# ‘Re-birding’ the Holbrook Landscape

Holbrook Landcare

A revegetation strategy for the Upper Billabong Catchment

Natural Heritage Trust

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## A revegetation strategy for the Upper Billabong Catchment

### July 2000


### Report compiled by Stuart Collard

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## Acknowledgments

Special thanks to Catherine Hulm for her guidance and support throughout the project and to Emmo Willinck for his help and expert advice during its initial stages. To the Holbrook Landcare staff - Andrew, Nige and Barb; members of the project's technical steering committee - Ian Davidson, David Freudenberger, Doug Robinson and Geoff Barrett; and members of the community steering committee - Beverly and Margaret Geddes, Phillip Locke, Don Vickery, Wendy Swan and Sue Pugh.

This project would not have been possible without the support of the Landholders whose properties were used for bird surveys (refer Appendix 1). To Julian Seddon, Greg Hood and Stuart Doyle from CSIRO for their assistance with data handling and analysis. Field assistance was provided by Ian Davidson, Doug Robinson and Tracy Meiklejohn. The project was funded through the Natural Heritage Trust as part of Holbrook Landcare Group's 'Re-birding' project.


**Front cover** (top-bottom): 1) Yellow-tufted Honeyeater (Crome & Webber); 2) Eucalypt dieback, typical of the Holbrook area; & 3) Swift Parrot (Forshaw & Chapman)

*Report commissioned and published by:*

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*Study funded by:*

Natural Heritage Trust
Helping Communities
Helping Australia
A Commonwealth Government Initiative

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## Contents

## Summary

There have been many studies conducted, reviews written, and management recommendations proposed for the preservation of woodland bird communities of temperate southern Australia. This wealth of accumulated knowledge relating to woodland birds is a previously little-recognised, yet invaluable aid to the landscape-scale habitat restoration and enhancement necessary to remedy the severe environmental problems facing the agricultural regions of southern Australia.

In the past, environmental restoration projects have been conducted largely without scientifically determined guidelines designed to maximise the environmental benefits of revegetation. The 'Re-birding' project however, aims to determine the minimum habitat requirements of sensitive woodland birds and then use this information to provide specific guidelines for restoring the forest and woodland habitats of the Upper Billabong Catchment. Enhancing natural habitat throughout the Catchment is expected to rejuvenate existing ecosystem processes, thus contributing to a reduction in eucalypt dieback.

A 'focal species' analysis was used to determine the spatial and habitat parameters of patches of vegetation required to support woodland bird species of varying sensitivity to disturbance. Patches of at least six hectares with a habitat complexity score of six or greater were required for all but the most sensitive woodland birds. Patches that were smaller than six hectares, but isolated from other vegetation by less than 1 kilometre, were more likely to support a diversity of moderately sensitive woodland birds than more isolated small patches.

Existing stands of remnant vegetation provide the most logical foundation from which to develop landscape-scale habitat restoration. Hence, the protection of forest, woodland and riparian remnants throughout the Upper Billabong Catchment is essential to the success of the 'Re-birding' project and to the preservation of biodiversity in the area. Particular emphasis should be placed on revegetating and enhancing remnants in the more fertile, low altitude areas of the Catchment.

This report completes phase one of a continuing three-year Landcare project, which primarily aims to revegetate large areas of the Upper Billabong Catchment in an attempt to mitigate eucalypt dieback. It presents the findings of the first year of research to determine a relationship between the spatial and habitat characteristics of patches of vegetation, woodland bird communities and eucalypt dieback.

# Introduction

## The Upper Billabong Catchment

### *General information*

The Upper Billabong Catchment is situated in the eastern division of the Murray-Riverina region of NSW and comprises 171 000 ha of fertile, undulating agricultural land. The town of Holbrook is located in the centre of the Catchment and is approximately 50 kilometres north-west of Albury. Holbrook receives an annual average rainfall of 695 mm (LWMP 1999) and the altitude within the Catchment ranges from 220 to 889 metres above sea level.

The Wiradjuri people are acknowledged as the traditional owners of an area that includes the Holbrook district (Carnegie, 1973). European settlement dates from 1837. More than 2700 people now live in the Upper Billabong Catchment, where the predominant land use is the grazing of sheep and cattle.

### *Clearance of native vegetation*

Prior to European settlement, eucalypt forest and woodland, with an understorey of low trees, shrubs, sedges and native grasses (Davies 1988), covered large areas of temperate southern Australia (Yates and Hobbs 1997). The fertile woodland areas were highly favoured by early settlers for clearance and conversion into exotic cropland and pasture (Hobbs and Hopkins 1990; Lunt 1991). As a result, woodland habitats in the agricultural areas of south-eastern and south-western Australia have been irreparably altered and fragmented remnants of varying size, quality and isolation are often all that remain of a once widespread and diverse natural habitat (Yates and Hobbs 1997).

The Upper Billabong Catchment is typical of such fertile woodland areas which have been extensively cleared for agricultural production. Much of the clearing took place before the Second World War (LWMP 1999), when the "opening-up" of the land was generally regarded as a worthy achievement and was endorsed by settlers and the authorities alike (Carnegie 1973). Indeed, during the years following settlement, cleared land was a source of great prosperity and a rich cultural ethos and heritage evolved around agricultural production. However, within less than a century of settlement, serious environmental problems such as soil erosion, rising water tables, biodiversity loss and dieback are affecting large areas of the Catchment. Similar problems affect the arable land throughout much of south-eastern Australia, a direct result of the land clearance which occurred so many years before.

Today, less than 20% of the original vegetation of the Upper Billabong Catchment remains in a relatively undisturbed state (Woodward 1998). A large proportion of this remaining vegetation is situated on the less fertile slopes and hills (i.e. those areas less suitable for agriculture). The 'grassy woodland' and 'open woodland' associations of the fertile, lower-lying areas have been decimated to the extent that only 0% and 0.3% respectively of these vegetation types remain intact (Table 1). Even the few existing remnants have been disturbed by current land-use practices such as grazing, burning, and pasture improvement.

**Table 1.** Estimated percentage cover of native vegetation communities throughout the Upper Billabong Catchment prior to European settlement and in 1998 (Table derived from LWMP 1999)

| Vegetation associations (topography) | Area (ha) pre-settlement | Area (ha) uncleared (1998) | Area % uncleared (1998) |
|---|---|---|---|
| 1) Riparian (flats) | 8 700 (5%) | < 1 000 ha | 0.6% |
| 2) Grassy Woodlands (flats) | 18 900 (11%) | 0 ha | 0.0% |
| 3) Open Woodlands (flats/slopes) | 78 000 (45%) | < 500 ha | 0.3% |
| 4) Open forest (slopes/hills) | 67 100 (39%) | 20 200 ha | 11.8% |

Despite the extensive vegetation clearance and the decline in structural and floristic diversity of vegetation communities throughout the Upper Billabong Catchment, a wide range of plants survive in the fragmented woodland and forest remnants. Of particular note are the large areas of undisturbed dry sclerophyll forest and a network of riparian strips. A wide variety of native organisms continue to survive in the limited habitat provided by these generally high quality remnants.

## Habitat destruction and declining woodland birds

The major changes to forest and woodland habitats, which have occurred throughout much of south-eastern Australia in the course of agricultural development, have inevitably affected bird communities on both a local and regional scale. In particular, many of the birds reliant on the aforementioned, heavily cleared low-lying areas, are today declining and some are even threatened with extinction. The rapid decline of woodland bird communities, in response to habitat destruction, has been well-documented (e.g. Saunders 1989; Barrett *et al.* 1994; Robinson and Trail 1996; Reid 1999) showing that in recent years, sensitive woodland bird species have become locally extinct in many environments dominated by agriculture. Such a decline is evident in the Upper Billabong Catchment, where widespread alteration of natural habitat has occurred.

Historically 162 bird species have been recorded throughout the Upper Billabong Catchment (Appendix 2). Among these, are species that are today regarded as nationally threatened such as the Regent Honeyeater (*Xanthomyza phrygia*) and Swift Parrot (*Lathamus discolor*) and some which are threatened only in NSW such as the Painted Honeyeater (*Grantiella picta*), Turquoise Parrot (*Neophema pulchella*) and Bush Stone-curlew (*Burhinus magnirostris*). Many of these species have declined or become locally extinct because of the widespread clearance of habitat critical to their survival. For example, the Stone-curlew, which was once common throughout the Catchment (*pers comm* B. Geddes), has declined because of both habitat loss and predation by foxes and cats.

## Dieback

Eucalypt dieback in the temperate agricultural areas of southern Australia has been well documented (e.g. Old *et al.* 1980; Landsberg 1984-90; Heatwole and Lowman 1986). Table 2 presents the most common factors known to contribute to tree dieback and some of their consequences observed in the Holbrook area.

**Table 2.** The known causes and effects of eucalypt dieback in the temperate agricultural zones of southern Australia (Landsberg 1997).

| Cause | Most damaging | Effect |
|---|---|---|
| Insect attack | Psyllids (lerps)<br>Scarab and Chrysomelid beetles<br>Skeletonising caterpillars | Damage to foliage (compounded by exclus$^{n}$ of other birds by Noisy Miners) |
| Stock grazing | Sheep and cattle | Increased soil nutrients<br>Trampling of roots<br>Ring-barking |
| Chemical drift | Herbicides, pesticides and fertilizers | Inhibits growth |
| Increased exposure | Wind, sun | Damage to foliage and tree structure from wind and temperature extremes |

Tree dieback has become obvious in the Holbrook area only during the last decade (Davidson, *pers comm*). Repeated seasons of attack by phytophagous (leaf-feeding) insects such as psyllids (lerps) and Christmas beetles have resulted in a widespread decline in condition, and consequent death of many eucalypt trees. Scattered trees growing in the intensely farmed low-altitude areas have been worst affected by this dieback.

In 1994, members of the Holbrook community realised that the tree dieback evident throughout much of the Catchment was a manifestation of a more serious underlying ecosystem problem. During the ensuing 3 years, a survey was conducted to address the problem of dieback. The study revealed that 41% of trees within the Catchment were suffering from severe dieback and 22% were showing symptoms of dieback (Bacon 1997).

The insects that are the main cause of dieback are predominantly native and are indeed important components of a natural woodland ecosystem. The degradation and simplification of this system as a result of human activities has allowed some of these insects to proliferate and thus become a problem (Landsberg 1990).

## Aims and objectives

### The ‘Re-birding’ project

To date, large-scale habitat restoration projects have been conducted generally without scientifically determined guidelines used to maximise the environmental benefits of revegetation. The ‘Re-birding’ project is different in this regard because it has a particular focus: It uses an experimental approach to determine the spatial and habitat requirements of sensitive woodland bird species. By using this approach, the physical attributes of patches of vegetation required to support individual woodland bird species can be defined with confidence. Knowledge of these habitat requirements will enable specific recommendations to be made for the landscape-scale revegetation and habitat enhancement proposed for the Upper Billabong Catchment.

A primary objective of the ‘Re-birding’ project is to fence and protect from stock, 2000 hectares of revegetation and existing remnants. During the implementation phase of the project, an estimated 1.2 million seedlings will be planted within these protected areas. All revegetation works will comprise plantings of at least 50% shrubs, enhancing both the structural and floristic diversity of the vegetation throughout the Upper Billabong Catchment. It is proposed that such landscape-scale habitat enhancement will rejuvenate existing ecosystem processes (e.g. predation of insects by birds) and thus contribute to a reduction in eucalypt dieback.

### Research and community consultation phase

This report presents baseline information obtained during the yearlong research phase of the ‘Re-birding’ project. Bird surveys and vegetation assessments were conducted in patches of vegetation throughout the Upper Billabong Catchment, enabling the minimum habitat requirements of sensitive woodland bird species (focal species) to be determined. Specific guidelines, based on these minimum requirements, will be used during the implementation phase of the project to provide the best possible habitat for locally extinct or declining woodland birds.

An important aspect of the ‘Re-birding’ project, one usually overlooked in the course of a purely research project, has been consultation with, and close involvement of local communities, with a view to raising their awareness of environmental issues. In particular, it is hoped that increased awareness of the declining woodland birds of the Holbrook area will encourage community involvement in such scientific research projects and increase participation in current and future Landcare activities.

# Methods

## Site selection and spatial interpretation

Study sites were located using 5 m x 5 m resolution orthophotos of the Catchment. Each site was visited and selected on the basis of its suitability as a study site (e.g. vegetation type, size, condition etc). The spatial characteristics of each site, such as area and isolation, were determined using 'ArcView' geographic information systems (GIS) software (version 3.0). An 'isolation index' was calculated for each site by determining the average distance to the closest five neighbouring patches of vegetation greater than 0.5ha. This index has been found useful in other focal species analyses (e.g. Lambeck 1999, Freudenberger 1999). Appendix 3 shows the position of each survey site in relation to the Catchment boundary.

Study sites were stratified according to size and elevation and included mostly smaller sites (i.e. 2 – 6 ha), thereby reflecting the actual availability of survey sites throughout the Catchment (refer Table 3). Selection of size categories was based on research conducted by Barrett (1995). Considerable effort was required to locate and gain access to the study sites because most were on privately-owned land.

**Table 3.** Stratification of the selected study sites based on size and elevation. Size categories were adapted from a study by Barrett (1995). Sites on the flats were generally situated in grassy/ open woodlands whereas hill sites were predominantly in patches of dry sclerophyll forest. Bird surveys and vegetation assessments were conducted in all 94 sites.

| Site size | Flats | Hills | Total |
|---|---|---|---|
| 2 - 6 ha | 20 | 20 | 40 |
| 6 - 20 ha | 10 | 10 | 20 |
| 20 - 100 ha | 8 | 7 | 15 |
| > 100 ha | - | - | 5 |
| Creeklines | - | - | 14 |
| **Total** | **38** | **37** | **94** |

**Bird Surveys**

Bird surveys at each site were conducted using the following methods:

1) **Strip transect** (150m x 50m – the maximum size that could be accommodated by the smallest study site). Transects were accurately measured and marked with flagging tape or spray paint at 50 m intervals. All birds seen or heard within the boundaries of the transect during a 20 minute search along its mid-line were recorded as per Recher (1988).

2) **20 minute search** of a larger area (approx. 2ha) surrounding the strip transect (0.75 ha) in order to detect those species not recorded during transect assessments i.e. those which were inconspicuous and/ or scared away by the observer. All birds seen or heard during this search were recorded.

Only those birds deemed by the observer to be associated with the vegetation of the site were included in the data analysis. A bird was said to be associated with the vegetation if it was: 1) perched in the vegetation; 2) flying through the vegetation; or 3) flying less than five metres above the canopy. All birds flying more than five metres above the canopy were recorded as opportunistic sightings. An example of an opportunistic sighting would be a predatory bird such as a Peregrine Falcon flying overhead.

**Vegetation assessments**

*Transect assessments*

Detailed habitat assessments were conducted within the strip transects established for bird surveys. An emphasis was placed on assessing the structural, rather than floristic, components of the vegetation, however the predominant tree and shrub species were also recorded. Appendix 4 shows an example of a datasheet used for detailed habitat assessment.

In the few sites where young eucalypts or shrubs occurred at high density, detailed habitat assessments were conducted in smaller representative sections of the transect. Estimates for the whole transect were determined by multiplying each habitat component by the appropriate factor i.e. assuming it is representative of the entire transect area (150 m x 50 m). For example, if a 50 m x 50 m section of the transect was sampled, all of the habitat components were multiplied by three.

*Habitat Complexity Score (HCS)*

Woodland bird assemblages are, in general, closely related to the characteristics of the vegetation they inhabit (Morcombe 1986). In particular, structural diversity (i.e. the variety of different habitat components) has a strong influence on the abundance and diversity of bird species. The structural components of a typical temperate forest or woodland habitat can be grouped into height-related layers e.g. canopy, mid and low shrub, and ground-layer features such as groundcover, logs and litter. The presence and condition of any or all of these habitat components may determine which bird species will be present. Hence, habitat assessments conducted in conjunction with woodland bird surveys should target those components known to influence woodland bird assemblages.

The structural diversity of the vegetation in each study site was measured using a rapid appraisal method developed by Newsome and Catling (1979) and used by Catling and Burt (1995). The habitat within the area surveyed during the 20-minute bird search (including the site transect) was assigned a complexity score based on the percentage areal cover of six structural components: tree canopy, tall shrubs (2 - 4 m), low shrubs (0.5 - 2 m) and ground components including herbage, rocks/ logs and litter (refer Appendix 5 for sample data sheet). Each of the six habitat components was given a score from 0 - 3 based on an estimated percentage cover and the sum of these individual scores gave a total habitat complexity score (HCS). A score below 6 represented a structurally poor woodland habitat. A score from 6-7 represented a moderately complex system with at least 10-20% shrub cover. A score greater than 7 represented a structurally complex system with a diversity of habitat components.

*Dieback assessments*

At each site, 20 trees were selected and individually assessed for dieback severity in Spring and Autumn. The assessment was an adaptation of a scoring system developed by Landsberg (1997) in which three separate components of dieback were identified, namely old damage, new damage, and new growth. Individual trees were assigned a score from 0-3 for each of the dieback components using an explicit set of guidelines (refer Appendix 6). Instead of removing and inspecting samples from the canopy, as suggested by Landsberg (1997), assessments of new damage and new growth were estimated by close inspection through binoculars.

*The author of this report conducted all bird surveys and habitat assessments, eliminating the bias often inherent in large-scale, multiple-observer surveys. Photographs were taken of the typical vegetation at each of the 94 study sites for the purpose of long-term comparison.

**Data analysis**

The “focal species” approach to biodiversity conservation was developed by Lambeck (1997). In his study of fragmented patches of vegetation in the sheep-wheat belt of south-western Australia, Lambeck (1999) identified key threats to the landscape and proposed a management regime for the preservation of native biota. In particular, he identified species with the most demanding habitat requirements (e.g. area, isolation, habitat complexity) and named them ‘focal’ species. It was assumed that if the focal species could survive in a patch of vegetation, then the spatial and habitat attributes of that patch were also sufficient to support all other species with less demanding habitat requirements. Hence, if the landscape were managed to meet the needs of the focal species, adequate habitat would also be provided for all other species reliant on the same resources.

Lambeck (1999) provides a schematic procedure, useful for identifying key landscape threats and for selecting focal species (Appendix 7). Using this procedure, the key factors limiting species preservation in the Holbrook area were identified as patch size, habitat complexity, and isolation. Woodland birds were thus grouped into tolerant, moderately sensitive, and highly sensitive categories based on critical values for area, isolation, and habitat complexity (Appendix 8). Only those bird species recorded in three or more study sites were considered as candidate focal species. Creekline sites were not included in the focal species analysis because of their indefinable spatial characteristics (e.g. area and isolation).

All data were entered into a ‘Microsoft Access’ relational database. The presence or absence of each bird species recorded during site surveys was plotted against the area, isolation and habitat complexity of each site using a ‘Microsoft Excel’ macro-spreadsheet developed by Hood (2000). Abundance and detailed habitat data are yet to be thoroughly examined.

# Results

## Site details

*Area, Isolation, and Habitat complexity*

The size of the 80 non-riparian study sites ranged from 2.02 ha to 916 ha, with a median size of 6.32ha. The isolation index for each site (i.e. the mean distance to its five nearest neighbours) ranged from 0.38 km to 2.99 km, with a median isolation of 1.23km. Habitat complexity values ranged from 3.5 to 9.5 with a median score of 5.5. Regardless of its size, each patch was equally likely to be isolated by the same amount (Figure 1a). There were no sites smaller than 100 ha with HCS > 8. (Figure 1b) and no sites smaller than 6 ha with HCS >7. There was a significant correlation ($r = 0.49$, $p < 0.01$) between the logarithm of site size and habitat complexity (i.e. habitat complexity was generally higher in larger sites) (Figure 1b). There were no significant linear associations between isolation and area or isolation and habitat complexity (Figures 1a & 1c).

*Dieback*

There was no significant correlation between dieback and site size or habitat complexity (Figures 2a & 2b). However there was a significant correlation ($r = 0.35$, $p < 0.01$) between dieback and isolation (Figure 2c), indicating that trees growing in isolated sites were more likely to suffer from dieback.

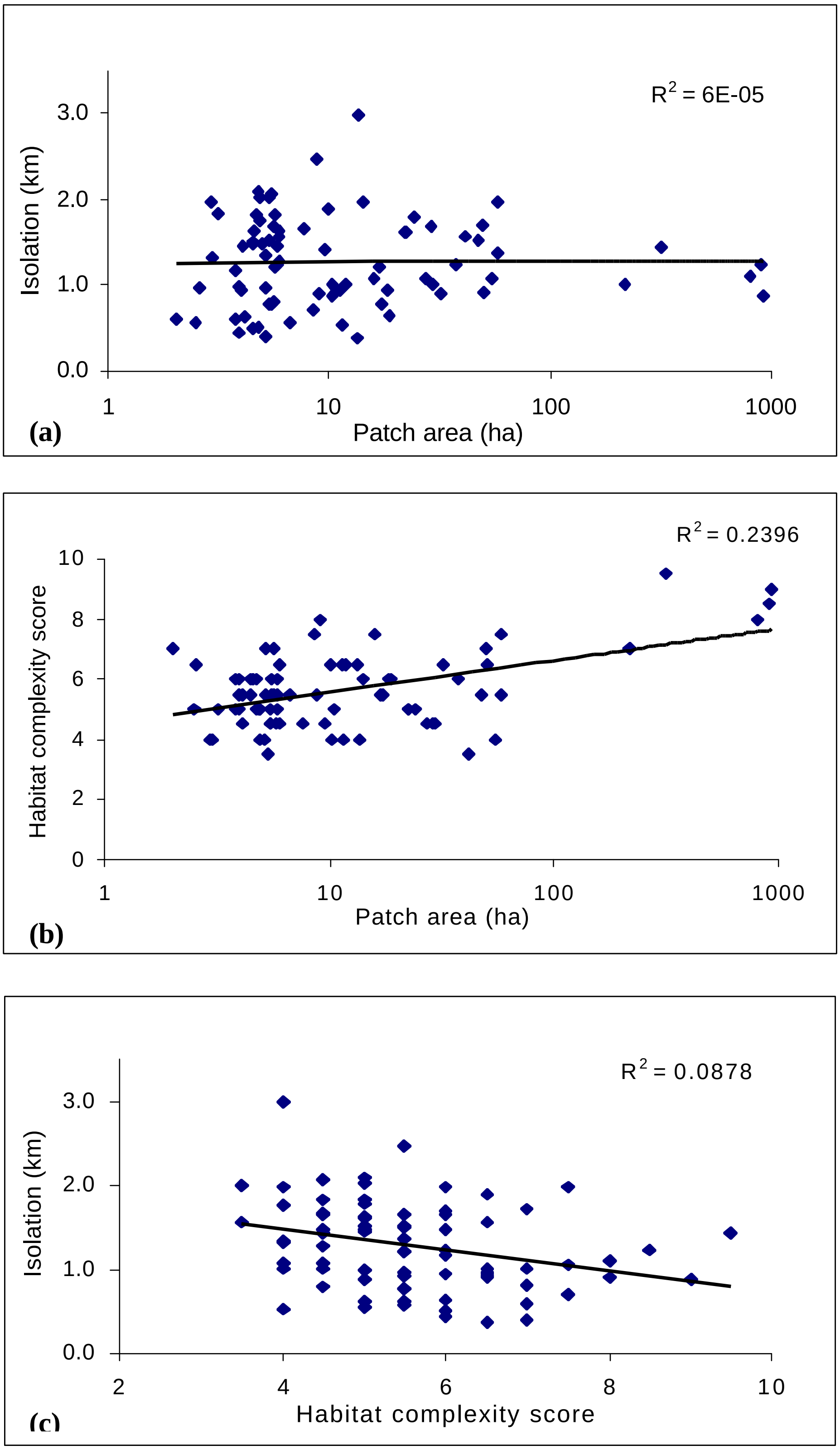



**Figure 1.** Relationships between: (a) isolation and the logarithm of patch area; (b) habitat complexity score and log. of patch area; and (c) isolation and habitat complexity score for 80 study sites established throughout the Upper Billabong Catchment.

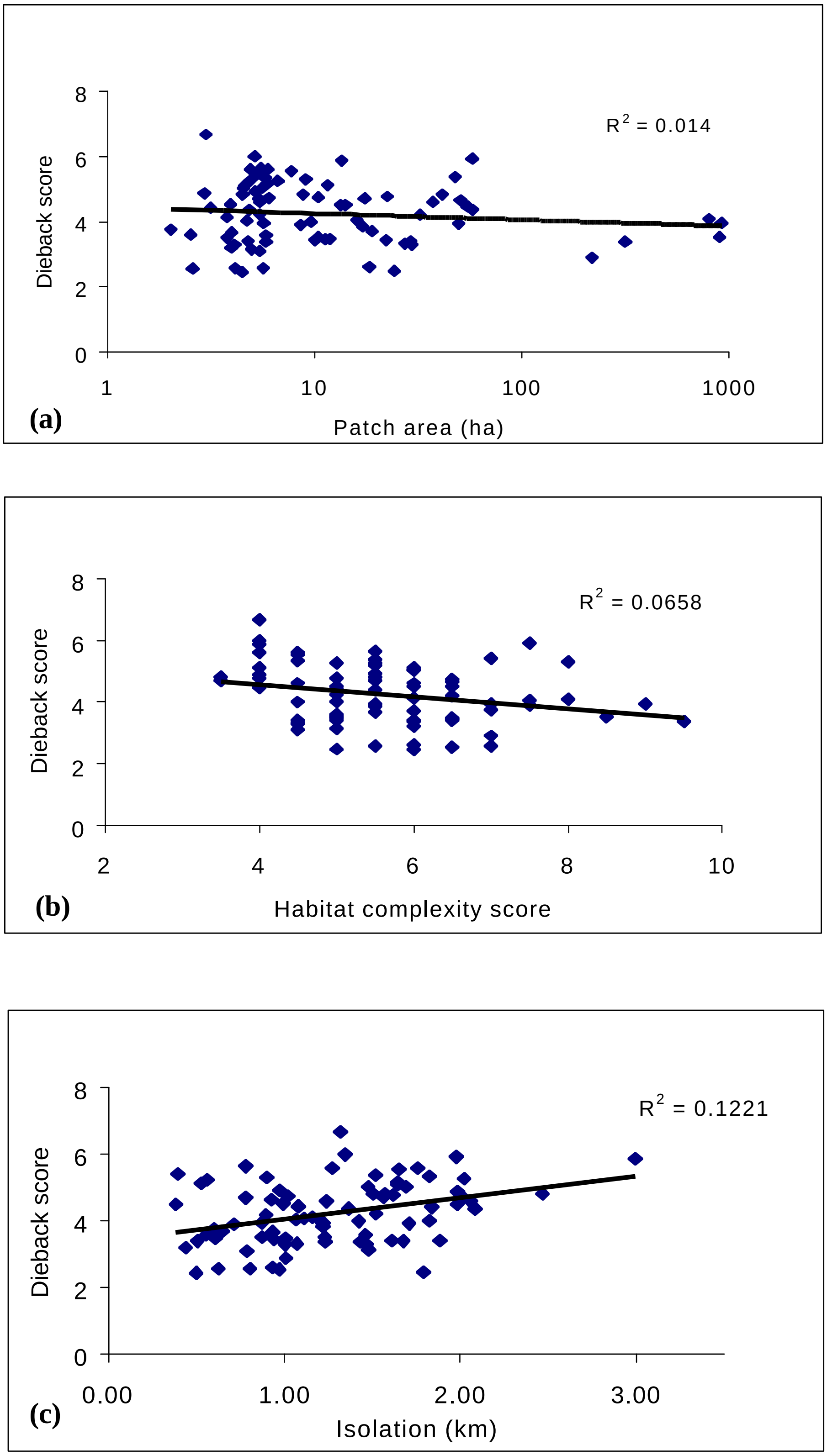



**Figure 2.** Relationships between: (a) dieback and the logarithm of patch area; (b) dieback and habitat complexity score; and (c) dieback and isolation for 80 sites throughout the Upper Billabong Catchment.

*Dieback of individual tree species*

Ten eucalypt species were identified and assessed for dieback across the 94 study sites. Among these species, at the time of both the Spring and Autumn assessments, Blakely’s Red Gum (*E. blakelyi*) had: 1) the highest mean dieback score; 2) the most old damage; 3) the greatest amount of recently damaged foliage; and 4) the least amount of new growth (Table 4). Yellow Box and Scribbly gum were the species least affected by dieback. However, in some isolated areas, Yellow Box did appear to suffer from severe dieback (*pers. obs*.). For all species except Yellow Box (species 8 in Table 4), overall dieback scores were higher in the Autumn survey, largely the result of an increase in recent damage and a decrease in new growth.

**Table 4.** Average (± standard error) for three categories of eucalypt dieback; old damage, recent damage and new growth (Landsberg 1997). 1=E. albens, 2=E. blakelyi, 3= E. bridgesiana, 4=E. camaldulensis, 5=E. microcarpa, 6=E. polyanthemos, 7=E.macrorhyncha, 8=E.melliodora, 9=E. rossii, 10=E. goniocalyx. Small values for the ‘new growth’ assessment, indicate more vigorous growth. Highlighted values represent the highest value among the species.

| Tree species | Old Damage | | Recent Damage | | New Growth | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Spring | Autumn | Spring | Autumn | Spring | Autumn | Spring | Autumn |
| 1 | 0.75 ± 0.06 | 0.71 ± 0.06 | 1.20 ± 0.05 | 1.31 ± 0.04 | 1.30 ± 0.05 | 1.76 ± 0.05 | 3.25 ± 0.11 | 3.87 ± 0.12 |
| 2 | **2.14 ± 0.04** | **2.11 ± 0.04** | **1.39 ± 0.03** | **1.70 ± 0.03** | **1.94 ± 0.03** | **2.27 ± 0.03** | **5.36 ± 0.08** | **6.07 ± 0.07** |
| 3 | 1.00 ± 0.10 | 1.77 ± 0.10 | 1.01 ± 0.08 | 1.37 ± 0.07 | 1.74 ± 0.07 | 2.02 ± 0.08 | 3.75 ± 0.18 | 4.56 ± 0.20 |
| 4 | 1.91 ± 0.05 | 1.48 ± 0.06 | 1.02 ± 0.03 | 1.34 ± 0.03 | 1.29 ± 0.04 | 1.72 ± 0.04 | 4.22 ± 0.09 | 4.54 ± 0.10 |
| 5 | 0.94 ± 0.21 | 0.80 ± 0.20 | 1.13 ± 0.13 | 1.30 ± 0.16 | 1.06 ± 0.17 | 1.85 ± 0.13 | 3.13 ± 0.43 | 3.95 ± 0.41 |
| 6 | 0.44 ± 0.04 | 0.57 ± 0.04 | 1.18 ± 0.04 | 1.35 ± 0.37 | 1.50 ± 0.04 | 1.64 ± 0.04 | 3.12 ± 0.08 | 3.57 ± 0.09 |
| 7 | 1.15 ± 0.05 | 1.16 ± 0.05 | 0.94 ± 0.04 | 1.09 ± 0.04 | 1.30 ± 0.04 | 1.53 ± 0.04 | 3.38 ± 0.09 | 3.78 ± 0.10 |
| 8 | 0.75 ± 0.06 | 0.66 ± 0.05 | 1.12 ± 0.03 | 1.11 ± 0.04 | 1.46 ± 0.05 | 1.46 ± 0.04 | 3.34 ± 0.10 | 3.23 ± 0.10 |
| 9 | 0.57 ± 0.13 | 0.73 ± 0.23 | 0.50 ± 0.14 | 0.93 ± 0.15 | 1.93 ± 0.16 | 1.80 ± 0.14 | 3.00 ± 0.30 | 3.47 ± 0.41 |
| 10 | 1.33 ± 0.33 | 1.00 ± 0.33 | 1.33 ± 0.33 | 1.36 ± 0.15 | 1.33 ± 0.33 | 2.00 ± 0.13 | 4.00 ± 0.58 | 4.36 ± 0.51 |

## Results of bird surveys

*General information*

From June 1999 to May 2000, 143 species of bird were recorded throughout the Catchment (Appendix 2). Of these species, the Swift Parrot is regarded as nationally threatened and the Painted Honeyeater and Turquoise Parrot are threatened in south-eastern NSW (NPWS 1999). Many of the other species observed have been identified as declining woodland birds in the South-west Slopes region (Reid 1999).

The Eastern Rosella (*Platycercus eximius*), Australian Magpie (*Gymnorhina tibicens*) and Striated Pardalote (*Pardalotus striatus*) were the most common species and were found in 93%, 91% and 88% of all sites respectively. Several species, including the Leaden Flycatcher, Painted Honeyeater, Red-capped Robin and Spotted Quail-thrush were recorded in only one (i.e. 1.1%) of the sites.

*Species Richness*

There were significant correlations between species richness and both remnant size ($r = 0.59$, $p < 0.005$) (Figure 3a) and habitat complexity ($r = 0.67$, $p < 0.005$) (Figure 3b). However, there was no significant correlation between species richness and isolation ($r = -0.14$, $p > 0.005$) or dieback ($r = 0.20$, $p > 0.005$) (Figures 3c & 3d). These results indicate that larger, more complex sites were able to support more bird species.

Sites 77 (Manoora) and 80 (Duntulm) had the highest species richness, with a combined spring and autumn count of 49 species. Both of these sites were larger than 100 hectares and had a habitat complexity score greater than 8.5. Site 22 had the lowest species richness with only 4 species recorded. Despite its relatively high habitat complexity (HCS 6 – due to large numbers of logs on the ground), this site was small (≈ 4.5 ha), isolated (1.5 km), and dominated by highly territorial Noisy Miners.

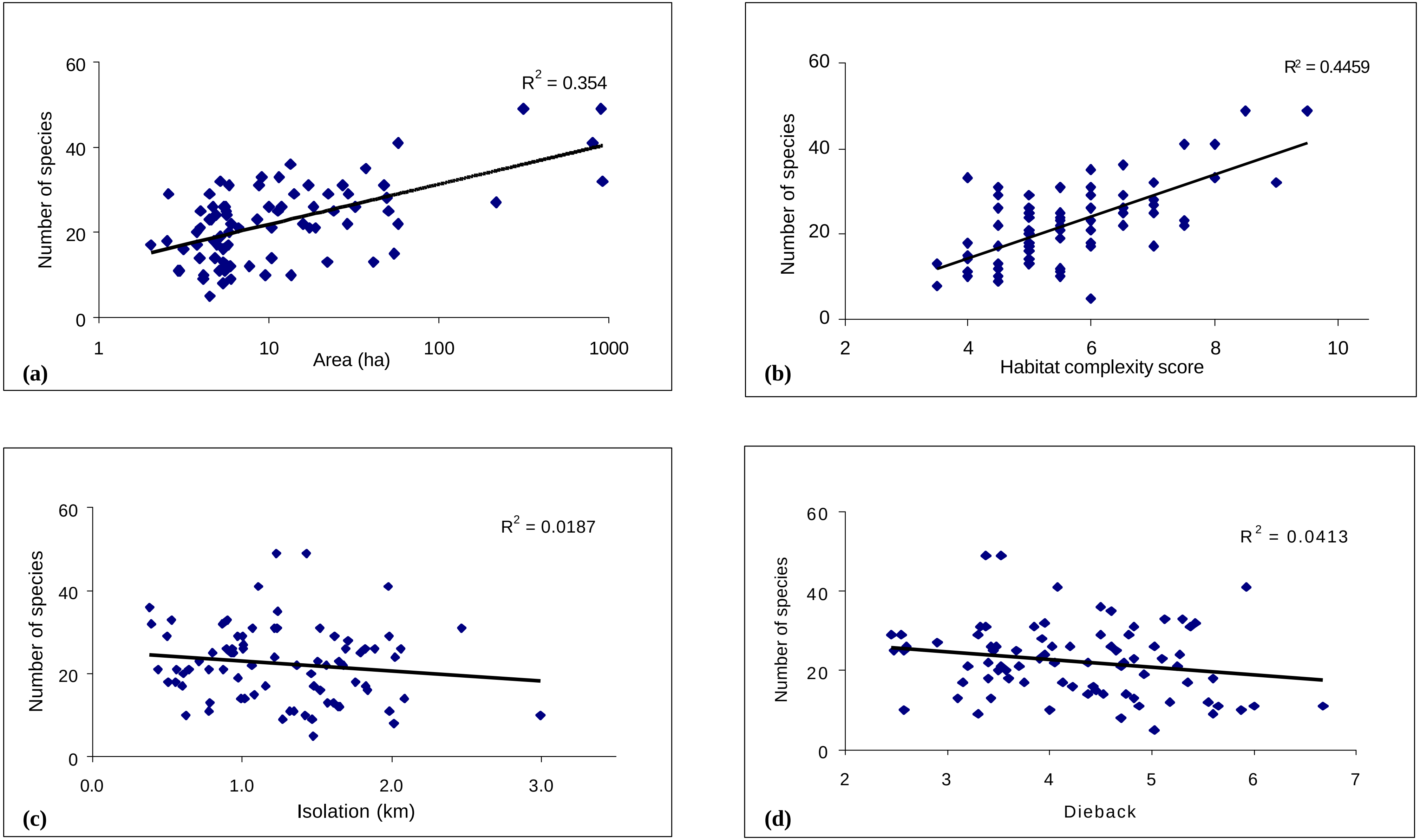



**Figure 3.** Relationships between bird species richness and: (a) the logarithm of patch area; (b) habitat complexity; (c) isolation; and (d) dieback. Graphs (a) and (c) present data collected from 80 non-riparian study sites throughout the Upper Billabong Catchment. Graphs (b) and (d) present data collected from 94 study sites, including creeklines.

## Size categories

Compared with all other size categories, sites from 2-6 hectares situated on the flats (i.e. woodland communities) had the lowest average values for species richness and habitat complexity and were worst affected by dieback (Table 5). In contrast, study sites in patches of vegetation larger than 100 hectares, had significantly higher values for both species richness and habitat complexity than sites in any of the other size categories. The lowest scores for dieback were also recorded in sites larger than 100 hectares. Dieback was less prevalent in sites situated on the slopes and hills than in sites on the flats (Table 5). Creekline sites had the lowest average habitat complexity scores, moderate dieback scores and relatively low species richness. Bird abundance was highest in sites larger than 100 ha and lowest in hills sites from 20-100 ha (Table 5).

**Table 5.** Patch variables ± standard error for the various size/ altitude categories. Values for habitat complexity score (HCS) and dieback were calculated by averaging Spring and Autumn results. The dieback value represents an average of all tree species combined. Species richness is a cumulative count of the number of species recorded during the combined Spring and Autumn bird counts. Highlighted values represent the highest values for each category.

| Patch size (ha) | HCS (± s.e.) | Dieback | Species Richness | Abundance |
|---|---|---|---|---|
| 2 – 6 flats | 5.13 ± 0.21 | **4.98 ± 0.16** | 18.05 ± 1.59 | 19.78 ± 1.74 |
| 2 – 6 hills | 5.50 ± 0.17 | 3.62 ± 0.19 | 18.80 ± 1.52 | 20.68 ± 1.57 |
| 6 – 20 flats | 5.35 ± 0.37 | 4.81 ± 0.23 | 22.30 ± 2.67 | 20.75 ± 1.69 |
| 6 – 20 hills | 6.15 ± 0.36 | 3.82 ± 0.22 | 24.80 ± 2.22 | 21.4 ± 3.21 |
| 20 – 100 flats | 5.38 ± 0.40 | 4.47 ± 0.38 | 26.13 ± 3.52 | 23.06 ± 2.32 |
| 20 - 100hills | 5.36 ± 0.47 | 3.89 ± 0.21 | 25.14 ± 2.02 | 17.64 ± 3.22 |
| >100 | **8.40 ± 0.43** | 3.57 ± 0.21 | **39.60 ± 4.45** | **24.2 ± 3.72** |
| Creeklines | 4.96 ± 0.19 | 4.34 ± 0.15 | 21.29 ± 1.10 | 21.75 ± 2.88 |

## Creekline assessments

A total of 47 bird species was recorded in 14 different creekline sites throughout the Catchment. 14 of these species were moderately sensitive woodland birds in the Holbrook area (Appendix 8) and 6 species are regarded as declining throughout the sheep-wheat belt of NSW (Reid 1999).

**Focal species analysis (woodland birds only)**

Graphs of the presence or absence of woodland bird species versus the area, habitat complexity and isolation of each site, proved to be the most informative tool for interpreting data (refer Appendix 9). The information provided by these focal species graphs allowed bird species to be assigned to categories based on their apparent sensitivity to patch size, habitat complexity, and isolation (i.e. the landscape threats identified in Appendix 7). Bird species were thus allocated to the following three groups:

**Tolerant**: those species able to survive in simplified landscapes, i.e. patch size < 6 ha, habitat complexity score < 6 and unaffected by isolation (e.g. Australian Magpie)

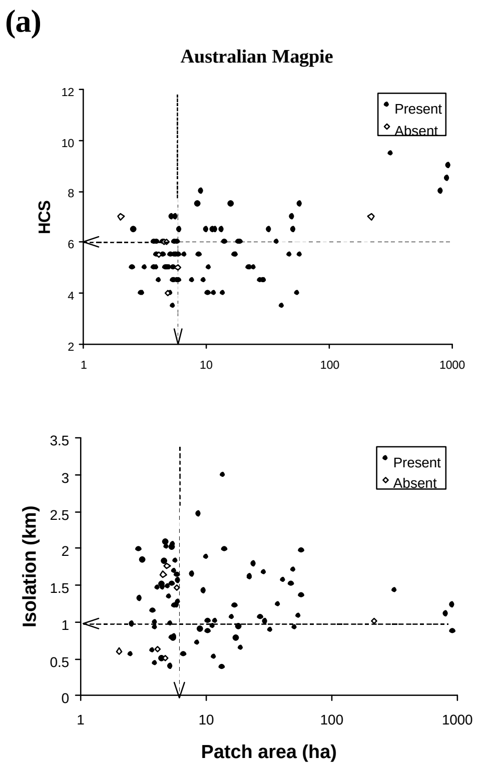
**Moderately sensitive:** those species able to survive in moderately disturbed landscapes patches from 6-20 ha or isolated by less than 1 km and with habitat complexity score of 6-7 (e.g. Eastern Yellow-robin).

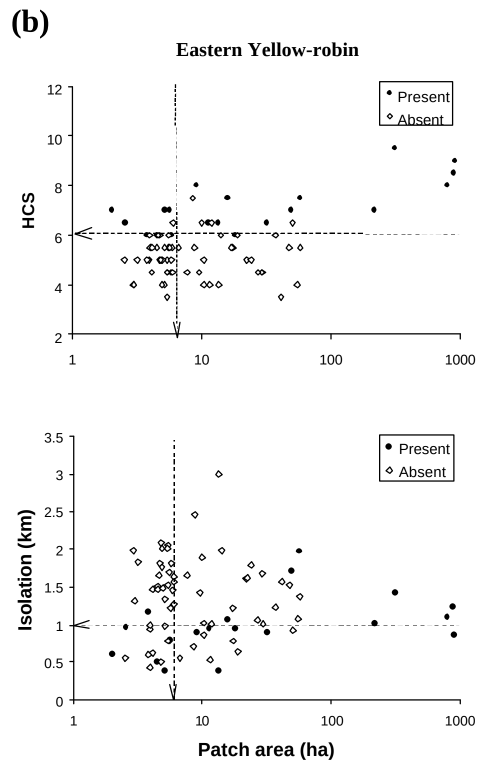
**Highly sensitive:** those species with the most demanding habitat requirements i.e. patch size > 20 ha or isolated by < 1km and with habitat complexity score >7 (e.g. Yellow-tufted Honeyeater)

Appendix 8 displays the grouping of woodland bird species into the above three sensitivity categories. Figure 4 shows a typical focal species graph for one species assigned to each sensitivity group.

*Yellow-tufted Honeyeater*

The Yellow-tufted Honeyeater (*Lichenostomus melanops*) was selected as the focal species for this study because it had the most demanding habitat requirements of all species in the highly sensitive category (Appendix 8). This gregarious, medium-sized honeyeater was detected in only 4 of the study sites. Invariably, these sites were large and structurally diverse patches of vegetation in fertile woodland areas. In all of the sites where the Yellow-tufted Honeyeater was recorded, habitat complexity was ≥ 8. With the exception of one 9 hectare site which was isolated from surrounding vegetation by only 900 metres, these birds were recorded only in patches > 100 hectares (Figure 4c).



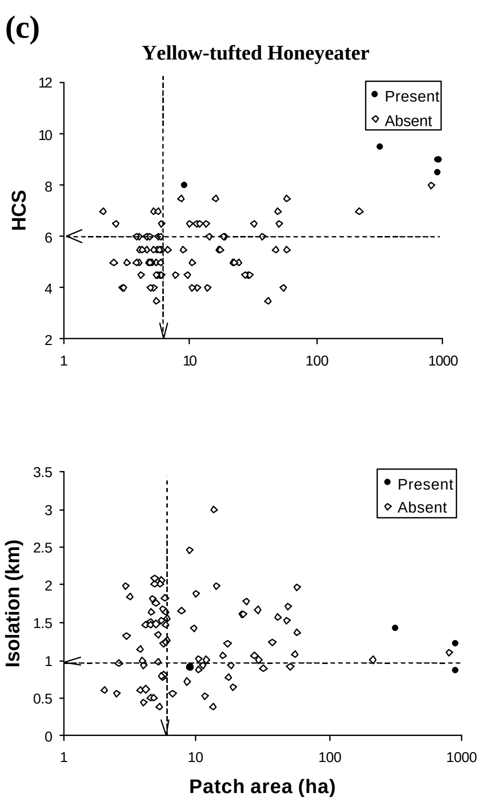




**Figure 4.** Focal species graphs for representative woodland bird species from each of the three sensitivity categories: (a) Australian Magpie (tolerant); (b) Eastern Yellow-robin (moderately sensitive); and (c) Yellow-tufted Honeyeater (highly sensitive – selected as the focal species). Graphs at the top display the effects of patch area and habitat complexity (HCS) on the presence or absence of woodland birds.
Graphs on the bottom show the effects of area and isolation; area is plotted on a logarithmic scale. Arrows indicate the minimum area, habitat complexity and isolation requirements of moderately sensitive woodland bird species.

**Noisy Miners**

Noisy Miners were recorded in sites throughout the Catchment, but were generally more abundant in sites in the northern and western sections. These aggressive, territorial birds were not recorded in sites with a habitat complexity score greater than 6.5 and were dominant only in sites where habitat complexity was 6 or less (Figure 5). Habitat complexity, rather than patch size, appeared to limit the distribution and abundance of the Noisy Miners in remnant woodland patches.

Noisy Miners were detected in 47 of the 94 study sites and were the dominant bird species in 36 of these sites. They were notably absent from all of the creekline sites.

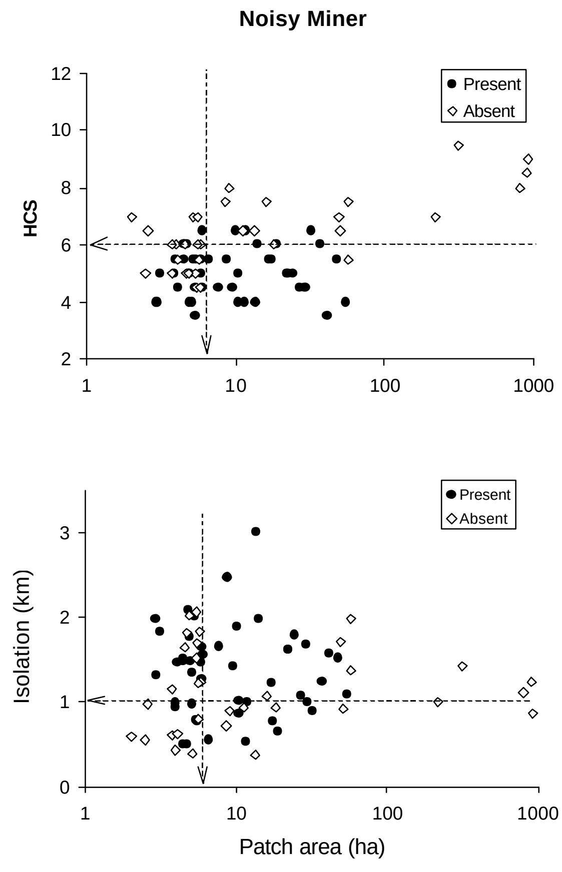



**Figure 5.** The influence of patch area, habitat complexity, and isolation on the presence or absence of the Noisy Miner in 80 survey sites (area plotted on a logarithmic scale). Arrows indicate the minimum area, habitat complexity and isolation requirements of moderately sensitive woodland bird species.

# Discussion

## Birds as bio-indicators

Woodland birds are particularly susceptible to changes brought about by habitat modification because of their direct or indirect reliance on the resources that various habitat components provide (Bennett and Ford 1997). In this regard, they are considered good bio-indicators and can therefore be used, albeit cautiously, for testing ecological theory and monitoring environmental change (Furness *et al.* 1984, Recher 1988).

For a bio-monitor to be useful, it must respond in a sensitive way to the specific perturbation it is being used to measure, and its response must be predictable and easy to measure (Furness *et al.* 1984). The advantages of using birds as bio-monitors are:

1) they are easy to observe and identify in the field;
2) they are abundant and generally diurnal;
3) their classification and systematics are well established; and
4) their response is measurable at a landscape-scale

A further clear advantage that birds have over other potential bio-monitors is that there is wide community interest in them, perhaps more so than in most other animals. This community interest is of benefit in that amateur observers can be enlisted for useful monitoring over large areas.

## Habitat diversity

Widespread change to the structure of forest and woodland habitats has adversely affected many bird species once common throughout the temperate agricultural zones of southern Australia. Preserving and re-creating the structure of vegetation throughout the Upper Billabong Catchment is a primary objective of the 'Re-birding' project and is an essential prerequisite for maintaining and increasing woodland bird diversity. Habitat diversity, both structural and floristic, is directly related to faunal diversity and is vital for maintaining natural ecosystem processes and thus for sustaining agricultural production.

Bird communities can be divided into 'guilds' based on the feeding habits and substrate preferences of individual species. Different guilds are adapted to exploit different resources and many bird species are unique in their use of particular habitat components (i.e. they fill different ecological niches). For example, the Brown Treecreeper specialises in foraging for insects under the bark of tree trunks, fallen logs and stumps. This species was found only in sites with at least 10% cover of fallen branches. If sufficient change occurs to the natural habitat of the Brown Treecreeper (e.g. tidying up fallen branches, firewood collection etc), this species will disappear from the landscape.

The most highly modified structural components of the vegetation in the Holbrook area are the low shrub and ground layers. In an undisturbed system, both of these components provide a highly diverse foraging substrate for a variety of woodland bird species. Without these vital components, some species are unable to survive. For example, the Speckled Warbler was found to occur only in complex patches of vegetation (HCS > 6) where low shrub cover (0.5 – 2 m) was greater than 20%. The ground layer of a natural woodland or forest consists of low shrubs, grasses and sedges and an extensive cover of leaf, bark and branch litter. A combination of grazing and pasture improvement has substantially reduced the naturally high diversity of foraging substrates available to woodland birds at ground level. The Hooded Robin (*Melanodryas cucullata*) is an example of a ground-foraging species which has declined throughout much of its range due largely to the modification of its preferred foraging substrate.

The severity of eucalypt dieback has been linked to the abundance and diversity of canopy-foraging insectivorous birds (Grey *et al.* 1993). Hence, in order to reduce dieback, suitable habitat should be provided for these birds. However, a management strategy should also consider the role played by other foraging guilds in maintaining vital ecosystem functions. For example, most canopy-feeding birds, in addition to their preferred foraging substrate (i.e. canopy foliage), also utilize other layers of the vegetation in response to resource availability and for shelter. For example, the Yellow-tufted Honeyeater was observed feeding anywhere from the canopy layer to the low shrub layer. This movement between layers is also a characteristic of other small insectivores such as thornbills and small honeyeaters, birds which are capable of consuming a considerable biomass of the insects which contribute to eucalypt dieback (e.g. psyllids).

**Application of the focal species approach**

The focal species approach to biodiversity conservation (Lambeck 1997) identifies landscape-scale threats to the persistence of native biota. The key threats to biodiversity in the Upper Billabong Catchment were identified as degradation (i.e. loss of structural diversity), isolation, and loss of existing vegetation. The 'Re-birding' project aims to address these threats by using the results of a focal species analysis to carry out strategic revegetation. The rationale behind using a focal species is that the spatial and habitat requirements of the selected species will encompass the habitat needs of all other species.

The Yellow-tufted Honeyeater (*Lichenostomus melanops*) was identified as the focal species for the Upper Billabong Catchment by virtue of its demanding habitat requirements. This species was found only in structurally complex patches of vegetation (i.e. habitat complexity ≥ 8) with minimum habitat requirements of > 20% tree canopy cover, > 10% shrub cover (0.5 - 4m), > 40% cover of native ground herbage, > 10% cover of fallen logs and >10% cover of litter. With the exception of one 9-hectare site which was isolated from surrounding vegetation by only 900 metres, these birds were restricted to patches larger than 100 hectares (Figure 4c) and isolated by less than 1.5 km. It is assumed that the above habitat characteristics are sufficient to meet the needs of all other woodland bird species recorded during this survey.

The Yellow-tufted Honeyeater is not regarded as a threatened or declining woodland bird species in the sheep-wheat belt of New South Wales (Reid 1999). However, it is generally associated with low altitude forest and woodland habitats with a well-developed understorey, particularly along creeks (Pizzey and Knight 1997). These lowland habitats are generally in poor condition throughout the temperate agricultural landscapes of southern Australia (Bennett and Ford 1997; Reid 1999).

*Intermediate focal species*

Despite the large-scale revegetation planned for the Upper Billabong Catchment over the next few years, it is unlikely that woodland patches will be created of sufficient size or structural diversity to provide suitable habitat for the Yellow-tufted Honeyeater. Even if the spatial and habitat requirements of this species are met, newly planted vegetation will take decades to develop enough maturity. Therefore, an 'intermediate focal species' (Freudenberger 1999) which can be used to measure the short-term success of habitat restoration is required.

The Eastern Yellow-robin (*Eopsaltria australis*) is a medium-sized, yellow-breasted bird, common in the forests and woodlands of eastern and south-eastern Australia (Morcombe 1986). This species was moderately sensitive to habitat disturbance in the Upper Billabong Catchment and was found only in vegetation patches of at least 6 hectares in size (or isolated by less than 1 km) and with habitat complexity score of at least 6. It is predicted that the presence of this species in revegetated areas will be an early indication of successful habitat restoration.

*Comparison with other focal species analyses*

Compared with the results of a focal species analysis conducted in rural areas surrounding Canberra (Freudenberger 1999), the woodland birds of the Upper Billabong Catchment appeared to be less demanding in their minimum habitat requirements. For example, some of the moderately sensitive species found in patches as small as 6 hectares in the Holbrook area, were found only in patches larger than 10 hectares in the ACT study (e.g. Eastern Yellow-robin).

The Hooded Robin was identified as the focal species for the Canberra area, being found only in patches >100 hectares with habitat complexity scores greater than 12 and an isolation score of less than 1 000m. In contrast, Hooded Robins in the Holbrook area were found in patches as small as 11.5 ha with habitat complexity ranging from 4 - 6.5. However, all of the patches inhabited by Hooded Robins in the Holbrook study were isolated from large, complex patches by less than 1 000 metres.

Some woodland bird species regarded as threatened and declining in areas surrounding the Upper Billabong Catchment were recorded in a surprising number of study sites during this survey. For example, the Brown Treecreeper, Dusky Woodswallow and Restless Flycatcher, identified by Reid (1999) as declining throughout the NSW sheep-wheat belt, were found in 59%, 58% and 50% respectively of all study sites. Species such as the Black-chinned Honeyeater, which elsewhere in its range is highly sensitive to habitat disturbance (e.g. Mt Lofty Ranges, S.A.), was found with unexpected frequency in moderately degraded woodland sites.

**Noisy Miners**

In the intensive agricultural areas of the Upper Billabong Catchment where woodland associations remain largely intact (i.e. the remnant trees remain at natural densities) the diversity of bird species is much lower than observed elsewhere in continuous, undisturbed natural woodland systems (*pers. obs.*) This conundrum suggests that activities taking place not only in the immediate vicinity, but also in the surrounding agricultural matrix, are adversely affecting bird communities in the ‘largely intact’ remnant woodlands. Perhaps in these more open woodland systems, clearing and associated habitat alteration on a landscape or regional scale, have provided a more desirable habitat for highly territorial and competitive ‘edge-preferring’ species to the exclusion of others, hence reducing species diversity.

The Noisy Miner (*Manorina melanocephala*) is one such competitive species which has benefited from the widespread clearance of native vegetation throughout south-eastern Australia. It has thrived in fragmented open woodlands with sparse understorey and has considerably increased its abundance and distribution in these habitats (Grey *et al.* 1997). Noisy Miners were absent in all study sites with a habitat complexity score greater than 6.5 in the Upper Billabong Catchment. Hence planting shrubs to increase the structural diversity of remnant vegetation throughout the Catchment may lead to a reduction in the number of this species.

The Noisy Miner displays communal interspecific territorial aggression in protecting food resources (Dow 1977), to the exclusion of other species. Studies have shown that there is probably a link between competitive exclusion of insectivorous birds by aggressive species such as Noisy Miners and tree dieback as a consequence of infestation by phytophagous insects (e.g. Landsberg 1990). Experiments involving the removal of Noisy Miners (e.g. Grey *et al.* 1997) and similarly aggressive Bell Miners (Loyn *et al.* 1983) from eucalypt woodland affected by dieback, resulted in a greater number of species (e.g. small honeyeaters) and a concomitant improvement in condition of the vegetation.

The surprising absence of Noisy Miners from all creekline sites surveyed during this study can probably be attributed to the inadequate foraging substrate provided by the smooth-barked River Red Gums (*E. camaldulensis*) which dominate the riparian habitats of the Upper Billabong Catchment. Collard (1999) found a similar absence of Noisy Miners from smooth-baked Pink Gums (*Eucalyptus fasciculosa*) in the Lower south-east of South Australia. Paradoxically, River Red Gums assessed during this current Upper Billabong survey were found to suffer from moderately severe dieback, perhaps suggesting that Noisy Miners are not the major contributors to loss of tree condition in the Catchment.

**Limitations to bird dispersal**

The fragmented patches of remnant woodland vegetation which exist throughout the agricultural zones of southern Australia provide an excellent basis from which to recreate functional habitat linkages across regional landscapes (Reid 1999). For example, the remaining vegetation of the Upper Billabong Catchment exists largely as fragmented patches of varying size, quality and isolation, connected by an intermittent network of roadside verges and riparian strips. The extensive areas of high quality remnant vegetation which surround much of the Catchment provide excellent habitat for a wide diversity of native woodland birds. A network of functional linkages emanating from these high quality areas will enable birds to disperse freely into newly restored areas such as those created for the 'Re-birding' project.

There is a fundamental lack of knowledge about the size, structure and composition of man-made habitat corridors needed by woodland birds for successful dispersal. In particular, it is uncertain how wide a corridor must be to provide suitable habitat for sensitive woodland birds. The minimum width of corridors being established for the 'Re-birding' project is 20 m, an arbitrary value based on limited research. Revegetation using linear strips is the preferred method of most landowners because vegetation corridors can be established along existing property boundaries, providing shelter for stock and crops. However, further research should be conducted into the effectiveness of such narrow corridors in the Holbrook area before any great effort and resources are expended in establishing revegetation which may be of limited value to sensitive woodland birds.

While remnant patches of vegetation are of greatest importance to the re-birding of the Upper Billabong Catchment, scattered trees also form a significant element. These lone and often isolated trees comprise a significant proportion of the remnant vegetation throughout large areas of agriculturally dominated south-eastern Australia and therefore should be considered as a unique and valuable component of the 'variegated' landscape (McIntyre and Barrett 1992). These trees provide valuable habitat for a diversity of native organisms (Hill *et al.* 1997) and aid in the dispersal of woodland birds (Collard 1999). The condition of many such scattered trees in the Holbrook area is deteriorating due to severe dieback and there are no regenerating trees to replace them when they die. Landholders should be encouraged to plant and nurture replacements for these trees. Replacement tree species should be selected for resistance to insect attack.

**Potential sources of error**

The following points outline the limitations of this study and the potential sources of error which may have influenced the interpretation of results:

- The focal species for this study was selected from woodland bird species recorded in 3 or more survey sites i.e. species such as the Red-capped Robin and Fan-tailed Cuckoo were not considered because they were found only in 1 or 2 sites.
- The focal species approach does not take into account those species which have already disappeared from the landscape.
- Flowering of eucalypts in some sites during the spring census may have influenced the bird assemblages recorded at these sites.
- Study areas were situated in a wide variety of habitat types including riparian, woodland, and dry forest communities - bird species composition varies according to habitat type.
- The isolation index for each site was calculated by averaging the distance to the five closest patches of remnant vegetation > 0.5 ha. However, this index does not take into account the relative sizes of the neighbouring patches.
- Only living trees were assessed for dieback, however some study sites had large numbers of dead trees presumably killed by dieback.

The high mobility of birds allows them to travel large distances and to move freely into areas where they would not usually be found - they may occasionally visit highly degraded areas to exploit short-term resources such as flowering trees. For example, honeyeaters are highly opportunistic, they are strong fliers and may travel large distances across agricultural areas to exploit resources e.g. flowering scattered trees (*pers. obs,*). Hence, some bird species recorded in ecologically degraded areas such as the agricultural landscape may be only short-term, opportunistic species. Bird surveys in these degraded habitats may therefore misrepresent the resident bird assemblages. Despite their apparent success in degraded areas, such opportunistic bird species may actually require larger, more complex habitats for their long-term survival (e.g. Black-chinned Honeyeater).

## Conclusions

The eucalypt forests and woodlands of the temperate agricultural zones of south-eastern Australia have been extensively cleared in the course of agricultural development. This landscape-scale modification, in particular the reduction of structural diversity, has adversely affected many woodland bird species.

The ‘Re-birding’ project aims to restore selected areas of the highly modified Upper Billabong Catchment to their original natural state, thus rejuvenating ecosystem processes (e.g. predation of phytophagous insects by birds) and ultimately achieving an improvement in the present generally poor tree condition. The specific objectives of the research phase of the project were to provide guidelines for habitat restoration and encourage community involvement in current and future Landcare activities.

A ‘focal species’ analysis was used to determine the habitat requirements of woodland bird species of varying sensitivity to habitat disturbance. This analysis showed that woodland patches needed to be at least six hectares in size with a habitat complexity score of six or greater to accommodate all but the most sensitive woodland species. Patches that were smaller than six hectares, but which were isolated from other vegetation by less than 1 kilometre, were more likely to support a diversity of moderately sensitive woodland birds than more isolated small patches.

The Yellow-tufted Honeyeater (*Lichenostomus melanops*) was identified as a suitable ‘focal species’ for the Upper Billabong Catchment by virtue of its demanding habitat requirements. This species was found chiefly in large (>100 ha), structurally diverse patches of vegetation (i.e. habitat complexity ≥ 8) with minimum habitat requirements of > 20% tree canopy cover, > 10% shrub cover (0.5 – 4 m height), > 40% cover of native ground herbage, > 10% cover of fallen logs and >10% cover of litter.

Considering the demanding habitat requirements of the Yellow-tufted Honeyeater and the generally limited resources available for habitat restoration, an ‘intermediate focal species’ was selected. The Eastern Yellow-robin, a moderately sensitive species in the Holbrook area, was found in woodland patches of at least 6 hectares (or isolated by less than 1 km) and with habitat complexity score of at least 6. The presence of this species in enhanced and newly revegetated areas should be an early indication of successful habitat restoration.

Revegetating only 1% of the Upper Billabong Catchment (the proposed target for the ‘Re-birding’ project) will probably not lead to an immediate increase in bird numbers and tree condition throughout the Catchment. It may take years, even decades, before the benefits of the project become apparent and the structural diversity of the vegetation develops enough to provide suitable habitat for sensitive woodland birds. However, the project provides a sound basis for future habitat restoration in the area and will, given time, help to address other environmental problems such as salinity and soil erosion.

It is recommended that further research be conducted into the woodland bird communities of both the Upper Billabong Catchment and surrounding areas, to measure the effectiveness of the ‘Re-birding’ project and to test the focal species recommendations made in the initial research phase of the project to date. In particular, an investigation into the biodiversity value of existing and newly established linear strips (corridors) of vegetation is essential. Specifically, is the recommended 20m corridor width sufficient?

This study has confirmed that the focal species approach to landscape-scale habitat restoration is applicable to the ‘variegated’ landscapes of the south-west slopes of New South Wales. Perhaps its greatest benefit has been that preliminary recommendations for habitat restoration were able to be made with confidence shortly after the completion of bird and habitat assessments.

## Recommendations

It is suggested that the following actions be taken to protect and enhance woodland bird populations of the Upper Billabong Catchment:

- Cease broad-acre clearance within the Catchment and in surrounding areas.

- Restore the Holbrook landscape according to defined focal species criteria i.e.:

  - Minimum patch size ≥ 6 hectares (blocks),
  - Isolation < 1 km, and
  - Habitat complexity score (HCS) ≥ 6.

Patches of vegetation with these specifications will provide suitable habitat for all but the most sensitive woodland birds.

- Manage the landscape with due consideration given to the habitat requirements of threatened and declining bird species.

- Protect and enhance existing patches of remnant vegetation and use these remnants as the basis for revegetation in surrounding areas.

- Give priority to remnant enhancement and revegetation in the more fertile low altitude areas particularly in riparian and woodland environments.

- Undertake active management of protected areas (e.g. weed control, on-going planting of shrubs and grasses) - it is not enough to fence, revegetate, and then forget.

- Address issues such as firewood collection - fallen logs provide valuable habitat for a wide variety of native organisms e.g. Treecreepers, native marsupials etc

- Increase the number of survey sites to include patches outside Holbrook Landcare boundaries to increase sample size and validate findings and recommendations of this study. In particular target large (>20 ha) and small (< 2 ha) woodland patches.

- Continue monitoring of bird communities and habitat condition in new and established study sites consistent with the project methodology i.e. focal species analysis using birds as bio-indicators, tree dieback etc.

- All data should be entered into the Microsoft 'Access' database set up for the 'Re-birding' project.

- Perform further analysis of data. In particular, bird abundance data and detailed habitat assessments should be examined more thoroughly than was possible in the course of this study.

- Commence monitoring of existing and newly planted corridors to determine effectiveness of 20 m wide corridors as a dispersal medium for woodland birds.

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## Appendix 1

Property names, owners/managers, and relevant habitat variables for 94 study sites used for bird and vegetation assessments throughout the Upper Billabong Catchment. HCS = habitat complexity score, RLPB = Rural Lands Protection Board, TSR = Travelling stock reserve. Remnant size is measured in hectares, isolation is an index, calculated by averaging the distance to the five nearest patches of vegetation >0.5 ha, HCS is a measure of the structural complexity of the habitat.

| Site ID | Property Name | Property Owner/Manager | Remnant Size | Isolation | HCS |
|---|---|---|---|---|---|
| 1 | Eajar | James Lawson | 5.97 | 1.27 | 4.5 |
| 2 | Triangle Paddock | James Lawson | 5.37 | 2.01 | 3.5 |
| 3 | Kelvin Grove | Fraser Parker | 3.92 | 0.99 | 5 |
| 4 | Koombahla | Peter Trescowthick | 5.51 | 0.78 | 5.5 |
| 5 | Four Mile TSR | RLPB | 5.44 | 2.06 | 4.5 |
| 6 | Yammacoona | Bill Wearn | 4.57 | 1.65 | 6 |
| 7 | Ingleburn | Russell Parker | 3.15 | 1.84 | 5 |
| 8 | YarraGlen | John Keogh | 2.02 | 0.60 | 7 |
| 9 | Kinross | Darky Barr-Smith | 5.17 | 0.97 | 5.5 |
| 10 | Kinross | Darky Barr-Smith | 5.93 | 1.64 | 5.5 |
| 11 | Wongalee | Russell Ross | 2.94 | 1.98 | 4 |
| 12 | Warranboo | David Geddes | 5.18 | 0.40 | 7 |
| 13 | Aberfeldy | Ian Ross | 5.76 | 1.83 | 4.5 |
| 14 | Fairview | Phillip Locke | 3.96 | 0.93 | 5.5 |
| 15 | Forestvale North | Andrew Watson | 4.48 | 1.51 | 5.5 |
| 16 | Windermere | John Hassett | 4.87 | 2.02 | 5 |
| 17 | Marianella | Norm McLaurin | 5.12 | 1.35 | 4 |
| 18 | YarraYarra | Bruce Saxton | 5.55 | 1.69 | 6 |
| 19 | Wandara | Evan Hulme | 4.69 | 1.82 | 5 |
| 20 | Mount Raven | Andrew Watson | 2.99 | 1.32 | 4 |
| 21 | Boorook | Brett Schulz | 5.99 | 1.56 | 6.5 |
| 22 | Boorook | Brett Schulz | 4.51 | 1.48 | 6 |
| 23 | Hillside | Rob Chatfield | 4.47 | 0.50 | 6 |
| 24 | Pajara | Richard Hulme | 4.96 | 1.48 | 5 |
| 25 | Stonehaven | Neil Ross | 4.10 | 1.47 | 4.5 |
| 26 | Old Murrumbung | Tony Chaston | 5.83 | 1.23 | 6 |
| 27 | Old Murrumbung | Tony Chaston | 2.57 | 0.97 | 6.5 |
| 28 | Lowana | Bill Clancy | 4.75 | 0.51 | 6 |
| 29 | Teripta | Steven Finlay | 4.81 | 2.08 | 5 |
| 30 | Mount Raven | Andrew Watson | 5.41 | 0.79 | 4.5 |
| 31 | Duntulm | Max Meiklejohn | 2.51 | 0.56 | 5 |
| 32 | Duntulm | Max Meiklejohn | 3.77 | 0.61 | 5 |
| 33 | Warranboo | David Geddes | 5.62 | 0.80 | 7 |
| 34 | Widgee | Richard Harbison | 4.13 | 0.63 | 5.5 |
| 35 | Upper Duntulm | Ian Meiklejohn | 3.95 | 0.44 | 6 |
| 36 | Glenruben | Leo Corrigan | 5.67 | 1.22 | 5.5 |
| 37 | Corringle | Paul Rossiter | 4.90 | 1.76 | 4 |
| 38 | Elmarno | Wendy Swan | 3.78 | 1.16 | 6 |

| Site ID | Property Name | Property Owner/Manager | Remnant Size | Isolation | HCS |
|---|---|---|---|---|---|
| 39 | Shenandoah | David Morton | 5.41 | 1.52 | 5 |
| 40 | Siena | Val Ciblis | 5.83 | 1.46 | 5 |
| 41 | Eajar | James Lawson | 10.37 | 1.02 | 4 |
| 42 | Jerra TSR | RLPB | 13.53 | 2.99 | 4 |
| 43 | Forestvale North | Andrew Watson | 14.08 | 1.98 | 6 |
| 44 | Kameroo | Ted Gain | 9.06 | 0.90 | 8 |
| 45 | Mountain View | Lawrie Cottrell | 8.76 | 2.47 | 5.5 |
| 46 | - | Laura Harrison | 6.64 | 0.56 | 5.5 |
| 47 | Wybalena | Andrew Mathie | 17.40 | 0.78 | 5.5 |
| 48 | Two-mile TSR | RLPB | 7.69 | 1.65 | 4.5 |
| 49 | Ladykirk Swamp | James Lawson | 10.38 | 0.88 | 5 |
| 50 | Forestvale North | Andrew Watson | 17.05 | 1.22 | 5.5 |
| 51 | Craigow | Peter Waite | 11.86 | 1.01 | 6.5 |
| 52 | Lowana | Bill Clancy | 15.94 | 1.07 | 7.5 |
| 53 | Mount Raven | Joan Nion | 10.02 | 1.89 | 6.5 |
| 54 | YarraGlen | John Keogh | 13.40 | 0.38 | 6.5 |
| 55 | Wantagong | Peter Stead | 11.27 | 0.94 | 6.5 |
| 56 | Widgee | Richard Harbison | 18.82 | 0.65 | 6 |
| 57 | Upper Duntulm | Ian Meiklejohn | 8.53 | 0.71 | 7.5 |
| 58 | Kanimbla | Fiona Anderson | 9.55 | 1.42 | 4.5 |
| 59 | Kitchener | Craig Rowe | 18.28 | 0.94 | 6 |
| 60 | Pine Hill | Andrew Hicks | 11.52 | 0.53 | 4 |
| 61 | Karrara | John McKenzie | 57.55 | 1.37 | 5.5 |
| 62 | Back Creek TSR | RLPB | 24.07 | 1.79 | 5 |
| 63 | Wantagong | Peter Stead | 41.28 | 1.57 | 3.5 |
| 64 | Mountain Creek | Frank Sorraghan | 22.38 | 1.62 | 5 |
| 65 | Blue Metal TSR | RLPB | 57.57 | 1.98 | 7.5 |
| 66 | Koonawarra | Val Ciblis | 47.65 | 1.52 | 5.5 |
| 67 | Marianella | Gerard McLaurin | 37.10 | 1.24 | 6 |
| 68 | Holbrook Common | - | 22.11 | 1.61 | 5 |
| 69 | Yallock | Tony Geddes | 49.31 | 1.71 | 7 |
| 70 | No Man's Land | - | 50.58 | 0.93 | 6.5 |
| 71 | Kitchener | Craig Rowe | 32.11 | 0.90 | 6.5 |
| 72 | Doughty's TSR | RLPB | 28.99 | 1.68 | 4.5 |
| 73 | Steadman's TSR | RLPB | 27.15 | 1.07 | 4.5 |
| 74 | The Gap TSR | RLPB | 54.67 | 1.08 | 4 |
| 75 | Stonehaven | Neil Ross | 29.44 | 1.00 | 4.5 |
| 76 | Rossmore | Craig Rowe | 216.98 | 1.01 | 7 |
| 77 | Manoora | Bev Geddes | 900.04 | 1.23 | 8.5 |
| 78 | Wybalena | Andrew Mathie | 800.00 | 1.11 | 8 |
| 79 | Woomargama SF | - | 916.00 | 0.87 | 9 |
| 80 | Duntulm | Max Meiklejohn | 314.63 | 1.43 | 9.5 |
| 81 | Lindawarra | Ross Trethowan | Creekline | | 5.5 |
| 82 | Little Billabong TSR | RLPB | Creekline | | 4.5 |
| 83 | Church TSR | RLPB | Creekline | | 4.5 |
| 84 | Fairview | Phillip Locke | Creekline | | 4.5 |

| Site ID | Property Name | Property Owner/Manager | Remnant Size | Isolation | HCS |
|---|---|---|---|---|---|
| 85 | Wandara | Evan Hulme | Creekline | | 5.5 |
| 86 | Forestvale North | Andrew Watson | Creekline | | 4 |
| 87 | Yammacoona | Bill Wearn | Creekline | | 5 |
| 88 | Yammacoona | Bill Wearn | Creekline | | 5 |
| 89 | Aberfeldy | Ian Ross | Creekline | | 5.5 |
| 90 | Kimberley Park | Ian Scobie | Creekline | | 4 |
| 91 | Wantagong | Peter Stead | Creekline | | 5.5 |
| 92 | Wilungah | Dallas Hawkins | Creekline | | 4.5 |
| 93 | Roachdale | Tim Trescowthick | Creekline | | 6.5 |
| 94 | Yarra Yarra | Bruce Saxton | Creekline | | 5 |

# Appendix 2

Comprehensive bird species list for the Upper Billabong Catchment 1999-2000.

## Bird species List - Upper Billabong Catchment 1999-2000

***Indicates** species threatened in NSW

Conservation status codes: S = stable, D = declining, V = vulnerable, E = endangered

| Species code | Common Name | Scientific Name | Conservation Status (NSW) |
|---|---|---|---|
| | **Water birds** | | |
| 062 | Hoary-headed Grebe | *Poliocephalus poliocephalus* | S |
| 061 | Australasian Grebe | *Tachybaptus novaehollandiae* | S |
| 096 | Great Cormorant | *Phalocrocorax carbo* | S |
| 100 | Little Pied Cormorant | *Phalacrocorax melanoleucos* | S |
| 099 | Pied Cormorant | *Phalacrocorax varius* | S |
| 106 | Australian Pelican | *Pelicanus conspicillatus* | S |
| 188 | White-faced Heron | *Ardea novaehollandiae* | S |
| 189 | Pacific Heron | *Ardea pacifica* | S |
| 192 | Nankeen Night Heron | *Nycticorax caledonicus* | S |
| 181 | Royal Spoonbill | *Platalea regia* | S |
| 182 | Yellow-billed Spoonbill | *Platalea flavipes* | S |
| 180 | Straw-necked Ibis | *Threskiornis spinicollis* | S |
| 179 | Sacred Ibis | *Threskiornis aethiopica* | S |
| 207 | Australian Shelduck | *Tadorna tadornoides* | S |
| 203 | Black Swan | *Cygnus atratus* | S |
| 202 | Australian Wood Duck | *Chenonetta jubata* | S |
| 215 | Hardhead | *Aythya australis* | S |
| 208 | Pacific Black Duck | *Anas superciliosa* | S |
| 212 | Australasian Shoveller | *Anas rhynchotis* | S |
| 211 | Grey Teal | *Anas gracilis* | S |
| 210 | Chestnut Teal | *Anas castanea* | S |
| 213 | Pink-eared Duck | *Malacorhynchus membranaceus* | S |
| 133 | Masked Lapwing | *Vanellus miles* | S |
| 144 | Black-fronted Dotterel | *Charadrius melanops* | S |
| 146 | Black-winged Stilt | *Himantopus himantopus* | S |
| | **Nocturnal birds** | | |
| 249 | Barn Owl | *Tyto alba* | S |
| 242 | Southern Boobook | *Ninox novaeseelandiae* | S |
| 317 | Australian Owlet-nightjar | *Aegotheles cristatus* | S |
| 313 | Tawny Frogmouth | *Podargus strigoides* | S |
| | **Diurnal Birds** | | |
| 221 | Brown Goshawk | *Accipiter fasciatus* | S |
| 218 | Spotted Harrier | *Circus assimilis* | S |
| 219 | Swamp Harrier | *Circus approximans* | S |
| 225 | Little Eagle | *Hieraaetus morphnoides* | S |
| 224 | Wedge-tailed Eagle | *Aquila audax* | S |
| 232 | Black-shouldered Kite | *Elanus notatus* | S |
| 239 | Brown Falcon | *Falco berigora* | S |

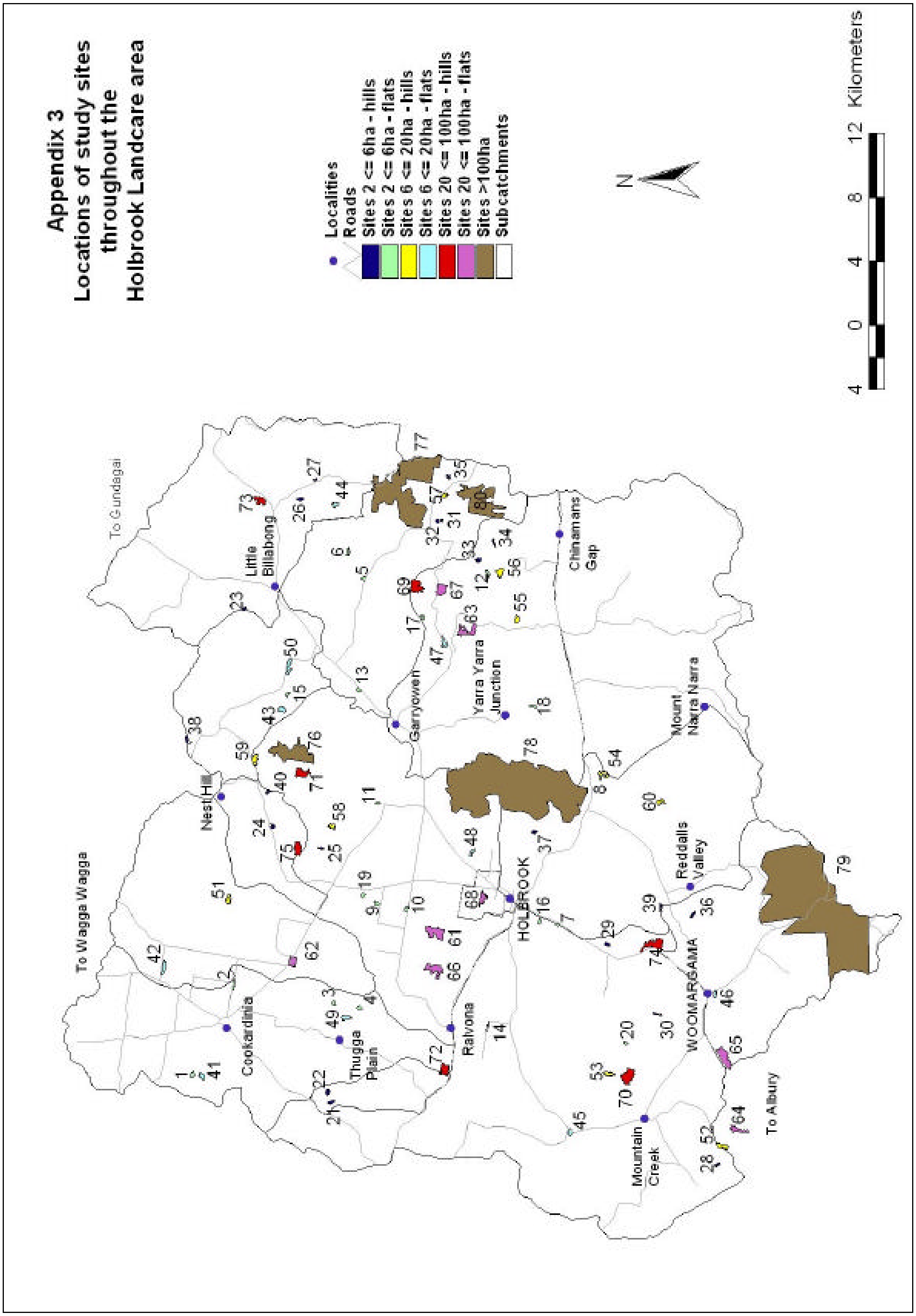
| Species code | Common Name | Scientific Name | Conservation Status (NSW) |
|---|---|---|---|
| 235 | Australian Hobby | *Falco longipennis* | S |
| 240 | Nankeen Kestrel | *Falco cenchroides* | S |
| 237 | Peregrine Falcon | *Falco peregrinus* | S |
| 014 | ***Painted Button Quail*** | *Turnix varia* | ***D*** |
| 011 | Brown Quail | *Coturnix australis* | S |
| 009 | Stubble Quail | *Coturnix pectoralis* | S |
| 043 | Crested Pigeon | *Ocyphaps lophotes* | S |
| 034 | Common Bronzewing | *Phaps chalcoptera* | S |
| 030 | Peaceful Dove | *Geopelia striata* | S |
| 268 | Gang-gang Cockatoo | *Callocephalon fimbriatum* | S |
| 269 | Sulphur-crested Cockatoo | *Cacatua galerita* | S |
| 273 | Galah | *Cacatua roseicapilla* | S |
| 271 | Little Corella | *Cacatua pastinator* | S |
| 309 | ****Swift Parrot*** | *Lathamus discolor* | ***E*** |
| 260 | Little Lorikeet | *Glossopsitta pusilla* | S |
| 281 | Australian King Parrot | *Alisterus scapularis* | S |
| 274 | Cockatiel | *Nymphicus hollandicus* | S |
| 288 | Eastern Rosella | *Platycercus eximius* | S |
| 282 | Crimson Rosella | *Platycercus elegans* | S |
| 295 | Red-rumped Parrot | *Psephotus haematonotus* | S |
| 302 | ****Turquoise Parrot*** | *Neophema pulchella* | ***V*** |
| 338 | Fan-tailed Cuckoo | *Cuculus pyrrhophanus* | S |
| 337 | Pallid Cuckoo | *Cuculus pallidus* | S |
| 344 | Shining Bronze-Cuckoo | *Chrysococcyx lucidus* | S |
| 342 | Horsfield's Bronze-cuckoo | *Chrysococcyx basalis* | S |
| 322 | Laughing Kookaburra | *Dacelo novaeguineae* | S |
| 326 | Sacred Kingfisher | *Halcyon sancta* | S |
| 329 | Rainbow Bee-eater | *Merops ornatus* | S |
| 318 | Dollarbird | *Eurystomus orientalis* | S |
| 334 | White-throated Needletail | *Hirundapus caudacutus* | S |
| 357 | Welcome Swallow | *Hirundo neoxena* | S |
| 360 | Fairy Martin | *Cecropis ariel* | S |
| 359 | Tree Martin | *Cecropis nigricans* | S |
| 647 | Richard's Pipit | *Anthus novaeseelandiae* | S |
| 509 | Rufous Songlark | *Cinclorhamphus mathewsi* | S |
| 508 | Brown Songlark | *Cinclorhamphus cruralis* | S |
| 424 | Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | S |
| 425 | White-bellied Cuckoo-shrike | *Coracina papuensis* | S |
| 430 | White-winged Triller | *Lalage tricolor* | S |
| 382 | Flame Robin | *Petroica phoenica* | S |
| 381 | ***Red-capped Robin*** | *Petroica goodenovii* | ***D*** |
| 380 | Scarlet Robin | *Petroica multicolor* | S |
| 385 | ***Hooded Robin*** | *Melanodryas cucullata* | ***D*** |
| 392 | ***Eastern Yellow Robin*** | *Eopsaltria australis* | ***D*** |
| 377 | ***Jacky Winter*** | *Microeca leucophaea* | ***D*** |
| 416 | ***Crested Shrike-tit*** | *Falcunculus frontatus* | ***D*** |
| 398 | Golden Whistler | *Pachycephala pectoralis* | S |
| 401 | ***Rufous Whistler*** | *Pachycephala rufiventris* | ***D*** |
| 408 | Grey Shrike-thrush | *Colluricincla harmonica* | S |
| 369 | ***Restless Flycatcher*** | *Myiagra inquieta* | ***D*** |
| 365 | Leaden Flycatcher | *Myiagra rubecula* | S |
| 361 | Grey Fantail | *Rhipidura fuliginosa* | S |

| Species code | Common Name | Scientific Name | Conservation Status (NSW) |
|---|---|---|---|
| 364 | Willy Wagtail | *Rhipidura leucophrys* | S |
| 436 | Spotted Quail-thrush | *Cinclosoma punctatum* | S |
| 445 | ***White-browed Babbler*** | *Pomatostomus superciliosus* | ***D*** |
| 443 | ***Grey-crowned Babbler*** | *Pomatostomus temporalis* | ***D*** |
| 525 | Golden-headed Cisticola | *Cisticola exilis* | S |
| 524 | Australian Reed-Warbler | *Acrocephalus australis* | S |
| 529 | Superb Fairy-wren | *Malurus cyaneus* | S |
| 488 | White-browed Scrubwren | *Sericornis frontalis* | S |
| 504 | ***Speckled Warbler*** | *Sericornis sagittata* | ***D*** |
| 463 | Western Warbler | *Gerygone fusca* | S |
| 453 | White-throated Warbler | *Gerygone olivacea* | S |
| 470 | Striated Thornbill | *Acanthiza lineata* | S |
| 471 | Yellow Thornbill | *Acanthiza nana* | S |
| 465 | ***Weebill*** | *Smicrornis brevirostris* | ***D*** |
| 466 | Southern Whiteface | *Aphelocephala leucopis* | S |
| 484 | Buff-rumped Thornbill | *Acanthiza reguloides* | S |
| 486 | Yellow-rumped Thornbill | *Acanthiza chrysorrhoa* | S |
| 475 | Brown Thornbill | *Acanthiza pusilla* | S |
| 549 | ***Varied Sitella*** | *Daphoenositta chrysoptera* | ***D*** |
| 558 | White-throated Treecreeper | *Cormobates leucophaea* | S |
| 560 | Red-browed Treecreeper | *Climacteris erythrops* | S |
| 555 | ***Brown Treecreeper*** | *Climacteris picumnus* | ***D*** |
| 638 | Red Wattlebird | *Anthochaera carunculata* | S |
| 646 | Little Friarbird | *Philemon citreogularis* | S |
| 645 | Noisy Friarbird | *Philemon corniculatus* | S |
| 641 | Blue-faced Honeyeater | *Entomyzon cyanotis* | S |
| 634 | Noisy Miner | *Manorina melanocephala* | S |
| 578 | White-naped Honeyeater | *Melithreptus lunatus* | S |
| 583 | Brown-headed Honeyeater | *Melithreptus brevirostris* | S |
| 580 | Black-chinned Honeyeater | *Melithreptus gularis* | S |
| 619 | Yellow-tufted Honeyeater | *Lichenostomus melanops* | S |
| 617 | White-eared Honeyeater | *Lichenostomus leucotis* | S |
| 614 | Yellow-faced Honeyeater | *Lichenostomus chrysops* | S |
| 625 | White-plumed Honeyeater | *Lichenostomus penicillatus* | S |
| 613 | Fuscous Honeyeater | *Lichenostomus fuscus* | S |
| 598 | ****Painted Honeyeater*** | *Grantiella picta* | ***V*** |
| 591 | Eastern Spinebill | *Acanthorhynchus tenuirostris* | S |
| 574 | Silvereye | *Zosterops lateralis* | S |
| 564 | Mistletoebird | *Dicaeum hirundinaceum* | S |
| 448 | White-fronted Chat | *Ephthianura albifrons* | S |
| 565 | Spotted Pardalote | *Pardalotus punctuatus* | S |
| 976 | Striated Pardalote | *Pardalotus striatus* | S |
| 662 | Red-browed Finch | *Aegintha temporalis* | S |
| 652 | ***Diamond Firetail*** | *Emblema guttatum* | ***D*** |
| 999 | Common Starling | *Sturnus vulgaris* | S |
| 671 | Olive-backed Oriole | *Oriolus sagittatus* | S |
| 415 | Magpie-lark | *Grallina cyanoleuca* | S |
| 693 | White-winged Chough | *Corcorax melanorhamphos* | S |
| 547 | ***Dusky Woodswallow*** | *Artamus cyanopterus* | ***D*** |
| 700 | Pied Butcherbird | *Cracticus nigrogularis* | S |
| 702 | Grey Butcherbird | *Cracticus torquatus* | S |
| 694 | Pied Currawong | *Strepera graculina* | S |

| Species code | Common Name | Scientific Name | Conservation Status (NSW) |
|---|---|---|---|
| 697 | Grey Currawong | *Strepera versicolor* | S |
| 705 | Australian Magpie | *Gymnorhina tibicen* | S |
| 930 | Australian Raven | *Corvus coronoides* | S |

**Species previously recorded within the Catchment, but not during this research**

| | | | |
|---|---|---|---|
| 101 | Australian Darter | *Anhinga melanogaster* | S |
| 977 | Cattle Egret | *Ardeola ibis* | S |
| 216 | ***Blue-billed Duck** | *Oxyura australis* | ***V*** |
| 217 | Musk Duck | *Biziura lobata* | S |
| 222 | Collared Sparrowhawk | *Accipiter cirrhocephalus* | S |
| 230 | ***Square-tailed Kite** | *Lophoictinia isura* | ***V*** |
| 228 | Whistling Kite | *Haliastur sphenurus* | S |
| 233 | Letter-winged Kite | *Elanus scriptus* | S |
| 174 | ***Bush Stone-curlew** | *Burhinus magnirostris* | ***E*** |
| 045 | Lewin's Rail | *Rallus pectoralis* | S |
| 056 | Dusky Moorhen | *Gallinula tenebrosa* | S |
| 059 | Eurasian Coot | *Fulica atra* | S |
| 058 | Purple Swamphen | *Porphyrio porphyrio* | S |
| 135 | Banded Lapwing | *Vanellus tricolor* | S |
| 035 | Brush Bronzewing | *Phaps elegans* | S |
| 267 | Yellow-tailed Black-cockatoo | *Calyptorhynchus funereus* | S |
| 248 | ***Powerful Owl** | *Ninox strenua* | ***V*** |
| 246 | ***Barking Owl** | *Ninox connivens* | ***V*** |
| 330 | White-throated Nightjar | *Eurostopodus mysticalis* | S |
| 993 | Skylark | *Alauda arvensis* | S |
| 331 | Spotted Nightjar | *Eurostopodus guttatus* | S |
| 421 | Eastern Whipbird | *Psophodes olivaceus* | S |
| 500 | Striated Fieldwren | *Sericornis fuliginosus* | S |
| 608 | Singing Honeyeater | *Lichenostomus virescens* | S |
| 622 | Yellow-plumed Honeyeater | *Lichenostomus ornatus* | S |
| 603 | ***Regent Honeyeater** | *Xanthomyza phrygia* | ***E*** |
| 653 | Zebra Finch | *Poephila guttata* | S |
| 996 | European Goldfinch | *Carduelis carduelis* | S |
| 995 | House Sparrow | *Passer domesticus* | S |
| 546 | Black-faced Woodswallow | *Artamus cinereus* | S |
| 545 | White-browed Woodswallow | *Artamus superciliosus* | S |
| 679 | Satin Bowerbird | *Ptilinorhynchus violaceus* | S |


Appendix 3
Locations of study sites throughout the Holbrook Landcare area
Localities
Roads
Sites 2 <= 6ha - hills
Sites 2 <= 6ha - flats
Sites 6 <= 20ha - hills
Sites 6 <= 20ha - flats
Sites 20 <= 100ha - hills
Sites 20 <= 100ha - flats
Sites >100ha
Subcatchments
N
4 0 4 8 12 Kilometers
To Wagga Wagga
To Gundagai
To Albury
Little Billabong
Nest Hill
Cookardinia
Thugga Plain
Garryowen
Yarra Yarra Junction
HOLBROOK
Ralvona
Chinamans Gap
Mount Narra Narra
Reddalls Valley
WOOMARGAMA
Mountain Creek

## Appendix 4

Data sheet used for detailed habitat assessments.

Site # :
Date of inspection:
Grid reference :
Property and Landholder name :
Remnant size and category :
Shape and dimensions:
Slope: 0 1 2 3
Connectivity: 0 1 2 3
Flowering : 0 1 2 3

Current grazing pressure: 0 1 2 3
Time since last grazed:
Fertilizer application (also in adjoining area) :
Dist. to nearest permanent water source :
Dist. to nearest marked water course :
Distance of 5 nearest neighbours (>0.5ha) :
1: 2: 3: 4: 5:
Average dist:

Total # live trees/ transect (>1m)

| DBH | = 5cm | 6-10cm | 11-30cm | 31-60cm | 61-90cm | >90cm |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Number of eucalypt species : | | | | | |
| Rel. abundance (%) of Euc sp. | | | | | |

# Dead trees

| DBH | <11cm | 11-30cm | 31-60cm | 61-90cm | >90cm |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

Shrub cover (>1m)

| Dimensions | 1 - 2m | >2m (<5cm) | >2m (>5cm) |
|---|---|---|---|
| # | | | |
| | | | |

Acacia spp present + rel. abundance :

Logs (>2m long)

| Diameter | 10-30cm | 31-60cm | >60cm |
|---|---|---|---|
| # | | | |
| | | | |

| | |
|---|---|
| # Stumps (<2m tall >10cm diam) : | |
| # Mistletoe per transect : | |

Ground and low shrub cover (<1m) - in 2x2m quadrat

| | Bare ground | Leaf litter | Grass | Low shrub cov. |
|---|---|---|---|---|
| % | | | | |

Grass % : Native :
Other features : ...........................................................................................................................

## Appendix 5

Data sheet used for habitat complexity assessment
(derived from Catling and Burt (1995)).

Site #:
Date:

| **Score** | 0 | 1 | 2 | 3 | Score |
|---|---|---|---|---|---|
| Cover | 0-10% | 10-20% | 20-50% | >50% | |
| Tree canopy (% cover) | | | | | |
| Mid-shrub cover (2-4 m, %) | | | | | |
| Low-shrub cover (0.5-2m) | | | | | |

| Cover | 0-10% | 10-40% | 40-70% | >70% | |
|---|---|---|---|---|---|
| Ground herbage (<0.5m) | | | | | |
| Logs/branches | | | | | |
| Litter | | | | | |
| **Total** | | | | | |

Ground herbage (%): Native:

Other features: ..........................................................................................

# Appendix 6

Dieback assessment scheme used in study sites established for the 'Re-birding project'. Twenty individual trees were assessed at each site during spring and autumn.

## Dieback assessment scheme

**Jill Landsberg, CSIRO Wildlife & Ecology, PO Box 84, Lyneham ACT 2602** 27 October 1997

The scheme is an attempt to capture three different categories about tree growth and damage that, in combination, indicate the severity of dieback for individual trees. Each of the first three categories should be scored independently (i.e. the score for one category should not influence the score for either other one.) A series of photos or diagrams would help keep assessments objective.

**A. Evidence of old canopy damage**

Evidence of damage that occurred at least the season before last.

| | |
|---|---|
| 0 = None: | no dead branches projecting above the main canopy area. |
| 1 = Slight: | very few dead branches projecting above the main canopy area. |
| 2 = Moderate: | dead branches readily apparent above the main canopy area. |
| 3 = Severe: | no proper canopy; leaves mainly coppiced along the main branches or trunk. |

**B. Evidence of recent canopy damage**

Evidence of damage on leaves produced during the most recent growing season. Collect at least four different branches. Assess about five fully-expanded leaves per branch, taken from near each branch tip.

| | |
|---|---|
| 0 = None: | leaves are generally in very good condition and very few have more than an eighth of their area damaged or missing. |
| 1 = Slight: | leaves are generally in reasonably good condition and few have more than a quarter of their area damaged or missing. |
| 2 = Moderate: | many leaves are moderately damaged, with about half their area damaged or missing. |
| 3 = Severe: | many leaves are severely damaged, with nearly all their area damaged or missing. |

**C. Evidence of recent canopy growth**

Evidence that the tree is capable of producing new leaves when conditions are favourable. Best assessed after some good spring or autumn rains. Leaves that have been produced within the last few months will be brighter coloured and softer than leaves that are a year or more old. Recent canopy growth is a useful category for damaged trees, because it shows how well they are recovering.

| | |
|---|---|
| 0 = Vigorous: | young leaves apparent over most parts of the canopy. |
| 1 = Moderate: | young leaves apparent in some parts of the canopy. |
| 2 = Slight: | few young leaves apparent anyway in canopy. |
| 3 = None: | no young leaves apparent anyway in canopy. |

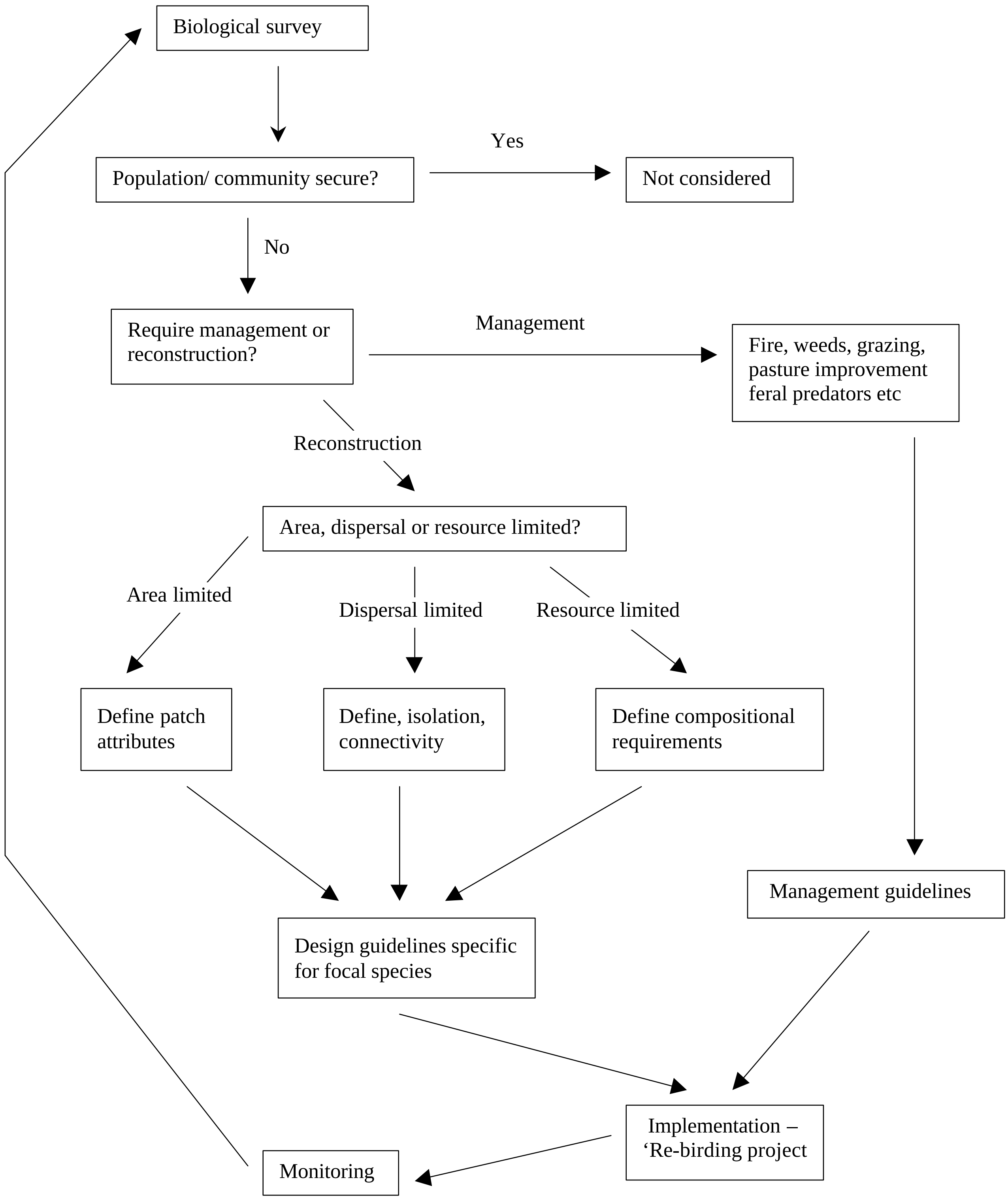
**D. Dieback severity**

Calculate from **A + B + C.** The higher the score, the more severe the dieback. Note, however, that trees with dieback do not necessarily all have the same prognosis: some could be recovering and some could be getting worse. Some example scores are given, to show the possible range of values.

| | |
|---|---|
| 0 + 0 + 0 = 0: | very healthy tree |
| 1 + 1 + 1 = 3: | moderately healthy tree: slight previous and current damage and moderate regrowth |
| 3 + 0 + 0 = 3: | tree with good recovery potential: there is evidence of previous severe dieback but no recent damage and very vigorous regrowth |
| 2 + 2 + 2 = 6: | Tree with moderately severe dieback: there is moderately severe previous and current damage and not much sign of recovery |
| 3 + 3 + 3 = 9: | tree with severe and long-standing dieback and no sign of recovery |

## Appendix 7

Landscape threat analysis for the Holbrook area and suggested management regime for preservation of the focal species (derived from Lambeck 1999).



# Appendix 8

Sensitivity categories for woodland bird species of the Upper Billabong Catchment.

| **Tolerant** | **Moderately sensitive** | **Highly sensitive** |
|---|---|---|
| Australian Magpie | Brown-headed Honeyeater | Striated Thornbill |
| Australian Raven | Brown Thornbill | Yellow-tufted Honeyeater |
| Black-chinned Honeyeater | Buff-rumped Thornbill | White-bellied Cuckoo-shrike |
| Black-faced Cuckoo-shrike | Common Bronzewing | Golden Whistler |
| Brown Treecreeper | Crested Shrike-tit | |
| Crested Pigeon | Crimson Rosella | |
| Dusky Woodswallow | Diamond Firetail | |
| Eastern Rosella | Eastern Yellow Robin | |
| Little Friarbird | Fuscous Honeyeater | |
| Magpie-lark | Grey Fantail | |
| Noisy Friarbird | Grey-crowned Babbler | |
| Noisy Miner | Grey Shrike-thrush | |
| Red-rumped Parrot | Hooded Robin | |
| Restless Flycatcher | Horsfield's Bronze-cuckoo | |
| Striated Pardalote | Jacky Winter | |
| White-plumed Honeyeater | Mistletoebird | |
| White-winged Chough | Olive-backed Oriole | |
| Willy Wagtail | Painted Button-quail | |
| | Pallid Cuckoo | |
| | Peaceful Dove | |
| | Pied Currawong | |
| | Red Wattlebird | |
| | Red-browed Finch | |
| | Rufous Whistler | |
| | Scarlet Robin | |
| | Southern Whiteface | |
| | Speckled Warbler | |
| | Spotted Pardalote | |
| | Superb Fairy-wren | |
| | Turquoise Parrot | |
| | White-browed Babbler | |
| | White-throated Treecreeper | |
| | White-throated Warbler | |
| | Yellow-faced Honeyeater | |
| | Yellow-rumped Thornbill | |
| | Silvereye | |
| | Weebill | |

## Appendix 9

"Focal species" graphs – 'Re-birding' Project Research phase, July 2000.

These graphs consist of an additional 75 pages, so have been omitted from this version of the report.

The scatter graphs represent all 80 non-riparian study sites, detailing:

| | |
|---|---|
| HCS | Habitat Complexity Score – value assigned to indicate the structural complexity of the vegetation |
| Isolation | An index determined by averaging the distance to the 5 nearest neighbouring patches >0.5ha |

Each of these is graphed against Vegetation Patch Size.

Each graph is compared to the minimum area, habitat complexity and isolation requirements of moderately sensitive woodland bird species.

If inspection of these graphs is required, contact:

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