THREATENED AND DECLINING BIRDS IN THE NEW SOUTH WALES SHEEP-WHEAT BELT:

I. DIAGNOSIS, CHARACTERISTICS AND MANAGEMENT

Hooded Robins (Photograph by Graeme Chapman)

JULIAN R.W. REID

C/- CSIRO Wildlife and Ecology, GPO Box 284, Canberra 2601;
j.reid@dwe.csiro.au

OCTOBER 1999

A consultancy report prepared for the New South Wales National Parks and Wildlife Service through Threatened Species Unit funding.

THREATENED AND DECLINING BIRDS IN THE NEW SOUTH WALES SHEEP-WHEAT BELT:

I. DIAGNOSIS, CHARACTERISTICS AND MANAGEMENT

Julian R.W. Reid **October 1999**

Project Manager:

Sue V. Briggs

CSIRO Wildlife and Ecology, GPO Box 284, Canberra 2601; s.briggs@dwe.csiro.au

Design and Layout Assistance:

Jenny Baxter

CSIRO Wildlife and Ecology, GPO Box 284, Canberra 2601; j.baxter@dwe.csiro.au

Disclaimer:

Citation:

Reid, J.R.W. 1999. *Threatened and declining birds in the New South Wales Sheep-Wheat Belt: I. Diagnosis, characteristics and management.* Consultancy report to NSW National Parks and Wildlife Service. CSIRO Wildlife and Ecology, Canberra.

Threatened and declining birds in the New South Wales Sheep-Wheat Belt:

I. Diagnosis, characteristics and management

'One thing that is very vivid in my mind is riding through our back paddock as a child on a wonderful spring day. The country was uncleared in those early years and was moderately timbered with Wilga, Rosewood, Buddah, Currant Bush, Narrow-leafed Box etc. Along with the scent of the daisies, Wilga and Buddah flowers is the beautiful call of the ***Crested Bellbird****. Equally vivid is the memory of lying in bed at night listening to the haunting call of the* ***Bush Curlew*** *and, on a moonlit night, the excited chorus as they danced. Since the land was cleared both have become a rarity.'*

David M. Johnston, Baradine, 29 April 1999

ACKNOWLEDGMENTS

This report completes Phase 1 of a continuing research program that is examining the status, threats, habitat, life-history characteristics and other management needs of threatened and declining bird species in the Sheep-Wheat Belt of New South Wales. I owe my chief debt of gratitude to the Project Manager, Dr Sue Briggs (NSW NPWS), for initiating the research and for subsequent direction and collaboration; her colleagues, J. Seddon and S. Doyle, have also been unstinting in their help – for access to their preliminary results from unpublished data sets, thanks to all three. Sue gave the report the benefit of a final edit. To David Freudenberger (CSIRO Wildlife and Ecology) and James Watson (ADFA) for access to preliminary results from unpublished data sets, again much appreciation. Colleagues R. Allen, M. Clayton, A. Fisher, C. Kinross, R. Major, D. Robinson, N. Schrader and B. Traill have also been liberal with their expertise and materials in advance of formal publication.

In addition to the aforementioned, the research has benefited from discussions with and comments on a draft report by the following: M. Austin, G. Barrett, G. Carpenter, C. Catterall, J. Eckert, H. Ford, D. Goldney, D. Johnston, N. Kurtz, R. Lambeck, D. Lindenmayer, R. Mac Nally, P. Masters, I. McAllan, A. Morris, N. Nicholls, D. Oliver, A. Overs, D. Paton, H. Recher, N. Reid, D. Saunders, D. Shelly, B. Walker, S. Walpole, A. Wilson and J. Woinarski.

Finally, Steve Morton's enthusiasm and guidance have been essential to the study's progress. Through his support and that of the host institution generally, CSIRO Wildlife and Ecology, I am provided with professional succour and nourishment second to none. I particularly thank Guy Barnett, Jenny Baxter and Inge Newman for their help.

Julian Reid, 28 October 1999

TABLE OF CONTENTS

EXECUTIVE SUMMARY

It is emerging that bird communities throughout the southern Australian regions dedicated to cereal growing and sheep production are in crisis. In many parts of the 'temperate agricultural zone' (TAZ), over 80% of the original native vegetation cover, and frequently over 90%, has been cleared for production. Populations of bird species dependent on natural habitats have been devastated. At the same time, a smaller number of opportunistic native and a few exotic species have benefited from the wholesale changes to the land, allowing them to spread and increase so that they now dominate the regional avifaunas. Massive changes have occurred to the structure and composition of the bird communities in these production landscapes, as some species have declined or disappeared while others have increased and spread. Increasing homogenisation of the avian biota across temperate southern Australia is occurring as bird communities become increasingly similar in their composition. More insidious than these changes, however, is the 'new' wave of declines and local extinctions among certain bird species, reported from all parts of the TAZ. These trends towards local extinctions, reduced avian diversity and increased homogenisation of regional landscapes appear to be accelerating **despite the fact that in most regions land clearance has effectively halted.**

In view of these alarming circumstances a study was commissioned by the NSW National Parks and Wildlife Service to review the topic of threatened and declining birds in the state's sheep-wheat belt and provide advice on their management. Specific objectives of the study were to collect information and knowledge about:

1. Bird species at risk (threatened and declining) in the sheep-wheat belt of NSW,
2. Characteristics of these bird species (i.e. intrinsic factors such as life-history attributes),
3. Characteristics of the habitats needed to sustain viable populations of these species; and to
4. Prepare preliminary guidelines for rehabilitation of habitats to meet the requirements of threatened and declining bird species in the sheep-wheat belt of NSW.

The sheep-wheat belt (SWB) as defined here extends from the western portion of the central tablelands to the Western Division boundary, but excludes a large chunk of wet forests and alpine and sub-alpine formations in the far south of the state. Woodlands and open (dry) forests are the major structural forms of vegetation in the region, but mallee, other shrublands and grasslands are included in this review. A list of 251 species of landbirds of regular and historical occurrence was compiled for the SWB. These were the primary focus of the study. This list includes 103 non-passerine and 148 passerine species; 11 are introduced species.

Species were classified into two status categories, Threatened and Declining. The Threatened category includes Endangered and Vulnerable bird species formally listed under federal and state legislation. Declining species were identified by this study as explained below. As well, two species of Special Concern were identified based on other information from the NSW SWB and the wider TAZ – their rarity and declining status indicate they are Vulnerable to extinction.

There are 38 Threatened (Vulnerable and Endangered) species of landbird, listed under federal and state conservation legislation, that occur (or occurred historically) in the NSW SWB. Eleven of these are classified nationally as Threatened. A further 27 are listed as Threatened in NSW. The taxonomic relationships and life-history attributes of these Threatened species were compared statistically with the group of 20 Declining species identified by this study to see if the two groups differed in certain biological and ecological aspects.

Three main types of information were used to identify Declining species. First, the primary ornithological literature was reviewed with particular attention paid to authoritative reviews of a district's avifauna (published expert opinion). Second, unpublished expert opinion was solicited from a few regional ornithological authorities. The third source comprised the results of modern, quantitative, stratified surveys of regional avifaunas, designed partly to shed light on potential risk factors that have been implicated in the decline of woodland birds.

Eleven primary studies and sources of expert opinion were designated as comprehensive. These were used to tabulate the frequency with which species were diagnosed as being at risk within a particular district or region in the SWB. In the case of three of the primary sources the diagnoses were based partly on my interpretation of the survey data. Otherwise the diagnoses had already been made. Altogether, 85 species were identified in at least one study to be locally extinct, declining or otherwise at risk. For reasons of generality, Declining species were defined for the purposes of this study to be species identified as being at risk in at least three studies, and 20 bird species in the SWB were so diagnosed. They are:

Emu	*Dromaius novaehollandiae*
Painted Button-quail	*Turnix varia*
Brown Treecreeper	*Climacteris picumnus*
Speckled Warbler	*Chthonicola sagittata*
Chestnut-rumped Thornbill	*Acanthiza uropygialis*
Southern Whiteface	*Aphelocephala leucopsis*
Jacky Winter	*Microeca fascinans*
Red-capped Robin	*Petroica goodenovii*
Hooded Robin	*Melanodryas cucullata*
Eastern Yellow Robin	*Eopsaltria australis*
Grey-crowned Babbler	*Pomatostomus temporalis*
White-browed Babbler	*P. superciliosus*
Varied Sittella	*Daphoenositta chrysoptera*
Crested Shrike-tit	*Falcunculus cristata*
Crested Bellbird	*Oreoica gutturalis*
Rufous Whistler	*Pachycephala rufiventris*
Restless Flycatcher	*Myiagra inquieta*
White-browed Woodswallow	*Artamus superciliosus*
Dusky Woodswallow	*A. cyanopterus*
Diamond Firetail	*Stagonopleura guttata*

All 11 studies and sources identified the Hooded Robin as being at risk, and it is the standout Declining bird species in the SWB. All but two of the 20 Declining species are passerines or 'typical bush' birds. This contrasts with the 38 Threatened species – 24 non-passerine and 14 passerine species. Both these results are significant departures from the expected ratio of 2:3, the approximate proportion of non-passerines to passerines for all SWB birds. In terms of the taxonomic composition of the 18 passerine 'Decliners', four families are over-represented: Pardalotidae (thornbills and allies: 3 spp.), Petroicidae (robins: 4), Pomatostomidae (babblers: 2), Pachycephalidae (whistlers: 3). Significantly, the large Family Meliphagidae (honeyeaters) is not represented among the Declining species. It is noted that four of its members are formally Threatened, while a fifth, the Black-chinned Honeyeater *Melithreptus gularis*, is highlighted as a species of Special Concern in the SWB despite it not warranting inclusion using the above criterion (chiefly because it is too scarce to be detected!). The Black-chinned Honeyeater epitomises the plight of birds in south-eastern Australian temperate woodlands and open forests, having its natural (historical) range confined to this region. A second species of Special Concern, White-browed Treecreeper *Climacteris affinis*, was diagnosed from the primary ornithological literature reviewed other than the 11 comprehensive studies. It too is a scarce species, infrequently recorded. However, although restricted within the study region to the drier western margins of the SWB, this species extends further west into semi-arid regions.

As previous observers have noted, members of the 'Australian flycatcher' assemblage[1] are strongly represented among the Decliners – 8 of the 22 species occurring in the SWB. Four of the remainder in this group[1] are already listed as Vulnerable or Endangered. That is, more than half of the 'flycatcher' guild is at risk of disappearance from extensive tracts of the NSW SWB. Most of these species were described by early ornithologists in the region as common and widespread.

When the 60 landbird species at most risk (Threatened, Decliners, Special Concern) are considered together, the following (loosely taxonomic) groups stand out with 20% or more of their members represented. The groups are diurnal raptors (5); owls (4); dryland waders (2); pigeons (2); parrots and cockatoos (9); treecreepers (2); wrens, thornbills and allies (7); robins (6); babblers and quail-thrushes (3); whistlers and allies (5); finches (2). Old Australasian and Gondwanan lineages are much more at risk than 'recent' invaders that include cuckoos, corvids, finches, swallows, and true (Sylviid) warblers. Monotypic genera are also over-represented amongst Threatened and Declining species, lending further support to the notion that taxonomic isolation ('old age' in evolutionary time) predisposes a species to extinction.

Ecologically, the 20 Decliners are characterised most strongly by being ground and/or low-shrub feeders and dwellers – only three species are classified as canopy foragers, and two are aerial insectivores (the woodswallows). There is a predominance of insectivores among the ground feeders (15) and among all 20 Decliners, but seed-eaters are as well represented as expected from their proportion of all SWB bird species. This result is at direct odds with that for Threatened species in which significantly fewer insectivores are represented.

Several other striking ecological contrasts between Decliners (D) and Threatened (T) species were revealed by simple two-way table analysis (likelihood ratio chi-square tests). Considering passerines only, there is no difference in absolute mass or mean local density estimates for either group relative to all species in the SWB but, when their Australia-wide

---

[1] this group was until recently considered to be a natural taxonomic lineage contained within one large cosmopolitan Family. Australian species are now placed in three distinct Families

geographic ranges are considered, **T species have significantly smaller ranges and D species significantly greater ranges than all species**. This difference between D and T bird species was reflected in the following results. A greater proportion of T passerines is restricted to lower-rainfall portions of the country than high-rainfall areas or both. By contrast D passerines are over-represented, though not significantly, in both low and high rainfall regions across Australia. T species, both non-passerine and passerine, forage in significantly fewer ‘macrohabitats’ than all species, while the trend is reversed in D species, again non-significantly. Macrohabitats are the broad life zones defined previously in the *Action Plan for Australian Birds*. Having relatively large Australian ranges, Declining bird species therefore tend to occupy a broader range of climates and habitats than the average SWB bird.

Threatened species, non-passerines and passerines combined, are not more variable in the range of dietary items they consume, but Decliners (and all At Risk taxa combined) consume significantly fewer types of food than SWB birds in general. Neither the absolute mass of D nor T passerine species varies when compared to the average SWB passerine. However, when potentially confounding effects of phylogeny are controlled for, At Risk passerines (n = 32, i.e. D and T combined) tend to be heavier than their mean Family weight ($P < 0.05$; this trend is apparent for D and T species analysed separately, but the results were not significant). There are no significant trends in the range of vertical habitat strata used for foraging by D or T species when compared, respectively, with all SWB bird species. Generally then, Threatened and Declining bird species in the SWB share these characteristics: they tend towards dietary specialisation and they are slightly heavier than the average member of the Family to which they belong.

The Decliners are a different group of birds, ecologically and biogeographically, from the listed Threatened species. Threatened species are typically of low abundance (rare) and/or restricted range, often being top predators or having a relictual distribution. Historically, Decliners held large Australian ranges but, in the sheep-wheat belt at least, where they were formerly common, their populations are dwindling and they are at risk of local extinction across extensive parts of the landscape. It is an article of faith or supposition only, that populations of these species will be secure in the larger national parks and some other large tracts of (semi-) natural habitat within the region. The gathering of baseline data, implementation of sound (long-term) monitoring programs, and active management, even manipulation, of habitat patches **and entire landscapes**, will be crucial elements in conservation planning aiming to arrest these declines. Focussed, single-species research, targetting a few of these Decliners, needs to be instigated urgently to uncover the precise reasons for the negative population trends. However, the lack of definitive research results should not be used as an excuse for any delay in immediately implementing management and rehabilitation of habitats and landscapes in the SWB of NSW (and elsewhere in Australia). Results from short-term research may be inconclusive or even misleading if considered in isolation. For example, the following observation recurs frequently in conversation and the literature - ‘that bad drought of '82 (or '97 or '65) really knocked the small birds around; they never seemed to recover.’ Hence longer-term, community-wide monitoring is argued for, to complement intensive single-species research.

Droughts and some other natural events cannot be planned for, or managed directly. Other pressures can be managed, however, and sound planning and sensitive management may help to ameliorate the effects of ‘catastrophic’ events like drought. The selective clearance of particular vegetation types on fertile soils has probably been the major, ultimate cause of the current plight of most Declining and Threatened bird species in the SWB. Further clearance of these associations should be halted forthwith; these most fertile and better-watered portions of the landscape should become the major focus of landscape remediation including, but much more than, revegetation.

If over-clearance, generally, and selective clearance are the ultimate drivers of decline in bird populations and diversity in the temperate agricultural zone, then the ongoing decline in habitat quality at the patch level is likely to be the proximate threatening process that needs most urgent attention. Stock grazing pressure is considered the biggest single risk factor in this respect. Grazing pressure will need to be removed entirely from the best examples of remnants on fertile soils, and present grazing levels and tactics modified over a significant portion of the remainder. Fencing and adequate compensation are two crucial elements in this restoration strategy, but it has to be stressed that the social context is all-important. Grazing of unimproved pastures, often in remnant woodland patches, is a widespread and legitimate land use. In many cases **tactical stock grazing**, integrated with other measures, could prove to be an **essential ingredient in achieving specific management objectives depending on the state and structure of remnant vegetation.** The strategic, regionally-based, deployment of resources will be vital to ensure that positive outcomes are maximised: the planning of fencing, grazing tactics and revegetation across all spatial scales – farm through district/Shire to catchment/region – will need to become spatially explicit.

Implicit in the need to manage grazing better within remnants is the conclusion that the loss of habitat complexity and quality at the ground and sub-shrub level is the crux of the problem for Declining birds in the SWB of NSW. The loss of green productive plant matter (lichens, bryophytes, herbs, shrubs) is not the sole concern, here. Nor is it simply the loss of structural complexity these plants provide. It is thought that rocks, coarse litter and fallen timber are important contributors to surface and near-surface 'roughness' and microhabitat diversity in intact healthy habitats. In intensively managed farmscapes, even if an overtopping tree cover remains, these ground-layer textural elements disappear over time. No doubt there are sound agricultural, but also partly cultural, reasons as to why such tidying-up practices on a farm are widespread. However, it is possible that their cumulative effect over 150 years has been considerable, and severely detrimental to the terrestrial and soil invertebrate fauna. This may help to explain why ground-foraging, specialised, insectivorous birds have been so adversely affected in these landscapes. Possibly as, or more, serious is the collection of dead timber for fuelwood whether for domestic or commercial use. The southern big centres and cities are the major users of this firewood. Both these issues require urgent and sensitive attention. Other threats are posed by the spread of weeds and pasture species. The conversion of a patchily vegetated ground layer to full cover is detrimental to some ground-foraging bird species. In the short term, the cumulative effects of all these factors should be reversed. Not only should current threatening processes be curtailed, but also deliberate manipulation will be required to restore surface roughness and patchiness to the ground layer through the provisioning of rocks, logs, coarse litter and other debris.

The timber that is preferred for fuelwood tends to be the same species of eucalypts that have been selectively cleared for agriculture. Whether the timber is living, dead and standing, or fallen, it is a precious component of these highly fragmented and modified, remnant landscapes. Urgent review of the commercial fuelwood industry is required, and conversion to 100% use of plantation timber needs to be implemented as soon as possible. It is calamitous that the current rates of removal of natural timber from these landscapes are permitted. Farm forestry offcuts, produced during thinning and harvest operations, could provide an important source of coarse woody debris for restoring ground cover complexity to degraded remnants. Dead timber, standing and fallen, is highlighted in the literature as important components of habitat for two of the worst-affected Declining species in the SWB, namely Hooded Robin and Brown Treecreeper.

I have focussed on management issues from the narrow perspective of avian biodiversity in the NSW SWB. It hardly needs to be stressed that finding appropriate ways to integrate biodiversity conservation measures into whole-farm, whole-catchment, and whole-region planning and management, to meet diverse socio-economic needs and aspirations, is as vital as any of the recommendations made above. Finding novel ways to implement disturbance regimes at patch and landscape scales may, in the long term, be a vital component in the maintenance of biodiversity across all spatial scales in the NSW sheep-wheat belt. The use of fire may be crucial in this respect to allow the regeneration of, and creation of a suitable habitat for an array of biotic groups (not just some plants) that may depend on periodic fires. However, there is a range of forms of mechanically implemented disturbance – chaining, cutting, surface scarifying – that require investigation with experimental trials. The results from these sorts of experiments will best be evaluated over medium to longer time scales, and so these trials need to be instigated immediately. Experimental in this context indicates the need for considerable replication (with controls).

At the landscape scale the imperative is to link remnants functionally so that dispersing birds have a greater chance of colonising patches, whether newly created, unoccupied or presently occupied. Roadside vegetation and stream corridors provide the existing framework on which to plan strategic revegetation initiatives to effect better linkages. It is pleasing to note that some Landcare and catchment-management groups have started to plan strategically in this way already.

One measure of the oft-expressed aspiration for Australian agriculture to achieve environmental sustainability will be the fate of Declining birds in these production landscapes. Unlike the case with formally Threatened species that are generally restricted in occurrence or habitat, a range of the Declining bird species identified in this report occur naturally in most landscapes, at farm scales, across the SWB of NSW. Monitoring systems are currently being established so that their fate will be determined in ensuing years. Getting the right mix of regional planning to link remnants across landscapes and prioritising on-ground management activities to restore habitat quality within and between remnants is the big challenge.

1. INTRODUCTION

There is increasing recognition of the plight of biodiversity in the extensively cleared and modified agricultural production zones of southern and eastern temperate Australia (SEAC 1996). This region, that includes most of the country's higher-rainfall sheep production and lower-rainfall cereal cropping, is hereafter referred to as the 'temperate agricultural zone' (TAZ). The TAZ includes the bulk of the agricultural lands in temperate Australia but excludes both the western pastoral zone and most of the high-rainfall wood-production, forested regions (Fig. 1). The TAZ generates most of the nation's agricultural wealth but, in so doing, the conversion of natural landscapes to largely modified production lands has occurred at the price of the loss of many species of plants and animals from these landscapes. Although known extinctions have been confined mainly to plants (Briggs and Leigh 1995) and mammals (Short and Smith 1994), many other life forms have suffered extensive declines and local extinctions within the TAZ (Recher and Lim 1990). The loss of biotic resources and diversity amongst little-known organisms such as invertebrate animals and non-vascular plants has probably been equally acute, but knowledge of these groups is limited (see Hobbs and Saunders 1993).

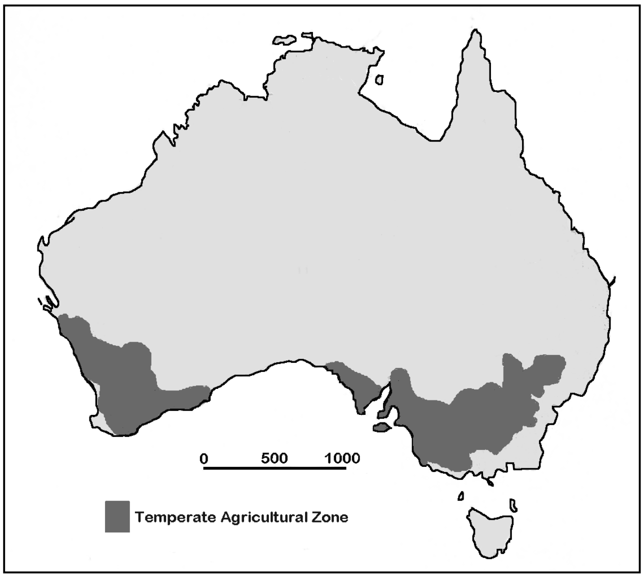


Figure 1 Australia's Temperate Agricultural Zone (TAZ) Re-drawn from Williams, Hook & Gascoigne (1998)

At the same time as biodiversity losses have occurred, land degradation in a variety of guises has impaired the agricultural productivity of these lands over vast areas. At the heart of both these problems has been the removal of most of the original native vegetation cover, the effects of which have been felt and continue to operate across all spatial scales. At local scales, the excessive clearance of native vegetation from hillsides or sand dunes and the overgrazing of the ground cover on both types of landforms have led to soil erosion. At larger scales, from districts, through river catchments to entire drainage basins, the problems of dryland salinity are steadily worsening as a consequence of broad-scale tree removal. Often in these latter cases, land degradation is felt most acutely in locations far removed from where the process of tree removal has had most impact on water table levels. The magnitude of these various problems, and of their solutions, is immense (SEAC 1996).

Australian society and its governments and institutions are acting to tackle the problems of declining productivity and biodiversity in the TAZ. Revegetation is a major plank in the strategy to stem the tide of these losses in productivity and biodiversity and, through diverse funding arrangements, federal and state governments are promoting many initiatives in this area. While the focus of this study and report is just one component of biodiversity, birds, the larger perspective has to be considered. Much of the effort being invested in revegetation, and landscape rehabilitation generally, is directed primarily at restoring health and productivity to ailing agricultural systems. It would be sensible if procedures (e.g. management and administrative processes, communication) could be found whereby a diverse range of benefits, including biodiversity gains, could be maximised from these restoration efforts (e.g. Saunders and Ingram 1995).

Birds are a convenient organism on which to focus: They are diverse (species rich); they are readily studied by direct observation and by amateurs and professionals alike; they are an obvious and vocal component of any landscape and so fondly regarded by much of the wider community; there is a solid historical record for them; their basic ecology and habitat requirements are better understood than for most organisms; and they embrace a wide range of functional types of (consumer) organisms. Amongst animals they are the group most amenable to community-oriented or participatory monitoring, and community participation is a central theme in many of the federal initiatives under the National Heritage Trust umbrella (e.g. the NHT-funded, second 'Atlas of Australian Birds' scheme operated by Birds Australia). While the decline and serious plight of woodland birds in the TAZ have received much attention in recent years (Saunders 1989; Saunders and Ingram 1995; Robinson 1991, 1993, 1994; Robinson and Traill 1996; Ford et al. 1995), much of the information and management recommendations generated has either been general, e.g. broadly applicable to the whole of the TAZ, or too locally specific. Current research activity in this field – the effects of habitat loss and fragmentation on birds - by government agencies and research institutions is increasing. This research, reliant on quantitative and systematic field study techniques, is providing vital information for guiding landscape and habitat restoration in the regions where the research is being conducted (Barrett et al. 1994; Fisher 1997; Major et al. 1998; Date et al. in press). Lunney et al. (1997) concluded that review of and further research into the conservation status of birds across the whole of NSW was required.

This study bridges the gap in management information between the broad and general continental scale and the focussed regional scale. The study's recommendations apply largely to the NSW Sheep-Wheat Belt (SWB) as a whole. This report meets the contractual requirements of the study - Phase 1 of a continuing collaboration between the author, Dr S.V. Briggs, and CSIRO Wildlife & Ecology. Future reports in the series will address these issues at finer regional scales.

English names are used predominantly in the text and scientific names are given in Appendix 1. Many propositions and ecological concepts presented in the report are speculative and have yet to be validated by research in Australian ecosystems. The target audience embraces but is broader than scientific circles.

1.1 Scope, Focus and Aims

A contract was let between the National Parks and Wildlife Service (NPWS) and the author to carry out a 'desktop' review the status of birds in the NSW SWB, focussing on identifying declining species in the SWB, and then on habitat and management requirements of threatened and declining species in the SWB. The duration of Phase 1 was approximately seven weeks and the primary research was undertaken part-time between February and May 1999.

Specific objectives of the study were to collect information and knowledge about:

1. Bird species at risk (threatened and declining) in the sheep-wheat belt of NSW;
2. Characteristics of these bird species (i.e. intrinsic factors such as life-history attributes);
3. Characteristics of the habitats needed to sustain viable populations of these species; and to
4. Prepare preliminary guidelines for rehabilitation of habitats to meet the requirements of threatened and declining bird species in the sheep-wheat belt of NSW.

For the purposes of the study these ‘At Risk’ bird species will be considered in two groups. First, there are the formally recognised threatened species, those listed in relevant NSW and federal legislature (‘Critically Endangered,’ ‘Endangered’ and ‘Vulnerable’). Only the NSW schedules of Endangered and Vulnerable species need to be considered in this context as all nationally listed species are automatically included (*Threatened Species Conservation Act, 1995*; Ayers et al. 1996). These are hereafter referred to as Threatened species. Then there are those species whose populations in the SWB appear to be declining or that otherwise are thought to be at risk of extinction from sizeable portions of their historical range within the region (e.g. Recher 1999): Declining bird species. The definitions and criteria for classifying Declining bird species are made more explicit in a later section of this report. In this report the term extinction (unqualified) relates to species-wide extirpation, while ‘local extinction’ means the loss of a breeding population from a historically occupied area (patch to region). The ‘extinction process’ refers to the process of population decline whether operating locally or globally within the species’ range.

Implicit in the study’s stated aims is the need to consider the threatening factors that are thought to have caused bird species to become vulnerable to extinction and decline (Garnett 1992, 1993). However, as expressed in the objectives above, greater emphasis is given in this study to increasing our understanding of the **habitat requirements** of declining species so that corrective measures can be implemented. However, one example will suffice to illustrate why the full gamut of threatening processes needs to be considered rather than habitat needs alone. There is much circumstantial evidence linking fox predation to the decline and local endangerment of the Bush Stone-curlew (Ford 1979; Reid & Fleming 1992; Garnett 1993; Saunders and Ingram 1995) in the southern half of Australia. Fox predation is probably a major threat, and fox control at the landscape or regional scale would therefore be an integral component of any plan to rehabilitate grassy woodland habitats through vegetation management for the benefit of this species. That is, rehabilitation of patches of habitat at the local scale (on farms) for the stone-curlew is unlikely to be successful in itself without regional and local fox control. Ideally, the prioritising of scarce management funds would take such contingencies into account.

Birds of dryland habitats in the region are the main focus of the study. Wetlands and waterbirds are largely excluded. Dryland habitats in this context include forest, woodland, mallee and grassland. It is becoming increasingly obvious (Robinson 1991, 1993; Ford et al. 1995; Lambeck 1997), that a characteristic suite of species associated with woodland has been hardest hit among all Australian birds by the myriad changes that have accompanied European occupation and land use in Australia. For instance, in Western Australia woodlands were indicative of 'good' agricultural soils, therefore selectively cleared, and so woodland birds suffered mor habitat loss and modification (Saunders and Ingram 1995). Five of the 18 threatening processes identified by Garnett (1993: Table 2) in his analysis of the threats facing Rare and Endangered Australian bird species stand out. Clearance and fragmentation of habitat for agriculture has affected most species (67), followed in order by direct human exploitation, altered fire regimes, grazing, and predation (this last threat mainly relates to offshore island taxa). There is a gap then to competition (by exotic and native species) and shortage of nesting hollows with 24 taxa affected apiece. Obviously the loss of, modification to, and altered configuration of, natural habitat is of major concern. Land clearance for agriculture was identified as the 'single largest threat to biodiversity' in Australia (SEAC 1996). While grassy woodlands on arable soils have been the broad vegetation type most targeted for agricultural development, there are many Threatened birds which depend on heath, forest and mallee communities in temperate Australia (Garnett 1992). All these environments have suffered from excessive clearance to varying degrees. In fact, Garnett's (1992) analysis of the distribution of **nationally Threatened** bird taxa amongst the major habitats in Australia did not reveal temperate woodlands to be as badly off as several other types. It is only when the focus is scaled down to regions and districts that the alarming plight of woodland birds becomes most apparent (e.g. Taylor and COG 1992; Robinson 1991, 1993; Paton et al. 1994; Fisher 1997; Recher 1999).

The geographic scope of the study extends approximately from the western portions of the central tablelands to the Western Division boundary, but excluding a large chunk of wet forests and alpine and sub-alpine formations in the far south of the state (Fig. 2).

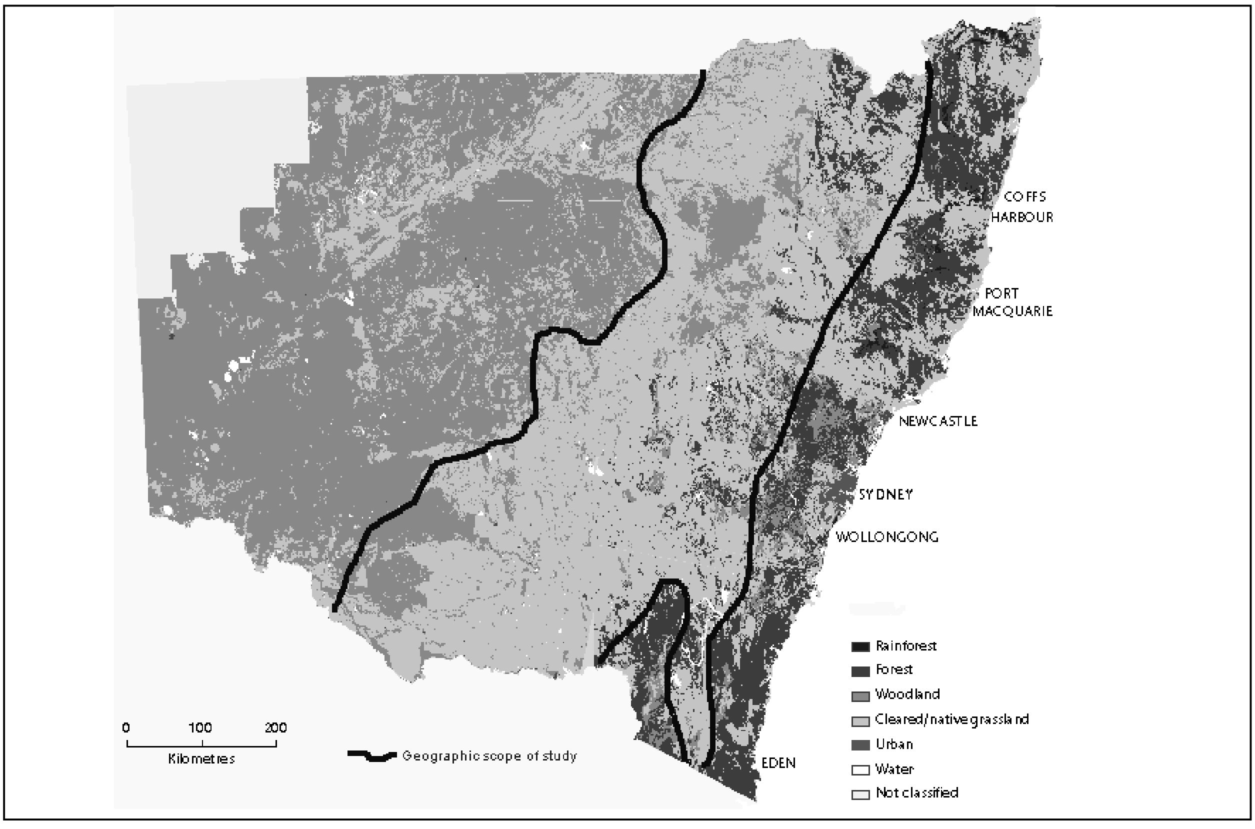


Figure 2: Geographic scope of the study.
Map taken from *Benson (1999)*

The region so defined includes most or all of the following (sub)regions of the interim biogeographic regionalisation for Australia (Thackway and Cresswell 1995):

BBS – the southern (NSW) lobe of the Brigalow Belt South:

DRP – Darling Riverine Plains;

NAN – Nandewar;

NSS – New South Wales South-western Slopes;

and large parts of:

CP – Cobar Peneplain;

NET – New England Tableland;

RIV – Riverina;

SEH – South-East Highlands.

The region is an interesting 'interzone' both climatically and biogeographically (Bauer and Goldney in press). Two patterns in rainfall account for this. One is seasonality, and the line of summer-winter rainfall equivalence practically bisects the region, with an increasing summer predominance to the north (e.g. Nix 1982). The other is the moderately steep gradient in mean annual rainfall across the region; it decreases from some 1000 mm in the east to 300 mm in the west. Many bird species with Torresian or tropical affinities and origins penetrate the northern (and eastern) parts of the study region; a few occur throughout. While the avifauna as a whole has predominant Bassian affinities in line with the entire south-eastern Australian fauna, a marked faunal changeover occurs from east to west within the region, with Eyrean species becoming more frequent as the rainfall decreases. The natural patterns in bird distribution are much more complex than this simplified account portrays, and Schodde (1981, 1990) can be consulted for further details. One pattern has relevance here: Schodde (1990) recognised that the mallee biome has played an integral role in the development, in evolutionary terms, of the Eyrean avifauna, and he described several putative speciation pathways as evidence. Many examples of replacement taxa occur in the SWB – both members of pairs of closely related subspecies or species that are allopatric or parapatric occur in the region. These biogeographic patterns, with many taxa having distribution limits within the region, have more than academic interest. Within species, populations at the margin of their range contribute greatly to genetic diversity and, ultimately, speciation events. The ultimate goal of biological conservation is to allow evolution to follow its 'natural' course. Also and related, niche theory predicts (Brown 1984) and empirical evidence shows (Rey Benayas et al. 1999) that species at the margin of their geographic distribution tend to occur patchily and at low abundance (Barrett et al. 1994).

Land use patterns reflect much of the biophysical variation expressed in the region and briefly described above. Sheep grazing on improved pastures is the predominant agricultural activity on the tablelands and upper slopes in the higher-rainfall eastern districts, while cereal cropping is the major activity on the plains. Vegetation clearance patterns reflect these and other influences, and so variegated landscapes (McIntyre and Barrett 1992; Barrett et al. 1994), where scattered remnant trees are left over improved and some native pastures, are characteristic of grazing lands, while patch-structured, fragmented landscapes typify the cropping areas. Again, the spatial arrangement of remnant vegetation, including isolated trees, that results from the conversion of once naturally vegetated landscapes to production landscapes is thought to influence significantly avian responses to land clearance. However, the most pervasive influence is the percentage of native vegetation cleared or extensively modified (Bennett and Ford 1997), and the comparison of 'remnancy' figures across similar sized districts and regions is the most useful indicator of the health of an area's avifauna, once clearance has proceeded beyond 70-80%. Any biota dependent on natural habitat is predicted to be in a parlous state once these thresholds are breached (Fahrig 1997). Therefore it is somewhat surprising to find some Australian research that indicates 10% remnancy may suffice to conserve most of the habitat-dependent avifauna: in northern Victorian box and ironbark landscapes (Bennett and Ford 1997) and in the Western Australian Wheatbelt (Lambeck 1999). Other important aspects of remnant vegetation, such as type, size and condition - none of which are independent of the other - are discussed below.

1.2 DIAGNOSIS OF THREATENED AND DECLINING SPECIES

Endangered and Vulnerable bird species of the SWB were defined as that subset of the scheduled NSW species that are considered to have been of regular occurrence in the region. Species of vagrant occurrence (as determined from Morris et al. 1981) were excluded, as were species that occurred at the extreme eastern margin of the region only.

There are 110 species and distinct subspecies classified as Threatened or Extinct in NSW and its offshore territories. Of these, 25 are offshore species (marine and oceanic islands) and 16 are coastal. Of the remainder, 11 are waterbirds and 58 are landbirds. Of this group of 69 inland species, eight waterbirds and 38 landbirds and raptors are considered to be, or to have been once, of regular occurrence in the SWB (Table 1). When the state is divided into three arbitrary rainfall zones – dry (Western Division), SWB (sub-humid) and wet (coastal plains and eastern parts of the Dividing Range) – more Threatened NSW bird taxa occur predominantly in the other two zones than in the SWB. Considering landbirds alone, 21 Threatened species occur predominantly or co-predominantly in 'forest' (includes wet heath), 17 in woodland and grassy woodland, and 19 in arid-zone habitats. Only one species was historically widespread in all three zones, the Bush Stone-curlew, and it was assigned to the woodland group as this is the species' preferred habitat/zone. One species, the Eastern Grass Owl, could not be assigned to any of these broad climatic zones. Using a finer-grained regionalisation, Lunney et al. (1997) concluded that south-eastern NSW contained the greatest number of threatened birds. When it is remembered that more NSW species of birds occur in damp forest and other moist habitats than in the other two zones, and that fewest occur in arid lands, it eventuates that the state's arid and semi-arid lands have the greatest proportion of threatened bird species. The SWB woodlands and allied habitats do not support a greater proportion of listed or scheduled Threatened species than expected by chance (so why the fuss?). This result contrasts with the earlier analyses of Robinson (1991, 1994) who demonstrated convincingly that woodland birds in Victoria were much more 'at risk' than birds of other broad vegetation formations. However, he adopted a broader definition of conservation risk than the formal state list of Vulnerable and Endangered species.

Table 1. NSW-Listed Threatened Dryland Birds of the Sheep-Wheat Belt

Species	National	NSW	Typical Woodland Species
Malleefowl	E	E	
Osprey	-	V	*
Square-tailed Kite	-	V	W
Black-breasted Buzzard	-	V	*
Red Goshawk	E	E	
Grey Falcon	V	V	*
Australian Bustard	-	E	
Plains-wanderer	E	E	
Bush Stone-curlew	-	E	W
Flock Bronzewing	-	E	*
Squatter Pigeon	-	E	*
Red-tailed Black-Cockatoo	-	V	*
Glossy Black-Cockatoo	-	V	W
Major Mitchell's Cockatoo	-	V	
Purple-crowned Lorikeet	-	V	*
Superb Parrot	-	V	W
Regent Parrot	-	E	
Swift Parrot	V	V	W
Paradise Parrot	X	X	
Turquoise Parrot	-	V	W
Powerful Owl	-	V	*
Barking Owl	-	V	W
Masked Owl	-	V	W
Grass Owl	-	V	
Striated Grasswren	-	V	
Thick-billed Grasswren	V	E	
Shy Heathwren	-	V	
Redthroat	-	V	
Regent Honeyeater	E	E	W
Purple-gaped Honeyeater	-	V	*
Painted Honeyeater	-	V	W
Pied Honeyeater	-	V	
Pink Robin	-	V	*
Southern Scrub-robin	-	V	
Chestnut Quail-thrush	-	V	
Red-lored Whistler	V	E	
Gilbert's Whistler	-	V	W
Black-throated Finch	-	E	

* atypical birds, vagrants only in Sheep-Wheat Belt or records confined to extreme margin (A. Morris, *personal communication)*
E: Endangered; V: Vulnerable; Nat.: National Status anticipates proposed changes (S. Garnett and G. Crowley, *personal communication*).
Distributional sources: Morris et al. (1981); Blakers et al. (1984)

The identification of Declining species as distinct from listed Threatened species is more problematic. There are problems of scale, generality and the lack of hard data. The strongest evidence for decline is derived from a historical baseline (gathered over a sufficient period, years, to encompass shorter-term fluctuations) to which subsequent data can be compared. Ideally, we would have long and continuous time series of population abundance for all species of management interest. I am unaware of any such data sets for dryland bird species of conservation significance in NSW, but some may exist.

A theoretical definition of a Declining species is one whose population has decreased by a significant amount greater than that predicted by the direct loss of its suitable habitat alone. Of course this is not a workable definition because, as just indicated, we do not know the size of populations at *ca* 1750, nor the natural densities of species in different classes of habitat. In general, we must use indirect means for identifying Decliners. However, range contraction and local extinction at scales greater than the individual patch are deemed to provide fairly hard evidence for decline (e.g. Garnett 1993; Smith and Smith 1994). Similarly, the loss of a species from a number of individual patches in different districts would also constitute solid evidence for decline.

In the absence of high quality trend data, we are reliant on four types of information sources and methodologies to identify Declining species:

1. Expert opinion;
2. Deduction from general principles of ecological theory;
3. 'Low quality' trend or change data (e.g. Atlas data from two or more time periods);
4. Large quantitative data sets that are analysed
   A) to show rarity, whether low local abundance or low frequency of occurrence, and
   B) to detect a systematic trend, spatially, in response to postulated threatening processes.

The boundaries between these categories blur, but they provide a useful framework from which to tackle the problem. I have largely used information sources 1 and 4 for the diagnosis of Declining species in the NSW SWB. Expert opinion ranges from unpublished anecdote to published syntheses (but not data driven) of long-term, knowledgeable residents in an agricultural district (e.g. Baldwin 1975: Inverell; Schrader 1987: Parkes Shire). A range of ecological surveys and community studies has been conducted in the region in recent years, but few have been widely published (but see Barrett et al. 1994). Similarly, regional Bird Atlasses that are analysed rigorously can be informative, and in the SWB there are two published examples: for the ACT (Taylor and COG 1992), and the Armidale region (Ford and McFarland 1991). The Victorian Bird Atlas (Emison et al. 1987) is another good example from outside the region. Atlasses become most useful for diagnosing species that have changed in distribution or 'abundance' (detection frequency actually) when they can be repeated. A good example of this can be found in the two Atlasses of the Adelaide region (SAOA 1977; Paton et al. 1994), conducted ten years apart. Paton et al. (1994) concluded that a wide range of woodland bird species had declined in the intervening 10 years and observed that it was a similar set to that identified by Robinson (1991, 1993) in Victoria. See also Saunders and Ingram's (1995) use of Atlas data for the Western Australian Wheatbelt to detect historical declines.

Systematic ecological surveys (e.g. Barrett et al. 1994; Fisher 1997; Lambeck 1997; Major et al. 1998; Freudenberger 1999), if carefully designed using an appropriate stratification, are particularly revealing. Species exhibiting the following patterns in patch use and occupancy are likely to be most at risk:

- occurring in only a few patches;
- confined to large remnants;
- restricted to one or few habitat types;
- restricted to patches in very good condition (as indicated generally by ground cover, surface roughness, coarse litter and debris, and shrubbiness);
- (and perhaps) isolation – absent from patches a long distance from similar- or greater-sized patches.

This last indication of decline, involving isolation, is derived from island biogeography theory and is unlikely to be apparent **on its own** for birds in fragmented agricultural landscapes. The other responses will generally be more immediately apparent. In fact most of these effects are not independent of the rest, and Declining species usually exhibit a number of these responses (Caughley 1994; Fisher 1997; Lambeck 1997, 1999; Major et al. 1998; Freudenberger 1999; J. Seddon and S. Briggs *personal communication*).

Although there is much ecological theory underpinning the use of survey data for indirectly getting at the identity of Declining species, the method is a distinctly different process from that used to derive information from source 2 (deduction from first principles alone) in that it is data-driven and regionally focussed. Ecology does not have a good record in making accurate predictions from theory alone and, while it is an insightful practice to undertake before collecting data (see, for an example, Mac Nally and Bennett 1997), little confidence can usually be placed in the outcomes (R. Mac Nally and A. Bennett *personal communication*; Lambeck 1999). The combination of sound theory and empirical data provides far more powerful tools. Other things being equal, rarity does predispose a species to extinction (Soulé 1986; Pimm 1993; Gaston 1994), and in a highly fragmented landscape most of the patch-occupancy indicators listed above are surrogates for rarity of one form or another (Rabinowitz et al. 1986).

Many separate sources of information were used to assist with the identification of Declining bird species in the NSW SWB. The quality of the information varies as does the spatial scale at which it applies. For example an ornithologist may have studied the birds of the back paddock for 30 years and recorded three species that disappeared in that time. While this is convincing evidence that those species did become locally extinct at this small scale, the observation has no generality of itself. Only if a species is reported to have disappeared from a number of such patches can it be concluded that the species is likely to be in decline. Often the information is not as specific as the first example, but applies to a broader area, e.g. a rural district (or Shire) around the main shopping centre. Here, the observations often take the form of, for example, 'the species not seen for many years, since the big drought of 1982', or 'Hooded Robins now scarce where they were once common'. Because such information applies to a broader area and assuming the statements are factual, greater weight should be accorded them than to an isolated patch extinction event. Where the same species is reported to be in decline or locally extinct in three or more districts within the SWB, this is construed as firm evidence for the generality of the problem such a species is facing and its status as a Declining species. Generality does not necessarily imply that the species is at risk of local extinction throughout (the greater part of) the SWB (regional extinction), but in some cases such as Hooded Robin this appears to be the case. In other cases, such as the Grey-crowned Babbler, the extinction process has not operated so uniformly in a geographic sense. The nominate subspecies is effectively extinct in the south-eastern parts of its historical range (South East of South Australia and western Victoria, e.g. Parker et al. 1983), undergoing an alarming decline in north-central Victoria and adjacent parts of NSW (D. Robinson and A. Overs *personal communications*), but is still moderately common further north in the NSW SWB (D. Johnston *in litt.*).

This sort of complexity just described – variation within and among bird species in the geographic (and temporal) patterns of decline – will have to be dealt with and understood, if we are to find solutions to the problem of Declining species in the SWB and maximise the effectiveness of finite management resources. A start is made with this study.

1.3 Threatening Processes

As indicated earlier, the removal and fragmentation of native vegetation for agricultural development is considered to be the major cause of decline of birds in the TAZ generally and in the NSW SWB (Saunders 1989; Hobbs and Hopkins 1990; Robinson 1991, 1993; Robinson & Traill 1994; Garnett 1992; Ford et al. 1995). Any small scale satellite scene of the country graphically depicts the scale and severity of the problem in the heart of the agricultural belt (e.g. Graetz et al. 1992:63-81).

Accurate, current figures on the percentage of the landscape cleared have not been located for the entire region, but Sivertsen (1994) highlighted the severity of the problem for sizeable portions of the northern SWB. In 1977 there was between 46% and 67% native vegetation remaining in three regions in 1977, but by 1984-85 these figures had decreased to 22-25%, an alarming rate of conversion as Sivertsen (1994) observed, and one that he claimed showed no halt in the ensuing eight years (but no data presented). One albeit coarse map of the conversion of forest, woodland and shrubland to agricultural lands indicates that the loss of habitat has been even more severe in the southern half of the SWB (Castles 1992:231, Fig. 5.1.9). Except at its margins in the east and the west, remnancy at district scales throughout the southern two thirds of the SWB frequently lies between 5% and 15%.

As drastic as these extreme rates of loss of habitat may prove to be (see Ford and Howe 1980) in the absence of remediation, their impacts on particular species and communities of birds are exacerbated by the selective nature of vegetation clearance (Robinson 1991, 1993; Saunders and Ingram 1995). Again accurate figures cannot be found for the SWB, but it is a well documented pattern for particular vegetation types associated with fertile soils, often grassy woodlands in the region (Goldney and Bowie 1990; Prober and Thiele 1993) and interstate (Ford et al. 1995). Several NSW Vulnerable and Endangered species characteristic of such woodlands appear to have been particularly affected by selective clearance of their preferred habitats, e.g. Superb Parrot, Swift Parrot and Regent Honeyeater (Franklin et al. 1989; Ford et al. 1993; Garnett 1993).

As well as the direct impacts of clearance, which are compounded by fragmentation effects at these very high levels, and the additional impacts of selective clearance in the higher-quality portions of the landscape, there are many indirect and interactive effects of clearing on birds. Indirect effects include the potential for predation and competition by ‘Increasers’ such as Pied Currawongs, Pied Butcherbirds, some parrots, corvids and miners – species that have benefited by the whole-sale conversion of the country into production landscapes (Clarke 1984; Morris 1986; Loyn 1987; Major et al. 1998; Saunders and Ingram 1995). Eucalypt dieback is another serious problem that decreases the value of habitat for birds (Ford and Bell 1982; Howling 1996). Dieback has multiple causes and can be regarded generally as an indirect impact of clearance and fragmentation. A positive feedback loop may be set up, whereby insectivorous birds decline in affected remnants which, in turn, exacerbates instances of dieback caused by insects. Other compounding activities and land uses implicated in the causes of dieback include the harvesting of dead timber, fallen and standing, for fuelwood, and the grazing of remnant vegetation (Scougall et al. 1993). Both activities rank highly in the list of threatening processes identified and quantified by Garnett (1992, 1993). It has been estimated recently that, Australia wide, the annual harvest of remnant timber for domestic firewood exceeds woodchip export quotas (Robinson 1994) - given the distribution of the major southern population centres, the sheep-wheat belts of Victoria and southern NSW are hardest hit (Howling 1996).

A range of threatening processes has been canvassed by Garnett (1992, 1993). They include, in addition to those already mentioned, direct human exploitation (for food historically: Magpie-Goose; Emu, Australian Bustard, ducks, quail, snipe; for aviculture: parrots, quail and finches), altered fire and other disturbance regimes, grazing and trampling, swamp drainage, damming and other diversions of water, and predation by introduced carnivorous mammals, amongst others. These threats are not the primary focus of this study, as the problem of declining birds in the extensively cleared SWB in most cases is agreed to occur as a result of loss of habitat, ultimately. However, the management of some of these other threats, particularly grazing, will be crucial if many of the declines are to be arrested.

1.4 Interspecific Comparisons of Life-History, Habitat and other Ecological Traits

Birds vary, interspecifically, in a whole host of characters. This type of variation, evident in all life forms, has been used extensively by ecologists and evolutionary biologists to describe systematic patterns and so formulate hypotheses about the organisation of communities and ecosystems, generally (e.g. by trophic levels or types: Elton 1927; MacArthur 1972; Pimm 1982; Fox 1987;), and in relation to different physical environments and disturbance regimes (e.g. Grime 1979; Huston 1979). So too the comparative approach has been used to contrast the defining characteristics and attributes of threatened species with secure species (e.g. in Australia: Burbidge and McKenzie 1989; Robinson 1991; Garnett 1992; Smith and Smith 1994; Smith and Quinn 1996; Davies et al. in press). Lunney et al. (1997) applied this method broadly to vertebrates, excluding fish, in NSW, but found little association overall between threatened vertebrates and ecological attributes.

The analyses of Robinson (1991) and Garnett (1992) were restricted to formally Threatened bird species in Victoria and Australia respectively. Robinson (1991) concluded that birds typical of mallee, woodland and open (dry) forest were more at risk than those of wet forests and heaths; ground nesters and hollow nesters were more at risk; fruit and seed eaters and flesh eaters were more at risk; ground feeders were worse off than canopy feeders. Garnett's (1992, 1993) results were broadly similar at the scale of the entire continent except for habitats; Garnett also found that larger birds were more likely to be threatened than smaller birds. Smith and Smith (1994) classified the birds of the Western Division of NSW into 'increaser', 'decreaser' and 'no population change' categories. Their results were slightly divergent to the above in that they found no systematic variation in weight among the three classes of birds. Also, species having small clutch size were more likely to be decreasers, as were landbirds that do not need to drink; finally resident taxa were more likely to be decreasers than migratory birds. All three studies found waterbirds to be surprisingly well off ‘despite the amount of wetland drainage and degradation that has occurred’ (Garnett 1993), who further observed that this was perhaps because waterbirds ‘have always had to be adaptable to cope with the vagaries of the Australian climate.’ Smith and Smith (1994) observed that phylogeny exerted a strong influence on the patterns of decline and increase – certain Orders were over-represented in the decreaser group (as noted by Garnett 1993 for Threatened species) and Australian endemic taxa were over-represented. Reid and Fleming (1992) reviewed the conservation status of birds in arid Australia and, while not using statistics, observed similar trends in the characteristics of Threatened and Declining birds to those just described.

Phylogeny and various life-history attributes are likely to be tightly correlated (Harvey and Pagel 1994), and a school of ecological thought is emerging that dependencies of this sort should be accounted for in comparative analyses (e.g. Harvey 1996; Gaston et al. 1997). For example, the fact that both the Order Psittaciformes and the hollow-nesting attribute are over-represented among decliners (Robinson 1991; Garnett 1992, 1993; Reid and Fleming 1992; Smith and Smith 1994) should not come as a surprise. The flesh-eating habit and membership of the Orders Falconiformes and Strigiformes are over-represented among Threatened species; again, one result implies the other. An extreme view holds that the ecological content of the information shared by phylogeny and ecology is of no interest if it can all be explained by the phylogeny (e.g. Harvey et al. 1995; Rees 1995; Harvey 1996), but others disagree (Westoby et al. 1995a,b,c). Tight relationships such as the examples just given should be looked for and pointed out, but there is no reason to dismiss the ecological content as being irrelevant. In terms of managing Threatened species, for instance, it will be of greater use to know that they require large hollows, rather than that they are owls or cockatoos *per se*! Before these comparative analyses can be performed, however, the species pool for the SWB has to be gathered and refined.

2. METHODS

2.1 BIRD SPECIES OF THE NSW SWB AND LIFE-HISTORY DATA SOURCES

A list of species of (historical) regular occurrence in the NSW SWB was compiled from the following sources: Morris et al. (1981); Blakers et al. (1984); Cooper and McAllan (1995). The primary ornithological literature, mainly in the journals *Emu*, *Australian Birds* and *Corella*, was also scanned. A list of 345 species was compiled (Appendix 1), but 94 of these are waterbirds belonging to the Orders Anseriformes, Podicipediformes, Pelecaniformes, Ciconiiformes, Gruiformes and Charadriiformes. Of the 251 landbirds retained for further consideration – including Australian Bustard: Gruiformes; Plains-wanderer and Bush Stone-curlew: Charadriiformes – 11 are introduced species. Diurnal raptors (Falconiformes, 22 species), which lie outside the main scope of the study in that they utilise landscapes at scales greater than most bushbirds, were retained for comparative analyses. Further details of the procedures followed to decide whether to include or exclude species are presented below.

The 240 native species of landbird were classified into four main groups, based on their (assumed) conservation status, as follows:

1. Formally classified as Threatened species
   A) Nationally listed, and
   B) NSW additions;
2. Declining species (diagnosed here);
3. Stable populations (diagnosed here), 'Stable species';
4. Increasing species (diagnosed here).

Species were placed in the "Stable" category if they were not assigend to one of the other categories. Some or even many of these species could in fact be declining, but there are insufficient data to tell (Recher 1999).

There may be systematic differences in life history among the four main groups. Furthermore, although impeded by small sample size, cursory consideration of the 'NSW additions' in the Threatened species category suggests that these species may differ in significant ways from their continent-wide counterparts. Many of the additional NSW-listed species appear to have small state distributions because they are naturally on the margins of their Australian range, whether they be Torresian, Eyrean or mallee species, and confined to restricted north-eastern, north-western and south-western portions, respectively, of NSW.

Garnett et al. (1992) compiled an extensive data base on life-history attributes of Australian birds. The attributes include measures or classes of weight, clutch size, diet, foraging zone, nesting site, nest type and broad habitat (life-zone) preferences. To these characteristics I have added size of geographic range (Australian), and I have replaced weight classes with actual weight. Birds were assigned to classes of mobility/sedentariness based on earlier classifications of Morris et al. (1980), Smith and Smith (1994), and Mac Nally (1995), and from perusal of the ornithological literature (e.g. Pizzey 1980; Blakers et al. 1984; Schodde and Tidemann 1986). There is much debate and speculation, both here and overseas, as to whether different mobility strategies (e.g. short- or long- distance migrants, resident vs nomadic) predispose birds to greater risks of extinction. For instance, in one of the first studies of its kind, Pimm et al. (1988) examined the ecological attributes of populations on small British islands known to have gone extinct based on a long period of annual censusing.

They found that migratory birds were at a significantly greater risk of extinction than resident species, after controlling for correlated factors. Smith and Smith (1994) found that sedentary species were at greater risk than mobile birds in the Western Division of NSW, a result generalisable to arid Australia as a whole (Reid and Fleming 1992). In the Western Australian Wheatbelt Saunders and Ingram (1995) also found sedentary species to be most at risk. However, Recher (1999) declares migratory Australian species to be at greater risk of extinction, and cites examples of the Swift and Superb Parrots, Rufous Whistler and honeyeaters in general (e.g. Regent and Painted Honeyeaters). His reasoning may have been influenced by the North American literature. Nearctic migrants have generally been thought to be at greater risk of extinction in the Americas than short-distance migrants or residents, but the evidence for this notion is not as firm as assumed previously (Bohning-Gaese et al. 1993; Sauer et al. 1996). While the evidence in Australia is not consistent either, on balance, sedentariness predisposes a bird to greater risk (e.g. Paton et al. 1994; Bentley and Catterall 1997; sources cited above).

Because landbirds were classified into four (or five) groups, the distribution of continuous life-history data (weight, geographic range size) among groups was analysed with parametric and non-parametric ANOVA as appropriate, while the goodness of fit test was used for categorical attributes.

2.2 Diagnosis of Threatened and Declining Species

Justification for the methods used is presented above. Threatened bird species in NSW are listed under the provisions of the *Threatened Species Conservation Act, 1995*. Of these 110 taxa, Threatened landbird species in the NSW SWB were selected using the following criteria:

- species of current or former, regular (i.e. non-vagrant), occurrence within the region were included;
- wet-forest species that occur along the eastern margin of the region were excluded, as this environment is not the focus of the study;
- conversely, mallee and other semi-arid shrubland species restricted to the western margins of the region were included.

Declining species were classified into two groups depending on the strength and consistency of their trends across the SWB: ‘Decliners’ and ‘Possible Decliners’. Other researchers have found it convenient to recognise two or more tiers of decliners (or similar status categories) because of the contradictory evidence for decline, no trend or increase that is available within a single species (Reid and Fleming 1992; Barrett et al. 1994; Smith and Smith 1994). Decliners here are those species reported to have declined (without recovery) in three or more districts within the SWB. Several other criteria were used to screen or confirm the inclusion of a species in the Declining category:

- evidence of documented local extinction from at least two patches of habitat of non-trivial size (> 10 ha);
- low reporting rate in systematic surveys in regions where the available evidence suggests the species should occur;
- evidence of high vulnerability to any of the four risk factors as identified through systematic survey, namely, narrow habitat specificity, minimum areas, habitat condition and isolation;
- absence of evidence that the species is generally an Increaser in modified landscapes.

The last point is important as some species in some studies were listed as declining or predicted to decline (e.g. Fisher 1997) when there is evidence to the contrary in the wider SWB. This is not to suggest that Fisher's (1997) predictions are incorrect for his study region (Bathurst).

The regional ornithological literature was scanned, with particular attention paid to articles that reviewed the status of birds in a district within the SWB of NSW. Even where the conclusions were not borne of a particularly long residency in the district by the observer, sometimes the views of longer-term residents would be included in the paper (e.g. Heron 1973a). Over 50 articles referred to declines in landbirds in the sheep-wheat belt. Not all the readily available literature could be scanned. Three weeks were devoted to this task, and a similar length of time would be required to finalise a fairly comprehensive literature search. Information from the primary ornithological literature was combined with information derived from quantitative ecological research. This latter category included several works in progress at the time of drafting the report:

- study of birds in box woodland fragments in the mid-Lachlan catchment (J. Seddon and S. Briggs, NPWS, personal communication);
- study of birds in woodland fragments in the Canberra region (Freudenberger 1999);
- study of birds in large vs small, linear roadside remnants in the Condobolin region (J. Reid, unpubl. data).

The most informative published results of ecological research in the SWB is Barrett et al. (1994: New England Tableland). The doctoral thesis of Fisher (1997: Bathurst region) and report of Major et al. (1998: Forbes region) are also valuable.

Directly communicated, expert opinion on the identity of declining bird species in particular regions was provided by N. Schrader for the Parkes Shire region; this is additional to the wealth of his published material on the subject (e.g. Schrader 1980, 1987). Discussions with him have afforded invaluable insights into the causes of local extirpations and the habitat needs of threatened species in this region. Mr D. Johnston of Baradine and Mr N. Kurtz of Mudgee also allowed me the benefit of their expert opinion on the subject.

Information from all these sources (including isolated observations as reported in annual 'bird reports', e.g. Lindsay 1985), that could be used to identify Declining species, are in the process of being allocated to bioregion (after Thackway and Cresswell 1995) so that regional differences in trends within the SWB can be detected. This exercise also allows geographic gaps in information to be identified. Results of this continuing research will be presented in a subsequent report.

While focussing on the diagnosis of Declining species in the foregoing exercise, attention was also paid to any sources of information on Increasing species. Increasers are defined as those species that prefer open agricultural landscapes or the edges of native vegetation and which are often common in small degraded remnants (e.g. Barrett et al. 1994). By default, species which were not classified as Threatened, Declining or Increasing were allocated to the 'Stable species' (no apparent trends) group. In reality, the classification process was more complicated than this, due to contradictory patterns, trends and opinions for a large number of species. The justification for final allocations is presented in the Results, as allocations tended to follow a 'case by case' approach.

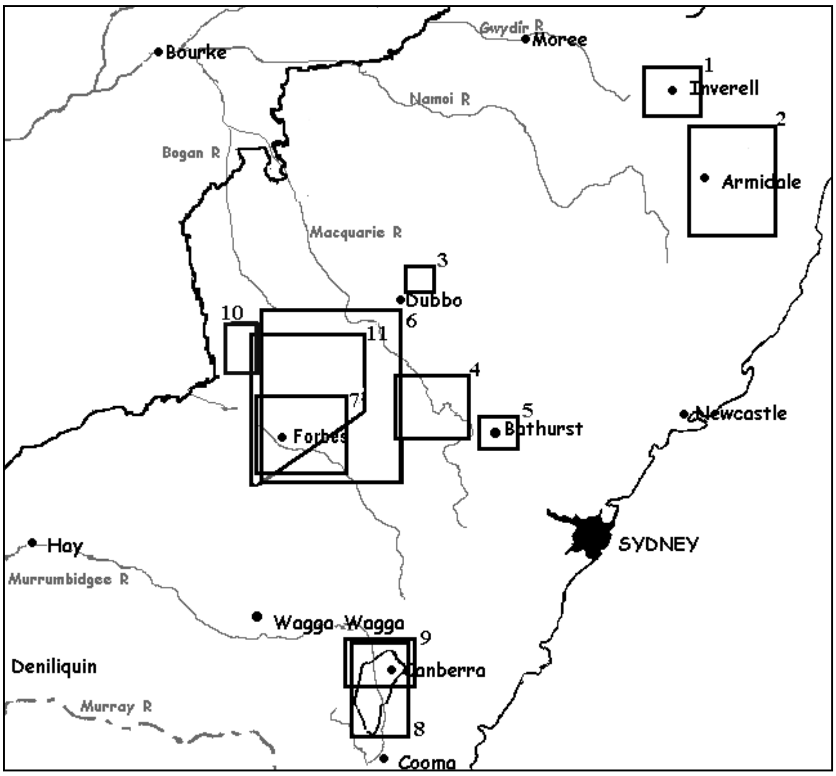
Eleven comprehensive studies were selected from the numerous information sources scanned in the literature survey (Table 2 and Figure 3). They were selected on the basis of thoroughness, survey design (where applicable), reputation of the authority providing expert opinion (where applicable), and geographic scope (the study encompassed an area larger than the local, e.g. single farm, scale).

Table 2. Eleven major studies used as the primary source of diagnosis of Declining species. Bioregions after Thackway and Cresswell (1995):

Study	District	Bioregion
Baldwin (1975)	Inverell	NAN
Barrett et al. (1994)	New England	NET
Heron (1973b)	Goonoo SF (NE Dubbo)	NNS
Heron (1973a)	Orange	NNS
Fisher (1997)	Bathurst	SEH
Schrader (1987, *unpubl.*)	Parkes	NSS
Major et al. (1998)	Forbes	NSS
Taylor & COG (1992)	ACT	SHE
Freudenberger (1999)	ACT	SEH
J. Reid & P. Masters (*unpubl.*)	Condobolin	CP
J. Seddon & S. Briggs (*unpubl.*)	Forbes	NSS

NAN - Nandewar; NET – New England Tableland; NNS – NSW South western Slopes; SEH – South Eastern Highlands; CP – Cobar Peneplain.

Figure 3 Location of primary source studies listed in Table 2



2.3 COMPARATIVE ANALYSES

Due to the complexities just described, it was originally intended that exhaustive comparative analyses of life-history, habitat and other ecological attributes be conducted on several classifications of birds in different status categories. Smith and Smith (1994) found that some conclusions about the ecological characteristics of declining birds differed depending on whether a narrow or broad view of Threatened species was adopted. However, time constraints prevented this full analysis from being pursued.

The 240 native landbird species in the NSW SWB were allocated exclusively to the Threatened, Decliner, Increaser and Stable groups. A data set summarising life-history attributes of Australian birds compiled by Garnett et al. (1992) was used as the basis for comparisons among groups. Life history includes various habitat, foraging behaviour, and nesting behaviour attributes (Table 3). The categories have been modified, usually reduced in scope, because birds of off-shore islands and coastal and inland waters were excluded from this study. The weight classes of Garnett et al. (1992) have been replaced with mean weight (for passerines only at this stage: 134 species). Data on the size of geographic ranges and distributions patterns (from Blakers et al. 1984) have been added and analysed for passerine species, because of the general view that species with restricted ranges are more likely to be at risk than those with broader distributions (Gaston 1994; Lawton 1996). This concept can be extended to habitat specificity, i.e. geographic or environmental range (Table 3). Finally, various phylogenetic attributes were assembled to test, among other propositions, whether species in monotypic (or small) genera were more extinction prone than those in speciose genera (see Johnson 1998), or whether (evolutionary) recent invaders were less prone to extinction than ancient Australo-Papuan lineages.

Table 3. Life-history and ecological attributes drawn and as modified from Garnett et al. (1992) for use in comparative analyses (3a).

Attribute	Classes or Range of Response
3a)	
Clutch Size	1, 2, 3-4, >4
Nest Behaviour	Solitary, Colonial, Parasitic
Nest Site	Ground, Shrub, Tree
Nest Type	Hollow, Dome, Cup, (Cup-Supported, Cup-Hanging)
Diet	Flesh, Invertebrates, Nectar and Pollen, Fruit, Seed, Omnivore
Foraging Zone	Aerial, Canopy, Trunk and Major Limbs, Shrubs, Ground
Broad Habitat Preferred	Swamp, Riparian, Woodland and Open Forest, Wet Forest, Dry Forest, Grassland, Dry Heath, Mallee-Spinifex, Acacia Scrub, Chenopod Steppe, Agricultural
No. Habitats Used	1, 2, 3-4, > 4
3b)	
Weight	continuous variable (passerines only)
Geographic Range:	
Australia	'continuous' variable
NSW	< 10%, 10-30%, 30-90%, 'All'
Biome	TAZ only, TAZ+Forests+Coast, TAZ+Arid, 'All' (+/- tropics)
Mean density	continuous variable (most passerines only)
Mobility Type	Sedentary, Short-Distance Nomad, Short-Distance or Partial Migrant, Long-Distance Nomad, Long-Distance Regular Migrant

.....continued

Table 3. Continued Life-history and ecological attributes drawn and as modified from Garnett et al. (1992) for use in comparative analyses (3a).

Attribute	Classes or Range of Response
3c) Phylogeny	
Australian endemic	0, 1
Monotypic	0, 1
Genus Size	'continuous' variable (number of species in Australia)
'Australo-Papuan'	0, 1
Order	
Family if Passerine	

Weight data from HANZAABs, ANWC, Ford et al. (1985) and Baker et al. (1997); geographic range data from Morris et al. (1981), Blakers et al. (1984) and Cooper and McAllan (1995); mobility strategies from primary literature, and Pizzey (1980), Blakers et al. (1984) and Schodde and Tidemann 1986 (3b). Phylogenetic data from Christidis and Boles (1994) and Stanger et al. (1998) (3c).

Although only a limited amount of basic foraging and within-habitat use data has been gathered by ecologists in the heart of the SWB, results have been extrapolated from the much greater body of literature on this topic in eastern Australian forest and woodland environments (e.g. Ford et al. 1986; Recher et al. 1985). It is assumed here that while the habitats occupied by a species will vary from one region to the next, the height strata occupied and foraging tactics employed generally will not.

A large number of statistical tests was performed and so Type I errors can be expected. Probability levels are given to three decimal places to allow readers their own interpretation. Many of the attributes are intercorrelated, but these relationships are not explored in this report. The results of the contrasts across status categories were used to bunch Threatened and Declining species into functional groups that I have interpreted to be facing similar threats and in need of similar solutions. Likely threatening factors have also been assessed from the primary ornithological literature, the results of the quantitative ecological studies, and from the unpublished data base of N. Schrader.

Three main sources were drawn upon to prepare the preliminary guidelines for the rehabilitation of the species at risk in the SWB. They are the results of the comparative analyses and their subsequent interpretation, the risk assessment of threatening processes, and habitat requirement data derived from the sources of information used to diagnose the status of SWB bird species as described above.

3. RESULTS

3.1 SNIPPETS FROM THE LITERATURE AND LOCAL EXPERTS

Having rapidly browsed some 300 ornithological bird notes, articles and papers, the author was surprised to find that the 'writing has been on the wall' for quite some time. It is strange then has it taken until this decade (Robinson 1991) for the plight of woodland birds in the extensively cleared sheep and wheat belts in eastern Australia to come to prominent attention. The prescience of Recher and Lim (1990) and Goldney and Bowie (1990) in recognising the magnitude of the problems facing biodiversity conservation in these production-dominated landscapes deserves mention.

Father S.J. Heron was stationed in various rural parishes in southern Australia before moving to Papua New Guinea in 1973. Wherever he went he kept records of birds, taking a systematic approach to their study and soliciting advice from long-term resident observers and other enthusiasts (e.g. Heron 1972, 1973a,b). In particular, writing of the Goonoo state Forest, north-east of Dubbo, Heron (1973b) observed (emphasis added): 'Four birds, **recorded before the 1965 drought but not after**, were the **Hooded Robin**, **Eastern Shrike-tit**, Eastern Silvereye and **Diamond Firetail**. The Little Woodswallow, **Crested Bellbird** and **Turquoise Parrot** were last seen in 1952.' He also predicted the **Gilbert Whistler** would become scarcer, as clearing of its preferred mallee habitat continued apace in the surrounding agricultural districts. Other species recorded by earlier observers in the 1950s and 60s in Goonoo State Forest, but not recorded by the meticulous Heron in his seven months' stay in 1972 are also telling: **Southern Whiteface**, White-throated Warbler, White-plumed Honeyeater, **Black-chinned Honeyeater**, Black Honeyeater, **Restless Flycatcher**, Richard's Pipit, White-winged Triller, Olive-backed Oriole and Rufous Songlark. The Black Honeyeater, woodswallow, triller and songlark are irregular spring-summer visitors from semi-arid and arid Australia, while the oriole, warbler and silvereye may also be irregular in occurrence this far west, being more common in higher-rainfall regions. There is nothing surprising, therefore, about the absences of these species during Heron's brief residence. Most of the highlighted species, however, are sedentary and it is not so easy to account for Heron having failed to detect them. These species in bold are either Threatened or Declining species in the NSW SWB.

Mrs Merle Baldwin prepared a comprehensive list of 199 species for the Inverell district, briefly describing their status, breeding and habitats, from 'personal observations made almost daily from 1962 to 1973' (Baldwin 1974): for **Bush Stone-curlew** and **Crested Bellbird** she wrote 'Once common; now rare.' The **Jacky Winter** and **Brown Treecreeper** were described as 'Common but decreasing', and the **Hooded Robin** had 'decreased' (Baldwin 1974).

Mr Norman Kurtz of the Mudgee district noted (*in litt.* 17 May 1999) 'a decline in the Brown Treecreeper since 1972', while 'the Pied Butcherbird has increased over the same period.' Mr David Johnston of Baradine writes evocatively (*in litt.* 29 April 1999) of the Bush Stone-curlew and Crested Bellbird, two common species in his childhood when the land was undeveloped:

'One thing that is very vivid in my mind is riding through our back paddock as a child on a wonderful spring day. The country was uncleared in those early years and was moderately timbered with Wilga, Rosewood, Buddah, Currant Bush, Narrow-leafed Box etc. Along with the scent of the daisies, Wilga and Buddah flowers is the beautiful call of the

Crested Bellbird. Equally vivid is the memory of lying in bed at night listening to the haunting call of the Bush Curlew and, on a moonlit night, the excited chorus as they danced. Since the land was cleared both have become a rarity.'

These sorts of observations by farmers and rural people generally are sobering, and point to an enormous body of knowledge that lies in these lands largely untapped.

From preliminary conversations with Mr Neville Schrader of Parkes (and also as communicated to S. Briggs, *unpubl.*), the decline in certain woodland bird species throughout the Parkes Shire area **accelerated alarmingly** in the past two years. Schrader (*personal communication)* attributes this crash to the 1997 drought that did not break until winter 1998. For example, early in 1999 he could locate very few Hooded Robins in their usual haunts, despite making a specific search for the species in localities they had occupied for many years. Schrader communicated to S. Briggs a list of 13 Threatened and 24 Declining dryland bird species, which he prepared for the Mid-Lachlan Regional Vegetation Management Committee and upon which I have drawn heavily in subsequent analyses (Appendix 2). Given the recent drought and its effects in his region, he has new concerns for the long-term viability of more species than those listed here.

3.2 Diagnosis of Declining Species

Seventy-four species were diagnosed as having declined, gone to local extinction or otherwise being at risk in at least one of the 11 comprehensive studies used for this compilation. Fisher (1997) identified another 11 species to be at risk of local extinction if current land management practices continued, but these were ignored for these purposes because they were recorded at moderate or high frequency in his study. Of the 74 species the majority (54) were identified as at risk in only one or two studies. The remainder (20) are diagnosed as Decliners (Table 4).

While no species is totally ubiquitous, i.e. occupying commonly all possible habitats in a large region, some are more ubiquitous than others. The Hooded Robin was identified as being at risk in all 11 studies. This is thought to reflect two things – first, the species was historically distributed throughout the SWB, and second, it has declined alarmingly throughout the region. The Emu was probably also widespread prior to European occupation, but seemed to be an early casualty, through direct persecution, in closely settled districts. While some of the remaining species probably (historically) occupied most or all of the SWB (e.g. Brown Treecreeper, Rufous Whistler, Restless Flycatcher, Dusky Woodswallow), others were probably always confined by climate and/or habitat to parts only of the sheep-wheat belt. Species that may always have been absent from the driest regions – the south-west and westerly margins of the SWB – include Painted Button-quail, Speckled Warbler and Eastern Yellow Robin. Species such as Chestnut-rumped Thornbill, Red-capped Robin, White-browed Babbler and Crested Bellbird may have always avoided the wetter, more densely forested regions and habitats in the east.

Table 4. The 20 landbird species diagnosed as Decliners in the NSW Sheep-Wheat Belt.

Species	*f*	Species	*f*
Emu	7	Grey-crowned Babbler	3
Painted Button-quail	3	White-browed Babbler	5
Brown Treecreeper	6	Varied Sittella	3
Speckled Warbler	6	Crested Shrike-tit	5
Chestnut-rumped Thornbill	3	Crested Bellbird	4
Southern Whiteface	3	Rufous Whistler	4
Jacky Winter	7	Restless Flycatcher	3
Red-capped Robin	3	White-browed Woodswallow	3
Hooded Robin	11	Dusky Woodswallow	3
Eastern Yellow Robin	3	Diamond Firetail	6

f is the number of comprehensive studies in which the species was deemed to be at risk ($n = 11$).

As mentioned in the Introduction, distribution pattern is likely to be an important influence on the pattern of decline exhibited by a vulnerable species. Brown (1984) invoked niche theory to explain the common phenomenon noticed by any alert birdwatcher – species on the edge of their natural range become rarer (less abundant, less widespread). Brown (1984) argued that this could be explained by the fact that there is a decreasing likelihood of all its (multidimensional) niche requirements being met, as locations become more marginal. Accordingly, we might expect species that have the limits of their distribution within the SWB to be most vulnerable to new forces and factors (European occupation broadly) in these areas. The pattern in decline of Chestnut-rumped Thornbill and Crested Bellbird may best reflect this process. Their ranges appear to be contracting towards the inland. However, proximate factors, although not at odds with Brown's (1984) hypothesis, may provide more satisfactory explanations. Perhaps these two species historically occupied a narrow breadth of habitats in eastern districts within the SWB, basically structurally open woodland formations (e.g. sheoak, native pine) or shrublands, and that these formations were distributed patchily historically. Selective clearance of these elements in the landscape, or their targetting for grazing, may have caused their loss and degradation to proceed to a point where bird species reliant on them could no longer maintain viable populations. The foregoing is speculative in the extreme, although I observe that both these species have retracted from the wetter portions of their historical distributions in South Australia as well (e.g. Parker and Reid 1983; Taylor 1987; Hutchins 1991; Paton et al. 1994; Stokes 1996). The main point is that there appear to be a number of different patterns in decline within the SWB expressed by the 20 species diagnosed as Decliners.

The Grey-crowned Babbler is a prime example of complexity in observed patterns of decline. The species is effectively extinct in the South East of South Australia, the historical western limits of the nominate subspecies' distribution. It is classified as Endangered in Victoria, having been extirpated from most of western Victoria, and it appears to be in serious population decline in the southern parts of the SWB (A. Overs *personal communication*). Yet, the species is still moderately common in (parts at least of) the northern half of the SWB and in the words of Mr D. Johnston of Baradine (*in litt.*), 'Some sources express concern over the serious dwindling of numbers, I doubt if this applies to this area.' We are witnessing in this species a slow-moving, inexorable tide of extinction that has moved along a semi-circular path around the TAZ, starting in south-eastern South Australia – whether it will stop of its own accord is unknowable. This must be one of the most intriguing examples of decline and, more importantly, it affords the rare opportunity of comparative research that may enable the species' recovery in the southern portions of its range to be assisted.

It has to be stressed that most of these 20 species are still locally common or relatively abundant in parts of the SWB. National Parks, larger Nature Reserves, better-managed State Forests, and large habitat blocks on private land are all likely to support 'healthy' populations of some of these species, depending on their location geographically, position in the landscape (i.e. habitats) and management history. However, in the landscape context, these parcels of land are relatively rare. I do not have a figure for the percentage of uncleared land, away from ranges and ridge lines, greater than 400 ha, protected from any but light stock grazing pressure, for the entire sheep-wheat belt of NSW, but I suspect it is tiny. What of the remaining 95-98% of these extensive, more fertile parts of these landscapes? Do we accept that all these species, and more, may in time be effectively extirpated from this much land? Can we be sure, given the predictions of metapopulation theory, that populations will be secure **in the longer term** even in the large, well-managed habitat preserves? The answer to the last of these rhetorical question I can legitimately address – we cannot be sure. Small, spatially fragmented populations **without the means for dispersal between them**, have finite and short expected persistence times - Hanski et al. (1996) refer to them as zombie populations, the 'living-dead'.

In terms of the characteristics of the 20 Decliners, several first impressions can be stated. They are mainly passerines. Most are insectivorous or include a large proportion of invertebrates in their diet. They are mainly sedentary ground-feeders. All these characteristics parallel the conclusions of Saunders and Ingram (1995) in the Western Australian Wheatbelt, and of Smith and Smith (1994) in western NSW. One novel insight is that most of these species occupy larger home ranges than the typical passerine of their size range. This topic is dealt with at greater length in the next section.

Two species not diagnosed by the formal selection procedures were identified by other means as being of 'Special Concern' in the SWB of NSW. The Black-chinned Honeyeater, merits particular attention, as the differentiated nominate form is confined to the eastern Australian temperate woodland and open forest formation. It appears to be genuinely rare (low abundance); worse, it has been shown to be vulnerable to local extinction in other parts of its range (Paton et al. 1994; Reid et al. 1996). Major et al. (1998) did not record the species in their survey of 195 habitat remnants in a considerable-sized region centred on Forbes, **in the heart of the species' range**. N. Schrader (*personal communication*; Appendix 2) considers it to be vulnerable to extinction in the adjacent Parkes region. There is a current proposal to nominate this subspecies of the Black-chinned Honeyeater for listing as a Vulnerable taxon nationally (S. Garnett and G. Crowley, *personal communication*). The other species of Special Concern is the White-browed Treecreeper which is similarly rare and restricted to particular habitats. Fortunately, it favours semi-arid open tall shrubland/low woodland formations, particularly black oak *Casuarina cristata*, and so occurs widely if patchily through the southern arid zone. More importantly, much of its distribution lies beyond the limits of agriculture. However, within the SWB, the species is at risk due to its rarity (e.g. Hobbs 1961), and again it is classified as Vulnerable interstate (Radford 1998). There are undoubtedly other species that warrant inclusion in this category, but there is insufficient information available currently. For instance B. Traill (*personal communication*) recommends the inclusion of the Spotted Nightjar in the list of Decliners for the SWB of NSW. It is also a ground-dwelling insectivore, but is distinguished from the others in being nocturnal and an aerial insectivore.

A similar but cruder approach was adopted for the identification of Increaser species as was used in the diagnosis of Decliners. Several studies have identified species that have increased, are predicted to increase, or which are frequently recorded in small habitat remnants (Barrett et al. 1994; Smith et al. 1994; Fisher 1997; N. Schrader *unpubl.*). In addition to these, I took the summary data presented in the ACT Bird Atlas (Taylor and COG 1992), and selected species with a reporting rate > 30% and where the highest reporting rates occurred in their 'Pastoral' or jointly in their Pastoral and 'Urban' regions. Seven introduced and 29 native Increaser species are presented in Table 5.

Table 5. The 29 native landbird species diagnosed as Increasers in the NSW Sheep-Wheat Belt followed by seven introduced species.
The tag 'Increaser' does not imply that in all cases these species' populations have increased in the NSW SWB since *ca* 1750, but they all are at least moderately plentiful in some highly fragmented landscapes**.**

Species	Species
Nankeen Kestrel	House Sparrow
Crested Pigeon	Magpie-lark
Peaceful Dove	Willie wagtail
Galah	Black-faced Cuckoo-shrike
Little Corella	Black-faced Woodwallow
Sulphur-crested Cockatoo	Pied Butcherbird
Cockatiel	Australian Magpie
Eastern Rosella	Pied Currawong
Bluebonnet	Australian Raven
Red-rumped Parrot	Little Raven
Yellow-rumped Thornbill	White-winged Chough
Noisy Miner	Richard's Pipit
Yellow-throated Miner	Zebra Finch
White-plumed Honeyeater	Welcome Swallow
Brown Songlark	Fairy Martin
Rock Dove	European Goldfinch
Spotted Turtle-Dove	Common Blackbird
Skylark	Common Starling

Some of these species are commensals of humans or show commensal traits (Rock Dove, House Sparrow, Welcome Swallow). Some are clearly species that have benefited from the creation of extensive grasslands and open habitats with scattered trees, in which they spend most of their time (Nankeen Kestrel, Crested Pigeon, Galah, Skylark, Richard's Pipit, Brown Songlark, the swallows etc). Some others probably have much larger populations in and around towns than in the agricultural landscapes and remnant habitat patches (Rock Dove, Spotted Turtle-Dove, House Sparrow), but many utilise the native remnants extensively, for shelter and breeding if not feeding as well. A few species have been reported to go locally extinct in areas subject to extreme modification of habitat elsewhere in their large Australian ranges (Yellow-rumped Thornbill, Zebra Finch). It is probable that retention of some natural habitat in the landscape is essential for the persistence of many of the birds in this list. Current conditions, however, in the NSW SWB amply meet the needs of this suite of birds. Moreover, the large population sizes of some of these species have been implicated in the decline of other native birds, whether through competition for nesting hollows, interference and exploitative competition, or nest predation (reviewed in Garnett 1993). Indirect evidence for the notion that these Increasers might lie generally at the heart of the problems suffered by Decliners could be suggested if Increasers and Decliners are similar types of birds. For instance, Reid and Fleming (1992) found some support for this notion in arid Australia. It would constitute only weak evidence, however, as alternative, equally parsimonious explanations could be mounted.

3.3 Characteristics of Declining Species

There are 60 species of Threatened and Declining species recognised for the NSW SWB – 38 listed Vulnerable and Endangered, 20 Decliners and two of Special Concern. When these 60 species' characteristics are compared against the general characteristics of all 240 native landbird species, the following significant differences are found (Table 6). At risk species are more likely to:

- be resident than mobile;
- occupy fewer habitat zones (macrohabitats);
- include fewer broad food groups in their diet;
- be insectivorous.

Table 6. Results of likelihood ratio chi-square tests for 58 At-Risk species in the NSW SWB by risk category and taxonomic group

Risk group *(n)*		Threatened (38)		Declining (20)		At Risk (58)	
Macrohabitats							
Zones	pass	***	fewer	*ns*	(more)	*ns*	(fewer)
	n-p	***	fewer		$n = 2$	**	fewer
	all	***	fewer	*ns*	(more)	**	fewer
Foraging and Diet							
Dietary Items	pass	*ns*	(fewer)	*	fewer	**	fewer
	n-p	*ns*	(fewer)		$n = 2$	*ns*	(fewer)
	all	*ns*	(fewer)	*	fewer	**	fewer
Seeds	all	*ns*	(more)	*ns*	(fewer)	*ns*	
Insects	all	***	fewer	**	more	*	fewer
Foraging Strata	pass	*ns*	(fewer)	*ns*		*ns*	
	n-p	*ns*			$n = 2$	*ns*	
	all	*ns*	(fewer)	*ns*	(more)	*ns*	
Ground1	all	*ns*	(more)	*ns*		*ns*	(more)
Ground2	all	*ns*		*	more	*ns*	(more)
Mobility (1: mobile, 0: sedentary)							
	pass	*ns*	(fewer)	*	fewer	**	fewer
	n-p	*ns*	(fewer)	$n = 2$		*	fewer
	all	*ns*	(fewer)	*	fewer	**	fewer

(pass: passerine; n-p: non-passerine).
Foraging categorisations from Garnett et al. (1992), and then classified into dichotomous states:
No. macrohabitats/life zones – $1 <= x <= 3$ (0), $3 < x <= 10$ (1);
No. dietary items – $x = 1$ (0), $1 < x <= 4$ (1); No. strata – $x = 1$ (0), $1 < x <= 4$ (1).
Significance levels: *** $P < 0.001$; ** $P < 0.01$; $P < 0.05$. Trends shown for significant results and in brackets for $P < 0.5$.
Ground1: 1 = exclusive ground feeders; Ground2: 1 = any species that feeds on ground.

Size of geographic distribution, whether passerine or non-passerine, foraging height (vertical zone), nectarivory and granivory did not vary significantly between the 60 species of conservation significance and the remainder.

The second and third significant results listed above are in agreement with niche theory in relation to rarity as a predictor of extinction risk (Brown 1984; Gaston 1994; Lawton 1996; Gaston et al. 1997): specialisation predisposes a species to exist at low abundance. The other two characteristics, insectivory and sedentariness, may help us to identify the threats facing these species. Perhaps the range in, abundance of, or particular types of, invertebrates has decreased as a result of extensive habitat loss and fragmentation. Sedentariness suggests that fragmentation effects (isolation, impediments to dispersal) may be operating.

While the results obtained for all 60 at risk species are valid as they stand, they belie some interesting complexity which emerges when the group is examined at finer scales of resolution. First, the representation of passerines and non-passerines among the two main classes of Threatened and Declining is highly non-random – Threatened species are more likely to be non-passerines, Decliners passerine. Because only two species of non-passerine were diagnosed as Decliners, the following analyses were only applied to passerines.

Size of geographic range of passerines varies significantly among the two risk categories – whereas Threatened species have smaller Australian ranges, Decliners have larger distributions than average passerines. Mean local abundance among passerines did not vary significantly between risk groups, or for 'at risk' species as a whole compared with all passerines. This last result is at odds with rarity/niche theory which predicts species at low abundance to be at risk. A weak trend towards lower local abundance among Decliners and all species at risk is apparent (Table 7), but even if this weak trend was substantiated its interpretation would be difficult. Low abundance could be a corollary of their declining status as much as a 'natural' ecological feature of their life history. Much of the historical ornithological literature suggests many of the Decliners occurred at least locally in moderate or greater abundance – and a few anecdotes were reported earlier in this report to support this notion (also see Goldney 1987).

Passerine birds of lower-rainfall regions are more likely to at risk than those from higher-rainfall regions or both. The preponderance of species from lower-rainfall regions is probably accounted for by the high number of mallee specialists included in the state's list of Threatened fauna (e.g. Shy Hylacola, Purple-gaped Honeyeater, Southern Scrub-robin, Gilbert's Whistler). In one sense, this can be seen as a geographical artefact, because the mallee biome and its specialised biota are constrained to occupy only a small proportion of NSW. Alternatively, because the mallee biome lies largely within the agricultural zone, it and its biota are indeed at considerable risk, a position taken and argued cogently by Schodde (1990). Mass did not vary among groups or for at-risk birds as a whole. However, the second measure of relative mass, that accounts for strong phylogenetic dependencies in this variable, returned a weakly significant result – at-risk passerines are larger on average than the familial mean.

Finally, there are some important differences between Threatened and Declining taxa, other than in phylogeny alone (Table 6). Only Threatened species occupied fewer macrohabitats than average birds; in fact the trend for Decliners, though non-significant, was in the reverse direction, in line with the range-size result for passerines. Range of food items consumed was significantly low only for Decliners, and while Decliners were more likely to consume insects, Threatened species were less likely to consume insects than the average bird. Ground-feeding is a risk habit for Decliners only, not Threatened species.

Table 7. Results of likelihood ratio chi-square tests for At-Risk passerine species in the NSW SWB by risk category.

Risk group	Threatened		Declining		At Risk	
n		**10**		**18**		**28**
SQUARES	***	smaller	*	larger	*ns*	
LNDEN	*ns*		*ns*	(lower)	*ns*	(lower)
n		**14**		**18**		**32**
MASS	*ns*		*ns*	(larger)	*ns*	(larger)
MR1	*ns*	(larger)	*ns*	(larger)	*ns*	(larger)
MR2	*ns*	(larger)	*ns*	(larger)	*	larger
CLIMATE	***	dry	*ns*	(both)	**	(dry)

Australian range size (SQUARES – no of 1º cells) from Blakers et al. (1984): < 200 (0); >= 200 (1).
Local densities per 10 ha (LNDEN), taken from a range of sources: < 2.5 (0); > 2.5 (1).
Mass (g), MR1 and MR2 (relative mass), where for MASS, 0 = species whose mass is less than mean mass for all 135 passerines; MR1: 0 = species whose mass < mean mass of Family; MR2: same as for MR1 except that 'monotypic' Families excluded.
CLIMATE – species assigned to one of three categories according to its Australian distribution pattern; dry: lower-rainfall regions; high: higher rainfall regions; both: both regions (e.g. mallee specialists are 'dry', Dusky Woodswallow 'high', Black-faced Cuckoo-shrike 'both).

Passerine Increasers (n = 18) were significantly heavier than the average for uncorrected mass, and at the margin of significance (P = 0.058) for the measure relative to Family weight. Mean local abundances among Increasers and all other passerines were similar. Increasers were overwhelmingly climate generalists (P < 0.001) with 16 assigned to the 'both' (lower- and higher- rainfall regions) category. Not surprisingly then, Increasers had much larger Australian distributions than the average passerine. In this last respect then, Increasers are similar to Decliners, but not Threatened passerines; also in that their composition is dominated by passerines rather than non-passerines. When all 29 species of Increaser were compared across the categories derived from Garnett et al. (1992), more ate seeds more (P = 0.022) and they were more likely to use the ground layer (not exclusively) for foraging (P < 0.001) than the average bird. Increasers, therefore, differed from Decliners in a few of these categories, in that they do not have a narrow dietary range, nor are they significantly sedentary, and they tend to eat seeds rather than insects. In their ground-foraging behaviour, both groups show similar responses. Seed eaters of inland Australia that have become more abundant in the TAZ have probably benefited as much from the provision of reliable water sources and habitat modification generally as from the direct provisioning of seed resources.

3.4 IDENTIFICATION OF THREATENING PROCESSES

Drought is a natural event, a periodic expression of the extreme climatic variability for which Australia is renowned (Ellyard 1994). Ignoring the complex issue of anthropogenic climate change, a reasonable first assumption might be to consider that, because the Australian biota has evolved in an uncertain environment climatically, it should be generally well adapted to events like drought. However, in the highly fragmented (and quite unnatural) landscapes of the TAZ, I argue that the interaction between drought and fragmentation is likely to be a potent extinction driver for birds with poor dispersal capabilities. Droughts tend to affect large regions, and so their patch-specific effects will be contemporaneous. A two-year drought can be expected not only to depress reproductive output but also to cause adult mortality. Metapopulation models predict that these conditions will reduce survival probabilities. Patch extinctions are increased, there are few dispersing propagules, and the predominantly agricultural terrain may be a formidable barrier to dispersal of small sedentary bushbirds (e.g. Brooker et al. 1999). It has been reported numerous times in the Australian ornithological literature how individuals of many species wander widely during drought. It is a predictable evolutionary response. Even normally sedentary species have this vagility to varying degrees. In former times when the landscape was composed of large contiguous areas (patches) of habitat, individuals had far greater opportunity for within-patch movement, to seek respite from drought. If the average size of occupied patches is smaller than these postulated drought-induced movement distances and if inter-patch movements are impeded in the agricultural matrix, then habitat loss and fragmentation have delivered a double blow. Patch dependability is reduced and the difficulty of inter-patch movement is increased.

Stafford Smith and Morton (1990) and Morton (1990) presented an extinction model for arid Australia, and it can be adapted to the TAZ. Additional pressure will be felt by biota in times of drought, in that the formerly most dependable parts of the landscape (riparian and run-on areas, fertile soils) are now the foci for the most intense agricultural use. Whatever ‘drought-refuge’ value they historically held has been largely usurped. Mobile species will be as adversely impacted by this effect as more sedentary species. A secondary negative role for Increaser birds can be envisaged here - they too are generally likely to suffer under drought conditions, and they, in their relative abundance, will target these same portions of the landscape, as will other mobile forms of wildlife.

Drought and some other natural events cannot be controlled or, therefore, managed directly. Other pressures can be managed, however, and sound planning and sensitive management should be able to ameliorate the effects of ‘catastrophic’ events like drought in fragmented landscapes.

As stated in the previous paragraphs, clearance generally and the selective clearance of particular vegetation types and fertile soils have probably constituted the ultimate cause of the current plight of most Declining and Threatened bird species in the SWB of NSW (and the TAZ generally). Irrespective of the singular or interactive effects of drought, the wholesale conversion of natural habitat to agriculturally productive land must necessarily take its toll on bush-dependent elements of the biota (Barrett et al. 1994). The endangerment of typical woodland-dependent species, such as Superb Parrot, Swift Parrot and Regent Honeyeater, is thought to have resulted in large part from the selective clearance of the most fertile and productive woodland types (Franklin et al. 1989; Ford et al. 1993; Garnett 1993). There may be two components to the impacts of this habitat loss on mobile species such as these that track particularly rich resources through space and time over large scales. First, there is the selective clearance in itself, and second, there now may be unbridgeable gaps – either shortfalls in nectar production at certain times of the year, and/or overly great, intervening spatial distances between productive patches. There is certainly emerging evidence for this type of spatial asynchrony in the provision of floral resources in the south-eastern Australian forest and woodland biomes (Mac Nally and MacGoldrick 1997).

Further clearance of vegetation communities associated with the more productive parts of the landscape will only exacerbate these impacts; these most fertile and better-watered portions of the landscape need to become the major focus of landscape remediation including, but not restricted to, revegetation efforts.

Land clearance, with its cascading effects of direct habitat loss and fragmentation, is viewed here as the ultimate driver of decline and extinction of birds in the TAZ. However, the ongoing decline in habitat quality at the patch level is equally as serious, and can be viewed as the proximate driver, especially with regard to patch extinctions. Stock grazing pressure is assumed to be the biggest single risk factor for birds (and other biota), and the results emerging from current research in the SWB is bearing this out (Freudenberger 1999; J. Seddon and S. Briggs, *unpubl.*; J. Reid, *unpubl.*). Even quite-small remnants can support a good number of declining species if they are in excellent condition. Consider the following observation of Eyre Peninsula (SA) farmer, Mr Kieran Fitzgerald, on this subject (from Wotton 1996):

> *'I would like to stress the urgency of stock-proofing existing trees, belts, blocks, shelters or individual. The one outstanding thing to come out of my heritage land which is fenced and from which stock are excluded, is to identify the desecration stock are causing to existing native vegetation. I would be prepared to say that all the activities of* Trees for Life *and* Greening Australia *combined are negated by existing tree losses. Further, if the rich variety of species in the natural shelters could be counted I am sure that at least one billion native plants now existing will be lost before the turn of the century unless further action is taken.'*

Implicit in the need to modify and curtail current grazing practices is the diagnosis that loss of habitat complexity and quality at the ground and sub-shrub level lies at the heart of the problem. The loss of green productive plant matter (lichens, bryophytes, herbs, shrubs: the sources of autochthonous inputs of energy at this stratum) is not the sole concern, here. Nor is it simply the loss of structural complexity these plants provide. Much surface and near-surface microhabitat complexity (or 'surface roughness and texture') in intact healthy habitats is provided by rocks, coarse litter and fallen timber. In intensively managed farmscapes, even if an overtopping tree cover remains, these ground-layer textural elements tend to disappear over time. No doubt there are sound agricultural reasons as to why such tidying-up practices on a farm are widespread (and they are also due undoubtedly to cultural reasons involving personal standing and civic responsibility). However, it is possible that the cumulative effect of over 150 years of such 'tidying up' has been considerable and severely detrimental to the terrestrial and soil invertebrate fauna. This may help to explain why ground-foraging, specialised, insectivorous birds have been so adversely affected in these landscapes. Ground-layer and soil ecosystem function have probably been greatly impaired, as indicated by research into similar issues in areas adjacent to the SWB (Tongway and Ludwig 1997).

Equally as serious, perhaps more so, certainly at some scales, is the collection of dead timber for fuelwood, whether for domestic use or as a commercial operation. The southern big centres and cities are the major users of fuelwood, and so timber-harvesting activities tend to be concentrated around these centres. Fuelwood harvesting is not restricted to dead timber. This clearing of remnant woodland for fuelwood, whether as isolated living trees or as intact habitat patches, adds to broad-acre clearance for agriculture. Moreover, the timber that is preferred firewood tends to be the same species of eucalypts that have been selectively cleared for agriculture. An overhaul of this industry is urgently required to mitigate against these impacts (Robinson 1994; Howling 1996; J. Wall *ms submitted*). Dead timber, standing and fallen, are highlighted in the literature as important components of habitat for two of the worst-affected Declining species in the SWB, namely Hooded Robin and Brown Treecreeper.

I have focussed on those issues I consider to be the most important and broad-scale in the SWB. There are many other threatening processes. They have been dealt with fully by other authors (Robinson 1991, 1994; Robinson and Traill 1996; Garnett 1993; Ford et al. 1995; Howling 1996) and include, in no particular order:

- land degradation, particularly salinity and dieback;
- grazing by feral herbivores;
- weed invasions;
- loss of and competition for hollows;
- lack of or limited regeneration in remnants;
- predation by feral carnivores.

4. DISCUSSION

The traditional (1970s and 80s) search for 'rare and endangered' species to consider for listing in I.U.C.N. red data books or NPWS schedules, tended to focus on species that occurred in low abundance and had restricted distributions. Both attributes result in small population size that, invoking simple theory (e.g. Soulé 1986), automatically predisposes a species to greater risk of extinction. Predators high in the food chain, biogeographic relics, and charismatic species were all good candidates for inclusion, and there are very sound reasons why such species are likely to be more at risk than abundant, widespread and cryptic species. However, a qualification needs to be added to this last statement – they are sound reasons, provided other factors, particularly threatening processes, operate uniformly across and within landscapes. These simple rules fall down when threatening processes operate in anything but uniform ways across a region, state or nation. Also, scientific perception of the degree of risk that should be attached to different threats has undoubtedly changed and matured. Illegal trapping and trafficking were long considered a major threat to certain Australian parrot and finch species. As deleterious, locally, as these depradations may be, the most serious threats to these birds are now known to be habitat loss and degradation (e.g. Joseph 1988; Woinarski 1993), i.e. threatening processes that operate over extensive areas of land.

As the analyses reported here reveal, lists of species of formal conservation significance largely still reflect these traditional concerns, sometimes with good reason. However, it would appear that extinction theory as reported in the ecological literature and its application to risk assessment may require some revision. If the results reported for Declining bird species in the NSW SWB prove general, it suggests that ways need to be found to match the particular nature of threatening processes with the characteristics of species that would predispose them to risk. As argued in the Introduction, case-specific approaches may prove more effective in identifying the risk of extinction than the application of general theory in isolation.

Declining bird species in the NSW SWB are characterised by having **large distributions** in Australia, and their local abundance is not significantly lower than the average bird. Indeed, many of these species appear to have been quite abundant historically as far as can be judged (see Goldney 1987). Theory predicts species with low abundance and small geographic ranges to be extinction prone (e.g. Lawton 1996). While Declining species were shown to be dietary specialists, in most niche dimensions the results were inconclusive with respect to specialisation, and a trend towards a broad use of available vertical strata was noted. How general might these results be?

When compared with other parts of the TAZ, the NSW results appear concordant with those for Victoria (Robinson 1991, 1993, 1994; Reid and Pedler 1989), South Australia (Reid et al. 1985; Reid and Pedler 1989; Paton et al. 1994) and Western Australia (Saunders 1989; Saunders and Ingram 1995; Lambeck 1999). The species identified as being prone to local extinction or declining are broadly similar in all areas. It has not been possible in the time available to pursue the parallels more closely. Ideally, one would need to find ways to differentiate objectively between the 'traditional rare and endangered' and the more recently emerging Decliner type, and then see if the contrasts in life-history characteristics described here apply generally. There are certainly discrepancies among these regions, and some of these may simply reflect inadequate knowledge of the true state of affairs. For example, Robinson (1994) shows the Zebra Finch to be a Decliner in parts of the SWB in NSW and Victoria, yet here I have diagnosed it as an Increaser. Better information bases are required, and the new Australian Bird Atlas Scheme should go someway towards meeting this need, although Atlas data are no substitute for rigorous census data in certain cases (e.g. Mac Nally 1997).

Within the one region, the NSW SWB, there are a sufficient number of divergent trends or contrasting patterns in species' declines to warrant a much wider range of ecological research to be undertaken. Consider the following:

- the complex geographic pattern of decline in Grey-crowned Babbler; the Regent Honeyeater is exhibiting a similar decline, masked somewhat by its nomadic and irruptive behaviour;
- the contraction of range towards drier inland regions suggested by the decline of species such as Chestnut-rumped Thornbill and Crested Bellbird;
- the (virtual) extinction (and range contraction northwards) of several species associated with summer-rainfall dominated grassy environments in the north of the region, e.g. Squatter Pigeon, Paradise Parrot, Black-throated Finch.

I would be surprised, given the above trends, if there are not examples of birds typical of the wet sclerophyll forest formation that historically occupied the eastern portions of the SWB and which have contracted coastwards (to invoke the theory of Brown 1984 again). There appears to be a counter-example to this last proposition, however, in that the Eastern Yellow Robin is suggested to have expanded its range in the reverse direction (Schodde 1965). Silvicultural practices in native forest reserves (and grazing impacts) have promoted dense shrubbing up of native pine in many areas of the drier SWB, and this habitat modification probably accounts for the species' range expansion. Reid and Fleming (1992), who considered briefly the geographic patterns in decline of arid Australian birds, concluded that there could be systematic trends in the direction of range contraction dependent on the affected taxon's biogeographic affinities. A synthetic analysis along these lines could prove illuminating, and should the regular patterns suggested here be further substantiated, they may allow generalisations about recovery guidelines to be made for suites (or functional groups) of like species.

A disturbing corollary to this previous line of thought concerns those species that are confined almost entirely to the TAZ woodland biome. For these species – exemplified by the Superb Parrot, Regent Parrot, Swift Parrot, Regent Honeyeater and Black-chinned Honeyeater – there is no central environment to which they can fall back. The TAZ is it for such species, they have no fall backs. Better management of existing remnants and the restoration of whole landscapes are required if these species' futures are to be secured.

5. Conclusions and Recommendations

5.1 Conclusions

Further broad-acre clearance of native vegetation in the core of the NSW SWB is indefensible and should halt forthwith. Clearance controls, once they included a compensation component, finally proved effective in stopping broad-acre clearance in the agricultural regions of South Australia in the late 1980s (Dendy and Murray 1996). Yet, and predictably (e.g. Ford and Howe 1980), the status, health and stocks of birdlife in those regions continue to erode (Paton et al. 1994), and the critically endangered, dwindling Mount Lofty Ranges population of Black-chinned Honeyeater serves as an apposite example of this (D. Paton *personal communication*). Without an effective halt to further clearance, the prognosis for Threatened and Declining birds in the SWB, serious already, can only become more acute.

At the same time as the introduction of effective and just clearance controls (in place to a degree in NSW), improving the management of existing remnants should be accorded equal priority. Here, a more strategic approach to the management of existing remnants and to revegetation is needed, and a focused research component will be vital to the success of such efforts. Inevitably, some remnants are more valuable than others, and so a prioritisation process established along sound, **theoretical and practical**, lines needs to be developed. This planning process has to be tightly integrated with regional revegetation works – an appropriate vision for future landscapes in the SWB is first needed. The results presented in this report suggest two immediate priorities for such a vision. First, habitat linkages are missing in the contemporary broad sweep of SWB agricultural landscapes, and these linkages need to be restored. Second, certain parts of the landscape (under topographic control of drainage and runoff redistribution), particularly the more fertile soil-vegetation associations, have to be the primary focus of landscape rehabilitation. We need to recreate extensive areas of open woodland formation, with structurally diverse ground layers, that encompass patchy grass and shrub coverage, dead timber, and small-scale soil and moisture traps. A three-pronged strategy is thus envisaged for habitat management and landscape rehabilitation:

- rapid, regional prioritisation of existing remnants under private tenure, so that financial resources can be dedicated to fencing, stock management and the curtailment of other degrading practices (fuelwood harvesting);
- implementation of a spatially-explicit, revegetation strategy to restore habitat linkages between identified, high-value remnants;
- implementation of spatially-explicit, revegetation and interventionist management strategies for priority habitat patches, focussing immediately on the need to restore ground-layer complexity and increase their size, but, in the longer term, to introduce patchy disturbance regimes.

This strategy is similari in outline to the ‘focal species’ conservation planning process devised by Lambeck (1997), which is currently being implemented in the Western Australian Wheatbelt (Lambeck 1998; Beecham et al. 1999). The focal species approach is the logical starting point from which to adapt and devise suitable processes tailored to the needs of the NSW SWB. Work on this approach in NSW has already commenced (Freudenberger 1999; J. Seddon & S. Briggs *unpubl.*), and the provisional results appear heartening (S. Morton *personal communication*).

The larger habitat remnants in the favoured topographic portions of the landscape will be accorded the highest priority in the first case. Riparian zones have been identified repeatedly as key habitats and elements in these eastern TAZ landscapes (Mac Nally 1990; Fisher 1997; Major et al. 1998; Bennett et al. 1998; N. Schrader *personal communication*). Not only are they biodiverse, possess high complementarity, are habitat for many Threatened and Declining bird species, and house abundant avifaunas, but they already provide the logical skeleton for recreating functioning linkages across regional landscapes. There has been a tendency to over-emphasise the importance of the grassy-box woodland formations to the detriment of river red gum and river oak associations. The restoration of both formations will be vital if the prospects of bird conservation in the SWB are to improve. Therefore, it is the largest (and longest) existing remnants of these two formations that should receive high priority in the absence of detailed on-ground investigations.

Neither the magnitude nor the urgency of the problems facing biodiversity conservation in these landscapes will allow the comprehensive field surveys that would provide the ideal basis for conservation planning. However, many solid foundations have been laid and further survey effort should build upon these studies (e.g. Barrett et al. 1994; Fisher 1997; Major et al. 1998; Date et al. in press). Future surveys should aim to fill the gaps geographically and address issues of landscape-scaled patterning of remnant vegetation that may bear upon the design of revegetation initiatives.

Before the envisaged regional planning strategy can be implemented, all relevant, spatially-explicit data sets on remnant vegetation (area, type, condition etc.), riparian zones, road reserves, land tenure etc. need to be assembled and integrated within a GIS environment. Undoubtedly much of this activity is occurring already, but sufficient resources and focus need to be devoted to it as a central objective. The importance of using natural river corridors in large-scale planning for targeted revegetation has been emphasised already. Equally important in this respect, and often superimposed on the landscape at finer scales than the vegetated stream corridors, are the Travelling Stock Routes, Stock Reserves and Road Reserves. These areas frequently retain valuable native vegetation remnants, and a system of vegetated linkages aiming to increase the connectivity between larger remnants in the landscape can be planned around them.

A whole raft of good, general, research and management recommendations has been proposed to help combat the problems faced by birds and other aspects of biodiversity in these highly fragmented, Australian production landscapes. See, in particular, Robinson (1994); Ford et al. (1995); Saunders and Ingram (1995); Robinson and Traill (1996); Howling (1996); Bennett et al. (1998); Lambeck (1998). There is no need to reiterate them here, but ‘someone’ (individuals, society, institutions, community groups, government) has to take them on board and proceed with them to the next step – implementation and actual management and restoration.

5.2 Recommendations

The following vital research and baseline information gaps need to be addressed, if progress with finding solutions to the biodiversity crisis in the SWB is to be advanced.

Recommendation *:*
Accurate figures on remnants classified into broad vegetation types are required for all districts within the SWB. Where possible, accurately dated histories of land clearance should be compiled.

Recommendation *:*
Given the urgency attached to the serious plight of the regional biota, attributed ultimately to the extensive loss of habitat, building an expanded vision for a revegetation strategy is an immediate imperative. Broad-acre vegetation clearance has been the problem, and so that approach to agricultural development should guide revegetation implementation objectives – REVEGETATION MUST BECOME BROAD-ACRE: EFFICIENT AND EFFECTIVE DIRECT-SEEDING PROCEDURES AND GUIDELINES ARE URGENTLY REQUIRED!

Recommendation *:*
There is uneven coverage of information on the contemporary distribution and abundance of birds in the NSW SWB. In particular, the districts to the north of Pilliga and west of the New England Plateau require better coverage. Targeted survey effort is required in these northern districts.

Recommendation *:*
Resources are required to adopt the 'oral history' approach with older ornithologists who have resided in the SWB for long periods. They are undoubtedly the repository of a vast store of untapped knowledge and wisdom about woodland birds in the SWB.

Recommendation *:*
The Grey-crowned Babbler needs to become the focus of intensive research over a greater portion of its range. Comparative studies of populations in the southern, central and northern portions of the SWB should afford insight into the extinction process and, just as importantly, identify the conditions necessary for the maintenance of viable local populations of this species ***if these northern populations are not already in decline****. Comparative studies of ecologically similar pairs or guilds of species, in which one member is declining to a greater degree than others, should also maximise the return of information of value to management.*

REFERENCES

Ayers D., Nash S. and Baggett K. (1996). *Threatened Species of Western New South Wales.* NSW National Parks and Wildlife Service, Sydney.

Baker G.B., Dettmann E.B., Scotney B.T., Hardy L.J. and Drynan D.A.D. (1997). *Report on the Australian Bird and Bat Banding Scheme, 1995-96.* ABBBS, EA, Canberra.

Barrett G.W., Ford H.A. and Recher H.F. (1994). Conservation of woodland birds in a fragmented rural landscape. *Pac. Conserv. Biol.* **1**:245-256.

Bauer J.J. and Goldney D.C. (in press). Extinction and Degradation in complex landscape systems. *Nature Conservation 5: Conservation in Production Environments: Managing the Matrix.* Surrey Beatty & Sons, Sydney.

Beecham B.C., Hopkins A.J.M., Beeston G.R. and Lambeck R.J. (1999). Description of the [Dongolocking] study area. Pp. 21-33. *In* Wallace K.J. (ed.). *Dongolocking Pilot Planning Project for Remnant Vegetation.* Final Report (Phase 1). Department of Conservation and Land Management, Perth.

Bennett A., Brown G., Lumsden L., Hespe D., Krasna S. and Silins J. (1998). *Fragments for the Future. Wildlife in the Victorian Riverina (the Northern Plains).* Dept Natural Resources and Environment, Melbourne.

Bennett A.F. and Ford L.A. (1997). Land use, habitat change and the conservation of birds in fragmented rural environments: a landscape perspective from the Northern Plains, Victoria, Australia. *Pac. Conserv. Biol.* **3**:244-261.

Benson J. (1999). *Setting the Scene: The Native Vegetation of New South Wales.* Native Vegetation Advisory Council, Background Paper No. 1, Sydney.

Bentley J.M. and Catterall C.P. (1997). The use of bushland, corridors, and linear remnants by birds in southeastern Queensland, Australia. *Conserv. Biol.* **11**:1173-1189.

Blakers M., Davies S.J.J.F. and Reilly P.N. (1984). *The Atlas of Australian Birds.* RAOU and Melbourne University Press, Melbourne.

Bohning-Gaese K., Taper M.L. and Brown J.H. (1993). Are declines in North American songbirds due to causes on the breeding range? *Conserv. Biol.* **7**:76-85.

Briggs J.D. and Leigh J.H. (1995). *Rare or Threatened Australian Plants.* CSIRO Publishing, Melbourne.

Brooker L., Brooker M. and Cale P. (1999). Animal dispersal in fragmented habitat: measuring habitat connectivity, corridor use, and dispersal mortality. *Conserv. Ecol.* [online] **3**(1): article 4.

Brown J.H. (1984). On the relationship between abundance and distribution of species. *Am. Nat.* **124**:225-279.

Burbidge A.A. and McKenzie N.L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biol. Conserv.* **50**:143-98.

Cale P. (1994). Temporal changes in the foraging behaviour of insectivorous birds in a sclerophyll forest in Tasmania. *Emu* **94**:116-126.

Castles I. (1992). *Australia's Environment: Issues and Facts.* Cat. No. 4140.0. Aust. Bur. Statistics, Canberra.

Caughley G. (1994). Directions in conservation biology. *J. Anim. Ecol.* **63**:215-244.

Christidis L. and Boles W.E. (1994). *The Taxonomy and Species of Birds of Australia and its Territories.* RAOU Monogr. 2, Melbourne.

Clarke M.F. (1984). Interspecific aggression within the genus *Manorina*. *Emu* **84**:113-115.

Cooper R.M. and I.A.W. McAllan (1995). *The Birds of Western New South Wales: A Preliminary Atlas.* NSW Bird Atlassers Inc., Albury.

Date E.M., Goldney D.C., Bauer J.J. and Paull D.C. (in press). The distribution and abundance of threatened vertebrate fauna in NSW Cypress woodlands: implications for State Forest management. *Nature Conservation 5: Conservation in Production Environments: Managing the Matrix.* Surrey Beatty & Sons, Sydney.

Davies K.F., Margules C.R. and Lawrence J.F. (in press). Which traits of species predict population declines in experimental forest fragments? *Ecology*

Debus S.J.S. (1997). The Barking Owl in New South Wales. *Aust. Birds* **30**:53-80.

Dendy T. and Murray J. (eds) (1996). *From Conflict to Conservation. Native Vegetation Management in Australia. A Focus on the South Australian Program and other Australian Initiatives.* Department of Environment and Natural Resources, Adelaide.

Ellyard D. (1994). *Droughts and Flooding Rains. The Weather of Australia.* Angus & Robertson, Sydney.

Elton C. (1927). *Animal Ecology.* Sidgwick & Jackson, London.

Emison W.B., Beardsell C.M., Norman F.I., Loyn R.H. and Bennett S.C. (1987). *Atlas of Victorian Birds.* Dept Conservation, Forests and Lands and RAOU, Melbourne.

Fahrig L. (1997). Relative effects of habitat loss and fragmentation on population extinction. *J. Wildl. Manag.* **61**:603-610.

Fisher A.M. (1997). *The Distribution and Abundance of Avifauna in the Bathurst Landscape: Implications for Conservation and Land Management.* Ph.D. Thesis, Environmental Studies Unit, Faculty of Science and Agriculture, CSU, Bathurst, NSW.

Ford H.A. (1979). Birds. Pp. 103-114 *In* M.J. Tyler, C.R. Twidale and J.K. Ling (eds) *Natural History of Kangaroo Island.* Royal Soc. S. Aust., Adelaide.

Ford H.A. and Bell H. (1982). Density of birds in eucalypt woodland affected to varying degrees by dieback. *Emu* **81**:202-208.

Ford H.A., Bell H., Nias R. and Noske R. (1986). The relationship between ecology and the incidence of cooperative breeding in Australian birds. *Behav. Ecol. Sociobiol.* **22**:239-249.

Ford H.A., Bridges L. and Noske S. (1985). Density of birds in eucalypt woodland near Armidale, north-eastern New South Wales. *Corella* **9**:78-107.

Ford H., Davis W.E., Debus S., Ley A., Recher H. and Williams B. (1993). Foraging and aggressive behaviour of the Regent Honeyeater *Xanthomyza phrygia* in northern New South Wales. *Emu* **93**:277-281.

Ford H.A. and Debus S. (1994). Aggressive behaviour of Red Wattlebirds *Anthochaera carunculata* and Noisy Friarbirds *Philemon corniculatus*. *Corella* **15**:141-147.

Ford H. and Howe R. (1980). The future of birds in the Mount Lofty Ranges. *S. Aust. Ornithol.* **28**:85-89.

Ford H.A., Lynch J.L., Recher H.F. and Saunders D.A. (1995). *The Effect of Habitat Loss, Fragmentation and Degradation on Bird Communities in Southern Australia.* Project 141 for World Wide Fund for Nature, Australia. WWF, Sydney.

Ford H.A. and McFarland D.C. (1991). Faunal survey of New England. Part III. Birds. *Mem. Queensl.Mus* **30**:381-431.

Ford H.A., Noske S. and Bridges L. (1986). Foraging of birds in eucalypt woodland in north-eastern New South Wales. *Emu* **86**:168-179.

Fox B.J. (1987). Species assembly and the evolution of community structure. *Evol. Ecol.* **1**:201-213.

Franklin D.C., Menkhorst P.W. and Robinson J.L. (1989). Ecology of the Regent Honeyeater *Xanthomyza phrygia*. *Emu* **89**:140-154.

Freudenberger D. (1999). *Guidelines for Enhancing Grassy Woodlands for the Vegetation Investment Project.* A report commissioned by Greening Australia, ACT & SE NSW, Inc. CSIRO Wildlife and Ecology, Canberra.

Garnett S.T. (1992). *An Action Plan for Australian Birds*. Australian National Parks and Wildlife Service, Canberra.

Garnett S.T. (1993). *Threatened and Extinct Birds of Australia.* RAOU Report 82. Royal Australasian Ornithologists Union and Australian National Parks and Wildlife Service, Melbourne.

Garnett S.T., Crowley G.M., Fitzherbert K. and Bennett S. (1992). *Life History Database for Australian Birds.* RAOU, Melbourne.

Gaston K. (1994). *Rarity.* Chapman & Hall, London.

Gaston K.J., Blackburn T.M. and Lawton J.H. (1997). Interspecific abundance-range size relationships: an appraisal of mechanisms. *J. Anim. Ecol.* **66**:579-601.

Goldney D.C. (1987). The vertebrate fauna of the central western region. Pp. 136-160 *In* D.C. Goldney and I.J.S. Bowie (eds) *The National Trust of Australia (NSW) Scenic and Scientific Survey of the Central Western Region.* Report to the Australian Heritage Commission, Vol. I. Mitchell College of Advanced Education, Bathurst, NSW.

Goldney D.C. and Bowie I.J.S. (1990). Some management implications for the conservation of vegetation remnants and associated fauna in the central western region of New South Wales. *Proc. Ecol. Soc. Aust.* **16**:427-440.

Graetz D., Fisher R. and Wilson M. (1992). *Looking Back. The Changing Face of the Australian Continent, 1972-1992.* CSIRO, Canberra.

Grime J.P. (1979). *Plant Strategies and Vegetation Processes.* John Wiley & Sons, Chichester, England.

Haila Y. (1991). Implications of landscape heterogeneity for bird conservation. Proc. Internat. Ornithol. Congr. **XX**:2286-2291.

Hanski I., Moilanen A. and Gyllenburg M. (1996). Minimum viable metapopulation size. *Am. Nat.* **147**:527-541.

Harvey P.H. (1996). Phylogenies for ecologists. *J. Anim. Ecol.* **65**:255-263.

Harvey P.H. and Pagel M.D. (1991). *The Comparative Method in Evolutionary Biology.* Oxford University Press.

Harvey P.H., Read A.F. and Nee S. (1995). Why ecologists need to be phylogenetically challenged. *J. Ecol.* **83**:535-536.

Heron S.J. (1973a). Birds of the Orange district, NSW. *Emu* **73**:1-8.

Heron S.J. (1973b). Birds of Goonoo State Forest, N.S.W. *Emu* **73**:119-123.

Hobbs J.N. (1961). The birds of south-west New South Wales. *Emu* **61**:21-55.

Hobbs R.J. (ed.) (1992). *Biodiversity in Mediterranean Ecosystems in Australia*. Surrey Beatty & Sons, Sydney.

Hobbs R.J. and Hopkins A,J.M. (1990). From frontier to fragments: European impact on Australia's vegetation. *Proc. Ecol. Soc. Aust.* **16**:93-114.

Hobbs R.J. and Huenneke L.F. (1992). Disturbance, diversity and invasion: implications for conservation. *Conserv. Biol.* **6**:324-337.

Hobbs R.J. and Mooney H.A. (1998). Broadening the extinction debate: population deletions and additions in California and Western Australia. *Conserv. Biol.* **12**:271-283.

Hobbs R.J. and Saunders D.A. (eds) (1993). *Reintegrating Fragmented Landscapes: Towards Sustainable Production and Nature Conservation.* Springer-Verlag, New York.

Howling G.M. (1996). *Temperate Woodlands: Their Conservation Status in Australia.* A WWF Australia Research Report, Sydney.

Huston M. (1979). A general hypothesis of species diversity. *Am. Nat.* **113**:81-101.

Hutchins B.R. (1991). *Checklist of Birds, Sandy Creek Conservation Park.* Unpubl. leaflet for the Friends of Sandy Creek Conservation Park, Adelaide.

Jokimaki J. and Huhta E. (1996). Effects of landscape matrix and habitat structure on a bird community in northern Finland: a multi-scale approach. *Orn. Fenn.* **73**:97-113.

Johnson C.N. (1998). Species extinction and the relationship between distribution and abundance. *Nature* **394**:272-274.

Joseph L. (1988). A review of the conservation status of Australian parrots in 1987. *Biol. Conserv.* **46**:261-280.

Lambeck R.J. (1997). Focal species: a multi-species umbrella for nature conservation. *Conserv. Biol.* **11**:849-856.

Lambeck R.J. (1999). *Landscape Planning for Biodiversity Conservation in Agricultural Regions. A Case Study from the Wheatbelt of Western Australia.* Biodiversity Tech. Paper No. 2. Environment Australia, Canberra.

Lawton J.H. (1996). Population abundances, geographic ranges and conservation: 1994 Witherby Lecture. *Bird Study* **43**:3-19.

Loyn R.H. (1987). Effects of patch area and habitat on bird abundances, species numbers and tree health in fragmented Victorian forests. Pp. 65-77 *In* D. A. Saunders, G. W. Arnold, A.A. Burbidge and A.J.M. Hopkins (eds) *Nature Conservation: the Role of Remnants of Native Vegetation.* Surrey Beatty & Sons, Sydney.

Tongway D.J. and Ludwig J.A. (1997). Pp. 50-61 *In* J. Ludwig, D. Tongway D. Freudenberger, J. Noble and K. Hodgkinson. (eds) *Landscape Ecology, Function and Management: Principles from Australia'' Rangelands.* CSIRO, Melbourne.

Lunney D., Curtin A.L., Fisher D., Ayers D. and Dickman C.R. (1997). Ecological attributes of the threatened fauna of New South Wales. *Pac. Conserv. Biol.* **3**:13-26.

MacArthur R.H. (1972). *Geographical Ecology.* Harper & Rowe, New York.

Mac Nally R.C. (1990). Modelling distributional patterns of woodland birds along a continental gradient. *Ecology* **71**:360-374.

Mac Nally R.C. (1995). A protocol for classifying regional dynamics, exemplified by using woodland birds in south-eastern Australia. *Aust. J. Ecol.* **20**:442-454.

Mac Nally R. (1997). Population densities in a bird community of a wet sclerophyllous Victorian forest. *Emu* **97**:253-258.

Mac Nally R. and Bennett A.F. (1997). Species-specific predictions of the impact of habitat fragmentation: local extinction of birds in the box-ironbark forests of central Victoria, Australia. *Biol. Conserv.* **82**:147-155.

Mac Nally R. and MacGoldrick J. (1997). Mass flowering and landscape dynamics of bird communities in some eucalypt forests of central Victoria, Australia. *J. Avian Biol.* **28**:171-183.

Major R., Christie F. and Gowing G. (1998). *The value of remnant vegetation for birds in the New South Wales wheatbelt.* Unpubl. final report to Environmental Trusts. Aust. Museum, Sydney.

McIntyre S. and Barrett G.W. (1992). Habitat variegation, an alternative to fragmentation. *Conserv. Biol.* **6**:146-147.

Morris A.K. (1986). The birds of Sydney Harbour National Park, New South Wales. *Aust. Birds* **20**:65-81.

Morris A.K., McGill A.R. and Holmes G. (1981). *Handlist of Birds in New South Wales.* NSW Field Ornithologists Club, Sydney.

Morton S.R. (1990). The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proc. Ecol. Soc. Aust.* **16**:201-13.

Nix H. (1982). Environmental determinants of biogeography and evolution in Terra Australis. Paper 5, pp. 47-66 *In* W.R. Barker and P.J.M. Greenslade (eds) *Evolution of the Flora and Fauna of Arid Australia.* Peacock, Adelaide.

Parker S.A. and Reid N.C.H. (1983). Birds. Pp. 135-150 *In* M.J. Tyler, C.R. Twidale, J.K. Ling and J.W. Holmes (eds). *Natural History of the South East.* The Royal Society of South Australia, Adelaide.

Paton D.C., Carpenter G. and Sinclair R.G. (1994). A second bird atlas of the Adelaide region. Part 1: changes in the distribution of birds: 1974-75 vs 1984-85. *S. Aust. Ornith.* **31**:151-193.

Pearson S.M. (1993). The spatial extent and relative influence of landscape-level factors on wintering bird populations. *Landsc. Ecol.* **8**:3-18.

Pimm S.L. (1982). *Food Webs.* Chapman & Hall, London.

Pimm S.L. (1993). Life on an intermittent edge. *TREE* **8**:45-46.

Pimm S.L., Jones H.L. and Diamond J. (1988). On the risk of extinction. *Am. Nat.* **132**:757-785.

Pizzey G. (1980). *A Field Guide to the Birds of Australia.* Collins, Sydney.

Prober S.M. and Thiele K.R. (1993). The ecology and genetics of remnant grassy white box woodlands in relation to their conservation. *Vic. Nat.* **110**:30-36.

Rabinowitz D., Cairns S. and Dillon T. (1986). Seven forms of rarity and their frequency in the flora of the British Isles. Pp. 182-205 *In* M.E. Soulé (ed.) *Conservation Biology: The Science of Scarcity and Diversity.* Sinauer, Sunderland, Mass.

Radford J. (1998). White-browed Treecreepers and me. *Bird Observer* **790**:7-8.

Recher H.F. (1985). Synthesis: a model of forest and woodland bird communities. Pp. 129-135 *In* A. Keast, H.F. Recher, H. Ford and D. Saunders (eds) *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management.* Surrey Beatty, Sydney.

Recher H.F. (1999). The state of Australia's avifauna: a personal opinion and prediction for the new millennium. *Aust. Zool.* **31**:11-27.

Recher H.F., Holmes R.J., Schulz M., Shields J. and Kavanagh R. (1985). Foraging patterns of breeding birds in eucalypt forest and woodland of southeastern Australia. *Aust. J. Ecol.* **10**:399-419.

Recher H.F. and Lim L. (1990). A review of current ideas of the extinction, conservation and management of Australia's terrestrial vertebrate fauna. *Proc. Ecol. Soc. Aust.* **16**:287-301.

Rees M. (1995). EC-PC comparative analyses? *J. Ecol.* **83**:891-892.

Reid J.R.W., Barritt M.K. and Houston C. (1985). *Birds and Habitats of the Bangham District*. Nature Conservation Society of South Australia Inc., Adelaide.

Reid J.R.W., Carpenter G.A. and Pedler L.P. (1996). Birds. Pp. 132-148 *In*: M. Davies, C.R. Twidale and M.J. Tyler (eds) *The Natural History of the Flinders Ranges.* The Royal Society of South Australia, Adelaide.

Reid J. and Fleming M. (1992). The conservation status of birds in arid Australia. *Rangel. J.* **14**:65-91.

Reid J. and Pedler L. (1989). Book review: *Atlas of Victorian birds. S. Aust. Ornithol.* 30:218-220.

Rey Benayas J. M., Scheiner, S. M. García Sánchez-Colomer, M. and Levassor. C. (1999). Commonness and rarity: theory and application of a new model to Mediterranean montane grasslands. *Conserv. Ecol.* **3**(1): Art. 5.

Robinson D. (1991). Threatened birds in Victoria: their distributions, ecology and future. *Vic. Nat* **3**:67-77.

Robinson D. (1993). Vale Toolern Vale: the loss of our woodland birds. *Wingspan* **9**:1-3, 20-21.

Robinson D. (1994). *Research Plan for Threatened Woodland Birds of Southeastern Australia*. Arthur Rylah Institute Technical Report No. 133. Department of Conservation & Natural Resources, Melbourne.

Robinson D. and Traill B.J. (1996). *Conserving Woodland Birds in the Wheat and Sheep Belts of Southern Australia.* RAOU Conservation Statement No. 10. RAOU, Melbourne.

Sandbrink J. and Robinson D. (1994). An observation of communal breeding by Southern Whitefaces. *Corella* **18**:88.

Sauer J.R., Pendleton G.W. and Peterjohn B.G. (1996). Evaluating causes of population change in North American insectivorous songbirds. *Conserv. Biol.* **10**:465-478.

Saunders D.A. (1989). Changes in the avifauna of a region, district and remnant as a result of fragmentation of native vegetation: the wheatbelt of Western Australia. A case study. *Biol. Conserv.* **50**:99-135.

Saunders D.A., Hobbs R.J. and Margules C.R. (1991). Biological consequences of ecosystem fragmentation: a review. *Conserv. Biol.* **5**:18-32.

Saunders D.A. and Ingram J.A. (1995). *Birds of Southwestern Australia. An atlas of Changes in the Distribution and Abundance of the Wheatbelt Avifauna.* Surrey Beatty & Sons, Sydney.

Saunders D.A. and de Rebeira C.P. (1991). Values of corridors to avian populations in a fragmented landscape. Pp. 221-240 *In* D.A. Saunders and R.J. Hobbs (eds) *Nature Conservation 2: The Role of Corridors.* Surrey Beatty & Sons, Sydney.

Schodde R. (1965). Observations on new distribution and habitat of five Australian land birds. *Emu* **64**:204-208.

Schodde R. (1990) The bird fauna of the mallee - its biogeography and future. Pp. 61-70 *In* J.C. Noble, P.J. Joss and G.K. Jones (eds) *The Mallee Lands: A Conservation Perspective.* CSIRO, Melbourne.

Schodde R. and Tidemann S.C. (eds) (1986). *Reader's Digest Complete Book of Australian Birds.* 2nd ed. Reader's Digest, Sydney.

Scougall S.A., Majer J.D. and Hobbs R.J. (1993). Edge effects in grazed and ungrazed Western Australian wheatbelt remnants in relation to ecosystem reconstruction. Pp. 163-178 *In* D.A. Saunders, R.J. Hobbs and P.R. Ehrlich (eds) *Nature Conservation 3: Reconstruction of Fragmented Ecosystems.* Surrey Beatty & Sons, Sydney.

Schrader N.W. (1980). A review on the distribution of the Superb Parrot in central New South Wales. *Aust. Birds* **14**:45-50.

Schrader N.W. (1987). Birds. Ch. 4 pp. 46-63 *In* Schrader N. (ed.) *The Flora and Fauna of the Parkes Shire.* Parkes Naturalists Group, Parkes, NSW.

SEAC (State of the Environment Advisory Council) (1996). *Australia: State of the Environment 1996. Executive Summary.* CSIRO Publishing, Melbourne.

Short J. and Smith A. (1994). Mammal decline and recovery in Australia. *J. Mammal.* **75**:288-297.

Smith A.P. and Quin D.G. (1996). Patterns and causes of extinction and decline in Australian Conilurine rodents. *Biol. Conserv.* **77**:243-267.

Smith P.J., Pressey R.L. and Smith J.E. (1994). Birds of particular conservation concern in the Western Division of New South Wales. *Biol. Conserv.* **69**:315-338.

Smith P. and Smith J. (1994). Historical change in the bird fauna of western New South Wales: ecological patterns and conservation implications. Pp. 123-147 *In* D. Lunney, S. Hand, P. Reed and D. Butcher (eds). *Future of the Fauna of Western New South Wales.* Royal Zoological Society of NSW, Mosman.

Soulé M.E. (ed.) (1986). *Conservation Biology: The Science of Scarcity and Diversity.* Sinauer, Sunderland, Mass.

Stafford Smith D.M. and Morton S.R. (1990). A framework for the ecology of arid Australia. *J. Arid Environ.* **18**:255-278.

Stanger M., Clayton M., Schodde R., Wombey J. and Mason I. (1998). *CSIRO List of Australian Vertebrates. A Reference with Conservation Status.* CSIRO Publishing, Melbourne.

Stokes A.L. (1996). *A Biological Survey of Box and Buloke Grassy Woodland in the Upper South-East of South Australia.* SA Dept Environment and Natural Resources, Adelaide.

Taylor M. and COG (Canberra Ornithologists Group) (1992). *Birds of the Australian Capital Territory: an Atlas.* Canberra Ornithologists Group, Canberra.

Taylor P.W. (1987). Birds of the Port Wakefield district, 1968-1985. *S. Aust. Ornithol.* **30**:62-73.

Thackway R. and Cresswell I. (eds) (1995). *An interim biogeographic regionalisation for Australia: a framework for establishing the national system of reserves, version 4.0.* Australian Nature Conservation Agency, Canberra.

Wall J. (*submitted*). Fuelwood in Australia: impacts and opportunities. (*ms*, Department of Ecosystem Management, University of New England, Armidale, NSW).

Westoby M., Leishman M. and Lord J. (1995a). On misinterpreting the 'phylogenetic correction'. *J. Ecol.* **83**:531-534.

Westoby M., Leishman M. and Lord J. (1995b). Further remarks on phylogenetic correction. *J. Ecol.* **83**:727-734.

Westoby M., Leishman M. and Lord J. (1995c). Issues of interpretation after relating comparative datasets to phylogeny. *J. Ecol.* **83**:892-893.

Williams J., Hook R.A., and Gascoigne H.L. (eds) (1998) *Farming action catchment reaction: the effect of dryland farming on the natural environment* CSIRO Publishing, Collingwood, Victoria.

Woinarski J.C.Z. (1993). Australian tropical savannas, their avifauna, conservation status and threats. Pp. 45-63 *In* C.P. Catterall, P.V. Driscoll, K. Hulsman, D. Muir and A. Taplin (eds) *Birds and their Habitats: Status and Conservation in Queensland.* QOS, Brisbane.

Wotton D. (1996). Presentation of certificates to early Heritage Agreement participants. Pp. 83-85 *In* T. Dendy and J. Murray (eds) *From Conflict to Conservation. Native Vegetation Management in Australia. A Focus on the South Australian Program and other Australian Initiatives.* Department of Environment and Natural Resources, Adelaide.

APPENDIX 1 -List of 251 Landbird and 94 Waterbird Species in the NSW SWB and their Assigned Conservation Status Ranks

CS	Code	Common	Order	Family	Scientific
	B001	Emu	STRUTHIONIFORMES	CASUARIIDAE	*Dromaius novaehollandiae*
	B008	Australian Brush-turkey	GALLIFORMES	MEGAPODIIDAE	*Alectura lathami*
E	B007	Malleefowl	GALLIFORMES	MEGAPODIIDAE	*Leipoa ocellata*
	B009	Stubble Quail	GALLIFORMES	PHASIANIDAE	*Coturnix pectoralis*
	B011	Brown Quail	GALLIFORMES	PHASIANIDAE	*Coturnix ypsilophora*
	B012	King Quail	GALLIFORMES	PHASIANIDAE	*Coturnix chinensis*
V	B199	Magpie Goose	ANSERIFORMES	ANSERANATIDAE	*Anseranas semipalmata*
	B205	Plumed Whistling-Duck	ANSERIFORMES	ANATIDAE	*Dendrocygna eytoni*
	B204	Wandering Whistling-Duck	ANSERIFORMES	ANATIDAE	*Dendrocygna arcuata*
V	B216	Blue-billed Duck	ANSERIFORMES	ANATIDAE	*Oxyura australis*
	B217	Musk Duck	ANSERIFORMES	ANATIDAE	*Biziura lobata*
V	B214	Freckled Duck	ANSERIFORMES	ANATIDAE	*Stictonetta naevosa*
	B203	Black Swan	ANSERIFORMES	ANATIDAE	*Cygnus atratus*
	B207	Australian Shelduck	ANSERIFORMES	ANATIDAE	*Tadorna tadornoides*
	B206	Radjah Shelduck	ANSERIFORMES	ANATIDAE	*Tadorna radjah*
	B202	Australian Wood Duck	ANSERIFORMES	ANATIDAE	*Chenonetta jubata*
E	B200	Cotton Pygmy-goose	ANSERIFORMES	ANATIDAE	*Nettapus coromandelianus*
	B201	Green Pygmy-goose	ANSERIFORMES	ANATIDAE	*Nettapus pulchellus*
	B948	Mallard	ANSERIFORMES	ANATIDAE	*Anas platyrhynchos*
	B208	Pacific Black Duck	ANSERIFORMES	ANATIDAE	*Anas superciliosa*
	B212	Australasian Shoveler	ANSERIFORMES	ANATIDAE	*Anas rhynchotis*
	B211	Grey Teal	ANSERIFORMES	ANATIDAE	*Anas gracilis*
	B210	Chestnut Teal	ANSERIFORMES	ANATIDAE	*Anas castanea*
	B213	Pink-eared Duck	ANSERIFORMES	ANATIDAE	*Malacorhynchus membranaceus*
	B215	Hardhead	ANSERIFORMES	ANATIDAE	*Aythya australis*
	B061	Australasian Grebe	PODICIPEDIFORMES	PODICIPEDIDAE	*Tachybaptus novaehollandiae*
	B062	Hoary-headed Grebe	PODICIPEDIFORMES	PODICIPEDIDAE	*Poliocephalus poliocephalus*
	B060	Great Crested Grebe	PODICIPEDIFORMES	PODICIPEDIDAE	*Podiceps cristatus*
	B101	Darter	PELECANIFORMES	ANHINGIDAE	*Anhinga melanogaster*
	B100	Little Pied Cormorant	PELECANIFORMES	PHALACROCORACIDAE	*Phalacrocorax melanoleucos*
	B099	Pied Cormorant	PELECANIFORMES	PHALACROCORACIDAE	*Phalacrocorax varius*
	B097	Little Black Cormorant	PELECANIFORMES	PHALACROCORACIDAE	*Phalacrocorax sulcirostris*
	B096	Great Cormorant	PELECANIFORMES	PHALACROCORACIDAE	*Phalacrocorax carbo*
	B106	Australian Pelican	PELECANIFORMES	PELECANIDAE	*Pelecanus conspicillatus*
	B188	White-faced Heron	CICONIIFORMES	ARDEIDAE	*Egretta novaehollandiae*
	B185	Little Egret	CICONIIFORMES	ARDEIDAE	*Egretta garzetta*
	B189	White-necked Heron	CICONIIFORMES	ARDEIDAE	*Ardea pacifica*
	B187	Great Egret	CICONIIFORMES	ARDEIDAE	*Ardea alba*
	B186	Intermediate Egret	CICONIIFORMES	ARDEIDAE	*Ardea intermedia*
	B977	Cattle Egret	CICONIIFORMES	ARDEIDAE	*Ardea ibis*
	B192	Nankeen Night Heron	CICONIIFORMES	ARDEIDAE	*Nycticorax caledonicus*
	B195	Little Bittern	CICONIIFORMES	ARDEIDAE	*Ixobrychus minutus*
V	B196	Black Bittern	CICONIIFORMES	ARDEIDAE	*Ixobrychus flavicollis*
V	B197	Australasian Bittern	CICONIIFORMES	ARDEIDAE	*Botaurus poiciloptilus*
	B178	Glossy Ibis	CICONIIFORMES	THRESKIORNITHIDAE	*Plegadis falcinellus*
	B179	Australian White Ibis	CICONIIFORMES	THRESKIORNITHIDAE	*Threskiornis molucca*
	B180	Straw-necked Ibis	CICONIIFORMES	THRESKIORNITHIDAE	*Threskiornis spinicollis*
	B181	Royal Spoonbill	CICONIIFORMES	THRESKIORNITHIDAE	*Platalea regia*
	B182	Yellow-billed Spoonbill	CICONIIFORMES	THRESKIORNITHIDAE	*Platalea flavipes*
V	B183	Black-necked Stork	CICONIIFORMES	CICONIIDAE	*Ephippiorhynchus asiaticus*
V	B241	Osprey	FALCONIFORMES	ACCIPITRIDAE	*Pandion haliaetus*
	B234	Pacific Baza	FALCONIFORMES	ACCIPITRIDAE	*Aviceda subcristata*

CS	Code	Common	Order	Family	Scientific
	B232	Black-shouldered Kite	FALCONIFORMES	ACCIPITRIDAE	*Elanus axillaris*
	B233	Letter-winged Kite	FALCONIFORMES	ACCIPITRIDAE	*Elanus scriptus*
V	B230	Square-tailed Kite	FALCONIFORMES	ACCIPITRIDAE	*Lophoictinia isura*
V	B231	Black-breasted Buzzard	FALCONIFORMES	ACCIPITRIDAE	*Hamirostra melanosternon*
	B229	Black Kite	FALCONIFORMES	ACCIPITRIDAE	*Milvus migrans*
	B228	Whistling Kite	FALCONIFORMES	ACCIPITRIDAE	*Haliastur sphenurus*
	B226	White-bellied Sea-Eagle	FALCONIFORMES	ACCIPITRIDAE	*Haliaeetus leucogaster*
	B218	Spotted Harrier	FALCONIFORMES	ACCIPITRIDAE	*Circus assimilis*
	B219	Swamp Harrier	FALCONIFORMES	ACCIPITRIDAE	*Circus approximans*
	B221	Brown Goshawk	FALCONIFORMES	ACCIPITRIDAE	*Accipiter fasciatus*
	B220	Grey Goshawk	FALCONIFORMES	ACCIPITRIDAE	*Accipiter novaehollandiae*
	B222	Collared Sparrowhawk	FALCONIFORMES	ACCIPITRIDAE	*Accipiter cirrhocephalus*
E	B223	Red Goshawk	FALCONIFORMES	ACCIPITRIDAE	*Erythrotriorchis radiatus*
	B224	Wedge-tailed Eagle	FALCONIFORMES	ACCIPITRIDAE	*Aquila audax*
	B225	Little Eagle	FALCONIFORMES	ACCIPITRIDAE	*Hieraaetus morphnoides*
	B239	Brown Falcon	FALCONIFORMES	FALCONIDAE	*Falco berigora*
	B235	Australian Hobby	FALCONIFORMES	FALCONIDAE	*Falco longipennis*
V	B236	Grey Falcon	FALCONIFORMES	FALCONIDAE	*Falco hypoleucos*
	B238	Black Falcon	FALCONIFORMES	FALCONIDAE	*Falco subniger*
	B237	Peregrine Falcon	FALCONIFORMES	FALCONIDAE	*Falco peregrinus*
	B240	Nankeen Kestrel	FALCONIFORMES	FALCONIDAE	*Falco cenchroides*
V	B177	Brolga	GRUIFORMES	GRUIDAE	*Grus rubicunda*
	B046	Buff-banded Rail	GRUIFORMES	RALLIDAE	*Gallirallus philippensis*
	B045	Lewin's Rail	GRUIFORMES	RALLIDAE	*Rallus pectoralis*
	B050	Baillon's Crake	GRUIFORMES	RALLIDAE	*Porzana pusilla*
	B049	Australian Spotted Crake	GRUIFORMES	RALLIDAE	*Porzana fluminea*
	B051	Spotless Crake	GRUIFORMES	RALLIDAE	*Porzana tabuensis*
	B058	Purple Swamphen	GRUIFORMES	RALLIDAE	*Porphyrio porphyrio*
	B056	Dusky Moorhen	GRUIFORMES	RALLIDAE	*Gallinula tenebrosa*
	B055	Black-tailed Native-hen	GRUIFORMES	RALLIDAE	*Gallinula ventralis*
	B059	Eurasian Coot	GRUIFORMES	RALLIDAE	*Fulica atra*
E	B176	Australian Bustard	GRUIFORMES	OTIDIDAE	*Ardeotis australis*
	B018	Little Button-quail	TURNICIFORMES	TURNICIDAE	*Turnix velox*
	B019	Red-chested Button-quail	TURNICIFORMES	TURNICIDAE	*Turnix pyrrhothorax*
	B014	Painted Button-quail	TURNICIFORMES	TURNICIDAE	*Turnix varia*
E	B020	Plains-wanderer	CHARADRIIFORMES	PEDIONOMIDAE	*Pedionomus torquatus*
	B168	Latham's Snipe	CHARADRIIFORMES	SCOLOPACIDAE	*Gallinago hardwickii*
V	B152	Black-tailed Godwit	CHARADRIIFORMES	SCOLOPACIDAE	*Limosa limosa*
	B153	Bar-tailed Godwit	CHARADRIIFORMES	SCOLOPACIDAE	*Limosa lapponica*
	B151	Little Curlew	CHARADRIIFORMES	SCOLOPACIDAE	*Numenius minutus*
	B150	Whimbrel	CHARADRIIFORMES	SCOLOPACIDAE	*Numenius phaeopus*
	B149	Eastern Curlew	CHARADRIIFORMES	SCOLOPACIDAE	*Numenius madagascariensis*
	B159	Marsh Sandpiper	CHARADRIIFORMES	SCOLOPACIDAE	*Tringa stagnatilis*
	B158	Common Greenshank	CHARADRIIFORMES	SCOLOPACIDAE	*Tringa nebularia*
	B154	Wood Sandpiper	CHARADRIIFORMES	SCOLOPACIDAE	*Tringa glareola*
	B157	Common Sandpiper	CHARADRIIFORMES	SCOLOPACIDAE	*Actitis hypoleucos*
	B129	Ruddy Turnstone	CHARADRIIFORMES	SCOLOPACIDAE	*Arenaria interpres*
	B164	Red Knot	CHARADRIIFORMES	SCOLOPACIDAE	*Calidris canutus*
	B162	Red-necked Stint	CHARADRIIFORMES	SCOLOPACIDAE	*Calidris ruficollis*
	B965	Long-toed Stint	CHARADRIIFORMES	SCOLOPACIDAE	*Calidris subminuta*
	B978	Pectoral Sandpiper	CHARADRIIFORMES	SCOLOPACIDAE	*Calidris melanotos*
	B163	Sharp-tailed Sandpiper	CHARADRIIFORMES	SCOLOPACIDAE	*Calidris acuminata*
	B161	Curlew Sandpiper	CHARADRIIFORMES	SCOLOPACIDAE	*Calidris ferruginea*
	B934	Ruff	CHARADRIIFORMES	SCOLOPACIDAE	*Philomachus pugnax*
V	B170	Painted Snipe	CHARADRIIFORMES	ROSTRATULIDAE	*Rostratula benghalensis*

CS	Code	Common	Order	Family	Scientific
V	B171	Comb-crested Jacana	CHARADRIIFORMES	JACANIDAE	*Irediparra gallinacea*
E	B174	Bush Stone-curlew	CHARADRIIFORMES	BURHINIDAE	*Burhinus grallarius*
	B146	Black-winged Stilt	CHARADRIIFORMES	RECURVIROSTRIDAE	*Himantopus himantopus*
	B147	Banded Stilt	CHARADRIIFORMES	RECURVIROSTRIDAE	*Cladorhynchus leucocephalus*
	B148	Red-necked Avocet	CHARADRIIFORMES	RECURVIROSTRIDAE	*Recurvirostra novaehollandiae*
	B006	Pacific Golden Plover	CHARADRIIFORMES	CHARADRIIDAE	*Pluvialis fulva*
	B136	Grey Plover	CHARADRIIFORMES	CHARADRIIDAE	*Pluvialis squatarola*
	B143	Red-capped Plover	CHARADRIIFORMES	CHARADRIIDAE	*Charadrius ruficapillus*
	B140	Double-banded Plover	CHARADRIIFORMES	CHARADRIIDAE	*Charadrius bicinctus*
	B142	Oriental Plover	CHARADRIIFORMES	CHARADRIIDAE	*Charadrius veredus*
	B145	Inland Dotterel	CHARADRIIFORMES	CHARADRIIDAE	*Charadrius australis*
	B144	Black-fronted Dotterel	CHARADRIIFORMES	CHARADRIIDAE	*Elseyornis melanops*
	B132	Red-kneed Dotterel	CHARADRIIFORMES	CHARADRIIDAE	*Erythrogonys cinctus*
	B135	Banded Lapwing	CHARADRIIFORMES	CHARADRIIDAE	*Vanellus tricolor*
	B133	Masked Lapwing	CHARADRIIFORMES	CHARADRIIDAE	*Vanellus miles*
	B172	Oriental Pratincole	CHARADRIIFORMES	GLAREOLIDAE	*Glareola maldivarum*
	B173	Australian Pratincole	CHARADRIIFORMES	GLAREOLIDAE	*Stiltia isabella*
	B125	Silver Gull	CHARADRIIFORMES	LARIDAE	*Larus novaehollandiae*
	B111	Gull-billed Tern	CHARADRIIFORMES	LARIDAE	*Sterna nilotica*
	B112	Caspian Tern	CHARADRIIFORMES	LARIDAE	*Sterna caspia*
	B110	Whiskered Tern	CHARADRIIFORMES	LARIDAE	*Chlidonias hybridus*
	B109	White-winged Black Tern	CHARADRIIFORMES	LARIDAE	*Chlidonias leucopterus*
	B957	Rock Dove	COLUMBIFORMES	COLUMBIDAE	*Columba livia*
	B989	Spotted Turtle-Dove	COLUMBIFORMES	COLUMBIDAE	*Streptopelia chinensis*
	B034	Common Bronzewing	COLUMBIFORMES	COLUMBIDAE	*Phaps chalcoptera*
	B035	Brush Bronzewing	COLUMBIFORMES	COLUMBIDAE	*Phaps elegans*
E	B036	Flock Bronzewing	COLUMBIFORMES	COLUMBIDAE	*Phaps histrionica*
	B043	Crested Pigeon	COLUMBIFORMES	COLUMBIDAE	*Ocyphaps lophotes*
E	B039	Squatter Pigeon	COLUMBIFORMES	COLUMBIDAE	*Geophaps scripta*
	B031	Diamond Dove	COLUMBIFORMES	COLUMBIDAE	*Geopelia cuneata*
	B030	Peaceful Dove	COLUMBIFORMES	COLUMBIDAE	*Geopelia striata*
	B032	Bar-shouldered Dove	COLUMBIFORMES	COLUMBIDAE	*Geopelia humeralis*
V	B264	Red-tailed Black-Cockatoo	PSITTACIFORMES	CACATUIDAE	*Calyptorhynchus banksii*
V	B265	Glossy Black-Cockatoo	PSITTACIFORMES	CACATUIDAE	*Calyptorhynchus lathami*
	B267	Yellow-tailed Black-Cockatoo	PSITTACIFORMES	CACATUIDAE	*Calyptorhynchus funereus*
	B268	Gang-gang Cockatoo	PSITTACIFORMES	CACATUIDAE	*Callocephalon fimbriatum*
	B273	Galah	PSITTACIFORMES	CACATUIDAE	*Cacatua roseicapilla*
	B272	Long-billed Corella	PSITTACIFORMES	CACATUIDAE	*Cacatua tenuirostris*
	B271	Little Corella	PSITTACIFORMES	CACATUIDAE	*Cacatua sanguinea*
V	B270	Major Mitchell's Cockatoo	PSITTACIFORMES	CACATUIDAE	*Cacatua leadbeateri*
	B269	Sulphur-crested Cockatoo	PSITTACIFORMES	CACATUIDAE	*Cacatua galerita*
	B274	Cockatiel	PSITTACIFORMES	CACATUIDAE	*Nymphicus hollandicus*
	B254	Rainbow Lorikeet	PSITTACIFORMES	PSITTACIDAE	*Trichoglossus haematodus*
	B256	Scaly-breasted Lorikeet	PSITTACIFORMES	PSITTACIDAE	*Trichoglossus chlorolepidotus*
	B258	Musk Lorikeet	PSITTACIFORMES	PSITTACIDAE	*Glossopsitta concinna*
	B260	Little Lorikeet	PSITTACIFORMES	PSITTACIDAE	*Glossopsitta pusilla*
V	B259	Purple-crowned Lorikeet	PSITTACIFORMES	PSITTACIDAE	*Glossopsitta porphyrocephala*
	B281	Australian King-Parrot	PSITTACIFORMES	PSITTACIDAE	*Alisterus scapularis*
	B280	Red-winged Parrot	PSITTACIFORMES	PSITTACIDAE	*Aprosmictus erythropterus*
V	B277	Superb Parrot	PSITTACIFORMES	PSITTACIDAE	*Polytelis swainsonii*
E	B278	Regent Parrot	PSITTACIFORMES	PSITTACIDAE	*Polytelis anthopeplus*
	B282	Crimson Rosella	PSITTACIFORMES	PSITTACIDAE	*Platycercus elegans*
	B288	Eastern Rosella	PSITTACIFORMES	PSITTACIDAE	*Platycercus eximius*
	B286	Pale-headed Rosella	PSITTACIFORMES	PSITTACIDAE	*Platycercus adscitus*
	B294	Australian Ringneck	PSITTACIFORMES	PSITTACIDAE	*Barnardius zonarius*

CS	Code	Common	Order	Family	Scientific
	B297	Blue Bonnet	PSITTACIFORMES	PSITTACIDAE	*Northiella haematogaster*
V	B309	Swift Parrot	PSITTACIFORMES	PSITTACIDAE	*Lathamus discolor*
	B295	Red-rumped Parrot	PSITTACIFORMES	PSITTACIDAE	*Psephotus haematonotus*
	B296	Mulga Parrot	PSITTACIFORMES	PSITTACIDAE	*Psephotus varius*
X	B299	Paradise Parrot	PSITTACIFORMES	PSITTACIDAE	*Psephotus pulcherrimus*
	B310	Budgerigar	PSITTACIFORMES	PSITTACIDAE	*Melopsittacus undulatus*
	B304	Bourke's Parrot	PSITTACIFORMES	PSITTACIDAE	*Neopsephotus bourkii*
	B306	Blue-winged Parrot	PSITTACIFORMES	PSITTACIDAE	*Neophema chrysostoma*
V	B302	Turquoise Parrot	PSITTACIFORMES	PSITTACIDAE	*Neophema pulchella*
	B337	Pallid Cuckoo	CUCULIFORMES	CUCULIDAE	*Cuculus pallidus*
	B339	Brush Cuckoo	CUCULIFORMES	CUCULIDAE	*Cacomantis variolosus*
	B338	Fan-tailed Cuckoo	CUCULIFORMES	CUCULIDAE	*Cacomantis flabelliformis*
	B341	Black-eared Cuckoo	CUCULIFORMES	CUCULIDAE	*Chrysococcyx osculans*
	B342	Horsfield's Bronze-Cuckoo	CUCULIFORMES	CUCULIDAE	*Chrysococcyx basalis*
	B344	Shining Bronze-Cuckoo	CUCULIFORMES	CUCULIDAE	*Chrysococcyx lucidus*
	B347	Common Koel	CUCULIFORMES	CUCULIDAE	*Eudynamys scolopacea*
	B348	Channel-billed Cuckoo	CUCULIFORMES	CUCULIDAE	*Scythrops novaehollandiae*
V	B248	Powerful Owl	STRIGIFORMES	STRIGIDAE	*Ninox strenua*
V	B246	Barking Owl	STRIGIFORMES	STRIGIDAE	*Ninox connivens*
	B242	Southern Boobook	STRIGIFORMES	STRIGIDAE	*Ninox novaeseelandiae*
V	B250	Masked Owl	STRIGIFORMES	TYTONIDAE	*Tyto novaehollandiae*
	B249	Barn Owl	STRIGIFORMES	TYTONIDAE	*Tyto alba*
V	B729	Grass Owl	STRIGIFORMES	TYTONIDAE	*Tyto capensis*
	B313	Tawny Frogmouth	CAPRIMULGIFORMES	PODARGIDAE	*Podargus strigoides*
	B330	White-throated Nightjar	CAPRIMULGIFORMES	CAPRIMULGIDAE	*Eurostopodus mystacalis*
	B331	Spotted Nightjar	CAPRIMULGIFORMES	CAPRIMULGIDAE	*Eurostopodus argus*
	B317	Australian Owlet-nightjar	CAPRIMULGIFORMES	AEGOTHELIDAE	*Aegotheles cristatus*
	B334	White-throated Needletail	APODIFORMES	APODIDAE	*Hirundapus caudacutus*
	B335	Fork-tailed Swift	APODIFORMES	APODIDAE	*Apus pacificus*
	B319	Azure Kingfisher	CORACIIFORMES	ALCEDINIDAE	*Alcedo azurea*
	B322	Laughing Kookaburra	CORACIIFORMES	HALCYONIDAE	*Dacelo novaeguineae*
	B325	Red-backed Kingfisher	CORACIIFORMES	HALCYONIDAE	*Todiramphus pyrrhopygia*
	B326	Sacred Kingfisher	CORACIIFORMES	HALCYONIDAE	*Todiramphus sanctus*
	B329	Rainbow Bee-eater	CORACIIFORMES	MEROPIDAE	*Merops ornatus*
	B318	Dollarbird	CORACIIFORMES	CORACIIDAE	*Eurystomus orientalis*
	B558	White-throated Treecreeper	PASSERIFORMES	CLIMACTERIDAE	*Cormobates leucophaeus*
	B561	White-browed Treecreeper	PASSERIFORMES	CLIMACTERIDAE	*Climacteris affinis*
	B555	Brown Treecreeper	PASSERIFORMES	CLIMACTERIDAE	*Climacteris picumnus*
	B529	Superb Fairy-wren	PASSERIFORMES	MALURIDAE	*Malurus cyaneus*
	B532	Splendid Fairy-wren	PASSERIFORMES	MALURIDAE	*Malurus splendens*
	B536	Variegated Fairy-wren	PASSERIFORMES	MALURIDAE	*Malurus lamberti*
	B535	White-winged Fairy-wren	PASSERIFORMES	MALURIDAE	*Malurus leucopterus*
V	B513	Striated Grasswren	PASSERIFORMES	MALURIDAE	*Amytornis striatus*
E	B512	Thick-billed Grasswren	PASSERIFORMES	MALURIDAE	*Amytornis textilis*
	B565	Spotted Pardalote	PASSERIFORMES	PARDALOTIDAE	*Pardalotus punctatus*
	B566	Yellow-rumped Pardalote	PASSERIFORMES	PARDALOTIDAE	*Pardalotus xanthopygus*
	B976	Striated Pardalote	PASSERIFORMES	PARDALOTIDAE	*Pardalotus striatus*
	B488	White-browed Scrubwren	PASSERIFORMES	PARDALOTIDAE	*Sericornis frontalis*
	B498	Chestnut-rumped Heathwren	PASSERIFORMES	PARDALOTIDAE	*Hylacola pyrrhopygia*
V	B499	Shy Heathwren	PASSERIFORMES	PARDALOTIDAE	*Hylacola cauta*
V	B497	Redthroat	PASSERIFORMES	PARDALOTIDAE	*Pyrrholaemus brunneus*
	B504	Speckled Warbler	PASSERIFORMES	PARDALOTIDAE	*Chthonicola sagittata*
	B465	Weebill	PASSERIFORMES	PARDALOTIDAE	*Smicrornis brevirostris*
	B463	Western Gerygone	PASSERIFORMES	PARDALOTIDAE	*Gerygone fusca*
	B453	White-throated Gerygone	PASSERIFORMES	PARDALOTIDAE	*Gerygone olivacea*

CS	Code	Common	Order	Family	Scientific
	B475	Brown Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza pusilla*
	B476	Inland Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza apicalis*
	B481	Chestnut-rumped Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza uropygialis*
	B484	Buff-rumped Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza reguloides*
	B486	Yellow-rumped Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza chrysorrhoa*
	B471	Yellow Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza nana*
	B470	Striated Thornbill	PASSERIFORMES	PARDALOTIDAE	*Acanthiza lineata*
	B466	Southern Whiteface	PASSERIFORMES	PARDALOTIDAE	*Aphelocephala leucopsis*
	B638	Red Wattlebird	PASSERIFORMES	MELIPHAGIDAE	*Anthochaera carunculata*
	B640	Spiny-cheeked Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Acanthagenys rufogularis*
	B585	Striped Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Plectorhyncha lanceolata*
	B645	Noisy Friarbird	PASSERIFORMES	MELIPHAGIDAE	*Philemon corniculatus*
	B646	Little Friarbird	PASSERIFORMES	MELIPHAGIDAE	*Philemon citreogularis*
E	B603	Regent Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Xanthomyza phrygia*
	B641	Blue-faced Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Entomyzon cyanotis*
	B634	Noisy Miner	PASSERIFORMES	MELIPHAGIDAE	*Manorina melanocephala*
	B635	Yellow-throated Miner	PASSERIFORMES	MELIPHAGIDAE	*Manorina flavigula*
E	B967	Black-eared Miner	PASSERIFORMES	MELIPHAGIDAE	*Manorina melanotis*
	B605	Lewin's Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus lewinii*
	B614	Yellow-faced Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus chrysops*
	B608	Singing Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus virescens*
	B617	White-eared Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus leucotis*
	B619	Yellow-tufted Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus melanops*
V	B620	Purple-gaped Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus cratitius*
	B622	Yellow-plumed Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus ornatus*
	B623	Grey-fronted Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus plumulus*
	B613	Fuscous Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus fuscus*
	B625	White-plumed Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichenostomus penicillatus*
	B580	Black-chinned Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Melithreptus gularis*
	B583	Brown-headed Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Melithreptus brevirostris*
	B578	White-naped Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Melithreptus lunatus*
	B597	Brown Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Lichmera indistincta*
V	B598	Painted Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Grantiella picta*
	B631	New Holland Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Phylidonyris novaehollandiae*
	B632	White-cheeked Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Phylidonyris nigra*
	B594	White-fronted Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Phylidonyris albifrons*
	B593	Tawny-crowned Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Phylidonyris melanops*
	B591	Eastern Spinebill	PASSERIFORMES	MELIPHAGIDAE	*Acanthorhynchus tenuirostris*
	B589	Black Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Certhionyx niger*
V	B602	Pied Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Certhionyx variegatus*
	B586	Scarlet Honeyeater	PASSERIFORMES	MELIPHAGIDAE	*Myzomela sanguinolenta*
	B449	Crimson Chat	PASSERIFORMES	MELIPHAGIDAE	*Epthianura tricolor*
	B450	Orange Chat	PASSERIFORMES	MELIPHAGIDAE	*Epthianura aurifrons*
	B448	White-fronted Chat	PASSERIFORMES	MELIPHAGIDAE	*Epthianura albifrons*
	B377	Jacky Winter	PASSERIFORMES	PETROICIDAE	*Microeca fascinans*
	B380	Scarlet Robin	PASSERIFORMES	PETROICIDAE	*Petroica multicolor*
	B381	Red-capped Robin	PASSERIFORMES	PETROICIDAE	*Petroica goodenovii*
	B382	Flame Robin	PASSERIFORMES	PETROICIDAE	*Petroica phoenicea*
	B384	Rose Robin	PASSERIFORMES	PETROICIDAE	*Petroica rosea*
V	B383	Pink Robin	PASSERIFORMES	PETROICIDAE	*Petroica rodinogaster*
	B385	Hooded Robin	PASSERIFORMES	PETROICIDAE	*Melanodryas cucullata*
	B392	Eastern Yellow Robin	PASSERIFORMES	PETROICIDAE	*Eopsaltria australis*
V	B441	Southern Scrub-robin	PASSERIFORMES	PETROICIDAE	*Drymodes brunneopygia*
	B443	Grey-crowned Babbler	PASSERIFORMES	POMATOSTOMIDAE	*Pomatostomus temporalis*
	B445	White-browed Babbler	PASSERIFORMES	POMATOSTOMIDAE	*Pomatostomus superciliosus*

CS	Code	Common	Order	Family	Scientific
	B446	Chestnut-crowned Babbler	PASSERIFORMES	POMATOSTOMIDAE	*Pomatostomus ruficeps*
	B436	Spotted Quail-thrush	PASSERIFORMES	CINCLOSOMATIDAE	*Cinclosoma punctatum*
V	B437	Chestnut Quail-thrush	PASSERIFORMES	CINCLOSOMATIDAE	*Cinclosoma castanotum*
	B549	Varied Sittella	PASSERIFORMES	NEOSITTIDAE	*Daphoenositta chrysoptera*
	B416	Crested Shrike-tit	PASSERIFORMES	PACHYCEPHALIDAE	*Falcunculus frontatus*
	B419	Crested Bellbird	PASSERIFORMES	PACHYCEPHALIDAE	*Oreoica gutturalis*
E	B402	Red-lored Whistler	PASSERIFORMES	PACHYCEPHALIDAE	*Pachycephala rufogularis*
V	B403	Gilbert's Whistler	PASSERIFORMES	PACHYCEPHALIDAE	*Pachycephala inornata*
	B398	Golden Whistler	PASSERIFORMES	PACHYCEPHALIDAE	*Pachycephala pectoralis*
	B401	Rufous Whistler	PASSERIFORMES	PACHYCEPHALIDAE	*Pachycephala rufiventris*
	B408	Grey Shrike-thrush	PASSERIFORMES	PACHYCEPHALIDAE	*Colluricincla harmonica*
	B365	Leaden Flycatcher	PASSERIFORMES	DICRURIDAE	*Myiagra rubecula*
	B366	Satin Flycatcher	PASSERIFORMES	DICRURIDAE	*Myiagra cyanoleuca*
	B369	Restless Flycatcher	PASSERIFORMES	DICRURIDAE	*Myiagra inquieta*
	B415	Magpie-lark	PASSERIFORMES	DICRURIDAE	*Grallina cyanoleuca*
	B362	Rufous Fantail	PASSERIFORMES	DICRURIDAE	*Rhipidura rufifrons*
	B361	Grey Fantail	PASSERIFORMES	DICRURIDAE	*Rhipidura fuliginosa*
	B364	Willie Wagtail	PASSERIFORMES	DICRURIDAE	*Rhipidura leucophrys*
	B424	Black-faced Cuckoo-shrike	PASSERIFORMES	CAMPEPHAGIDAE	*Coracina novaehollandiae*
	B425	White-bellied Cuckoo-shrike	PASSERIFORMES	CAMPEPHAGIDAE	*Coracina papuensis*
	B429	Cicadabird	PASSERIFORMES	CAMPEPHAGIDAE	*Coracina tenuirostris*
	B423	Ground Cuckoo-shrike	PASSERIFORMES	CAMPEPHAGIDAE	*Coracina maxima*
	B430	White-winged Triller	PASSERIFORMES	CAMPEPHAGIDAE	*Lalage sueurii*
	B671	Olive-backed Oriole	PASSERIFORMES	ORIOLIDAE	*Oriolus sagittatus*
	B543	White-breasted Woodswallow	PASSERIFORMES	ARTAMIDAE	*Artamus leucorynchus*
	B544	Masked Woodswallow	PASSERIFORMES	ARTAMIDAE	*Artamus personatus*
	B545	White-browed Woodswallow	PASSERIFORMES	ARTAMIDAE	*Artamus superciliosus*
	B546	Black-faced Woodswallow	PASSERIFORMES	ARTAMIDAE	*Artamus cinereus*
	B547	Dusky Woodswallow	PASSERIFORMES	ARTAMIDAE	*Artamus cyanopterus*
	B548	Little Woodswallow	PASSERIFORMES	ARTAMIDAE	*Artamus minor*
	B702	Grey Butcherbird	PASSERIFORMES	ARTAMIDAE	*Cracticus torquatus*
	B700	Pied Butcherbird	PASSERIFORMES	ARTAMIDAE	*Cracticus nigrogularis*
	B705	Australian Magpie	PASSERIFORMES	ARTAMIDAE	*Gymnorhina tibicen*
	B694	Pied Currawong	PASSERIFORMES	ARTAMIDAE	*Strepera graculina*
	B697	Grey Currawong	PASSERIFORMES	ARTAMIDAE	*Strepera versicolor*
	B930	Australian Raven	PASSERIFORMES	CORVIDAE	*Corvus coronoides*
	B868	Forest Raven	PASSERIFORMES	CORVIDAE	*Corvus tasmanicus*
	B954	Little Raven	PASSERIFORMES	CORVIDAE	*Corvus mellori*
	B691	Little Crow	PASSERIFORMES	CORVIDAE	*Corvus bennetti*
	B692	Torresian Crow	PASSERIFORMES	CORVIDAE	*Corvus orru*
	B693	White-winged Chough	PASSERIFORMES	CORCORACIDAE	*Corcorax melanorhamphos*
	B675	Apostlebird	PASSERIFORMES	CORCORACIDAE	*Struthidea cinerea*
	B680	Spotted Bowerbird	PASSERIFORMES	PTILONORHYNCHIDAE	*Chlamydera maculata*
	B648	Singing Bushlark	PASSERIFORMES	ALAUDIDAE	*Mirafra javanica*
	B993	Skylark	PASSERIFORMES	ALAUDIDAE	*Alauda arvensis*
	B647	Richard's Pipit	PASSERIFORMES	MOTACILLIDAE	*Anthus novaeseelandiae*
	B995	House Sparrow	PASSERIFORMES	PASSERIDAE	*Passer domesticus*
	B994	Eurasian Tree Sparrow	PASSERIFORMES	PASSERIDAE	*Passer montanus*
	B653	Zebra Finch	PASSERIFORMES	PASSERIDAE	*Taeniopygia guttata*
	B655	Double-barred Finch	PASSERIFORMES	PASSERIDAE	*Taeniopygia bichenovii*
E	B667	Black-throated Finch	PASSERIFORMES	PASSERIDAE	*Poephila cincta*
	B661	Plum-headed Finch	PASSERIFORMES	PASSERIDAE	*Neochmia modesta*
	B662	Red-browed Finch	PASSERIFORMES	PASSERIDAE	*Neochmia temporalis*
	B652	Diamond Firetail	PASSERIFORMES	PASSERIDAE	*Stagonopleura guttata*
	B983	Nutmeg Mannikin	PASSERIFORMES	PASSERIDAE	*Lonchura punctulata*

CS	Code	Common	Order	Family	Scientific
	B657	Chestnut-breasted Mannikin	PASSERIFORMES	PASSERIDAE	*Lonchura castaneothorax*
	B997	European Greenfinch	PASSERIFORMES	FRINGILLIDAE	*Carduelis chloris*
	B996	European Goldfinch	PASSERIFORMES	FRINGILLIDAE	*Carduelis carduelis*
	B564	Mistletoebird	PASSERIFORMES	DICAEIDAE	*Dicaeum hirundinaceum*
	B358	White-backed Swallow	PASSERIFORMES	HIRUNDINIDAE	*Cheramoeca leucosternus*
	B357	Welcome Swallow	PASSERIFORMES	HIRUNDINIDAE	*Hirundo neoxena*
	B359	Tree Martin	PASSERIFORMES	HIRUNDINIDAE	*Hirundo nigricans*
	B360	Fairy Martin	PASSERIFORMES	HIRUNDINIDAE	*Hirundo ariel*
	B524	Clamorous Reed-Warbler	PASSERIFORMES	SYLVIIDAE	*Acrocephalus stentoreus*
	B523	Tawny Grassbird	PASSERIFORMES	SYLVIIDAE	*Megalurus timoriensis*
	B522	Little Grassbird	PASSERIFORMES	SYLVIIDAE	*Megalurus gramineus*
	B509	Rufous Songlark	PASSERIFORMES	SYLVIIDAE	*Cincloramphus mathewsi*
	B508	Brown Songlark	PASSERIFORMES	SYLVIIDAE	*Cincloramphus cruralis*
	B525	Golden-headed Cisticola	PASSERIFORMES	SYLVIIDAE	*Cisticola exilis*
	B574	Silvereye	PASSERIFORMES	ZOSTEROPIDAE	*Zosterops lateralis*
	B779	Bassian Thrush	PASSERIFORMES	MUSCICAPIDAE	*Zoothera lunulata*
	B991	Common Blackbird	PASSERIFORMES	MUSCICAPIDAE	*Turdus merula*
	B999	Common Starling	PASSERIFORMES	STURNIDAE	*Sturnus vulgaris*
	B998	Common Myna	PASSERIFORMES	STURNIDAE	*Acridotheres tristis*

APPENDIX 2 - Landbird species that are considered Threatened/ of concern within the central Lachlan catchment. Compiler: Neville Schrader, Parkes.

Letter-winged Kite

Square-tailed Kite *

Osprey *

White-bellied Sea-eagle

Black Falcon

Peregrine Falcon

Grey Falcon *

Australian Bustard *

Bush Stone-curlew *

Painted button-quail

Glossy Black Cockatoo *

Major Mitchell Cockatoo *

Yellow Rosella

Bourke Parrot

Powerful Owl *

Barking Owl

Azure Kingfisher (?)

Speckled Warbler

Regent Honeyeater *

Grey-fronted Honeyeater

Black-chinned Honeyeater

Orange Chat

Jacky Winter

Hooded Robin

Southern Scrub-robin *

Grey-crowned Babbler

White-browed Babbler

Spotted Quail-thrush

Chestnut Quail-thrush *

Varied Sittella

Crested Shriketit

Crested Bellbird

Red-lored Whistler *

Gilbert's Whistler *

White-bellied Cuckoo-shrike

Plum-headed Finch

White-backed Swallow

* listed as Endangered or Vulnerable under the NSW Threatened Species Conservation Act