Chapter 1.

General Introduction

1.1 Introduction

The Regent Honeyeater *Xanthomyza phrygia* is an endangered Australian woodland bird whose recent population decline and contrac ion in range has attracted the attention and concern of ecologists and conservationists. Consequently, the Regent Honeyeater has become a "flagship" species for the conservation of the woodland avifauna of southern Australia, which is rapidly declining from the clearance, fragmentation and degradation of 85% of woodland and associated habitats (Garnett 1992, Robinson and Traill 1996, Lunney *et al.* 1997, Recher 1998). The birds most affected by such habitat changes have been ground and hollow-dwellers, although the continued loss of trees and shrubs will, ultimately, lead to further declines and regional extinctions of canopy foraging and nesting birds, like the Regent Honeyeater, and continue the rapid loss of biodiversity (Recher 1998). While there is no way to test the reasons for the historical decline of the Regent Honeyeater, research on its ecology will assist in drawing up recovery plans in order to arrest and reverse the continued decline

This study investigates the ecology and conservation of the Regent Honeyeater in northern New South Wales. The objective of this study is to provide information that should help to identify the factors that have led to its decline. Other studies on endangered Australian honeyeaters have focused on sedentary species, which have localised populations in specific habitats, and which require specific resources, such as the Helmeted Honeyeater *Lichenostomus melanops cassidix*, and the Black-eared Miner *Manorina mel motis* (Wykes 1985, Pearce *et al.* 1994, Franklin 1996). Clarke (1997) found that breeding studies of common Australian birds were also biased towards sedentary species, and found few breed ng studies (4.3%) on threatened species. Clarke suggested that the bias for studying common, sedentary, and communally-breeding birds is due to the relative ease with which researchers can obtain publishable data. It is much more difficult to collect high quality and replicated data on threatened species. This difficulty is exacerbated when the species' occurrence and numbers at a location are unpredictable. This study of the Regent Honeyeater, which is nomadic and widely-dispersed is unique among Australian ornithological research.

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1.2 Honeyeaters - a dominant component of Australia's avifauna

Regent Honeyeaters belong to the fam ly Meliphagidae, a diverse passerine group of about 184 species, which is confined to the Austrilo-Pacific region. In Australia, honeyeaters are found in every habitat from arid desert to tropical rainforests (Ford and Paton 1985). Their active and aggressive foraging behaviour, primari y in arboreal situations, makes them a conspicuous and dominant element of the Australian avifeuna.

There are 73 Australian honeyeater species, which range in size from 8 to 150 grams, and share the common feature of a decurved bill and a brush-tipped tongue (Paton and Collins 1989). These assist in the collection of nectar, which s one of the most important foods selected by honeyeaters (Pyke 1980). By visiting flowers for nectar, honeyeaters provide a pollination service to over one thousand Australian plant species (Paton 1986a). While most honeyeaters have been recorded visiting flowers for nectar (Paton 1986a), they often select other carbohydrates such as lerp (the protective carbohydrate cap produced by psyllid insects), honeydew (the sugary excreta from certain Homoptera), manna (a sugary exudate from damaged eucalypt leaf and bark tissue), and sap, as well as pollen, fruit and arthropods (Paton 1980, Pyke 1980).

Honeyeaters have been categorised into different groups on the basis of their morphology, foraging ecology, and movement patterns (Keast 1968, Pyke 1980, Ford and Paton 1985). However, many honeyeaters have generalised diets, and their movements are poorly understood. Perhaps the clearest distinction among honeyeaters is based on the length of their bill (Collins and Paton 1989). The short-billed species tend to eat insects and carbohydrates other than nectar. In contrast, long-billed honeyeaters appear to be dependent on nectar for most of the year. However, the distinction between these two honeyeater guilds is loose. with some species, particularly short-billed ones, showing spatio-temporal differences in diet. There is overlap in foraging behaviour and resource selection (e.g., foraging substrate, plant species, foraging height) among many species at any location (Paton 1980, Ford 1989, McFarland and Ford 1990). The ability of honeyeaters to use a broad range of habitats and foods is one reason for their successful adaptive radiation (Keast 1976).

The species richness and abundance of honeyeaters in Australia is highest in southeastern dry sclerophyll forests and heathlands (Ford and Paton 1985), where they often represent 80% or more of the individuals (Ford and Pursey 1982). The abundance and diversity of a honeyeater

community is largely determined by the abundance and diversity of carbohydrates (Paton 1986b). Honeyeater community structure is organised by the large aggressive species, such as wattlebirds (*Anthochaera* spp.) and friarbirds (*Philemon* spp.), which exclude smaller energetically efficient species from the richest sources of nectar (Ford 1979). The smaller species exploit poorer more scattered resources than the larger species, which have higher energy requirements. This division of resources will often mean that larger honeyeaters use different plant species and habitats to smaller species. The structure of nectarivorous honeyeater communities changes throughout the year in relation to flowering phenology. There is less known about the community organisation of short-billed honeyeaters, though it is also probably based on a partitioning of resources along a gradient of food density, with the large aggressive miners excluding smaller species from the richest sources of lerp and insects (Wykes 1985, Paton 1986b).

1.3 Honeyeater conservation

The Regent Honeyeater is one of three endangered Australian honeyeaters (Collar *et al.* 1994). A fourth species, the Painted Honeyeater *Grantiella picta*, is considered rare (Garnett 1992); all four species are small to medium-sized honeyeaters (20 to 50 g). Both the Regent and Painted Honeyeater belong to mono-specific genera, which are phylogenetically distinct from other Australian honeyeaters (Schodde and McKean 1976). The taxonomic distinctness of the Regent Honeyeater alone warrants its high conservation status (Menkhorst 1997).

Regent Honeyeaters, and many other honeyeater species, are arboreal in their foraging and nesting habits. Most arboreal birds have managed to survive better than ground and hollow-dwelling birds in degraded woodlands, but only where some canopy trees are retained (Garnett 1992, Recher 1998). However, the continued loss of trees in forests and woodlands in southern Australia will, ultimately, lead to local and regional extinctions of many small to medium-sized honeyeaters, particularly the Regent Honeyeater (Robinson 1991, 1993, Recher 1998). For example, the Black-chinned Honeyeater *Melithreptus gularis* is critically endangered in the Mount Lofty Ranges of South Australia (Chapman 1997), though still relatively common in northeastern Australia. The Yellow-plumed Honeyeater *Lichenostomus ornatus* has disappeared from some areas of the Western Australian wheatbelt (Saunders 1993), but is still common in other parts of its range. It is perhaps only due to the lack of monitoring and historical data, that population declines in other honeyeater species have not been detected.

1.4 The endangered Regent Honeyeater *Xanthomyza phrygia*

1.4.1 General description

The Regent Honeyeater is a medium-sized honeyeater, with apparent affinities to the Papuasian genus *Melidectes*, and particularly resembling *M. torquatus* (Schodde and McKean 1976). It was described in 1794 in the *Zoology of New Holland* by John William Lewin, where it was incorrectly included in the bee-eater genus *Merops* and named the "Embroidered Merops" (Longmore 1991). It was later given the unglamorous name of Warty-faced Honeyeater, on account of the warty protuberances around each eye. A final, and warranted, name change to Regent Honeyeater, referring to the regal black and yellow plumage of the species, appeared in the literature from the early 1920s (Campbell 1921, Edwards 1925).

Adult Regent Honeyeaters are boldly coloured, distinguished by an embroidered breast, elaborate black, white and yellow patterning on the back and wing coverts, and obvious yellow primary and tail feathers (Plate 1.1). Distinctive patches of warty skin, ranging in colour from yellow-white to dull pink (Franklin and Menkhorst 1988a), surround the eyes, and generally develop with maturity. There is no obvious sexual dimorphism of plumage, although males tend to have sharper and glossier black plumage, which extends further down from the head to the breast than females (pers. obs.). Adults weigh between 31 and 50 grams, have a body length of 225 mm (Longmore 1991), and a wing length of between 103 and 119 mm (Schodde *et al.* 1992, Ley *et al.* 1996). Sexual dimorphism of morphometric features (body mass, head-bill length, wing length and tail length) has been found in the species, with males significantly larger than females (Schodde *et al.* 1992, Ley *et al.* 1996), although with some overlap.

Juvenile Regent Honeyeaters are much duller than adults. Fledglings have a dull grey-black head, throat and back, a light grey breast with no scalloping, no distinctive bare skin patch around the eye, and a prominent yellow gape (Ley and Williams 1994). At five weeks of age, fledglings begin developing scalloping on the breast, and a small eye patch is noticeable on some birds.

1.4.2 Historical ecological information

General

The nomadic behaviour and poorly understood movements of the Regent Honeyeater has meant that little ecological information was collected on the species until the late 1980s (Franklin *et al.*

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Plate 1.1   Adult male Regent Honeyeater at Gwydir River, Torryburn, New South Wales (photograph by R. Shepherd).

1989, Ley 1990, Webster and Menkhorst 1992). Historical accounts describe how Regent Honeyeaters would arrive in flocks, presumably in response to local eucalypt flowering, on just one occasion, or after an absence of many years, and would then disappear within weeks, unless they were nesting (Franklin *et al.* 1989). After the nesting season, which ends in early summer in the southern extent of the range in Victoria, and late summer in New South Wales, Regent Honeyeaters quickly disappear from their breeding habitat. One of the great mysteries about the ecology of this species is where they move post-breeding, what types of habitats they use, and over what distances they move. Keast (1968) suggested that Regent Honeyeaters are eruptive and nomadic, their movements strongly linked with the phenological patterns of flowering eucalypts.

Habitats and diet

Franklin *et al.* (1989) analysed archival literature and questionnaire data concerning the distribution, habitat selection, diet, feeding niche, and movement patterns of Regent Honeyeaters. They concluded that the Regent Honeyeater occurred mainly in temperate mainland southeastern Australia, and primarily selected dry sclerophyll open forest and woodland on the inland slopes of the Great Dividing Range. They were only infrequently sighted in coastal areas and the sub-tropics, and rarely in semi-arid areas.

Casual observations of Regent Honeyeater foraging behaviour indicated that the species was nectarivorous, selecting a narrow range of *Eucalyptus* species. On the basis of historical records, woodland dominated by Mugga Ironbark *Eucalyptus sideroxylon* was regarded as prime Regent Honeyeater habitat. Mugga Ironbark produces high nectar yields (Goodman 1973), which adds strength to the hypothesis that it is important to nectarivorous birds such as Regent Honeyeaters. This has led to a bias for bird watchers only to search for Regent Honeyeaters in Mugga Ironbark habitat, and to ignore other plant communities.

Pyke (1980) reported that Regent Honeyeaters fed on nectar, insect and plant exudates, invertebrates, and fruit. However, the importance of these foods was not quantified. Webster and Menkhorst (1992) concluded that Regent Honeyeaters were dependent on the nectar of Mugga Ironbark and several other key eucalypts, although their observations were restricted to breeding birds in Mugga Ironbark woodland, and not other habitats. The range of habitats and foods used by the Regent Honeyeater is a significant information gap that needs to be redressed.

1.4.3 Historical distribution and population size

The historical geographic distribution of the Regent Honeyeater extended from southeastern Queensland to Adelaide, South Australia (Figure 1.1). The species was mostly confined to 300 kilometres from the coastline, and was concentrated on the inland slopes of the Great Dividing Range from southeastern Queensland to Victoria (Franklin *et al.* 1989). Regent Honeyeaters were once common in Adelaide, particularly in the Mount Lofty Ranges, and in the riparian River Red Gum *E. camaldulensis* habitat at Lockleys (RAOU 1901, Ashby 1917, Mellor 1919, Franklin and Menkhorst 1988b), which are now urban areas of metropolitan Adelaide. Although it has been postulated that Regent Honeyeaters 'migrated" between the woodlands of the Mount Lofty Ranges/Adelaide plains and western Victoria (Terrill and Rix 1950), the species has never been recorded in the intervening mallee/heath habitat of eastern South Australia or western Victoria. Regent Honeyeater sightings were reported in the *South Australian Ornithologist* in all but six years between 1914 and 1939 (Franklin and Menkhorst 1988b). Between 1950 and the last known record in 1977 (Joseph 1977), sightings of small numbers of birds were irregular. There have been questionable records for the species extending far beyond their usual range, including one by Sturt (1849) (cited in Smith and Smith 1994) in *Banksia* heathland on the sandhills of the lower Darling River, one in Mackay, Queensland (Franklin *et al.* 1989), and two records from Kangaroo Island in South Australia (Sutton 1926, Wheeler 1960) (Figure 1.1).

There are no reliable estimates of the former Regent Honeyeater population size; only a few historical reports of flocks in the hundreds, or thousands (Ramsay 1866, White 1909), which sometimes visited fruit orchards, where they were destroyed as pests (Longmore 1991, Ford 1993). This suggests that the species was more abundant than at present, but probably never common. Historical sightings of large flocks were likely to be brief population explosions, or large concentrations in small areas.

1.4.4 Current distribution and population size

Peters (1979) was the first to report the decline of the Regent Honeyeater throughout its known range. He compared records from four periods (pre-1901; 1901-1950; 1951-1976 and 1977-1979) taken from *The Atlas of Australian Birds*, and found that the frequency of sightings had decreased in most 1° survey blocks since the 1951-1976 period, and that since then the species was no longer
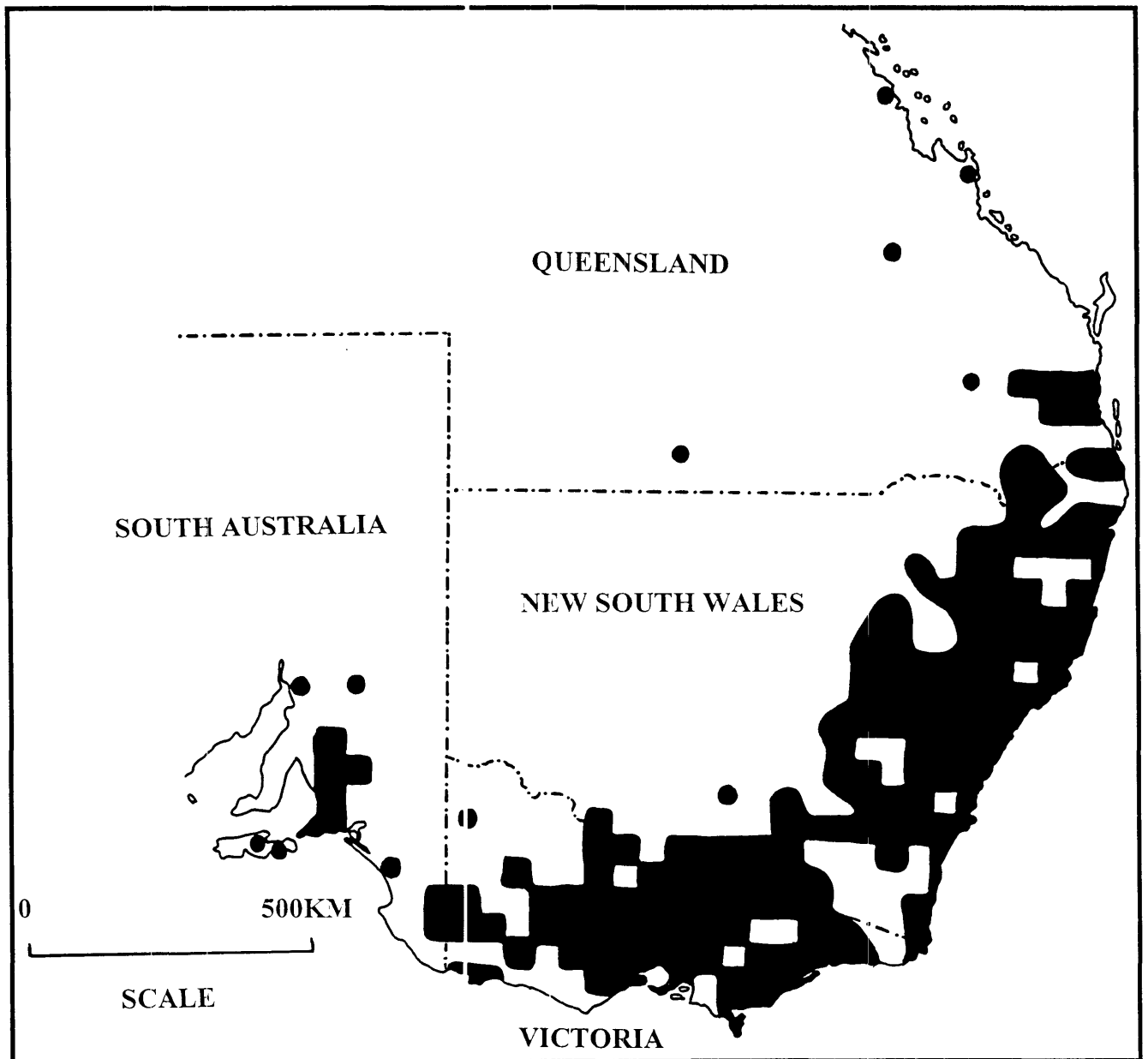
Figure 1.1   Map of the historical distribution of the Regent Honeyeater (● = unusual record). (Modified from Franklin *et al.* 1989 and Webster and Menkhorst 1992).

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found in six of these blocks (see Figure 1.2). Furthermore, the number of Regent Honeyeater records had decreased by about 60% since the 1951-1976 period. In particular, Peters noted the disappearance of Regent Honeyeaters from areas west of Bendigo, Victoria and concluded that further investigation into the decline of the species was warranted. During the same period that the species was declining in western Victoria, Regent Honeyeaters became extinct in South Australia, where they had bred irregularly until 1977 in the Mount Lofty Ranges (Franklin and Menkhorst 1988b). Sightings from south-easterr Queensland have always been infrequent, with just four between 1951 and 1979 (Peters 1979). There have been ten Regent Honeyeater records from this region in the last ten years (B. Williams pers. comm.).

The national decline of Regent Honeyeaters prompted the then Department of Conservation and Environment of Victoria to fund a two year survey to investigate the population status and general ecology of the species (Webster and Menkhorst 1992). This study deemed the national population to be between 500 and 1500 individuals, although the method of estimation was crude and conservative (P. Menkhorst pers. comm.). Based on numbers of sightings during this study, seven key Regent Honeyeater sites were identified; four in New South Wales and three in Victoria. The awareness raised about the plight of the Regent Honeyeater in the early 1990s incited bird watcher to search known and new locations, which resulted in the identification of three more key sites.

The Bundarra-Barraba region in northern New South Wales is one of only ten locations or local regions that support Regent Honeyeaters on a regular basis (Figure 1.2), and is the main study area for this study on Regent Honeyeater ecology.

1.5 Why have Regent Honeyeaters declined?

The major reasons for the decline and range contraction of Regent Honeyeaters, and over a quarter of other woodland bird species, are habitat loss, fragmentation, and degradation (Robinson and Traill 1996). Habitat loss removes essential resources, such as food, nesting sites and shelter. Fragmentation compounds these effects by isolating small sub-populations, and increasing the amount of edge habitat, which may advantage edge species that prey upon or compete with inferior species (Andren 1994).

The model for the decline and extinction of Australian arid-zone mammals by Morton (1990), may have relevance to the decline of woodland birds, particularly the Regent Honeyeater. Morton
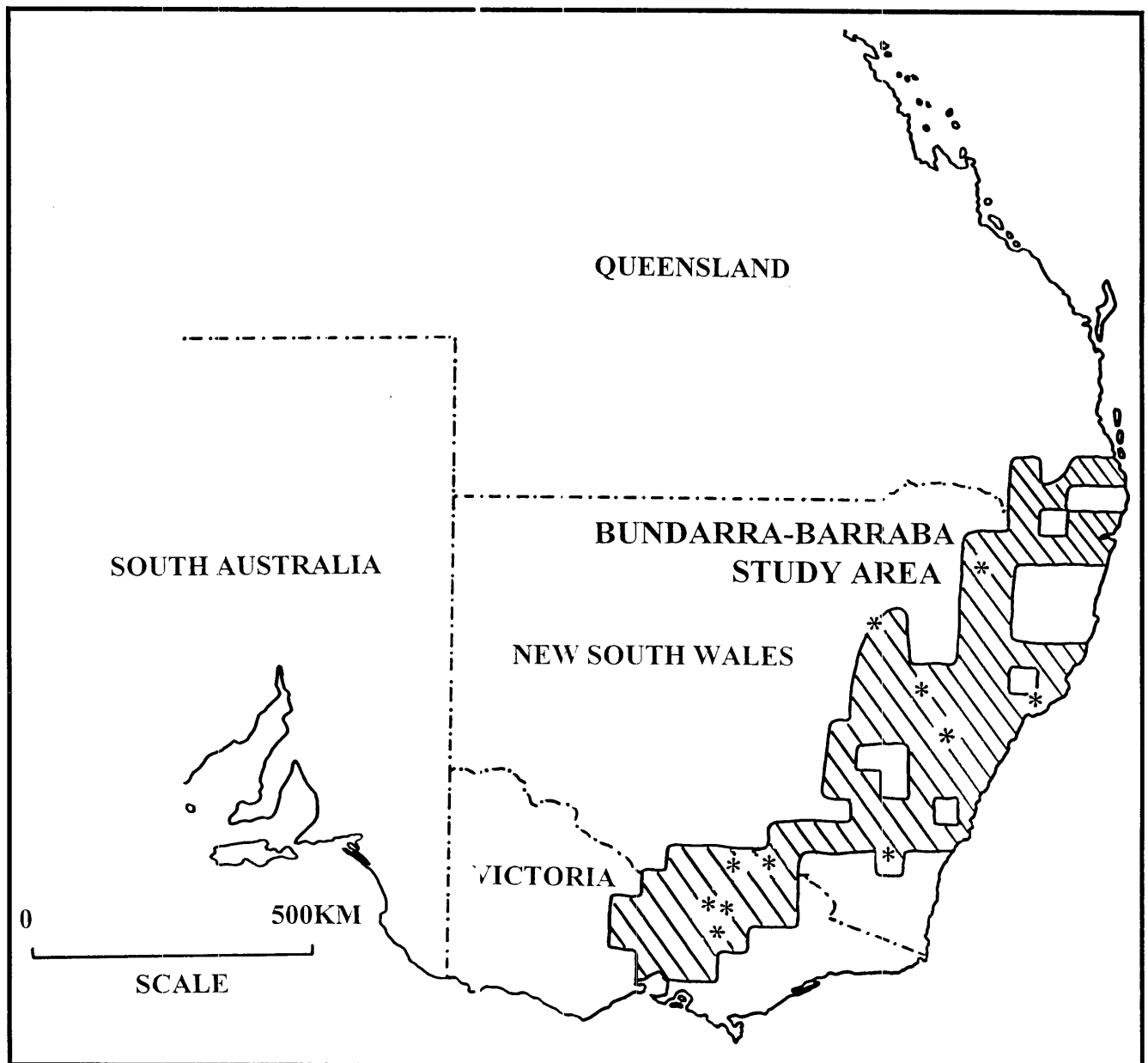
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Figure 1.2   Map of the current distribution of the Regent Honeyeater
(* = key breeding locatio 1).
(Modified from Franklin *e t al.* 1989 and Webster and Menkhorst 1992).

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suggested that during droughts, mamma s retreated to small fertile patches that were surrounded by a landscape of heavy-grazed habitats. In these scarce fertile patches, native mammals have to compete with introduced herbivores and predators, which has contributed to the extinction of local populations of mammals in the 5 to 5.000 gram range. Although birds are more mobile than mammals, allowing them to move between habitats, the loss of one or more of a seasonal sequence of nectar sources through fragmentation may be one reason why the Regent Honeyeater has declined. If the Regent Honeyeater is a Mugga Ironbark specialist, or if it moves among several habitats, it is especially at risk, as some habitats have been lost disproportionally. For example, Mugga Ironbark has been selectively removed for timber, and other high nectar-yielding eucalypts, particularly Yellow Box *E. melliodora*, and White Box *E. albens*, which occur on fertile soils, have been cleared for agricultural purposes.

Regent Honeyeaters are nomadic (Kea t 1968), but they may be unable or unwilling to disperse through parts of their fragmented environment that are totally cleared, or poorly connected by vegetation. This may restrict movements between subpopulations, which is critical for local and regional survival (Howe *et al.* 1991). The loss and fragmentation of nectar sources may also exacerbate the aggressive interactions between Regent Honeyeaters and other nectarivores (Davis and Recher 1993). In fragmented landscapes, there may be no foraging sites free from harassment, and the Regent Honeyeater may be forced into low quality sites. Degradation of habitat remnants through loss of shrubs, mature trees, and the introduction of exotic plants and animals, makes the landscape more suitable for aggressive or predatory bird species, at the expense of possibly more sensitive species, like the Regent Honeyeater. Many of the direct and indirect effects of the above habitat perturbations operate simultaneously and may exacerbate each other.

Much of the clearing of woodland in southern Australia took place before 1940 (Robinson and Traill 1996), when bird numbers were not well monitored. Therefore, any concurrent declines in numbers of Regent Honeyeaters would not have been detected. Furthermore, a lack of data on historical population sizes for Australian birds, particularly for mobile species, makes it difficult to interpret whether the Regent Honeyeater has been disproportionately affected by habitat perturbations, relative to bird species that are still considered "common".

The lack of temporal correspondence between the Regent Honeyeater decline and habitat clearance may be due to inherent time lags in the system. Such time lags arise if Regent Honeyeaters are

affected, not directly by habitat loss, but indirectly through the effects of habitat clearance on factors such as levels of competition for food or nesting resources with other bird species, or the level of nest predation (Yahner 1988, Martin 1993, Barrett *et al.* 1994). Time lags may also occur if the species is long-lived. Any impacts of habitat clearance could take time to occur since the abundance of competitors would not necessarily change immediately. These secondary effects of habitat clearance could affect the ecological repertoire, and ultimately the reproductive behaviour and success, of Regent Honeyeaters over a number of generations before having an impact on population size.

While it is accepted that the direct, or indirect, effects of the historic loss of woodland and other habitats have been responsible for the decline of the Regent Honeyeater, ecological research is needed to determine whether the species is still declining, and to identify recent factors responsible for the decline, so that they can be addressed through management.

1.6 Study aims

The overall aim of this study is to improve the ecological knowledge about the Regent Honeyeater, by investigating a number of aspects of its ecology, and to identify any factors that may be responsible for its continuing decline. The following is a list of the major components of my thesis, and the questions that I will address:

Population size

◆ **What is the population size of Regent Honeyeaters in the Bundarra-Barraba region?**

Presently, there is little information regarding the population size, or dynamics of Regent Honeyeaters at any of the remaining strongholds, including the Bundarra-Barraba region. Long-term monitoring and surveys are needed to look for trends in bird numbers, to determine whether the population(s) is stable, declining, or increasing. Chapter 2 of this thesis presents the regional population estimate for Regent Honeyeaters from a two-year bi-monthly survey in the Bundarra-Barraba region. In Chapter 8, the size of the Bundarra-Barraba breeding population in three breeding seasons is presented.

◆   **Do Regent Honeyeaters select habitat with high avian richness (i.e., a high *S* species) and abundance?**

Chapter 2 investigates whether Regent Honeyeaters use habitats, or belong to bird communities, which have a high avian species richness and abundance, which would further warrant the protection of these sites for general avian biodiversity.

Habitat selection

◆   **Are Regent Honeyeaters Mugga Ironbark woodland specialists?**

Regent Honeyeaters are regarded as Mugga Ironbark woodland specialists, but this is largely speculative, and needs to be tested, so that the relative value of protection of this and other habitat types can be assessed.   The two year Regent Honeyeater survey, outlined in Chapter 2, incorporated five different habitat types to look for preferences in habitat type by Regent Honeyeaters (Chapter 2).

◆   **What are the important microhabitat variables in, and the important landscape variables around, Regent Honeyeater habitats?**

In Chapter 3, habitat models which predict the occurrence of Regent Honeyeaters, based on certain habitat variables (microhabitat, landscape, GIS), were constructed to look for key habitat features that need protection and management, and to assess the suitability of unsurveyed sites for Regent Honeyeaters.

Resource selection

◆   **What are the important foods and plant species used for foraging and nesting by Regent Honeyeaters?**

In Chapter 5 observations of Regent Honeyeater behaviour were carried out to calculate the proportion of time spent taking different foods, to test whether the species is as nectar-dependent as previously thought.   The foods fed to juvenile Regent Honeyeaters were quantified in Chapter 6. Activity budgets in Chapter 5 also established the relative importance of different plant species as

sources of food, and to test further the hypothesis that Mugga Ironbark is important as a nectar source for Regent Honeyeaters. Nest site selection of Regent Honeyeaters in different tree species is presented in Chapter 8.

◆ **Do Regent Honeyeaters prefer large trees for foraging and nesting?**

Webster and Menkhorst (1992) provided evidence that Regent Honeyeaters usually fed in tall, vigorous eucalypts, and suggested that the loss of mature trees for timber may be a factor in their decline. In Chapter 5, I further test this hypothesis, by recording the height and trunk diameter of all trees used by Regent Honeyeaters for foraging, and compare these with trees that were not used, within the same habitat. In Chapter 8, I present data on the height of nest trees selected by Regent Honeyeaters.

Foraging and aggressive behaviour

◆ **Do Regent Honeyeaters spend excessive amounts of time foraging compared with other honeyeaters?**

Regent Honeyeaters may be spending excessive amounts of time trying to meet their energy requirements, and those of their progeny, because habitat loss, fragmentation and degradation has reduced the quality and quantity of food resources, such as Mugga Ironbark nectar. Spending too much time finding food reduces the amount of time for maintenance, predator surveillance, and the lack of food may eventually lead to starvation. In Chapter 4, I measured the time spent by Regent Honeyeaters in a range of activities to quantify the amount of time they spend feeding, to see whether they are experiencing difficulties obtaining enough food.

◆ **Are Regent Honeyeaters involved in high levels of aggression with other nectarivores, compared to other honeyeaters?**

The loss of nectar sources may have exacerbated the competition between Regent Honeyeaters and other nectarivores. Smaller honeyeaters like the Regent Honeyeater are displaced from the best quality nectar sources, by large aggressive honeyeaters such as Red Wattlebirds *Anthochaera carunculata* and Noisy Friarbirds *Philemon corniculatus* (Ford 1981, Ford and Debus 1994). There is some evidence to suggest that Regent Honeyeaters spend excessive time in aggression with

larger honeyeaters (Davis and Recher 1993). Aggressive territorial Noisy Miners *Manorina melanocephala*, which have increased in abundance due to habitat fragmentation and degradation, are also renowned for displacing Regent Honeyeaters, and other birds, from small woodland patches (Loyn 1985, Catterall *et al.* 1991, Barrett 1995, Grey *et al.* 1997). Unlike smaller honeyeaters that can use scarce resources efficiently, Regent Honeyeaters are probably too large to survive on poor food supplies, but are too small to defend themselves against larger species. In Chapter 4 I measured the aggressive behaviour of breeding and non-breeding Regent Honeyeaters to test whether this is a likely cause of decline.

Reproductive biology

◆ **Do Regent Honeyeaters show breeding behaviour comparable to other honeyeaters?**

Information about the breeding behaviour of Regent Honeyeaters is lacking, yet their decline may be related to aspects of their breeding behaviour. For example, they may, for some reason, not incubate their eggs properly, feed their young adequately, or defend their nest sufficiently to achieve a successful nesting outcome. In Chapter 7, the breeding behaviour of Regent Honeyeaters in two consecutive breeding seasons was investigated, to determine whether they display abnormal reproductive behaviour, or poor reproductive "effort", relative to common honeyeaters.

◆ **Are Regent Honeyeaters breeding successfully in the Bundarra-Barraba region?**

There is also a lack of information about the breeding success of Regent Honeyeaters in the Bundarra-Barraba region. The major aim of Chapter 8 was to monitor nests to determine their outcome, so that the breeding success and output (i.e., number of offspring) can be calculated.

Increased nest predation has been suggested as a reason for the decline of small birds in fragmented rural woodlands (Ford and Bell 1981, Barrett 1995), and along with brood parasitism (Ley and Williams 1994), may be the cause of Regent Honeyeater nest failure. In Chapter 8 I attempt to identify possible causes of nest failure.

The nesting requirements of Regent Honeyeaters are unknown, yet habitat simplification has potentially reduced the number of trees, nesting sites, and nesting material specifically used by Regent Honeyeaters. By documenting the nest site selection of Regent Honeyeaters in Chapter 8, I can speculate whether the species is declining due to a lack of nesting resources in the Bundarra-Barraba region, particularly stringybarks and shrubs, which are used to construct nests.

Applications to conservation

◆ **What is the future of the Bundarra-Barraba region population of Regent Honeyeaters?**

Chapter 9, the final chapter, is a general discussion, which provides an overview of the results and conclusions, and provides comment on whether the Regent Honeyeater will survive in the Bundarra-Barraba region in the absence of management, and if not, what management actions are required.

◆ **What insight does this study provide on (i) reasons for decline in the species?**

Chapter 9 critically assesses whether this study identifies recent causes for the decline of Regent Honeyeaters in northern New South Wales, and if not, whether there are information gaps that need addressing, which could provide further insight into their decline.

(ii) future management plans?

The ecological information in this thesis is incorporated into a regional recovery plan for Regent Honeyeaters in the Bundarra-Barraba region, which is presented in Appendix 9, and will form part of the New South Wales Regent Honeyeater Recovery Plan (Christie in prep.).

Chapter 2.

Regent Honeyeater surveys in the Bundarra-Barraba region

2.1 Introduction

Regent Honeyeaters occur predominantly in temperate eucalypt forests and woodlands in parts of southeastern Australia. Their habitat, which once supported a high diversity of vertebrate fauna (Robinson 1994), has been greatly altered by human activities, such as agriculture, since the middle of the nineteenth century. Such activities have caused the decline and extinction of a large number of woodland mammals (Bennett 1982) In contrast, only one bird species, the Paradise Parrot *Psephotus pulcherrimus*, is considered to have become extinct due to woodland destruction (Garnett 1992). However, a large proportion of bird species, including the Regent Honeyeater, have declined, or become locally extinct, particularly in South Australia and Victoria (Robinson 1994). In fact, many woodland bird species have disappeared from local regions throughout Australia in the last 20 to 30 years (Saunders 1989, Saunders and Curry 1990, Robinson 1991, 1993, Barrett *et al.* 1994, Robinson and Traill 1996).

Temperate woodlands used by Regent Honeyeaters are the most threatened wooded ecosystems in southern Australia, with some regions cleared of woodlands by up to 95% (Robinson and Traill 1996). Regent Honeyeaters are believed to rely heavily on the nectar from a small number of woodland eucalypts, particularly Mugga Ironbark (Plate 2.1), which has been selectively removed from remnant patches for its quality timber. The disproportionate removal of Mugga Ironbarks means that Box/Ironbark woodland is particularly threatened. Productive Box/Gum woodland is also used by Regent Honeyeaters (Franklin *et al.* 1989). Box/Gum woodland occurs on fertile soils, and has been selectively cleared for agriculture, which has further reduced the amount of reliable nectar sources for Regent Honeyeaters, and other nectarivores. Regent Honeyeater habitat is susceptible to other anthropogenic disturbances such as forestry, firewood harvesting, mining, altered fire regimes, grazing by exotic herbivores (e.g., rabbits, goats, sheep and cattle), and the introduction of weeds, feral vertebrate predators (cats and foxes), and invertebrates (e.g., honeybees). Less obvious impacts include the suppression of seedling recruitment by stock

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Plate 2.1   Mugga Ironbark *Eucalyptus sideroxylon* woodland in the Bundarra-Barraba region.

grazing, whereby mature trees are not replaced when they die. Apicultural practices can dramatically reduce the nectar and pollen available for native woodland pollinators, including Regent Honeyeaters, and potentially reduce the pollination success of some native plants (Paton 1993).

Significance of Regent Honeyeaters in the Bundarra-Barraba region

The Bundarra-Barraba region, on the inland slopes of the Great Dividing Range in northwestern New South Wales (Figure 2.1), is one of the few remaining areas where Regent Honeyeaters are recorded on a regular basis (Ley 1990, Webster and Menkhorst 1992, Menkhorst 1997). Regent Honeyeaters breed here regularly, which highlights the importance of this region to the survival of the species in northern New South Wales. The species has been studied opportunistically since 1984, with as many as 30 birds recorded breeding in Mugga Ironbark woodland (Ley and Williams 1994). However, intensive ecological research needs to be carried to gain a better understanding of the population size, and the habitat and resource requirements of Regent Honeyeaters in the region.

The Bundarra-Barraba region not only supports Regent Honeyeaters, but also a high species richness and abundance of other birds including other nationally threatened species, such as Swift Parrots *Lathamus discolor*, and Square-tailed Kites *Lophoictinia isura*. Some bird species, which have become locally extinct in South Australia and Victoria, are still relatively common in parts of the Bundarra-Barraba region (e.g., Hooded Robin *Melanodryas cucullata*, Grey-crowned Babbler *Pomatostomus temporalis*, Speckled Warbler *Sericornis sagittatus*). The conservation value of the region for avian biodiversity is probably related to the high proportion of native vegetation, relative to many other woodland areas of southeastern Australia. The average tree cover for the region is about 43% (North West Slopes and Northern Tablelands Database, NSW NPWS 1997) (Figure 2.2), compared to an average of about 15% for other woodland areas in southern Australia (Robinson and Traill 1996). However, like other woodland areas, the Bundarra-Barraba landscape is fragmented (Saunders 1989), and variegated (McIntyre and Barrett 1992), ranging from healthy woodland, through degraded remnants, and sparsely treed pasture, to open grassland. Most woodland remnants here are small, and cleared pasture now supports low densities of solitary trees, often revealing signs of environmental stress from dry soil salinisation, dieback and mistletoe infestation (Heatwole and Lowman 1986, Landsberg *et al.* 1990). In other words, the
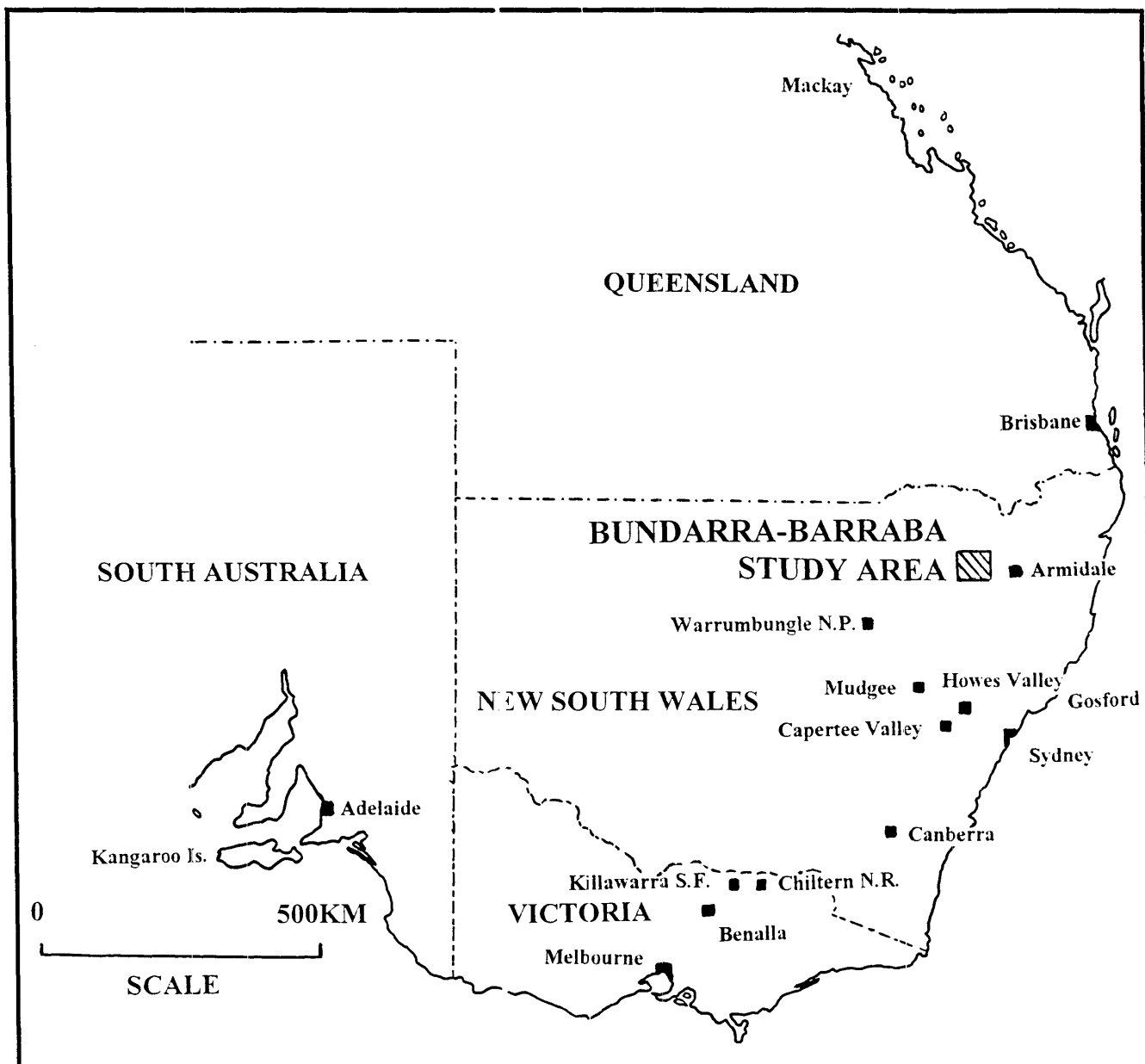
Figure 2.1 Location of Bundarra-Barraba region study area in northern New South Wales.

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Figure 2.2   Projected vegetation cov r of the Bundarra-Barraba region (Copyright NPWS
North West Slopes and Northern Tablelands Database 1997). (Δ = transect
with no Regent Honeyeater record, ▲ = transect with Regent Honeyeater
record(s), ✕ = opportuni tic Regent Honeyeater sighting).

Bundarra-Barraba Study Area
Scale 1:200000
Grid: 10000m

Ironbark patches (combined)
Dry Open Forest
Dry Plateau Complex
Disturbed Remnant Vegetation
Treeless

Service Estate Boundaries
Major Watercourses
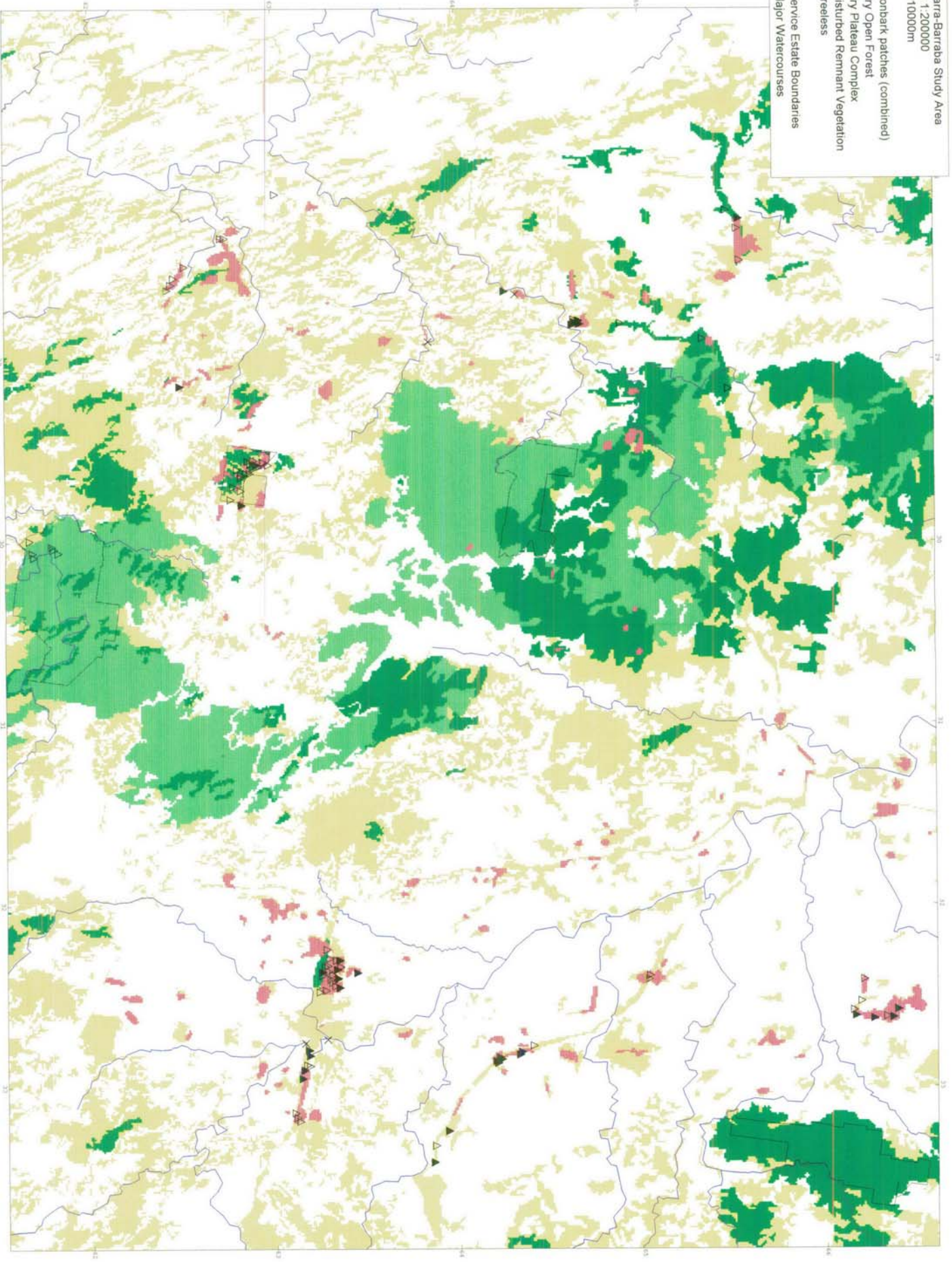
Bundarra-Barraba region has been subjected to the same types of anthropogenic habitat modifications as other woodland ecosystems in Australia.

Mugga Ironbark woodland, which I will refer to as Box/Ironbark woodland, appears to be important for Regent Honeyeaters in the Bundarra-Barraba region (Ley 1990, Ley and Williams 1994). However, because birds are not seen in the same sites every year, other types of woodland and forest may also be important. To determine the importance of Box/Ironbark woodland for Regent Honeyeaters, and to what extent the species uses other habitats, a range of woodland and forest types must be surveyed, year-round. All bird species should be recorded in these surveys to give an overall avian species richness, abundance and diversity in different habitat types, and particularly in habitats selected by Regent Honeyeaters, and those not. This will provide a quantitative index of conservation value for important habitats used by Regent Honeyeaters, to assist in the construction of regional management plans.

2.2 Aims

A two year, bi-monthly survey for Regent Honeyeaters, and all other birds, was conducted in the Bundarra-Barraba region, for the purpose of studying various aspects of the ecology of Regent Honeyeaters, which will be presented in the following seven chapters. This chapter presents results from the two year survey, with the main objectives being to determine the distribution of Regent Honeyeaters in the region in different seasons of the year, and to identify new sites, particularly those in habitats other than Box/Ironbark woodland. Secondly, I wanted to estimate the population size of Regent Honeyeaters in the region, and to try and establish whether the population was stable, decreasing or increasing. All birds species, including Regent Honeyeaters were recorded in survey transects in five different habitat types: Box/Ironbark woodland, Box/Gum woodland, Box/Stringybark woodland Dry plateau complex woodland, and Riparian gallery forest. This was done to compare avian species richness, abundance and diversity between different habitat types, and between habitats selected by Regent Honeyeaters, and those that were not. This will identify the habitats that need to be conserved and managed for Regent Honeyeaters, and general avian richness and abundance. Finally, to determine the importance of nectar for Regent Honeyeaters, I looked for relationships between the flowering intensities (i.e., nectar abundance) in survey transects, and the densities of Regent Honeyeaters, and other nectarivores, between seasons and different years. I also looked for associations between numbers of Regent Honeyeaters, and other nectarivores, to see whether they co-habitated with, or avoided, members of their guild.

2.3 Bundarra-Barraba study area

The chosen study area was the Bundarra-Barraba region, 30-120 km west of Armidale, New South Wales (Figures 2.1 and 2.2). This region covers some 300,000 hectares, roughly bounded by Bundarra (30°10'S, 151°04'E), Barraba (30°23'S, 150°36'E), Kingstown (30°30'S, 151°06'E), and Yarrowyck (30°28'S, 151°22'E), and has been described previously by Ley and Williams (1992). Elevation of the study area ranged from 500 m to 900 m. The climate of the Bundarra-Barraba region is temperate, with an annual rainfall ranging from 680 to 810 mm, with an annual temperature range of 5°C in July to 23°C in February (mean monthly temperatures). The region is predominantly vegetated by dry sclerophyll woodland habitat (10-30% canopy cover, Specht 1972). A large number of different vegetation associations, or habitat types, occur in the region. Five habitat types were chosen for bi-monthly Regent Honeyeater surveys: Box/Ironbark woodland, Box/Gum woodland, Box/Stringybark woodland, Dry plateau complex woodland, and riparian gallery forest (Table 2.1). In all of these habitats, the understorey was usually sparse, either naturally, or due to clearance, grazing, and erosion. The main shrub species were Sifton Bush *Cassinia arcuata*, Daisy Bush *Olearia viscidula* and *O. elliptica*, Blackthorn *Bursaria spinosa*, and a number of species of low shrubs belonging to the Epacridaceae and Fabaceae. A variety of wattles including *Acacia decora*, *A. dealbata*, *A. triptera*, *A. lanigera*, *A. viscidula*, and *A. ulicifolia* were also sometimes present

2.4 Methodology

2.4.1 Habitat types

I surveyed the Bundarra-Barraba region for Regent Honeyeaters, and all other bird species, using opportunistic, and standardised survey techniques. Bird abundances were measured within different habitats using a stratified sampling technique (Eberhardt and Thomas 1991). This allowed the high variation within and between woodland, and other vegetation types, to be sampled for the presence of Regent Honeyeaters.

Regent Honeyeaters have previously been recorded at four main Box/Ironbark woodland sites in the Bundarra-Barraba region (Ley and Williams 1994). My first objective was to establish survey transects at these sites. Following this, I wanted to find other sites with similar structure and floristic composition to the known Box/Ironbark sites. A total of 62 Box/Ironbark transects were chosen across the Bundarra-Barraba region. I also wanted to know whether Regent Honeyeaters selected habitats other than Box/Ironbark woodland. To do this, 31 transects were located in four

other habitat types. The number of transects in each habitat type is shown in Table 2.1. In hindsight, riparian gallery forest was under-represented in my sample design.

2.4.2 Landscape variables

Regent Honeyeaters appear to select Box/Ironbark woodland that is productive, and showing no signs of degradation. I, therefore, assumed that Regent Honeyeaters were more likely to be found at new sites in high quality habitats, than in badly degraded habitats. Consequently, bird transects were only established in woodland and gallery forest that appeared to be healthy. To test whether Regent Honeyeaters prefer large or small remnants of vegetation, transects were established in a range of different sized habitat remnants, ranging from a few hectares up to several thousand hectares. A balanced bird survey effort between large and small remnants was sought, by having a large number of transects (six to sixteen transects) within the largest remnants (>1000 ha.), with just one transect in small remnants (< 5 ha.).

I wanted to know whether Regent Honeyeaters use, or avoid, habitats that are isolated from other habitats, as an indication of whether habitat fragmentation is preventing them from exploiting all available resources in the region. Therefore, some transects were located in remnants that were isolated by nearly a kilometre, while others were in remnants close to, or diffusely connected to other remnants. Landscape information, such as patch size, connectivity, or isolation, can define strategies for protecting and managing the most suitable remnants, for Regent Honeyeater conservation. The distance between nearest transects within the same remnant ranged from 50 metres to 1200 metres, with an average of about 200 metres. Distance between closest surveyed remnants ranged from about 500 metres to 10 kilometres, with an average separation of about four kilometres. For each transect and the remnant to which it belonged, a series of microhabitat and landscape variables was measured for use in habitat modelling, which is detailed in Chapter 3.

2.4.3 Microhabitat variables

Regent Honeyeaters are thought to rely on nectar for survival (Franklin *et al.* 1989, Webster and Menkhorst 1992). To test whether nectar was an important microhabitat factor selected by Regent Honeyeaters, and other nectarivorous birds, I counted the number of eucalypt and mistletoe flowers (to an accuracy of 100 flowers) within each transect, for each bi-monthly survey. The number of flowers within each transect was later converted to a flowering index ranging from zero

Table 2.1   The five habitat types chosen for Regent Honeyeater surveys in the Bundarra-Barraba region.

Habitat type	Major tree species	Number of transects	% of total transects	number (%) of transects with RHEs
Box/Ironbark woodland	*Eucalyptus sideroxylon, E. melliodora, E. moluccana, E. albens E. blakelyi, E. caliginosa, E. mckiea ia,E.andrewsii, Angophora floribunda*	62	66.7%	21 (33.9%)
Box/Gum woodland	*E. melliodora, E. moluci ana, E. albens, E. blakelyi,E. prava, A. floribunda*	7	7.5%	1 (14.3%)
Box/Stringybark woodland	*E. melliodora, E. moluci ana, E. blakelyi, E. caliginosa, E. mckiea ia, E. andrewsii*	10	10.8%	1 (10.0%)
Dry plateau complex woodland	*E. caleyi, E. melanophlc ia, E. prava, E. dealbata, A floribunda, Callitris endlicheri*	10	10.8%	1 (10.0%)
Riparian gallery forest	*Casuarina cunninghami ina, E. viminalis, E. melliodora, E. camaldulensis, A. floribunda, Salix bab lonica*	4	4.3%	0 (0%)

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to seven, with zero representing no flowers, and seven more than 400,000 flowers per hectare. This ranking was also adjusted on the basis of nectar abundance per flower, measured in Chapter 5. Mugga Ironbark flowers were ranked as a level above other flowering species, based on nectar measurements (Chapter 5). For example, the equivalent index of two for non-Ironbark flowers was an index of one for Ironbark flowers. Other flowering indices included in analyses were number of tree species that flowered over the two year census period, and the number of surveys with flowering events (possible maximum of 13) as a measure of flowering reliability in each transect.

2.4.4 Transect and survey design

Between January 1995 and January 1997, I conducted regular bi-monthly surveys for Regent Honeyeaters, and all other bird species, in 93 one-hectare strip transects. A standardised bird censusing method within fixed-width (50 m wide), one hectare (200 m long) transects was chosen as the most appropriate sampling method. A one hectare transect was small enough to fit in the smallest remnants surveyed in this study. Transects counts have been widely accepted as a suitable method for surveying Australian forest and woodland birds (Pyke and Recher 1984, Recher 1988). A number of publications stress the importance of using a fixed-width transect method for censusing woodland avian communities (Shields and Recher 1984, Loyn 1986, Er *et al.* 1995).

All birds, including Regent Honeyeaters, seen or heard within 25 metres either side of the transect line were recorded in a fixed 20 minute period. Birds flying immediately over the transect were recorded. For the purposes of this study, only data for birds recorded in the transects, and not flying over, were analysed. All surveys were carried out within four hours of sunrise, and only in favourable weather conditions (Osborne and Green 1992).

If Regent Honeyeaters were seen during a census, I recorded which plants they were using, the size of the plant, and the type of food consumed, using a single-point method. These data are presented, and interpreted in Chapter 5. By taking single-point observations, the remainder of the bird count was not interrupted. After all bird counts were completed for the morning, sequential behavioural observations on Regent Honeyeater foraging and micro-habitat use were made when I returned to the transect(s) where I saw the birds. These data are presented in Chapters 4 and 5.

2.4.5 Analyses

Bird survey data

Bird count data from the 13 surveys at each one-hectare transect were divided into the following categories:

1. Mean density of all bird species of each one-hectare transect.

2. Mean density of nectarivorous birds of each transect.

3. Mean density of non-nectarivorous birds of transect.

4. Number of total bird species over two-year survey period for each transect.

5. Numbers of nectarivorous bird species over two-year survey period for each transect.

6. Number of non-nectarivorous bird species over two-year survey period for each transect.

7. Mean number of bird species per survey for each transect.

8. Mean number of nectarivorous bird species per survey for each transect.

9. Mean number of non-nectarivorous bird species per survey for each transect.

10. Simpson's diversity index $D = 1/\sum P_i^2$, where P_i is the proportion of the ith species (Begon *et al.* 1990).

11. Shannon diversity index $H = -\sum P_i \log P_i$ where P_i is the proportion of the ith species (Begon *et al.* 1990).

I wanted to know whether Regent Honeyeaters selected habitat with high avian richness, diversity and abundance. To do this I compared each of the above categories for transects used by Regent Honeyeaters, and those that were not, using Student's t tests. Data were log10-transformed to meet the assumptions of normality for parametric analysis.

To test whether Regent Honeyeaters used a particular habitat type more than others on the basis of numbers or species richness of birds, comparison was also made for each category between transects in the five different habitat types, using one-way analysis of variance (ANOVA). Data were also log10-transformed to meet the assumptions of normality and homogeneity of variance for parametric analyses.

Relationships between flowering indices and density of Regent Honeyeaters and other nectarivorous birds

I wanted to know if Regent Honeyeaters and other nectar-feeding birds chose transects on the basis of flowering, and hence nectar abundance, or not. To do this linear regression analyses were

carried out to look for correlations between the density of Regent Honeyeaters, densities of other nectarivores, and species richness of nectarivorous birds, with the abundance of flowers in each transect. Only birds that are predominantly nectarivorous were included in regression equations, as many honeyeaters are known to eat mostly foods other than nectar. Data on the densities of Musk and Little Lorikeets *Glossopsitta concinna* and *G. pusilla*, Red Wattlebirds, Noisy Friarbirds and Regent Honeyeaters were compared against the flowering index in each transect count (1209 counts in two years). A total count of these species in each transect (93 transects) over two years was also compared with 1) total flowering index over two years, 2) mean flowering index over two years, 3) number of tree species that flowered in two years, and 4) number of surveys with flowering events over two years. To check for correlations between predominantly non-nectarivorous honeyeaters and flowering indices, I included Fuscous Honeyeaters *Lichenostomus fuscus* and Noisy Miners density data into regression equations with flowering index. Density data were log10-transformed to meet the assumptions of normality for linear regression analysis, but flowering indices were not transformed.

Regent Honeyeaters may choose, or avoid habitats on the basis of occurrence of other bird species. It has been suggested that Regent Honeyeaters avoid aggressive species, such as Noisy Miners, which have the reputation of excluding many woodland bird species (Loyn 1987, Caterall *et al.* 1991, Clarke *et al.* 1995, Grey *et al.* 1997). To determine whether Regent Honeyeater co-habitate with, or avoid, other nectarivores, I used linear regressions to look for correlations between Regent Honeyeater density, and the density of other nectarivorous birds.

To elucidate patterns of Regent Honeyeater habitat selection based on flowering or nectar abundance, a comparison of flowering index, flowering frequency, and number of flowering species was made between transects selected by Regent Honeyeaters, and those that were not, using Student's *t* tests. To see whether Regent Honeyeaters choose habitat types on the basis of nectar abundance, I looked for differences in flowering indices between the five habitat types, by applying one-way ANOVAs.

2.5   Results

2.5.1 Bird survey data

Total bird species

Between January 1995 and January 1997, 13 bi-monthly bird counts were performed at the 93 transects, giving a total of 1,209 twenty minute censuses. A total of 66,280 birds were recorded, of which 51,747 were seen or heard within the transects and 14,533 were seen flying over the transects.

One hundred and thirty two bird species were recorded in transects during the two year census period (Table 2.2 (taxonomy and species based on Christidis and Boles (1994)). A further 37 bird species were recorded opportunistically away from transects or at other times (denoted by ✓ in Table 2.2), giving a total of 169 bird species observed during this study in the Bundarra-Barraba region. Twenty-one honeyeater species were recorded in the region.

Fuscous Honeyeaters were the most common birds in the Bundarra-Barraba region. They occurred on 84 of the 93 transects (90%), and represented 34.7% of all birds counted. The other five most common birds were Musk Lorikeets (6.5%), Noisy Friarbirds (5.6%), Noisy Miners (5.0%), Striated Pardalotes *Pardalotus striatus* (4.3%), and Weebills *Smicrornis brevirostris* (4.0%).

Regent Honeyeaters

A total of 115 Regent Honeyeaters, o 0.2% of all birds were observed during censusing. Of those, 109 were seen within transects, and six flew over transects. Regent Honeyeaters were recorded in eight of the thirteen survey periods; March, July, September and November of 1995, January, March, and November of 1996, and January 1997. The number of transects with Regent Honeyeater records in a single survey period ranged from one to nine (mean 4.3 ± 3.2 transects, n = 8). The highest number of birds seen in one census period was 28 in November 1995, and the highest number of birds seen in one transect was eight, in March 1995. A further 88 Regent Honeyeaters were found at other times and locations, giving a total of 203 birds recorded in two and a half years in the Bundarra-Barraba region. In January 1996, a total of 73 adult and 28 juvenile Regent Honeyeaters was recorded from all known breeding sites in the region, giving a total of 101 birds.

Table 2.2   Bird species recorded in the Bundarra-Barraba region in 93 transects and from opportunistic sightings between July 1994 and February 1997.

Common name	Scientific name	within transect total number recorded	transects with species recorded	flying over transect total number recorded	transects with species recorded	opportunistic sighting
Brown Quail	*Coturnix ypsilophora*	-	-	-	-	✓
Black Swan	*Cygnus atratus*	-	-	-	-	✓
Australian Shelduck	*Tadorna tadornoides*	-	-	-	-	✓
Australian Wood Duck	*Chenonetta jubata*	38	8	16	9	
Pacific Black Duck	*Anas superciliosa*	22	5	12	4	
Grey Teal	*Anas gracilis*	-	-	-	-	✓
Chestnut Teal	*Anas castanea*	-	-	-	-	✓
Hardhead	*Aythya australis*	-	-	-	-	✓
Australasian Grebe	*Tachybaptus novaehol. indiae*	-	-	-	-	✓
Hoary-headed Grebe	*Poliocephalus poliocej halus*	-	-	-	-	✓
Darter	*Anhinga melanogaster*	-	-	-	-	✓
Little-Pied Cormorant	*Phalacrocorax melano eucos*	-	-	2	1	
Pied Cormorant	*Phalacrocorax varius*	-	-	-	-	✓
Little Black Cormorant	*Phalacrocorax sulciro. tris*	-	-	-	-	✓
Great Cormorant	*Phalacrocorax carbo*	-	-	5	5	
Australian Pelican	*Pelecanus conspicullai is*	-	-	-	-	✓
White-faced Heron	*Egretta novaehollandii e*	-	-	6	5	
Little Egret	*Egretta garzetta*	-	-	-	-	✓
White-necked Heron	*Ardea pacifica*	-	-	-	-	✓
Great Egret	*Adrea alba*	-	-	-	-	✓
Nankeen Night Heron	*Nycticorax caledonicu.*	-	-	-	-	✓
Australian White Ibis	*Threskiornis molucca*	-	-	6	1	
Straw-necked Ibis	*Threskiornis spinicolli ·*	-	-	-	-	✓
Yellow-billed Spoonbill	*Platalea flavipes*	-	-	-	-	✓
Pacific Baza	*Aviceda subcristata*	2	1	-	-	
Black-shouldered Kite	*Elanus axillaris*	-	-	1	1	
Square-tailed Kite	*Lophoictinia isura*	3	2	2	2	
White-bellied Sea-Eagle	*Haliaeetus leucogastei*	-	-	2	1	
Brown Goshawk	*Accipiter fasciatus*	7	5	13	10	
Collared Sparrowhawk	*Accipiter cirrhocephal is*	3	3	11	6	
Wedge-tailed Eagle	*Aquila audax*	6	4	38	22	
Little Eagle	*Hieraaetus morphnoid ·s*	1	1	12	10	
Brown Falcon	*Falco berigora*	1	1	2	2	
Australian Hobby	*Falco longipennis*	-	-	5	3	
Peregrine Falcon	*Falco peregrinus*	-	-	-	-	✓
Nankeen Kestrel	*Falco cenchroides*	3	3	5	4	
Buff-banded Rail	*Gallirallus philippens. s*	-	-	-	-	✓
Purple Swamphen	*Porphyrio porphyrio*	-	-	-	-	✓
Dusky Moorhen	*Gallinula tenebrosa*	-	-	-	-	✓
Black-tailed Native-hen	*Gallinula ventralis*	-	-	-	-	✓
Eurasian Coot	*Fulica atra*	1	1	-	-	
Painted Button-quail	*Turnix varia*	53	30	-	-	
Black-fronted Dotterel	*Elseyornis melanops*	2	1	-	-	
Masked Lapwing	*Vanellus miles*	1	1	-	-	
Common Bronzewing	*Phaps chalcoptera*	149	54	7	6	
Crested Pigeon	*Ocyphaps lophotes*	34	18	9	7	
Peaceful Dove	*Geopelia striata*	92	31	2	2	
Yellow-tailed Black-Cockatoo	*Calyptorhynchus fune. eus*	-	-	-	-	✓
Galah	*Cacatua roseicapilla*	210	40	350	64	
Little Corella	*Cacatua pastinator*	-	-	-	-	✓
Sulphur-crested Cockatoo	*Cacatua galerita*	29	4	63	18	
Cockatiel	*Nymphicus hollandicu ·*	6	1	17	9	
Rainbow Lorikeet	*Trichoglossus haemat. dus*	54	11	111	19	
Musk Lorikeet	*Glossopsitta concinna*	3358	80	5603	92	
Little Lorikeet	*Glossopsitta pusilla*	1597	71	2586	89	
Australian King Parrot	*Alisterus scapularis*	80	29	45	21	
Red-winged Parrot	*Aprosmictus erythropi ?rus*	4	2	4	3	

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Table 2.2   (continued).

Common name	Scientific name	within transect total number recorded	transects with species recorded	flying over transect total number recorded	transects with species recorded	opportunistic sighting
Crimson Rosella	*Platycerus elegans*	348	59	72	22	
Eastern Rosella	*Platycerus eximius*	989	72	338	53	
Swift Parrot	*Lathamus discolor*	4	2	12	3	
Red-rumped Parrot	*Psephotus haematonoti s*	56	19	92	17	
Turquoise Parrot	*Neophema pulchella*	30	4	9	5	
Pallid Cuckoo	*Cuculus pallidus*	6	5	7	4	
Fan-tailed Cuckoo	*Cacomantis flabellifor nis*	19	15	-	-	
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	4	2	-	-	
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*	7	5	-	-	
Channel-billed Cuckoo	*Scythrops novaehollan liae*	4	2	16	10	
Barking Owl	*Ninox connivens*	-	-	-	-	✓
Southern Boobook	*Ninox novaeseelandiae*	-	-	-	-	✓
Tawny Frogmouth	*Podargus strigoides*	1	1	-	-	
Australian Owlet-nightjar	*Aegotheles cristatus*	2	2	-	-	
White-throated Needletail	*Hirundaptus caudacuti s*	-	-	9	4	
Azure Kingfisher	*Alcedo azurea*	-	-	-	-	✓
Laughing Kookaburra	*Dacelo novaeguinea*	106	39	6	3	
Sacred Kingfisher	*Todiramphus sanctus*	204	60	2	1	
Rainbow Bee-eater	*Merops ornatus*	14	8	52	18	
Dollarbird	*Eurystomus orientalis*	40	16	13	7	
White-throated Treecreeper	*Cormobates leucophae 1*	588	65	-	-	
Brown Treecreeper	*Climacteris picummus*	960	65	1	1	
Superb Fairy-wren	*Malurus cyaneus*	1212	61	-	-	
Variegated Fairy-wren	*Malurus lamberti*	24	3	-	-	
Spotted Pardalote	*Pardalotus punctatus*	205	48	-	-	
Striated Pardalote	*Pardalotus striatus*	2244	93	45	26	
White-browed Scrubwren	*Sericornis frontalis*	100	16	-	-	
Chestnut-rumped Heathwren	*Sericornis pyrrhopygii s*	2	1	-	-	
Speckled Warbler	*Chthonicola sagittatus*	224	42	-	-	
Weebill	*Smicrornis brevirostri.*	2046	77	49	9	
Western Gerygone	*Gerygone fusca*	-	-	-	-	✓
White-throated Gerygone	*Gerygone olivacea*	360	73	2	1	
Buff-rumped Thornbill	*Acanthiza reguloides*	32	6	-	-	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoc*	72	8	-	-	
Striated Thornbill	*Acanthiza lineata*	887	27	-	-	
Southern Whiteface	*Aphelocephala leucop. is*	8	2	-	-	
Red Wattlebird	*Anthochaera caruncul ita*	214	47	21	9	
Spiny-cheeked Honeyeater	*Acanthagenys rufogul ris*	86	21	9	1	
Striped Honeyeater	*Plectorhyncha lanceol ita*	78	31	-	-	
Noisy Friarbird	*Philemon corniculatus*	2874	93	719	91	
Little Friarbird	*Philemon citreogulari.*	88	27	1	1	
Regent Honeyeater	***Xanthomyza phrygia***	**109**	**24**	**6**	**4**	
Blue-faced Honeyeater	*Entomyzon cyanotis*	67	23	39	13	
Noisy Miner	*Manorina melanoceph ila*	2587	56	170	30	
Yellow-faced Honeyeater	*Lichenostomus chryso is*	774	43	32	15	
White-eared Honeyeater	*Lichenostomus leucoti ·*	552	30	4	4	
Yellow-tufted Honeyeater	*Lichenostomus melanc ps*	333	5	9	2	
Fuscous Honeyeater	*Lichenostomus flavesc ins*	17941	84	2178	75	
White-plumed Honeyeater	*Lichenostomus penicil atus*	812	10	31	4	
Black-chinned Honeyeater	*Melithreptus gularis*	335	57	23	15	
Brown-headed Honeyeater	*Melithreptus brevirost is*	604	73	73	14	
White-naped Honeyeater	*Melithreptus lunatus*	282	32	-	-	
Brown Honeyeater	*Lichmera indistincta*	9	7	-	-	
Painted Honeyeater	*Grantiella picta*	4	3	-	-	
Eastern Spinebill	*Acanthorhynchus tenu rostris*	61	20	2	1	
Black Honeyeater	*Certhionyx niger*	9	5	-	-	
Scarlet Honeyeater	*Myzomela sanguinolei ta*	6	4	-	-	

Table 2.2 (continued).

Common name	Scientific name	within transect total number recorded	transects with species recorded	flying over transect total number recorded	transects with species recorded	opportunistic sighting
Jacky Winter	*Microeca fascinans*	92	37	-	-	
Scarlet Robin	*Petroica multicolor*	20	9	-	-	
Red-capped Robin	*Petroica goodenovii*	12	3	-	-	
Rose Robin	*Petroica rosea*	1	1	-	-	
Hooded Robin	*Melanodryas cucullata*	39	10	1	1	
Eastern Yellow Robin	*Eopsaltria australis*	287	64	1	1	
Grey-crowned Babbler	*Pomatostomus temporalis*	-	-	-	-	✓
White-browed Babbler	*Pomatostomus superciliosus*	119	15	-	-	
Varied Sittella	*Daphoenositta chrysoptera*	77	13	-	-	
Crested Shrike-tit	*Falcunculus frontatus*	122	48	1	1	
Crested Bellbird	*Oreoica gutturalis*	8	6	-	-	
Golden Whistler	*Pachycephala pectoralis*	80	42	-	-	
Rufous Whistler	*Pachycephala rufiventris*	662	91	2	1	
Grey Shrike-thrush	*Colluricincla harmonica*	660	83	17	10	
Leaden Flycatcher	*Myiagra rubecula*	8	4	-	-	
Satin Flycatcher	*Myiagra cyanoleuca*	1	1	-	-	
Restless Flycatcher	*Myiagra inquieta*	148	53	1	1	
Magpie-lark	*Grallina cyanoleuca*	177	35	42	22	
Grey Fantail	*Rhipidura fuliginosa*	125	41	-	-	
Willie Wagtail	*Rhipidura leucophrys*	664	73	3	2	
Spangled Drongo	*Dicrurus bracteatus*	-	-	-	-	✓
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	194	72	46	29	
White-bellied Cuckoo-shrike	*Coracina papuensis*	189	56	19	14	
Cicadabird	*Coracina tenuirostris*	10	5	-	-	
White-winged Triller	*Lalage sueurii*	4	3	-	-	
Olive-backed Oriole	*Oriolus sagittatus*	77	39	-	-	
Masked Woodswallow	*Artamus personatus*	-	-	-	-	✓
White-browed Woodswallow	*Artamus superciliosus*	19	6	22	5	
Dusky Woodswallow	*Artamus cyanopterus*	580	51	388	55	
Little Woodswallow	*Artamus minor*	8	4	4	3	
Grey Butcherbird	*Cracticus torquatus*	161	59	6	4	
Pied Butcherbird	*Cracticus nigrogularis*	54	29	2	2	
Australian Magpie	*Gymnorhina tibicen*	217	45	125	44	
Pied Currawong	*Strepera graculina*	108	45	33	23	
Australian Raven	*Corvus coronoides*	67	32	372	86	
Little Raven	*Corvus mellori*	1	1	3	3	
White-winged Chough	*Corcorax melanorhamphus*	438	45	14	4	
Apostlebird	*Struthidea cinerea*	-	-	-	-	✓
Richard's Pipit	*Anthus novaeseelandiae*	1	1	-	-	
House Sparrow	*Passer domesticus*	-	-	-	-	✓
Zebra Finch	*Taenopygia guttata*	-	-	-	-	✓
Double-barred Finch	*Taeniopygia bichenovii*	91	21	11	2	
Plum-headed Finch	*Neochmia modesta*	-	-	-	-	✓
Red-browed Finch	*Neochmia temporalis*	154	13	-	-	
Diamond Firetail	*Stagonopleura guttata*	260	52	-	-	
Mistletoebird	*Diaceum hirundinaceum*	905	92	20	14	
White-backed Swallow	*Cheramoeca leucosternum*	-	-	6	4	
Welcome Swallow	*Hirundo neoxena*	-	-	6	4	
Tree Martin	*Hirundo nigricans*	-	-	-	-	✓
Fairy Martin	*Hirundo ariel*	8	2	128	24	
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	13	4	-	-	
Rufous Songlark	*Cinclorhamphus mathewsi*	207	49	1	1	
Silvereye	*Zosterops lateralis*	260	20	277	35	
Common Starling	*Sturnus vulgaris*	9	5	8	6	

Regent Honeyeaters were found in 24 of the 93 transects (26% of transects) (Table 2.1). Thirteen of these were new sites, and the other 11 had previous occupancy by Regent Honeyeaters recorded in the past. Twenty-one of the 24 occupied transects (87.5%) were in Box/Ironbark woodland. The remaining three transects comprised one in each of the Box/Gum, Box/Stringybark, and Dry plateau woodland habitats (Table 2.1). Twenty-one of the 62 (33.9%) Box/Ironbark transects, one of the seven (14.3%) Box/Gum, one o ' the 10 (10%) Box/Stringybark, and one of the 10 (10%) dry plateau woodland transects were used by Regent Honeyeaters. Regent Honeyeaters were not recorded in the four riparian gallery forest transects. However, many breeding birds were found opportunistically in riparian habitat 200 metres, or less, from two of the riparian transects in late 1995 (Chapters 7 and 8).

2.5.2 Total bird density

The mean density of total bird species for the 1,209 counts was 42.8 ± (s.d.) 12.3 birds/ha. (range 4-186 birds/ha.). The density of Regent Honeyeaters in the 93 survey transects equates to 0.095 birds per hectare. In their preferred Box/Ironbark woodland, the average density for the 62 Box/Ironbark transects was 0.13 birds per hectare. There are about 4,200 hectares of Box/Ironbark woodland in the Bundarra-Barraba region (NSW NPWS North West Slopes and Northern Tablelands Database 1997), which means that a maximum of around 520 Regent Honeyeaters could possibly occur in this habitat alone.

Transects chosen by Regent Honeyeaters had significantly greater densities of birds per count than transects not chosen (Figure 2.3). There was significant variation in the mean densities of birds per count in different habitat types (Figure 2.4). Riparian habitat had the highest average bird density, followed by Box/Ironbark woodland, Box/Gum woodland, Dry plateau woodland, and Box/Stringybark woodland (Figure 2.4). In particular, Box/Stringybark and Dry plateau woodland transects had significantly fewer birds per hectare, than the other three habitat types (Bonferroni pairwise comparisons).

2.5.3 Nectarivorous bird density

A mean density of 27.4 ± 11.8 nectarivorous birds/ha. (range 1-183 birds/ha.) was measured for all transects. Regent Honeyeater transects had a higher density of nectarivorous birds than non-
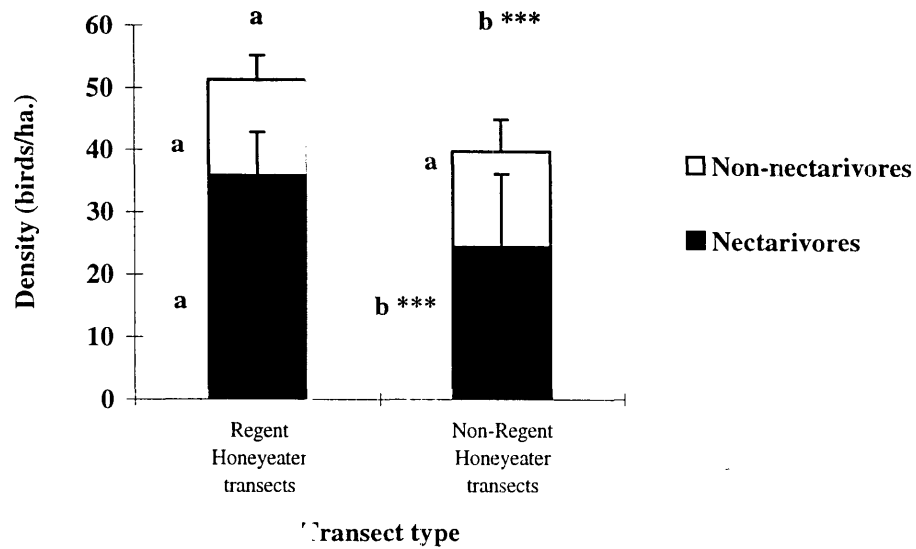
Figure 2.3 Comparison of mean bir(density (+ s.d.) between transects selected or not selected by Regent Honeyeaters i 1 the Bundarra-Barraba region. Labels next to and above histograms with different letters signify significant differences using t tests (d.f. = 91, *** = $p < 0.001$).
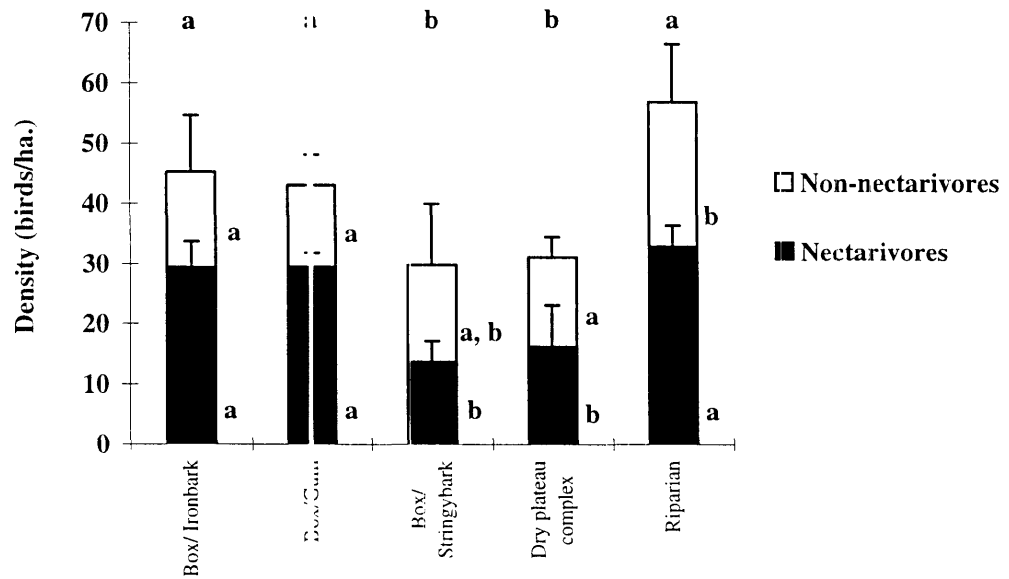

Figure 2.4 Comparison of bird densities (+ s.d.) in transects in different habitat types in the Bundarra-Barraba regior using one-way ANOVA. Densities differed significantly among habitat types for nectarivores ($F_{4, 88} = 18.21, p < 0.001$), non-nectarivores ($F_{4, 88} = 3.21, p < 0.05$), and for all bird species ($F_{4, 88} = 14.13, p < 0.001$). Labels next to and above (all bird species) histograms with different letters signify significant pairwise differences ($p < 0.05$) (Bonferroni pairwise comparisons).

Regent Honeyeater transects (Figure 2.3). There was also significant variation in nectarivore density between the five different habitat types (Figure 2.4). The same order for nectarivore abundance as total bird abundance was found, except that Box/Gum transects had slightly more nectarivores per hectare than Box/Ironbark transects. Again, the Box/Stringybark and Dry plateau woodland transects supported significantly fewer nectarivorous birds than the other three habitat types (Figure 2.4).

2.5.4 Non-nectarivorous bird density

A mean density of 15.4 ± 4.8 non-nectarivorous birds/ha. (range 0-83 birds/ha.) was recorded for all bird counts, and this did not differ between Regent Honeyeater transects and those not used by the species (Figure 2.3). However, there was a significant difference in non-nectarivore densities between habitats (Figure 2.4). Riparian transects had the highest density of non-nectarivorous birds followed by Box/Stringybark, Box/Ironbark woodland, Dry plateau woodland and Box/Gum transects. Riparian transects had significantly more non-nectarivorous birds per hectare than other habitat types except for Box/Stringybark transects (Figure 2.4).

2.5.5 Total species richness

The mean number of species recorded on each transect over the 13 surveys was 36.3 ± 6.0 species/ha. (range 23-53 species/ha.). Significantly more bird species were recorded in two years at Regent Honeyeater transects than in others (Figure 2.5). There was also a significant variation in species number between different habitats with riparian transects supporting the most bird species, followed by Box/Gum, Box/Ironbark, Box/Stringybark and Dry plateau sites (Figure 2.6). Dry plateau transects had significantly fewer bird species over two years than other habitat types except Box/Stringybark woodland transects.

2.5.6 Nectarivore species richness

A mean of 9.5 ± 2.4 nectarivorous bird species/ha. (range 3-16 species/ha.) was recorded for all transects in the two year survey period, and the species richness was the same in transects with and without Regent Honeyeater records (Figure 2.5). There were no differences in number of nectarivorous species over two years between habitat types (Figure 2.6).
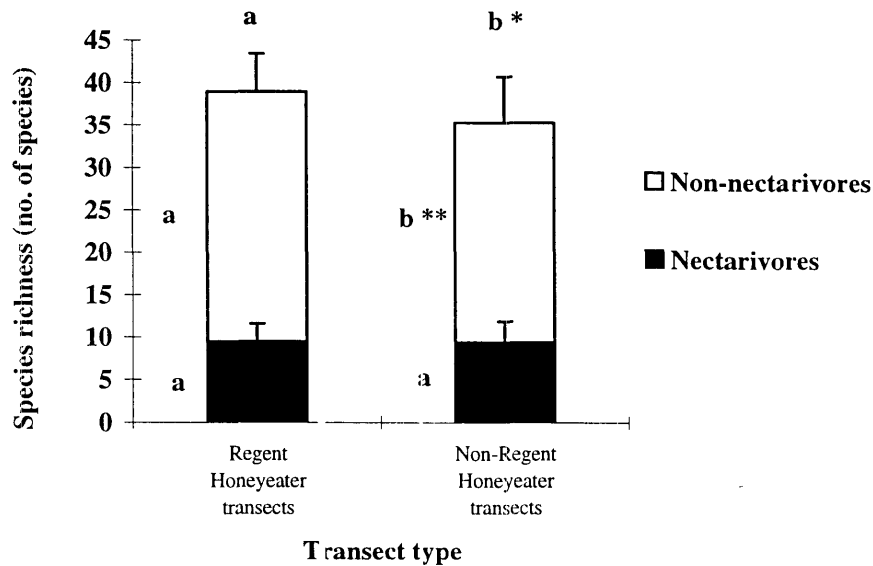
Figure 2.5 Comparison of bird spec es richness (+ s.d.) between transects selected or not selected by Regent Honeyeaters in the Bundarra-Barraba region. Labels next to and above histograms wi h different letters signify significant differences using t tests (d.f. = 91, * = $p <$ (.05, ** = $p < 0.01$).
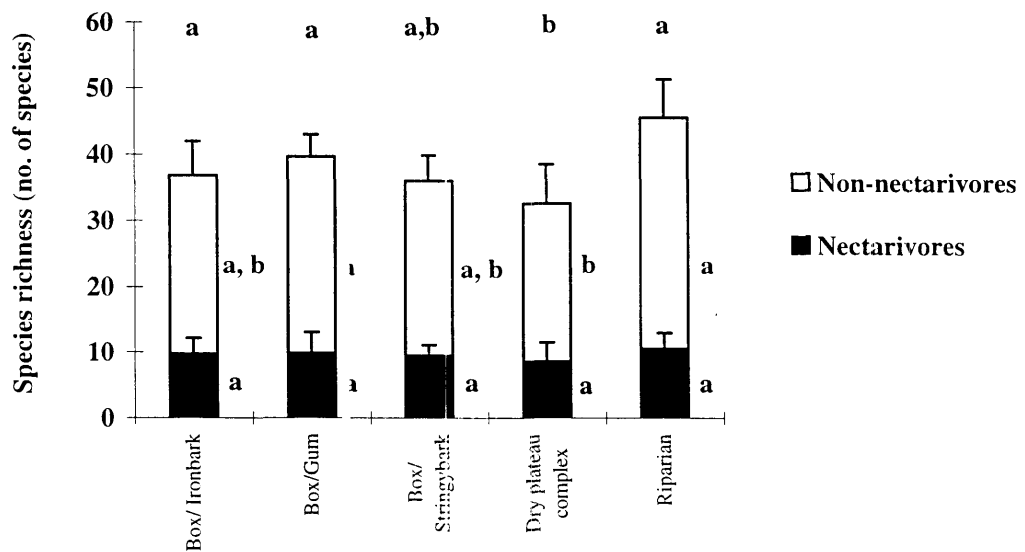

Figure 2.6 Comparison of bird spec es richness (+ s.d.) in transects in different habitat types in the Bundarra-Barraba region using one-way ANOVA. Species richness differed significantly am>ng habitat types for non-nectarivorous birds ($F_{4, 88}$ = 5.13, $p < 0.01$), and all bird species ($F_{4, 88}$ = 5.83, $p < 0.001$), but was not significantly different fo1 nectarivorous birds ($F_{4, 88}$ = 0.92, $p > 0.05$). Labels next to and above (all bi1d species) histograms with different letters signify significant pairwise diffe ences ($p < 0.05$) (Bonferroni pairwise comparisons).

2.5.7 Non-nectarivore species richness

The average number of non-nectarivorous bird species measured in all transects over two years was 26.9 ± 5.4 species/ha. (range 15-41 species/ha.), and there were more non-nectarivorous bird species recorded over two years in Regent Honeyeater transects than transects not chosen (Figure 2.5). There was also significant variation in non-nectarivorous bird species between habitat types, with riparian transects boasting the most species over two years, followed by Box/Gum, Box/Ironbark, Box/Stringybark, and Dry plateau woodland transects. Dry plateau woodland transects had significantly fewer non-nectarivorous species than riparian and Box/Gum transects (Figure 2.6).

2.5.8 Total species richness per census

An average of 9.7 ± 1.9 bird species/ha (range 2-23 species/ha.) was recorded for all of the 1,209 twenty-minute bird censuses. There were more bird species per census in Regent Honeyeater transects than others, and this difference was close to significance (Figure 2.7). Significant variation in mean bird species per count between transects in different habitat types was found. Riparian transects had the most bird species per count, followed by Box/Gum, Box/Ironbark, Box/Stringybark and Dry plateau wood and transects. Riparian transects had more bird species per count than all habitat types except Box/Gum, and Dry plateau transects had much lower species counts than all transect types except Box/Stringybark sites (Figure 2.8).

2.5.9 Nectarivore species richness per census

A mean of 3.1 ± 0.7 nectarivorous bird species/ha. (range 1-12 species/ha.) was recorded per count for all transects, and this did not vary between Regent Honeyeater transects and non-Regent Honeyeater transects (Figure 2.7). There was significant variation in nectarivorous bird species counts between transects in different habitat types, although there were no pairwise differences (Figure 2.8). Riparian transects had the highest number of nectar-feeding species per count, and Box/Stringybark the lowest.

2.5.10 Non-nectarivore richness per census

For all transects, 6.6 ± 1.6 non-nectarivorous bird species/ha. (range 0-18 species/ha.) were found during each bird count. More non-nectarivorous bird species were recorded in each count in
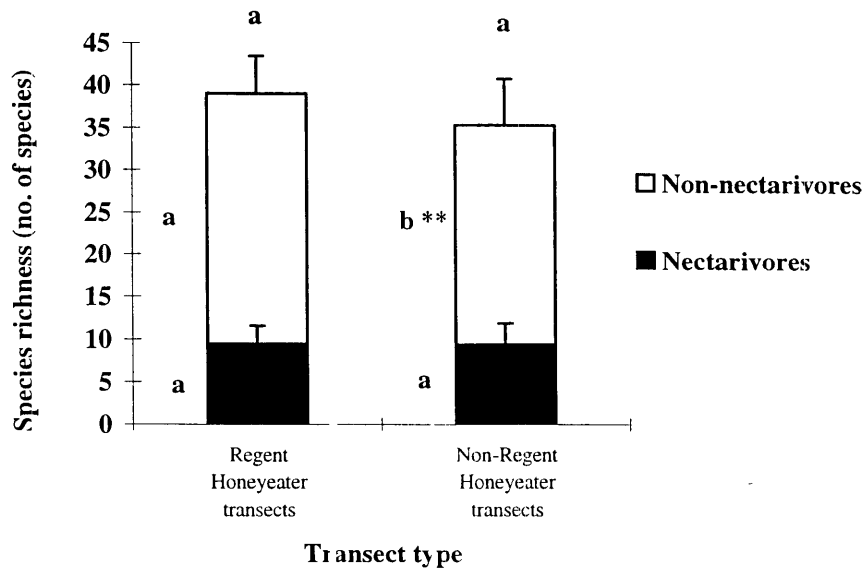
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Figure 2.7   Comparison of average bird species richness per census (+ s.d.) between transects selected or not selected by Regent Honeyeaters in the Bundarra-Barraba region. Labels next to and above histograms with different letters signify significant differences using t tests (d.f. = 9 .. * = $p < 0.05$).
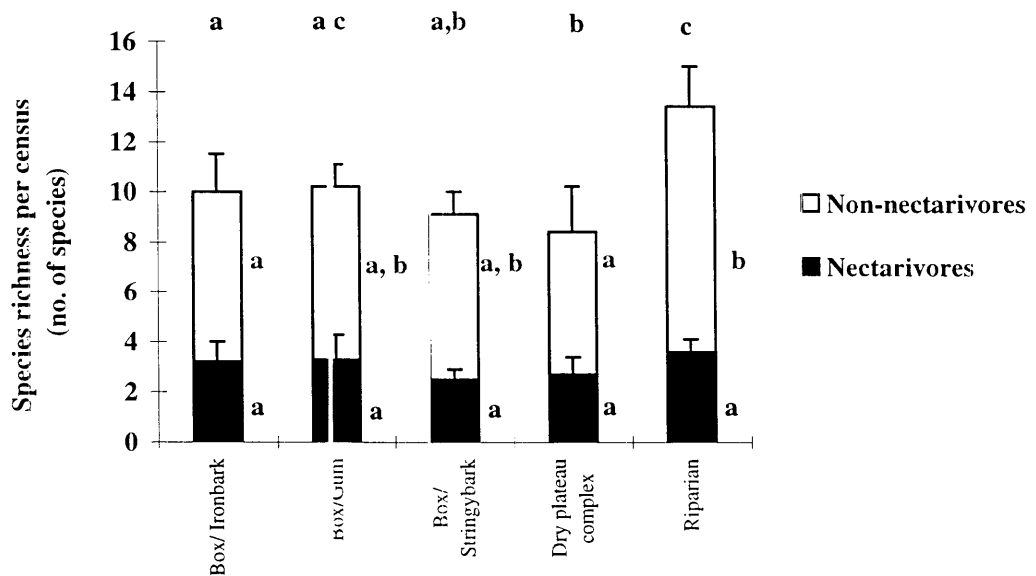

Figure 2.8   Comparison of the bird species richness per census (+ s.d.) in transects in different habitat types in the Bundarra-Barraba region using one-way ANOVA. Species richness per census differed significantly among habitat types for nectarivores ($F_{4, 88}$ = 3.83, $p < 0.01$), non-nectarivores ($F_{4, 88}$ = 5.01, $p < 0.01$), and for all bird species ($F_{4, 88}$ = 6.83, $p < 0.001$). Labels next to and above (all bird species) histograms with different letters signify significant pairwise differences ($p < 0.05$) (Bonferroni pairwise comparisons).

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Regent Honeyeater transects than other transects (Figure 2.7). Riparian transects had the highest number of non-nectarivores per count followed by Box/Gum, Box/Ironbark, Box/Stringybark and dry plateau complex transects, and the variation among habitat types was significant. Riparian sites had more species than Box/Ironbark and dry plateau woodland transects (Figure 2.8).

2.5.11 Diversity indices

Transects selected by Regent Honeyeaters had significantly lower diversity indices (both Simpson's and Shannon), than other transects (Figure 2.9). However, there was no significant variation between habitat types for either index of avian diversity.

2.5.12 Relationships between bird densities, habitat type and flowering indices

Flowering indices in different habitat types

There were no differences between transects selected, and those not selected by Regent Honeyeaters for total flower abundance, mean abundance, number of tree species that flowered in the two year survey, or the number of surveys with flowering events (Table 2.3). There was, however, significant variation between transects in the five habitats for all four flowering indices (Table 2.4). Box/Ironbark woodland transects had the highest total and mean flowering indices, which were significantly higher than those of Box/Gum woodland transects (Table 2.4). Box/Ironbark transects also had a significantly higher number of tree species that flowered and a higher number of surveys with flowering events than Box/Gum woodland (Table 2.4). Box/Gum woodland sites had the lowest flowering indices of all habitat types. Box/Stringybark transects had the highest number of tree species that flowered over two years. Riparian transects has the highest number of surveys with flowering present, because Needle-leaf Mistletoes *Amyema cambagei* flowered reliably every year and for prolonged periods.

Density of Regent Honeyeaters and other nectarivorous birds in relation to flowering indices

There were significant positive correlations between flowering abundance of each transect count (n = 1,209) and the corresponding number of total nectarivorous birds, the number of species of nectarivorous birds, and the number of Red Wattlebirds, Noisy Friarbirds, Regent Honeyeaters, and Musk and Little Lorikeets (Table 2.5), although the amount of variation explained in each model was sometimes very low. In particular, the r^2 value for the Regent Honeyeater model was only 0.033, which means that only 3.3% of total variance in data can be explained. There were non-
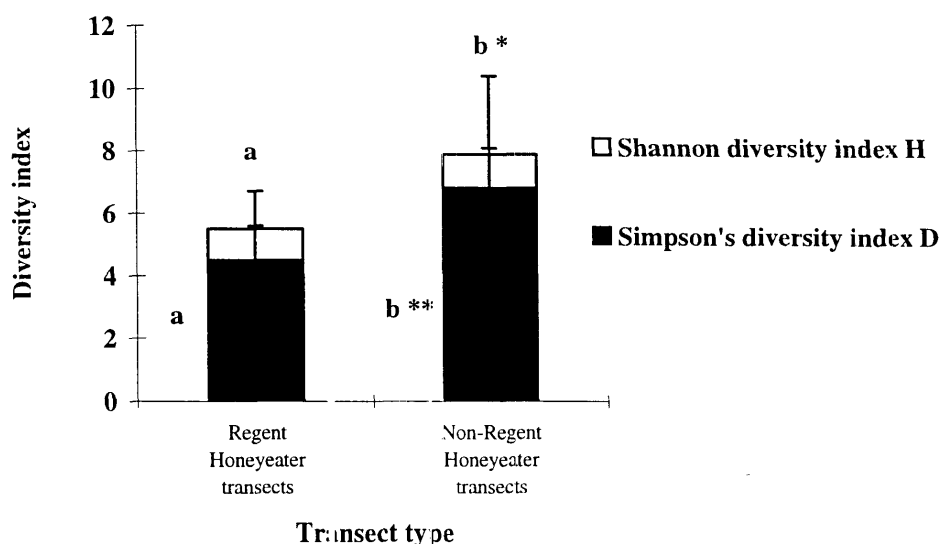
Figure 2.9 Comparison of Simpson's (*D*), and Shannon (*H*) diversity indices (+ s.d.) between transects selected, or not selected by Regent Honeyeaters in the Bundarra-Barraba region. Labels next to and above histograms with different letters signify significant differences using *t* tests (1.f. = 9 , * = $p < 0.05$, ** = $p < 0.01$).

Table 2.3 Comparison of flowering indices (± s.d.) in transects selected and not selected by Regent Honeyeaters i 1 the Bundarra-Barraba region using Student's *t* tests. n.s. = no significant diffe ence at $\alpha = 0.05$ level.

Flower index	Transec ts selected by Regent Honeyea:ers	Transects **not** selected by Regent Honeyeaters	*t*	d.f.	*p*
total no. of flowers	4. 33 ± 0.96	4.22 ± 1.50	0.35	91	n.s.
mean no of flowers	0.)5 ± 0.37	0.94 ± 0.50	0.02	91	n.s.
no. of flowering tree species	3.)0 ± 1.1C	2.99 ± 1.30	0.05	91	n.s.
no. of surveys with flowers in 2yrs.	4.)7 ± 1.8€	4.93 ± 2.16	0.53	91	n.s.

Table 2.4 Comparison of flowering indices (± s.d.) in transects in five different habitat types in the Bundarra-Barraba re ;ion, us:ng one-way ANOVA. * = $p < 0.05$, ** = $p < 0.01$. Means in rows with diffe ent letters differ significantly ($p < 0.05$, Bonferroni pairwise comparisons).

Flower index	Box/ Ironbark	Box/ Gum	Box/ Stringybark	Dry plateau	Riparian	$F_{4, 88}$	*p*
total no. of flowers	4.6 ± 1.3 a	3.1 ± 1.3 b	3.3 ± 1.3 b	3.9 ± 1.3 a,b	3.5 ± 1.3 a,b	4.54	**
mean no of flowers	1.1 ± 0.4 a	0.5 ± 0.4 b	0.7 ± 0.4 a,b	0.8 ± 0.4 a,b	0.8 ± 0.4 a,b	4.39	**
no. of flowering tree species	3.2 ± 1.1 a	1.4 ± 1.2 b	3.3 ± 1.2 a	2.4 ± 1.2 a,b	2.5 ± 1.2 a,b	4.98	**
no. of surveys with flowers in 2 yrs.	5.1 ± 2.0 a	2.7 ± 2.0 b	4.3 ± 2.0 a,b	5.1 ± 2.0 a,b	5.5 ± 2.0 a,b	2.57	*

significant negative correlations betwee 1 number of flowers and Fuscous Honeyeaters and Noisy Miners. Significant positive correlatior s were also found for the total number of all nectarivorous birds, Red Wattlebirds, Noisy Friarbirc s, Musk and Little Lorikeets over two years for the 93 transects, and the total number of flow ers in those transects over two years (Table 2.5). There were also significant linear relationship: between the mean number of flowers per survey for each transect and the total number of all nectt rivorous birds, Noisy Friarbirds and Musk Lorikeets (Table 2.6). There were no significant correl itions with bird numbers and the number of flowering tree species or number of flowering events over the two year survey in each transect. There were small, but non-significant, negative correlations between numbers of Regent and Fuscous Honeyeaters and Noisy Miners and the four flowering indices (Table 2.5).

Density of Regent Honeyeaters in rel: tion to density of other nectarivorous birds

For all 1,209 bird counts, there were strong positive correlations between the number of Regent Honeyeaters and the number of all nectt rivorous birds except Noisy Miners where a non-significant negative correlation was found (Table 2.6). There were also positive relationships between total number of Regent Honeyeaters in each ransect over two years, and the corresponding total number of all nectarivorous birds, Little Lorikeets and Fuscous Honeyeaters. There was an insignificant negative correlation between Regent Honeyeaters and Noisy Miners (Table 2.6).

2.6 Discussion

The unpredictable movements, and low densities of Regent Honeyeaters in the Bundarra-Barraba region, made it difficult to estimate the population size. There were 73 adults and 28 juveniles in the 1995/96 breeding season, which exceeds the previous estimate of 30 birds by Ley and Williams (1994). Eighty birds have been colour-banded in the region in the last four years (Ley *et al.* 1996), yet only fourteen have been resighted, among many unbanded birds, which would suggest that the population is well over 100 birds, unless mortality is high after birds are banded. There has been no evidence to suggest that birds remo /e or lose their leg bands, although occasionally the slightly smaller size four metal band slips beneath the size five plastic colour band. If colour-banding, and regular surveys were continued, a better population estimate might well be achieved.

The difficulty to obtain a population estimate also relates to the large amount of inaccessible habitat in the study area.. The density of Regent Honeyeaters in Box/Ironbark woodland sites was 0.13 birds per hectare, which means there may be enough Box/Ironbark woodland in the region to

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Table 2.5   Linear regression correlations between numbers of nectarivorous birds and flowering abundance in the Bundarra-Barraba region. r^2 values are presented where correlations are significant. n.s. = no significant correlation, for significant correlations $* = p < 0.05$ $** = p < 0.01$, $*** = p < 0.001$, (+) = positive correlation, (-) = negative correlation na = no analysis performed.

Bird parameters	flower index of each bird survey (n = 1,20?)	total flower index of each transect (n = 93)	mean flower index of each transect (n = 93)	number of tree species that flowered in each transect (n = 93)	number of surveys with flowers in each transect (n = 93)
No. of all nectarivorous birds	0.208 (+) ***	0.176 (+) ***	0.118 (+) ***	0.000 (+) n.s.	0.004 (+) n.s.
No. of species of nectarivorous birds	0.149 (+ ***	na	na	na	na
No. of Regent Honeyeaters	0.033 (+ ***	0.000 (+) n.s.	0.000 (-) n.s.	0.000 (-) n.s.	0.016 (-) n.s.
No. of Red Wattlebirds	0.022 (+ ***	0.033 (+) *	0.015 (+) n.s.	0.000 (+) n.s.	0.000 (+) n.s.
No. of Noisy Friarbirds	0.140 (+ ***	0.212 (+) ***	0.122 (+) ***	0.000 (+) n.s.	0.000 (+) n.s.
No. of Noisy Miners	0.000 (- n.s.	0.000 (-) n.s.	0.005 (-) n.s.	0.020 (-) n.s.	0.015 (-) n.s.
No. of Musk Lorikeets	0.202 (+ ***	0.103 (+) **	0.067 (+) **	0.000 (+) n.s.	0.012 (+) n.s.
No. of Little Lorikeets	0.108 (+ ***	0.035 (+) *	0.006 (+) n.s.	0.004 (+) n.s.	0.000 (+) n.s.
No. of Fuscous Honeyeaters	0.000 (- n.s.	0.000 (-) n.s.	0.000 (-) n.s.	0.000 (+) n.s.	0.001 (-) n.s.

Table 2.6   Linear regression correlations between abundance of Regent Honeyeaters and the abundance of other nectarivorous birds. r^2 values given for significant correlations. n.s. = no significant correlation, for significant correlations $* = p < 0.05$, $** = p < 0.01$, $*** = p < 0.001$, (+) = positive correlation, (-) = negative correlation. n = total number of counts/transects, RHE = number of counts/transects with Regent Honeyeater records, na = no analysis performed.

	No. of nectarivorous birds	No. of nectarivorous species	No. of Red Wattlebirds	No. of Noisy Friarbirds	No. of Noisy Miners	No. of Musk Lorikeets	No. of Little Lorikeets	No. of Fuscous Honeyeaters
All bird counts (n = 1,209) (RHE = 34)	0.04 (+) ***	0.035 (+) ***	0.004 (+) *	0.026 (+) ***	0.000 (-) n.s.	0.027 (+) ***	0.024 (+) ***	0.008 (+) **
All transects (n = 93) (RHE = 24)	0.047 (+) *	na	0.001 (+) n.s.	0.011 (+) n.s.	0.000 (-) n.s.	0.000 (+) n.s.	0.136 (+) ***	0.084 (+) **

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support about 520 Regent Honeyeaters. This assumes that all Box/Ironbark woodland is of similar quality to known Regent Honeyeater habitat. However, many of the Box/Ironbark woodland remnants in the Bundarra-Barraba region are degraded, and probably unsuitable for Regent Honeyeaters.

Regent Honeyeaters were recorded in four types of woodland. Box/Ironbark woodland was the habitat type most often selected by the species, which concurs with previous observations by Ley and Williams (1992, 1994), and Webster and Menkhorst (1992). My observations may be partly due to the high proportion (66.7%) of transects being placed in Box/Ironbark woodland. In hindsight, there should have been an equal replication of transects in the five habitat types. Despite this unbalanced sample design, my study has clearly shown that Regent Honeyeaters need Box/Ironbark woodland, but also use other habitat types. Incidental sightings away from transects highlight the role of riparian gallery forest as breeding refuges in some years.

Regent Honeyeater habitat supports significantly higher avian species richness and abundance than habitats not chosen by the species. Not only were there more nectar-feeding birds, but also more birds from other feeding guilds. Although there were higher numbers of species, and more individual birds in Regent Honeyeater transects, each species was unevenly distributed in terms of abundance across the community. In other words, the bird community in Regent Honeyeater habitat had a lower diversity (Begon *et al.* 1990), because of the high number of other honeyeater species, and because some bird species were very common, and others were rare. Nevertheless, Regent Honeyeater habitat provided a variety of resources (food, nesting sites) to many bird species, and protecting these habitats will have many benefits for the conservation of other birds that may be declining without detection

Woodland and riparian habitat used by Regent Honeyeater in the Bundarra-Barraba region, supported birds that are endangered or declining in other regions of southeastern Australia. Swift Parrots, Square-tailed Kites, Grey-crowned Babblers, Hooded Robins and Crested Bellbirds *Oreoica gutturalis* were only recorded in, or close to, Regent Honeyeater transects, and not elsewhere. These birds have become locally extinct or rare in parts of South Australia and Victoria (Robinson 1991, Robinson and Traill 1996), and are probably declining in the southern slopes and highlands of New South Wales where land clearance has been much greater than in my study area. Fifty kilometres east of the Bundarra-Barraba region, bird species have disappeared from parts of

the Armidale plateau in under 20 year; (Barrett *et al.* 1994). These include species which are still common in my woodland and riparian sites. In particular, the Peaceful Dove *Geopelia placida*, Red-browed Firetail *Neochmia temporalis*, Double-barred Finch *Taeniopygia bichenovii* and Hooded Robin, which are still quite common in the Bundarra-Barraba region, have recently disappeared from Eastwood State Forest, eight kilometres south-east of Armidale (H. Ford pers. comm.). Brown Treecreepers *Climacteris picumnus* are also declining rapidly on the Armidale plateau, and yet were abundant in many of my transects.

Relatively common birds in the Bundarra-Barraba region, including the Painted Button-quail *Turnix varia*, White-browed Babbler *Pomatostomus superciliosus*, and Fuscous and Black-chinned Honeyeater, have become locally extirct in parts of Victoria, and continue to decline in that state in what appears to be a north-easterly direction. That is similar to the pattern of local extinctions suffered by the Regent Honeyeater in Victoria (Peters 1979, Franklin *et al.* 1989), where it now mainly occurs in the northeastern region. Black-chinned Honeyeaters were relatively common in woodland and riparian habitat co-habitated by Regent Honeyeaters in my study area, and yet they have become rare in south-western Victoria (Robinson 1993), and appear likely to become extinct in the southern Mount Lofty Ranges of South Australia, where a population of fewer than 50 individuals survives today (Chapman 1997). Black-chinned and Regent Honeyeaters show the same patterns of decline, and are sending a warning about the danger of further bird extinctions in the 21st century (Recher 1996).

Although I did not find Regent Honeyeaters in any of the riparian transects, this was probably due to their under-representation in my sample design, because riparian gallery forest was not considered to be important habitat for the species prior to this study. However, Regent Honeyeaters bred in riparian habitat, only 200 metres away from two of my transects, in late 1995. The bird species richness and abundance at the two riparian breeding sites was very high (96 species in five hectares at the Gwydir River site, 56 species in two hectares at Ironbark Creek), although I did not measure their densities. Riparian transects consistently supported significantly higher avian species richness and abundance, than transects in any of the four woodland habitat types, including Box/Ironbark woodland, which was the most common habitat selected by Regent Honeyeaters. The Gwydir River site used by Regent Honeyeaters in 1995 provided a drought refuge for the rare Painted Honeyeater, and endangered Square-tailed Kite, and a breeding refuge for arid-zone

Cockatiels *Leptolophus hollandicus* and White-browed and Masked Woodswallows *Armatus superciliosus* and *A. personatus*. Successful breeding attempts by some of these inland visitors indicates that riparian habitat provided adequate resources for birds during droughts further inland.

My findings on the high bird species richness and abundance in riparian gallery forest concur with those of Chan (1990), who found that riparian habitat in northern New South Wales supported more species than the nearby woodland, and the ecotone between the two habitats. Fisher and Goldney (1997), also found that riparian gallery forest in the Central Tablelands of New South Wales supported a species rich avifaura. They recorded more birds species at riparian sites, than in Box/Gum woodland sites. Finally, Bentley and Catterall (1997) observed that within continuous bushland, riparian areas supported higher species richness and total bird abundance, than did dry eucalypt forest areas. My results add to the increasing body of evidence from Australia to support Knopf and Samson's (1994) contention that riparian zones are the "aorta of an ecosystem". The narrow band of riverine gallery forest in the Bundarra-Barraba region has been greatly fragmented from clearance for grazing, and is probably the most threatened wooded ecosystem in the region. Livestock grazing, which occurs at the Regent Honeyeater riparian breeding site, has been linked to a reduction in riparian vegetation, and decreased bird species diversity and abundance (Ammon and Stacey 1997). The importance of conserving the riparian habitat for Regent Honeyeaters and other birds will be further discussed in the chapters that follow.

The relatively high proportion of remnant vegetation in the Bundarra-Barraba region (43%), compared to other woodland areas in southeastern Australia, is a likely reason why arid-zone birds rely on the region as a drought refuge. This contrasts with the situation in Victoria, where invasions of arid-zone Letter-winged Kites *Elanus scriptus* in 1977 ended with high mortality from starvation (Robinson 1993). Robinson postulated that other inland birds such as Black Honeyeaters *Certhionyx niger*, woodswallows and chats probably suffer the same fate as the kites, due to lack of remaining quality habitat to support them. Drought compounds the effect of lack of habitat, as is the likely cause of the recent decline and disappearance of Little Lorikeets, Crested Bellbirds, and Jacky Winters *Microeca leucophaea*, in sites in Victoria (Robinson 1993). I have shown that the high productivity (Recher et al. 1996) woodland and riparian sites used by Regent Honeyeaters support a significantly high avian richness and abundance. Protecting these sites will provide benefits for other threatened birds of woodlands, and arid zone birds, which rely on these sites in years when conditions are unfavourable for survival or breeding further inland.

Habitat differences

Regent Honeyeaters were mainly recorded in Box/Ironbark woodland and riparian gallery forest in the Bundarra-Barraba region. On the other hand, Box/Gum woodland, which supported an avian richness and abundance equal to Box/Ironbark sites, had only one record of four Regent Honeyeaters, and one nest, over the two year survey. Box/Gum woodland supported similar, or sometimes higher, numbers of birds and bird species than Box/Ironbark woodland, despite having significantly lower flowering indices. These results contrast with those of Barrett (1995), who found that small remnants of Box/Gum woodland supported fewer bird species than other woodland types (e.g., Box/Stringybark). My results were probably affected by the small number of transects established in Box/Gum woodland (seven transects) in comparison to Box/Ironbark habitat (62 transects). It is, therefore, possible that my findings have understated the potential importance of Box/Gum woodland for Regent Honeyeaters.

The five habitat types surveyed in the Bundarra-Barraba region supported different bird species richness and abundances. A number of Australian studies have related avian and arboreal mammal species diversity to the rainfall, soil nutrients, foliage nutrients and productivity of forest communities (e.g., Recher 1985, Majer et al. 1994, Cork and Catling 1996, Recher et al. 1996). Strong interactions between the physical environment and the biotic community determine the composition of eucalypt forest and woodland faunas (Recher et al. 1996). Plant communities on soils high in nutrients and moisture generally support structurally complex habitat rich in plant taxa (Recher 1985), though a few studies have shown that the most diverse floras were associated with nutrient poor soils (e.g., Specht 1981). In general, however, complex and highly productive plant communities sustain a more diverse and abundant assemblage of birds than those on infertile soils that are structurally simple (Recher et a. 1990).

Box/Gum woodland and riparian gallery forest in the Bundarra-Barraba region occurs on soils with nutrient levels higher than in other woodland types, yet fewer flowers per hectare were produced in Box/Gum and riparian habitat, compared to Box/Ironbark woodland, which occurs on low fertility soils. The high avian richness and abundance in Box/Gum and riparian habitats may be related to variables other than flowering indices, such as structural and floristic complexity, levels of foliar nutrients, and abundance of insects and carbohydrates such as lerp and honeydew. To look for relationships between Box/Gum and riparian habitat variables, and avian richness and abundance, I should have measured rainfall, soil and foliar nutrients at all sites.

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Regent Honeyeaters were found in Box Stringybark woodland, which, typically, occurs on hillsides with infertile soils. Box/Stringybark woodland supported the most diverse bird communities, because abundances of bird species were more equitable. However, given the sensitivity of diversity indices from sampling errors, species richness and individual abundance are a better measure of the bird community complexities in my study. With this in mind, Box/Stringybark woodland sites supported relatively low species numbers and individual abundances. Box/Stringybark habitat appears to be structurally complex, and supports a high diversity of tree species. However, it has a relatively low nectar producing capacity.

I recorded only four Regent Honeyeaters using dry plateau complex woodland. The birds fed on the nectar of Caley's Ironbark for about two minutes, before leaving the transect. Dry plateau complex woodland occurs on infertile granite soils, and often comprises very stunted trees with low structural complexity. Nevertheless, Caley's Ironbark *E. caleyi*, which occurred in all dry plateau complex transects, is a relatively good nectar producing tree (Chapter 5), and its blossoms attracted high densities of honeyeaters in the Warrabah National Park in 1994.

Honeyeater densities and flowering abundance

I found weak correlations, with a large amount of variance, between local flowering indices and the number of Regent Honeyeaters in my survey transects. This is not surprising, as the data for endangered and low density species will always be few and will, therefore, limit the resolution of regression models. Entirely different relationships were found when I analysed data for each of the 1,209 bird counts, compared with when I pooled the survey data for each transect. In the first case, I found a positive correlation between flowering abundance and the number of Regent Honeyeaters, while I found a negative correlation for the pooled data. In contrast, there were stronger relationships between flowering intensities and some of the common nectarivores I measured. Noisy Friarbirds, Red Wattlebirds, and Musk and Little Lorikeet densities were correlated with one or more of the flowering indices, although the regression models only explained a small amount of the total variance observed in the data (10-20% of variance explained). There have been a number of Australian studies that have established a connection between local honeyeater densities and flowering intensities (Collins and Briffa 1982, Ford 1983, Collins *et al.* 1984, Collins and Newland 1986, McFarland 1986a, Cale 1990). For example, Ford (1983) found strong relationships between monthly flowering abundance of five plant species, as well as total flowering abundance, and the densities of eight honeyeater species. Cale (1990) found significant

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correlations between mean numbers cf Singing and Brown Honeyeaters *Lichenostomus virescens* and *Lichmera indistincta* and the quantity of flowers in roadside vegetation over twelve months in the Western Australian wheatbelt, and he also found a significant relationship between the change in foraging behaviour of the Singing Honeyeaters and availability of flowers.

Like other workers who have failed to find significant honeyeater/flower relationships (e.g., Pyke 1983, 1985), I was unable to determine the scale at which Regent Honeyeaters moved, and how they located flowering patches. One solution could be to view honeyeater densities as functions of regional flowering intensity or nectar availability (Collins and Newland 1986, Pyke and Recher 1986, Recher 1989). Mac Nally (1996) proposed that both local and regional factors affect the particular mix of species occurring within a community at any time. To understand nectarivore dynamics, studies have to be conducted at spatial scales at which recruitment, mortality and dispersal processes are operating (Mac Nally 1996, Mac Nally and McGoldrick 1997). The scales at which Regent Honeyeaters, and other highly mobile and widely-distributed species (e.g., Swift Parrots and Painted Honeyeaters) operate, are still unknown. Colour-banding and radio-telemetry could well determine the distances over which these birds disperse. However, it will be more difficult to know how they locate foraging patches. It seems likely that Regent Honeyeaters, Swift Parrots and Painted Honeyeaters do not select sites, on the basis of nectar availability, as they often feed on other foods (Chapters 5 and 6). From regular censusing, I found that Regent Honeyeaters often returned to the same sites whether they were flowering or not. The local physical structure (physiognomy) and species composition (floristics) of their habitat may be more important factors than resource availability, and this will be tested in Chapter 3.

Associations of Regent Honeyeaters with other honeyeaters

Regent Honeyeaters generally selected habitat that supported a high richness and abundance of other honeyeater species. In other words, they appear to be a high *S* species (Diamond 1975a). Regent Honeyeaters typically occupied habitat with low densities of the aggressive Noisy Miner, which is reputed for displacing many woodland birds from their territories (Loyn 1987, Caterall *et al.* 1991, Barrett 1995, Clarke *et al.* 1995, Grey *et al.* 1997). The densities of Noisy Miners in the Bundarra-Barraba region are much lower than in northeastern Victoria (Clarke *et al.* 1995, Grey *et al.* 1997), and parts of the Northern Tablelands of New South Wales (Barrett 1995). Therefore, Regent Honeyeaters in the Bundarra-Barraba region are less likely to interact with, or be displaced

by, Noisy Miners, than in other regions In fact, I recorded relatively few aggressive interactions between the two species in Chapters 4 a id 7.

Regent Honeyeaters were strongly associated with Noisy Friarbirds and Red Wattlebirds, which displace and out-compete smaller necta ivores, such as Regent Honeyeaters. Behavioural studies in Chapter 4 and 7, however, show that the level of aggression was relatively low between Regent Honeyeaters and Red Wattlebirds. Regent Honeyeaters mostly fought with Noisy Friarbirds and Fuscous Honeyeaters (Chapters 4 and 7), which is supported by the strong positive correlations between the species in my regression n odels. The rates of attack between Regent Honeyeaters, Fuscous Honeyeaters and Noisy Friarbi ds were much lower than those measured between Regent Honeyeaters and Noisy Friarbirds by Davis and Recher (1993), who postulated that Regent Honeyeaters may be declining due to breeding failure associated with high aggression with competitors. In situations where Regent Honeyeaters shared habitat with high densities of larger nectarivorous birds, they tended to avoid aggressive competition by selecting trees or patches with low densities of larger birds. It is possible that these patches had lower food value than those targeted by larger species. In other words, a hidden form of competitive exclusion from the best resources may exist between Regent Honeyeaters and larger honeyeaters, which cannot be measured behaviourally.

Significance of the Bundarra-Barraba region for general avian biodiversity

The species richness and abundance of birds in the Bundarra-Barraba region, is among the highest recorded for Australian wooded ecosystems. This high avian biodiversity is probably influenced by the region being in a transition zone be ween the semi-arid zone and eastern coastal forests. The mean density of birds (42.8 birds/ha.) in the region, is 11% higher than for birds in cool temperate rainforest (38.4 birds/ha.) (Shields *et al*. 1985), and over 300% greater than the highest density recorded by Mac Nally (1997) in a 100(ha. area of woodland east of Melbourne. Most surveys of birds in southeastern Australia have taken place in four major habitat formations; tall open forest, open forest, low open forest, and woodland (Recher 1985). Open forests have the smallest total bird densities (0.5-15 birds/ha.), followed by woodland and low open forest (12-24 birds/ha.), with the highest densities (30-35 birds/ha.) in tall open forest.

The highest number of birds recorded in a single one-hectare transect count during this study was 186, which is over twice the highest number recorded by Pyke and Recher (1986) (77 birds/ha.) in dry open forest and heathland near Sydney. The only study to report higher bird densities than mine was by Howe (1984), who recorded 54.5 birds/ha. in continuous areas of open forest near Walcha, New South Wales, which is 27% higher than my results. Howe did not use a transect survey method, and probably over-es imated density by using point counts, which included birds that came into the sites during the census. The use of small transects in my study probably also inflated bird densities, because they cid not incorporate larger scale variabilities in bird densities. Most bird surveys in Australia have used a strip transect protocol, but over greater distances and areas. However, it was necessary to confine my transects to one-hectare, as many of the patches I surveyed were too small for larger plots.

The average bird species richness for all 1,209 surveys in the Bundarra-Barraba region (9.7 species/ha.), was higher than that found by Shields *et al.* (1985) in wet forest in the Hasting's River catchment, in northern New South Wales (6-8 species/ha.), but lower than that found by Smith (1985) in forests near Bega, in southern New South Wales (6-18 species/ha.). Many bird surveys in open forest in coastal southeastern Australia have measured species richness at a variety of different spatial scales (Kavanagh *et al.* 1985, Loyn 1985, Milledge and Recher 1985, Recher *et al.* 1985, Shields *et al.* 1985, Smith 1985), with species richness ranging from one to 61 species, at scales from one to 50 hectares. Mulga woodland bird studies have also been conducted at different scales. Cody (1994) and Recher and Davis (1997), recorded 21.5 species in five hectares, and 19-37 species in 20 hectares, respectively. Hence, comparisons with my results are difficult.

The average bird species richness in the Bundarra-Barraba region was higher than the richest site (8.5 species/ha.) surveyed by Barrett (1995) on the nearby Armidale plateau. Furthermore, bird densities in my study were about four times higher than on the Armidale plateau during a prolonged drought (8.3-11.1 birds/ha.) (Ford *et al.* 1985), and twice as high as densities measured before the drought (21.5-23.6 birds/ha., Ford and Bell 1981). The studies by Ford and Barrett, and their colleagues, come from a variegated and degraded agricultural landscape, which has been cleared more extensively than the Bundarra-Barraba region. In contrast, I did not survey badly degraded habitat, such as narrow roadside strips or isolated farmland remnants. If I had surveyed the spectrum of habitat quality in the Bundarra-Barraba region, then the average bird density and species richness would have been lower. Many of my transects were either in continuous habitat or

remnants with some degree of connection to larger patches. Habitat quality, patch size and connectivity play an important role in maintaining avian richness and abundance (Barrett 1995). They may also be important in determining the presence of Regent Honeyeaters in the Bundarra-Barraba region. This will be addressed in the next chapter.

The high bird abundance and species richness in the Bundarra-Barraba region can be attributed to nectar-dependent bird species, which were attracted, in large numbers, to the copious flowering of Box/Ironbark woodland. Box/Ironbark woodland flowering events attract large numbers of lorikeets and honeyeaters to the Bundarra-Barraba region, and elsewhere in southeastern Australia (e.g., Mac Nally and McGoldrick 1997). Mugga Ironbark is a renowned nectar producer (Goodman 1973, Chapter 5), and supported as many as 183 nectarivores per hectare in the Bundarra-Barraba region in July 1994 In contrast, other forest and woodland types flower sporadically, and at levels much lower than in Box/Ironbark woodland and, therefore, support fewer nectarivores. However, the insectivorous bird species richness in other studies is the same, or higher than in my study.

2.7 Conclusions

The Bundarra-Barraba study area is an important stronghold for Regent Honeyeaters in northern New South Wales, and supports relatively large populations of other bird species, which are declining elsewhere. Therefore, sensitive management of all habitat types in this region is needed for the future survival of Regent Honeyeaters, and for the maintenance of richness and abundance of all bird communities. How to manage native vegetation in the Bundarra-Barraba region is a decision that has to be made quickly before further habitat decline occurs. If this can be achieved through co-operation and understanding from landowners, this region may one day be renowned for its biodiversity in woodlands and other habitats. Apart from the benefits to rural production associated with ecologically-sensitive management of remnant native vegetation, preserving Australia's natural heritage for future generations should be incentive enough for proper land management in the Bundarra-Barraba region.

The status of the Bundarra-Barraba region as an important stronghold for Australian woodland avian biodiversity will be diminished, however, if current land management practises continue. Habitat degradation will proceed in the same manner as it has in many parts of southeastern and southwestern Australia, with the eventual outcome of numerous local and regional extinctions of

bird species (Saunders 1989, Robinson 1991, Barrett *et al.* 1994, Recher 1996). Birds have already disappeared at an alarming rate in degraded woodland in Victoria, and the tablelands of New South Wales. Therefore, the need to protect and sensitively manage native vegetation in areas like the Bundarra-Barraba region becomes increasingly important for the future survival of Australia's unique natural heritage.