but it does approach the forest very closely, as at Maddington (Serventy 1928). Records published by Saunders and Ingram (1995) for the forest require substantiation.

Anthus novaeseelandiae RICHARD'S PIPIT
Richard's pipit is unlikely to have been an inhabitant of the primordial forest, as it is commonly recorded on farmland, road verges, and around dams within the forest. Carter (list 11) recorded that with settlement this species extended its range as the timber was burnt off. At Bickley, pipits appeared to increase with the spread of pasture (Serventy 1948). This species invades and breeds in clearfelled karri forest (lists 68, 126, 244–245); however, after about 2–3 years the regeneration becomes too thick and the amount of open ground is insufficient for persistence. This species also breeds in newly rehabilitated bauxite minesites while the understorey remains sparse. It disappears after 2 years (Kabay and Nichols 1980). Although this species is common in coastal habitats around Walpole (Wardell-Johnson unpublished), it was recorded only twice (as single birds) in nearby jarrah forest (list 260). Pipits were probably vagrants in the primaeval forest, occurring occasionally on heaths and rocky areas after fire had temporarily reduced the extent and height of vegetation. The only available density estimate is for heath: 0.03 birds/ ha (list 168).

Taeniopygia guttata ZEBRA FINCH
Zebra finches have been recorded as vagrant at Lake Muir (1916, list 11), Pemberton (2 birds, probably aviary escapes, *WABN* **74**, p. 3), and Piesse Brook (*WABN* **86**, p. 4). This species is not a forest bird.

Neochmia temporalis RED-BROWED FINCH
Red-browed finches were introduced in the 1950s from eastern Australia into farmland in jarrah forest in Kalamunda forest block, where they still breed (Dell 1964, *WABN* **45**, p. 3).

Cheramoeca leucosterna WHITE-BACKED SWALLOW
White-backed swallows are vagrant in the forest, having been recorded 15 km NW of Williams (Storr 1991), just east of the forest and 11 km WSW of Denmark (5 birds flying over farmland, Dell 1980).

Hirundo ariel FAIRY MARTIN
In the primal forest, Fairy martins were likely to have been vagrant and then mostly at the forest/woodland interface. The only breeding record is in a cave on the west bank of Frankland River, 3.2 km from the mouth [i.e. where it enters Nornalup Inlet]; this record (list 10) is actually just south of the present South Coast Highway and is therefore outside the forest. Other records are from the Yallingup area (list 12), Gorrie forest block – 6 birds perched in March 1986 (list 182), Poole forest block – jarrah forest (list 192), and sedgeland in Jane and Frankland forest blocks (lists 200, 202).

Cinclorhamphus mathewsi RUFOUS SONGLARK
Rufous songlarks are unlikely to have been present in the primaeval forest. They are currently recorded in partially cleared farmland, as near Gorrie (list 182) and Churchlands (list 40) forest blocks in the northern forests, and near Kingston (*WABN* **71**, p. 2), Diamond (list 41, breeding) and Central (list 168) forest blocks in the southern forests. Serventy and Whittell (1976) noted that this species occurs in cleared country near Boyup Brook and Bridgetown, apparently having penetrated westwards from Kojonup and Arthur River. This species is a migrant.

Cinclorhamphus cruralis BROWN SONGLARK
Brown songlarks are most unlikely to have occurred in the primaeval forest. However, with clearing their habitat requirements are met. There is only one record, 22 km NNE of Manjimup (near Kingston forest block), where one female was definitely observed in November 1993 by M. Craig (*WABN* **71**, p. 2 and personal communication). This species is a migrant.

Waterbirds

Stictonetta naevosa FRECKLED DUCK
Freckled ducks are infrequent visitors to the forest, having been recorded on Lake Yeagerup (1 bird, list 72), Lake Qualeup (2 birds, *WABN* **29**, p. 9), Harvey Dam (Storr 1991), and Little Darkin swamp in Flynn forest block (2 birds, *WABN* **86**, p. 3).

Cygnus olor MUTE SWAN
Mute swans, introduced to WA early this century, were recorded in 1971–1972 at Lake Muir (2 birds, Storr 1991).

Nettapus pulchellus GREEN PYGMY GEESE
Green pygmy geese have been reported only once in the forest, at Lake Muir in 1911 (list 11).

Chenonetta jubata AUSTRALIAN WOOD DUCK
Although Gilbert (MS) provided the Perth aboriginal name for this species, Australian wood ducks were first reported definitely in the forest in the 1930s near Bridgetown (list 17). According to Storr (1991) they were first recorded breeding in 1950, at Manjimup. Since then this species has been observed frequently, usually on pasture and around farm dams, though it does occur in sedgeland (list 200) and wetlands between Darkan and Albany. It is common at Logue Brook and Samson Brook dams (Dames and Moore 1978), and uncommon at Bungendore Park (list 271).

Malacorhynchus membranaceus PINK-EARED DUCK
Although Pink-eared ducks were present in the south-west in the 1840s (Gilbert records an aboriginal name from Perth), they were first reported in the forest in 1912 (Lake Muir, list 11). Since then they have mostly been recorded in wetlands at the extreme eastern margin of the forest between Darkan and Albany, with one record from a swamp near Manjimup (Serventy 1952). Breeding has been noted at Towerrining Lake, Deadmans Swamp and Moodiarrup Swamps.

Podiceps cristatus GREAT CRESTED GREBE
Although Gilbert (MS) recorded an aboriginal name for this species from Perth, Great crested grebes were originally irregular visitors to the South West Land Division. Carter (list 11) reported only three occurrences up to 1919. The only records since then from the forest are of 1–20 birds on wetlands at the eastern margin of the forest (Darkan to Albany), at Wilgarup Lake (*WABN* **82**, p. 16), at Lake Muir (*WABN* **86**, p. 22), and at Karakamia Sanctuary (list 259).

Phalacrocorax varius PIED CORMORANT
Pied cormorants are a coastal species, but they have been recorded once at Lake Muir Nature Reserve (list 133, 4 birds total) in the eastern sector of the forest.

Pelecanus conspicillatus AUSTRALIAN PELICAN
Australian pelicans are not known to have ever bred in any wetland within the forest. They only visit wetlands at the extreme eastern region of the forest, between Darkan and Albany, as well as occurring on estuaries south of the forest. The largest number seen is 46 birds at Byenup Lagoon (list 186).

Ardea pacifica WHITE-NECKED HERON
White-necked herons are infrequent visitors to the forest, usually singly or in small groups of up to 3 birds. In some years there is an irruption and large numbers appear (Serventy 1952), apparently as a result of drought in eastern Australia (Dell 1985). The largest flock recorded in the forest consisted of *c.* 50 birds (Christensen *et al.* 1985). This species is most often recorded on farms (dams, shallow inundated pasture). Records from natural situations (swamps, lakes) are all from the southern forest: Bridgetown (list 17), Cowerup Swamp (Christensen *et al.* 1985), Lake Muir Nature Reserve (list 133), Cobertup Swamp Nature Reserve (list 135), Unicup Lake (list 139), Moodiarrup SE swamp (141) and Higgins Swamp (*WABN* **73**, p. 2). The only record of breeding is from Moodiarrup SE swamp (list 141).

Ardea alba GREAT EGRET
Great egrets were first reported in the forest in the Donnybrook sunklands (list 26), presumably in pasture. This species has also been recorded on inundated pastures near Crystal Springs and Manjimup (list 73), at Karakamia Sanctuary (list 259), and on lakes and swamps between Darkan and Lake Muir in the eastern sector of the forest. According to Storr (1991), Great egrets were only a very rare and infrequent visitor up to 1917. Gilbert (MS) reported a 'large black legged' *Herodias*.

Ardea ibis CATTLE EGRET
Cattle egrets first appeared in the south-west in 1952 (Storr 1991), with a conspicuous irruption in 1959 (Jenkins and Ford 1960). Records in the forest come from Moodiarrup Swamps and Grasmere Lake in the extreme eastern sector, and from Collie, Middlesex, Northcliffe, Walpole, Nornalup and Denmark (up to 8 birds, always associated with farm animals).

Threskiornis aethiopicus SACRED IBIS
Sacred ibis were first recorded in the south-west in 1952 (Storr 1991). The only forest occurrences come from four wetlands in the extreme eastern sector, between Darkan and Albany, and at the southern margin of the forest (list 72).

Threskiornis spinicollis STRAW-NECKED IBIS
Straw-necked ibis were first reported in the south-west in 1892 (Storr 1991) and in the forest in 1911 (Lake Muir, list 11). Since then this species has been recorded sporadically: at Bickley in 1945 (Serventy 1948); at Northcliffe, Nornalup and Denmark in 1952 (Serventy 1952); on farmland (pasture) in the forest near Wooroloo (list 21); in streams in the extreme north-east sector of the forest (lists 40, 259); and rather more frequently in the southern forests (pastures; wetlands between Darkan and Albany, with 71 seen at Middlesex near Manjimup [*WA Bird Report* **1982**, p. 12]).

Plataleia regia ROYAL SPOONBILL
Royal spoonbills were first reported in the south-west by Gilbert (MS) and not in 1924 as stated by Storr (1991). The only record in the forest comes from wetlands 17 km north-east of Augusta (list 166).

Plataleia flavipes YELLOW-BILLED SPOONBILL
Yellow-billed spoonbills were first recorded in the south-west in 1920 but remained scarce until 1965 (Storr 1991). Nearly all forest records come from the eastern margin of the forest (Karakamia Sanctuary; wetlands between Darkan and Albany, particularly Lake Muir [Johnstone, personal communication]). There is also a record from Wilgarup Lake (*WABN* **82**, p. 16).

Gallirallus philippensis BUFF-BANDED RAIL
Although Gilbert (MS) provides a Perth aboriginal name for this species, Buff-banded rails are apparently vagrant to the forest, as they have been reported only three times: Grasmere Lake (list 132 and *WABN* **33**, p. 3) and in the Frankland area (*WABN* **53**, p. 2). The only breeding report (1984) pertains to farmland near Diamond forest block (Brown and Brown 1976–1991).

Gallinula tenebrosa DUSKY MOORHEN
Dusky moorhens were not noted by Gilbert in the 1840s, presumably indicating that this species did not occur in the south-west. They were first reported by Carter (list 11) in 1919 as numerous in swamps near the mouth of the Warren river, to the south of the forest, and as locally distributed elsewhere in suitable habitat. Whittell recorded this species as resident in small numbers near Bridgetown (list 17).

Since then Dusky moorhens have mainly been reported from dams on farmland (lists 30, 40, 41, 77), streams (lists 30, 40) and a few swamps in the extreme eastern sector of the forest (Moodiarrup Swamps, Yarnup Lagoon and Grasmere Lake, 1–6 birds).

Cladorhynchus leucocephalus BANDED STILT
Banded stilts breed in the semi-arid interior (Storr 1991) but occur in the forest (in aggregations usually up to 160) in dams and wetlands in the extreme eastern sector. In March 1998 more than 5 000 birds were reported at Lake Muir (*WABN* **86**, p. 3).

Recurvirostra novaehollandiae RED-NECKED AVOCET
Red-necked avocets breed in the semi-arid interior (Storr 1991) and occur in autumn (often in large numbers, up to 1 200) in wetlands between Lake Muir and Albany at the eastern margin of the forest.

Vanellus tricolor BANDED LAPWING
Banded lapwings were first recorded in the south-west in 1895 (Storr 1991). They were first reported in the forest at Lake Muir in 1912 (list 11), apparently on farmland. Since then this species has been recorded only a few times within the forest (including Bickley, Serventy 1948) but always on cleared land (pasture, recreation grounds, orchards). This species occurred abundantly in paddocks around Julimar, Dwellingup, Bowelling, Newlands, Balingup, Bridgetown, Boyup Brook, Dinninup, Pemberton and Nannup until the fox established in the 1940s. Christensen *et al.* (1985a) recorded this species as common and it has been reported recently near Bakers Hill, Collie, McAlinden, Boyup Brook, Kulikup, Dwalganup and Northcliffe.

Charadrius rubricollis HOODED PLOVER
Hooded plovers are known to occur in the forest only at Lake Kwornicup (at the eastern margin of the forest). They usually are present in small numbers (2 birds), with the greatest aggregation recorded as 78 birds. This species does not breed at Lake Kwornicup (*WABN* **77**, p. 13; **79** supplement, 14; **81**, p. 3).

Larus novaehollandiae SILVER GULL
Silver gulls are normally a coastal species, but have been recorded as breeding at Lake Muir (list 11) and Moodiarrup Swamps (list 141). They have also been reported as present in large numbers (up to 700 birds) in wetlands at the extreme eastern margin of the forest between Darkan and Albany.

Sterna bergii CRESTED TERN
Crested terns have been recorded occasionally at Lake Muir (list 11, Christensen *et al.* 1985a). They are normally a coastal species.

Sterna hybrida WHISKERED TERN
Whiskered terns are vagrant to the forest, though sometimes present in large numbers (up to 80 birds), at Lake Muir Nature Reserve (lists 133, 186) and Towerrining Lake Nature Reserve (list 134). Single birds were noted over a farm dam near Diamond forest block in April 1987 and March 1988 (Brown and Brown 1987–1988).

Species Inclusions and Exclusions

As already indicated in the above species commentaries, several species have been included or excluded on the basis of meagre information. Those species that have been included but may not have been part of the primaeval forest avifauna are *Anhinga melanogaster* (Darter) and *Nycticorax caledonicus* (Rufous night heron). If these two species are not accepted as members of the primordial forest avifauna, they should be transferred from Tables 1 and 2 to Table 4. Six species are not recognized by me as members of the primal forest avifauna but perhaps should be considered as species *in statu inquirenda: Hamirostra isura* (Square-tailed kite), *Oreoica gutturalis* (Crested bellbird), *Malacorhynchus membranaceus* (Pink-eared duck), *Podiceps cristatus* (Great crested grebe), *Gallirallus philippensis* (Buff-banded rail) and *Gallinula tenebrosa* (Dusky moorhen). Other scientists may differ in their interpretation of the original status of these species in the south-west forests.

DISCOVERY AND TAXONOMY OF SPECIES

Although the avifauna of south-west WA began to become known during the visits of the navigators Vlamingh (1696), Vancouver (1791), Baudin (1801, 1803), Flinders (1801) and d'Urville (1826), substantial progress in documenting, discriminating and describing species did not take place until the visit of John Gilbert in 1839. Gilbert obtained the first records of about 65 per cent of the bird species present in the primal forests (Fig. 9). That he did this, despite spending less than 10 per cent of his time in the forests, is a remarkable demonstration of the broad distribution of forest bird species in the south-west generally.

It has taken considerably longer to clarify the significance of variation in plumage and morphology in south-west populations of birds. Earlier workers

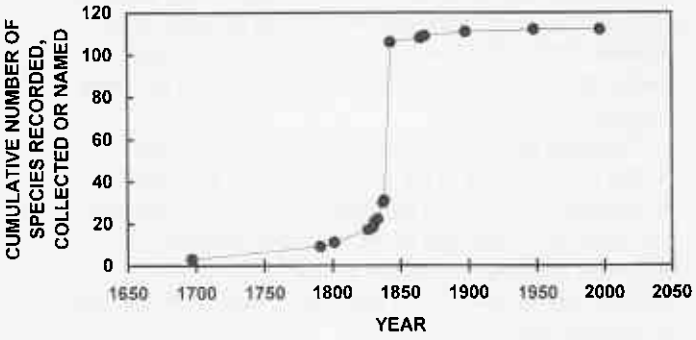

Figure 9. Most bird species present in south-west Western Australia were first recorded, collected or named within 20 years of European settlement. Information up to 1839 has been extracted from Alexander (1914, 1916, 1918).

recognized a high proportion of bird species as being distinctive and confined to south-west WA. Subsequent collection of specimens from elsewhere in WA and from other parts of Australia has provided the essential context for more considered taxonomic judgements. Cataloguing the diversity of nature was held to be important science up until the Great War, after which it became unfashionable because it was considered insufficiently analytical and theory-laden. There was laudable zeal for collecting specimens but excessive pre-occupation with naming entities and sub-entities, with the result that trivial variation was formally differentiated and named, often to prevent others from gaining priority. This approach was replaced by the advent of the 'new systematics' in the 1930s.

The taxonomist G. M. Mathews created many monotypic genera and assigned 48 per cent of forest landbird and 16 per cent of forest waterbird species a trinomen to characterize south-west Western Australian populations (Mathews 1912). Towards the end of his life he recognized 73 per cent and 42 per cent respectively of the primaeval forest land and waterbird faunas as endemic at the subspecies level (Mathews 1946). It was later demonstrated that isolates in south-west WA existed for 36 per cent and 9 per cent of landbird and waterbird species respectively (Keast 1961). Current views (Storr 1991, amended by Johnstone in press) are that moderately-differentiated isolates in south-west WA (i.e. valid, endemic subspecies) are recognized in only 20 per cent of landbird and 6 per cent of waterbird forest species. These taxa (none of which is (or was) confined to the primordial forests of south-west WA) are as follows:

Landbirds

Calyptorhynchus banksii naso
Cacatua pastinator pastinator
Platycercus zonarius semitorquatus
Platycercus icterotis icterotis
Platycercus icterotis xanthogenys
Stipiturus malachurus westernensis
Pardalotus striatus westraliensis
Phylidonyris nigra mystacalis
Anthochaera chrysoptera lunulata
Petroica multicolor campbelli
Eopsaltria australis griseogularis
Falcunculus frontatus leucogaster
Rhipidura fuliginosa preissi
Cracticus tibicen dorsalis
Strepera versicolor plumbea
Corvus coronoides perplexus

Waterbirds

Rallus pectoralis clelandi
Porphyrio porphyrio bellus

Modern taxonomists such as Sibley and Monroe (1990) apply the superspecies concept and treat *Calyptorhynchus latirostris* and *C. baudinii* as endemic allospecies of *C. funereus*, *Malurus elegans* as an endemic allospecies of *M. lamberti*, *Acanthiza inornata* as an endemic allospecies of *A. reguloides*, and *Melithreptus chloropsis* as an endemic allospecies of *M. lunatus*.

Abbott (1974) analyzed, using a multivariate approach, geographical variation in several of the above species. Subspecies endemic to south-west WA appeared unwarranted for *Anthochaera chrysoptera, Cracticus tibicen* and *Strepera versicolor*. This study did lend support to the recognition of *Phylidonyris nigra mystacalis* and *Eopsaltria australis griseogularis* and indicated that the south-west isolate of *P. novaehollandiae* should have subspecific status.

The lower south-west corner of Australia has acted as a high rainfall refuge during past periods of aridity, separated from the remainder of Australia by the so-called Murchison and Nullarbor barriers (Keast 1961; Ford 1987a). This has meant that species confined to this refuge during arid periods have then had the opportunity to expand in range during the subsequent pluvial period. Previously isolated populations have then come into contact with inland populations, thereby testing the degree of genetic divergence. For example, Bowler (1982) suggested that 30–50 ka BP, the forest was much more extensive than now, whereas 18 ka BP it had disappeared and had been replaced by woodland. It is therefore not surprising that only one unequivocal hybrid zone is known in the forested sector of the high rainfall refuge (Ford 1987a; Storr 1991): *Platycercus zonarius zonarius* and *P. z. semitorquatus* hybridize north of Armadale-Williams.

Two instances are known of apparent double invasions of the high rainfall south-west refuge (Serventy and Whittell 1976). *Eopsaltria georgiana* is thought to represent an early isolate of *E. australis*, with *E. a. griseogularis* the later invasion from south-east Australia. Less certainly, *Calyptorhynchus baudinii* and *C. latirostris* respectively represent early and later invasions (Ford 1980, 1987a).

Few instances of variation have been documented. *Eopsaltria australis* shows geographic variation in the colour of the rump (Ford 1963), the south-west population of *Dromaius novaehollandiae* has darker plumage than elsewhere, and *Platycercus icterotis* shows geographic

variation in plumage coloration (Johnstone, personal communication). Two instances of disjunct populations (distinct subspecies) in south-west WA are known. The southern population of *Cacatua pastinator* is larger than the northern one (Ford 1985, 1987b), and the southern population of *Calyptorhynchus banksii* has a larger bill and brighter female plumage. Extensive clearing in the wheat-belt has led to expansion in geographic range of both northern populations (*Cac. p. butleri* and *Cal. b. samueli*)[33]. These may in the near future make contact, *via* the eastern margin of forest now cleared for agriculture, with the southern populations and hybridize. A similar prospect may apply to *Calyptorhynchus latirostris* and *C. baudinii*.

Over the whole of continental Australia, most isolates (i.e. populations isolated from the main population by a geographic barrier) occur in eucalypt forests and woodlands (Keast 1961).

BIOGEOGRAPHY

Biodiversity is primarily structured by habitat, itself chiefly influenced by soil type, topographic variation, climatic gradients, and disturbance regime.

Distribution Patterns within the Primaeval Forests of South-west Western Australia

Nearly 52 per cent and 35 per cent of landbird and wetland species respectively occurred throughout the original forest (Table 5). A further 25 per cent and 39 per cent occurred only in the eastern sector of the forest. Species restricted to the southern forests accounted for an additional 9 per cent and 19 per cent. These three distribution patterns account for nearly 90 per cent of the landbird avifauna and nearly 95 per cent of the wetland avifauna. There is no altitudinal gradient in bird species distribution, which is not surprising, as most of the forest lies within 20 to 300 m above sea level, with the highest peak only 582 m.

Six species have (or had) extremely disjunct distribution in the northern/eastern and southern forests: *Coturnix novaezelandiae* (Stubble quail), *Eurostopodus argus* (Spotted nightjar), *Atrichornis clamosus* (Noisy scrub-bird), *Phylidonyris melanops* (Tawny-crowned honeyeater), *Nycticorax caledonicus* (Rufous night heron) and *Porzana pusilla* (Baillon's crake). These distributions, however, are likely to be artefacts resulting from misidentifications or inadequate survey effort.

Distribution Patterns in South-west Western Australia

Only one of the 112 bird species present in the original forest was confined to it (*Calyptorhynchus baudinii* Baudin's cockatoo, as a breeding species). All other species ranged to the west, north, east and/or south of the forest (Tables 6, 7). This broadness of distribution accords well with postulated major changes in the extent of eucalypt forests in south-west WA during the past 30 ka (Bowler 1982). The absence of obligate interior-forest species from these forests is in contrast to forests in North America.

The most predominant patterns of occurrence were WNES (i.e. breeding to the west, north, east and south of the original forest) for 68 per cent of the landbird species and WNE for 55 per cent of the waterbird species. The categories WNE accounted for a further 20 per cent of landbird species and WNES fitted an additional 36 per cent of waterbird species.

The species richness gradient for landbird species (Fig. 10) reveals a broad part of the lower south-west, including the forest, with 46–60 landbird species present. The forest landbird fauna is clearly impoverished relative to the majority of the South West Land Division. The reverse pattern applies to waterbird species (Fig. 11), with species richness greatest (22–25 species) in the wetter lower south-west. These trends are consistent with Christensen *et al.*'s (1985a) analysis showing little variation in species richness within the forest, but *c.* 25 per cent more species present on the Swan Coastal Plain. The proportion of species shared between 'faunal zones' averaged about 50 per cent. These findings are not compelling evidence for zonation of the south-west Western Australian avifauna.

Placed in a continental context (Gentilli 1992), this south-west regional gradient is of trivial significance. Consistent with this is the correlation of turnover of bird species in jarrah and karri forests with distance between sites but not with differences in vegetation structure between sites (Cody 1993).

Based on the new interpretations of the breeding geographical range of each bird species present in the primaeval forest (documented above), the species richness gradient for landbirds decreases from east to west (Fig. 12). The species richness gradient for waterbirds (Fig. 13) shows that most species occur in the south-east of the primaeval forest where the largest wetlands occur. These gradients do not agree with those at a continent-wide scale (Pianka and Schall 1981): species richness of birds increased with increasing rainfall but decreased with increasing variability of rainfall at this broad scale.

Comparison of Forest Avifaunas across Southern Australia

Lists of bird species breeding in forest (defined broadly as forest, woodland, heath and wetland present in the forest ecosystem) were compiled from reliable published sources.

South-east Australia: A region equal in area to the original area of forest in south-west WA and covering the same latitudes (31° 30'–35 °00' approx.) was chosen in New South Wales, roughly from Port Macquarie south to Nowra and inland to Orange and Cootamundra. At the beginning of European settlement, this region included a mixture of large patches of forests and woodlands (AUSLIG 1990) comprising 75 forest communities (Specht *et al.* 1995).

[33] As discussed earlier, *Cacatua pastinator* originally occurred widely throughout south-west Western Australia. It thus seems likely that the two subspecies currently recognized are the ends of a cline and hence may not be valid.

There is no equivalent of the synthesis by Storr (1991) for this region, so Kinghorn (1924), Hindwood (1931), Marshall (1932), Chisholm (1934), Hyem (1936, 1937), Hindwood and McGill (1958), Kikkawa (1968, Barrington area), Heron (1973), Morris (1975), Gibson (nd), Hoskin (1991), and Ford and McFarland (1991, Nundle area) were used. Mangrove species and open country or woodland species marginal to the western part of the region were excluded, but species in heath or woodland encircled by forest were included (the same criterion applied in WA).

Tasmania: Thomas (1979), Sharland (1981) and Green (1989b) were used. The estimated pre–1750 area of forest in Tasmania is 4.8 M ha (Anon. 1997), comprising 34 forest communities (Specht *et al.* 1995).

Mount Lofty Ranges: Anon. (1977), Stove (1994), Parker *et al.* (1979) and Parker *et al.* (1985) were used. Forest was defined on the basis of a map provided in Anon. (1977); the original area involved is 250 000 ha. This region supports only 5 forest communities (Specht *et al.* 1995).

Great care was taken to avoid including vagrant species or species which have colonized these regions following settlement by Europeans. However, there are bound to be misinterpretations on my part. I have therefore published the lists used (Table 8) so that they can be emended as necessary.

Comparison of the lists assembled shows that the forests of south-west WA have only 54 per cent of the number of species present in a similar sized area in south-east Australia. This is lower than the estimate of 70 per cent provided by Keast (1966) or the estimate of 68 per cent calculable from data in Pianka and Schall (1981, p. 1678; cells L2 *vs* L16), and is more comparable to the size of the Tasmanian forest landbird fauna relative to that of southern Victoria (56 per cent). The similarity between the south-west and south-east forest avifaunas is 0.51 (calculated as the number of landbird species common to the two lists divided by the mean number of species per list). The areographic analysis of Anderson and Marcus (1992) also demonstrates (their Fig. 7) the depauperate nature of the south-west Western Australian avifauna.

Occurrence of South-west Forest Species outside Western Australia

Of the 81 land bird species present in the primal forests of south-west WA, 65–67 are shared with South Australia, New South Wales and Victoria (Table 6), followed by Queensland (62), Northern Territory (45) and Tasmania (43). New Guinea holds only 23 species in common. Africa, Eurasia and the Americas share only 2 species.

The 31 waterbird species breeding in the primordial forests of south-west WA have a wider distribution than the land birds (Table 6): New South Wales and Queensland (31), South Australia and Victoria (30), Tasmania (26), Northern Territory (22), New Guinea (16), Eurasia (9), Africa (7) and the Americas (1).

Bassian, Eyrean and Torresian Elements in the Avifauna of the Primordial Forests of South-west Western Australia

Hall (1928) demonstrated that the avifauna of south-west WA is more allied with that of south-east Australia than with that of the Kimberley. Subsequently, Serventy and Whittell (1976) indicated that south-west WA cannot be classified as a simple biogeographic region (part of the Eyrean region as proposed by Spencer) or as a unique region. Instead, the region is best characterized as an intermingling of Bassian, Eyrean and Torresian elements.

Categorizing species as Bassian, Eyrean or Torresian in distribution is an uncomplicated matter for many species. Bassian species are those breeding in the higher rainfall parts of South Australia, Victoria, Tasmania, New South Wales and Queensland. Eyrean species occur in the lower rainfall sectors of Australia, such as the north-west corner of Victoria, western NSW and western parts of Queensland. Torresian species tend to breed in the high rainfall parts of tropical WA, Northern Territory and Queensland, and the extreme north-east of NSW. Other species occur so widely that it is not possible to assign them unequivocally to one of the above categories.

Of the 112 species constituting the primaeval forest avifauna of south-west WA, nearly half (54 species) could not be assigned as Bassian, Eyrean or Torresian; perhaps some of these represent widespread elements of the Gondwanan avifauna. Most of the remainder are Bassian (43 species), followed by 12 Eyrean species and 3 Torresian species (Table 6). Evidently as the climate of the south-west has fluctuated (particularly rainfall, e.g. Churchill 1968) there have been extinctions of some Bassian species, invasions of Eyrean species, extinction of some of these Eyrean species, and invasion by a few Torresian species (Kikkawa and Pearse 1969; Serventy and Whittell 1976 and earlier editions). It is also possible that some of the species recognized as Eyrean may have evolved from an isolated south-west Bassian remnant which has later dispersed inland to varying degrees. Possible examples of this include *Climacteris rufa* (Rufous treecreeper), *Malurus splendens* (Splendid fairy-wren) and *Acanthiza apicalis* (Broad-tailed thornbill). In other instances the Eyrean element is manifested only at the level of subspecies e.g. *Eopsaltria australis griseogularis* (Yellow robin), *Daphoenositta chrysoptera pileata* (Varied sittella) and *Colluricincla harmonica rufiventris* (Grey shrike-thrush).

The lower south-west of WA is unique because of the occurrence of two Eyrean species which have adapted to the high rainfall environment. These species are *Leipoa ocellata* (Malleefowl) and *Pomatostomus superciliosus* (White-browed babbler).

Although the forest landbird faunas of south-west WA, Mount Lofty Ranges and Tasmania are of similar size (69–90 species), the south-west forest avifauna is more similar to the Mount Lofty Ranges forest avifauna (0.56) than the Tasmanian one (0.45). This probably reflects the Eyrean species shared by south-west WA and the Mount

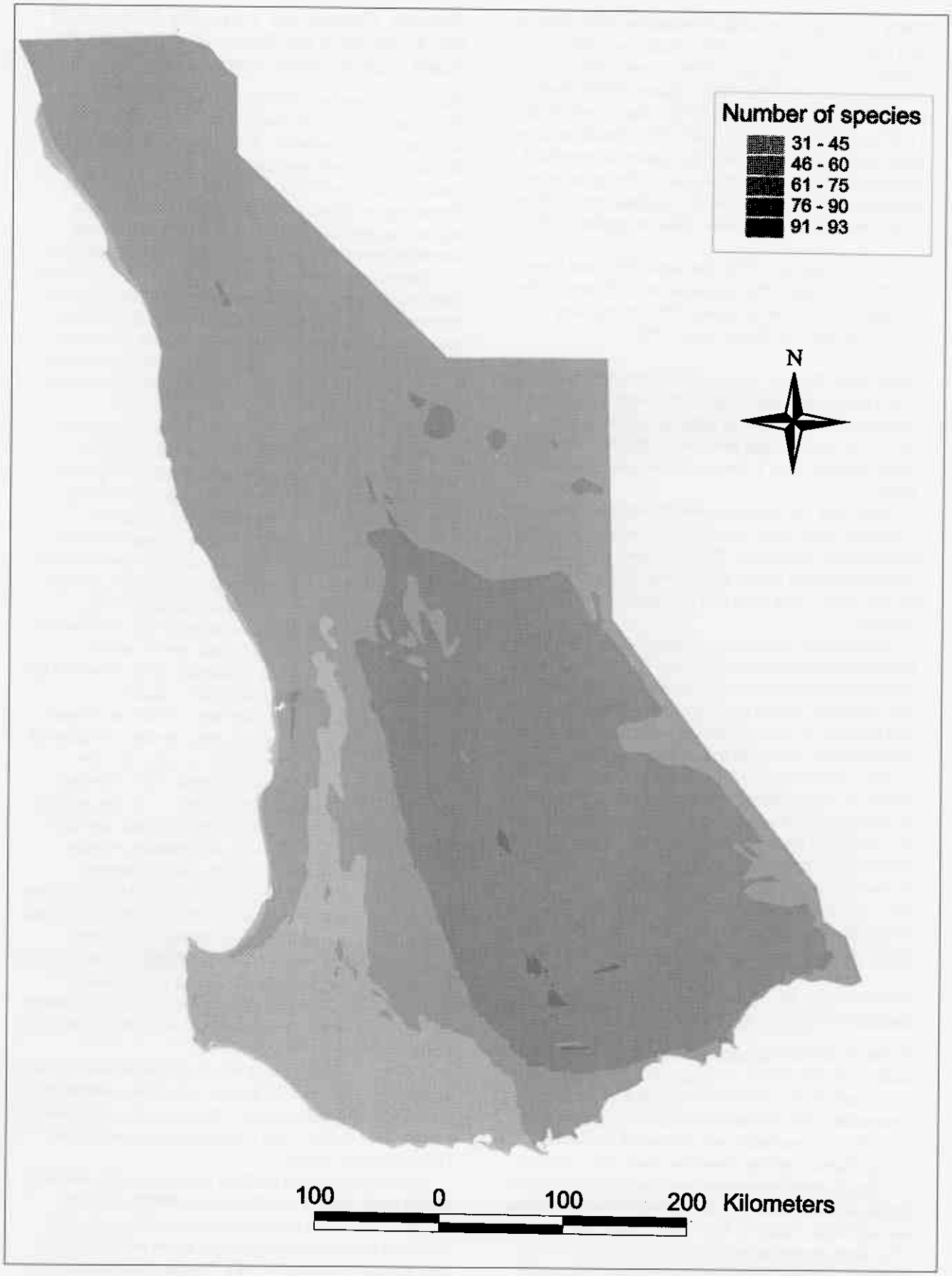

Figure 10. Species richness gradient for landbird species in the South West Land Division (based on original distributions as summarized by Storr 1991). Map by J.P. Pigott 1997: derived from coverages created by Micromine P/L.

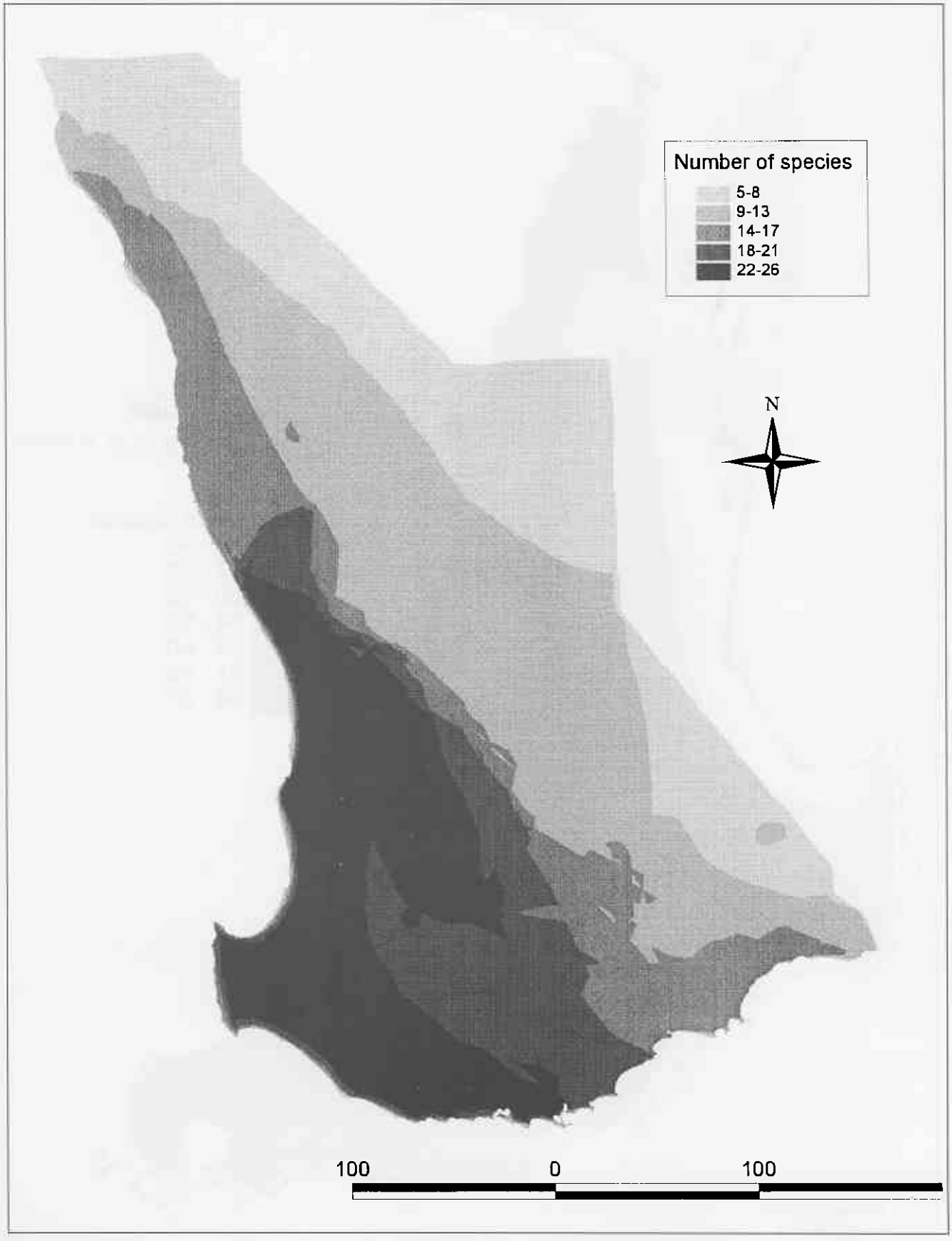

Figure 11. Species richness gradient for waterbirds in the South West Land Division (based on original distributions as summarized by Storr 1991). Note that this gradient is shown more broadly than it actually exists, as waterbirds breed only along streams or in or around lakes and swamps. Map by J.P. Pigott 1997: derived from coverages created by Micromine P/L.

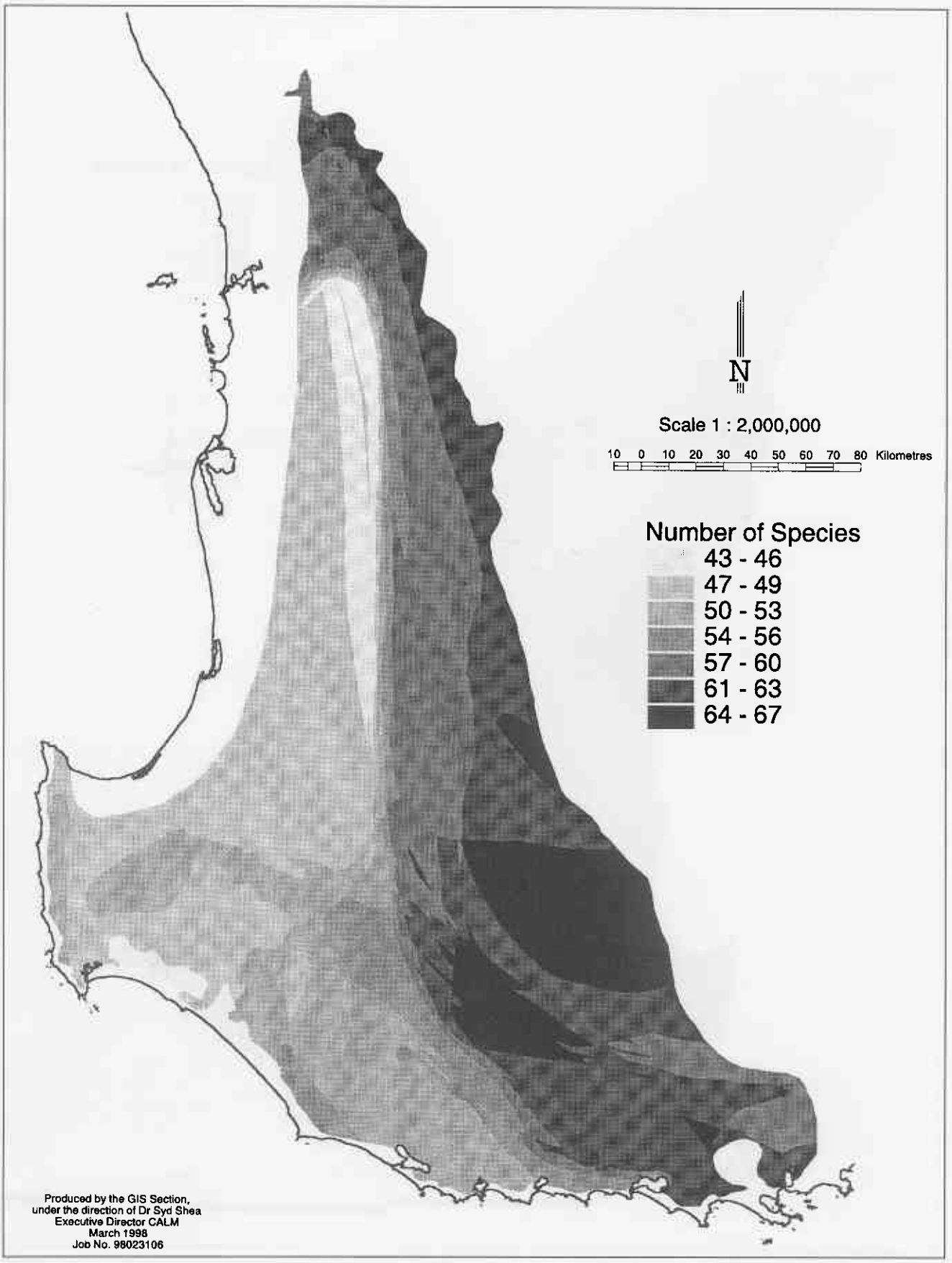

Figure 12. Species richness gradient for landbird species in the primaeval forest (based on interpretations justified in this paper).

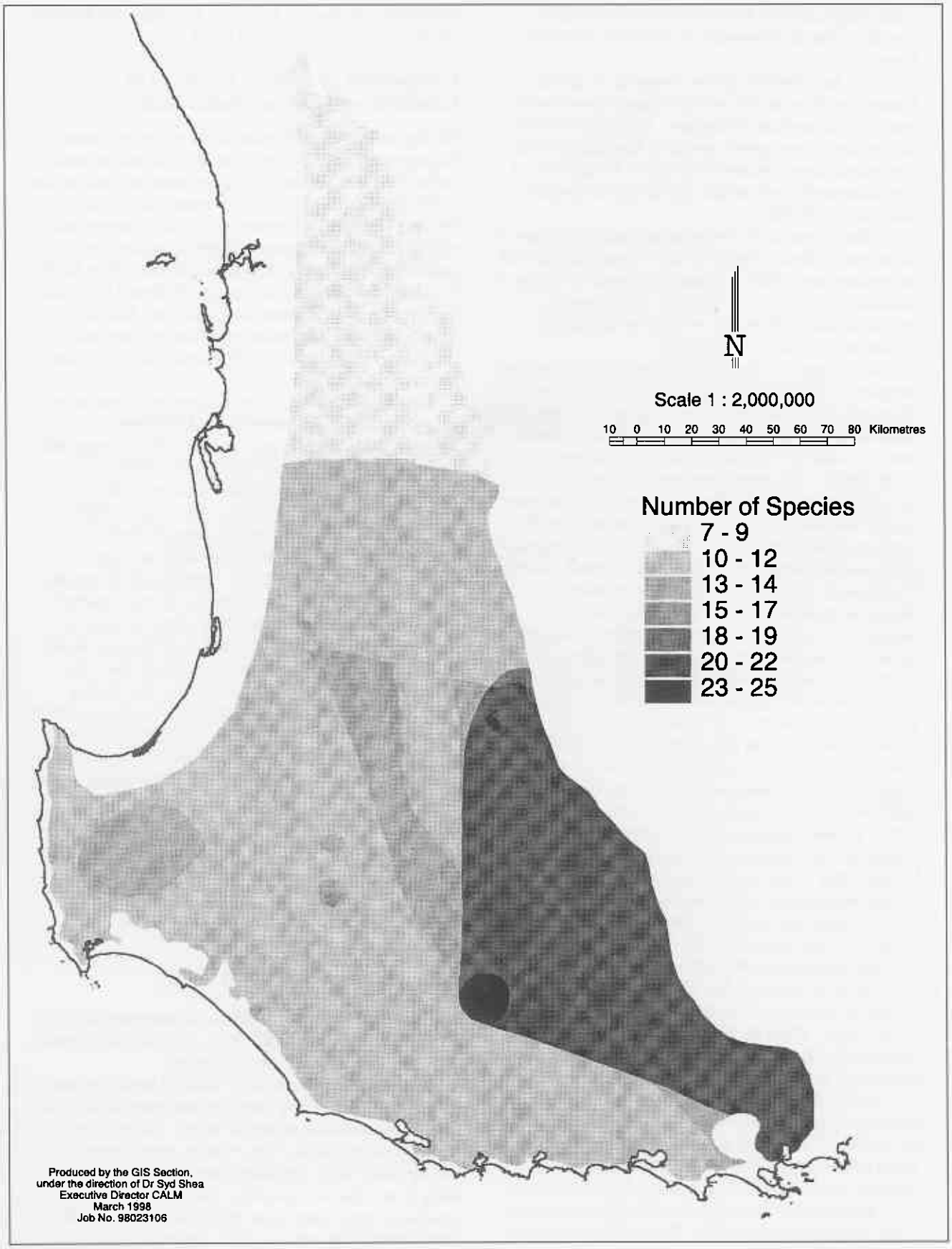

Figure 13. Species richness gradient for waterbird species in the primaeval forest (based on interpretations justified in this paper). Note that this gradient is shown more broadly than it actually exists, as waterbirds breed only along streams or in or around lakes and swamps.

Lofty Ranges, as both forests lie closer to semi-arid vegetation than do Tasmanian or south-east Australian forests.

All of the waterbird species present in the primal forests of south-west WA belong to genera shared with species in the northern hemisphere. It is therefore likely that species in these genera spread to Australia after the Gondwanan supercontinent broke up 55-60 Ma[34] BP. A few subsequently evolved into species (or subspecies) endemic to Australia.

Of the 35 species of non-passerine landbirds present in the primaeval forests, about half are in genera shared with the northern hemisphere. Presumably species in the genera *Haliastur, Chrysococcyx, Podargus, Eurostopodus, Aegotheles* and *Todiramphus* evolved in isolation in Gondwana or in parts of Gondwana.

The phylogeny of the passerines has been studied most completely (Sibley and Ahlquist 1985). Application of DNA technology has demonstrated that all but seven of the passerine species present in the primal forests of south-west WA radiated from an old endemic group present 55–60 Ma BP. This group continued to diversify, e.g. *Atrichornis c.* 40 Ma, *Artamus* 22 Ma BP. The seven species that have evolved from later invasions from the north are a finch *(Stagonopleura oculata),* a flowerpecker *(Dicaeum hirundinaceum),* 2 swallows *(Hirundo neoxena, H. nigricans),* 2 sylviids *(Acrocephalus stentoreus, Megalurus gramineus),* and a white-eye *(Zosterops lateralis).* Some of the Gondwanan species subsequently spread to the northern hemisphere and secondarily invaded Australia *(Coracina novaehollandiae, Corvus coronoides).*

South-west WA (as part of the Australian continent) gradually moved north (*c.* 55° S lat. 53–30 Ma BP; 45° S 21 Ma BP; 40° S 10 Ma BP; currently 35° S; Crook 1981). The northern sector of Australia reached the south-east corner of Eurasia (Sundaland) about 10 Ma BP. Forests in south-west WA lie on rocks 2.6 Ga old (Biggs and Wilde 1980). Without volcanic activity or other uplift, this plateau has been eroded to a broad peneplain (Bartle and Slessar 1989). These granites have subsequently been mantled with extensive deep laterites, developed under a tropical climate prevalent *c.* 25 Ma BP when covered with rainforest. Later uplift along the Darling Scarp rejuvenated drainage and dissected the lateritic regolith. Eucalypts are first detected in fossils 34 Ma BP, and the mediterranean climate of south-west Australia was established 5 Ma BP (White 1986). When the jarrah and karri forests came to dominate the Darling Plateau is not known, but presumably they cannot be older than 5 Ma.

Climatic changes in south-west WA have been extensive in the past (Wyrwoll 1979; Bowler 1982). From 80 to 20 ka BP there was an onset of arid conditions, which intensified 20–14 ka BP. Wetter conditions prevailed between 6 and 5 ka, with another arid phase up to 2.5 ka BP, followed by further wet/arid fluctuations up to the present (Churchill 1968). Thus, with such climatic instability, it is no surprise that many bird species cannot be classified as Bassian, Eyrean or Torresian, and that few species are confined strictly to forest.

Comparison of Species Richness of Landbirds at Various Spatial Scales

Having established differences in the size of avifaunas at biogeographic scales, I now compare avifaunas at smaller scales, from 2 ha upwards, using the same approach as that of Ford and Howe (1980). They assembled lists of breeding bird species (raptors, owls, quails, button-quails, nightjars, kingfishers, parrots, pigeons, cuckoos and passerines) for 22 areas of forest/woodland in New South Wales and the Mount Lofty Ranges. To these I have added lists for various sized areas from south-east Australia, compiled from gridded maps published by Aston and Balmford (1978), Anon. (1979), Norris *et al.* (1979) and Emison *et al.* (1987).

Lists for south-west Western Australian forests were compiled from information presented in Wardell-Johnson (1983), Nichols and Watkins (1984), Tingay and Tingay (1984), Abbott and Van Heurck (1985b), Christensen *et al.* (1985),Worsley Alumina (1985), Wykes (1985), Norwood (1991), Christensen (1992), Abbott (1995) and J. C. Serventy (unpublished).

The number of bird species breeding was then regressed against area (Fig. 14). Surprisingly the species impoverishment in Western Australian forests reported above at large (biogeographic) scales does not apply at smaller spatial scales (*c.* 1–100 ha). A 10 ha area should hold 20–25 breeding species irrespective of where the forest is in southern mainland Australia. This finding appears to indicate that the greater species richness of birds in eastern Australian forests arises from greater variety of forest types. According to Specht *et al.* (1995), the south-west forests of WA have only 3 forest communities present compared with 75 in south-east NSW. This large difference in between-habitat diversity is probably a function of more fertile soils, greater topographic relief, greater variation in annual rainfall, a larger area of forest, and greater proximity to New Guinea of the forests of eastern NSW.

HABITATS OCCUPIED

The following information updates the treatment provided by Kimber and Christensen (1977), for which only a small number of habitat types were recognized.

The habitats in which the 81 landbird species present in the primaeval forest have been recorded were listed in the species commentaries presented earlier. Eleven categories were recognized: jarrah, karri, wandoo, tingle, yarri and bullich forest; heath; sedgeland; wetlands; flooded gum along rivers; and rock outcrops. The number of species recorded in each habitat type varied from 5 to 70, with jarrah forest (70 species out of 81 species) having most species and rock outcrops (5) the least (Fig. 15). These differences probably reflect the extent of each habitat type and the number of observations made in each.

[34] Ma = 10^6 years; Ga = 10^9 years; ka = 10^3 years.

No species was recorded from all 11 habitat types (Fig. 16). *Pardalotus punctatus* (Spotted pardalote) was the most broadly distributed, being recorded in 9 types. Six species were recorded in 8 habitat types: *Phylidonyris novaehollandiae* (New Holland honeyeater), *Acanthorhynchus superciliosus* (Western spinebill), *Anthochaera chrysoptera* (Little wattlebird), *Corvus coronoides* (Australian raven), *Hirundo nigricans* (Tree martin) and *Zosterops lateralis* (Grey-breasted white-eye). The next most versatile suite of species (7 habitat types occupied) comprised *Falco peregrinus* (Peregrine falcon), *Platycercus zonarius* (Australian ringneck), *Platycercus spurius* (Red-capped parrot), *Platycercus icterotis* (Western rosella), *Todiramphus sanctus* (Sacred kingfisher), *Climacteris rufa* (Rufous treecreeper), *Malurus elegans* (Red-winged fairy-wren), *Stipiturus malachurus* (Southern emu-wren), *Pardalotus striatus* (Striated pardalote), *Sericornis frontalis* (White-browed scrubwren), *Gerygone fusca* (Western gerygone), *Acanthiza apicalis* (Broad-tailed thornbill), *Melithreptus chloropsis* (Western white-naped honeyeater), *Petroica multicolor* (Scarlet robin), *Pachycephala pectoralis* (Golden whistler), *Colluricincla harmonica* (Grey shrike-thrush), *Rhipidura fuliginosa* (Grey fantail) and *Strepera versicolor* (Grey currawong), 18 species in all.

Five species were associated with only one habitat type in the primal forest: *Circus approximans* (Swamp harrier) (wetlands), *Ninox connivens* (Barking owl) (jarrah forest), *Tyto alba* (Barn owl) (flooded gum woodland along rivers), *Acrocephalus stentoreus* (Clamorous reed warbler) (wetlands) *and Megalurus gramineus* (Little grassbird) (wetlands). Seven species were recorded in only 2 habitat types: *Leipoa ocellata* (Malleefowl), *Cacatua pastinator* (Western long-billed corella), *Tyto novaehollandiae* (Masked owl), *Meliphaga ornata* (Yellow-plumed honeyeater), *Petroica cucullata* (Hooded robin), *Pachycephala rufiventris* (Rufous whistler) and *Cracticus tibicen* (Australian magpie).

ABUNDANCE

Early literature emphasized the scarcity of birds in the forests of south-west WA:

- 'Bird and animal life are scarce in these forest solitudes' (Campbell 1890, referring to his observations in 1889 in karri forest between Karridale and Cape Leeuwin).
- 'There are not many birds about' (Campbell 1890, referring to his observations in 1889 in jarrah forest near Quindalup).
- 'The dense, dark Jarrah forests are peculiarly destitute of all birds' (Carter 1987, p. 63).
- 'areas of large Jarrah timber..., which forests are very dark and gloomy, and usually devoid of bird life to a very great extent...' (Carter in Mathews 1922–23, **10**, p. 358).
- Birds generally, both for numbers and species, were remarkably scarce'. (Campbell [in White 1921], referring to his observations in 1920 in jarrah forest near Barrabup).
- '...the striking thing about the avifauna of the district was the number of absentees and the comparative scarcity of many species present'. (Ashby and Le Soeuf 1928, referring to karri and tingle forest near Deep River).

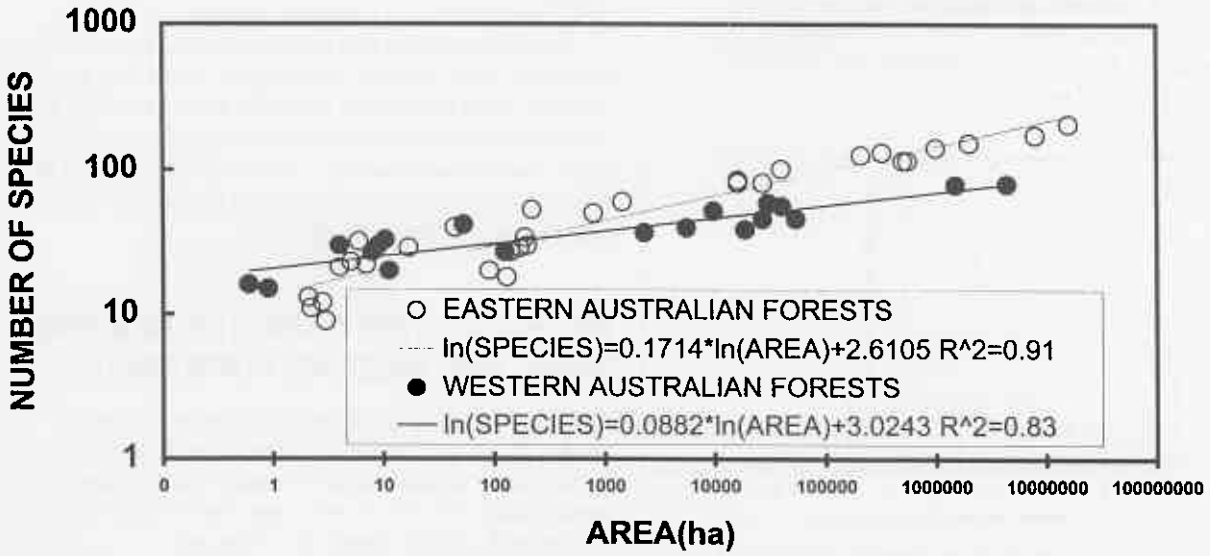

Figure 14. Number of breeding landbird species (as defined in text) regressed against area for forests/woodland in south-east Australia and south-west Australia.

These impressions have been confirmed for jarrah forest relative to open forest in Victoria (Wykes 1985), with total density of birds of 5–7/ ha vs 14/ ha. Similarly, karri forest has a total density[35] of birds of 5.6/ ha in contrast to 11.4/ ha in mountain ash forest in Victoria (Wykes 1985).

The probable explanation for this reduction in density of birds in Western Australian forests is that there are insufficient resources to support larger densities. Evidence for this for canopy arthropods comes from Recher *et al.* (1996), though the NSW vegetation type studied is not structurally comparable to jarrah forest. Another possible factor is that there is no year-round supply of nectar in Western Australian forests (Wykes 1985). Better integrated, plot-based studies of bird and insect populations and nectar and other carbohydrate sources across Australia are needed to address this issue in a comprehensive way.

[35] The densities presented in Table 3 of Wardell-Johnson (1984) have been miscalculated from the data provided in his Table 1. According to my understanding of the methods, the correct divisor is 163 (=144.π.60^2/10^4).

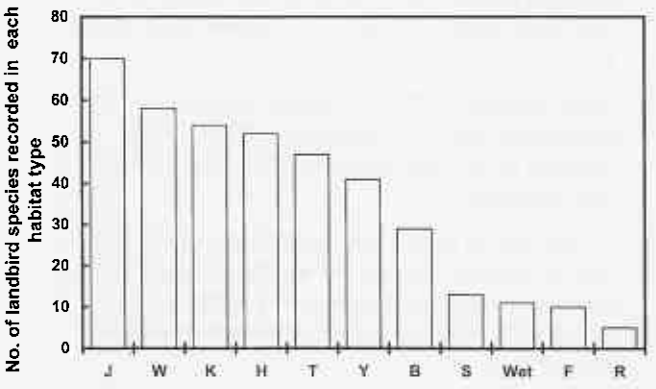

Figure 15. Habitat types in the forests of southwest Western Australia vary in the number of landbird species present. J, jarrah (Eucalyptus marginata) *forest; W, wandoo* (E. wandoo) *forest; K, karri* (E. diversicolor) *forest; H, heath; T, tingle* (E. jacksonii, guilfoylei and brevistylis) *forest; Y, yarri* (E. patens) *forest; B, bullich* (E. megacarpa) *forest; S, sedgeland; Wet, wetland; F, flooded gum* (E. rudis) *woodland; R, rock outcrop.*

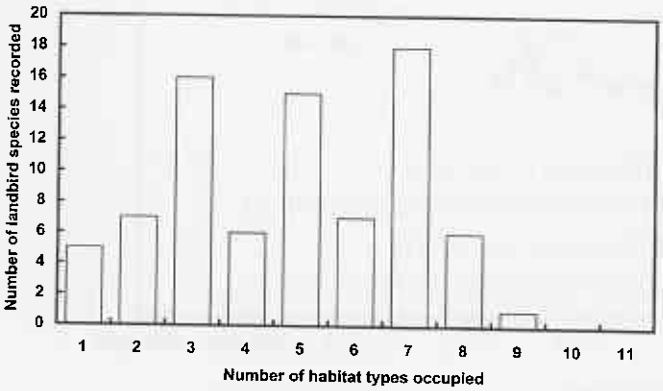

Figure 16. Most landbird species occur in 3–7 of the 11 habitat types present in the forests of south-west Western Australia.

Like many bird communities around the world, those in jarrah and karri forests show a skewed statistical distribution of species densities: most bird species occur at low densities (Fig. 17). Sedgwick (1955) established the same point in a slightly different way for jarrah forest.

Forests along watercourses support more species and greater densities of birds than upland forests (e.g. Smith, P. 1985; Recher *et al.* 1991; Loyn 1993; LaRue *et al.* 1995; Whitaker and Montevecchi 1997). Available data from south-west Western Australian forests support this. In the northern jarrah forest, jarrah forest supported 252 birds (26 species), much less than forest along streams (431 birds, 32 species, Wardell-Johnson 1982). Farther south, but still in the northern jarrah forest, yarri forest supported 60–80 birds (22–26 species) whereas upland jarrah forest supported only about 25 birds (20 species, Abbott and Van Heurck 1985b). In both cases, the number of bird species present is similar but birds are about twice as abundant in forest along streams. Near Collie, riparian forest had 155 individual birds present in contrast to only 63 in upland forest (Worsley Alumina 1985, p. 90). Differences in water and nutrient availability and amount of understorey between the two landscape positions (Havel 1975a, b) are probably responsible. There is also seasonal variation: in summer the difference in abundance between stream and upland forests is greater than in winter (O. Nichols, personal communication). This may reflect a need for water in summer and less flowering of upland plant species in summer.

Those bird species that are widespread generally occur locally at higher densities than species with limited ranges (Brown 1995, p. 106). In the forests of south-west WA, no such relationship is evident (Fig. 18), as is the case elsewhere in Australia (Ford 1990). This conclusion should be treated tentatively, as it rests on the assumption that the density estimates made by different observers are comparable (I attempted to address this by calculating the median rather than the arithmetic average).

Attempts to define bird communities using multivariate techniques have not been encouraging. In the best studied example, at Mt Saddleback (Worsley Alumina 1985), bird associations were linked with habitat types but were not stable from season to season. The framework devised by Havel (1975a, b), Strelein (1988) and Inions *et al.* (1990) may be a more appropriate approach.

REPRODUCTIVE CAPACITY, NESTING ZONE, AND NESTING SUBSTRATE

Reproductive capacity (or potential) can be indicated crudely by modal clutch size. Most of the bird species present in the original forests of south-west WA have a modal clutch size of 2 or more eggs (Storr 1991). Those species with a modal clutch size of one are: *Calyptorhynchus banksii* (Red-tailed black cockatoo), *C. baudinii* (Baudin's cockatoo), *Eurostopodus argus* (Spotted nightjar), *Atrichornis clamosus* (Noisy scrub-bird)

and *Anthochaera chrysoptera* (Little wattlebird). *Prima facie*, these should be among the least common bird species in the forest. This is indeed the case for all except *A. chrysoptera*. To this list should be added *Calyptorhynchus latirostris* (Carnaby's cockatoo) – although this species has a modal clutch size of 2, only one young is reared.

A more sophisticated measure of reproductive capacity is the number of young raised to independence per female each year; this, however, is known for only a few species (Long nd; Rowley and Russell 1991). It appears to be lower than in northern hemisphere bird species. Higher adult survival and repeated nesting in the same breeding season appear to compensate for the poor rate of fledging (Rowley and Russell 1991).

Twenty-two species (20 per cent of the primaeval forest avifauna) are known to practise co-operative breeding. This involves more than two individuals providing care in the rearing of a single clutch or brood, unlike the more usual situation where one pair is responsible for the rearing of the young. These species are (Clarke 1995):

Landbirds

Merops ornatus
Climacteris rufa
Malurus splendens
Malurus elegans
Pardalotus striatus
Sericornis frontalis
Smicrornis brevirostris
Acanthiza chrysorrhoa
Melithreptus chloropsis
Phylidonyris novaehollandiae
Anthochaera chrysoptera
Anthochaera carunculata
Eopsaltria australis
Eopsaltria georgiana
Daphoenositta chrysoptera
Falcunculus frontatus
Artamus cyanopterus
Cracticus tibicen

Waterbirds

Tachybaptus novaehollandiae
Porphyrio porphyrio

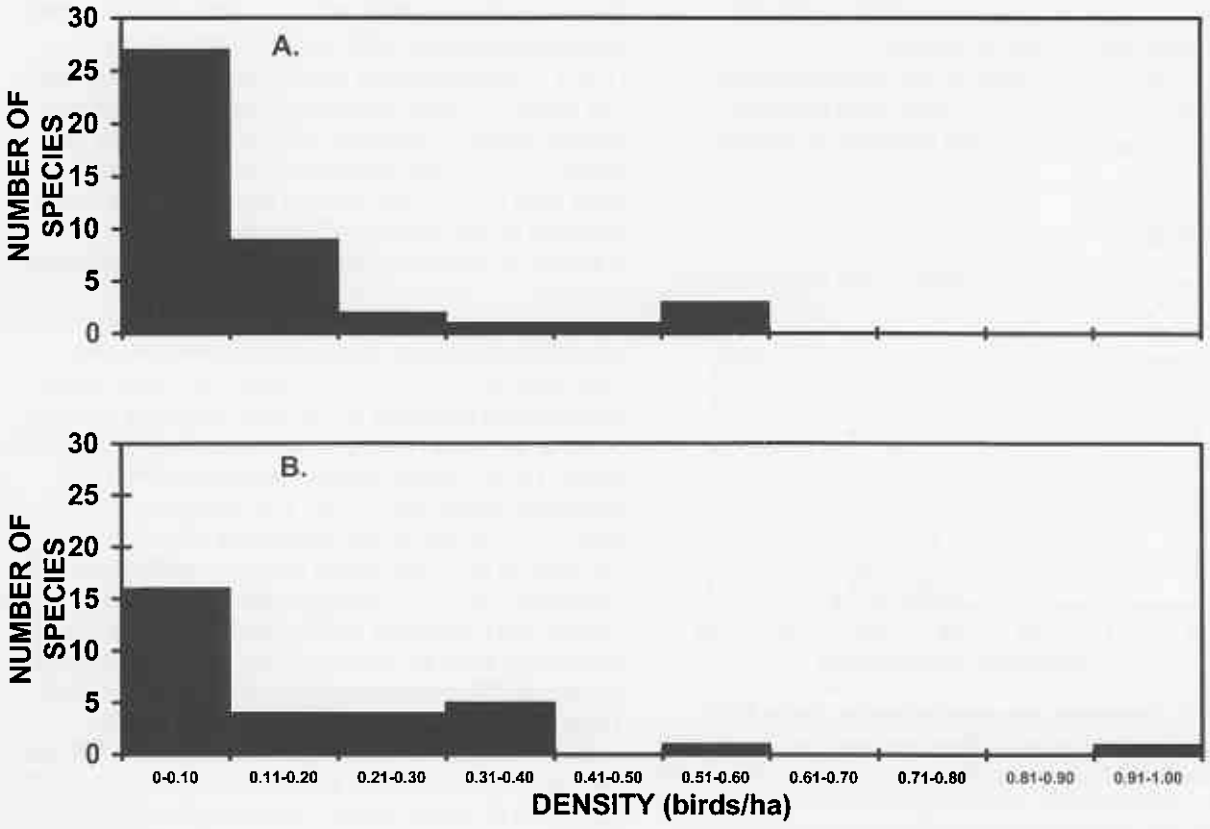

Figure 17. Most bird species in jarrah (A) and karri (B) forests occur at low densities. Sources: A Wykes (1985); B Wardell-Johnson (1984), site 1 in unlogged forest, spring 1982.

The reasons offered to explain co-operative breeding have an uncertain basis (Clarke 1995). There is also no obvious ecological characteristic linking all of the above species and at the same time excluding species that do not breed co-operatively.

Structural classes in south-west forests are defined in terms of height and projective foliage cover of the tallest stratum (Beard 1981). Both characteristics influence the degree to which lower strata are developed. Four strata are recognizable: ground, understorey, midstorey and overstorey. The limits of these strata vary with forest type. Thus, in jarrah forests the height of the understorey is 2–3 m, that of the midstorey is 5–12 m, and the overstorey reaches a maximum height of *c.* 30 m. Towards the eastern sector of the jarrah forest, overstorey height declines to 20 m and midstorey and understorey elements become infrequent (Havel 1975a, b). In karri forests, the understorey is very dense and, depending on when last burnt, may be as tall as 5–10 m. The midstorey (10–30 m) is sparse. The overstorey can attain a height of 80 m, though mean codominant height is 45 m. In parts of the southern forests there are extensive areas of shallow soils with impeded drainage. Such areas support low, open jarrah forest (<10 m tall).

Along rivers and streams there is a riparian zone consisting of woodland and dense thicket (3 m tall, depending on when last burnt). Swamps vary in size and in amount of open water present, but generally they are fringed by woodland and dense reedbeds, which may extend some distance into the swamp.

The nesting requirements of each bird species tend to be satisfied primarily by one of these strata (Table 9), though most species show some flexibility in selecting nesting sites.

Landbirds

Most species (77 per cent) construct a nest that is placed in foliage or on a branch in the understorey (27 species), midstorey (17 species), or overstorey (10 species). Nine species nest on the ground. Hollows, usually in the trunks or branches of the overstorey trees, are used by 18 species (22 per cent of the landbird avifauna). No species can excavate a hollow; instead the supply of hollows depends on the size (and hence age) of the tree, and damage caused to the tree by fire, termites or fungi.

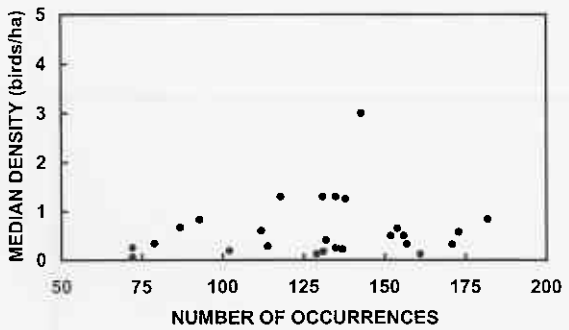

Figure 18. Abundance (measured as median density for 26 species of landbird for which density estimates are available for N≥5 localities) bears no significant relationship to distribution (number of occurrences, maximum possible = 187) in the forests of south-west Western Australia. Number of occurrences for a species refers to lists 11, 20, 22, 24–27 (inclusive), 38, 41–49, 53–61, 64–90, 92–107, 110–120, 122–129, 157–165, 167–185, 188–258, 260–270 in Tables 1 and 2. These lists are considered to be the most comprehensive.

This information provides the essential context for forest management: prescribed burning in spring is likely to impact most on species which nest in understorey, whereas prescribed burning in autumn is more likely to modify midstorey and even overstorey, as well as understorey, and thus also may impact on bird species which nest in these strata. Wildfires (generally occurring in summer) should have the most severe and hence the longest-lasting effect on nesting habitat. Shelterwood logging in jarrah forest should impact most on species that nest in overstorey, particularly in large hollows; whereas cutting to gaps in jarrah forest and clearfelling in karri forest should impact on all bird species until the regenerating forest once again supplies the nesting (and other) resources indispensable to each species.

The procedures in place to ensure that there is an ongoing supply of suitable hollows for hollow-nesting species are not well appreciated by some ornithologists (e.g. Blakers *et al.* 1984, p. 277; Saunders *et al.* 1985). The existence of a specific prescription (CALM 1989c) was not acknowledged by Garnett (1992a, p. 101), Mawson and Long (1994), Mawson (1995), Recher (1996), Saunders and Ingram (1995, pp. 116, 118) or Calver (1997). A plentiful supply of hollows is often linked with 'old growth', a North American concept not applicable to eucalypt forests (Christensen 1992, p. 34; Bradshaw and Rayner 1997b). Some ornithologists also believe that jarrah trees live to 1 000 years, so that large hollows are presumed to take hundreds of years to form and to be available for further hundreds of years (Mawson and Long 1994).

In fact, few large jarrah and karri trees are older than 250–350 years (Abbott and Loneragan 1984a; Rayner 1992; Burrows *et al.* 1995; Stoneman *et al.* 1997). Large hollows begin to develop at 120 years, becoming common by about 200 years (Whitford[36] unpublished; Bradshaw and Rayner 1997a). Stands become senescent by 300 years (Bradshaw and Rayner 1997a). The main safeguard for hollow-nesting species after clearfelling of karri forest is the retention of buffers around all coupes (well depicted in Christensen 1981, p. 18 and in Figure 14 of Wardell-Johnson and Christensen 1992). Maximum coupe size is restricted to 80 ha and where possible there is a maximum distance of 400 m between areas of mature forest (CALM 1994a). About 6 100 ha of pre–1940 regrowth and 6 000 ha of regrowth forest regenerated between 1940 and 1975 are to be managed on a rotation length of at least 100 years (CALM 1994a, 1995c). The extent that these stands will develop large hollows depends on how often they are

[36] K.W. Whitford, Department of Conservation and Land Management, Dwellingup.

to be thinned.

Since 1989, following the introduction of cutting to gaps in jarrah forest, hollow-nesting species have been safeguarded by leaving 3 marked habitat trees/ ha (CALM 1989c). New knowledge led to this prescription being improved, so that hollow nesters are now catered for by retention of 4 marked habitat trees/ ha and 6–8 marked potential habitat trees/ ha over the area of the gap (CALM 1995a). This provides a total of 40 habitat trees and 60–80 potential habitat trees in each gap. Many other potential habitat trees are retained but are not marked (Armstrong and Abbott 1996). In shelterwood jarrah forest (cut to encourage growth of existing lignotuberous seedlings) the same arrangement applies, with a large part of the midstorey being retained. These smaller cohorts of trees, because of their advanced size and the reduction in competition, may take only 20–40 years to attain the threshold size (60 cm d.b.h.o.b.) before large hollows form. In the existing multiple use jarrah forest, the density of trees large enough to form a suitably-sized nesting hollow has been estimated as follows: *Calyptorhynchus banksii* (Red-tailed black cockatoo) (13.3/ ha); *Cacatua pastinator* (Western long-billed corella) (4.5/ ha); *Platycercus zonarius* (Australian ringneck) (37.9/ ha); *P. spurius* (Red-capped parrot) (22.5/ ha); and *P. icterotis* (Western rosella) (37.9/ ha) (based on data provided by Mawson and Long [1994], Abbott [1998b, c], and CALM [1992a, p.172]).

Limited information is available about the home range of hollow nesters. Mawson (1995) established that *Platycercus spurius* (Red-capped parrot) (115 g body weight) has a core home range of 15 ha. This fact, combined with the density of trees large enough to form a suitably-sized nest hollow (22.5/ ha), indicates that a pair should have a choice of more than 300 nest trees within the home range. Abbott (1998c) estimated, on certain assumptions, that a pair of *Calyptorhynchus banksii* (Red-tailed black cockatoo) (600 g) should have a choice of more than 100 nest trees within the home range.

Retained habitat trees of jarrah and marri, being deep-rooted, will not readily be blown down. Of the 400 habitat trees marked and retained after logging of 100 ha of jarrah forest, it is estimated that only 96 will fall down within a 100-year period (Whitford and Williams 1997). Thus, loss of some retained habitat trees is unlikely to have a major impact on hollow availability during this period.

Recher (1991) speculated that nesting resources such as dead wood, logs on the ground, dead branches, bark, cobwebs and lichen may be in short supply in logged forests. However, in my experience in regrowth jarrah and karri forests of all ages these resources are abundant. Moreover, those species (e.g. *Eopsaltria australis* (Yellow robin), *Rhipidura fuliginosa* (Grey fantail)) that use such materials in or for their nests are common and widespread.

Although the study by McComb (1994) of *Platycercus zonarius* (Australian ringneck) and *Pardalotus striatus* (Striated pardalote) indicated that sufficient suitable hollows/ ha remained after timber harvesting, it rests on invalid methodology. Reliable data on the occurrence of hollows collected from 145 felled trees were amalgamated with subjective counts, made from the ground, of hollows in 218 standing trees. The latter flaw has been avoided in a study currently being prepared for publication (Whitford personal communication).

Waterbirds

Ninety per cent of waterbird species (Table 9) build a nest that is placed in understorey (reedbeds or rushes in water, 15 species), in overstorey (trees in or near swamps, 7 species), on the ground (4 species), or on water (2 species). Three species will use hollows in trees in or near swamps for nesting.

The nesting habitat of most waterbird species is vulnerable to burning of swamps or other riparian habitat. However, this risk is minimal if prescribed burning takes place in spring when soil is moist. Note, however, that aborigines were recorded by G. F. Moore burning swamp vegetation in summer (Meagher 1974, p. 62). Timber harvesting generally has little relevance to waterbirds as swamps contain no timber of commercial significance and logging of adjacent forest does not impact on water quality. Stoate and Bednall (nd) mention the conversion of paperbark (*Melaleuca preissiana*) flats in the upper reaches of some streams in the northern jarrah forest to wetlands dominated by sedges. They attributed this to wildfire removing litter in these flats and thinning out the forest canopy, causing a rise in water table.

FORAGING NICHE

The location of species in food chains and food webs is, after habitat, the most important way that biodiversity is structured. Information on food has been summarized in Table 9 from Serventy and Whittell (1976), Barker and Vestjens (1989, 1990), and RAOU (1990–1996). Foraging habit generally follows the terminology of Recher *et al.* (1985).

Landbirds

About half (42 species) of the land bird species present in the primal forest of south-west WA are insectivores (Table 9). However, they separate out on substrate (air, ground, foliage, bark), habitat (forest, heath, riparian), and feeding method (glean, pounce, snatch). Further niche subdivision is probably effected by differences between species in dimensions of the beak and vertical stratification in their use of foliage in the forest (Wooller and Calver 1981). This predominance of species foraging for insects on foliage is not surprising, given the vast surface area of green leaf matter in the forest. For example, a jarrah tree with d.b.h.o.b. of 30 cm (and height of 19 m) has a total single-sided leaf area of 56 m^2 (Whitford 1991); an average hectare of forest would have *c.* 40 trees/ ha with d.b.h.o.b. 30 cm (CALM 1992a). Because jarrah forest has a leaf area index of 1–2 (Stoneman *et al.* 1996), the total area of leaves per hectare should be 10 000–20 000 m^2. Detailed analyses of vertical use of forest by bird species have been presented for jarrah by Wykes (1985), for jarrah and

wandoo by Worsley Alumina (1985), and for karri by Wardell-Johnson (1985). Most activity is concentrated in two zones: near the ground (0–5 m) and in the mid and upper storeys.

Seed eaters (13 species) mainly separate out on the basis of beak size (for breaking open fruits), habitat, and size and hardness of the seed consumed. Some of these species subsist also on nectar, insects and soft fruits.

The next largest group consists of predators: species which kill and eat other birds, reptiles and mammals. These 11 species tend to separate out on degree of generalization of diet and whether foraging takes place during the day or at night.

There are 8 species of nectar feeders present. They subdivide this resource on the basis of habitat, bill length, degree of specialization on particular plant species and degree of dependence on insects.

Five species are omnivores, eating insects, fruits, seeds, vegetable matter and even carrion. They subdivide on the basis of habitat, substrate and beak size.

One species is a specialist on fruit of mistletoe but will also consume insects.

Waterbirds

The 31 species comprising the primal forest waterbird fauna are primarily insectivores (13 species), herbivores [consumers of vegetable matter such as leaves, tubers and seeds] (10 species) or predators (8 species). These species separate out on beak size, habitat, feeding behaviour, and depth of water required for feeding in.

Niche Shifts and Expansions

The absence of particular species from south-west Western Australian forests has apparently allowed ecological and morphological release in some of the species present.

The Western white-naped honeyeater *Melithreptus chloropsis* has evolved from a population of *M. lunatus* isolated in south-west WA in the absence of *M. gularis*. It has a longer bill and foot than *M. lunatus* (Keast 1968) and spends more of its foraging time probing bark for insects (personal observation), just as *M. gularis* does in eastern Australia (Keast 1968).

In south-west WA there are only 3 species of thornbill compared with 5 species in eastern Australia. *Acanthiza apicalis* and *A. inornata* have broader niches than their equivalents *A. pusilla* and *A. reguloides* in eastern Australia. They forage more in foliage in all strata in the forest (Keast 1961, 1976; personal observation). *A. chrysorrhoa*, the one species common to both sides of the continent, also feeds relatively more in the branches and foliage of trees than it does in eastern Australia (Keast 1976; personal observation). *Zosterops lateralis* can also be particularly versatile in its foraging niche (Mees 1969; Keast 1975).

Several species of raptor in south-west WA show different ratios of beak size between sexes and between species (Olsen 1995). Beak size of the sexes of *Accipiter cirrocephalus* (Collared sparrowhawk) converges (relative to south-east Australia), as is also the case for *Aquila audax* (Wedge-tailed eagle). In contrast beak size of the sexes of *Haliastur sphenurus* (Whistling kite) diverges, as does beak size of the sexes of *Falco berigora* (Brown falcon). The south-west population of *Tyto novaehollandiae* (Masked owl) resembles the Tasmanian population in its large body size and degree of size dimorphism between the sexes; in both features it is most unlike the population in south-east Australia (Debus 1993).

Keast (1976) documents other morphological (bill, wing and tarsal) shifts of south-west species of passerines relative to those (or comparable) species in Victoria. Some species also showed increased size dimorphism between the sexes. This was attributed to a need to minimize intraspecific competition for food, thus enabling the species involved to maintain higher population numbers.

POPULATION MOVEMENTS

Nearly 20 per cent of the landbird species (all insectivores) in the primal forest show some definite seasonal movement (migration) within or from the forest. Four species – *Todiramphus sanctus* (Sacred kingfisher), *Merops ornatus* (Rainbow bee-eater), *Hirundo nigricans* (Tree martin) and *Acrocephalus stentoreus* (Clamorous reed warbler) – are completely absent from the forest in winter presumably because of a decline in numbers of aerial insects. For two other species, *Accipiter fasciatus* (Brown goshawk) and *Cuculus pallidus* (Pallid cuckoo), nearly all of the population departs for the winter with only a few individuals resident all year. The reason for this is not known.

The remaining 10 species – *Cacomantis flabelliformis* (Fan-tailed cuckoo), *Chrysococcyx basalis* (Horsfield's bronze cuckoo), *C. lucidus* (Shining bronze cuckoo), *Pardalotus punctatus* (Spotted pardalote), *P. striatus* (Striated pardalote), *Gerygone fusca* (Western gerygone), *Rhipidura fuliginosa* (Grey fantail), *Coracina novaehollandiae* (Black-faced cuckoo-shrike), *Artamus cyanopterus* (Dusky woodswallow) and *Zosterops lateralis* (Grey-breasted white-eye) – more or less spend winter in only part of the forest. Usually these species move to the warmer and drier forests, though with *Ca. flabelliformis, Ch. basalis, Ch. lucidus* and *A. cyanopterus* a few birds remain in the southern forests all year.

Other kinds of movements are also evident. All species of course exhibit dispersal of independent young from the nesting territory or home range of the parents. These movements probably resemble diffusion, are more or less local, and ensure that any adult mortality (and consequent vacancies in home range) is compensated for. Species dependent on pollen and/or nectar (*Glossopsitta porphyrocephala* (Purple-crowned lorikeet), some honeyeaters) usually show irregular movements as they track the seasonal flowering of eucalypts, banksias, grevilleas etc. Particularly important is the flowering of marri in autumn, a season when nectar is in short supply. Many species of waterbird tend to concentrate in the wetter south-west during summer and then disperse inland during winter. Most of these movements take place at night and

tend to go unnoticed. Probably the most extreme type of movement is the irregular irruption into the south-west of *Gallinula ventralis* (Black-tailed native-hen) (Storr 1991).

Comprehensive and co-ordinated bird banding programs are needed if population movements are to be elucidated.

DISTURBANCE ECOLOGY

In a forest, a disturbance is a more or less discrete event that kills trees and/or other organisms. The space opened up can then be utilized by organisms of the same or different species.

Before 1829, disturbance gradients in the forest were probably relatively simple, being caused by spatial variation in wildfire (initiated by lightning strikes) and windthrow, fires set by aborigines, and senescence of individual trees and patches of trees. Gaps produced in the forest by these processes were then filled by regeneration, leading to diversity in stand structure. In the subsequent 170 years disturbance gradients have become considerably complicated, with up to 15 factors interacting in a single locality. A broad spectrum of sites now exists, from those continuously disturbed (e.g. pasture, towns, saline wetlands and rivers) to those infrequently disturbed (e.g. forest unburned for 60 years, forest unlogged).

Whitlock (1914) raised the important issue of why a small and feeble-flying species such as *Stipiturus malachurus* (Southern emu-wren) is able to persist, whereas larger species such as *Atrichornis clamosus* (Noisy scrub-bird) and *Dasyornis longirostris* (Western bristlebird) in the same habitat verged on becoming extinct. The answer is likely to be found in how and for how long a species' habitat is changed by disturbance such as fire.

1. Scale, Intensity and Frequency of Disturbances in the Forest

The major environmental impacts in the forests of south-west WA are as follows:

Permanent Destruction of Forest

Agriculture. This is the most significant factor, as it has resulted in deforestation (clearing of forest). It took the Bussells, pioneer settlers at Augusta in 1829, 4 years to clear 1.2 ha of karri forest in order to grow vegetables for their own consumption (Cullity 1979). As markets developed, settlers in the forest learned that stocking rates could be improved if trees were ringbarked and later burned to promote the growth of native herbage. The rate of clearing of forest was slow, however, until early this century, when the Government purchased Millars' timber concession near Denmark for agricultural settlement. After the Great War, despite Parliament introducing the Forests Act in 1918, the Government of WA actively promoted land settlement at the expense of jarrah and karri forest, aided by the introduction of superphosphate and subterranean clover. It was not until a change in government in 1924 that substantial areas of forest became State forest. By 1930, almost 1.2 M ha of forest had been permanently withheld from agricultural purposes (Forests Department 1969). After World War II, bulldozers increased the rate of deforestation on farmland.

The geographical extent of deforestation can be gauged by examining the difference between the original distribution of forest and the extent of State forest (Fig. 1). Much of the jarrah and wandoo forest between Mundaring and Julimar has been cleared, as has forest in the eastern sector, particularly east of Dwellingup, between Darkan and Boyup Brook, between Boyup Brook and Albany (Jarvis 1979), and along major river valleys such as the Preston and Blackwood (e.g. Christensen *et al.* 1981). About 1.5 M ha or 42 per cent of the original forest is either partially or completely cleared (Beard and Sprenger 1984). More detailed estimates of clearing, in particular forest ecosystems, are tabulated in Commonwealth and Western Australian Regional Forest Agreement Steering Committee (1998, p. 125). Regeneration of trees is prevented by continual grazing by stock. Significant portions of high quality forest have been removed in the vicinity of Collie, Kirup, Bridgetown, Manjimup, Pemberton, Northcliffe and Walpole for agricultural purposes. Riparian habitat has also been destroyed or extensively modified by orchards, particularly in forest east of Perth (McArthur and Mulcahy 1980).

River regulation. Damming of rivers for water supply to towns, cities and irrigated farms has destroyed significant amounts of riparian habitat. Such habitat does not re-develop upstream of dams. Waterways affected include Munday Brook (dammed 1891), Helena River (1902), Bickley Brook (1921), Churchman Brook (1928), Canning River (1940), Wungong Brook (1979), Serpentine River (1961), Dandalup River (1974 and 1994), Drakes Brook (1966), Samson Brook (1941), Logue Brook (1963), Harvey River (1916 and 1948), Collie River (1933 and 1960) and Harris River (1990). By my calculation *c.* 192 km of riparian habitat have been destroyed. The water surface of all dams (when full) totals 9 200 ha (Watts[37], personal communication).

Waters in domestic supply reservoirs are deep, cool and nutrient poor, and large fluctuations in water level prevent establishment of reeds and sedges (Lane and McComb 1988). These impoundments thus tend to be unsuitable breeding habitat for most waterbird species.

Potential dam sites still exist in the Harvey, Collie, Preston, Donnelly, Warren, Shannon, and Denmark water resource basins (Western Australian Water Resources Council 1989; Commonwealth and Western Australian Regional Forest Agreement Steering Committee 1998, map 18). As the human population of south-west WA increases, it is difficult to imagine that further river regulation and consequent loss of riparian habitat will not take place.

[37] P. Watts, Water Corporation, Leederville.

Urbanization. Clearing of forest has taken place, at various scales, to enable humans to settle in villages, towns and cities. Early this century deforestation was very local and at a scale of *c.* 1 ha to support one forester (hut, pasture paddock for horse [the only mode of transport]; see Havel 1989, p. 290). Next in the scale of disturbance was the small spot mill. The area cleared of forest would not have exceeded 2–3 ha. This type of village was temporary, being dependent on the local availability of suitable timber. The third type of urban development was the large timber mills. These had several hundred people resident (Ednie-Brown 1896) and some (such as Jarrahdale, Dwellingup, and Pemberton) eventually achieved permanence. The area cleared of forest was initially of the order of 50–100 ha. Finally, towns developed at Glen Forrest, Jarrahdale, Dwellingup, Pemberton, Denmark, etc. and served as a focus for the establishment of other industries. In some cases horticulture, mining and other industries came first and timber milling developed later, e.g. Stoneville, Bickley and Karragullen, Donnybrook (orchards); Collie and Greenbushes (coal and tin mining respectively); Boyup Brook (sheep farming); and Margaret River (dairying). In the forest immediately adjacent to Perth, extensive fragmentation took place following settlement around villages at Darlington, Mundaring, Kalamunda, Lesmurdie and Roleystone.

By my calculation there are 32 towns situated within the original forest boundary; the total area of forest cleared is estimated at *c.* 3 000 ha.

Pine plantations. Pinus radiata has been extensively planted in parts of the high quality original forest, particularly near Dwellingup, Collie and Nannup. Some 23 000 ha have been affected in this way (Kaye[38], personal communication). No publicly-owned native forest has been cleared for pine plantations since 1983.

Tramway, road, railway and powergrid construction. An extensive temporary light railway system radiated from timber mills in the period 1870–1950 (Heberle 1997), totalling *c.* 4 800 km (Gunzburg and Austin 1997). Many of these tramways were converted to tracks and roads after World War II. Railways were extended into the forest after 1893 to support the mining and timber industries, and by 1897 the south-west railway (from Perth and Bunbury) had reached Bridgetown. There is an extensive network of bitumenized roads through the forest, connecting towns. Within the forest there are many secondary roads and tracks used by loggers, tourists, miners, conservationists, farmers, fishers, energy suppliers (electricity, gas), water suppliers and apiarists. The total length of roads that had been constructed and was still maintained in 1968 was *c.* 27 000 km (Forests Department 1969, p. 36). Many roads were closed, however, in the 1970s to prevent further spread of dieback disease. Radiating from the Collie coalfields is a network of 330 kV transmission lines, which has necessitated clearing of 200 m wide corridors through forest.

[38] J. Kaye, Department of Conservation and Land Management, Bunbury.

Temporary Modification of Forest

Pastoralism. Pioneer farmers in the forest always settled next to a river and allowed their stock to browse in the forest. Stock would have preferentially browsed native grasses and other soft nutritious feed, but the concurrence of continuous grazing and drought years led to stock being forced to eat less nutritious scrub (Cullity 1979). By the 1860s rickets in cattle, from eating *Macrozamia*, was widespread. It was found that cattle depastured on coastal vegetation near the forest from December to August improved in condition. Large pastoral leases were widespread last century throughout the forest, as evidenced by inspection of official maps. Flocks of sheep were shepherded to prevent depredation by dingoes and foraging on poison pea (*Gastrolobium* species). Because of the rough forage, the density of sheep was low (*c.* 1/ 5 ha, K. Smith personal communication). Shepherds adopted the aboriginal practice of burning patches of vegetation each year in late summer and autumn to encourage green pick (*cf.* Glover 1979). Cattle were run in the wetter forests. Palatable plant species would have been preferentially grazed and the ground vegetation and lower understorey should have become more open. The impact of these changes on bird populations is unknown, but presumably was minor and temporary. Most grazing leases were resumed by Government following the Homestead Act of 1893, and released for closer settlement and agricultural development entailing deforestation.

Logging. Timber extraction from the forest commenced last century, and many parts of the forest have been cut over up to 3 or 4 times (Heberle 1997). The most heavily impacted forest is the high quality forest (Fig. 1). In the period before the Forests Act of 1918, logged forests received no silvicultural management (Abbott and Loneragan 1986). Up to the second world war, most of the high quality jarrah forest was given a 'regeneration cleaning' in which large marri trees or senescent jarrah trees containing no merchantable timber were either ring-barked or removed (Abbott and Loneragan 1986).

The structure of the forest before logging took place was apparently open, resembling parkland, except along streams where undergrowth was dense. Lane-Poole (nd) noted that the virgin jarrah forest had 'a very scattered lower storey' with a small 'number of groups of pole and pile wood' and was 'open enough to ride through easily [on a horse] ... the old hands report that the forest was still more open in the early days of the colony. There was less sapling growth say they'. Hutchins (1916) recorded that the jarrah forest is 'open, so much so as to be generally traversible in any direction, on foot, or on horseback, without paths'. These remarks are supported by my interviews with landholders and foresters born before 1928.

Forest structure in the virgin forest appears to have been greatly influenced by fire, set by lightning, aborigines and the early settlers, interacting with soil and litter moisture gradients determined by topography, aspect, climate, time of year, and weather conditions (Wallace 1966; Talbot 1973; Underwood 1978; Hallam 1985, p. 15). Most of my informants who lived in the karri or jarrah forests in the 1920s recalled that fires were lit by farmers around their properties in autumn after a little rain had fallen and could be as frequent as every 2–4 years. Although large areas were burnt, burning was patchy and of low intensity. Once the forest canopy was reduced through logging and the spread of dieback disease, understorey proliferated (Abbott and Loneragan 1984b), particularly after the policy of excluding fire from regrowth stands was adopted in the late 1920s.

The major difference in structure between the primaeval forest and the modern forest is the limited distribution of understorey thickets (especially in the northern forest), a less open forest canopy, and the greater density of very large trees in the original forest.

All forest logged in State forest is regenerated soon after timber harvesting is completed. Within 5 years of logging in jarrah forest, both overstorey and total cover exceeded 80 per cent of the value for unlogged jarrah (Stoneman *et al.* 1989a). In karri forest overstorey cover reached the value for unlogged karri forest by 8 years and total cover was the same as in unlogged karri forest by 5 years (Stoneman *et al.* 1989a). The amount of State forest logged each year is *c.* 1–3 per cent. About 33 per cent of jarrah forest and 46 per cent of karri forest have been excised as national parks, nature reserves, and road, river and stream reserves and will not be logged in the future. Logging systems vary in intensity and purpose, and have changed considerably during the past 120 years (Abbott and Loneragan 1986; Stoneman *et al.* 1989b; Christensen 1992; Breidahl and Hewett 1995).

Timber harvesting is an operation based on the science of silviculture, long-term planning, and careful management. Roading is constructed or selected so as to minimize ecological damage. Stream zones, diverse ecotype zones (heath, sedgeland, herbland, rock outcrops, swamps, lakes, woodlands), and dieback-free forest are avoided (CALM 1996). Before any logging of jarrah forest takes place, the status of existing regeneration (advance growth) is assessed (CALM 1997b). By marking the trees to be retained, the forester largely determines how the stand will develop after logging (CALM 1995a).

Each stand of jarrah forest is currently harvested in one of three ways, depending mainly on the structure of the forest: (a) thinning – to promote growth on retained trees; (b) gap creation – to release existing regeneration by complete removal [except for habitat trees] of competing overstorey trees; and (c) shelterwood – to promote establishment of seedlings by partial removal of competing overstorey trees. Selective harvesting takes place in dieback-affected forest and low rainfall jarrah forest where some harvestable trees are present, but not enough to justify thinning or creating a gap (CALM 1997g). Care is taken during thinning to ensure that up to 10 per cent of retained trees are marri and that under- and mid-storey trees of other species are protected. Some of the marri retained are crop trees (CALM 1995a). In gap creation, gaps have to be 50–100 m apart so that they are surrounded by corridors of forest (oldgrowth, old regrowth, shelterwood or thinned). Gaps cannot exceed 10 ha. Habitat trees, retained at the rate of 20 trees/ 5 ha over the gap, must be larger than 70 cm d.b.h.o.b. and be in senescence stages 2–5 (out of an 8 point scale) where possible. Potential habitat trees are retained at the rate of 6–8 trees/ ha over the gap and must be in senescence stages 2–4 (CALM 1995a).

In karri forest even-aged regrowth stands taller than 30 m are subject to thinning (CALM 1992b), with the retained basal area varying from 16–22 m^2/ ha, dependent on stand height. All sheoak, habitat trees and marri are retained. Because karri regenerates only from seed, it is necessary when regenerating stands to remove competing understorey vegetation by burning or mechanical disturbance so as to create a suitable seedbed (CALM 1997d). Mature stands with a single overstorey are clearcut and regenerated by one of three methods: retained seed trees (CALM 1997c); artificial spreading of seed; or planting of nursery-raised seedlings (CALM 1995b). Potential habitat trees could be grown by scorching their crowns (CALM 1995b), thereby promoting development of epicormics, which over several decades senesce. The ensuing dead branch stubs could then begin to form hollows. Such trees are capable of living for another 150 years.

Regrowth karri forest in the establishment phase has a very high density of karri (5000 stems/ ha, *c.* 6–10 m tall) by 8 years after clearfelling (Bradshaw and Rayner 1997a). The juvenile stage then commences with crown closure, and the stand gradually self-thins to a density of 400–500 stems/ ha (dominants *c.* 30 m tall) at 25–30 years. The remaining trees continue to reduce in density to 150–300 stems/ ha (at 50–60 years) and increase in stem diameter. Cover of the overstorey matches that of unlogged karri stands 10 years after cutting and after a further 10 years stabilizes at 10 per cent greater than that in unlogged stands (Stoneman *et al.* 1989a). Dominant trees achieve 90 per cent of their final height at 60–70 years (Rayner 1991). For a montage of colour photographs showing the regenerating karri forest up to 100 years after clearfelling, see White and Underwood (1974), Anon. (1976, pp. 8–9) and Christensen (1981). Recher (1991) pointed out that marri is not retained as seed trees in clearfelled karri coupes, implying that wildlife values were being neglected. However, marri regenerates readily from lignotubers and stumps (White and Underwood 1974), making the provision of seed trees unnecessary (CALM 1995b).

All cutover forest is subject to detailed survey of regeneration. Any understocked areas are infill-planted.

Wildfire. Although the forest is subject every year to lightning strikes (Abbott and Loneragan 1986; Underwood 1990; CALM 1994b), fires developing were probably not of significance to European settlers

until the 1860s, when aboriginal populations declined precipitously as a result of introduced diseases. Their burning[39] of the forest (presumably to provide food such as kangaroo, tubers and berries) then ceased, resulting in widespread build up of litter and branches on the forest floor. Under the right combination of critical circumstances (dry soil, dense litter and undergrowth, high ambient temperature, wind), a fire started by lightning, arson or other factor will quickly develop into a high intensity or crown fire. The best example in the past 50 years is the Dwellingup wildfire of 1961 in which 136 000 ha of forest were burned by 22 known fires over a period of 5 days.

By about 1870 European settlement began to spread and strategic (albeit limited) clearing of woodland on the adjacent Swan Coastal Plain and wheatbelt commenced (Jarvis 1979). Fires lit by settlers to clear their land of native vegetation and encourage fodder would have spread into the forests and caused crown fires. In the absence of logging debris, large trees of jarrah and marri respectively are not or rarely killed by such high intensity fires (Burrows 1987).

From the 1870s timber harvesting at Jarrahdale increased the amount of wood debris on the forest floor and thereby ensured that wildfires were able to burn out larger areas of forest than was probably the case in the first few decades of European settlement (McCaw and Burrows 1989). This impact commenced later farther south, once timber harvesting began at Dwellingup, Manjimup and Pemberton (1910–12). In the presence of logging debris, high intensity fire degrades the condition of tree crowns and facilitates the development of hollows.

A map of all (143) detected lightning-caused fires in the forests of south-west WA for the years 1987–93 demonstrates that such ignition points are geographically extensive (CALM*fire* 1994 unpublished). If it is assumed that these fires were left to burn for 4 days in moderate summer conditions, more than 50 per cent of the forest could be burned in a 6-year period. This is a very conservative assumption because summer fires are likely to burn for more than 4 days without suppression activities.

Thus, the large scale forest fires of the late 19th and early 20th centuries were the combined result of clearing of forest for agriculture, pastoral activity, dispossession of aboriginal people, and unregulated logging. The Forests Act of 1918 brought the forest under professional management, eventually leading to the modern policy of using prescribed burning to minimize the occurrence of large scale wildfire.

Prescribed burning. Although introduced in 1954, this management practice was not fully implemented until after the 1961 Dwellingup wildfire, supported by recommendations of a Royal Commission. Planned burning is based on scientific knowledge accumulated since the 1930s. Information on soil moisture, litter depth, soil dryness index, rate of spread of fire for various forest types, etc has been tabulated (Sneeuwjagt and Peet 1985). State forest is burned at the forest block scale in a mosaic pattern (DRSG 1982, p. 196), currently at an interval of 12–17 years (Commonwealth and Western Australian Regional Forest Agreement Steering Committee 1998, pp. 156 and 159). Areas to be harvested may be burned (preferably one season prior, and at low intensity) in order to reduce density of scrub (thereby allowing easier and safer access for treemarkers and fellers, CALM 1996, 1997a). Such fires are usually planned to occur during normal prescribed aerial burning.

Logging coupes are burned within 2 years of logging ('tops disposal burn'). Fire is excluded from regrowth karri stands for about 15 years. Forest around towns is burned more frequently than elsewhere in order to protect life and property from summer wildfires. Recent years have seen more effort put into varying the season of burning (Burrows 1990). Much of the forest is subject to a period from mid-December to mid-March when burning is prohibited by law and is permitted only under special circumstances. As the south-west of WA experiences a Mediterranean climate, it is normally impossible to undertake widespread prescribed burning in winter. Most burning is therefore done in late spring (October–December) and late autumn (April–May).

Fire intensity during spring burning shows very marked spatial variation (Underwood and Christensen 1981, p. 16), being influenced by aspect, location in the landscape, and age of the forest. With fires set in spring, the nature conservation intent is to produce a mosaic in intensity of burn (Figure 1 in McCormick 1972; Figure 1 in Kimber 1974; (Table 17 and Figure 11 in Christensen and Kimber 1975; Underwood and Christensen 1981, p. 15; Van Heurck *et al.* 1998), with about 20–30 per cent of the total ground area left unburnt. Much of the overstorey is left unscorched (see, for example, Underwood and Christensen 1981, p. 11). Any localized scorching of tree crowns is followed by dense refoliation in summer. Full refoliation of ground vegetation takes 2–3 years. Autumn fires result in more crown scorching and often almost complete combustion of ground vegetation (e.g. Van Heurck *et al.* 1998 found that 10–30 per cent of leaf litter was unburned). In karri forest, the cover contributed by ground vegetation and the overstorey returns to pre-fire levels by 19 months after 'severe' fire. Cover contributed by the shrub and lower understorey takes longer (Christensen and Kimber 1975), with maximum density of shrubs achieved by 6 years after a prescribed fire (Tingay and Tingay 1984).

The impact of various fire intensities on regeneration following the fire, particularly the vertical distribution of foliage, has been summarized diagrammatically by Underwood and Christensen (1981, p. 24). The current standards to be achieved with hazard reduction fire and

[39] The details of Noongar burning practices are unknown, apart from the fact that most took place in summer (Burrows *et al.* 1995). Presumably their use of fire was both skilful and managed, otherwise bird species restricted to riparian habitat in the drier northern jarrah forest would not have persisted with frequent and broadscale burning of this habitat. Indeed, it is likely that species such as *Atrichornis clamosus* (Noisy scrub-bird), *Malurus splendens* (Splendid fairy-wren), *Malurus elegans* (Red-winged fairy-wren), *Eopsaltria georgiana* (White-breasted robin) and *Stagonopleura oculata* (Red-eared firetail) had greatly insularized distributions in the northern jarrah forest.

silvicultural fire using aerial prescribed burning in the southern forests are clearly set out in CALM (1997h).

Vegetation in and around swamps can burn very intensely. Kimber (1974) noted that a prescribed (spring) fire will not generally run through a swamp until the vegetation is 7–8 years old. Refoliation from rootstocks is rapid: e.g. *Agonis linearifolia* exceeds 1.5 m in height one year after a fire in spring and is dense enough to make walking difficult. Plant species that dominate the understorey of riparian areas, forming thickets 2.5–5 m tall, and regenerate after fire only from seed (e.g. *Acacia pentadenia, Banksia seminuda, Bossiaea aquifolium, B. laidlawiana, Trymalium floribundum)* flower within 4–6 years of fire (Burrows[40], unpublished data; personal observation). Clearly, these species are adapted to fire frequencies of 8–12 years. These species also attain a height of at least 2 m as soon as 2–4 years after fire (Skinner 1984).

Recent research by Burrows and Friend (1998) has examined reproductive characteristics of key plant species after fire in jarrah forest. They propose that the time to flowering and fruiting of the slowest maturing species could be used as a biological standard for defining fire frequency. Based on such data, the sustainable minimum fire frequency for upland jarrah forest receiving rainfall > 900 mm/year is *c.* 6 years; that for upland jarrah forest with < 900 mm/year is *c.* 8 years; and that for riparian forest (> 900 mm/year) is *c.* 12 years. Burrows and Friend (1998) therefore have proposed a more diversified fire regime than that currently applied: fire in spring, followed 6 years later by another fire in spring, followed 6 years later by a fire in autumn, followed by 12 years with no fire, after which the cycle is repeated.

Rates of litter accumulation in jarrah forest after fire indicate that the minimum possible fire interval is 2–3 years (high rainfall forest) or 2–5 years (low rainfall forest) (Burrows *et al.* 1995). Studies of black bands on the stems of *Xanthorrhoea preissii* and historical records appear to indicate that aboriginal burning before European settlement was triennial over much ofthe south-west (Ward and Van Didden 1997; Ward 1998).

Some biologists (Woinarski and Recher 1997) evidently confuse edge burning (CALM 1993) by hand of forest block boundaries along public roads (no unburned understorey remaining for a distance of *c.* 100 m from the edge) with aerial burning in the interior of the forest block (many unburned patches remaining, crown scorch variable). The purpose of hand burning along such boundaries is to minimize the risk of fire escapes from aerial burning into adjacent unburned forest (The escape rate from prescribed burns is 5 per cent – CALM 1997g, p. 82). In the southern forests, scrub rolling is also used along the perimeter of areas to be prescription burned.

In summary, prescribed burning has been spectacularly successful in reducing the extent of wildfire, usually caused by lightning or arson (Bradshaw *et al.* 1991), and in producing an intricate mosaic of various ages of regeneration (Robertson 1998). The opinion expressed by Storr (1991, p. 10) that State forest is 'managed from the viewpoint of timber production' is only partially correct. Regenerating forests do need protection from fire if they are to develop into stands capable of producing both timber and habitat, as well as escaping the destructive impacts of periodic wildfire.

Dieback disease. Probably introduced soon after European settlement, the fungus *Phytophthora cinnamomi* has spread through much of the forest with suitable environmental conditions (Shearer and Tippett 1989). Low-lying parts of the forest in the higher rainfall zone are most prone to infection (Havel 1975b). More than 225 000 ha have been extensively affected; resulting in death of susceptible plant species, including jarrah, *Banksia grandis, Xanthorrhoea preissii* and other prominent components of the ground flora. Normally such 'graveyard' sites are colonized by resistant species such as marri, yarri, and bullich (photographs of graveyard sites are provided in Shea 1975; Postle *et al.* 1986, p. 48; Shearer and Tippett 1989; Beard 1990, p. 84). The cause of 'jarrah dieback' (as it was then known) was only established in 1965; this discovery 'was a watershed in forest management, as it necessitated a re-examination of all existing activities in the forest' (Havel 1989). Developments in policy and management of dieback disease are outlined in Bradshaw *et al.* (1991).

The most important principle regarding dieback disease in relation to timber harvesting is the need to minimize the risk of soil being transported from areas infested with the dieback pathogen to areas free of dieback (CALM 1997f). During silvicultural operations in dieback-affected forest (CALM 1989a), retention of resistant tree species (including any resistant jarrah) is emphasized in order to maintain forest canopy. Of equal priority is the protection of existing sapling regeneration from fire or logging damage (CALM 1989a) and the creation of ashbeds to promote regeneration (CALM 1989b).

Mining. Although mineral leases are extensive within State forest, economic deposits of minerals and ores tend to be highly localized. The area of forest so far removed for mining is 13 400 ha (bauxite), 2000 ha (coal, open cut since 1943), 1 600 ha (tin) and 280 ha (gold) (Caporn[41], personal communication). After mining, rehabilitation of the site takes place (Stedman 1988; Bartle and Slessar 1989). The objective is to re-establish a stand of trees with structural variety; increasing effort is involved in using local species such as jarrah and marri and in promoting an abundantly flowering understorey with a leguminous component (Kabay and Nichols 1980; Koch and Ward 1994; Ward and Koch 1995).

Aboriginal Utilization

Aborigines hunted several bird species for food (Meagher 1974). The flesh of *Dromaius novaehollandiae* (Emu) was

[40] Dr N.D. Burrows, Department of Conservation and Land Management, Crawley.

[41] N. Caporn, Department of Conservation and Land Management, Como.

highly esteemed for eating. *Cygnus atratus* (Black swan) was also taken when it was moulting. Other species particularly recorded in early colonial times as being eaten were *Aquila audax* (Wedge-tailed eagle) and *Phaps chalcoptera* (Common bronzewing) (Meagher 1974). Aborigines regarded young *Platycercus zonarius* (Australian ringneck) as a great delicacy and climbed trees with the aid of a tomahawk to obtain them (Green 1989a, pp. 24–25). Quail, cockatoos and waterfowl were recorded without detail as food items, and eggs and young of raptors, parrots, pigeons and waterfowl were collected from June to January (Meagher 1974).

Introduced Species

Predators. Cats would very likely have colonized the forest soon after European settlement commenced in 1826. Foxes arrived overland (from South Australia) in the late 1920s (Long 1988), following colonization by rabbits in 1916-1921 (Stodart and Parer 1988). Agricultural disturbance may have facilitated the spread of foxes and cats within the south-west forest region. Rabbits became a serious pest in the 1950s in the south-west and were controlled by '1080' poisoning (King 1990). The fox became very numerous in the 1970s once the myxoma virus replaced poison baiting of rabbits (King *et al.* 1981), though it was always least numerous in karri forest. Feral cats may be abundant in forest, e.g. 40 were killed during a period of 3 years around a house at Smith Brook south of Manjimup (Webster 1948). Both predators are likely to impact on the 9 species of landbirds and 4 species of waterbird nesting on the ground in the forest (Table 9; Burbidge and Fuller 1990). However, broadscale aerial baiting by CALM ('Western Shield' Project) is beginning to bring fox numbers under control (Bailey 1996).

The Laughing Kookaburra was introduced in south-west WA in the 1890s and soon established in the forest. Its impact on nesting birds has not been investigated.

Competitors. Very few introduced bird species are apparently able to establish permanent populations in the forests of south-west WA, evidenced by the information presented in Table 4. The Rainbow lorikeet (*Trichoglossus haematodus*), introduced to Perth in the 1960s, now occurs throughout the metropolitan area (Lamont and Burbidge 1996). Presumably it will spread south along the Swan Coastal Plain. Predictive modelling based on Bioclim indicates that much of south-west WA has a climate that would suit *T. haematodus*. If it invades the karri forests, it may compete with the native lorikeet species, *Glossopsitta porphyrocephala*. According to Lamont (1996) and Lamont and Burbidge (1996), *G. porphyrocephala* is unlikely to be displaced as it is smaller than *T. haematodus*, feeds on small eucalypt flowers, and apparently coexists with *T. haematodus* in south-east Australia. Nonetheless this species has been recorded feeding at flowers of jarrah and marri. It is also aggressive to other bird species (Lamont 1996).

Introduced prey species for native predators. The arrival of the rabbit in the forests of south-west WA increased the food supply of some raptor species, and may have compensated for the contraction in distribution, and decline in abundance, of many species of native mammals following the arrival of the fox. Introduced mice, rats and rabbits have also contributed to the diet of owls (Barker and Vestjens 1989; Debus and Rose 1994; Debus 1997).

Pollution

Salination of streams. Extensive clearing of native vegetation in the wheatbelt/sheepbelt has resulted in rivers (Avon, Murray, Collie, Blackwood, Warren, Frankland) draining this area becoming saline (Western Australian Water Resources Council 1992). The connexion between clearing of native vegetation and the development of secondary salination was noted in WA as early as 1897 (Wood 1924). Although clearing commenced early this century and peaked in the 1960s, widespread salination of freshwater lakes is a relatively recent event, e.g. Lake Towerrining was still fresh in 1966 (Froend and McComb 1991). Other large lakes at the eastern margin have also become permanently saline; in primaeval times, they probably became salty in summer/autumn but reverted to fresh water in winter/spring. Now the only fresh wetlands remaining in nature reserves on the fringe of the forest are Kukulikup, Dobaderry swamp, Yarnup lagoon, Poorginup swamp, and Grasmere Lake (Halse *et al.* 1993a). Streams and swamps draining habitats totally within State forest remain fresh (Peck and Hurle 1973; Schofield *et al.* 1988; Lane and McComb 1988), and timber harvesting operations are designed to avoid risk to water quality (Bradshaw *et al.* 1991, Underwood *et al.* 1991).

Increasing and then permanent salination eventually causes death of emergent vegetation (e.g. Froend and McComb 1991), impacting particularly on those waterbird species requiring dense rushes, reeds or trees (see Table 9; Sanders 1991). Halse (1987) indicated that only 6 species – *Cygnus atratus* (Black swan), *Tadorna tadornoides* (Australian shelduck), *Anas gracilis* (Grey teal), *A. rhynchotis* (Australian shoveler), *Phalacrocorax melanoleucos* (Little pied cormorant) and *Fulica atra* (Eurasian coot) – would be abundant and breed in saline lakes. Most waterbird species, however, are associated with brackish waters and breed successfully in such waters (Goodsell 1990; Halse *et al.* 1993b) apparently because of larger populations of invertebrates in brackish waters.

Creation of New Habitats

European settlement has introduced extensive areas of new habitats. These are open areas of grassland (pasture), open areas of cropland and stubble (wheat, oats), woodland (orchards), parkland in and around towns, and gardens in towns and on farms. Agricultural development has also created many small and relatively shallow waterbodies (farm dams) throughout parts of the forest. These are used

by 8 duck species (Jaensch and Vervest 1988b). Damming of rivers has created large areas of oligotrophic deep water used transiently by 4 duck species (Jaensch and Vervest 1988b).

Habitat Fragmentation?

To some biologists (e.g. Recher 1996; Russell and Rowley 1998), forest management (logging, prescribed burning) fragments forest and thereby has the potential to impact on the persistence of some bird species. However, this use of the concept of fragmentation is inappropriate. Fragmentation refers to the creation of remnant parcels of land containing native vegetation, as a result of *permanent* clearing of native vegetation for agriculture and urbanization. The intervening new habitat (wheatfields, pasture, buildings) is unsuitable habitat for most of the bird species present prior to clearing. Individual birds of these species seem unable or unwilling to disperse through hostile habitat. Populations effectively remain marooned in the remnants (sink populations, Pulliam 1988, in which reproduction does not compensate for mortality). There is a considerable difference between a small number of farms surrounded by forest (as for example at Jarrahdale) and an agricultural area (such as the wheatbelt near Kellerberrin) containing few large remnants of native vegetation. It is the permanent clearing of native vegetation that creates habitat fragmentation.

Because of subtle variation in water availability and physical and chemical properties of soils across the landscape, the primaeval eucalypt forests of south-west WA exhibited an extensive mosaic of natural patchiness at many scales (Mattiske Consulting 1997): site-vegetation types (Havel 1975a, b; Strelein 1988); vegetation complexes and ecological vegetation systems (Mattiske and Havel 1998, Commonwealth and Western Australian Regional Forest Agreement Steering Committee 1998); and forest ecosystems (Bradshaw *et al.* 1997). This, together with the island-like nature of the original forest, is why the North American concept of obligate forest-interior bird species (often requiring old growth) is not applicable to the forests of south-west WA.

With logging and prescribed burning, further heterogeneity is imposed on the landscape, but at a diversity of spatial scales (up to 10 ha for jarrah logging; up to 80 ha for karri clearfelling; up to *c.* 5 000 ha for prescribed burning, itself not uniform but containing unburnt patches varying in area from several m^2 to 10^4 m^2). These disturbances are then allowed to initiate ecological succession which is well advanced before the next disturbance is imposed, 5–100 years later.

This type of disturbance is well accommodated by the concept of habitat variegation (McIntyre and Barrett 1992). Disturbed vegetation is more aptly perceived as a modified version of the original vegetation and thus does not present a permanent barrier to most bird species. Recently harvested coupes and burned blocks are embedded in a forested landscape offering a spectrum of post-disturbance successional stages. As noted by Ford and Barrett (1995), many Australian bird species view their original habitat as patchy and varying in quality, and so do not have difficulty coping with a modified landscape. See, in addition, many of the species accounts so far published in RAOU (1990–1996). The subtle (and straightforward) distinction between habitat fragmentation and variegation is well illustrated by *Eopsaltria australis* (Yellow robin). In the extensively cleared Western Australian wheatbelt, Yellow robins occur only in fragments of native vegetation larger than 20 ha and less than 2 km from other patches of native vegetation 20 ha or more in area (Lambeck 1997). In contrast, Yellow robins in jarrah forest occur throughout the mosaic of available habitats resulting from logging and burning at various times in the past (see Tables 1, 2, 11).

2. Changes to Bird Species Richness following European Settlement

There have been extensive changes to the forest avifauna following the inroads of European settlement, mainly in the arrival of species not previously present. Some of these changes reflect habitat change in adjacent areas, particularly the wheatbelt and Swan Coastal Plain. This has enabled open country species to penetrate into cleared forest. The 12 species of landbird involved are *Aquila morphnoides* (Little eagle), *Cacatua roseicapilla* (Galah), *Neophema elegans* (Elegant parrot), *Meliphaga virescens* (Singing honeyeater), *Epthianura albifrons* (White-fronted chat), *Rhipidura leucophrys* (Willie wagtail), *Grallina cyanoleuca* (Magpie-lark), *Lalage tricolor* (White-winged triller), *Cracticus torquatus* (Grey butcherbird), *Anthus novaeseelandiae* (Richard's pipit), *Cinclorhamphus mathewsi* (Rufous songlark) and *C. cruralis* (Brown songlark). The six species of waterbird involved are *Chenonetta jubata* (Australian wood duck), *Malacorhynchus membranaceus* (Pink-eared duck), *Ardea pacifica* (White-necked heron), *Threskiornis spinicollis* (Straw-necked ibis), *Gallinula tenebrosa* (Dusky moorhen) and *Vanellus tricolor* (Banded lapwing).

Only one of these species (*A. morphnoides*) actually breeds in stands of forest trees; the others are dependent on pasture, remnant trees on farmland, gardens in towns and around farm buildings, or the provision of dams (earth tanks) for stock.

A further four species were introduced into Perth and have spread either unassisted (*Streptopelia senegalensis* (Laughing turtle-dove), *S. chinensis* (Spotted turtle-dove) or assisted (*Columba livia* (Domestic pigeon), *Dacelo novaeguineae* (Laughing kookaburra)) into areas with suitable habitat within the forested part of the south-west. A fifth species, *Neochmia temporalis* (Red-browed finch), was released directly into forest/farmland. Of these species, only *D. novaeguineae* and *N. temporalis* can live in uncleared forest.

Many other species occur regularly in farmland within the forest but are not yet known to breed. Examples include *Elanus caeruleus* (Black-shouldered kite), *Falco cenchroides* (Australian kestrel), *F. longipennis* (Australian hobby), *Polytelis anthopeplus* (Regent parrot) and *Petroica goodenovii* (Red-capped robin).

The remaining species (Table 4) are mainly vagrant or

infrequently recorded. In the future some of these may colonize the south-west of WA and establish either on cleared land surrounding State forest or in natural habitats within State forest.

On the debit side, one forest species, *Rallus pectoralis* (Lewin's rail) is presumed to have become extinct in south-west WA (disappearing from wetland irrespective of land tenure; after 1850 near Perth, after 1880 near Albany, after 1907 near Margaret River, and after 1932 at Wilgarup). Judged by the small numbers of specimens collected or sighted (8) and the few locations at which the species was recorded (4), this species seems to have been very rare from its discovery in the 1840s until the last record in 1932. It is possible that this species, with its apparent greatly-insularized geographical range, was sensitive to too frequent burning of its habitat as European farming advanced. Blakers *et al.* (1984) mention predation of this species by cats.

A second species, *Atrichornis clamosus* (Noisy scrub-bird), disappeared from its habitat within forest and almost everywhere else probably before 1900 (Smith 1985a). This species was evidently very rare in colonial times – only *c.* 20 specimens were collected and it was recorded from only 6 localities. Its apparent excessively-insularized geographical range left it vulnerable to a change in fire regime once European settlement advanced rapidly in the 1890s. In that decade the population of WA trebled following the discovery of gold (Jarvis 1979). The ensuing shortages of food led the government to encourage agricultural development. This would have greatly increased the clearing of native vegetation, burning off, and fire escapes.

The number of species extinctions in State forest is much less than in the adjoining Swan Coastal Plain, wheatbelt, and subcoastal region from Cape Naturaliste to Hopetoun (Fig. 19). Of the 27 extinctions listed for the South West Land Division (Table 10), only 2 (7 per cent) occurred in the primaeval forest. Armstrong and Abbott (1995) attributed this to extensive permanent clearing of native vegetation (78–93 per cent) in these areas relative to State forest (2 per cent). In addition, extinction is an ongoing process (Fig. 20): there are many species on the Swan Coastal Plain and in the wheatbelt that have declined dramatically since European settlement began, and now occur in few areas (Abbott 1997; Table 10). Some of these species will become locally extinct on the Swan Coastal Plain and in the wheatbelt during the next few decades, e.g. in the wheatbelt (*c.* 95 per cent cleared), island biogeography theory predicts that only 51 per cent ($0.05^{0.25}$) of the original avifauna will persist (Rosenzweig 1995). Of the 64 contracted distributions listed, only 4 (6 per cent) are from the primaeval forest. This is in striking comparison to elsewhere in the world, where forest is the habitat for 65 per cent of all threatened bird species (Collar *et al.* 1994). The main reason for this is that tropical forests are rapidly being fragmented by clearing for agriculture or ranching.

In summary, the original avifauna of 112 breeding species (81 land, 31 water) now totals 134 breeding species. This recognizes that forest now cleared for farming or mining constitutes a permanent additional habitat, intimately part of the original forest as mapped in Figure 1. Overall, the present patchwork of eucalypt forest, pasture, cropland, gardens and pine plantations has led to an increase in the diversity of bird species compared with that in 1829.

3. Contracted Distributions of Species following European Settlement

Based mainly on information synthesized by Storr (1991), 4 species out of the 112 species present in the primordial forest now have smaller geographical distributions.

Leipoa ocellata. Malleefowl no longer occur near Yelverton or Lake Muir. Clearing of forest for agriculture and the arrival of the fox are probably responsible for these extinctions.

Calyptorhynchus banksii. The Forest red-tailed black cockatoo no longer occurs east of Chidlow–Boddington-Boyup Brook–Mt Barker as a breeding species (see also Abbott 1998b, c). Excessive clearing of forest for agriculture is probably responsible for this decline.

Cacatua pastinator. The Western long-billed corella is no longer recorded in the 'Blackwood district' [Bridgetown] or 'Lower Blackwood district' [Nannup] (Curr 1886) and it no longer visits the alluvial and swamp flats between Augusta and Pt D'Entrecasteaux in summer. Poisoning by farmers is thought to be responsible for this.

Climacteris rufa. The Rufous treecreeper no longer occurs in the forest between Julimar and Wooroloo. This decline may be attributable to fragmentation of forest through agricultural development (see map in McArthur and Mulcahy 1980 and McCracken and Astley-Boden 1982).

Two presumed extinct species (*Rallus pectoralis* and *Atrichornis clamosus*) have been discussed above.

4. Species that have taken Advantage of Disturbances caused by European Settlement

Several species that appear to have been rare in the primordial forest have increased in distribution and abundance in the forest following disturbances generated by European settlement: *Acanthiza chrysorrhoa* (Yellow-rumped thornbill), *Lichmera indistincta* (Brown honeyeater), *Anthochaera carunculata* (Red wattlebird), *Anhinga melanogaster* (Darter), and *Fulica atra* (Eurasian coot). Most bird species of the primordial forest have also exploited opportunities provided by European settlement. Table 11 is a synopsis of available information.

Most species (69) appear to use (to varying extent) farmland and towns situated in the forest. This illustrates the importance of the scale of clearing relative to the matrix of forest reserved as State forest, nature reserve or national park (see, for example, Underwood and Christensen 1981, p. 2). Most public roads through

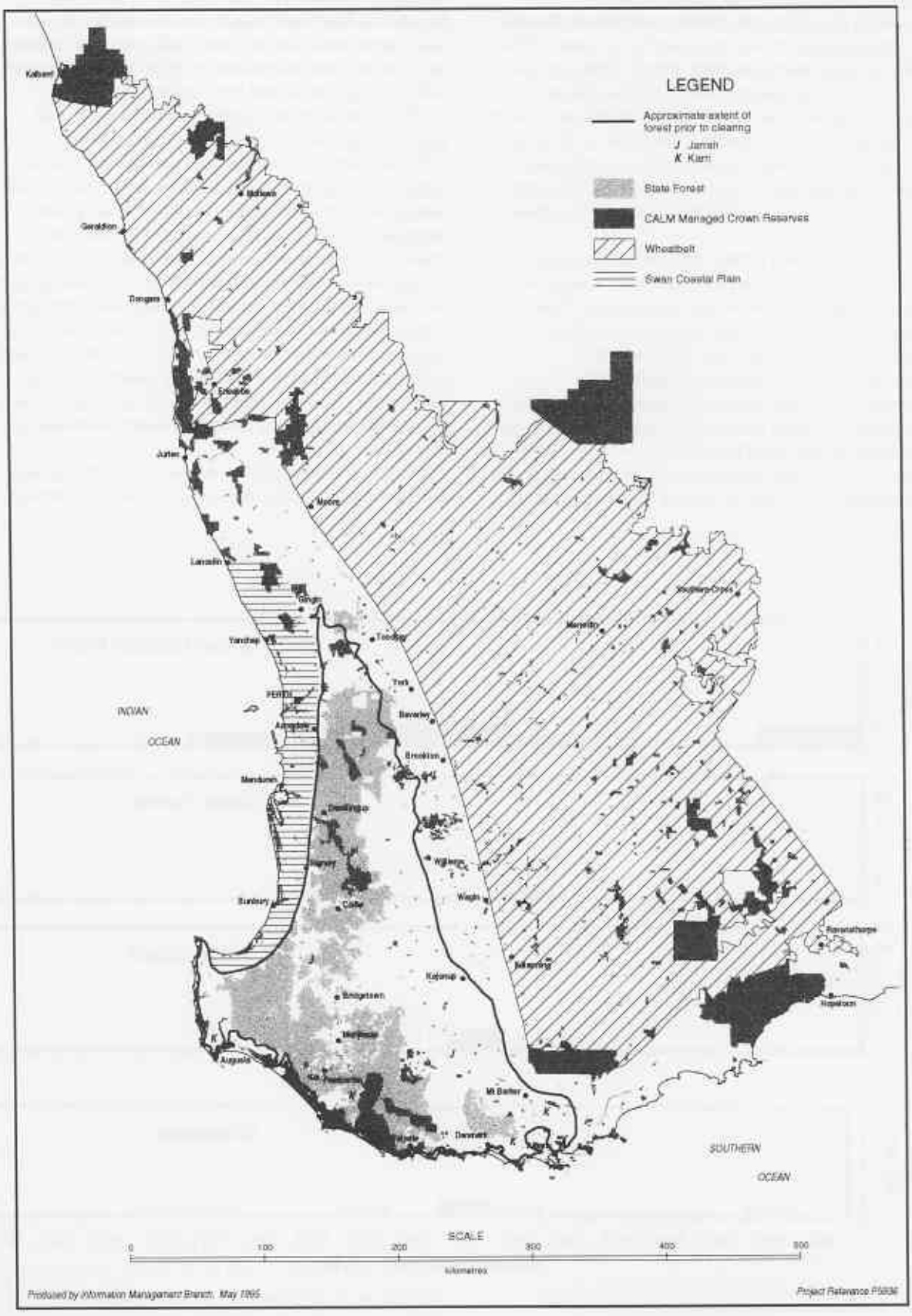

Figure 19. South-west Western Australia showing the areas designated as Swan Coastal Plain, wheatbelt, State forest and the primaeval forest.

farmland provide a corridor of remnant overstorey trees, together with understorey in varying degrees of degradation through weed invasion and dieback disease. The farms themselves may have patches of forest left but usually the understorey has been grazed. Drainage lines may provide a degraded corridor of riparian habitat. Paddocks may have one or two large trees left per 10 ha to offer shelter for stock. Similarly, townsites in the forest have patches of remnant forest or trees, planted trees, parkland, and gardens. Evidently this type of disturbance suits more than half of the landbird fauna of the primal forests.

Brown and Brown (1986–1987) noted that pines planted on farms near Manjimup provided 'unexpectedly acceptable' habitat for *Acanthiza chrysorrhoa* (Yellow-rumped thornbill), *Anthochaera carunculata* (Red wattlebird), *Petroica multicolor* (Scarlet robin), *Gymnorhina tibicen* (Australian magpie) and *Stagonopleura oculata* (Red-eared firetail). Vegetation along roads traversing farmland in the same area was used by 24 landbird species of the primal forest (Brown and Brown 1978–79); this utilization was frequent enough for these species to be killed by moving vehicles (Brown *et al.* 1986). Other species making use of roads and roadside habitat are discussed in RAOU (1990–1996). The supposition that roads impede the movements of south-west forest birds (Recher 1996) lacks empirical support and is in any case inconsistent with the open structure of both the virgin jarrah and karri forests.

Pine plantations are known to be used by 43 bird species. Regarded by some as 'biological desert', softwood plantations are more accurately described as simplified ecosystems (Friend 1980). Pine trees provide nesting sites for some species, there are small glades throughout where pines have died, and the network of tracks may be lined with native plant species able to persist in edge habitats. In the first few years after planting, pines provide dense thickets suitable for many small bird species. Plantations have also provided a large food resource for *Calyptorhynchus latirostris* (Carnaby's cockatoo). Friend (1982) provides a synthesis of many eastern Australian studies of birds in pine plantations; his data and review are consistent with usage by birds of Western Australian pine plantations.

Artificial water supplies such as reservoirs and farm dams provide utilizable habitat for 30 species. Thirteen

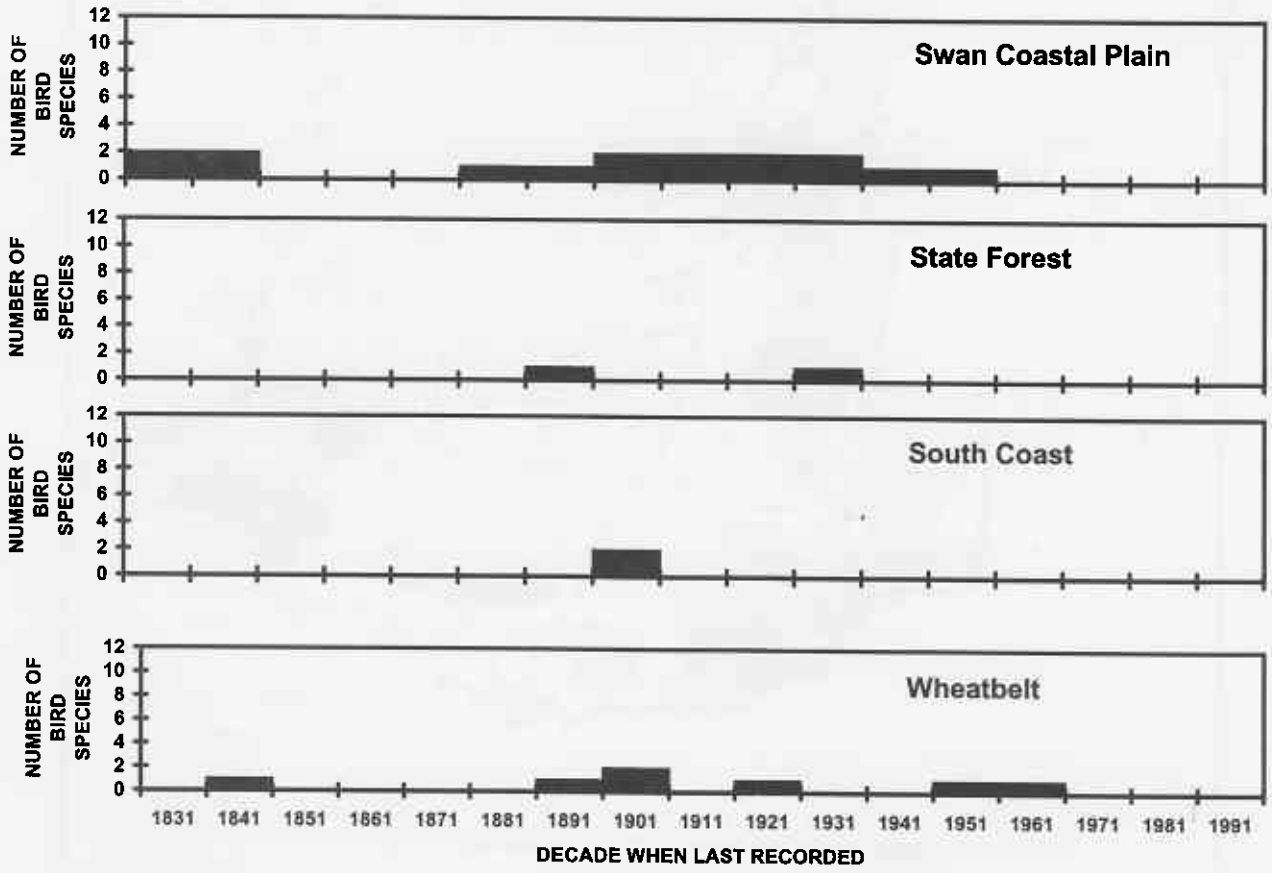

*Figure 20. Extinctions continue to occur regularly in the most heavily cleared parts of south-west Western Australia. Note the extinction of one species hypothesized to have occurred in State forest (*Atrichornis clamosus *(Noisy scrub-bird), arbitrarily set at decade 1891).*

species of swan, duck, grebe, cormorant, heron, crake, rail and wader have been recorded breeding on farm dams within the forest. Other species use the thickets around dams as breeding habitat.

Fifty species of primaeval forest birds have been recorded using bauxite minesites within 5 years of rehabilitation.

When considered collectively as habitats not represented in the forest before 1826, farms, towns, dams, reservoirs, permanently saline lakes, pine plantations, rehabilitated minesites, roads and cuttings provide habitats used by 75 landbird species and 19 waterbird species. This is 84 per cent of the primaeval forest avifauna. The species for which I could find no primary record of use of such 'new' habitats within the original extent of the primal forest are:

Landbirds

Leipoa ocellata
Ninox connivens
Atrichornis clamosus
Petroica cucullata
Pomatostomus superciliosus

Waterbirds

Oxyura australis
Anas rhynchotis
Nycticorax caledonicus
Ixobrychus minutus
I. flavicollis
Botaurus poiciloptilus
Rallus pectoralis
Porzana fluminea
Gallinula ventralis
Himantopus himantopus
Charadrius ruficapillus
Erythrogonys cinctus

However, elsewhere in Australia, some of these species have been recorded as benefiting (to varying extent) from European settlement (RAOU 1990–1996).

The demonstrated versatility of a large fraction of the primaeval avifauna of the forests of south-west WA agrees with some other studies of change following European settlement, e.g. south-west USA (Brown and Davis 1995) and Western Australian rangelands (Saunders and Curry 1990). Affected species can be either 'losers' or 'winners', though usually most species in an avifauna appear indifferent to changes imposed by European settlement. In other regions following European settlement, avifaunas support a lower diversity of species than before settlement, as in the Western Australian wheatbelt (Saunders and Curry 1990), Perth metropolitan area (How and Dell 1993), County of Cumberland, NSW (Hoskin 1991), semi-arid NSW (Smith *et al.* 1994), and well-vegetated suburbs of Brisbane, Queensland (Sewell and Catterall 1998). Such differences presumably reflect the extent and intensity of disturbances imposed by European settlement patterns.

5. Impacts of Disturbance on Biodiversity and Total Abundance of Bird Species

Disturbance is common to all ecosystems (Attiwill 1997; Stott 1998) and biodiversity is influenced by disturbance regime. Long periods of little change or of continuous disturbance result in loss of species (Huston 1994). Current theory holds that intermediate levels of disturbance (in terms of magnitude, frequency or duration) tend to maximize biodiversity (Connell 1978). Forest managers in south-west WA, well before these theories had been proposed, were imposing disturbance at intermediate scales, both spatial and temporal. The reasons for this were the comparatively slow growth rate of tree species of commercial significance (especially jarrah) and the gradual increase in combustible fuels after fire.

Once a stand had been logged, it was not profitable to harvest timber again until the trees retained had grown into larger sawlog sizes. Thus, overstorey was disturbed every 20–30 years in jarrah and karri forest for thinning. With fire management, forests were nominally to be burned on average every 5–7 years (high quality jarrah forest), 7–10 years (low quality jarrah forest) and 5–10 years (karri), once litter and other potential fuel items had reached 8 t/ ha (jarrah) and at least 15 t/ ha (karri). The rationale is described in CALM (1994b). The total area of jarrah and karri forest prescription burned each year has declined from 370 000 ha in 1979 to 150 000 ha in 1993 (CALM 1994b). Thus, understorey and to a lesser extent midstorey were disturbed every 5–26 years (CALM 1997g, p. 83).

In the era of unregulated logging and burning (before 1919), disturbance was intense but the cut-over forests were then left, to be disturbed again at intervals by summer wildfires. Much of the jarrah forest (for example, around Dwellingup) was effectively clearfelled before the Great War, but the regenerating forests were left undisturbed until the 'regeneration cleaning' of the Depression years, selective logging in the 1960s, and the introduction of prescribed burning in the 1960s (Abbott and Loneragan 1986; Heberle 1997).

Avian biodiversity, in the face of ongoing disturbance, is maintained at the landscape scale but at local scales usually decreases immediately after disturbance (depending on the magnitude, scale and transience of the disturbance). Successional change (regeneration) in vegetation is then initiated and bird species recover their pre-disturbance abundance or recolonize the previously disturbed area as their shelter and food requirements are satisfied.

Disturbances caused by fire and timber harvesting in the south-west forests of WA are considered by some to be processes that threaten biodiversity. However, the considerable body of scientific evidence (the information collated for this review) against this viewpoint is overlooked or not cited; instead a political, forensic and ideological agenda has been followed to oppose, exclude or minimize planned burning and timber harvesting in native forests (see also examples discussed in CALM 1990a; Abbott and Christensen 1994, 1996; Christensen 1997a; Underwood 1998). In some cases, e.g. Tingay and Tingay (1984), the conclusions reached by authors are not

supported by the data presented.

This review found that some publications by ornithologists about forest birds reveal oversimplified, limited or incorrect understanding of how fire and timber harvesting are managed by professional foresters. The main reason for this inadequate conceptualization appears to be lack of familiarity with current and publicly available information on forest management presented in management plans, prescriptions, guidelines, codes of practice, and annual reports to Parliament.

Some of the literature dealing with impacts of disturbance on birds in jarrah and karri forests can be legitimately criticized because of some incorrect species identifications (e.g. Kimber 1974; Norwood 1992) and methodological limitations, including insufficient replication (e.g. Tingay and Tingay 1984), pseudoreplication (e.g. Abbott and Van Heurck 1985b; Wardell-Johnson 1985), lack of an appropriate control (Rowley *et al.* 1988; Wooller and Calver 1988) and inappropriate sampling technique and scale (e.g. Wooller and Brooker 1980; McComb 1994). These imperfections of course vary in their importance and thus determine the extent that conclusions drawn from each study need to be qualified. Nonetheless, taken together, analysis of the data collected in most of these studies produces remarkably consistent conclusions (see the individual species commentaries and below).

Alternative conclusions offered by Mawson and Long (1994), Recher (1996) and Calver (1997) are derived from a restricted information base and rest on misconceptions about silviculture, the strategic management of forest structure, and the spatially and temporally dispersed nature of forest operations. These erroneous perspectives have been addressed where appropriate in the species commentaries, in the sections treating reproductive capacity and temporary modification of forest, and in Abbott and Christensen (1996) and Abbott and Burrows (1999).

Forest managers undertake to uphold nature conservation values in forests, particularly biodiversity. There has not been a commitment given to maintaining abundance of all species at levels in unburnt or unlogged forest, for the obvious reason that there is no single abundance of a species. Thus this criticism (e.g. Tingay and Tingay 1984, p. 9) is void of meaning. Moreover, the few detailed population studies of bird species in south-west Western Australian forests have demonstrated that natural mortality is appreciable without disturbance by fire, with *c.* 9–17 per cent of juveniles banded of *Malurus elegans, Sericornis frontalis* and *Eopsaltria georgiana* in karri forests dead within one year of banding (Brown and Brown 1990). Some individual birds are known through banding studies to be able to survive low intensity prescribed fire (Wooller and Brooker 1980).

Overall, the data assembled in this review uphold the suggestion of Abbott and Van Heurck (1985b) that most forest bird species in south-west WA have a high threshold level of tolerance to disturbance and are thus resilient to habitat changes caused by timber harvesting and prescribed burning.

Fire

Davies (1979) reviewed the breeding season of bird species in southern WA. Using data for only 6 common species which were members of the primaeval forest avifauna, he concluded that burning in spring jeopardized breeding effort, damaged future food supplies, and was therefore more damaging than burning in autumn (when little breeding occurs). However, for 4 of these species most breeding took place before October (see below).

Empirical data do not support Davies' conclusions. Prescription burning under moist soil conditions (spring in jarrah forest, early summer in karri forest) had no impact on bird species richness in jarrah forest (Kimber 1974), largely because unburned patches (in two dimensions) within the burned forest and unburned forest blocks adjacent to the burned forest act as a reservoir from which birds repopulate burned areas as soon as they refoliate. In karri forest, however, species richness increased for 3–6 years after fire (Figs 21, 22). This type of fire tends to increase total abundance of birds in jarrah forest (Fig. 23) and karri forest (Fig. 24). Other studies (Wooller and Brooker 1980; Wooller and Calver 1988) are difficult to interpret reliably as sampling was biased, being based on mist-netting.

Kimber's (1974) study of 12 (actually 11) passerine species, which were resident, breeding in jarrah forest and easily identified, grouped these species into 4 classes:

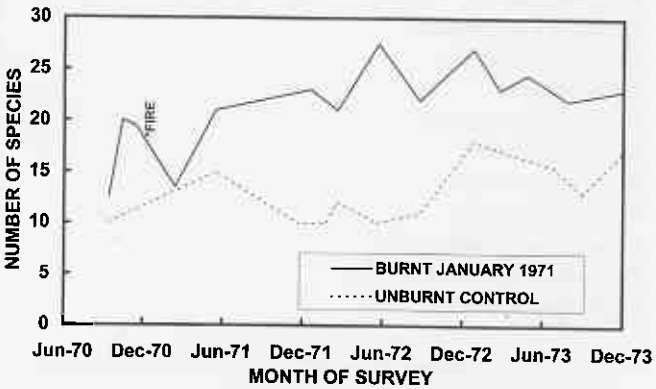

Figure 21. Number of bird species in karri forest decreased initially after fire and then progressively increased (Christensen and Kimber 1975).

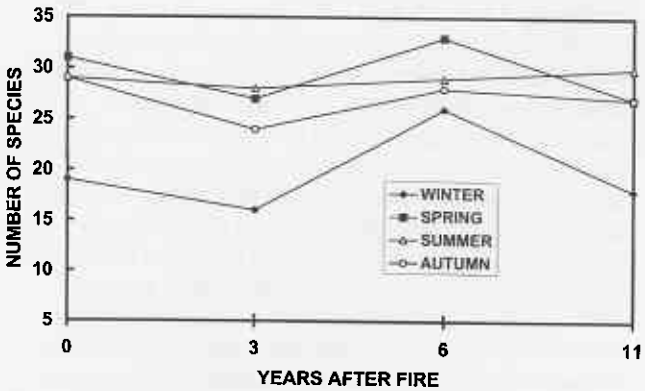

Figure 22. Number of bird species in mature karri forest was greatest 6 years after fire (Tingay and Tingay 1984).

those present in the 0–10 m, 10–15 m, 15–25 m, and > 25 m strata. Not unexpectedly, the only group that decreased in abundance immediately after the fire was the group of bird species in the 0–10 m stratum. By one year after the fire, this group was once again as abundant as before the fire. The group of species in the 10–15 m stratum declined in abundance between 1 and 12 months after the fire, but appeared to recover by 2 years after the fire.

The other reason that mild fires have no or few detrimental effects on species richness/total abundance is that most fires are lit after September (Fig. 25). Most forest bird species commence nesting in July and August (Fig. 25; also Kimber 1974). This fact, together with the deliberate spatial and annual dispersal of burning, ensures that any mortality caused to species nesting on the ground or in foliage scorched can be made good by dispersal of newly fledged birds from nearby unburned forest. Monitoring of 15 nests located prior to burning in late November-early December demonstrated that nesting had finished in 11 of them. Young were reared successfully from the 4 nests active at the time of the fire (Kimber 1974).

The 8 species which commence nesting in October are *Coturnix ypsilophora* (Brown quail), *Calyptorhynchus baudinii* (Baudin's cockatoo), *Ninox connivens* (Barking owl), *Eurostopodus argus* (Spotted nightjar), *Todiramphus sanctus* (Sacred kingfisher), *Merops ornatus* (Rainbow bee-eater), *Acrocephalus stentoreus* (Clamorous reed warbler) and *Stagonopleura oculata* (Red-eared firetail) (Storr 1991). Of these, *C. ypsilophora* and *E. argus* nest on the ground and are probably the most likely to be impacted on. *A. stentoreus* and *S. oculata* are confined to riparian habitat, *Merops ornatus* nests in a burrow, and *C. baudinii, N. connivens,* and *T. sanctus* nest in hollows in standing trees.

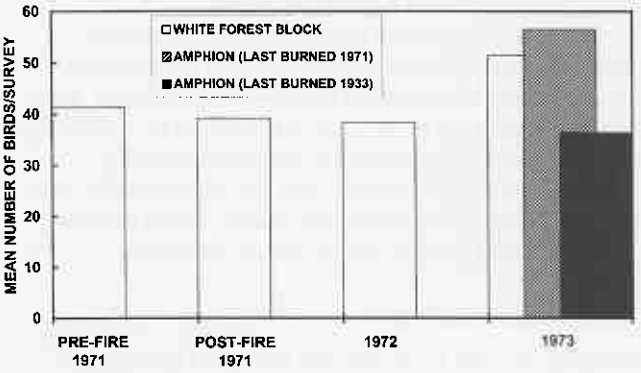

Figure 23. Abundance of birds (for 12 species) initially declined after spring fire in jarrah forest but increased after 2 years. Long-unburned forest did not have more birds than burned forest (Kimber 1974).

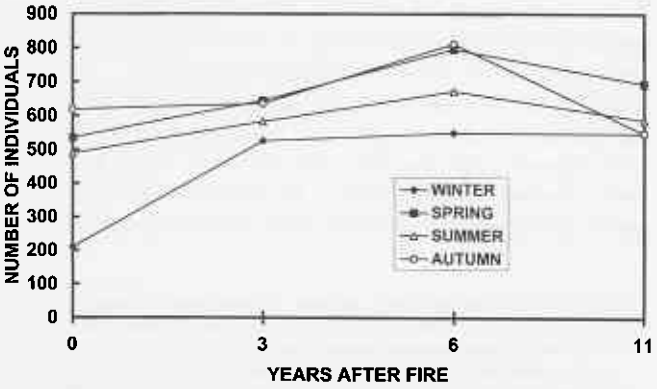

Figure 24. Abundance of birds in mature karri forest was greatest 6 years after fire (data from Appendix 2 of Tingay and Tingay 1984).

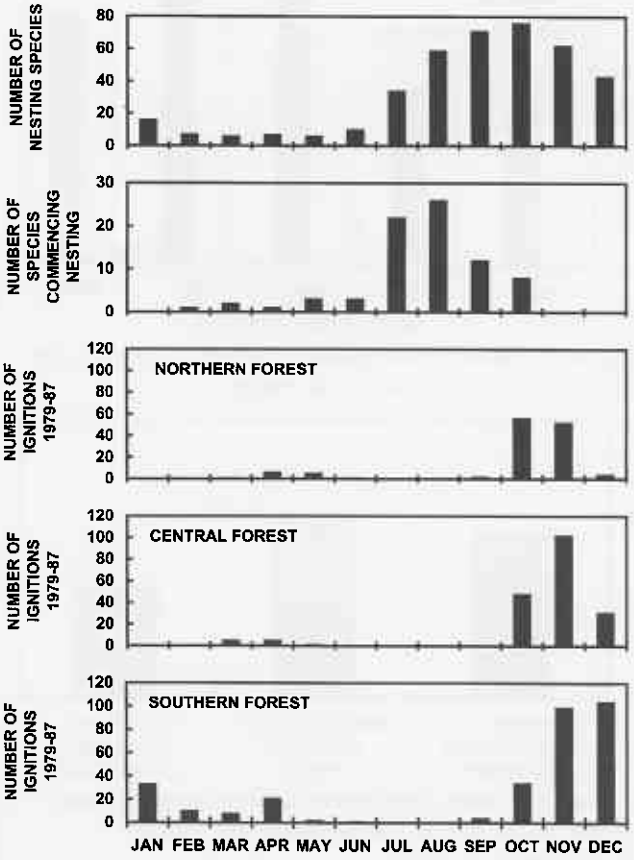

*Figure 25. Most bird species in the forests of south-west Western Australia nest in the period from July to December inclusive (based on data provided by Storr 1991). Most nesting commences in July and August, well before most prescribed burning begins (data on fire ignitions courtesy of CALM*fire*).*

Planned burning under dry soil conditions (in autumn) results invariably in scorching of foliage to a greater height than in mild (moist soil) fires (Burrows 1997). Even so, more bird species are recorded after autumn burning (Fig. 26). Note that wildfire (in autumn) has the opposite effect – bird species richness is reduced relative to long unburned forest and mildly-burned forest (Fig. 27). Because wildfires are unplanned, they are often extensive (see, for example, Underwood and Christensen 1981, p. 18). Total bird abundance also increases after autumn fire (Fig. 28) but is much reduced after wildfire (Fig. 29). Burning in autumn has minimal impact on nesting of bird species (Fig. 25).

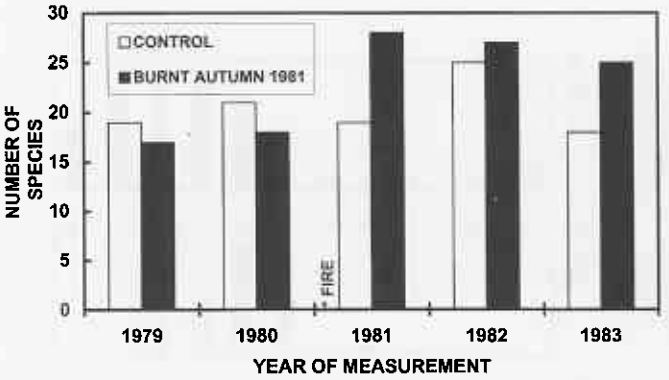

Figure 26. Number of bird species increased after autumn fire in jarrah forest (Christensen et al. *1985b).*

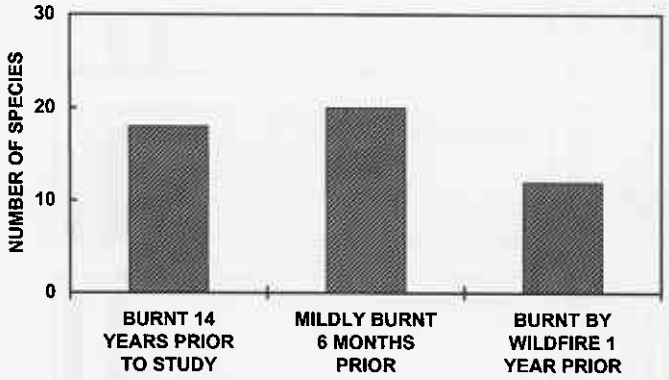

Figure 27. Number of bird species in jarrah forest increased after a low intensity fire but decreased after wildfire (Christensen et al. *1985b).*

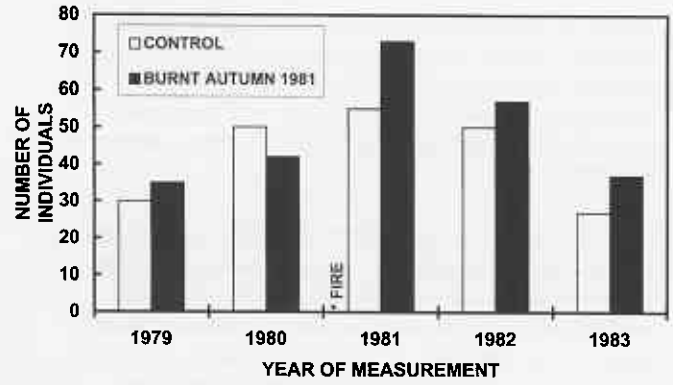

Figure 28. Abundance of birds increased after autumn fire in jarrah forest (Christensen et al. *1985b).*

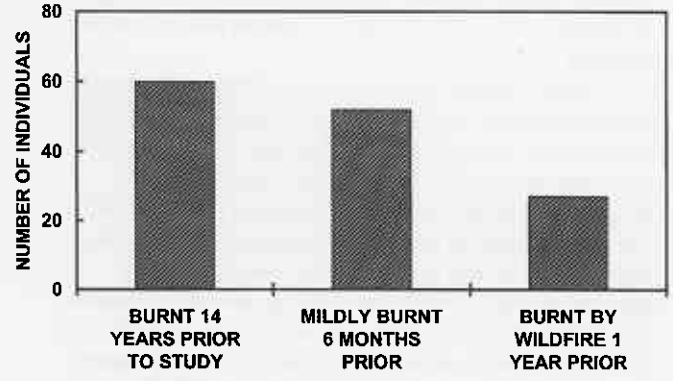

Figure 29. Abundance of birds in jarrah forest was lowest after wildfire and highest in forest not burned for14 years (Christensen et al. *1985b).*

The conclusion of Rowley and Russell (1991) that most passerine species 'are not capable of a rapid reproductive effort to re-establish a devastated local population after a major disaster or to recolonize an area from which the population has been eliminated' is not supported by the empirical evidence summarized in this review. They also advocated burning in autumn if such fires 'could be controlled sufficiently'. It is difficult to reconcile this viewpoint with past frequent burning by aborigines in summer (Hallam[42] 1975; Ward and Van Didden 1997) and the prevalence of fires set by lightning strikes, both of which should have selected for rapid reproductive effort in order that burned areas can be repopulated.

This viewpoint has been reiterated by Russell and Rowley (1998), who also cite a long-term study by Brooker (1998) in support. Both studies lack a control and are not relevant to fire management in forests. The study site at Smith Brook is not in State forest but is a nature reserve and consists of karri and jarrah forest within farmland 0.5 and 1.0 km from the nearest State forest. In addition, the historical rotation period of prescribed burning in karri forest is mainly 0 or 1 fire in a 20-year period (Robertson 1998), much less than the nominal 2–3. The study by Brooker (1998) is in heath adjacent to an urban area and thus subject to burning by arsonists.

Christensen and Kimber (1975) correctly pointed out that no single burning regime will encourage maximum population levels of *all* the species present.

The actual or potential response of bird species to wildfire and prescribed burning in terms of early, mid or late succession was tabulated by Christensen (1997b). He judged 79 species to be reduced in abundance by wildfire and 45 species to be affected by prescription burning. Some species were favoured by burning (his Appendix 2b). In the late stage of the succession, nearly all bird species were considered to have attained stable populations.

Timber Harvesting

Thinning of jarrah forest does not impact on bird species richness (Fig. 30) but creating gaps and establishing a regenerating stand either has no impact (Fig. 31) or tends to increase the number of bird species present (Fig. 32). The most severe impact on bird species richness is caused by clearfelling in karri forests, as predicted by Forests Department (nd = ?1973). About half of the species present before harvesting are unable to utilize the regrowth available a few months after clearfelling (Fig. 33). By 12 years after clearfelling, 85 per cent of the bird species present in mature karri forest are recorded in karri regrowth (with time since fire the same). After 50 years, regrowth karri still lacks *c.* 15 per cent of the bird species present in mature forest. Bird species dependent

[42] The observations of George Grey in 1839 east of Harvey (quoted in Hallam 1975, p. 26) are often cited as evidence of lack of aboriginal burning in jarrah forest. Grey actually mentions the ground vegetation and understorey as 'in some places completely destroyed by native fires'. His observation of many fallen trunks of trees may have simply reflected the passage of storm force winds in the recent past. It is not an indication of lack of fire, as contemporary observations demonstrate that log residues on the forest floor last many decades with frequent burning.

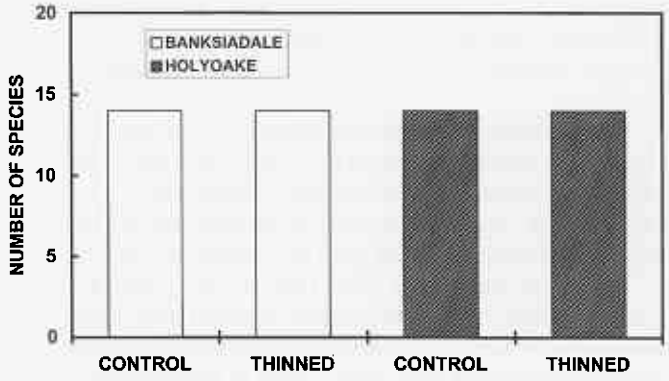

Figure 30. Number of bird species was not affected by thinning of jarrah forest (based on data in Norwood 1991).

on large nesting hollows are unable to breed in unthinned regrowth karri stands before *c.* 120 years. They are catered for by both the formal reserve system and the informal reserve system, which includes extensive reserves of mature karri forest along roads, rivers and streams adjacent to coupes. At the landscape scale these reserves form a continuous network of unlogged forest. Initially, individual coupes were to be no larger than 800 ha (Forests Department nd = ?1973), but in practice coupes average only 50 ha (Abbott and Christensen 1994), with the maximum allowable size being 80 ha (CALM 1994a).

Total bird abundance follows a similar pattern of recovery after clearfelling of karri forest (Fig. 34). In jarrah forest total abundance can either decrease or increase following thinning (Fig. 35). After logging, jarrah forest birds were either unaffected (Fig. 36) or most abundant in logged areas and ecotones between harvested and unlogged forest (Fig. 37).

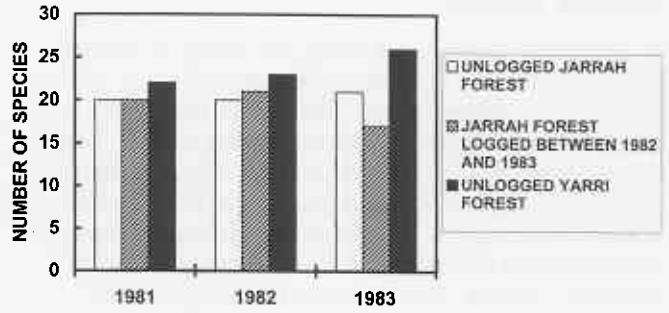

Figure 31. Number of bird species in jarrah forest was unaffected by intensive logging. Note that streamside forest (dominated by yarri) consistently had more bird species present than jarrah forest (from data in Abbott and Van Heurck 1985b).

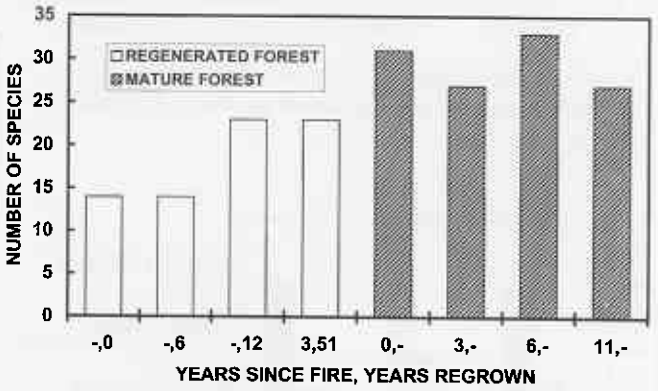

Figure 33. Number of bird species in karri forest increased steadily after clearfelling (data from Appendix 2 of Tingay and Tingay 1984).

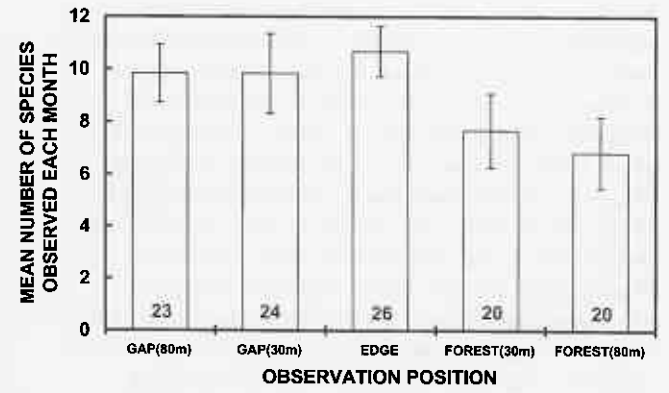

Figure 32. Number of bird species in jarrah forest was least in unlogged forest and greatest at the ecotone between logged and unlogged forest. The numerals in the columns are the total number of bird species recorded during each month (April to September inclusive) of the study (based on data in Norwood 1992). SEMs are shown.

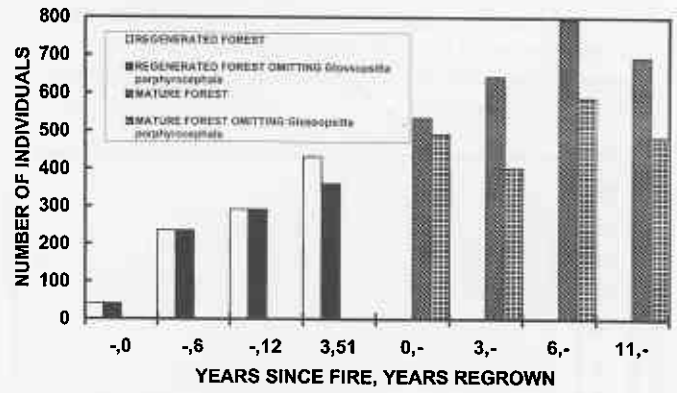

Figure 34. Abundance of birds in karri forest increased steadily after clearfelling (data from Appendix 2 of Tingay and Tingay 1984). The Purple-crowned lorikeet (Glossopsitta porphyrocephala) *is a blossom nomad and contributes in some years to much of the abundance of birds in mature karri forest.*

It should be no surprise that most bird species can utilize karri forest regenerated after clearfelling, as this is similar to how most karri forest regenerated primaevally. Unlogged karri forest occurs in patches of varying size reflecting the severity and extent of past fires caused by lightning and aboriginal burning. According to Bradshaw and Rayner (1997a, b), patches larger than 20 ha constitute only *c.* 20 per cent of the karri forest. Nearly 60 per cent of the existing unlogged karri forest has a structure indicating that it regenerated in a single dominant cohort (Bradshaw and Rayner 1997b, their Fig. 3). The remainder has multiple cohorts; as the dominant cohort dies a younger subdominant cohort will become the dominant one.

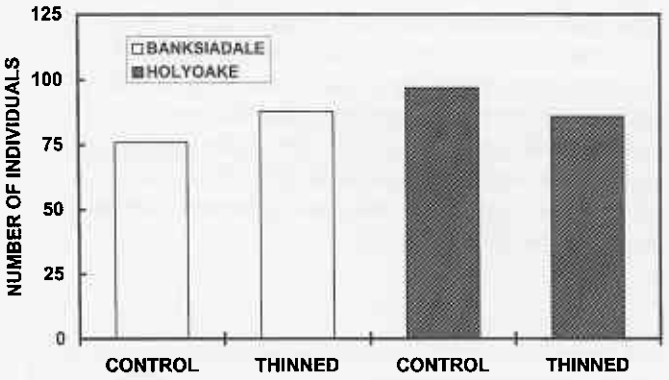

Figure 35. Abundance of birds in jarrah forest showed variable response to thinning (based on data in Norwood 1991).

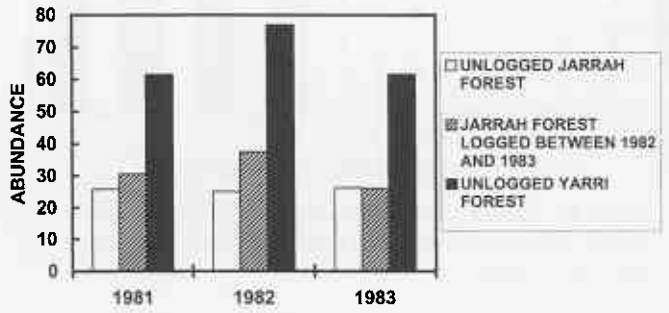

Figure 36. Abundance of birds (median number of individuals counted per 100 m of transect line per hour) in jarrah forest was unaffected by intensive logging. Note that streamside forest (dominated by yarri) consistently had more birds present than jarrah forest (based on data in Abbott and Van Heurck 1985b, p. 234).

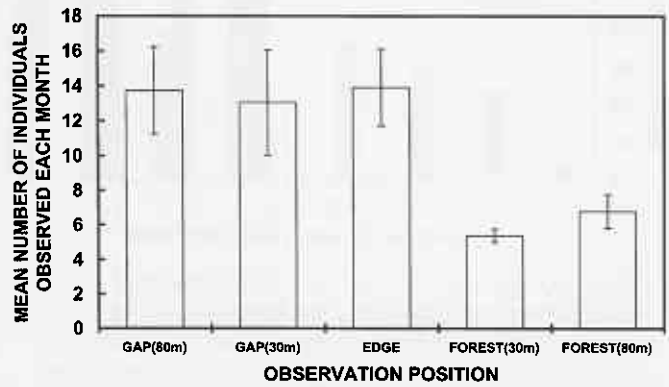

Figure 37. Abundance of birds in jarrah forest was greatest in logged forest and in the ecotone between logged and unlogged forest (based on data in Norwood 1992). SEMs are shown.

In the infrequent droughts experienced in the karri forest (as in 1937), fires would have been fierce and have killed large patches (several hundreds of hectares) of mature forest. In other years fires set by lightning strikes might only have killed small (<10 ha) patches of forest.

In addition, karri forest of the Donnelly and Gardner/ Chudalup types was naturally insular in occurrence, being surrounded by jarrah forest and other non-forest vegetation types (Bradshaw and Lush 1981). Fires in such patches would have led to some natural selection enhancing dispersal capability of bird species. Climatic fluctuations (Churchill 1968) would presumably have also partially insularized the broadest karri forest type, the Warren/ Dombakup type.

Dieback Disease

In 'graveyard' sites in jarrah forest, tree density is reduced by about 90 per cent (Nichols and Watkins 1984), dramatically reducing foliage. Bird species richness is almost half that of healthy jarrah forest (Figs 38, 39). Total abundance of birds in some years in these degraded sites is also reduced (Figs 40, 41). Other dieback-affected forest, in which tree density is only reduced by about 25 per cent, may or may not impact on both species richness and total abundance of birds. Marri becomes a more significant component of the understorey after the forest becomes infected by *Phytophthora* disease (McDougall 1996). Although the overstorey of karri forest is unaffected by dieback disease, many plant communities within the southern forests are susceptible to this disease (Christensen 1992).

Mining

Because it is the most disruptive disturbance in jarrah forest, mining provides an instructive illustration of the versatility of many bird species. After open-cut bauxite mining has been completed, the pits are re-shaped, overburden and topsoil are returned, and the site is revegetated (Bartle and Slessar 1989). The proportion of jarrah forest bird species recorded feeding, resting, or breeding in rehabilitated bauxite minesites increased from 75 per cent in 1980 to 85 per cent in 1987, and to 93 per cent in 1992 (Kabay and Nichols 1980; Nichols and Watkins 1984; Nichols 1994). Species richness in rehabilitated minesites (16–19 species) was similar to that in adjacent healthy jarrah forest (18–21 species), but total abundance was more variable (7–12 birds/ ha vs 13 birds/ ha) in healthy jarrah forest (Ward *et al.* 1990). Although only 12 bird species were proven to breed in revegetated minesites (compared with 19 species in adjacent jarrah forest), density of breeding birds was similar to that in unmined forest (Curry and Nichols 1986). This study was conducted in 1981; more species should now nest in rehabilitated forest. Several riparian species

(*Malurus elegans* (Red-winged fairy-wren), *Sericornis frontalis* (White-browed scrubwren) and *Eopsaltria georgiana* (White-breasted robin)) were recorded breeding in those minesite areas with dense understorey (Curry and Nichols 1986).

A related study (Wykes 1985) similarly found little difference between jarrah forest and rehabilitated minesites in bird species richness (26 vs 25 species) or total abundance (66 vs 63 birds). Several riparian species were more abundant in the rehabilitated areas.

Creation of Ecotones

Ecotones represent zones of transition, usually steep, between unlike patches of vegetation (Risser 1995). They have long been held to be important through the provision of resources for species (e.g. Abbott and Christensen 1994). Forest-edges provide important habitat for many bird species (e.g. in eucalypt forest [Bell 1980], rainforest in New Guinea [Beehler *et al.* 1995]). Ecotones can occur at different scales, from local clumping of vegetation units to larger scale disjunctions between vegetation types (as between a wetland and surrounding forest). Clearly, disturbance such as logging and burning creates many edges.

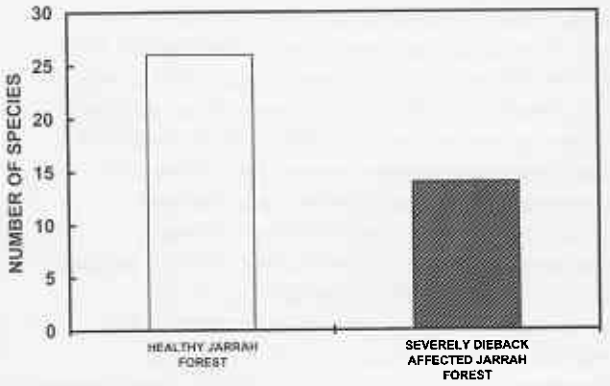

Figure 38. Number of bird species is much lower in jarrah forest severely degraded ('graveyard sites') by dieback disease (Wykes 1985).

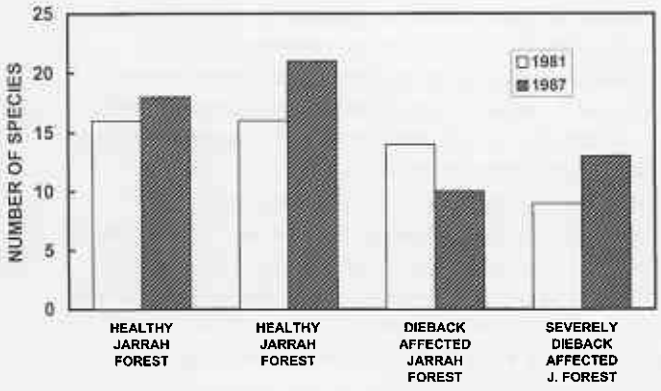

Figure 39. Number of bird species in jarrah forest is reduced as a result of progressive degradation of overstorey crowns and loss of susceptible understorey caused by dieback disease (Nichols and Watkins 1984; Ward et al. 1990; Nichols personal communication).

Logging in karri and jarrah forests creates ecotones and these have been demonstrated to increase, temporarily, bird species richness and total abundance (Wardell-Johnson and Williams 1995; Norwood *et al.* 1995). In karri forest before logging, no gradient in bird species richness or total abundance was detected along an 800 m long transect within the forest. Two years after clearfelling more species were recorded within the forest close to the edge than in the forest interior. In subsequent years most species were recorded *c.* 200 m away from the edge. On the clearfelled side of the edge, bird species richness was greatest within 50 m of the edge for 2–4 years after logging, indicating that many forest bird species were feeding in regrowth close to the edge. Total abundance showed similar trends (Wardell-Johnson and Williams 1995).

In jarrah forest, most bird species were recorded at the edge between logged gaps and unlogged[43] forest (Norwood *et al.* 1995; see also Fig. 32). Total abundance was also greatest at the edge (Fig. 37).

[43] That is, unlogged at that point of time – it had been logged several decades before.

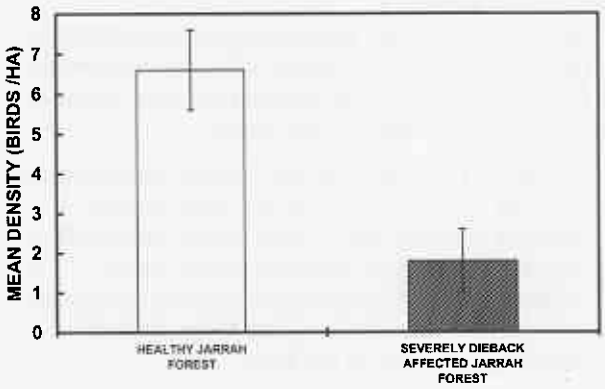

Figure 40. Abundance of birds in jarrah forest is reduced by about one third where forest is severely degraded ('graveyard sites') by dieback disease (based on data in Wykes 1985). SEMs are shown.

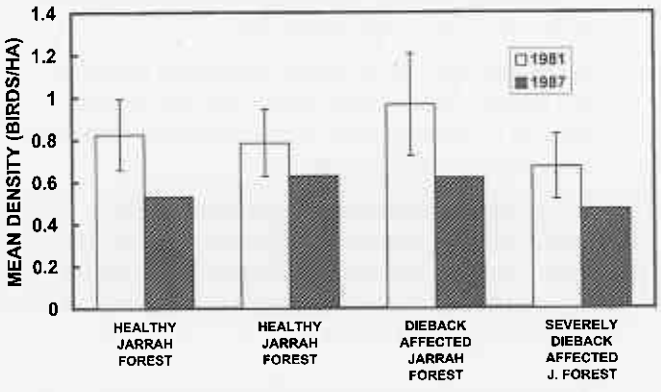

Figure 41. Abundance of birds in jarrah forest is least in forest severely degraded ('graveyard sites') by dieback disease (based on data in Nichols and Watkins 1984; Ward et al. 1990; Nichols personal communication). SEMs for 1981 are shown. Those for 1987 could not be calculated as the raw data are unavailable.

6. Possible Impact of Long Term Climatic Change on Forest Bird Species

Increasing concentrations (Vitousek 1994) in the global atmosphere of carbon dioxide, the most abundant greenhouse gas, may lead to increased temperatures in south-west WA. Although the magnitude of global warming is uncertain, the most recent estimates are of an increase of 0.1–0.35° C per decade in the period 1990–2050 (IPCC 1996).

Given the inverse relationship between annual rainfall and mean annual temperature in south-west WA (Specht and Specht 1995), it appears that annual rainfall could decrease by 10–30 per cent. This would decrease leaf area. In the past 50 years there has been a decrease in winter rainfall in the south-west (Nicholls and Lavery 1992; Gentilli 1995). Yet, the period 1870–1910 was also a dry period (Allan and Haylock 1993). The question is whether the recent decrease in rainfall is part of natural variability. The major current uncertainty appears to be whether summer rainfall may increase next century. One global climate model in contrast predicts a 5 per cent increase in rainfall by 2050 in south-west WA in both summer and winter once CO_2 levels in the atmosphere have doubled (IPCC 1996, p. 308).

Because of these and other considerable uncertainties (Eamus and Jarvis 1989; O'Brien 1990), it is not possible to do more at this stage than speculate about the potential impacts of such changes on bird species:

- Increasing temperature should increase competition for water by plant species. In the long term this may decrease the basal area of forest stands, with stands becoming more open. Such a change in forest structure may allow greater penetration of bird species currently restricted to the eastern sector of the forest or occurring to the east of the forest.
- Increasing levels of CO_2 should increase rates of photosynthesis of some plant species. This may lead to changes in floristic composition of forest stands. In addition, plant tissue may contain lower concentrations of nutrients, reducing the density of folivorous insects upon which many bird species feed.
- Increasing temperature should increase the frequency and intensity of unplanned fires. This may result in changes in forest structure, tending to favour some bird species and disfavour others.
- Increasing temperature (?and decreasing rainfall) should alter the distribution of Bassian species of birds. The geographic range of these species should contract towards the higher rainfall sector of the lower south-west (Arnold 1988).

Recent modelling (McMurtrie 1998) suggests, however, that increasing temperature in nutrient-limited forests such as jarrah may be beneficial (increasing growth rates of trees) because it stimulates decomposition of organic matter. However, a reduction in rainfall should counter this effect by truncating the moist period in which most decomposition occurs (Stoneman[44], personal communication).

7. Conservation of Bird Species in Forests

The long-term preservation of viable populations of bird species in the forests of south-west WA – as these forests exist currently – is managed for in several ways.

First, the dedication of the forests remaining in the 1920s as State forest prevented any further loss of forest to agricultural development, 'a hard slog by an insular Forests Department against many opponents' (Rundle 1996). This without doubt was the most significant change in policy in terms of the long term conservation of bird species.

Second, there is an extensive area of forests protected from future logging, as national parks, nature reserves, road, river and stream reserves, diverse ecotype zones and other informal reserves (Christensen 1992; CALM 1994a). Continual improvements in reservation are underpinned by new knowledge. Thus in 1977, 56 ecologically representative areas of State forest were set aside (total area 284 000 ha) in which conservation of flora, fauna and landscape was the prime purpose (Forests Department 1977). Five years later these 56 areas were increased to 294 000 ha (Forests Department 1982). Subsequent developments are outlined by Bradshaw *et al.* (1991). Another example concerns the informal reserve system. Road, river and stream reserves were developed in 1970 and were 800 m wide (along major roads), 400 m wide (along rivers) and 200 m wide (along selected streams). The concept was reviewed in 1988 (CALM 1988) and redistribution to maximize conservation values was recommended, principally on the basis that most biodiversity occurs in riparian habitats. These recommendations were refined further (Wardell-Johnson *et al.* 1991; CALM 1992a [contrast Fig. 17 with Fig.18]) before being adopted (CALM 1994a). The conservation value of these reserves was further demonstrated by CALM (1995d, e). These stream reserves have a total length of 17 610 km (G. Stoneman, personal communication).

Third, the Western Australian Government endorsed the National Forest Policy Statement in 1992. This commits the Government to retaining the integrity and biodiversity of WA's forests and ensuring that forest resources are used in an environmentally sensitive and sustainable manner (Commonwealth of Australia 1992).

Fourth, the overall management of commercial forests (State forest, timber reserves) is subject to a formal management plan (CALM 1994a) approved by the Minister for the Environment. In place are forest structural goals which set goals for the proportion of forest in the various stages of development: establishment (jarrah 5 per cent, karri 4 per cent); juvenile (15 per cent, 8 per cent), immature (40, 48 per cent); and mature/senescent (40, 40 per cent) (CALM 1994a).

Fifth, particular types of logging operations are managed by detailed guidelines (CALM 1989a, b; 1995a;

[44] Dr G. L. Stoneman, Department of Conservation and Land Management, Crawley.

1997a, b for jarrah forest; CALM 1990b, 1992a, 1995b, 1997c, d for karri forest). The best scientific knowledge available underpins the Management Plan and these guidelines. For example, up to 1995, 3 habitat trees (specially marked) were retained per hectare during timber harvesting in jarrah forests. In 1995 this number was increased to 4 trees/ ha following scientific advice furnished by CALM scientists (CALM 1995a). CALM is also contributing to the funding of a Western Australian Museum study of the nesting ecology of forest cockatoos; new information about the characteristics of nest trees will be incorporated into logging guidelines once the study is completed.

Prescribed fires are planned so as to diversify the spatial and temporal extent of burning within each of the three CALM forest regions. Adjacent forest blocks are not burned in the same year. The reduced fuels resulting from this managed fire system serve to minimize the risk of extensive and high impact summer wildfires.

Furthermore, forests in south-west WA are managed compatibly with ecological principles (Abbott and Christensen 1994, 1996).

Finally, the Minister for the Environment in the Western Australian Government issues from time to time a list of specially protected fauna. Any person who takes without license, or unlawfully possesses, protected fauna is liable to a penalty of $10 000 (Wildlife Conservation Act of Western Australia, Sect. 14 ba (ii)). The current notice (Government Gazette, WA, 14 July 1998) includes 8 bird species occurring in forest:

Schedule 1 – Fauna that is Rare or Likely to Become Extinct

Landbirds

Leipoa ocellata Malleefowl [vulnerable][45]
Calyptorhynchus latirostris Carnaby's cockatoo [endangered]
C. baudinii Baudin's cockatoo [vulnerable]
Cacatua pastinator pastinator Western long-billed corella [endangered]
Atrichornis clamosus Noisy scrub-bird [vulnerable]

Waterbirds

Botaurus poiciloptilus Australasian bittern [vulnerable]

Schedule 2 – Fauna Presumed to be Extinct

Waterbirds

Rallus pectoralis Lewin's rail

Schedule 3 – Birds Protected under an International Agreement

No forest species listed

[45] These rankings were determined by the Threatened Species Scientific Committee according to World Conservation Union (IUCN) criteria.

Schedule 4 – Other Specifically Protected Fauna

Landbirds

Falco peregrinus Peregrine falcon

Since 1985 only *C. latirostris*, *Ca. pastinator* and *F. peregrinus* have been subject to offences against provisions of this Act. Penalties ranged from a letter of warning to a conviction (with fine of $2 500). Attempted illegal export of *C. latirostris* has led to 18 months' imprisonment under Federal law. Reference to the individual species commentaries (above) shows that none of the 8 species listed is (or has been) directly or indirectly threatened by forest management practices.

8. Birds as Indicators of Ecologically Sustainable Utilization of Forests

Birds as a group offer many advantages over other groups: they are well-known taxonomically and no new species in the south-west forests are likely to be discovered; they can be readily identified without recourse to microscope or dichotomous keys; many species occur in the south-west forests; they are conspicuous and do not usually need to be collected in order to be studied; their distribution and ecology is relatively well understood; most species are not impacted on by extraneous factors such as fox predation; and they can be profitably studied by both amateurs and professionals.

Various bird species can be selected to indicate how completely forest habitats have recovered (especially in structure, Wardell-Johnson and Nichols 1991), after being disturbed by forest management practices such as prescribed burning, thinning, gap logging, shelterwood logging, and clearfelling. Furthermore, some sensitive species can serve to indicate the adequacy of forest management practices integrated over landscape scales.

Based on this review of literature, several species are recommended for further assessment (Table 12). In addition, the continued failure of species characteristic of disturbed or sparsely-wooded habitats and woodland to establish in logged forests could be used as an indicator of ecological integrity of regrowth forests. Examples of such species are *Elanus caeruleus* (Black-shouldered kite), *Falco cenchroides* (Australian kestrel), *Meliphaga virescens* (Singing honeyeater), *Epthianura albifrons* (White-fronted chat), *Petroica goodenovii* (Red-capped robin), *Rhipidura leucophrys* (Willie wagtail), *Grallina cyanoleuca* (Magpie-lark), *Lalage tricolor* (White-winged triller), *Cracticus torquatus* (Grey butcherbird) and *Anthus novaeseelandiae* (Richard's pipit).

PRESSING UNANSWERED QUESTIONS

Although the forest avifauna of south-west WA is well-studied, some aspects of it remain poorly understood. Both amateurs and professionals can contribute to remedying

this at various levels. Most of the species requiring further study are either cryptic or uncharismatic, and thus evade human attention.

Leipoa ocellata. As populations of foxes decrease following the progressive implementation of CALM's Western Shield Project, the small number of Malleefowl currently present in or near karri regrowth stands should increase and then expand into more open habitats such as south coast heaths, woodland and jarrah forest. This predicted expansion should be monitored.

Coturnix novaezelandiae. The distribution of Stubble quail requires attention – is this species more widespread than the few valid records indicate? Has this species been confused with *C. ypsilophora* or *Turnix varia* in the northern jarrah forest?

Ninox connivens and *Tyto novaehollandiae*. The distribution of the Barking and Masked owls requires elucidation, using appropriate census methods such as playback of taped calls (Debus 1995).

Eurostopodus argus. The distribution of Spotted nightjars requires specialized study – is this species more widespread than the few records suggest?

Stipiturus malachurus. The map published by CALM (1997e) showing the location of diverse ecotypes larger than 5 ha may assist ornithologists to ascertain whether the Southern emu-wren occurs more widely in the forest.

Pomatostomus superciliosus. Are the sunklands (Blackwood Plateau) and karri forest populations of the White-browed babbler connected?

Falcunculus frontatus. Given that the density of this species along the Blackwood River between Bridgetown and Boyup Brook was estimated at one pair/ 200–300 m of river frontage (G. Lodge, quoted by Garnett 1992a), does the Crested shrike-tit occur in similar habitat west of Bridgetown and along other rivers to the north? In eastern Australia this species feeds extensively on decorticating bark of eucalypts. In the last decade *Eucalyptus globulus* has been planted extensively (90 000 ha) in south-west WA within the natural range of the Crested Shrike-tit. Will this species colonize bluegum plantations? In addition, Crested shrike-tits have been recorded in eastern Australia feeding on caterpillars of Autumn gum moth (*Mnesampela privata*) (Barker and Vestjens 1990); these larvae are sometimes common in Western Australian bluegum plantings.

Oreoica gutturalis. Does the Crested bellbird occur in suitable habitat in the sunklands?

Waterbirds. Secretive species of heron (*Nycticorax caledonicus*), bittern (*Ixobrychus minutus, I. flavicollis, Botaurus poiciloptilus*), and crake (*Porzana pusilla, P. fluminea*) require special effort. Some wetlands within the forest do not appear to have been surveyed, e.g. Nalyerin Lake, Yourdamung Lake, Lake Ngartiminny and Camballan Swamp.

Taxonomy. Some changes in species concepts can be expected as DNA technology is applied. Already there appears to be a trend towards the species concept prevalent early this century, when many south-west taxa were regarded as distinct from elsewhere in Australia. It is essential that taxonomy has an objective basis; the rationale that '[u]nless threatened populations have separate identity, efforts to conserve them may be deemed unnecessary' (Ford 1987b) is spurious, unscientific, and ought to be rejected. Priority taxa requiring DNA analysis include *Dromaius novaehollandiae (rothschildi), Leipoa ocellata, Calyptorhynchus banksii (naso), Platycercus icterotis (icterotis* and *xanthogenys), Pomatostomus superciliosus* and *Rallus pectoralis (clelandi)*. The status of *Acanthiza pusilla leeuwinensis* requires investigation (*cf.* Serventy 1953). Is this taxon the end of a cline in variation in *A. apicalis* or does it represent an isolate of *A. pusilla* (Campbell 1922)? The taxonomic status of all endemic taxa needs re-appraisal with additional collections and with molecular genetic techniques.

Distribution and abundance. With the recent production of 1:250 000 forest association maps (Bradshaw *et al.* 1997), 1:500 000 scale forest ecosystem maps (Commonwealth and Western Australian Regional Forest Agreement Steering Committee 1998), and 1:250 000 scale vegetation complex maps (Mattiske and Havel 1998), there now exists a detailed framework in which information on densities of bird species can be collected more strategically and systematically than was possible in the past. The vegetation complex maps in particular should allow valid modelling of the distribution of most bird species present in the south-west forests. It would also be useful to improve understanding of habitat usage by bird species at the finer scale of site-vegetation types (Havel 1975a, b), particularly the impact of dieback disease. Recent assessments of the environmental values of wetlands and waterways in the south-west also provide a valuable framework for more detailed study of the bird faunas associated with these habitat types (Pen 1997; Bosveld *et al.* in press).

Home range. The core home range of species requiring large hollows in standing trees for nesting should be determined. This information will then allow more detailed estimates of the availability of hollows required to conserve these species throughout the forest.

Unified datasets. It would be valuable if all records of specimens and eggs of bird species collected from the south-west Western Australian forests were collated from the world's museums, and combined with the records cited in this review and those held by the Western Australian chapter of the RAOU (Birds Australia).

Although knowledge of the forest avifauna is founded on several hundred bird lists, some areas remain inadequately covered. Bird watchers may find Figure 1 helpful in deciding where to profitably direct future sampling effort.

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APPENDIX 1

Noongar names for bird species and subspecies present in the primal forests and endemic to south-west Western Australia.

ENDEMIC TAXON	RECOMMENDED NAME	APPROXIMATE PRONUNCIATION*
Species		
Calyptorhynchus latirostris	Ngobyenook	Gnaw-bye-nook
Calyptorhynchus baudinii	Ngoorlak	Gnaw-lark
Cacatua pastinator	Manyte	Marn-ite
Platycercus spurius	Djarrilboordang	Char-ill-bore-dan
Platycercus icterotis	Booldoonbooldoon	Bool-doon-bool-doon
Atrichornis clamosus	Djimolook	Chee-maw-look
Malurus elegans	Djidjal	Cheer-chal
Acanthiza inornata	Djobooldjobool	Jaw-bull-jaw-bull
Melithreptus chloropsis	Bangin	Barn-een
Acanthorhynchus superciliosus	Booldjit	Bull-chit
Eopsaltria georgiana	Bodjil	Baw-cheel
Stagonopleura oculata	Boorrin	Bore-reen
Subspecies		
Calyptorhynchus banksii	Karrak	Car-rark
Platycercus zonarius	Dowan	Daw-arn
Stipiturus malachurus	Djurdjilya	Chur-cheel-ya
Pardalotus striatus	Widopwidop	Wid-up-wid-up
Phylidonyris nigra	Bandoong	Barn-doong
Anthochaera chrysoptera	Djangang	Chan-an
Petroica multicolor	Kooba	Koo-bar
Eopsaltria australis	Bamboon	Barm-boon
Falcunculus frontatus	Koorbitkoorbit	Koor-bit-koor-bit
Rhipidura fuliginosa	Kadjinnak	Cad-chin-nark
Cracticus tibicen	Koorbat	Koor-bart
Strepera versicolor	Djilak	Chee-lark
Corvus coronoides	Woordang	War-dan
Rallus pectoralis	Nyoony	En-yourn
Porphyrio porphyrio	Koolema	Cool-em-are

*Emphasize the first syllable; pronounce ng as in singer, not finger; ny as in onion; oo as in book.

The Western Australian forester C. E. Lane-Poole in 1920 introduced the Noongar word Marri to replace the settlers' descriptive Red gum. In doing so he was acting on an earlier precedent when the Noongar word Jarrah was adopted by timber millers in the 1860s to replace the settlers' term Mahogany. In preparing this list, I follow these precedents and Abbott (1983). There seems little inconvenience to bird watchers and ornithologists if Noongar names were to replace English vernacular names currently in use for bird species endemic to Western Australia. However, replacing English names of endemic subspecies will probably be seen by some as too radical; notwithstanding this, Noongar names have been tabulated for these.

Another reason for promoting the use of aboriginal names is that their use by all Australians is a symbolic and important gesture that may assist, in a small way, the current process of reconciliation between aborigines and later settlers of Western Australia.

Following the approach of Abbott (1983, Appendix), a name for each species and subspecies has been taken from Gilbert (MS). Where there were two or more names available, one was chosen on the basis of euphony, brevity and pronounceability. Gilbert's phonetic orthography has been recast to conform as far as possible with the conventions published in Whitehurst (1992). This list should be treated as provisional. Constructive, documented suggestions for modification or extension are invited. Other aboriginal names for bird species are documented in Bindon and Chadwick (1992).

TABLE 1
Species recorded in the forests of south-west Western Australia, 1840–1932. Details of locations (1–17) and times of the lists are provided on pages 4–7.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LANDBIRDS																	
Dromaius novaehollandiae			•	•		•		•		•	•						•
Leipoa ocellata					•		•				•						
Coturnix novaezelandiae																	•
Coturnix ypsilophora		•	•	•	•						•						•
Haliastur sphenurus		•						•		•	•						
Accipiter fasciatus		•	•	•				•		•	•						•
Accipter cirrhocephalus		•	•	•				•			•						•
Aquila audax							•	•		•	•	•				•	•
Circus approximans		•	•	•							•					•	
Falco berigora		•	•	•	•		•	•			•	•			•		•
Falco peregrinus											•						
Turnix varia		•	•					•									•
Phaps chalcoptera		•	•	•													•
Phaps elegans	•	•	•	•	•			•		•	•						•
Calyptorhynchus banksii	•	•		•	•	•	•		•	•	•						•
Calyptorhynchus latirostris																	
Calyptorhynchus baudinii		•	•	•	•	•	•	•	•	•	•	•	•	•		•	•
Cacatua pastinator		•	•	•							•						•
Glossopsitta porphyrocephala		•		•	•	•	•	•	•	•	•	•	•	•		•	•
Platycercus zonarius	•	•	•	•	•	•	•	•	•	•	•	•				•	•
Platycercus spurius	•	•	•	•	•	•	•	•	•	•	•	•					•
Platycercus icterotis			•	•	•	•	•	•	•	•	•		•	•		•	•
Cuculus pallidus			•			•		•			•				•	•	•
Cacomantis flabelliformis			•			•	•	•		•	•	•				•	•
Chrysococcyx basalis			•														
Chrysococcyx lucidus			•				•	•		•	•	•					•
Ninox connivens				•							•						
Ninox novaeseelandiae		•		•	•	•		•		•	•					•	•
Tyto novaehollandiae			•		•						•						
Tyto alba											•						•
Podargus strigoides		•	•	•	•			•		•	•		•		•		•
Eurostopodus argus			•							•							
Aegotheles cristatus					•						•						
Todiramphus sanctus		•	•	•				•		•	•	•		•	•		•
Merops ornatus											•	•					•
Atrichornis clamosus	•	•	•	•	•												
Climacteris rufa		•		•	•	•	•	•	•	•	•	•	•	•		•	•
Malurus splendens	•	•	•	•	•		•			•	•	•		•			•
Malurus elegans	•	•	•	•	•	•	•	•			•		•				•
Stipiturus malachurus		•	•					•			•						
Pardalotus punctatus			•	•	•		•	•		•	•					•	•
Pardalotus striatus			•	•	•		•	•		•	•	•		•	•	•	•
Sericornis frontalis	•	•	•	•				•		•	•			•		•	•
Smicrornis brevirostris											•			•			
Gerygone fusca	•		•	•	•	•	•	•		•	•	•		•	•	•	•

TABLE 1 (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Acanthiza apicalis	•	•	•	•	•	•		•		•	•	•		•		•	•
Acanthiza inornata	•	•	•	•		•	•	•		•	•		•	•	•		•
Acanthiza chrysorrhoa		•	•			•		•			•	•	•		•	•	•
Lichmera indistincta			•					•			•			•		•	•
Meliphaga ornata																	
Melithreptus chloropsis	•		•	•		•	•	•	•	•	•	•		•	•	•	•
Phylidonyris novaehollandiae	•		•	•	•	•		•	•	•	•	•				•	•
Phylidonyris nigra			•	•							•						
Phylidonyris melanops	•		•	•	•			•		•	•	•					
Acanthorhynchus superciliosus	•		•	•	•	•		•	•	•	•	•	•	•	•	•	•
Anthochaera chrysoptera	•		•	•	•			•	•	•	•	•			•	•	•
Anthochaera carunculata	•		•	•							•	•			•		•
Petroica multicolor		•	•	•	•	•	•	•		•	•	•	•	•	•	•	•
Petroica cucullata			•	•													•
Eopsaltria australis	•	•	•	•	•	•		•		•	•			•	•	•	•
Eopsaltria georgiana	•	•	•	•	•		•	•		•	•		•			•	•
Pomatostomus superciliosus						•		•		•	•			•			
Daphoenositta chrysoptera		•	•	•		•	•	•		•	•	•			•		•
Falcunculus frontatus					•					•							•
Pachycephala pectoralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pachycephala rufiventris		•	•	•							•						•
Colluricincla harmonica	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•
Myiagra inquieta						•	•	•								•	•
Rhipidura fuliginosa	•	•	•	•	•	•		•		•	•					•	•
Coracina novaehollandiae		•	•			•	•	•		•	•	•		•	•		•
Artamus cyanopterus	•	•	•	•				•		•	•			•		•	•
Cracticus tibicen			•		•		•	•			•	•		•	•		•
Strepera versicolor		•	•	•	•	•	•	•		•	•	•		•	•	•	•
Corvus coronoides		•	•	•			•	•		•	•	•					•
Stagonopleura oculata	•		•	•	•	•	•	•		•	•			•			•
Dicaeum hirundinaceum			•									•					•
Hirundo neoxena			•	•			•	•		•	•			•		•	•
Hirundo nigricans			•			•		•			•	•	•	•		•	•
Acrocephalus stentoreus			•								•						•
Megalurus gramineus				•				•			•						•
Zosterops lateralis		•	•	•	•	•	•	•	•	•	•	•		•	•	•	•
WATERBIRDS																	
Oxyura australis		•															•
Biziura lobata		•	•		•			•			•					•	•
Cygnus atratus										•	•					•	•
Tadorna tadornoides								•			•						•
Anas gracilis		•									•						•
Anas castanea		•	•	•							•						
Anas superciliosa		•	•		•			•		•	•					•	•
Anas rhynchotis		•	•														•
Aythya australis		•									•						•
Tachybaptus novaehollandiae											•						•

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Poliocephalus poliocephalus		▪		▪													▪
Anhinga melanogaster																	▪
Phalacrocorax carbo	▪				▪						▪					▪	
Phalacrocorax sulcirostris					▪						▪						
Phalacrocorax melanoleucos			▪		▪			▪			▪	▪				▪	▪
Ardea novaehollandiae			▪					▪		▪	▪	▪					▪
Nycticorax caledonicus									▪	▪						▪	
Ixobrychus minutus																	▪
Ixobrychus flavicollis		▪						▪			▪						▪
Botaurus poiciloptilus		▪	▪		▪			▪			▪						
Rallus pectoralis		▪		▪				▪									▪
Porzana pusilla		▪															▪
Porzana fluminea		▪															
Porzana tabuensis	▪		▪	▪				▪			▪						▪
Porphyrio porphyrio			▪	▪				▪		▪	▪						▪
Gallinula ventralis				▪				▪									
Fulica atra											▪						
Himantopushimantopus																	
Charadrius ruficapillus		▪	▪					▪									
Charadrius melanops			▪								▪						
Erythrogonys cinctus																	

TABLE 2

Species recorded in the forests of south-west Western Australia, 1950–1998. Details of locations (18–272) and times of the lists are provided on pages 7–13. x indicates that a more accurate identification to species is not possible.

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
LANDBIRDS																
Dromaius novaehollandiae				•	•			•	•	•				•	•	•
Leipoa ocellata										•				•		•
Coturnix novaezelandiae														•		•
Coturnix ypsilophora											•			•		
Haliastur sphenurus					•		•	•	•	•				•	•	•
Accipiter fasciatus			•	•	•		•		•	•				•		•
Accipter cirrhocephalus			•	•	•					•				•	•	•
Aquila audax			•	•	•		•		•	•				•	•	•
Circus approximans												•		•		
Falco berigora			•	•	•			•	•	•				•	•	•
Falco peregrinus														•		
Turnix varia				•	•									•		•
Phaps chalcoptera		•	•	•	•	•			•	•				•	•	•
Phaps elegans								•	•	•				•	•	•
Calyptorhynchus banksii						•			•	•				•	•	•
Calyptorhynchus latirostris				•	•											
Calyptorhynchus baudinii	•		•			•	•	•	•	•				•	•	•
Cacatua pastinator														•		
Glossopsitta porphyrocephala				•	•					•				•	•	•
Platycercus zonarius	•	•	•	•	•	•	•	•	•	•				•	•	•
Platycercus spurius		•	•	•	•	•	•	•	•	•				•	•	•
Platycercus icterotis	•			•	•	•	•	•	•	•				•	•	•
Cuculus pallidus	•	•	•	•	•				•	•				•	•	•
Cacomantis flabelliformis	•	•	•	•	•				•	•				•	•	•
Chrysococcyx basalis			•	•	•					•				•	•	•
Chrysococcyx lucidus	•	•	•	•	•				•	•						
Ninox connivens																
Ninox novaeseelandiae				•	•		•		•	•				•	•	•
Tyto novaehollandiae															•	
Tyto alba														•	•	
Podargus strigoides				•	•	•		•	•	•				•	•	•
Eurostopodus argus																
Aegotheles cristatus				•				•	•	•				•	•	
Todiramphus sanctus	•	•	•	•	•			•	•	•				•	•	•
Merops ornatus		•	•	•	•	•		•	•	•				•		•
Atrichornis clamosus																
Climacteris rufa				•	•	•	•	•	•	•				•	•	•
Malurus splendens	•		•	•	•	•	•		•		•			•	•	•
Malurus elegans					•		•	•	•		•			•	•	
Stipiturus malachurus								•	•					•		
Pardalotus punctatus	•	•	•	•	•	•	•	•	•	•				•	•	•
Pardalotus striatus	•	•	•	•	•	•	•		•	•				•	•	•
Sericornis frontalis					•		•		•		•			•	•	•
Smicrornis brevirostris		•	•	•				•	•	•				•	•	•
Gerygone fusca	•	•	•	•	•	•	•	•	•	•				•	•	•

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Acanthiza inornata	•	•	•	•	•	•	•	•	•	•				•	•	•
Acanthiza inornata	•	•	•	•	•	•	•	-	•	•				•	•	•
Acanthiza chrysorrhoa	•	•	•	•	•	•	•		•	•				•	•	•
Lichmera indistincta	•	•	•	•	•					•				•		•
Meliphaga ornata				•												
Melithreptus chloropsis		•	•	•	•		•		•	•				•	•	•
Phylidonyris novaehollandiae	•		•	•	•		•	•	•		•			•	•	•
Phylidonyris nigra																•
Phylidonyris melanops								•	•							•
Acanthorhynchus superciliosus	•	•	•	•	•	•	•	•	•	•				•	•	•
Anthochaera chrysoptera	•	•	•	•	•			•	•	•				•	•	•
Anthochaera carunculata	•	•	•	•	•		•		•	•				•	•	•
Petroica multicolor	•	•	•	•	•	•	•	•	•	•				•	•	•
Petroica cucullata			•	•										•		•
Eopsaltria australis		•		•	•	•	•	•	•					•	•	•
Eopsaltria georgiana					•		•	•	•		•			•	•	•
Pomatostomus superciliosus									•						•	•
Daphoenositta chrysoptera	•	•	•	•	•	•	•	•	•	•				•	•	•
Falcunculus frontatus															•	•
Pachycephala pectoralis	•	•	•	•	•	•	•	•	•	•				•	•	•
Pachycephala rufiventris		•	•	•			•							•	•	•
Colluricincla harmonica		•	•	•	•	•	•		•	•				•	•	•
Myiagra inquieta					•		•							•	•	•
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•	•				•	•	•
Coracina novaehollandiae	•	•	•	•	•	•		•	•	•				•	•	•
Artamus cyanopterus			•	•	•	•	•	•	•	•				•	•	•
Cracticus tibicen	•	•	•	•	•		•	•	•			•		•	•	•
Strepera versicolor	•			•	•	•	•	•	•	•				•	•	•
Corvus coronoides	•	•	•	•	•	•	•	•	•	•				•	•	•
Stagonopleura oculata	•				•		•	•	•		•					
Dicaeum hirundinaceum				•										•		•
Hirundo neoxena				•	•		•		•	•				•		•
Hirundo nigricans	•	•	•	•	•		•	•	•	•				•	•	•
Acrocephalus stentoreus				•	•									•		
Megalurus gramineus											•			•		
Zosterops lateralis	•	•	•	•	•		•	•	•		•			•	•	•

WATERBIRDS

Oxyura australis														•		
Biziura lobata					•		•		•				•	•	•	
Cygnus atratus					•		•						•	•		
Tadorna tadornoides							•	•	•					•	•	
Anas gracilis					•		•							•	•	•
Anas castanea																
Anas superciliosa			•	•	•		•	•	•				•	•	•	•
Anas rhynchotis													•			
Aythya australis							•							•		

TABLE 2 (continued)

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Tachybaptus novaehollandiae				•	•			•	•				•	•	•	•
Poliocephalus poliocephalus																
Anhinga melanogaster					•		•	•	•				•			
Phalacrocorax carbo					•		•						•	•	•	
Phalacrocorax sulcirostris					•			•	•				•	•	•	
Phalacrocorax melanoleucos				•	•		•	•	•				•	•	•	•
Ardea novaehollandiae			•	•	•		•	•	•				•	•	•	•
Nycticorax caledonicus															•	
Ixobrychus minutus																
Ixobrychus flavicollis													•			
Botaurus poiciloptilus								•	•							
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis									•		•			•		
Porphyrio porphyrio				•										•	•	
Gallinula ventralis				•												
Fulica atra					•		•							•		
Himantopus himantopus																
Charadrius ruficapillus														•		
Charadrius melanops					•		•							•		•
Erythrogonys cinctus																

	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
LANDBIRDS																
Dromaius novaehollandiae					•	•					•		•	•		
Leipoa ocellata																
Coturnix novaezelandiae													•			
Coturnix ypsilophora														•		
Haliastur sphenurus	•				•	•	•	•		•	•		•	•		
Accipiter fasciatus					•	•	•									
Accipter cirrhocephalus					•	•	•	•					•		•	
Aquila audax					•	•			•	•	•				•	
Circus approximans							•									
Falco berigora					•	•										
Falco peregrinus																
Turnix varia					•	•										
Phaps chalcoptera						•		•				•				
Phaps elegans													•			
Calyptorhynchus banksii						•		•			•	•				
Calyptorhynchus latirostris					•	•										
Calyptorhynchus baudinii								•	•	•	•	•			•	•
Cacatua pastinator																
Glossopsitta porphyrocephala						•		•		•	•		•	•		
Platycercus zonarius					•	•		•	•	•	•	•	•		•	•
Platycercus spurius					•			•	•	•	•	•	•	•	•	•
Platycercus icterotis					•	•		•		•	•	•	•		•	•

	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Cuculus pallidus					•	•		•	•	•	•			•		
Cacomantis flabelliformis					•	•		•	•	•	•	•			•	•
Chrysococcyx basalis					•	•			•			•			•	•
Chrysococcyx lucidus					•	•		•		•	•		•	•	•	
Ninox connivens																
Ninox novaeseelandiae					•	•		•						•		
Tyto novaehollandiae																
Tyto alba														•		
Podargus strigoides					•	•		•						•		
Eurostopodus argus																
Aegotheles cristatus														•		
Todiramphus sanctus					•	•		•	•		•			•		
Merops ornatus					•	•			•				•	•		•
Atrichornis clamosus																
Climacteris rufa		•	•		•	•		•	•	•	•	•	•	•	•	
Malurus splendens					•	•		•	•		•	•	•	•	•	•
Malurus elegans								•	•	•	•			•	•	
Stipiturus malachurus																
Pardalotus punctatus			•	•	•	•		•	•			•	•	•		
Pardalotus striatus		•	•	•	•	•		•	•	•	•	•	•	•	•	•
Sericornis frontalis								•	•	•	•			•	•	•
Smicrornis brevirostris					•	•			•			•	•			
Gerygone fusca		•	•	•	•	•		•	•	•	•	•	•	•	•	•
Acanthiza apicalis		•	•	•	•	•		•	•	•	•	•	•	•	•	•
Acanthiza inornata		•	•	•	•	•				•	•	•	•	•	•	•
Acanthiza chrysorrhoa					•	•		•			•	•	•			
Lichmera indistincta			•	•	•	•		•				•				
Meliphaga ornata					•	•		•								
Melithreptus chloropsis		•	•	•	•	•		•	•	•	•	•	•		•	•
Phylidonyris novaehollandiae					•	•		•	•	•	•	•		•	•	•
Phylidonyris nigra					•	•		•					•			
Phylidonyris melanops					•									•		
Acanthorhynchus superciliosus		•	•	•	•	•		•	•	•	•	•	•	•	•	•
Anthochaera chrysoptera					•	•		•	•	•	•		•	•	•	
Anthochaera carunculata					•	•		•		•	•	•	•		•	•
Petroica multicolor					•	•		•	•	•	•	•		•		•
Petroica cucullata						•			•							
Eopsaltria australis		•	•	•	•	•		•	•	•		•	•	•	•	
Eopsaltria georgiana								•	•	•	•	•			•	
Pomatostomus superciliosus								•								
Daphoenositta chrysoptera					•	•				•	•	•	•	•		•
Falcunculus frontatus								•								
Pachycephala pectoralis		•	•	•	•	•		•	•	•	•	•	•	•	•	•
Pachycephala rufiventris					•	•										
Colluricincla harmonica		•	•	•	•	•		•	•	•	•		•	•	•	•
Myiagra inquieta					•	•		•								
Rhipidura fuliginosa					•	•		•	•	•	•	•	•	•	•	•
Coracina novaehollandiae					•	•		•		•	•	•				•
Artamus cyanopterus					•	•		•	•		•			•		
Cracticus tibicen					•	•		•	•			•				

TABLE 2 (continued)

	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Strepera versicolor					•				•	•	•	•				
Corvus coronoides					•	•		•	•	•	•	•			•	•
Stagonopleura oculata								•			•		•	•		
Dicaeum hirundinaceum					•	•										
Hirundo neoxena													•			
Hirundo nigricans					•	•		•	•	•	•		•	•	•	
Acrocephalus stentoreus						•										
Megalurus gramineus																
Zosterops lateralis					•	•		•			•	•		•	•	•
WATERBIRDS																
Oxyura australis	•															
Biziura lobata	•															
Cygnus atratus	•															
Tadorna tadornoides	•						•									
Anas gracilis	•						•									
Anas castanea	•															
Anas superciliosa	•				•	•	•									
Anas rhynchotis	•															
Aythya australis	•															
Tachybaptus novaehollandiae	•						•									
Poliocephalus poliocephalus																
Anhinga melanogaster	•															
Phalacrocorax carbo	•															
Phalacrocorax sulcirostris	•															
Phalacrocorax melanoleucos	•						•									
Ardea novaehollandiae	•					•	•									
Nycticorax caledonicus	•															
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis	•															
Porphyrio porphyrio	•						•									
Gallinula ventralis							•									
Fulica atra	•						•									
Himantopus himantopus																
Charadrius ruficapillus	•															
Charadrius melanops	•						•									
Erythrogonys cinctus																

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
LANDBIRDS																
Dromaius novaehollandiae				•								•				
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora																
Haliastur sphenurus																
Accipiter fasciatus												•				
Accipter cirrhocephalus												•				•
Aquila audax				•								•				
Circus approximans																
Falco berigora																
Falco peregrinus																
Turnix varia				•								•				
Phaps chalcoptera				•								•			•	
Phaps elegans																
Calyptorhynchus banksii				•								•				
Calyptorhynchus baudinii	•			•											•	•
Calyptorhynchus latirostris												•				
Cacatua pastinator																
Glossopsitta porphyrocephala						•									•	•
Platycercus zonarius				•	•	•	•	•				•			•	•
Platycercus spurius				•	•		•	•	•	•	•	•			•	
Platycercus icterotis	•	•	•					•			•	•			•	•
Cuculus pallidus												•				
Cacomantis flabelliformis			•	•								•			•	•
Chrysococcyx basalis	•	•										•				
Chrysococcyx lucidus				•								•			•	•
Ninox connivens																
Ninox novaeseelandiae												•				
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides				•												
Eurostopodus argus																
Aegotheles cristatus																
Todiramphus sanctus										•						
Merops ornatus										•	•	•				
Atrichornis clamosus																
Climacteris rufa				•				•	•			•			•	•
Malurus splendens		•				•	•		•			•				
Malurus elegans		•		•											•	•
Stipiturus malachurus																
Pardalotus punctatus				•				•				•			•	•
Pardalotus striatus	•	•	•	•	•	•	•	•	•	•	•	•			•	•
Sericornis frontalis		•													•	•
Smicrornis brevirostris								•	•	•		•				
Gerygone fusca	•	•	•	•	•	•	•	•	•	•	•	•			•	•
Acanthiza apicalis		•		•	•	•	•	•	•		•	•			•	•
Acanthiza inornata		•	•	•		•	•	•	•	•	•	•				
Acanthiza chrysorrhoa							•					•				

TABLE 2 (continued)

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Lichmera indistincta				•	•		•					•				
Meliphaga ornata																
Melithreptus chloropsis	•	•		•	•		•	•	•			•			•	•
Phylidonyris novaehollandiae				•								•			•	•
Phylidonyris nigra												•				
Phylidonyris melanops																
Acanthorhynchus superciliosus	•	•	•	•	•	•	•	•	•		•	•			•	•
Anthochaera chrysoptera		•		•							•	•			•	•
Anthochaera carunculata		•		•								•			•	•
Petroica multicolor			•	•			•			•		•			•	•
Petroica cucullata																
Eopsaltria australis						•		•	•			•				
Eopsaltria georgiana		•													•	•
Pomatostomus superciliosus															•	•
Daphoenositta chrysoptera	•		•	•		•	•		•		•	•				
Falcunculus frontatus															•	•
Pachycephala pectoralis	•	•	•	•		•		•				•			•	•
Pachycephala rufiventris												•				
Colluricincla harmonica	•		•	•		•		•	•			•			•	•
Myiagra inquieta												•			•	
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•			•			•	•
Coracina novaehollandiae	•		•	•							•	•			•	•
Artamus cyanopterus										•		•			•	•
Cracticus tibicen												•				
Strepera versicolor				•								•				
Corvus coronoides		•	•	•	•		•					•			•	•
Stagonopleura oculata															•	
Dicaeum hirundinaceum												•				
Hirundo neoxena												•				
Hirundo nigricans		•		•	•		•		•		•	•			•	•
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis			•	•	•	•	•				•	•			•	•

WATERBIRDS

Oxyura australis																
Biziura lobata																
Cygnus atratus														•		
Tadorna tadornoides														•		
Anas gracilis														•		
Anas castanea																
Anas superciliosa													•	•		
Anas rhynchotis													•			
Aythya australis																
Tachybaptus novaehollandiae														•		

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Poliocephalus poliocephalus																
Anhinga melanogaster																
Phalacrocorax carbo													•			
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos													•			
Ardea novaehollandiae													•			
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio													•			
Gallinula ventralis																
Fulica atra														•		
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops														•		
Erythrogonys cinctus																

	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
LANDBIRDS																
Dromaius novaehollandiae							•	•	•	•	•	•	•	•	•	•
Leipoa ocellata														•		
Coturnix novaezelandiae															•	•
Coturnix ypsilophora			•													
Haliastur sphenurus							•	•		•	•	•		•		
Accipiter fasciatus		•	•			•	•	•	•			•		•	•	
Accipter cirrhocephalus			•									•	•			
Aquila audax							•	•	•	•		•		•	•	•
Circus approximans																•
Falco berigora								•	•	•	•	•	•	•	•	•
Falco peregrinus								•						•		
Turnix varia										•						
Phaps chalcoptera			•	•			•	•	•	•	•	•				
Phaps elegans							•	•	•	•	•	•	•	•	•	•
Calyptorhynchus banksii							•	•	•	•				•	•	
Calyptorhynchus latirostris																
Calyptorhynchus baudinii	•	•			•		•	•	•	•	•	•	•	•	•	•
Cacatua pastinator																
Glossopsitta porphyrocephala	•	•			•	•		•	•	•				•	•	•
Platycercus zonarius	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Platycercus spurius	•	•				•	•	•	•	•		•	•	•	•	•
Platycercus icterotis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Cuculus pallidus	•				•		•	•	•	•		•	•	•		•
Cacomantis flabelliformis	•	•	•		•	•	•	•	•	•	•		•	•		

TABLE 2 (continued)

	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Chrysococcyx basalis							▪	▪	▪		▪		▪	▪		
Chrysococcyx lucidus	▪	▪		▪	▪	▪				▪		▪	▪	▪		▪
Ninox connivens																
Ninox novaeseelandiae		▪					▪	▪		▪	▪			▪	▪	▪
Tyto novaehollandiae														▪		
Tyto alba										▪	▪	▪				
Podargus strigoides							▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Eurostopodus argus														▪		
Aegotheles cristatus							▪			▪		▪			▪	▪
Todiramphus sanctus	▪	▪			▪				▪	▪	▪	▪		▪		▪
Merops ornatus												▪				
Atrichornis clamosus																
Climacteris rufa	▪	▪				▪	▪	▪	▪	▪		▪		▪	▪	▪
Malurus splendens							▪	▪	▪	▪	▪	▪	▪	▪		▪
Malurus elegans	▪	▪	▪	▪	▪	▪	▪		▪	▪	▪	▪	▪	▪	▪	
Stipiturus malachurus			▪				▪	▪			▪		▪		▪	
Pardalotus punctatus	▪	▪		▪	▪	▪	▪	▪	▪	▪	▪		▪	▪	▪	▪
Pardalotus striatus	▪	▪		▪	▪	▪	▪	▪		▪	▪	▪	▪	▪	▪	
Sericornis frontalis	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Smicrornis brevirostris										▪			▪	▪		
Gerygone fusca	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪			▪	▪	▪	
Acanthiza apicalis	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Acanthiza inornata								▪	▪	▪		▪	▪	▪	▪	▪
Acanthiza chrysorrhoa			▪				▪	▪	▪	▪		▪		▪	▪	
Lichmera indistincta	▪						▪	▪	▪	▪	▪	▪	▪			
Meliphaga ornata																
Melithreptus chloropsis	▪	▪		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Phylidonyris novaehollandiae	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Phylidonyris nigra							▪	▪								
Phylidonyris melanops								▪	▪			▪	▪	▪	▪	▪
Acanthorhynchus superciliosus	▪	▪	▪	▪	▪		▪	▪	▪			▪	▪	▪	▪	▪
Anthochaera chrysoptera	▪	▪		▪	▪	▪	▪	▪	▪	▪		▪	▪	▪		▪
Anthochaera carunculata	▪	▪		▪	▪	▪	▪	▪	▪	▪	▪	▪		▪	▪	▪
Petroica multicolor	▪		▪			▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Petroica cucullata																
Eopsaltria australis							▪	▪	▪	▪		▪	▪			
Eopsaltria georgiana	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Pomatostomus superciliosus	▪	▪				▪	▪	▪						▪	▪	▪
Daphoenositta chrysoptera							▪	▪	▪	▪	▪	▪	▪	▪		▪
Falcunculus frontatus	▪	▪				▪		▪		▪						
Pachycephala pectoralis	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Pachycephala rufiventris										▪	▪	▪				
Colluricincla harmonica	▪	▪		▪	▪	▪	▪	▪	▪	▪		▪	▪	▪	▪	
Myiagra inquieta	▪	▪				▪		▪		▪	▪	▪		▪	▪	
Rhipidura fuliginosa	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Coracina novaehollandiae	▪	▪	▪		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Artamus cyanopterus	▪	▪	▪			▪		▪	▪	▪	▪	▪		▪	▪	▪
Cracticus tibicen			▪				▪	▪	▪	▪	▪	▪	▪	▪		
Strepera versicolor			▪	▪		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪

	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Corvus coronoides	•			•	•	•	•	•	•	•	•	•	•	•	•	•
Stagonopleura oculata	•	•		•			•	•	•		•	•		•	•	•
Dicaeum hirundinaceum																
Hirundo neoxena							•			•		•				•
Hirundo nigricans	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•
Acrocephalus stentoreus							•									
Megalurus gramineus							•		•							
Zosterops lateralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

WATERBIRDS

Oxyura australis							•									
Biziura lobata							•		•	•		•		•		•
Cygnus atratus										•		•				•
Tadorna tadornoides										•		•			•	•
Anas gracilis									•	•						•
Anas castanea																
Anas superciliosa							•	•	•	•	•	•	•	•		•
Anas rhynchotis									•							
Aythya australis																
Tachybaptus novaehollandiae							•		•	•		•			•	
Poliocephalus poliocephalus																•
Anhinga melanogaster							•	•		•		•				
Phalacrocorax carbo																•
Phalacrocorax sulcirostris										•					•	
Phalacrocorax melanoleucos							•		•	•		•			•	•
Ardea novaehollandiae							•	•	•	•		•		•	•	•
Nycticorax caledonicus							•			•				•		
Ixobrychus minutus																
Ixobrychus flavicollis										•					•	
Botaurus poiciloptilus							•									
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis							•		•				•			
Porphyrio porphyrio							•		•			•				•
Gallinula ventralis																
Fulica atra							•		•	•		•				•
Himantopus himantopus																
Charadrius ruficapillus							•	•								•
Charadrius melanops										•						
Erythrogonys cinctus																

TABLE 2 (continued)

	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
LANDBIRDS																
Dromaius novaehollandiae	•	•	•	•								•				•
Leipoa ocellata																
Coturnix novaezelandiae		•														
Coturnix ypsilophora				•												
Haliastur sphenurus	•	•														•
Accipiter fasciatus		•		•												
Accipter cirrhocephalus	•															
Aquila audax	•	•	•	•							•					
Circus approximans			•	•												
Falco berigora		•	•													
Falco peregrinus																
Turnix varia		•														
Phaps chalcoptera															•	•
Phaps elegans	•	•	•	•												
Calyptorhynchus banksii		•		•				•	•							•
Calyptorhynchus latirostris															•	•
Calyptorhynchus baudinii	•	•	•	•												
Cacatua pastinator																
Glossopsitta porphyrocephala	•	•	•	•												
Platycercus zonarius	•	•	•	•	•		•		•					•	•	•
Platycercus spurius	•	•		•		•		•	•				•	•	•	•
Platycercus icterotis	•	•	•	•												•
Cuculus pallidus	•	•	•													
Cacomantis flabelliformis	•		•	•	•		•									•
Chrysococcyx basalis				•												
Chrysococcyx lucidus	•		•													
Ninox connivens																
Ninox novaeseelandiae	•															
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides	•	•		•												
Eurostopodus argus																
Aegotheles cristatus	•	•		•										•		•
Todiramphus sanctus	•		•											•		
Merops ornatus																
Atrichornis clamosus																
Climacteris rufa	•	•	•						•					•		•
Malurus splendens	•	•	•	•		•	•		•				•	•		•
Malurus elegans	•															
Stipiturus malachurus			•													
Pardalotus punctatus	•	•		•					•					•		
Pardalotus striatus	•		•	•					•					•	•	
Sericornis frontalis	•	•	•	•												
Smicrornis brevirostris						•			•					•	•	•
Gerygone fusca	•		•	•									•	•		
Acanthiza apicalis	•	•	•	•	•	•	•		•			•			•	•
Acanthiza inornata		•	•	•		•			•			•				•

	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
Acanthiza chrysorrhoa		•		•												
Lichmera i ndistincta		•							•		•	•	•	•	•	
Meliphaga ornata																
Melithreptus chloropsis	•	•	•	•							•			•		•
Phylidonyris novaehollandiae	•	•	•	•	•		•					•	•			•
Phylidonyris nigra																
Phylidonyris melanops												•				
Acanthorhynchus superciliosus		•	•	•					•		•	•	•	•	•	
Anthochaera chrysoptera							•					•				•
Anthochaera carunculata	•	•	•	•			•					•				
Petroica multicolor	•	•	•	•		•	•		•			•	•	•		•
Petroica cucullata																
Eopsaltria australis	•	•		•				•	•		•			•		•
Eopsaltria georgiana	•	•	•	•												
Pomatostomus superciliosus	•		•													
Falcunculus frontatus	•															
Daphoenositta chrysoptera	•	•	•	•							•					•
Pachycephala pectoralis	•	•	•	•					•		•		•	•	•	•
Pachycephala rufiventris		•														
Colluricincla harmonica	•	•	•	•					•		•		•	•	•	•
Myiagra inquieta		•		•									•	•		
Rhipidura fuliginosa	•	•	•	•	•	•	•		•					•		•
Coracina novaehollandiae	•	•	•	•	•				•							
Artamus cyanopterus	•	•	•	•												
Cracticus tibicen	•	•	•	•												
Strepera versicolor	•	•	•	•									•		•	•
Corvus coronoides	•	•	•	•	•										•	•
Stagonopleura oculata	•		•	•												
Dicaeum hirundinaceum																
Hirundo neoxena		•														
Hirundo nigricans	•		•	•												•
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis	•	•	•	•			•									

WATERBIRDS

Oxyura australis																
Biziura lobata				•												
Cygnus atratus																
Tadorna tadornoides																
Anas gracilis																
Anas castanea																
Anas superciliosa		•	•	•												
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus																

TABLE 2 (continued)

	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
Anhinga melanogaster			•	•												
Phalacrocorax carbo			•	•												
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos		•	•													
Ardea novaehollandiae	•	•	•	•												
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis	•															
Porphyrio porphyrio	•															
Gallinula ventralis																
Fulica atra				•												
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113
LANDBIRDS																
Dromaius novaehollandiae						•						•		•		•
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora																
Haliastur sphenurus																
Accipiter fasciatus				•			•							•		
Accipter cirrhocephalus													•			
Aquila audax					•										•	
Circus approximans																
Falco berigora																
Falco peregrinus																
Turnix varia													•	•	•	
Phaps chalcoptera	•				•		•			•		•	•	•		•
Phaps elegans																
Calyptorhynchus banksii	•			•			•		•			•	•			•
Calyptorhynchus latirostris	•				•		•			•						•
Calyptorhynchus baudinii																
Cacatua pastinator																
Glossopsitta porphyrocephala													•			•
Platycercus zonarius	•	•	•	•	•		•	•	•	•		•	•		•	•
Platycercus spurius	•		•	•	•		•	•	•	•		•	•	•	•	•
Platycercus icterotis	•						•		•	•		•	•	•	•	•
Cuculus pallidus												•				•
Cacomantis flabelliformis	•	•		•			•					•	•			•

	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113
Chrysococcyx basalis												•	•	•		•
Chrysococcyx lucidus								•	•	•						
Ninox connivens																
Ninox novaeseelandiae																
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides																
Eurostopodus argus																
Aegotheles cristatus				•			•							•		
Todiramphus sanctus				•						•						•
Merops ornatus					•							•				•
Atrichornis clamosus																
Climacteris rufa	•			•			•		•	•		•		•		•
Malurus splendens	•	•	•	•	•		•	•	•	•		•	•	•	•	•
Malurus elegans	•								•	•						
Stipiturus malachurus																
Pardalotus punctatus	•			•			•	•	•	•		•	•	•		•
Pardalotus striatus	•			•	•		•	•	•	•		•	•	•	•	•
Sericornis frontalis	•							•	•	•			•		•	
Smicrornis brevirostris	•			•	•		•					•	•	•	•	•
Gerygone fusca	•	•		•	•		•	•	•	•		•	•	•	•	•
Acanthiza apicalis	•	•		•	•	•	•	•	•	•		•	•	•	•	
Acanthiza inornata				•		•	•	•	•	•		•	•	•	•	•
Acanthiza chrysorrhoa				•			•					•				
Lichmera indistincta				•	•	•						•	•	•	•	•
Meliphaga ornata																
Melithreptus chloropsis	•			•	•		•	•	•	•		•	•	•		•
Phylidonyris novaehollandiae	•	•		•	•	•		•	•	•		•	•	•	•	•
Phylidonyris nigra		•												•	•	
Phylidonyris melanops					•	•							•	•		
Acanthorhynchus superciliosus	•			•	•	•		•	•	•		•	•	•	•	•
Anthochaera chrysoptera	•	•			•	•			•			•	•	•		
Anthochaera carunculata	•	•				•						•				•
Petroica multicolor	•	•		•	•	•	•	•	•		•	•	•	•	•	•
Petroica cucullata																
Eopsaltria australis				•	•		•						•			•
Eopsaltria georgiana	•	•						•	•	•						
Pomatostomus superciliosus																
Daephoenositta chrysoptera	•				•		•	•		•			•	•	•	•
Falcunculus frontatus																
Pachycephala pectoralis	•	•		•	•		•	•	•	•		•	•	•	•	•
Pachycephala rufiventris																•
Colluricincla harmonica	•	•		•	•		•	•	•	•	•	•	•	•	•	•
Myiagra inquieta				•	•											•
Rhipidura fuliginosa	•	•	•	•			•	•	•	•		•	•	•		•
Coracina novaehollandiae	•			•	•		•	•	•						•	•
Artamus cyanopterus				•										•		
Cracticus tibicen												•			•	•
Strepera versicolor			•		•		•		•			•	•		•	•
Corvus coronoides	•	•	•		•		•		•	•		•	•			•

TABLE 2 (continued)

	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113
Stagonopleura oculata	•	•														
Dicaeum hirundinaceum																
Hirundo neoxena											•					
Hirundo nigricans	•			•			•	•	•		•			•	•	•
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis	•	•					•	•	•	•		•	•	•	•	•
WATERBIRDS																
Oxyura australis																
Biziura lobata											•					
Cygnus atratus											•					
Tadorna tadornoides											•	•				
Anas gracilis											•					
Anas castanea																
Anas superciliosa											•	•				
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae											•					
Poliocephalus poliocephalus											•					
Anhinga melanogaster																
Phalacrocorax carbo																
Phalacrocorax sulcirostris											•					
Phalacrocorax melanoleucos											•					
Ardea novaehollandiae											•					
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio											•					
Gallinula ventralis																
Fulica atra																
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops											•					
Erythrogonys cinctus																

	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129
LANDBIRDS																
Dromaius novaehollandiae			•	•	•								•	•		
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora													•			
Haliastur sphenurus												•				
Accipiter fasciatus									•		•	•	•	•		
Accipter cirrhocephalus		•							•		•	•	•	•		
Aquila audax		•			•	•			•					•		
Circus approximans																
Falco berigora												•				
Falco peregrinus					•											
Turnix varia		•				•										
Phaps chalcoptera	•		•	•		•	•		•				•			
Phaps elegans												•	•			
Calyptorhynchus banksii			•	•	•		•		•			•				•
Calyptorhynchus latirostris																
Calyptorhynchus baudinii												•	•	•		
Cacatua pastinator																
Glossopsitta porphyrocephala		•						•				•	•			
Platycercus zonarius	•	•	•	•	•	•	•		•	•	•	•	•	•		•
Platycercus spurius	•	•	•	•	•	•			•	•		•	•	•		•
Platycercus icterotis	•									•	•	•	•	•		•
Cuculus pallidus				•										•		
Cacomantis flabelliformis	•		•		•	•	•		•			•	•	•	•	•
Chrysococcyx basalis	•	•	•	•			•					•				
Chrysococcyx lucidus	•			•	•	•	•		•			•	•	•		•
Ninox connivens																
Ninox novaeseelandiae						•			•			•		•		
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides		•							•							
Eurostopodus argus																
Aegotheles cristatus		•			•											
Todiramphus sanctus							•		•				•			
Merops ornatus			•		•	•				•				•		
Atrichornis clamosus																
Climacteris rufa	•	•			•	•			•			•	•		•	
Malurus splendens		•	•	•					•	•	•	•	•			•
Malurus elegans									•	•		•	•			•
Stipiturus malachurus													•			
Pardalotus punctatus	•	•	•	•		•	•	•	•	•		•	•	•	•	•
Pardalotus striatus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Sericornis frontalis	•							•	•	•		•	•			•
Smicrornis brevirostris	•	•	•	•	•	•				•						
Gerygone fusca	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Acanthiza apicalis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Acanthiza inornata	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•
Acanthiza chrysorrhoa				•		•										

TABLE 2 (continued)

	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129
Lichmera indistincta	•	•	•	•	•	•	•						•	•	•	•
Meliphaga ornata																
Melithreptus chloropsis	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•
Phylidonyris novaehollandiae			•	•					•			•	•			•
Phylidonyris nigra																
Phylidonyris melanops													•			
Acanthorhynchus superciliosus	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•
Anthochaera chrysoptera		•	•	•	•	•	•					•	•	•		•
Anthochaera carunculata			•					•				•	•	•		
Petroica multicolor	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•
Petroica cucullata																
Eopsaltria australis	•	•	•	•	•	•	•	•	•	•				•	•	
Eopsaltria georgiana								•	•			•	•			•
Pomatostomus superciliosus												•	•			
Daphoenositta chrysoptera	•	•	•	•	•	•	•		•	•				•		•
Falcunculus frontatus												•	•			
Pachycephala pectoralis	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•
Pachycephala rufiventris									•							
Colluricincla harmonica	•	•	•	•	•	•	•		•	•		•	•	•	•	•
Myiagra inquieta												•	•			
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Coracina novaehollandiae	•	•				•	•		•			•	•	•		•
Artamus cyanopterus							•	•	•	•		•	•		•	•
Cracticus tibicen					•	•		•								
Strepera versicolor	•	•	•		•	•	•		•			•		•		
Corvus coronoides	•	•	•	•	•	•	•	•	•			•	•	•		
Stagonopleura oculata						•						•	•			
Dicaeum hirundinaceum																
Hirundo neoxena																
Hirundo nigricans		•				•	•	•	•	•	•	•	•			•
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

WATERBIRDS

Oxyura australis
Biziura lobata
Cygnus atratus
Tadorna tadornoides
Anas gracilis
Anas castanea
Anas superciliosa
Anas rhynchotis
Aythya australis

	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus																
Anhinga melanogaster																
Phalacrocorax carbo																
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos																
Ardea novaehollandiae																
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio																
Gallinula ventralis																
Fulica atra																
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145
LANDBIRDS																
Dromaius novaehollandiae																
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora																
Haliastur sphenurus																
Accipiter fasciatus																
Accipter cirrhocephalus		•														
Aquila audax																
Circus approximans			•	•	•	•	•	•		•	•	•	•			
Falco berigora																
Falco peregrinus																
Turnix varia																
Phaps chalcoptera																
Phaps elegans																
Calyptorhynchus banksii																
Calyptorhynchus latirostris																
Calyptorhynchus baudinii																
Cacatua pastinator																
Glossopsitta porphyrocephala																
Platycercus zonarius		•														
Platycercus spurius	•	•														
Platycercus icterotis	•	•														
Cuculus pallidus																

TABLE 2 (continued)

	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145
Cacomantis flabelliformis	.															
Chrysococcyx basalis																
Chrysococcyx lucidus	.	.														
Ninox connivens																
Ninox novaeseelandiae																
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides																
Eurostopodus argus																
Aegotheles cristatus																
Todiramphus sanctus		.														
Merops ornatus																
Atrichornis clamosus																
Climacteris rufa		.														
Malurus splendens	.	.														
Malurus elegans	.	.														
Stipiturus malachurus																
Pardalotus punctatus	.	.														
Pardalotus striatus	.	.														
Sericornis frontalis	.	.														
Smicrornis brevirostris																
Gerygone fusca	.															
Acanthiza apicalis	.	.														
Acanthiza inornata	.	.														
Acanthiza chrysorrhoa																
Lichmera indistincta																
Meliphaga ornata		.														
Melithreptus chloropsis		.														
Phylidonyris novaehollandiae	.	.														
Phylidonyris nigra																
Phylidonyris melanops		.														
Acanthorhynchus superciliosus	.	.														
Anthochaera chrysoptera																
Anthochaera carunculata																
Petroica multicolor		.														
Petroica cucullata		.														
Eopsaltria australis	.	.														
Eopsaltria georgiana	.	.														
Pomatostomus superciliosus																
Daphoenositta chrysoptera		.														
Falcunculus frontatus																
Pachycephala pectoralis	.	.														
Pachycephala rufiventris		.														
Colluricincla harmonica		.														
Myiagra inquieta																
Rhipidura fuliginosa	.	.														
Coracina novaehollandiae																
Artamus cyanopterus	.	.														
Cracticus tibicen																

	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145
Strepera versicolor																
Corvus coronoides																
Stagonopleura oculata	•	•														
Dicaeum hirundinaceum																
Hirundo neoxena																
Hirundo nigricans																
Acrocephalus stentoreus			•	•	•	•		•		•	•		•	•		
Megalurus gramineus			•	•	•			•		•	•	•		•		
Zosterops lateralis	•	•														

WATERBIRDS

Oxyura australis			•	•	•		•					•				
Biziura lobata			•	•	•		•	•		•	•	•	•	•	•	
Cygnus atratus				•	•		•	•	•	•		•				
Tadorna tadornoides			•	•	•		•		•	•		•				
Anas gracilis			•	•	•		•	•	•	•	•	•				
Anas castanea			•		•		•		•			•				
Anas superciliosa			•	•	•	•	•	•	•	•	•	•		•	•	•
Anas rhynchotis			•	•	•		•		•	•		•				
Aythya australis			•	•	•		•					•				
Tachybaptus novaehollandiae			•	•	•		•					•				
Poliocephalus poliocephalus			•	•	•		•					•				
Anhinga melanogaster				•	•							•				
Phalacrocorax carbo					•		•					•				
Phalacrocorax sulcirostris			•	•	•		•			•		•				
Phalacrocorax melanoleucos			•	•	•		•	•		•		•				
Ardea novaehollandiae			•	•	•		•	•		•	•	•	•	•	•	
Nycticorax caledonicus					•											
Ixobrychus minutus			•	•				•			•			•		
Ixobrychus flavicollis																
Botaurus poiciloptilus			•	•		•		•			•		•	•		
Rallus pectoralis																
Porzana pusilla			•									•				
Porzana fluminea			•													
Porzana tabuensis			•	•		•		•		•	•			•		
Porphyrio porphyrio			•	•		•	•	•		•	•	•	•	•	•	
Gallinula ventralis			•		•							•	•			
Fulica atra			•	•	•		•					•				
Himantopus himantopus			•	•	•		•		•	•		•				
Charadrius ruficapillus			•	•			•		•	•		•				
Charadrius melanops			•	•	•		•			•		•				
Erythrogonys cinctus			•		•		•					•				

TABLE 2 (continued)

	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161
LANDBIRDS																
Dromaius novaehollandiae												•				•
Leipoa ocellata												•				
Coturnix novaezelandiae												•				
Coturnix ypsilophora																
Haliastur sphenurus											•					
Accipiter fasciatus										•						
Accipter cirrhocephalus												•		•		•
Aquila audax	•				•		•									
Circus approximans												•				
Falco berigora												•				
Falco peregrinus																
Turnix varia												•	•	•		
Phaps chalcoptera												•	•	•		
Phaps elegans																
Calyptorhynchus banksii												•	•	•		
Calyptorhynchus latirostris												x	•		•	
Calyptorhynchus baudinii												x				
Cacatua pastinator																
Glossopsitta porphyrocephala												•				•
Platycercus zonarius											•	•	•			•
Platycercus spurius												•	•	•	•	•
Platycercus icterotis										•		•		•		
Cuculus pallidus												•				
Cacomantis flabelliformis										•	•	•				
Chrysococcyx basalis												•				
Chrysococcyx lucidus										•		•				
Ninox connivens																
Ninox novaeseelandiae																
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides																
Eurostopodus argus																
Aegotheles cristatus																
Tadiramphus sanctus											•	•				
Merops ornatus													•			•
Atrichornis clamosus																
Climacteris rufa									•	•	•			•	•	•
Malurus splendens									•		•	•	•	•	•	•
Malurus elegans									•	•				•		
Stipiturus malachurus																
Pardalotus punctatus										•						•
Pardalotus striatus											•	•	•			•
Sericornis frontalis									•	•		•	•	•	•	•
Smicrornis brevirostris													•			
Gerygone fusca											•	•	•	•	•	•
Acanthiza apicalis									•	•	•	•	•		•	•
Acanthiza inornata												•	•	•	•	•
Acanthiza chrysorrhoa												•	•	•		

	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161
Lichmera indistincta												•		•		•
Meliphaga ornata																
Melithreptus chloropsis									•	•	•			•		•
Phylidonyris novaehollandiae									•	•		•	•	•	•	•
Phylidonyris nigra													•			
Phylidonyris melanops												•				
Acanthorhynchus superciliosus											•	•	•	•	•	•
Anthochaera chrysoptera											•	•		•		•
Anthochaera carunculata										•		•				
Petroica multicolor									•	•	•	•	•	•	•	
Petroica cucullata																
Eopsaltria australis											•					
Eopsaltria georgiana									•	•				•		•
Pomatostomus superciliosus										•						
Daphoenositta chrysoptera												•				
Falcunculus frontatus																
Pachycephala pectoralis									•	•	•	•	•	•	•	•
Pachycephala rufiventris																
Colluricincla harmonica									•	•		•		•		•
Myiagra inquieta																•
Rhipidura fuliginosa									•	•	•	•	•	•	•	•
Coracina novaehollandiae									•			•	•			
Artamus cyanopterus									•			•				•
Cracticus tibicen														•		
Strepera versicolor										•		•				•
Corvus coronoides											•	•	•			
Stagonopleura oculata									•	•		•		•		
Dicaeum hirundinaceum																
Hirundo neoxena												•				
Hirundo nigricans												•	•	•	•	•
Acrocephalus stentoreus	•		•													
Megalurus gramineus	•		•													
Zosterops lateralis									•	•		•	•	•		

WATERBIRDS

Oxyura australis																
Biziura lobata	•			•			•									
Cygnus atratus	•						•									
Tadorna tadornoides						•	•									
Anas gracilis	•					•	•									
Anas castanea																
Anas superciliosa	•						•									
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus						•										
Anhinga melanogaster																

TABLE 2 (continued)

	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161
Phalacrocorax carbo																
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos	.		.				.									
Ardea novaehollandiae	.	.	.				.									
Nycticorax caledonicus																
Ixobrychus minutus	.															
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis	.			.										.		
Porphyrio porphyrio			.	.												
Gallinula ventralis																
Fulica atra							.									
Himantopus himantopus																
Charadrius ruficapillus						.										
Charadrius melanops																
Erythrogonys cinctus																

	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177
LANDBIRDS																
Dromaius novaehollandiae		.			.	.										
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora							.									
Haliastur sphenurus																
Accipiter fasciatus																
Accipter cirrhocephalus									.							
Aquila audax							.									
Circus approximans																
Falco berigora						.										
Falco peregrinus							.									
Turnix varia										.						
Phaps chalcoptera		.		.	.	.	.		.	.		.			.	.
Phaps elegans																
Calyptorhynchus banksii			.	.											.	
Calyptorhynchus latirostris				x		x	x		.	.	.		.	.	.	
Calyptorhynchus baudinii				x		x	x									
Cacatua pastinator																
Glossopsitta porphyrocephala																
Platycercus zonarius		.	.	.	.	.	.	.	.	.	.	.			.	.
Platycercus spurius		.	.					.	.	.	.	.	.	.	.	.
Platycercus icterotis				.	.	.										.
Cuculus pallidus				.		.	.	.			.	.				
Cacomantis flabelliformis				.		.	.	.			.	.	.		.	
Chrysococcyx basalis				.		.					.	.				

	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177
Chrysococcyx lucidus				•	•	•	•			•	•	•	•		•	
Ninox connivens																
Ninox novaeseelandiae									•							
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides				•		•										
Eurostopodus argus																
Aegotheles cristatus				•												
Todiramphus sanctus			•	•		•		•			•	•		•	•	
Merops ornatus		•						•	•	•		•			•	
Atrichornis clamosus																
Climacteris rufa								•		•	•	•				•
Malurus splendens	•		•	•		•	•	•	•	•		•	•	•	•	x
Malurus elegans				•	•		•									x
Stipiturus malachurus				•			•									
Pardalotus punctatus			•	•	•				•							
Pardalotus striatus			•	•			•	•	•	•	•	•	•		•	•
Sericornis frontalis			•	•	•	•	•					•				•
Smicrornis brevirostris								•	•		•	•	•			
Gerygone fusca			•	•		•		•	•	•	•	•	•		•	
Acanthiza apicalis			•	•		•	•		•	•	•		•	•	•	•
Acanthiza inornata	•	•	•	•		•		•	•	•	•	•	•	•	•	•
Acanthiza chrysorrhoa				•		•	•			•			•	•		
Lichmera indistincta				•		•		•	•	•		•	•		•	
Meliphaga ornata																
Melithreptus chloropsis	•	•	•	•						•			•		•	
Phylidonyris novaehollandiae		•	•	•		•	•								•	
Phylidonyris nigra		•		•												
Phylidonyris melanops				•		•										
Acanthorhynchus superciliosus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Anthochaera chrysoptera		•	•	•	•	•										
Anthochaera carunculata				•	•	•	•		•	•			•		•	
Petroica multicolor	•	•	•	•						•	•	•	•		•	•
Petroica cucullata																
Eopsaltria australis																•
Eopsaltria georgiana			•	•												
Pomatostomus superciliosus																
Daphoenositta chrysoptera				•					•		•			•		•
Falcunculus frontatus																
Pachycephala pectoralis	•		•	•		•	•	•	•	•	•		•		•	•
Pachycephala rufiventris				•		•			•	•	•	•	•		•	
Colluricincla harmonica			•	•				•	•	•	•	•	•		•	•
Myiagra inquieta																
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Coracina novaehollandiae			•	•	•	•	•	•			•	•			•	
Artamus cyanopterus		•	•	•		•	•							•		•
Cracticus tibicen				•	•	•	•	•			•		•		•	
Strepera versicolor						•					•					
Corvus coronoides			•	•		•	•	•	•	•	•	•	•		•	•
Stagonopleura oculata			•				•									

TABLE 2 (continued)

	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177
Dicaeum hirundinaceum												•				
Hirundo neoxena							•									
Hirundo nigricans		•	•	•		•	•	•			•	•	•		•	
Acrocephalus stentoreus																
Megalurus gramineus					•											
Zosterops lateralis			•	•		•	•	•	•	•		•	•	•	•	•
WATERBIRDS																
Oxyura australis																
Biziura lobata																
Cygnus atratus																
Tadorna tadornoides																
Anas gracilis																
Anas castanea																
Anas superciliosa					•	•										
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus																
Anhinga melanogaster																
Phalacrocorax carbo																
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos					•											
Ardea novaehollandiae				•			•									
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio																
Gallinula ventralis																
Fulica atra																
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193
LANDBIRDS																
Dromaius novaehollandiae						•						•			•	
Leipoa ocellata																

	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193
Coturnix novaezelandiae																
Coturnix ypsilophora					•		•									
Haliastur sphenurus					•			•			•					
Accipiter fasciatus					•	•		•				•				•
Accipter cirrhocephalus					•	•	•				•					
Aquila audax				•	•	•	•	•								
Circus approximans									•	•						
Falco berigora		•			•						•					
Falco peregrinus					•	•		•								
Turnix varia			•	•		•	•									
Phaps chalcoptera					•	•	•	•			•	•				
Phaps elegans						•										
Calyptorhynchus banksii		•				•	•	•			•	•		•		
Calyptorhynchus latirostris					x		•	x								
Calyptorhynchus baudinii		•	•	•	x	•		x			•	•			•	
Cacatua pastinator																
Glossopsitta porphyrocephala					•	•	•	•			•			•	•	
Platycercus zonarius	•		•	•	•	•	•	•			•	•		•	•	
Platycercus spurius	•	•	•	•	•	•		•			•	•			•	
Platycercus icterotis		•			•	•	•	•			•	•		•	•	
Cuculus pallidus					•											
Cacomantis flabelliformis		•	•		•	•	•	•			•	•		•	•	•
Chrysococcyx basalis					•	•		•			•					
Chrysococcyx lucidus					•	•	•	•				•		•	•	•
Ninox connivens																
Ninox novaeseelandiae						•	•				•	•		•	•	
Tyto novaehollandiae																
Tyto alba											•					
Podargus strigoides							•				•	•				
Eurostopodus argus																
Aegotheles cristatus						•					•	•		•		
Todiramphus sanctus					•			•			•	•				
Merops ornatus					•			•				•				
Atrichornis clamosus																
Climacteris rufa	•				•	•	•	•			•	•				
Malurus splendens	x	•	•	•	•	•	•	•			•		•		x	
Malurus elegans	x	•	•	•		•	•				•		•		x	
Stipiturus malachurus																
Pardalotus punctatus	•	•	•		•	•	•				•	•		•	•	
Pardalotus striatus					•	•	•	•			•	•		•	•	•
Sericornis frontalis	•	•	•	•	•	•	•	•			•		•	•	•	
Smicrornis brevirostris					•							•				
Gerygone fusca				•	•	•	•	•			•	•		•	•	•
Acanthiza apicalis	•	•	•	•	•	•	•	•			•		•	•	•	
Acanthiza inornata	•	•	•	•	•	•	•	•			•				•	
Acanthiza chrysorrhoa		•			•	•	•	•								
Lichmera indistincta					•	•	•	•			•		•			
Meliphaga ornata					•	•										
Melithreptus chloropsis		•	•	•	•	•	•	•			•	•		•	•	•
Phylidonyris novaehollandiae					•	•	•	•			•		•	•	•	•

TABLE 2 (continued)

	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193
Phylidonyris nigra					•											
Phylidonyris melanops					•		•									
Acanthorhynchus superciliosus	•	•	•	•	•	•	•	•			•	•				
Anthochaera chrysoptera					•	•		•			•		•		•	
Anthochaera carunculata	•	•	•		•	•	•	•			•				•	•
Petroica multicolor	•	•	•	•	•	•	•	•			•	•				
Petroica cucullata					•											
Eopsaltria australis	•	•	•	•	•	•	•	•			•					
Eopsaltria georgiana						•	•				•		•	•		
Pomatostomus superciliosus														•		
Daphoenositta chrysoptera	•	•	•	•	•	•	•				•	•		•	•	
Falcunculus frontatus					•	•	•									
Pachycephala pectoralis	•		•	•	•	•	•	•			•	•		•	•	•
Pachycephala rufiventris					•	•		•			•					
Colluricincla harmonica	•	•	•	•	•	•	•	•			•	•		•	•	
Myiagra inquieta					•	•	•									
Rhipidura fuliginosa	•	•	•	•	•	•	•	•			•	•		•	•	•
Coracina novaehollandiae	•				•	•	•	•			•	•			•	
Artamus cyanopterus	•	•	•	•	•	•	•	•				•		•		
Cracticus tibicen					•	•	•	•								
Strepera versicolor		•	•	•	•	•	•				•	•				
Corvus coronoides	•	•	•	•	•	•	•	•			•	•		•		
Stagonopleura oculata		•				•	•				•		•			
Dicaeum hirundinaceum																
Hirundo neoxena					•	•										
Hirundo nigricans		•	•	•	•	•	•	•			•	•			•	•
Acrocephalus stentoreus																
Megalurus gramineus									•	•						
Zosterops lateralis	•	•	•	•	•	•	•	•			•		•		•	

WATERBIRDS

Oxyura australis									•	•						
Biziura lobata									•	•						
Cygnus atratus									•	•						
Tadorna tadornoides							•		•	•						
Anas gracilis									•	•						
Anas castanea									•							
Anas superciliosa					•				•	•			•			
Anas rhynchotis									•							
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus									•							
Anhinga melanogaster									•	•						
Phalacrocorax carbo									•	•						
Phalacrocorax sulcirostris									•	•						
Phalacrocorax melanoleucos									•	•						

	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193
Ardea novaehollandiae					•				•	•			•			
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus									•	•						
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio									•	•						
Gallinula ventralis																
Fulica atra									•	•						
Himantopus himantopus									•							
Charadrius ruficapillus									•	•						
Charadrius melanops									•							
Erythrogonys cinctus																

	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209
LANDBIRDS																
Dromaius novaehollandiae																
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora																
Haliastur sphenurus																
Accipiter fasciatus							•									
Accipter cirrhocephalus																
Aquila audax																
Circus approximans																
Falco berigora																
Falco peregrinus																
Turnix varia																
Phaps chalcoptera			•													
Phaps elegans																
Calyptorhynchus banksii											•	•	•	•	•	•
Calyptorhynchus latirostris																
Calyptorhynchus baudinii	•	•	•				•				•			•		
Cacatua pastinator																
Glossopsitta porphyrocephala	•		•													
Platycercus zonarius			•				•				•		•	•	•	•
Platycercus spurius							•				•		•	•	•	•
Platycercus icterotis	•		•				•	•					•	•		•
Cuculus pallidus							•									
Cacomantis flabelliformis	•	•	•		•		•				•	•			•	
Chrysococcyx basalis								•		•						
Chrysococcyx l ucidus	•	•			•		•	•		•						
Ninox connivens																
Ninox novaeseelandiae	•	•	•												•	
Tyto novaehollandiae																

TABLE 2 (continued)

	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209
Tyto alba																
Podargus strigoides				•			•									
Eurostopodus argus																
Aegotheles cristatus																
Todiramphus sanctus													•			
Merops ornatus																
Atrichornis clamosus																
Climacteris rufa				•												•
Malurus splendens		x	x		•	x		x	x	x	•		•	•		
Malurus elegans		x	x		•	x		x	x	x			•			
Stipiturus malachurus																
Pardalotus punctatus	•	•	•							•			•	•	•	•
Pardalotus striatus	•		•										•	•	•	
Sericornis frontalis	•	•	•		•									•		
Smicrornis brevirostris											•	•	•	•		
Gerygone fusca	•	•	•			•					•		•	•		•
Acanthiza apicalis	•	•			•		•				•	•	•	•	•	•
Acanthiza inornata		•			•		•				•		•	•	•	•
Acanthiza chrysorrhoa														•		
Lichmera indistincta																
Meliphaga ornata																
Melithreptus chloropsis	•	•	•									•	•		•	•
Phylidonyris novaehollandiae	•	•	•	•		•	•	•		•				•		
Phylidonyris nigra																
Phylidonyris melanops																
Acanthorhynchus superciliosus		•		•	•	•	•	•		•	•	•	•	•	•	•
Anthochaera chrysoptera								•		•						
Anthochaera carunculata	•	•	•				•									•
Petroica multicolor							•			•	•	•		•	•	•
Petroica cucullata																
Eopsaltria australis															•	•
Eopsaltria georgiana											•			•		
Pomatostomus superciliosus			•													
Daphoenositta chrysoptera											•				•	•
Falcunculus frontatus	•		•													
Pachycephala pectoralis	•	•	•			•					•	•	•	•	•	•
Pachycephala rufiventris			•													•
Colluricincla harmonica	•	•	•								•	•				
Myiagra inquieta																
Rhipidura fuliginosa	•	•	•	•		•	•				•	•	•	•	•	•
Coracina novaehollandiae	•		•			•	•						•			
Artamus cyanopterus							•									
Cracticus tibicen	•															
Strepera versicolor		•									•		•	•	•	•
Corvus coronoides	•	•	•				•				•	•	•	•	•	•
Stagonopleura oculata					•								•	•		
Dicaeum hirundinaceum																
Hirundo neoxena																
Hirundo nigricans																•

	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209
Acrocephalus stentoreus																
Megalurus gramineus							•									
Zosterops lateralis	•	•			•		•			•	•		•	•	•	•

WATERBIRDS

Oxyura australis																
Biziura lobata																
Cygnus atratus																
Tadorna tadornoides							•									
Anas gracilis																
Anas castanea																
Anas superciliosa							•									
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus																
Anhinga melanogaster																
Phalacrocorax carbo																
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos																
Ardea novaehollandiae																
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio																
Gallinula ventralis																
Fulica atra																
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225

LANDBIRDS

Dromaius novaehollandiae					•	•		•		•		•				
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora																
Haliastur sphenurus																
Accipiter fasciatus																

TABLE 2 (continued)

	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225
Accipter cirrhocephalus																
Aquila audax			•				•									
Circus approximans																
Falco berigora														•		
Falco peregrinus	•															
Turnix varia							•									
Phaps chalcoptera															•	
Phaps elegans					•										•	
Calyptorhynchus banksii		•				•	•		•		•		•	•		•
Calyptorhynchus latirostris																
Calyptorhynchus baudinii		•	•			•	•	•				•			•	•
Cacatua pastinator																
Glossopsitta porphyrocephala																
Platycercus zonarius	•	•	•	•	•	•	•	•	•	•	•	•		•		•
Platycercus spurius	•	•	•	•	•	•	•		•	•	•		•	•	•	•
Platycercus icterotis	•	•	•		•	•					•	•		•	•	
Cuculus pallidus																
Cacomantis flabelliformis														•		•
Chrysococcyx basalis																•
Chrysococcyx lucidus																
Ninox connivens																
Ninox novaeseelandiae														•		
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides																
Eurostopodus argus																
Aegotheles cristatus																
Todiramphus sanctus		•														
Merops ornatus							•									
Atrichornis clamosus																
Climacteris rufa	•		•													
Malurus splendens	•	•	•		•	•	•			•	•	•	•	•	•	•
Malurus elegans	•	•	•			•	•				•	•	•	•	•	•
Stipiturus malachurus																
Pardalotus punctatus	•	•	•	•		•	•		•	•	•	•		•	•	•
Pardalotus striatus		•	•	•	•	•	•	•	•	•	•	•				
Sericornis frontalis			•			•				•	•		•	•	•	•
Smicrornis brevirostris	•						•	•					•	•		•
Gerygone fusca	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Acanthiza apicalis	•	•	•		•	•	•		•	•	•	•	•	•	•	•
Acanthiza inornata	•	•	•	•	•	•	•		•	•		•	•	•		•
Acanthiza chrysorrhoa							•									
Lichmera indistincta	•	•				•					•			•	•	•
Meliphaga ornata																
Melithreptus chloropsis	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•
Phylidonyris novaehollandiae	•	•	•		•	•	•			•	•	•	•	•	•	•
Phylidonyris nigra																
Phylidonyris melanops																
Acanthorhynchus superciliosus	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•

	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225
Anthochaera chrysoptera	•	•			•		•									•
Anthochaera carunculata		•				•	•						•			
Petroica multicolor	•	•	•				•	•			•	•				•
Petroica cucullata																
Eopsaltria australis				•			•	•	•	•		•				•
Eopsaltria georgiana	•	•	•	•	•	•					•	•	•	•	•	
Pomatostomus superciliosus																
Daphoenositta chrysoptera		•	•	•			•	•						•		
Falcunculus frontatus																
Pachycephala pectoralis	•	•	•	•	•	•			•	•	•	•	•	•	•	•
Pachycephala rufiventris			•				•		•			•		•		•
Colluricincla harmonica					•				•		•			•	•	
Myiagra inquieta																
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Coracina novaehollandiae	•						•		•			•				
Artamus cyanopterus												•	•		•	
Cracticus tibicen							•	•				•				
Strepera versicolor		•	•	•	•		•	•	•	•	•	•	•	•		•
Corvus coronoides	•		•	•	•	•	•	•	•	•	•	•	•	•		•
Stagonopleura oculata	•	•			•							•	•			
Dicaeum hirundinaceum																
Hirundo neoxena																
Hirundo nigricans	•											•	•	•	•	•
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

WATERBIRDS

Oxyura australis
Biziura lobata
Cygnus atratus
Tadorna tadornoides
Anas gracilis
Anas castanea
Anas superciliosa
Anas rhynchotis
Aythya australis
Tachybaptus novaehollandiae
Poliocephalus poliocephalus
Anhinga melanogaster
Phalacrocorax carbo
Phalacrocorax sulcirostris
Phalacrocorax melanoleucos
Ardea novaehollandiae
Nycticorax caledonicus
Ixobrychus minutus
Ixobrychus flavicollis

TABLE 2 (continued)

	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio																
Gallinula ventralis																
Fulica atra																
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241
LANDBIRDS																
Dromaius novaehollandiae				•	•			•								
Haliastur sphenurus																
Accipiter fasciatus																
Accipter cirrhocephalus																
Aquila audax																
Circus approximans																
Falco peregrinus																
Falco berigora																
Leipoa ocellata																
Coturnix novaezelandiae							•									
Coturnix ypsilophora																
Turnix varia	•	•														
Phaps chalcoptera			•			•										
Phaps elegans																
Calyptorhynchus banksii	•			•			•	•	•				•	•		•
Calyptorhynchus latirostris																
Calyptorhynchus baudinii	•				•								•	•		•
Cacatua pastinator																
Glossopsitta porphyrocephala																
Platycercus zonarius	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Platycercus spurius		•			•	•	•	•	•	•	•	•	•	•		•
Platycercus icterotis										•					•	•
Cuculus pallidus																
Cacomantis flabelliformis	•	•							•			•			•	
Chrysococcyx basalis																
Chrysococcyx lucidus																
Ninox connivens																
Ninox novaeseelandiae																
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides			•					•								
Eurostopodus argus																

	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241
Aegotheles cristatus																
Todiramphus sanctus									•							•
Merops ornatus									•		•			•		
Atrichornis clamosus																
Climacteris rufa				•			•						•		•	•
Malurus splendens				•	•	•			•	•		•	•	•	•	•
Malurus elegans	•	•			•	•			•	•			•	•	•	•
Stipiturus malachurus																
Pardalotus punctatus		•	•	•	•	•	•	•				•	•	•	•	
Pardalotus striatus			•	•	•		•	•	•	•			•	•	•	•
Sericornis frontalis	•	•		•	•				•	•						•
Smicrornis brevirostris	•	•	•	•	•		•			•	•					
Gerygone fusca	•	•	•	•	•			•	•	•	•	•	•	•	•	•
Acanthiza apicalis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Acanthiza inornata	•	•	•	•	•				•	•	•					•
Acanthiza chrysorrhoa				•					•	•		•		•		
Lichmera indistincta		•			•				•	•		•		•	•	•
Meliphaga ornata																
Melithreptus chloropsis	•	•		•	•		•	•	•	•		•		•	•	•
Phylidonyris novaehollandiae		•		•	•	•			•				•	•	•	•
Phylidonyris nigra															•	
Phylidonyris melanops																
Acanthorhynchus superciliosus	•	•	•		•		•		•	•	•	•		•	•	
Anthochaera chrysoptera						•						•			•	•
Anthochaera carunculata				•	•				•	•		•		•	•	
Petroica multicolor	•	•	•	•	•		•	•	•	•	•	•	•	•	•	
Petroica cucullata																
Eopsaltria australis	•	•	•	•				•	•	•			•			•
Eopsaltria georgiana					•	•			•					•	•	•
Pomatostomus superciliosus																
Daphoenositta chrysoptera			•		•				•		•	•		•		
Falcunculus f rontatus																
Pachycephala pectoralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pachycephala rufiventris		•	•						•	•	•		•		•	•
Colluricincla harmonica		•	•					•	•					•		•
Myiagra inquieta																
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Coracina novaehollandiae		•	•					•	•			•		•		
Artamus cyanopterus						•										
Cracticus tibicen																
Strepera versicolor	•	•	•	•				•	•	•	•		•	•	•	•
Corvus coronoides		•	•	•	•	•	•	•			•	•	•			•
Stagonopleura oculata										•				•	•	•
Dicaeum hirundinaceum																
Hirundo neoxena																
Hirundo nigricans		•				•	•	•		•	•			•	•	
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis	•	•	•		•		•	•	•	•	•	•	•	•	•	•

TABLE 2 (continued)

	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241
WATERBIRDS																
Oxyura australis																
Biziura lobata																
Cygnus atratus																
Tadorna tadornoides																
Anas gracilis																
Anas castanea																
Anas superciliosa																
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus																
Anhinga melanogaster																
Phalacrocorax carbo																
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos																
Ardea novaehollandiae																
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio																
Gallinula ventralis																
Fulica atra																
Himantopus himantopus															•	
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257
LANDBIRDS																
Dromaius novaehollandiae			•	•	•	•						•				•
Leipoa ocellata																
Coturnix novaezelandiae																
Coturnix ypsilophora		•														
Haliastur sphenurus																
Accipiter fasciatus		•														
Accipter cirrhocephalus		•														
Aquila audax		•														
Circus approximans																
Falco berigora		•														
Falco peregrinus																
Turnix varia																

	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257
Phaps chalcoptera		•														
Phaps elegans														•		
Calyptorhynchus banksii	•	•	•													
Calyptorhynchus latirostris																
Calyptorhynchus baudinii		•	•	•							•					
Cacatua pastinator																
Glossopsitta porphyrocephala			•	•		•	•					•	•			
Platycercus zonarius	•	•	•	•			•	•		•	•	•	•	•	•	
Platycercus spurius	•	•														
Platycercus icterotis	•	•	•	•	•	•	•			•	•	•	•	•	•	•
Cuculus pallidus																
Cacomantis flabelliformis			•				•		•	•	•	•				
Chrysococcyx basalis		•														
Chrysococcyx lucidus		•														
Ninox connivens																
Ninox novaeseelandiae		•		•												
Tyto novaehollandiae																
Tyto alba																
Podargus strigoides		•		•	•	•					•				•	
Eurostopodus argus																
Aegotheles cristatus																
Todiramphus sancta	•	•														
Merops ornatus	•	•														
Atrichornis clamosus																
Climacteris rufa		•	•		•			•								
Malurus splendens	•	•														
Malurus elegans	•		•	•	•		•	•	•	•	•	•	•		•	
Stipiturus malachurus																
Pardalotus punctatus		•		•	•	•	•	•	•	•	•	•	•		•	•
Pardalotus striatus		•		•	•	•	•	•	•	•	•	•				•
Sericornis frontalis	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•
Smicrornis brevirostris		•														
Gerygone fusca	•	•	•	•	•	•					•	•				•
Acanthiza apicalis	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•
Acanthiza inornata	•	•														
Acanthiza chrysorrhoa		•														
Lichmera i ndistincta		•														
Meliphaga ornata		•														
Melithreptus chloropsis	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•
Phylidonyris novaehollandiae	•	•		•	•	•	•		•	•	•	•	•	•	•	•
Phylidonyris nigra																
Phylidonyris melanops																
Acanthorhynchus superciliosus	•	•		•												
Anthochaera chrysoptera		•	•						•			•	•		•	•
Anthochaera carunculata		•	•	•		•	•	•	•	•	•	•	•	•		
Petroica multicolor	•	•	•													
Petroica cucullata																
Eopsaltria australis	•	•														
Eopsaltria georgiana	•			•	•	•	•		•		•	•		•	•	•
Pomatostomus superciliosus			•				•		•	•	•			•		

TABLE 2 (continued)

	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257
Daphoenositta chrysoptera		•														
Falcunculus frontatus		•														
Pachycephala pectoralis	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•
Pachycephala rufiventris		•														
Colluricincla harmonica	•	•	•				•				•	•			•	•
Myiagra inquieta																
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•
Coracina novaehollandiae		•	•	•	•			•								
Artamus cyanopterus		•	•	•			•					•				
Cracticus tibicen	•	•														
Strepera versicolor	•	•										•				
Corvus coronoides	•	•		•												
Stagonopleura oculata												•				
Dicaeum hirundinaceum																
Hirundo neoxena		•														
Hirundo nigricans	•	•	•	•	•	•					•			•		
Acrocephalus stentoreus																
Megalurus gramineus																
Zosterops lateralis	•	•	•	•	•					•	•	•		•	•	•

WATERBIRDS

Oxyura australis																
Biziura lobata																
Cygnus atratus																
Tadorna tadornoides																
Anas gracilis																
Anas castanea																
Anas superciliosa	•	•														
Anas rhynchotis																
Aythya australis																
Tachybaptus novaehollandiae																
Poliocephalus poliocephalus																
Anhinga melanogaster																
Phalacrocorax carbo																
Phalacrocorax sulcirostris																
Phalacrocorax melanoleucos																
Ardea novaehollandiae		•														
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla																
Porzana fluminea																
Porzana tabuensis																
Porphyrio porphyrio																

	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257
Gallinula ventralis																
Fulica atra																
Himantopus himantopus																
Charadrius ruficapillus																
Charadrius melanops																
Erythrogonys cinctus																

	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
LANDBIRDS															
Dromaius novaehollandiae															
Leipoa ocellata															
Coturnix novaezelandiae		▪													
Coturnix ypsilophora			▪			▪	▪								
Haliastur sphenurus															
Accipiter fasciatus		▪	▪	▪		▪	▪							▪	
Accipter cirrhocephalus				▪											
Aquila audax		▪	▪							▪				▪	
Circus approximans															
Falco berigora			▪	▪			▪							▪	
Falco peregrinus		▪												▪	
Turnix varia		▪												▪	
Phaps chalcoptera		▪	▪								▪			▪	▪
Phaps elegans			▪			▪	▪								
Calyptorhynchus banksii		▪	▪				▪	▪						▪	▪
Calyptorhynchus latirostris		▪												▪	x
Calyptorhynchus baudinii		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	x
Cacatua pastinator															
Glossopsitta porphyrocephala		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	
Platycercus zonarius		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Platycercus spurius		▪	▪					▪						▪	▪
Platycercus icterotis		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Cuculus pallidus		▪	▪		▪	▪	▪	▪	▪					▪	
Cacomantis flabelliformis		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Chrysococcyx basalis			▪			▪	▪	▪							
Chrysococcyx lucidus		▪	▪	▪		▪	▪	▪			▪		▪	▪	
Ninox connivens		▪													
Ninox novaeseelandiae		▪												▪	
Tyto novaehollandiae							▪								
Tyto alba		▪	▪											▪	
Podargus strigoides		▪	▪									▪		▪	
Eurostopodus argus				▪											
Aegotheles cristatus		▪											▪	▪	
Todiramphus sanctus		▪	▪	▪		▪	▪							▪	
Merops ornatus		▪												▪	
Atrichornis clamosus															
Climacteris rufa		▪	▪	▪		▪	▪	▪	▪		▪	▪		▪	
Malurus splendens		▪	▪	▪	▪	▪	▪		▪	▪	▪	▪	▪	▪	▪
Malurus elegans	▪		▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪

TABLE 2 (continued)

	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
Stipiturus malachurus			•		•							•	•		
Pardalotus punctatus	•	•	•	•	•	•	•	•	•	•	•	•		•	•
Pardalotus striatus	•	•	•	•	•	•	•	•	•		•	•		•	•
Sericornis frontalis	•		•	•	•	•	•	•	•	•	•	•	•	•	•
Smicrornis brevirostris		•	•											•	
Gerygone fusca	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Acanthiza apicalis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Acanthiza inornata		•	•	•	•	•	•			•	•	•		•	•
Acanthiza chrysorrhoa		▪	•		•									•	•
Lichmera indistincta		▪	•		•	•								•	•
Meliphaga ornata		▪												•	
Melithreptus chloropsis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Phylidonyris novaehollandiae	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Phylidonyris nigra		•												•	
Phylidonyris melanops		•	•											•	
Acanthorhynchus superciliosus		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Anthochaera chrysoptera		•	•				•	•		•				•	
Anthochaera carunculata		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Petroica multicolor		•	•	•	•	•	•	•	•	•	•		•	•	•
Petroica cucullata															
Eopsaltria australis		•					•						•	•	•
Eopsaltria georgiana	•		•	•	•	•	•	•	•	•	•	•	•	•	•
Pomatostomus superciliosus			•	•		•	•	•	•			•			
Daphoenositta chrysoptera		•	•	•		•	•	•						•	•
Falcunculus frontatus						•	•	•							
Pachycephala pectoralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pachycephala rufiventris		•				•								•	•
Colluricincla harmonica	•	•	•	•	•	•	•	•	•	•	•		•	•	•
Myiagra inquieta			•	•		•	•	•							
Rhipidura fuliginosa	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Coracina novaehollandiae		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Artamus cyanopterus		•	•			•	•							•	•
Cracticus tibicen		•	•	•	•	•	•	•		•	•	•	•	•	•
Strepera versicolor		•	•	•	•	•	•	•	•	•	•	•	•	•	
Corvus coronoides		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Stagonopleura oculata			•	•		•	•	•	•	•	•			•	
Dicaeum hirundinaceum														•	
Hirundo neoxena		•										•		•	
Hirundo nigricans		•	•	•	•	•	•	•	•	•			•	•	•
Acrocephalus stentoreus															
Megalurus gramineus															
Zosterops lateralis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

	258	259	260	261	262	263	264	265	266	267	268	268	270	271	272
WATERBIRDS															
Oxyura australis															
Biziura lobata		•													
Cygnus atratus		•													
Tadorna tadornoides		•												•	
Anas gracilis		•													
Anas castanea															
Anas superciliosa		•												•	
Anas rhynchotis															
Aythya australis															
Tachybaptus novaehollandiae		•													•
Poliocephalus poliocephalus															
Anhinga melanogaster		•													
Phalacrocorax carbo		•													
Phalacrocorax sulcirostris		•													
Phalacrocorax melanoleucos		•												•	
Ardea novaehollandiae		•												•	
Nycticorax caledonicus		•													
Ixobrychus minutus															
Ixobrychus flavicollis															
Botaurus poiciloptilus															
Rallus pectoralis															
Porzana pusilla															
Porzana fluminea															
Porzana tabuensis		•													
Porphyrio porphyrio		•													
Gallinula ventralis															
Fulica atra		•													
Himantopus himantopus		•													
Charadrius ruficapillus															
Charadrius melanops		•													
Erythrogonys cinctus															

TABLE 3

Hypothetical core areas occupied by the Noisy scrub-bird in 1830, based on the occurrence of steep south-facing slopes†.

No.	LOCATION	APPROX SLOPE (°)	LENGTH (m)	ESTIMATED No. of PAIRS*	SUBSEQUENT TENURE
1	Brockman R (trib.)	13	1 000	10	Farmland
2	Brockman R (trib.)	13	1 000	10	Farmland
3	Brockman R (trib.)	15	3 200	32	Farmland
4	Spice Bk	7	1 100	11	Farmland
5	Brockman R (trib.)	9	650	6	Farmland
6	Brockman R	11	3 000	30	Farmland
7	Brockman R (trib.)	9	1 000	10	Farmland
8	Brockman R (trib.)	10	550	5	Farmland
9	Brockman R (trib.)	12	1 300	13	Farmland
10	Avon R	15–18	23 000 2 500	255	9 000 National Park; rest Farmland
11	Jimperding Bk	13	2 000	20	Farmland
12	Avon R	17	9 000	90	2000 National Park; rest Farmland
13	Wooroloo Bk	27•	750	7	Farmland
14	Wooroloo Bk	15•	1 750	17	Farmland
15	Swan R (trib.)	13–15	750	7	Farmland
16	Swan R (trib.)	17	250	2	Farmland
17	Helena R	6–18	11 000 12 500 5 000	285	11 000 Parklands; 12 500 State Forest; 5 000 State Forest
18	Whistlepipe Gully	16	250	2	Parklands
19	Lesmurdie Bk	20	500	5	National Park
20	Bickley Bk	10–13	2 250	22	1 000 Farmland; 1 250 Parklands
21	Canning R	11–13	11 500	115	5 500 Parklands; 6 000 Farmland
22	Wungong Bk (trib.)	24	1 000	10	Farmland
23	Wungong Bk	18	3 000	30	Farmland
24	Beenyup Bk	11	750	7	Farmland
25	Cardup Bk	17	1 000	10	Farmland
26	Manjedal Bk	20	750	7	Farmland
27	Gooralong Bk	11	1 250	12	National Park
28	Serpentine R	16	16 500	165	4 500 National Park; 12 000 State Forest
29	Dirk Bk	10	1 000	10	Farmland
30	Myara Bk	20	1 000	10	Farmland
31	N Dandalup R (trib.)	10	250	2	Farmland
32	Goomaljerup Ck	9	1 000	10	Farmland
33	N Dandalup R	16	1 250	12	State Forest
34	Conjurunup Ck	11	500	5	Farmland
35	S Dandalup R	17	2 500	25	2 250 Farmland; 250 State Forest
36	Oakley Bk	9	500	5	250 Farmland; 250 State Forest
37	Oakley Bk (trib.)	16	500	5	Farmland
38	Marrinup Bk	6	1 250	12	Farmland
39	Murray R (trib.)	11	1 000	10	Farmland
40	Murray R	22	14 000	140	5 500 Farmland; 3 000 State Forest; 750 Farmland; 2 500 Farmland; 2 250 State Forest
41	Murray R	102	500	25	State Forest

No.	LOCATION	APPROX SLOPE (°)	LENGTH (m)	ESTIMATED No. of PAIRS*	SUBSEQUENT TENURE
42	Nanga Bk	10	2 250	22	State Forest
43	Drakes Bk	14	4 750	47	Farmland
44	Samson Bk	9–10	3 750	37	3 500 Farmland; 250 State Forest
45	McKnoe Bk	18–201	750	17	Farmland
46	Yalup Bk	8	1 000	10	Farmland
47	Bancell Bk	9–11	1 250	12	Farmland
48	Bancell Bk (trib.)	11	1 500	15	Farmland
49	Clarke Bk	10	1 000	10	Farmland
50	Harvey R	22	5 000	50	2 000 Farmland; 3 000 State Forest
51	Collie R (trib.)	22	500	5	Farmland
52	Collie R (trib.)	14	500	5	Farmland
53	Collie R	13	1 250	12	Farmland
54	Collie R	22	12 250	122	4 250 Farmland; 6 000 State Forest; 2 000 Farmland
55	Collie R	6	4 000	40	Farmland
56	Near Cape Clairault	8	1 000	10	National Park
57	Ellen Bk	11	750	7	Farmland
58	Margaret R	11	750	7	National Park
59	Boodjidup Bk	13	750	7	National Park
60	Boranup	5	2 500	25	National Park
61	Near Augusta	5–7	2 500	25	1 500 National Park; 1 000 Farmland
62	Blackwood R	13	4 000	40	Farmland
63	Blackwood R	13	1 750	17	Farmland
64	Blackwood R	15	4 000	40	Farmland
65	Blackwood R	16	2 000	20	Farmland
66	Blackwood R	16	4 000	40	Farmland
67	Blackwood R	14	3 000	30	Farmland
68	Donnelly R	8	5 000	50	State Forest
69	Donnelly R	9	7 000	70	State Forest
70	Warren R	11	2 000	20	State Forest and Farmland
71	Warren R	18	1 750	17	State Forest
72	Mt Chudalup	8	1 000	10	National Park
73	Deep R (trib.)	16	2 000	20	State Forest
74	Mitchell forest block	7	3 000	30	State Forest
75	Frankland forest block	11	5 000	50	State Forest
76	Soho forest block	16	1 250	12	State Forest
77	Soho forest block	13	3 750	37	State Forest
78	Keystone forest block	18	1 500	15	State Forest
79	Keystone forest block	6	1 500	15	State Forest
80	Deep R	9	5 250	52	National Park
81	Giants forest block	6	3 000	30	State Forest
82	Mt Lindsay	9	4 000	40	State Forest
83	Happy Valley Rd	6	1 750	17	Farmland
84	Loc.2090	10	750	7	Farmland
85	Scotsdale	8	1 750	17	750 State Forest;1 000 Farmland
86	Mt Shadforth	8	2 000	20	1 000 Parklands;1 000 Farmland
87	Mt Hallowell	9	3 000	30	Parklands
88	Tennessee	9	1 200	12	Farmland
89	South Downs	11	700	7	Farmland
90	Near Lake William	11	1 700	17	National Park
91	North of Tennessee	10	1 750	17	Farmland

TABLE 3 (continued)

No.	LOCATION	APPROX SLOPE (°)	LENGTH (m)	ESTIMATED No. of PAIRS*	SUBSEQUENT TENURE
92	Wilgie Hill	8	1 500	15	Farmland
93	Mt Barker	5	1 500	15	Farmland and Parklands
94	St Werburgh	5	1 000	10	Farmland
95	Mt Barrow	11	1 250	12	Farmland
96	Porongurup Range	22	10 500	105	National Park
97	Willyung Hill	11	700	7	Farmland
98	Mt Clarence	14	600	6	Parklands
99	Peak Head	9	1 300	13	National Park
100	Mt Martin	11	1 400	14	National Park
101	Mt Taylor	8	3 000	30	National Park
102	Mt Mason	8	2 300	23	Farmland
103	Mt Gardner	20	5 000	50	National Park
104	Mt Manypeaks	10	7 500	75	National Park
105	Near Waychinicup R	14	3 000	30	National Park
106	Warriup Hill	8	4 500	45	Farmland

* Given that the core area of the home range of this species averages 1.25 ha (Smith 1985a), I have converted the length of the hypothetical distribution to number of pairs as follows: each 100 m of habitat length is assumed to support at least another 125 m upslope of suitable habitat, giving 1.25 ha. The habitat length divided by 100 therefore gives the population size in pairs.

† Some slopes between Capes Naturaliste and Leeuwin face east, and support karri forest. These have been included here.

TABLE 4
Species not considered to have been part of the original forest avifauna (with occurrence indicated).
*Species not native to Western Australia

SPECIES	REASON	LIST/REFERENCES
LANDBIRDS		
Pandion haliaetus	Breeding occasionally in forest but feeding in coastal waters	81, 263
Elanus caeruleus	No habitat (now vagrant)	22, 29, 31, 38–9, 47, 61, 84, Brown & Brown (1976-91)
Hamirostra isura	Vagrant	31, 33, 47–8, 51, 107, 182-3, 235, 259, 263, Serventy (1948); WABN **29**, p. 11; **33**, p. 9; **37**, p. 7; **41**, p. 2; **42**, p. 2; **51**, p. 2; **53**, p. 2; **61**, p. 3; **72**, p. 2.
Hamirostra melanosternon	Misidentification	31
Milvus migrans	Vagrant	WABN **26**, p. 10
Aquila morphnoides	Self-introduced (now breeding)	2, 10, 20–1, 23, 26–7, 31, 33, 38–9, 47, 66–7, 71, 75, 79, 80, 115, 117, 122–4, 169, 182, 185, 188–9, 234, 239, 259–60, 269, Serventy (1948), Dell (1971), Brown & Brown (1976–91)
Haliaeetus leucogaster	Breeding occasionally in forest but feeding in coastal waters	4, 6, 8, 11, 74, 81, 167
Circus assimilis	Vagrant	2, 73, Serventy (1952)
Falco cenchroides	No habitat (now vagrant)	11, 17, 29, 31, 33, 46–7, 73–7, 79, 83–5, 157, 165, 168, 179, 260, 263–4
Falco longipennis	Self-introduced (now non-breeding visitor)	2, 11, 20–2, 24, 27, 31, 33, 39, 41, 66, 73–5, 77, 157, 165, 184, 259–60; WABN **61**, p. 31; **78**, p. 22; **80**, p. 21
Otis australis	Vagrant	Serventy & Whittell (1976), Talbot (pers. comm.)
Burhinus grallarius	No habitat (now vagrant)	8, 11–12, 17, 21–2, 39
**Columba livia*	Self-introduced	31–3, Long (1988)
**Streptopelia senegalensis*	Self-introduced	20–1, 31, 40, Serventy (1948), Sedgwick (1958)
**Streptopelia chinensis*	Self-introduced	20–1, 176, Serventy (1948), Sedgwick (1958, 1965), Storr (1991)
Ocyphaps lophotes	Self-introduced (now vagrant)	22, 184
Geopelia cuneata	Vagrant	21
Cacatua roseicapilla	Self-introduced (now vagrant)	22, 33, 39, 169, 171–4, 176, 259, Storr (1991)
Cacatua sanguinea	Self-introduced (now vagrant)	22
Cacatua galerita	Self-introduced (now vagrant)	Storr (1991)

TABLE 4 (continued)

SPECIES	REASON	LIST/REFERENCES
Nymphicus hollandicus	Vagrant	17; WABN **37**, p. 8
Polytelis anthopeplus	No habitat. Self-introduced (now vagrant)	1, 17, 21–2, 27, 39, Serventy (1948)
Platycercus elegans	Vagrant	271
Neophema elegans	No habitat. Self-introduced (now vagrant)	1, 3, 4, 17, 21–2, 26–7, 31, 33, 38–9, 41–2, 46–7, 49, 73–5, 83, 130, 156, 160, 165, 167–8, 173, 182–3, 259, 272, Foley (1928), Serventy (1948), Dell (1964)
Melopsittacus undulatus	Vagrant	21–2, 182
**Dacelo novaeguineae*	Both introduced and self-introduced	11–12, 16–27, 31–3, 38–9, 41–6, 48, 51, 53, 56, 58, 61, 64–7, 71–86, 88, 90, 95–9, 101–2, 105–7, 110, 113–6, 119, 122–3, 125–6, 128, 154–5, 157, 165–7, 169–174, 176, 179–180, 182–5, 188–9, 191–7, 200–1, 204–7, 209–16, 218–9, 221, 224–5, 227–8, 230–1, 233–5, 237–8, 240–3, 259–72
Malurus leucopterus	Vagrant	Little (1990)
Certhionyx niger	Vagrant	21
Meliphaga virescens	No habitat. Vagrant	12, 17, 19–22, 31, 33, 38–9, 46, 61, 95, 101, 182, 213, 234, 239, 243, 259, Biddiscombe (1985), Brown & (1976–91)
Brown		
Melithreptus brevirostris	Vagrant (Some misidentification)	20–1, 27, 38–9, 56, 61, 182, 243, 259
Phylidonyris albifrons	Vagrant	WABN **74**, p. 5
Manorina flavigula	?Misidentification/vagrant	12, 73
Epthianura albifrons	Vagrant	3, 8–9, 11, 17, 20–22, 31–33, 39, 46, 108, 126, 157, 165, 167–8, 265, Biddiscombe (1985)
Epthianura tricolor	Vagrant	Milhinch (1983a)
Microeca fascinans	Misidentification; vagrant	13, 16, 243, Storr (1991)
Petroica goodenovii	Vagrant	1, 8, 17, 21–2, 31, 33, 40–1, 77, 111, 170, 182, 243, 259, Serventy (1948), McEvey & Middleton (1968)
Oreoica gutturalis	Misidentification	26
Rhipidura leucophrys	No habitat	3, 7, 16, 17, 22, 27, 31–33, 39, 41–2, 46–7, 61, 72–7, 83, 157, 165, 167, 182–5, 243, 259, 264
Grallina cyanoleuca	No habitat/vagrant	2, 3, 11, 17, 20–2, 24, 26, 29, 31–3, 41, 47, 73–7, 83–4, 157, 165, 167–8, 182–4, 243, 259–62, Serventy (1948), Storr (1954)
Pteropodocys maximus	Vagrant	17, 171

SPECIES	REASON	LIST/REFERENCES
Lalage tricolor	Vagrant	3, 4, 17, 22, 27, 31, 38–9, 41, 60–1, 75, 121, 157–8, 165, 182, 185, 237, 259–60, Biddiscombe (1985)
Artamus personatus	Vagrant	21, Serventy (1948), Milhinch (1983b)
Artamus cinereus	Vagrant (some misidentification)	40, 47, 61, 165, 234, 243, Slater (1962)
Cracticus torquatus	No habitat/vagrant	3–5, 11–12, 14–5, 20–2, 24, 29, 31, 33, 38–9, 46–7, 73, 157, 159, 165, 167–8, 170–4, 176, 182, 243, 259, 272
Cracticus nigrogularis	Vagrant	61, Serventy (1948)
Corvus bennetti	Vagrant	31–2, 38-9
Anthus novaeseelandiae	Vagrant	3, 8, 10–12, 15, 17, 21, 25–6, 29, 31, 33, 46–7, 68, 72–7, 79–85, 108, 126, 157, 168, 243–5, 260, Serventy (1948)
Taenopygia guttata	Vagrant	11
Neochmia temporalis	Introduced	Dell (1964), WABN **45**, p. 3
Cheramoeca leucosterna	Vagrant	Dell (1980), Storr (1991)
Hirundo ariel	Vagrant (occasional breeding)	10–12, 31, 33, 182, 192, 200, 202
Cincloramphus mathewsi	No habitat (vagrant)	40–1, 168, 182
Cincloramphus cruralis	No habitat (vagrant	WABN **71**, p. 2
WATERBIRDS		
Stictonetta naevosa	Visitor	72
Cygnus olor	Introduced and vagrant	Storr (1991)
Nettapus pulchellus	Vagrant	11
Chenonetta jubata	Irregular visitor (now breeding)	2, 4, 11, 17, 22, 24–6, 30–4, 39–41, 62–3, 75, 77, 79, 84–5, 108–9, 132–4, 136, 138, 141, 143, 157, 165, 168, 182, 200, 243, 259, 272, Dames & Moore (1978)
Malacorhynchus membranaceus	Irregular visitor (now breeding)	11, 31, 34, 132, 134, 136, 139, 141, Serventy (1952)
Podiceps cristatus	Self-introduced	11, 34, 132–4, 136, 139, 141, 186, 259, WABN **82**, p. 16
Phalacrocorax varius	Vagrant (marine species)	10, 76, 81, 133
Pelecanus conspicillatus	Visitor (non-breeding)	81, 84, 132–4, 136, 139, 141, 186–7
Ardea pacifica	Visitor (occasional breeding)	4, 17, 21, 30–1, 34, 40, 75, 79, 80–1, 83–4, 133, 135, 139, 141, 167–8
Ardea alba	Originally irregular visitor (still non-breeding)	26, 73, 133–6, 139, 141, 152, 186–7, 259
Ardea ibis	Vagrant	132, 141, Jenkins & Ford (1960)

TABLE 4 (continued)

SPECIES	REASON	LIST/REFERENCES
Threskiornis aethiopicus	Self-introduced	34, 72, 132–3, 141, 186
Threskiornis spinicollis	Self-introduced	11, 21, 31–2, 34, 40, 72, 75–7, 132–4, 141, 167, 186, 259, Serventy (1948, 1952), WA Bird Report 1982, 12
Plataleia regia	Self-introduced	166
Plataleia flavipes	Self-introduced	132–4, 136, 141, 152, 186–7, 259, WABN **82**, p. 16
Gallirallus philippensis	Visitor (one breeding report)	132, Brown & Brown (1976–91)
Gallinula tenebrosa	Self-introduced	11, 17, 30–2, 34, 40, 77, 132, 140–1
Cladorhynchus leucocephalus	Visitor	63, 132, 139, 141, 151, 186
Recurvirostra novaehollandiae	Non-breeding visitor	3, 132, 138–9, 187
Vanellus tricolor	No habitat; self-introduced	11, 17, 22, 31, 33, 73, 75, Serventy (1948)
Charadrius rubricollis	Visitor	WABN **77**, p. 13; **79** suppl., p. 14; **81**, p. 3
Larus novaehollandiae	Visitor (marine species); occasional breeding	8, 11, 73, 76, 81, 132-3, 136, 138–9, 141, 186–7, 259
Sterna bergii	Visitor (marine species)	11, 76, 81
Sterna hybrida	Visitor	133, 134, 186, Brown & Brown (1987–8)

WABN = Western Australian Bird Notes

TABLE 5
Occurrence of species within the primaeval forests of south-west Western Australia.

DISTRIBUTION PATTERN	LANDBIRDS	WATERBIRDS	ALL SPECIES
Throughout	42	11	53
Northern forests only	0	0	0
Southern forests only	7	6	13
Eastern forests only	20	12	32
Western sector in northern forests & southern forests	5	0	5
Eastern sector in northern forests & southern forests	3	0	3
Uncertain/ Very disjunct	4	2	6

TABLE 6

Extent of breeding geographical range of bird species present in the primaeval forests of Western Australia outside of the forests in Western Australia, elsewhere in Australia, New Guinea, Africa, mainland Eurasia, and the Americas.

W, N, E and S refer to the occurrence of species to the west, north, east or south of the primaeval forests of south-west Western Australia. Occurrence elsewhere in Australia is coded South Australia (SA), Northern Territory (NT), Victoria (Vic), Tasmania (Tas), New South Wales (NSW) and Queensland (Qld). Occurrence in New Guinea, Africa, mainland Eurasia or the American continent is indicated under columns headed NG, AF, EU and AM. Biogeographic element is coded as B (Bassian), E (Eyrean) or T (Torresian)

SPECIES	OCCURRENCE OUTSIDE THE FORESTS													
	WESTERN AUSTRALIA													
	W	N	E	S	SA	NT	VIC	TAS	NSW	QLD	NG	AF	EU	AM
LANDBIRDS														
Dromaius novaehollandiae	•	•	•	•	•	•	•	•	•	•				
Leipoa ocellata (E)	•	•	•	•	•	•	•		•					
Coturnix novaezelandiae (B)	•	•	•	•	•		•	•	•	•				
C. ypsilophora			•	•	•	•	•	•	•	•	•			
Haliastur sphenurus	•	•	•		•	•	•	•	•	•	•			
Accipter fasciatus	•	•	•	•	•	•	•	•	•	•	•			
A. cirrhocephalus	•	•	•		•	•	•	•	•	•	•			
Aquila audax	•	•	•	•	•	•	•	•	•	•	•			
Circus approximans	•	•	•	•	•		•	•	•					
Falco berigora	•	•	•	•	•	•	•	•	•	•	•			
F. peregrinus	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Turnix varia (B)	•	•	•	•	•		•	•	•	•				
Phaps chalcoptera	•	•	•	•	•	•	•	•	•	•				
P. elegans (B)	•	•	•	•	•		•	•	•	•				
Calyptorhynchus banksii (T)	•	•	•	•	•	•	•		•	•				
C. latirostris (B)	•	•	•											
C. baudinii (B)														
Cacatua pastinator (B)	•	•	•	•										
Glossopsitta porphyrocephala (B)[1]		•	•		•		•		•					
Platycercus zonarius (E)	•	•	•	•	•	•	•		•	•				
P. spurius	•	•	•	•										
P. icterotis (B)	•	•	•	•										
Cuculus pallidus	•	•	•	•	•	•	•	•	•	•				
Cacomantis flabelliformis (B)	•	•	•	•	•		•	•	•	•	•			
Chrysococcyx basalis[2]	•	•	•		•	•	•	•	•	•				
C. lucidus (B)	•	•	•	•	•		•	•	•	•				
Ninox connivens	•		•	•	•	•	•		•	•	•			
N. novaeseelandiae	•	•	•	•	•	•	•	•	•	•	•			
Tyto novaehollandiae	•	•	•	•		•	•	•	•	•	•			
T. alba	•	•	•		•	•	•	•	•	•	•	•	•	•
Podargus strigoides	•	•	•	•	•	•	•	•	•	•				
Eurostopodus argus		•	•		•	•	•		•	•				
Aegotheles cristatus	•	•	•	•	•	•	•	•	•	•	•			
Todiramphus sanctus	•	•	•	•	•	•	•	•	•	•				
Merops ornatus[4]			•	•	•		•	•	•		•	•		
Artichornis clamosus (B)		•		•	•									
Climacteris rufa (E)[3]			•	•	•		•							
Malurus splendens (E)[3]			•	•	•	•	•	•	•		•	•		
M. elegans (B)			•		•	•								
Stipiturus malachurus (B)		•		•	•	•		•	•	•	•			
Pardalotus punctatus (B)		•	•	•	•	•		•	•	•	•			

SPECIES	OCCURRENCE OUTSIDE THE FORESTS													
	WESTERN AUSTRALIA													
	W	N	E	S	SA	NT	VIC	TAS	NSW	QLD	NG	AF	EU	AM
P. striatus (B)			•	•	•	•	•	•	•	•	•	•		
Sericornis frontalis (B)		•	•	•	•	•		•		•	•			
Smicrornis brevirostris (E)		•	•	•		•	•	•		•	•			
Gerygone fusca (E)[3,4]	•	•	•	•	•	•	•		•	•				
Acanthiza apicalis (E)[3]	•	•	•	•	•	•	•		•	•				
A. inornata (B)	•	•	•	•										
A. chrysorrhoa	•	•	•	•	•	•	•	•	•	•				
Lichmera indistincta (T)	•	•	•		•	•			•	•	•			
Meliphaga ornata (E)[3]	•	•	•		•		•		•					
Melithreptus chloropsis (B)	•	•	•	•										
Phylidonyris novaehollandiae (B)	•	•	•	•	•		•	•	•	•				
P. nigra (B)	•	•	•	•					•	•				
P. melanops (B)	•	•	•	•	•		•	•	•					
Acanthorhynchus superciliosus (B)	•	•	•	•										
Anthochaera chrysoptera (B)	•	•	•	•	•		•	•	•	•				
A. carunculata (B)	•	•	•		•		•		•	•				
Petroica multicolor (B)	•	•	•	•	•		•	•	•	•				
P. cucullata	•	•	•		•	•	•		•	•				
Eopsaltria australis (B)	•	•	•	•	•		•		•	•				
E. georgiana	•		•	•										
Pomatostomus superciliosus (E)[3]	•	•	•		•	•	•		•	•				
Daphoenositta chrysoptera	•	•	•	•	•	•	•		•	•	•			
Falcunculus frontatus[5]	•	•	•	•	•	•	•		•	•				
Pachycephala pectoralis (B)	•	•	•	•	•		•	•	•	•	•			
P. rufiventris	•	•	•		•	•	•		•	•	•			
Colluricincla harmonica (B)	•	•	•	•	•	•	•	•	•	•	•			
Myiagra inquieta[3]	•	•	•	•	•	•	•		•	•	•			
Rhipidura fuliginosa[3]	•	•	•	•	•	•	•	•	•	•				
Coracina novaehollandiae	•	•	•	•	•	•	•	•	•	•	•			
Artamus cyanopterus (B)[2]	•	•	•		•		•	•	•	•				
Cracticus tibicen	•	•	•	•	•	•	•	•	•	•	•			
Strepera versicolor (B)[1]	•	•	•	•	•	•	•	•	•					
Corvus coronoides[3,6]	•	•	•	•	•	•	•		•	•				
Stagonopleura oculata (B)	•		•	•										
Dicaeum hirundinaceum[4]	•	•	•		•	•	•		•	•				
Hirundo neoxena (B)	•	•	•	•	•		•	•	•	•				
H. nigricans[3]	•	•	•	•	•		•	•	•	•				
Acrocephalus stentoreus	•	•	•	•	•	•	•	•	•	•	•			
Megalurus gramineus[5]	•	•	•	•	•	•	•	•	•	•	•			
Zosterops lateralis (B)	•	•	•	•	•		•	•	•	•				
WATERBIRDS														
Oxyura australis (B)	•	•	•		•		•	•	•	•				
Biziura lobata (B)	•	•	•		•		•	•	•	•				
Cygnus atratus	•	•	•		•	•	•	•	•	•				
Tadorna tadornoides (B)	•	•	•		•		•	•	•	•				
Anas gracilis	•	•	•		•	•	•	•	•	•	•			
A. castanea (B)	•		•		•		•	•	•	•				

TABLE 6 (continued)

SPECIES	OCCURRENCE OUTSIDE THE FORESTS													
	WESTERN AUSTRALIA													
	W	N	E	S	SA	NT	VIC	TAS	NSW	QLD	NG	AF	EU	AM
A. superciliosa	•	•	•		•	•	•	•	•	•	•			
A. rhynchotis (B)	•		•	•		•		•	•	•	•			
Aythya australis	•		•	•		•	•	•	•	•	•	•		
Tachybaptus novaehollandiae	•		•	•		•	•	•	•	•	•	•		
Poliocephalus poliocephalus	•		•	•	•	•	•	•	•	•	•			
Anhinga melanogaster	•		•	•		•	•	•		•	•	•	•	•
Phalacrocorax carbo	•		•		•		•	•	•	•		•	•	•
P. sulcirostris	•		•	•		•	•	•	•	•	•	•		
P. melanoleucos	•		•	•		•	•	•	•	•	•	•		
Ardea novaehollandiae	•		•	•	•	•	•	•	•	•	•	•		
Nycticorax caledonicus	•		•	•		•	•	•	•	•	•	•		
Ixobrychus minutus	•		•	•	•	•	•	•		•	•	•	•	•
I. flavicollis (T)	•		•	•	•		•			•	•	•		•
Botaurus poiciloptilus (B)	•		•	•	•	•		•	•	•	•			
Rallus pectoralis (B)	•				•		•	•	•	•	•			
Porzana pusilla	•		•	•	•	•	•	•	•	•	•	•	•	•
P. fluminea (B)	•		•	•	•	•	•	•	•	•	•			
P. tabuensis (B)	•		•	•	•	•	•	•	•	•	•	•		
Porphyrio porphyrio	•		•	•	•	•	•	•	•	•	•	•	•	•
Gallinula ventralis (E)	•		•	•		•	•	•		•	•			
Fulica atra	•		•	•	•	•		•	•	•	•	•	•	•
Himantopus himantopus	•		•	•		•	•	•	•	•	•		•	•
Charadrius ruficapillus	•		•	•	•	•	•	•	•	•	•			
C. melanops (E)	•		•	•		•	•	•	•	•	•			
Erythrogonys cinctus (E)	•		•	•		•	•	•		•	•	•		

WA – Western Australia (Source: Storr 1991)
SA – South Australia (Condon 1969, Parker *et al.* 1979, 1985))
NT – Northern Territory (Storr 1977)
VIC – Victoria (Emison *et al.* 1987)
TAS – Tasmania (Thomas 1979, Sharland 1981, Green 1989b)
NSW – New South Wales (Blakers *et al.* 1984)
QLD – Queensland (Storr 1984)
NG – New Guinea (Beehler *et al.* 1986)
AF – Africa (generally Sibley and Monroe 1990)
EU – Eurasia (mainland) (generally Sibley and Monroe 1990)
AM – America (generally Sibley and Monroe 1990)

[1] Treated as Eyrean by Serventy and Whittell (1976)
[2] Treated as Eyrean by Schodde (1990)
[3] Treated as Bassian by Schodde (1990)
[4] Treated as Torresian by Schodde (1982, 1990)
[5] Treated as Bassian by Serventy and Whittell (1976)
[6] Treated as Bassian by Serventy (1953)

TABLE 7

Geographical pattern of breeding occurrence of original forest bird species outside of the forest in south-west Western Australia (W = West, N = North, E = East, S = South of forest). Based on information presented in Table 6.

PATTERN OF OCCURRENCE	LANDBIRD SPECIES	WATERBIRD SPECIES
W, N, E, S	55	11
W, N, E	16	17
W, E, S	6	
N, E	2	
W, E		2
E, S	1	
W		1
Not breeding outside forest	1	

TABLE 8

Occurrence of breeding bird species in the primaeval forests of south-east Australia, south-west Western Australia, Mount Lofty Ranges, and Tasmania.

Sequence of species follows Christidis and Boles (1994), and names follow Christidis and Boles (1994) and Johnstone (in press).

SPECIES	SE AUST	SW AUST	MLR	TAS
LANDBIRDS				
Dromaius novaehollandiae	•	•	•	•
Alectura lathami	•			
Leipoa ocellata		•		
Coturnix pectoralis	•	•	•	•
Coturnix ypsilophora	•	•	•	•
Coturnix chinensis	•			
Aviceda subcristata	•			
Haliastur sphenurus	•	•	•	
Circus approximans	•	•	•	•
Accipiter fasciatus	•	•	•	•
Accipiter novaehollandiae	•			•
Accipter cirrhocephalus	•	•	•	•
Erythrotriorchis radiatus	•			
Aquila audax	•	•	•	•
Aquila morphnoides	•		•	
Falco berigora	•	•	•	•
Falco longipennis	•		•	
Falco peregrinus	•	•	•	•
Turnix varia	•	•	•	•
Columba leucomela	•			
Macropygia amboinensis	•			
Chalcophaps indica	•			
Phaps chalcoptera	•	•	•	•
Phaps elegans	•	•	•	•
Geopelia striata	•		•	
Leucosarcia melanoleuca	•			
Ptilinopus magnificus	•			
Ptilinopus regina	•			
Lopholaimus antarcticus	•			
Calyptorhynchus banksii		•		
Calyptorhynchus lathami	•			
Calyptorhynchus funereus	•		•	•
Calyptorhynchus latirostris		•		
Calyptorhynchus baudinii		•		
Callocephalon fimbriatum	•			
Cacatua pastinator		•		
Cacatua galerita	•		•	•
Trichoglossus haematodus	•		•	
Trichoglossus chlorolepidotus	•			
Glossopsitta concinna	•		•	•
Glossopsitta pusilla	•			
Glossopsitta porphyrocephala		•	•	
Alisterus scapularis	•			
Platycercus caledonicus				•
Platycercus elegans	•		•	

SPECIES	SE AUST	SW AUST	MLR	TAS
Platycercus eximius	•			•
Platycercus icterotis		•		
Platycercus zonarius		•		
Platycercus spurius		•		
Lathamus discolor				•
Pezoporus wallicus	•			
Neophema chrysogaster	•			
Cuculus pallidus	•	•	•	•
Cacomantis variolosus	•			
Cacomantis flabelliformis	•	•	•	•
Chrysococcyx basalis	•	•	•	•
Chrysococcyx lucidus	•	•	•	•
Eudynamys scolopacea	•			
Scythrops novaehollandiae	•			
Centropus phasianinus	•			
Ninox strenua	•			
Ninox connivens	•	•		
Ninox novaeseelandiae	•	•	•	•
Tyto tenebricosa	•			
Tyto novaehollandiae	•	•		•
Tyto alba	•	•	•	
Podargus strigoides	•	•	•	•
Eurostopodus mystacalis	•			
Eurostopodus argus		•	•	
Aegotheles cristatus	•	•	•	•
Alcedo azurea	•			•
Dacelo novaeguineae	•		•	
Todiramphus sanctus	•	•	•	
Merops ornatus	•	•	•	
Eurystomus orientalis	•			
Pitta versicolor	•			
Menura novaehollandiae	•			
Atrichornis rufescens	•			
Atrichornis clamosus		•		
Cormobates leucophaeus	•		•	
Climacteris erythrops	•			
Climacteris picumnus	•		•	
Climacteris rufa		•		
Malurus cyaneus	•		•	•
Malurus splendens		•		
Malurus lamberti	•			
Malurus elegans		•		
Malurus melanocephalus	•			
Stipiturus malachurus	•	•		
Pardalotus punctatus	•	•	•	•
Pardalotus quadragintus				•
Pardalotus striatus	•	•	•	•
Dasyornis brachypterus	•			
Pycnoptilus floccosus	•			
Origma solitaria	•			
Sericornis citreogularis	•			

TABLE 8 (continued)

SPECIES	SE AUST	SW AUST	MLR	TAS
Sericornis frontalis	•	•	•	
Sericornis humilis				•
Sericornis magnirostris	•			
Acanthornis magnus				•
Hylacola pyrrhopygia	•		•	
Chthonicola sagittata	•			
Smicrornis brevirostris	•	•	•	
Gerygone mouki	•			
Gerygone fusca		•		
Gerygone olivacea	•			
Acanthiza pusilla	•		•	•
Acanthiza apicalis		•		
Acanthiza ewingii				•
Acanthiza inornata		•		
Acanthiza reguloides	•		•	
Acanthiza chrysorrhoa	•	•	•	
Acanthiza nana	•		•	
Acanthiza lineata	•		•	
Anthochaera carunculata	•	•	•	
Anthochaera paradoxa				•
Anthochaera chrysoptera	•	•	•	•
Plectrorhyncha lanceolata	•			
Philemon corniculatus	•			
Philemon citreogularis	•			
Xanthomyza phrygia	•			
Entomyzon cyanotis	•			
Manorina melanophrys	•			
Manorina melanocephala	•		•	•
Meliphaga lewinii	•			
Meliphaga chrysops	•		•	
Meliphaga leucotis	•			
Meliphaga flavicollis				•
Meliphaga melanops	•			
Meliphaga ornata		•		
Meliphaga fusca	•			
Meliphaga penicillata	•		•	
Melithreptus gularis	•		•	
Melithreptus validirostris				•
Melithreptus brevirostris	•		•	
Melithreptus lunatus	•		•	
Melithreptus chloropsis		•		
Melithreptus affinis				•
Lichmera indistincta		•		
Phylidonyris pyrrhoptera	•		•	•
Phylidonyris novaehollandiae	•	•	•	•
Phylidonyris nigra	•	•		
Phylidonyris melanops	•	•	•	
Acanthorhynchus tenuirostris	•		•	•
Acanthorhynchus superciliosus		•		
Myzomela sanguinolenta	•			

SPECIES	SE AUST	SW AUST	MLR	TAS
Epthianura albifrons	•			
Microeca fascinans	•		•	
Petroica multicolor	•	•	•	•
Petroica phoenicea	•			•
Petroica rosea	•			
Petroica rodinogaster				•
Petroica cucullata		•	•	
Petroica vittata				•
Tregellasia capito	•			
Eopsaltria australis	•	•		
Eopsaltria georgiana		•		
Orthonyx temminckii	•			
Pomatostomus temporalis	•			
Pomatostomus superciliosus		•	•	
Psophodes olivaceus	•			
Cinclosoma punctatum	•		•	•
Daphoenositta chrysoptera	•	•	•	
Falcunculus frontatus	•	•	•	
Pachycephala olivacea	•			•
Pachycephala pectoralis	•	•	•	•
Pachycephala rufiventris	•	•	•	
Colluricincla harmonica	•	•	•	•
Monarcha melanopsis	•			
Monarcha trivirgatus	•			
Myiagra rubecula	•			
Myiagra cyanoleuca	•			•
Myiagra inquieta	•	•	•	
Rhipidura rufifrons	•			
Rhipidura fuliginosa	•	•	•	•
Dicrurus megarhynchus	•			
Coracina novaehollandiae	•	•	•	•
Coracina papuensis	•			
Coracina tenuirostris	•			
Lalage tricolor			•	
Oriolus sagittatus	•			
Sphecotheres viridis	•			
Artamus cyanopterus	•	•	•	•
Cracticus torquatus	•			•
Cracticus tibicen	•	•	•	•
Strepera graculina	•			
Strepera fuliginosa				•
Strepera versicolor	•	•	•	•
Ptiloris paradiseus	•			
Corvus coronoides	•	•		
Corvus tasmanicus	•			•
Corvus mellori	•		•	
Corcorax melanorhamphos	•		•	
Ailuroedus crassirostris	•			
Sericulus chrysocephalus	•			
Ptilonorhynchus violaceus	•			

TABLE 8 (continued)

SPECIES	SE AUST	SW AUST	MLR	TAS
Taeniopygia bichenovii	•			
Neochmia temporalis	•		•	
Stagonopleura guttata			•	
Stagonopleura bella	•		•	•
Stagonopleura oculata		•		
Lonchura castaneothorax	•			
Dicaeum hirundinaceum	•	•	•	
Cheramoeca leucosternus	•			
Hirundo neoxena	•	•	•	•
Hirundo nigricans	•	•	•	•
Hirundo ariel	•		•	
Acrocephalus stentoreus	•	•	•	•
Megalurus gramineus	•	•	•	•
Cisticola exilis	•		•	
Zosterops lateralis	•	•	•	•
Zoothera lunulata	•		•	•
TOTAL	172	81	90	69
WATERBIRDS				
Oxyura australis		•	•	
Biziura lobata	•	•		•
Cygnus atratus	•	•		•
Tadorna tadornoides		•		•
Chenonetta jubata			•	
Anas superciliosa	•	•	•	•
Anas rhynchotis	•	•		•
Anas gracilis	•	•	•	•
Anas castanea	•	•	•	•
Malacorhynchus membranaceus			•	
Aythya australis		•	•	
Tachybaptus novaehollandiae	•	•	•	•
Poliocephalus poliocephalus	•	•		•
Anhinga melanogaster		•		
Phalacrocorax melanoleucos	•	•	•	•
Phalacrocorax varius	•			
Phalacrocorax sulcirostris	•	•		•
Phalacrocorax carbo	•	•		•
Ardea novaehollandiae	•	•	•	•
Ardea pacifica	•			
Nycticorax caledonicus	•	•		
Ixobrychus minutus	•	•		
Ixobrychus flavicollis	•	•		
Botaurus poiciloptilus	•	•		•
Gallirallus philippensis	•			
Rallus pectoralis	•	•	•	•
Porzana pusilla	•	•		•
Porzana fluminea	•	•		•
Porzana tabuensis	•	•	•	•
Porphyrio porphyrio	•	•	•	•

SPECIES	SE AUST	SW AUST	MLR	TAS
Gallinula tenebrosa	•		•	
Gallinula ventralis		•	•	
Gallinula mortieri				•
Fulica atra	•	•	•	•
Rostratula benghalensis	•			
Irediparra gallinacea	•			
Himantopus himantopus	•	•		
Charadrius ruficapillus	•	•		•
Charadrius melanops	•	•	•	•
Erythrogonys cinctus	•	•	•	
Vanellus miles	•		•	
Sterna hybrida	•			
	34	31	19	23
GRAND TOTAL	206	112	109	92

TABLE 9

Foraging niche, nesting zone and nesting substrate of bird species present in the primaeval forests of Western Australia.

SPECIES	FORAGING HABIT	NESTING ZONE	NESTING SUBSTRATE
LANDBIRDS			
Dromaius novaehollandiae	Omnivore (ground)	Ground	
Leipoa ocellata	Omnivore (ground)	Ground (mound)	
Coturnix novaezelandiae	Seed eater, Insectivore (ground)	Ground	
Coturnix ypsilophora	Seed eater, Insectivore (ground)	Ground	
Haliastur sphenurus	Predator, Scavenger, Insectivore	Overstorey	
Accipiter fasciatus	Predator (birds), Insectivore	Overstorey	
Accipter cirrhocephalus	Predator (birds)	Overstorey	
Aquila audax	Predator, Scavenger (mammals)	Overstorey	
Circus approximans	Predator	Ground (swamp)	
Falco berigora	Predator, Insectivore	Overstorey	
Falco peregrinus	Predator (birds)	Rock ledge, Overstorey	Large hollow
Turnix varia	Seed eater, Insectivore (ground)	Ground	
Phaps chalcoptera	Seed eater, Insectivore (ground)	Midstorey	
Phaps elegans	Seed eater (ground)	Midstorey	
Calyptorhynchus banksii	Seed eater	Overstorey	Large hollow
Calyptorhynchus latirostris	Seed eater	Overstorey	Large hollow
Calyptorhynchus baudinii	Seed eater, insectivore	Overstorey	Large hollow
Cacatua pastinator	Seed, corm, bulb eater	Overstorey	Large hollow
Glossopsitta porphyrocephala	Eucalypt nectar feeder	Overstorey	Small hollow
Platycercus zonarius	Seed, fruit eater, cambial tissue	Overstorey	Medium hollow
Platycercus spurius	Seed, fruit eater	Overstorey	Medium hollow
Platycercus icterotis	Seed, fruit eater	Overstorey	Small hollow
Cuculus pallidus	Insectivore (ground pouncer)	Understorey	
Cacomantis flabelliformis	Insectivore (ground pouncer)	Understorey	
Chrysococcyx basalis	Insectivore (foliage)	Understorey	
Chrysococcyx lucidus	Insectivore (foliage)	Understorey	
Ninox connivens	Predator, Insectivore	Overstorey	Large hollow
Ninox novaeseelandiae	Predator, insectivore	Overstorey	Medium hollow
Tyto novaehollandiae	Predator, Insectivore	Overstorey	Large hollow
Tyto alba	Predator, Insectivore	Overstorey	Medium hollow
Podargus strigoides	Insectivore, Predator	Understorey	
Eurostopodus argus	Insectivore	Ground	
Aegotheles cristatus	Insectivore	Overstorey	Small hollow
Todiramphus sanctus	Insectivore, Predator (ground pouncer)	Overstorey	Small hollow
Merops ornatus	Insectivore (aerial)	Ground (burrow)	
Atrichornis clamosus	Insectivore (ground gleaner)	Understorey	
Climacteris rufa	Insectivore (trunk gleaner)	Overstorey	Small hollow
Malurus splendens	Insectivore (foliage gleaner)	Understorey	
Malurus elegans	Insectivore (foliage gleaner)	Understorey	
Stipiturus malachurus	Insectivore (foliage gleaner)	Understorey	
Pardalotus punctatus	Insectivore (foliage gleaner)	Ground (burrow)	
Pardalotus striatus	Insectivore (foliage gleaner)	Overstorey	Small hollow
Sericornis frontalis	Insectivore (foliage gleaner)	Understorey	
Smicrornis brevirostris	Insectivore (foliage gleaner)	Midstorey	
Gerygone fusca	Insectivore (foliage gleaner)	Midstorey	
Acanthiza apicalis	Insectivore (foliage gleaner)	Understorey	

SPECIES	FORAGING HABIT	NESTING ZONE	NESTING SUBSTRATE
Acanthiza inornata	Insectivore (foliage gleaner)	Understorey	
Acanthiza chrysorrhoa	Insectivore (ground gleaner)	Understorey	
Lichmera indistincta	Nectar feeder, Insectivore	Understorey	
Meliphaga ornata	Nectar feeder, Insectivore	Midstorey	
Melithreptus chloropsis	Insectivore (bark prober), Nectar feeder	Midstorey	
Phylidonyris novaehollandiae	Nectar feeder, Insectivore	Understorey	
Phylidonyris nigra	Nectar feeder, Insectivore	Understorey	
Phylidonyris melanops	Nectar feeder, Insectivore	Understorey	
Acanthorhynchus superciliosus	Nectar feeder, Insectivore	Understorey	
Anthochaera chrysoptera	Nectar feeder, Insectivore	Midstorey	
Anthochaera carunculata	Nectar feeder, Insectivore	Midstorey	
Petroica multicolor	Insectivore (ground and trunk pouncer)	Understorey	
Petroica cucullata	Insectivore (ground pouncer)	Understorey	
Eopsaltria australis	Insectivore (ground and trunk pouncer)	Understorey	
Eopsaltria georgiana	Insectivore (ground pouncer)	Understorey	
Pomatostomus superciliosus	Insectivore (foliage gleaner)	Midstorey	
Daphoenositta chrysoptera	Insectivore (bark gleaner)	Overstorey	
Falcunculus frontatus	Insectivore (bark prober and prizer)	Midstorey	
Pachycephala pectoralis	Insectivore (foliage snatcher)	Midstorey	
Pachycephala rufiventris	Insectivore (foliage snatcher)	Midstorey	
Colluricincla harmonica	Insectivore (bark gleaner)	Overstorey	
Myiagra inquieta	Insectivore (aerial)	Understorey	
Rhipidura fuliginosa	Insectivore (aerial)	Understorey	
Coracina novaehollandiae	Insectivore (foliage snatcher), Frugivore	Overstorey	
Artamus cyanopterus	Insectivore (aerial/ground)	Midstorey	
Cracticus tibicen	Insectivore (ground gleaner)	Overstorey	
Strepera versicolor	Omnivore	Midstorey	
Corvus coronoides	Omnivore	Overstorey	
Stagonopleura oculata	Seed eater	Midstorey	
Dicaeum hirundinaceum	Fruit eater and Insectivore (foliage gleaner)	Midstorey	
Hirundo neoxena	Insectivore (aerial)	Midstorey	
Hirundo nigricans	Insectivore (aerial)	Overstorey	Small hollow
Acrocephalus stentoreus	Insectivore (foliage)	Understorey (swamp)	
Megalurus gramineus	Insectivore (foliage)	Understorey (swamp)	
Zosterops lateralis	Omnivore	Understorey	
WATERBIRDS			
Oxyura australis	Herbivore, Insectivore (diver)	Understorey (swamp)	
Biziura lobata	Insectivore, Predator, Herbivore (diver)	Understorey (swamp)	
Cygnus atratus	Herbivore (grazer)	Understorey (swamp)	
Tadorna tadornoides	Herbivore, Insectivore (grazer)	Overstorey	Large hollow
Anas gracilis	Herbivore, Insectivore (dabbler)	Overstorey	Medium hollow
Anas castanea	Herbivore, Insectivore (grazer)	Understorey (swamp)	
Anas superciliosa	Herbivore, Insectivore (dabbler)	Overstorey, Understorey (swamp)	Large hollow
Anas rhynchotis	Insectivore, Herbivore (dabbler)	Understorey (swamp)	
Aythya australis	Herbivore, Insectivore (diver)	Understorey (swamp)	
Tachybaptus novaehollandiae	Predator, Insectivore (diver)	On water	
Poliocephalus poliocephalus	Insectivore, Predator (diver)	On water	
Anhinga melanogaster	Predator, Insectivore (diver)	Overstorey (swamp, river)	

TABLE 9 (continued)

SPECIES	FORAGING HABIT	NESTING ZONE	NESTING SUBSTRATE
Phalacrocorax carbo	Predator (diver)	Overstorey (swamp, river)	
Phalacrocorax sulcirostris	Predator (diver)	Overstorey (swamp, river)	
Phalacrocorax melanoleucos	Insectivore, Predator (diver)	Overstorey (swamp, river)	
Ardea novaehollandiae	Predator, Insectivore (ground)	Overstorey (swamp, river)	
Nycticorax caledonicus	Predator, Insectivore	Overstorey (swamp, river)	
Ixobrychus minutus	Insectivore, Predator	Understorey (swamp, river)	
Ixobrychus flavicollis	Predator, Insectivore	Overstorey (swamp, river)	
Botaurus poiciloptilus	Predator, Insectivore	Understorey (swamp, river)	
Rallus pectoralis	Insectivore, Predator	Understorey (swamp)	
Porzana pusilla	Insectivore, Seed eater	Understorey (swamp)	
Porzana fluminea	Insectivore, Seed eater	Understorey (swamp)	
Porzana tabuensis	Insectivore	Understorey (swamp)	
Porphyrio porphyrio	Herbivore, Insectivore	Understorey (swamp)	
Gallinula ventralis	Herbivore, Insectivore	Understorey (swamp)	
Fulica atra	Herbivore, Insectivore	Understorey (swamp)	
Himantopus himantopus	Insectivore, Seed eater	Ground (water's edge)	
Charadrius ruficapillus	Insectivore	Ground (water's edge)	
Charadrius melanops	Insectivore, Seed eater	Ground (water's edge)	
Erythrogonys cinctus	Insectivore, Seed eater	Ground (water's edge)	

*Considered broadly to include insects, crustacea and other invertebrate groups
Hollows are classified by entrance diameter: small (up to 50 mm); medium (50–100 mm); and large (>100 mm).

TABLE 10

Bird species present in the South West Land Division of Western Australia and which have changed in geographical range since European settlement (based on Storr 1991, this paper[1], Saunders and Ingram 1995[2] and Van Delft 1997[3]). * indicates species now vagrant/irregular non-breeding visitor.

SWAN COASTAL PLAIN	PRIMAEVAL FOREST	WHEATBELT	SOUTH COAST[4]
Species extinct			
16	2	7	2
Leipoa ocellata	*Rallus pectoralis*	*Pezoporus wallicus*	*Rallus pectoralis*
Rallus pectoralis[1]	*Atrichornis clamosus*	*Climacteris affinis*	*Dasyornis broadbenti*
*Otis australis**		*Amytornis textilis*	
Burhinus grallarius		*Psophodes nigrogularis*	
*Phaps elegans**		*Psophodes occidentalis*	
Cacatua pastinator		*Pachycephala inornata*	
Pezoporus wallicus		*Artamus cyanopterus**	
Ninox connivens			
*Climacteris rufa**			
Dasyornis longirostris			
*Melithreptus chloropsis**			
*Eopsaltria australis**			
Pomatostomus superciliosus			
Psophodes nigrogularis			
Falcunculus frontatus			
Stagonopleura oculata			
Species with contracted distribution			
17	4	36	7
Dromaius novaehollandiae	*Leipoa ocellata*[1]	*Dromaius novaehollandiae*	*Leipoa ocellata*
Ixobrychus flavicollis	*Calyptorhynchus banksii*	*Leipoa ocellata*[2]	*Platycercus icterotis*
Botaurus poiciloptilus	*Cacatua pastinator*[1]	*Ixobrychus flavicollis*	*Neophema petrophila*
Turnix varia	*Climacteris rufa*	*Botaurus poiciloptilus*[2]	*Pezoporus wallicus*
Phaps chalcoptera		*Hamirostra melanosternon*	*Atrichornis clamosus*
Calyptorhynchus banksii		*Porphyrio porphyrio*	*Psophodes nigrogularis*
Malurus splendens[3]		*Otis australis*[2]	*Dasyornis longirostris*
Malurus elegans		*Burhinus grallarius*[2]	
Meliphaga ornata		*Phaps elegans*	
Phylidonyris nigra		*Calyptorhynchus latirostris*	
Manorina flavigula		*Cacatua pastinator*	
Petroica multicolor[3]		*Cacatua leadbeateri*	
Petroica cucullata		*Glossopsitta porphyrocephala*[2]	
Pachycephala pectoralis		*Platycercus spurius*	
Colluricincla harmonica[3]		*Platycercus icterotis*	
Myiagra inquieta		*Neophema splendida*	
Strepera versicolor		*Climacteris rufa*	
		Malurus pulcherrimus	
		Malurus leucopterus	
		Sericornis frontalis	
		Aphelocephala leucopsis	
		Meliphaga plumula	
		Meliphaga ornata	

TABLE 10 (continued)

SWAN COASTAL PLAIN	PRIMAEVAL FOREST	WHEATBELT	SOUTH COAST[4]
		Meliphaga penicillata	
		Meliphaga cratitia	
		Melithreptus chloropsis	
		Petroica multicolor[2]	
		Petroica cucullata	
		Eopsaltria australis	
		Drymodes brunneopygius[2]	
		Cinclosoma castanotus	
		Falcunculus frontatus	
		Myiagra inquieta	
		Pteropodocys maximus[2]	
		Strepera versicolor	
		Dicaeum hirundinaceum[2]	

[4]The area from Cape Naturaliste to Hopetoun, between the coastline and the boundary of the primaeval forest or wheatbelt (see Fig. 1 and 19).

TABLE 11

Usage by species in the primaeval forest avifauna of disturbances caused by European settlement.

	FARMLAND AND TOWNS IN FOREST	RESERVOIRS AND FARM DAMS	PINE PLANTATIONS	ROADS, RAILWAYS AND CUTTINGS	CLEARFELLED KARRI FOREST 0–12 YRS	CLEARFELLED KARRI FOREST 51 YRS	THINNING – JARRAH FOREST	SELECTION CUTTING – JARRAH FOREST	CUTTING TO GAPS – JARRAH FOREST	PRESCRIBED BURNING – KARRI FOREST 0–6 YRS	PRESCRIBED BURNING – JARRAH FOREST 0–3 YRS	DIEBACK DISEASE (SEVERE)	REHABILITATED MINE SITE 0–5 YRS	RABBIT	RODENTS	SALINATION
LANDBIRDS																
Dromaius novaehollandiae	•		•	•				•		•	•		•			
Leipoa ocellata				•	•											
Coturnix novaezelandiae	•			•									•			
Coturnix ypsilophora	•				•											
Haliastur sphenurus	•	•	•					•					•	•		
Accipiter fasciatus	•		•		•	•								•		
Accipter cirrhocephalus	•		•		•					•	•	•	•			
Aquila audax	•		•					•			•		•			
Circus approximans		•												•		
Falco berigora	•		•						•					•		
Falco peregrinus	•															
Turnix varia									•				•			
Phaps chalcoptera	•		•	•	•					•	•		•			
Phaps elegans					•											
Calyptorhynchus banksii	•							•	•		•		•			
Calyptorhynchus latirostris	•		•													
Calyptorhynchus baudinii	•				•			•	•	•	•		•			
Cacatua pastinator	•															
Glossopsitta porphyrocephala	•				•	•		•		•						
Platycercus zonarius	•				•	•	•	•	•	•	•	•	•			
Platycercus spurius	•		•			•		•	•	•	•	•	•			
Platycercus icterotis	•		•	•	•	•		•	•	•	•	•	•			
Cucullus pallidus	•		•		•			•		•						
Cacomantis flabelliformis	•				•	•		•	•	•	•		•			
Chrysococcyx basalis	•															
Chrysococcyx lucidus	•		•		•	•		•		•	•		•			
Ninox connivens														•	•	
Ninox novaeseelandiae	•		•										•		•	
Tyto novaehollandiae				•										•	•	
Tyto alba	•		•	•											•	
Podargus strigoides	•		•								•		•			
Eurostopodus argus				•												
Aegotheles cristatus	•		•										•			
Todiramphus sanctus	•		•	•	•			•		•	•	•				
Merops ornatus	•		•	•							•	•	•			
Atrichornis clamosus																
Climacteris rufa	•			•		•	•	•		•	•					
Malurus splendens	•		•		•		•	•	•	•	•	•	•			
Malurus elegans	•	•	•		•	•	•	•	•	•	•		•			
Stipiturus malachurus	•				•											
Pardalotus punctatus	•			•	•	•	•	•	•	•	•		•			

TABLE 11 (continued)

	FARMLAND AND TOWNS IN FOREST	RESERVOIRS AND FARM DAMS	PINE PLANTATIONS	ROADS, RAILWAYS AND CUTTINGS	CLEARFELLED KARRI FOREST 0–12 YRS	CLEARFELLED KARRI FOREST 51 YRS	THINNING – JARRAH FOREST	SELECTION CUTTING – JARRAH FOREST	CUTTING TO GAPS – JARRAH FOREST	PRESCRIBED BURNING – KARRI FOREST 0–6 YRS	PRESCRIBED BURNING – JARRAH FOREST 0–3 YRS	DIEBACK DISEASE (SEVERE)	REHABILITATED MINE SITE 0–5 YRS	RABBIT	RODENTS	SALINATION
Pardalotus striatus	•				•	•		•		•	•	•	•			
Sericornis frontalis	•	•	•		•	•	•	•	•	•	•		•			
Smicrornis brevirostris	•											•	•			
Gerygone fusca	•		•		•	•		•		•	•	•	•			
Acanthiza apicalis	•		•		•	•	•	•	•	•	•	•	•			
Acanthiza inornata	•		•				•	•	•		•	•	•			
Acanthiza chrysorrhoa	•	•	•		•		•	•	•		•		•			
Lichmera indistincta	•		•		•			•		•	•		•			
Meliphaga ornata	•										•					
Melithreptus chloropsis	•				•	•		•	•	•	•	•	•			
Phylidonyris novaehollandiae	•	•	•		•	•		•		•	•		•			
Phylidonyris nigra	•												•			
Phylidonyris melanops	•				•						•					
Acanthorhynchus superciliosus	•		•		•		•	•	•	•	•					
Anthochaera chrysoptera	•				•	•		•		•	•		•			
Anthochaera carunculata	•		•		•	•	•	•	•	•			•			
Petroica multicolor	•		•		•	•	•	•	•	•	•	•	•			
Petroica cucullata											•					
Eopsaltria australis	•						•	•	•	•	•		•			
Eopsaltria georgiana	•				•	•		•		•	•		•			
Pomastomus superciliosus					•	•				•						
Daphoenositta chrysoptera	•						•	•	•		•					
Falcunculus frontatus	•					•				•						
Pachycephala pectoralis	•		•		•	•	•	•	•	•	•		•			
Pachycephala rufiventris	•		•													
Colluricincla harmonica	•		•		•	•	•	•	•	•	•		•			
Myiagra inquieta	•	•	•		•	•				•			•			
Rhipidura fuliginosa	•	•	•		•	•	•	•	•	•	•	•	•			
Coracina novaehollandiae	•		•		•	•	•	•		•	•		•			
Artamus cyanopterus	•		•		•	•	•	•	•	•	•	•	•			
Cracticus tibicen	•		•		•						•		•			
Strepera versicolor	•				•	•		•	•		•		•			
Corvus coronoides	•		•	•	•	•	•	•	•	•	•		•			
Stagonopleura oculata	•		•		•			•	•	•	•					
Dicaeum hirundinaceum	•															
Hirundo neoxena	•	•	•	•									•			
Hirundo nigricans	•	•	•	•	•			•	•	•	•	•	•			
Acrocephalus stentoreus		•														
Megalurus gramineus		•														
Zosterops lateralis	•		•		•	•	•	•	•	•	•	•	•			
	69	12	43	15	45	31	21	43	30	41	47	18	50	6	4	0

	FARMLAND AND TOWNS IN FOREST	RESERVOIRS AND FARM DAMS	PINE PLANTATIONS	ROADS, RAILWAYS AND CUTTINGS	CLEARFELLED KARRI FOREST 0–12 YRS	CLEARFELLED KARRI FOREST 51 YRS	THINNING – JARRAH FOREST	SELECTION CUTTING – JARRAH FOREST	CUTTING TO GAPS – JARRAH FOREST	PRESCRIBED BURNING – KARRI FOREST 0–6 YRS	PRESCRIBED BURNING – JARRAH FOREST 0–3 YRS	DIEBACK DISEASE (SEVERE)	REHABILITATED MINE SITE 0–5 YRS	RABBIT	RODENTS	SALINATION
WATERBIRDS																
Oxyura australis																•
Biziura lobata		•														•
Cygnus atratus		•														•
Tadorna tadornoides		•														•
Anas gracilis		•														•
Anas castanea		•														
Anas superciliosa		•														•
Anas rhynchotis																•
Aythya australis		•														•
Tachybaptus novaehollandiae		•														•
Poliocephalus poliocephalus		•														•
Anhinga melanogaster		•														•
Phalacrocorax carbo		•														•
Phalacrocorax sulcirostris		•														•
Phalacrocorax melanoleucos		•														•
Ardea novaehollandiae		•														•
Nycticorax caledonicus																
Ixobrychus minutus																
Ixobrychus flavicollis																
Botaurus poiciloptilus																
Rallus pectoralis																
Porzana pusilla		•														
Porzana fluminea																
Porzana tabuensis		•														
Porphyrio porphyrio		•														
Gallinula ventralis																•
Fulica atra		•														•
Himantopus himantopus																•
Charadrius ruficapillus																•
Charadrius melanops		•														•
Erythrogonys cinctus																•
	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	21

TABLE 11 (continued)

SOURCE:

Farmland and towns in forest
Lists 17, 20, 21, 22, 29; Masters & Milhinch 1974; Hall 1974; 41; Christensen *et al.* 1981; Nichols & Nichols 1984; Christensen *et al.* 1985; Worsley Alumina 1981, 1985; 243; Biddiscombe 1985; Cable Sands 1989; BHP–Utah Minerals Int. 1990; Brown & Brown 1986.
Reservoirs and farm dams
24, Dames & Moore 1978; Worsley Alumina 1981, 1985; Christensen *et al.* 1981.
Pine plantations
24; Christensen *et al.* 1981.
Roads, railways and cuttings
41, Christensen *et al.* 1985; Brown & Brown 1986.
Logging – clearfelled karri forest 0–12 yr old regrowth
68–70, 126
Logging – clearfelled karri forest 51 yr old regrowth
71
Thinning – jarrah forest
178
Selection logging – jarrah forest 0–6 yrs later
43–44, 128
Cutting to gaps – jarrah forest 0–3 yrs later
179, 180
Prescribed burning – karri forest 0–6 yrs later
Christensen & Kimber 1975; 64–67, Christensen *et al.* 1985; 154
Prescribed burning – jarrah forest 0–3 yrs later
23, 35–37, 52, 121, 131, 182
Dieback-affected jarrah forest (severe)
59, 124
Rehabilitated minesites 0–5 yrs later
Nichols & Watkins (1984); Wykes (1985); Curry & Nichols 1986.
Rabbits
See species commentaries
Rodents
See species commentaries
Salination
134, 136, 138, 139, 141

TABLE 12
Bird species with potential for use as indicators of ecologically sustainable utilization of forests.

SPECIES	TYPE OF FOREST	REASON
Calyptorhynchus banksii naso	All	Easily identified; requires large hollows in live trees for breeding; widespread
Climacteris rufa	Karri	Small home range; requires small hollows in live trees for breeding; now extinct on Swan Coastal Plain and nearly extinct in wheatbelt
Malurus elegans	Northern jarrah	Largely restricted to riparian habitat
Malurus splendens	Northern jarrah	Largely restricted to riparian habitat
Eopsaltria georgiana	Northern jarrah	Largely restricted to riparian habitat
Pomatostomus superciliosus	Karri	Colonial social organization; slow to recolonize regrowth stands
Pachycephala pectoralis	Jarrah	Numerical response to fire variable
Myiagra inquieta	Karri	Mobile species but slow to recolonize regrowth stands
Coracina novaehollandiae	Karri	Mobile species but slow to recolonize regrowth stands
Stagonopleura oculata	Northern jarrah	Breeding restricted to riparian habitat

NOTES ON AUTHOR

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