Bird Surveys in Travelling Stock Routes and Reserves on the Northwest Slopes and Plains: Perspectives on the Conservation Value of TSRs

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SUSTAINABLE ECOSYSTEMS

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Summary

The four Rural Lands Protection Boards of the Northwest Slopes and Plains of NSW (Tamworth, Narrabri, Moree and Northern Slopes and Plains) contracted CSIRO to contribute to the assessment of the conservation value of Travelling Stock Routes and Reserves (TSRs) managed by the Boards. CSIRO conducted a single-season (autumn) bird survey within 62 TSRs selected by the Board's Environmental Officer. Thirty-two Travelling Stock Routes were selected across four broad vegetation types, half of them with a shrubby understorey, the other half without shrubs. Thirty Stock Reserves in Box woodlands were also selected, half of them with a shrubby understorey. A rapid assessment of TSR structural complexity was conducted to quantify the coverage of trees, shrubs, fallen timber, litter and ground herbage.

There were 130 species of birds recorded across these TSRs that ranged in size, structural complexity and vegetation type (Grassland, Red Gum, Coolibah and various species of Box Eucalypts). Markedly more bird species were found in TSRs with a structurally diverse understorey than in simplified TSRs with little understorey. The composition of birds varied across this wide range of TSRs. Some species were only found in Grasslands, others only in Popular Box or River Red Gum woodlands. There were 11 species of declining or vulnerable woodland birds that were only found in relatively large and structurally complex TSRs.

The conservation value of TSRs in this extensively cleared region is high. Many TSRs are structurally complex and support bird species that do not occupy extensively cleared and intensively grazed landscapes. All the TSRs are relatively large and support a wide range of birds that do not occupy small patches (less than 10 ha) of native vegetation. Many TSRs are long and likely provide important corridors for the movement of animals and plants. Most importantly, TSRs occur across a wide range of vegetation types on a wide range of soils and slopes. This combination of size, connectivity, structural complexity and vegetation diversity supports an extraordinary range of birds, including many that are rapidly disappearing from the agricultural zone of NSW.

Maintaining a diversity of grazing pressures across these TSRs is fundamental to the maintenance of their conservation value. Neither continuous grazing nor complete exclusion is warranted across all TSRs. Management of grazing should continue to support a wide variation in TSR structural complexity – some with a shrubby understorey, some without. The conservation value of TSRs depends on Rural Lands Protection Boards being able to maintain a flexible and responsive control of grazing in these important areas of the agricultural landscape in NSW.

Introduction

The Rural Lands Protection Boards of the Northwest Slopes and Plains, through the Northern Slopes Rural Lands Protection Board at Warialda received Natural Heritage Trust funding to assess selected Stock Routes and Reserves and identify management priorities for the conservation of flora and fauna. The Boards are conducting a comprehensive survey of vegetation condition of their Travelling Stock Routes and Reserves (TSRs). The Boards also sought information on the habitat value of TSRs for native wildlife.

The objective of this study was to provide a rapid assessment of the conservation value of selected TSRs in order to assist in the development of management practices needed for the conservation of biodiversity and sustainable use of TSRs in the Northwest Slopes and Plains.

CSIRO examined the relationship between TSR vegetation condition and its habitat value for wildlife, particularly birds. Specifically, CSIRO Sustainable Ecosystems was contracted to provide the following services:

1) To conduct comprehensive woodland bird surveys at 62 TSR sites on the Northwest Slopes and Plains in order to provide a preliminary understanding of the relationship between TSR vegetation condition, structural complexity and its habitat value for wildlife, particularly birds.

2) Provide the following outputs:

    a) A meeting with representatives of the various Boards at the commencement of the research in order to discuss the scope and products derived from the study;

    b) A relational database for the bird and site data and printed bird lists for each site;

    c) A report providing CSIRO's interpretation of the results in terms of the relationship between TSR vegetation condition and wildlife habitat value; and

    d) An oral summary of the report, given over two consecutive days at meetings organised by the Northwest Slopes and Plains Rural Lands Protection Boards.

This report encompasses all of these services in part or in their entirety.

Habitat value of TSRs in the cropping zone of Northwest NSW

Clearing of native vegetation in the cropping zone of NSW has been rapid and extensive since the introduction of agriculture. In some areas of the sheep/wheat zone, 95 % of the native vegetation has been cleared for crops and pastures (MDBC 1987, Sivertsen 1994). The native vegetation that remains is often fragmented into small and isolated patches of woodland or grassland. The remaining remnants are found predominantly on shallow soils along stony ridges. Few remnants are found on fertile

soils in this highly arable region. Within the remaining remnants, continuous grazing has caused a dramatic reduction in the recruitment of shrubs and trees, which in turn contributes to a simplification (degradation) of the vegetation structure. As patches of vegetation become simplified and degraded they are prone to other physical changes including soil erosion and dryland salinity (Saunders *et al.* 1991).

Travelling Stock Routes and Reserves, managed by the Rural Lands Protection Boards of NSW, are a significant proportion of remnant vegetation, particularly on highly fertile soils. The Rural Lands Protection Boards manage an area approximately 2.5 % of NSW, which is similar to the area of NSW National Parks. In the study region of this project, an estimated 124,000 ha is under RLPB management.

The conservation value of these TSRs is largely unknown, particularly in northwest NSW. TSRs are only periodically grazed by travelling livestock, resulting in these lands being dominated by a range of native plants rather than by introduced pasture grasses and weeds. TSRs are also relatively large; many are over 100 ha in size. Patches of native vegetation on freehold land are mostly smaller than 10 ha in size. Travelling Stock Routes, combined with other roadside vegetation, may also play a significant role in providing connectivity for those species that can not move freely about landscapes dominated by crops and cleared pastures.

Many TSRs are likely to have conservation values of national significance (McIntyre & Lavoral 1994). Recent research found that nocturnal birds, possums, gliders and bats were found at remarkably high densities within TSRs and other roadside vegetation in central NSW. Current research in central NSW (A. Drew, unpublished data) has shown that TSRs with a diverse understorey provide occupiable habitat for many species of birds, including several vulnerable species. Additionally, such reserves have been found to provide nesting sites for declining woodland birds.

The use of birds as an indicator of conservation value

CSIRO was charged with providing a rapid assessment of the conservation significance of TSRs, particularly for wildlife. We chose to survey birds for the following reasons: Birds are relatively easy to survey, being abundant and visible during the day. Small marsupials are exposed to similar landscape threats, but their densities are low or they are often difficult to survey (eg. nocturnal and arboreal). Bats are useful indicators because they use landscapes at scales similar to those of birds (Lumsden *et al*. 1995), but they are technically more difficult and costly to sample (e.g. need for harp traps and acoustic detectors). Reptiles and invertebrates are useful for identifying finer-scale threats caused by loss of microhabitats such as logs or bark. However, these animals are difficult to sample or time consuming to sort and identify.

Birds are also useful indicators of conservation value because they are placed towards the top of food chains. Many woodland birds feed on a wide variety of insects (Ford 1986), which in turn require a mixture of plant species and types. Thus, it is assumed that the habitat requirements of some bird species will encompass the needs of a wide range of other biota.

Woodland birds were a focus of the surveys because it is well known that many species are sensitive to loss of habitat, fragmentation and habitat degradation (Barrrett *et al*. 1994, Reid 1999). Many of the woodland birds identified as declining throughout NSW occur, or once occurred within the boundaries of the Tamworth, Narrabri, Moree and Northern Slopes Rural Lands Protection Boards (Table 1). Of these declining woodland birds found within this region, the Hooded Robin, Brown Treecreeper, Black-chinned Honeyeater, Diamond Firetail, Grey-crowned Babbler and the Speckled Warbler have recently been proposed for listing as vulnerable in NSW under the Threatened Species Act. The Regent Honeyeater has already been formally listed as endangered. The clearance and modification of once widespread native forests and woodlands of Northwest Slopes and Plains threaten all these species.

Table 1. *Declining Woodland Birds of the Sheep/Wheat Zone of NSW (from Reid, 1999).*

Common name
Emu
Painted Button-quail
Brown Treecreeper
Speckled Warbler
Chestnut-rumped Thornbill
Southern Whiteface
Eastern Yellow Robin
Hooded Robin
Jacky Winter
Red-capped Robin
Grey-crowned Babbler
White-browed Babbler
Varied Sittella
Rufous Whistler
Crested Bellbird
Eastern Shrike-tit
White-browed Woodswallow
Dusky Woodswallow
Diamond Firetail
Restless Flycatcher

METHODS

Study area

The surveys were located within an area that covers approximately 2,434,000 ha on the Northern Slopes and Plains of New South Wales, encompassing the Tamworth, Narrabri, Moree and Northern Slopes Rural Lands Protection Boards. The woodlands that existed in this region prior to agriculture formed a continuous belt extending from southern Queensland through to Victoria (Sivertsen & Clarke 1999). The study region encompasses a wide range of vegetation types from dry sclerophyll forests on the upper ranges to native grasslands on the floodplains with extensive riparian communities along the streams and rivers that flow off the Northern Tablelands and Northwestern Slopes. Long and wide Travelling Stock Routes predominate on the plains whereas the slopes have a wide diversity of Routes and Reserves. Four broad vegetation types (Grasslands, River Red Gum, Poplar Box and Coolibah) characterise much of the diversity of Routes on the floodplains. Remnant vegetation of the slopes include woodlands dominated by either Yellow Box, Grey Box, White Box or Ironbark and were collectively termed Box woodlands.

The composition of these woodlands is influenced by factors such as climate (rainfall), soil type, topography, hydrology as well as large scale disturbances such as fire, floods and droughts (Prober & Thiele 1996). The vegetation of the study region, whilst falling into broad classifications is highly variable in composition. This high degree of variation is likely to support a broad diversity of birds.

Survey Sites

The range of vegetation types chosen for the bird surveys was determined in consultation with members from the participating Rural Lands Protection Boards. James Austen (Environmental Officer, RLPB) selected each site using previously recorded vegetation condition scores and local knowledge. He also provided estimates of the size (area) of each TSR. Previous experience (Freudenberger 1999 & 2001, A. Drew unpublished data) indicated that understorey of shrubs affect bird distribution. Thus James Austen provided a list of TSRs with and without a shrubby understorey. A total of 62 Travelling Stock Routes and Reserves were chosen, fitting into the following survey design:

Stock Routes by Four Vegetation Types

James Austen selected 32 Routes within the following categories:

Grassland:

i) 4 Grasslands Routes without Mimosa (*Acacia farnesiana*)
ii) 4 Grassland Routes with Mimosa

River Red Gum:

iii) 4 Red Gum Routes with no shrubby understorey
iv) 4 Red Gum Routes with a shrubby understorey

Poplar Box:

v) 4 Poplar Box Routes with no shrubby understorey
vi) 4 Poplar Box Routes with a shrubby understorey

Coolibah:

vii) 4 Coolibah Routes with no shrubby understorey or regeneration
viii) 4 Coolibah Routes with a shrubby understorey, or regeneration

Stock Reserves

James Austen also selected 30 Stock Reserves dominated by Box species of Eucalypts with and without a shrubby understorey.

Box Woodland Reserves:

ix) 15 Box Woodland Reserves with no shrubby understorey or regeneration
x) 15 Box woodland Reserves with an understorey or regeneration

Composition of surveyed Routes

Grassland survey sites were broadly similar across all eight Routes. The main difference was the presence of the shrub Mimosa (*Acacia farnesiana*). Grasses were a mixture of native and introduced species including several species of Speargrass (*Austrostipa*), Wiregrass (*Aristida*) and Panic (*Panicum*). Curly Mitchell Grass (*Astrebla lappacea)*, Queensland Bluegrass (*Dichanthium sericeum*) and Paspalum (*Paspalum dilatatum*) were also common. Dominant forbs included Purple-top (*Verbena bonariensis*) and species of *Sida, Oxalis*, *Glycine*, *Scleroleana*, and *Rhagodia*.

Red Gum sites consisted of an overstory dominated by River Red Gum (*Eucalyptus camaldulensis*). In the sites where an understorey was present it was typically composed of Wilga (*Geijera parviflora*), River Oak (*Casuarina cunninghamiana), Acacia* spp*., Atriplex* spp., *Marieana* spp. and Western Boobialla (*Myoporum montanum*). Grasses included several species of Bluegrass and Speargrass. Curly Mitchell Grass, Couch Grass (*Cynodon dactylon*) and Paspalum were also common, as were several sedge species. Common forbs included *Sida* spp., Wild turnip (*Brassica tournefortii*), Purple-top, and Fennel (*Foeniculum vulgare*).

Poplar Box sites were dominated by an overstory of Poplar Box (*Eucalyptus populnea*), with scattered Belah (*Casuarina cristata*). Understorey species included Wilga, Western Boobialla, several *Acacia* spp., African Boxthorn (*Lycium ferocissimum*), Warrior Bush (*Apophyllum anomalum*), Nepine (*Capparis lasiantha*), White Cypress Pine (*Callitris glaucophylla*) and Budda (*Eremophila mitchellii*). Common forbs and sub-shrubs included several species of Burr-daisy (*Calotis* spp), Oxalis, Peppercress (*Lepidium* sp), *Solanum* and *Maireana.* Grasses were mainly composed of *Austrostipa*, *Bothriochloa*, *Aristida, Enneapogon* and *Danthonia* species.

The dominant overstory of **Coolibah** sites was *E. coolabah,* with scattered Poplar Box and Red Gum. Understorey species consisted mainly of *Acacia*, Lignum (*Muehlenbeckia cunninghamii*), African Boxthorn and *Eucalyptus* regrowth. Several

species of grass were common, including Queensland Bluegrass, Curly Windmill Grass (*Enteropogon acicularis*), Couchgrass, and Paspalum. Also present were several species of *Austrodanthonia*, *Austrostipa* and *Aristida*. Forbs such as Common White Daisy (*Rhodanthe floribunda*) Common Nardoo (*Marsilea drummondii*), Lippia (*Phyla nodiflora*), and Bishops Weed (*Ammi majus*) were common.

Composition of surveyed Reserves

The vegetation of the Reserves was typical of that found in Box woodlands. Dominant overstory species included Poplar Box, White Box (*E. albens*) Grey Box (*E. microcarpa*) and Yellow Box (*E. melliodora*). A highly diverse understorey was present at some sites, with common species including Hop Bush (*Dodonea viscosa*), *Senna* sp, White Cypress Pine, several *Acacia* spp, Western Boobialla, Warrior Bush, Budda, Wilga and Kurrajong (*Brachychiton populeneum*). Grasses and forbs were similar to those found at the Poplar Box sites with many native annual and perennial species occurring at sites with a complex understorey.

Bird surveys

Occurrence and relative abundance data were collected from the 62 sites within the boundaries of the four Rural Lands Protection Boards (see Appendix 1 for survey site locations). Three 20-minute surveys were conducted at each site by Mark Clayton and Alex Drew, both experienced field ornithologists from CSIRO Sustainable Ecosystems. Each person visited each site at least once in order to reduce the effect of any operator error or bias. Bird surveys were carried out as described in Loyn (1986), where each site was actively searched by walking through the site in the time permitted. Occurrence and estimates of abundance of all birds were recorded based on either seeing the bird, or recognising its call. Birds flying overhead were noted but not included in the data set. Surveys were conducted in early mornings (shortly after sunrise) and late afternoons (starting no earlier than 3 hours prior to sunset), to coincide with peak periods of bird activity. Bird surveys were not conducted during the middle of the day, on rainy or very windy days. All surveys were conducted during May 2001. Surveys did not include nocturnal birds as there was no time for night surveys. Neither did the surveys include those birds that are summer residents. They would have likely migrated out of the region by the time we conducted our surveys. Surveys in the spring would have recorded additional species that are easier to detect in the breeding season, or move into the region to breed.

Habitat complexity

The distribution and abundance of birds depends on landscape variables such as the size of a habitat patch and the composition of vegetation. The structural diversity of a patch, i.e. its canopy cover, its density of shrubs and the amounts of litter, fallen timber and herbage cover have been shown to strongly influence the diversity of bird species in an area (Wiens 1989, Watson *et al*. 2001, Freudenberger 2001). Structural diversity was measured using a rapid appraisal method first developed by Newsome and Catling (1979) to explain the diversity of mammals found in a wide range of habitats and has recently been shown to explain a significant amount of variation in the distribution of woodland birds on the Southern Tablelands and South-western slopes (Watson *et al*. 2001, Freudenberger 2001). At each site, a habitat

complexity score, modified from one described by Catling and Burt (1995) was derived on the basis of six features: tree canopy cover, tall shrub cover (2–4 m), short shrub cover (0.5–2 m), ground herbage cover, the relative amounts of logs and/or rocks, and the relative amount of ground litter (see Appendix 2 for a sample data sheet).

Each feature was rated on a scale of 0-3, and the scores for the six features were totalled to give an overall score. For this study, a score of 6 or below represents a woodland with poor structure with no understorey shrubs, few logs on the ground, though often a complete cover of pasture (due to excellent seasonal conditions) (Fig.1a). A score of 4 or less represents a grassland without Mimosa shrubs, and greater than 4 is a grassland with shrubs. A score of 7-12 represents a grassy or shrubby woodland with moderate structure comprising > 20% shrubs and 10–50% cover of ground herbage, logs and litter. A score greater than 12 describes a structurally complex woodland (Fig.1b). The dominant tree species at each site and any signs of recent disturbance (e.g. fire) were also recorded.

Figure 1. *An example of (a) a Grey Box woodland remnant with a simple structure (habitat complexity score of 4), note how it is possible to 'see-through' a woodland with such a simplified structure. (b) A Grey Box remnant with a complex structure (a habitat score of 14).*

(a) (b)

Data analysis

All bird survey and habitat complexity data were entered into a relational database. This database allowed us to generate species lists for each survey site, and run numerous queries as reported in the next section of this report. The relationship between the number of species at each site and the habitat complexity score and the (log) area of each TSR was determined by linear regression. Graphical analysis was used to examine the effect of habitat complexity and area on a selected group of woodland birds.

Results

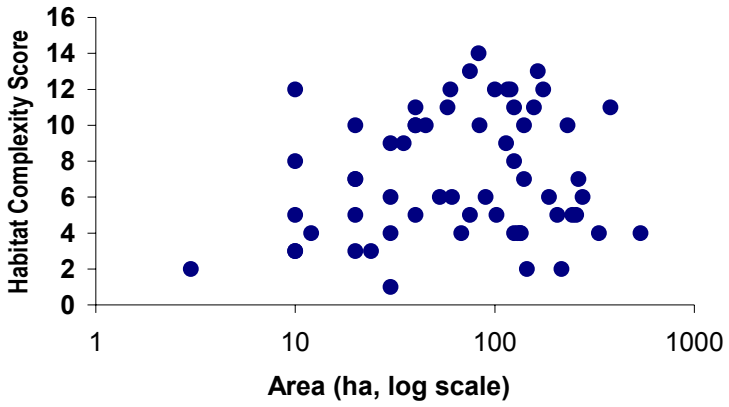
The analysis of the bird and habitat surveys are reported in the following sections:

1. All Routes and Reserves
2. Routes including all vegetation types
3. Routes distinguished by vegetation types
4. Box Woodland Reserves
5. Analysis of individual species
6. Declining woodland birds

1) All Routes and Reserves

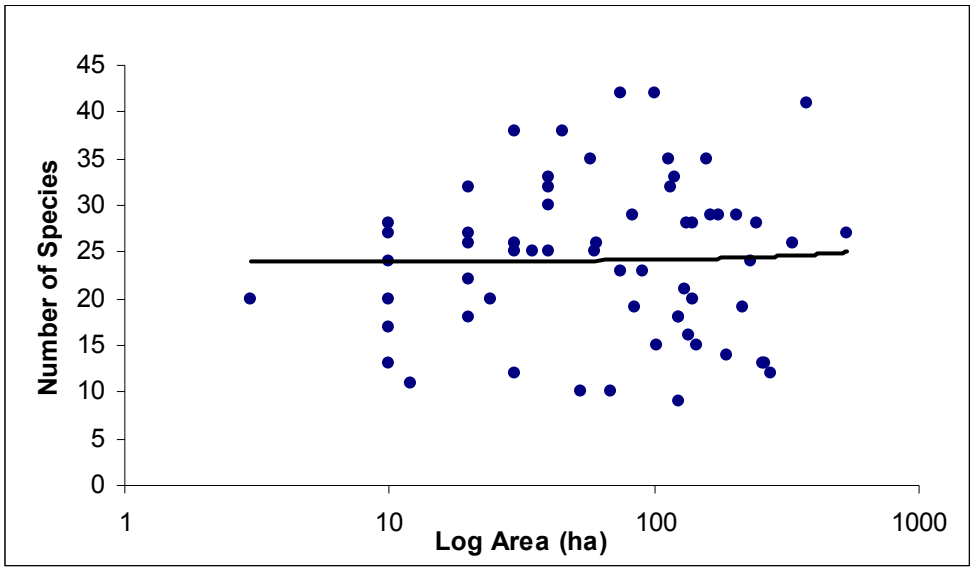
The surveys of Travelling Stock Routes and Reserves in the region successfully sampled a wide variation of vegetation types, sizes and habitat structures. Habitat complexity scores for the entire study ranged from 1-14, with a median score of 6 (Appendix 3). There was also a wide scatter of sizes, though there was only one surveyed TSR less than 10 ha in size (Fig. 2).

Figure 2. The area and structure (habitat complexity) of all TSRs surveyed in the Northern Slopes and Plains region of NSW, indicating that a wide diversity of the sites were selected.



A total of 130 species of birds were recorded during 186 individual surveys of 62 TSRs within the Northern Slopes and Plains study area. Of these 130 species, 95 were woodland and grassland birds, the others being birds of prey and wetland birds (Appendix 4). Surprisingly there was no statistically significant relationship between the number of bird species and TSR size (Fig. 3). Small sites had an equally large variation in number of species compared to large sites.

Figure 3. The number of bird species in relation to the size (area) of the TSRs surveyed in the Northern Slopes and Plains region of NSW (R^2= 0.0005, p>0.05), indicating that there was no apparent relationship.



However, there was a strong relationship between the number of bird species observed at a TSR and the structural complexity of the habitat (Fig.4). Twice as many bird species were recorded at sites with a complex structure made up of a diverse understorey of young trees, shrubs, tussock grasses and fallen timber. Only 10-20 bird species were found in sites with a sparse overstorey of trees and an understorey of just annual grasses (low habitat complexity score).

Figure 4. The number of bird species in relationship to site structural complexity (habitat complexity score) of all TSRs surveyed in the Northern Slopes and Plains region of NSW (y=1.5x + 13.5; R^2= 0.37, p<0.001), indicating that the number of bird species increases with increasing habitat complexity.

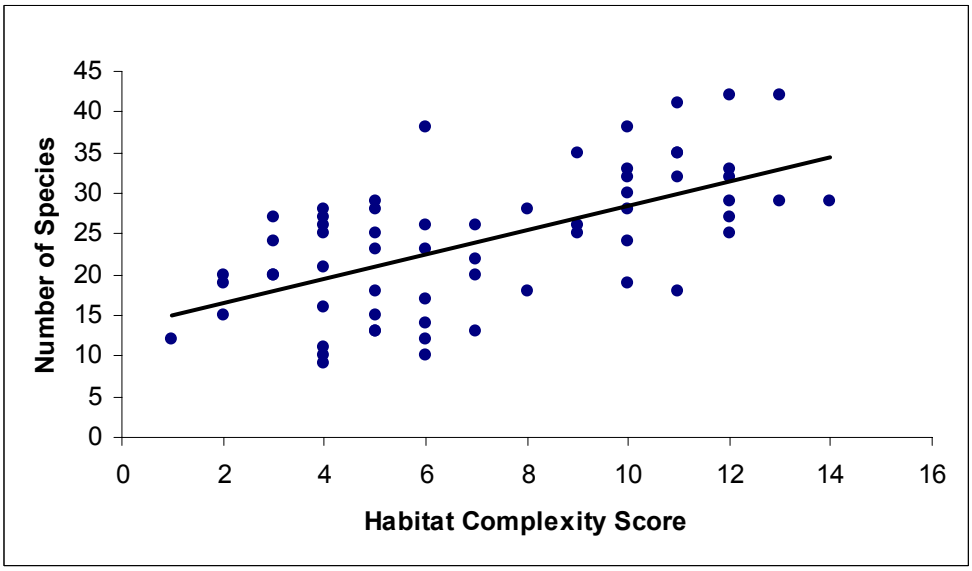
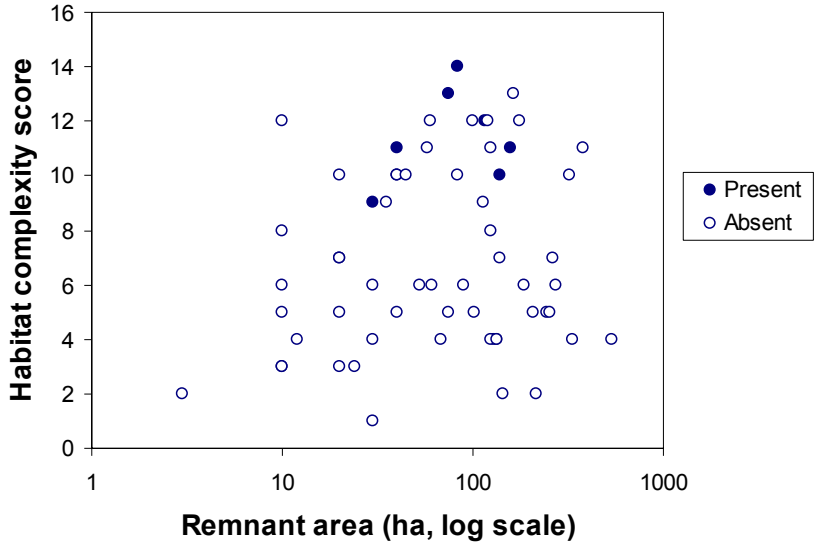


Figure 4 clearly indicates that the structure of available habitat is a strong predictor of the number of bird species that are likely to be present at a site. However, both area and habitat complexity are interrelated when individual bird species are examined. For example, the Jacky Winter (a declining woodland bird, see Table 1) had a minimum threshold for both habitat complexity and woodland area required for this species to be present (Fig. 5). The Jacky Winter was found only in TSRs at least 20 ha in size and where the structural complexity of the habitat had a score above 9. Further examples of the importance of habitat structural complexity and TSR size (area) for a range of woodland birds are shown in Appendix 5.

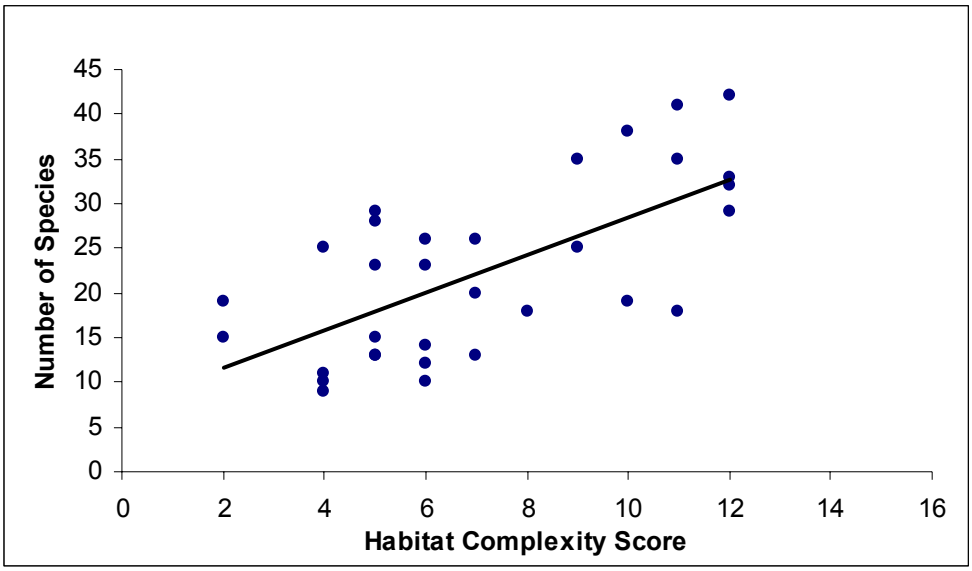
Figure 5. Relationship between remnant area (size) and habitat structural complexity for the Jacky Winter over all TSRs surveyed in the Northern Slopes and Plains region of NSW, indicating the threshold of habitat complexity and area required for the Jacky Winter.



2) Routes including all vegetation types

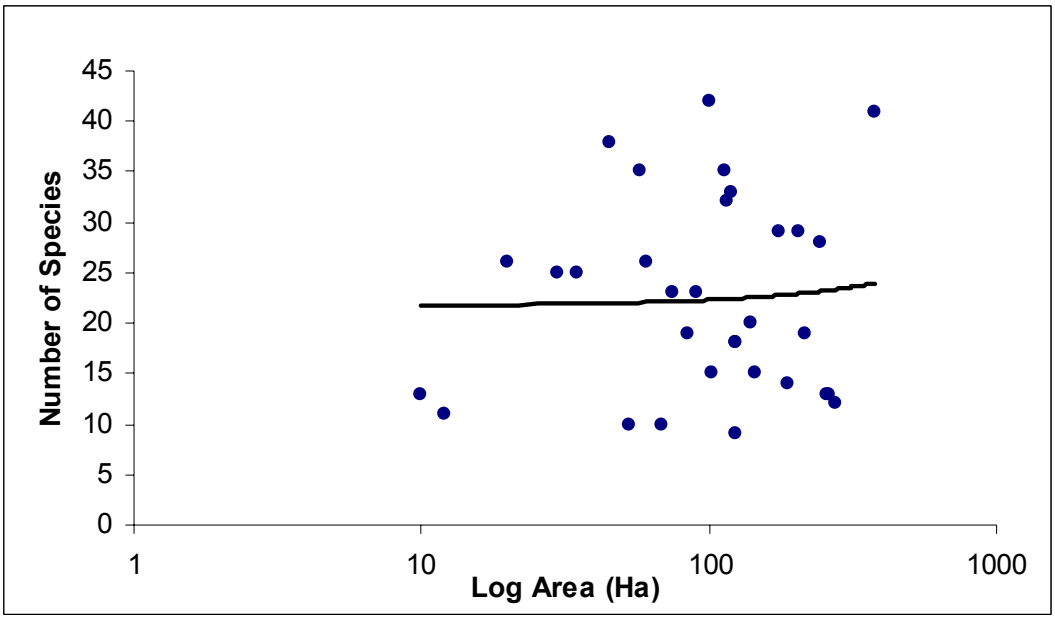
The 32 Routes surveyed ranged in habitat complexity from 1 to 12, with a median score of 6. The size of the sites ranged from 10 ha to 380 ha. Of the total of 130 species observed during the study, 105 species were observed in the Routes. There was a clear relationship between the number of bird species recorded at a site and the structural complexity of the site (Fig. 6). Two to three times more species were found in Routes with a complex structure of overstorey trees and an understorey of young trees, shrubs, tussock grasses and fallen timber.

Figure 6. The relationship between habitat structural complexity and number of bird species observed for all Travelling Stock **Routes** surveyed in the Northern Slopes and Plains region of NSW ($y=2.1x+7.4$; $R^2= 0.45$, $p<0.001$). Stock Routes with a complex understorey of shrubs and fallen timber have more species of birds than Routes with little understorey.



There was no significant relationship between Stock Route size (area) and the number of species (Fig. 7). That is, Route size did not seem to affect the number of species found along the Route.

Figure 7. The relationship between Stock **Route** size (area) and number of bird species observed (R^2= 0.003, p>0.05).



3) Routes distinguished by vegetation types

The effect of structural complexity was also apparent within three of the four different vegetation types surveyed (Red Gum, Poplar Box and Coolibah Routes). Structurally complex woodland sites tended to have more species of birds than simple sites (Table 2). However, grasslands with a complex (shrubby) vegetation layer had the same average number of species as grasslands with no Mimosa (*Acacia farnesiana*) shrubs.

Table 2. Site characteristics and number of bird species encountered within four broad vegetation types and two structures at Stock Routes surveyed in the Northern Slopes and Plains region of NSW.

Vegetation Type	Structure	Number of Sites	Habitat Complexity Score (mean)	Number of Species (mean)	Number of Declining Species	Number of Unique Species
Coolibah	Simple	4	6	20	0	0
Coolibah	Complex	4	10	26	1	6
Poplar Box	Simple	4	5	16	1	0
Poplar Box	Complex	4	12	28	5	7
Red Gum	Simple	4	5	27	0	7
Red Gum	Complex	4	11	38	2	5
Grassland	Simple	4	3	13	0	4
Grassland	Complex	4	6	12	0	4*

*These 4 bird species were unique to Grasslands with both simple and complex structure

Three times more species of birds were found at Red Gum Routes compared to Grassland Routes. However, a third of bird species recorded at Grassland Routes were unique to that vegetation type (Table 3). Birds like the Brown Songlark and the Golden-headed Cisticola were found in large numbers at Grassland Routes, but no where else. Each of the other three vegetation types also had unique species found in no other vegetation type (Table 3).

Table 3. Number of bird species found during surveys of broadly different vegetation types along Stock Routes, and bird species unique to each vegetation type (data from both structurally simple and complex sites combined).

	Coolibah	Red Gum	Poplar Box	Grassland
Total number of species	63	75	62	34
Number of unique species	6	12	7	8
Name of unique species	Great Cormorant	Little Black Cormorant	Pink-eared Duck	Stubble Quail
	Southern Boobook	Australian White Ibis	Black-fronted Dotterel	Little Button-quail
	Brown Treecreeper*	Masked Lapwing	Inland Thornbill	Spotted Harrier
	Variegated Fairy-wren	Black Kite	Singing Honeyeater	Wedge-tailed Eagle
	Buff-rumped Thornbill	Bar-shouldered Dove	Eastern Yellow Robin*	Black-faced Woodswallow
	Common Starling	Musk Lorikeet	Jacky Winter*	Brown Songlark
		Australian King-Parrot	Apostlebird	Golden-headed Cisticola
		White-browed Scrubwren		Horsfield's Bushlark
		Golden Whistler		
		Restless Flycatcher*		
		Tree Martin		
		Plum-headed Finch		

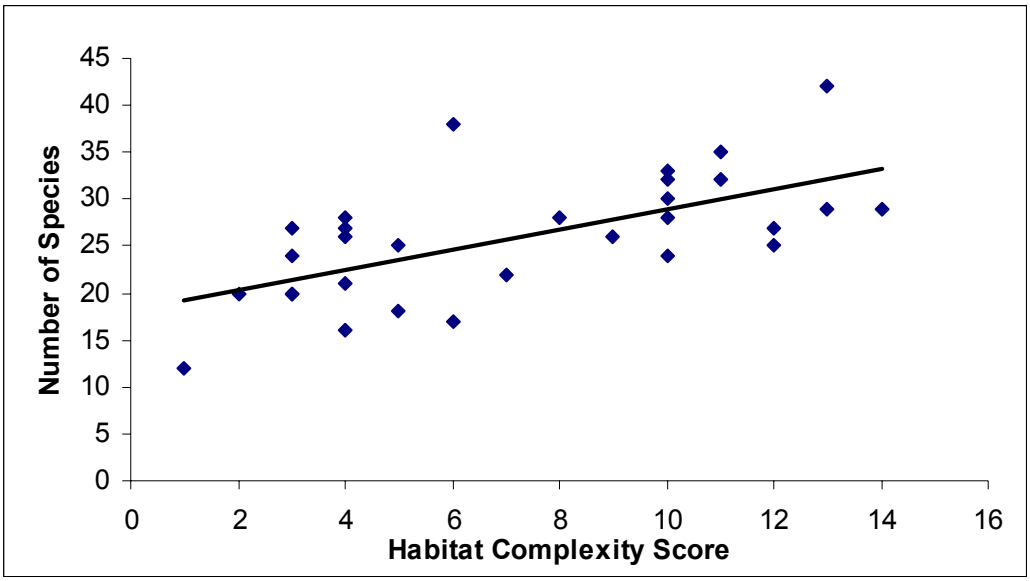
* Denotes declining woodland birds (Reid 1999)

4) Box Woodland Reserves

The 30 surveyed Travelling Stock Reserves ranged in habitat complexity from 1 to 14, with a median score of 7 and they ranged in size from 3-538 ha.

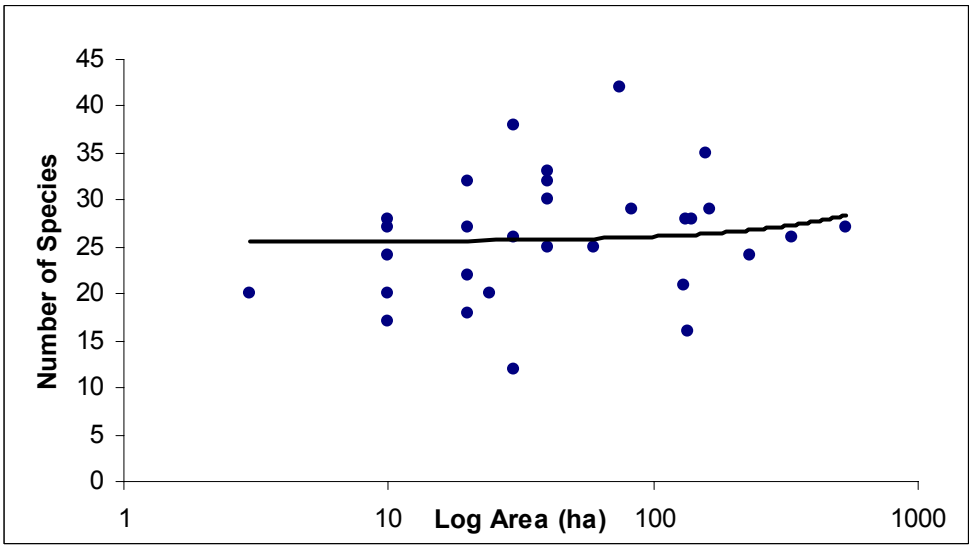
There were 100 individual bird species were recorded during the surveys at the 30 Reserves, five species fewer than were recorded during the surveys of the Stock Routes. 81 of the 100 species were woodland birds; the others were grassland birds, birds of prey or wetland birds. A minimum of 11 woodland birds was recorded at each site, with a maximum of 42. There was a significant relationship between habitat complexity and number of bird species, with a greater number of bird species observed at complex sites than at simple sites (Figure 8).

Figure 8. Relationship between habitat structural complexity and number of bird species observed for all Travelling Stock **Reserves** surveyed in the Northern Slopes and Plains region of NSW (y=1.1x + 18.2; R^2= 0.40, p<0.001).



There was no apparent effect of Reserve size (area) on the number of bird species. There were just as many birds in small Reserves as in large Reserves (Fig. 9).

Figure 9. The relationship between Stock **Reserve** size (area) and number of bird species observed (R^2= 0.008, p>0.05).



5) Analysis of individual species

Individual species of woodland and grassland birds were classified by their sensitivity to habitat structural complexity and by number of occurrences (Table 4). For example, a bird species was classified as rare and sensitive if it was recorded in three or fewer TSRs and in TSRs with a habitat complexity score of greater than six.

Table 4. Classification categories for woodland and grassland birds as defined by presence or absence at sites with various levels of habitat structural complexity, and by number of occurrences across 62 Travelling Stock Routes and Reserves in the Northwest Slopes and Plains of NSW.

Classification	Habitat Complexity Score	Frequency of Occurrence (Number of Sites)
Tolerant	Less than or equal to 6	More than 3 sites
Sensitive	Greater than 6	More than 3 sites
Rare and Tolerant	Less than or equal to 6	3 sites or less
Rare and Sensitive	Greater than 6	3 sites or less

Of the 74 woodland and grassland bird species recorded during the surveys of Stock Routes, 30 species were only recorded in sites with at least a moderate level of complexity (a habitat complexity score of greater than 6). These species have been classified as sensitive to habitat simplification (Table 5). 44 species were found in sites with a habitat complexity score of less than or equal to 6, and these species have been classified as tolerant to habitat simplification. Some birds were only recorded at 3 or fewer sites; these species have been termed rare. Of the 30 bird species found at sites with a habitat complexity score of greater than 6, 19 species were recorded at 3 or fewer sites (Table 5).

Table 5. Classification of woodland and grassland birds recorded during surveys of Travelling Stock Routes in the Northwest Slopes and Plains of NSW (classifications defined in Table 4).

Tolerant	Sensitive	Rare and Tolerant	Rare and Sensitive
Crested Pigeon	Peaceful Dove	Stubble Quail	Bar-shouldered Dove
Galah	Spotted Pardalote	Brown Quail	Sacred Kingfisher
Little Corella	Western Gerygone	Masked Lapwing	Brown Treecreeper*
Sulphur-crested Cockatoo	Yellow Thornbill	Rock Dove	White-browed Scrubwren
Cockatiel	Striped Honeyeater	Tree Martin	Weebill
Eastern Rosella	Rufous Whistler*	Brown Songlark	Inland Thornbill
Laughing Kookaburra	Grey Shrike-thrush	Little Lorikeet	Buff-rumped Thornbill
Superb Fairy-wren	Grey Fantail	Little Button-quail	Yellow-rumped Thornbill
White-winged Fairy-wren	Olive-backed Oriole	Australian King-Parrot	Spiny-cheeked Honeyeater
Striated Pardalote	Double-barred Finch	Red-winged Parrot	Eastern Yellow Robin*
White-plumed Honeyeater	Musk Lorikeet		Jacky Winter*
Noisy Miner			Golden Whistler
Blue-faced Honeyeater			Restless Flycatcher*
Little Friarbird			Apostlebird
Grey-crowned Babbler*			Silvereye
Willy Wagtail			Bluebonnet
Magpie-lark			Variegated Fairy-wren
Grey Butcherbird			Singing Honeyeater
Pied Butcherbird			Plum-headed Finch
Australian Magpie			
Black-faced Cuckoo-shrike			
Australian Raven			
White-winged Chough			
Common Starling			
Welcome Swallow			
Horsfield's Bushlark			
Mistletoebird			
Zebra Finch			
Australian Ringneck			
Red-rumped Parrot			
Yellow-throated Miner			
Torresian Crow			
Straw-necked Ibis			
Golden-headed Cisticola			
Number of species: 34	11	10	19

* Denotes species listed as declining (Table 1; Reid 1999)

A similar analysis was conducted of woodland birds found in Box woodland Reserves. The 48 woodland bird species found in sites with a habitat complexity of less than or equal to 6 have been classified as tolerant to habitat simplification (Table 6). 31 species were classified as sensitive, only occurring in sites that had a habitat complexity of greater than 6. There was a smaller group of woodland birds that were classified as rare; they were only detected in three or fewer sites, though few of these rare birds were recorded in structurally simple sites. Of the 31 bird species found to be sensitive to reduction in habitat complexity, 22 have been classified as "rare and sensitive", as they were observed at three or fewer sites. Eight of the eleven declining

woodland bird species recorded at Stock Reserves, were recorded at less than 3 sites. Grassland birds, wetland birds and birds of prey were not analysed for their sensitivity to woodland structure.

Table 6. Classification of woodland birds recorded during surveys of Travelling Stock Reserves in the Northwest Slopes and Plains of NSW (classifications defined in Table 4).

Tolerant	Sensitive	Rare and Tolerant	Rare and Sensitive
Crested Pigeon	Common Bronzewing	Brown Quail	Little Corella
Galah	Peaceful Dove	Rock Dove	White-throated Treecreeper
Sulphur-crested Cockatoo	Brown Treecreeper*	Brown-headed Honeyeater	Spotted Pardalote
Cockatiel	Black-chinned Honeyeater	Australian Ringneck	Speckled Warbler*
Eastern Rosella	Jacky Winter*	White-bellied Cuckoo-shrike	Western Gerygone
Laughing Kookaburra	Rufous Whistler*	Torresian Crow	Inland Thornbill
Superb Fairy-Wren	Grey Shrike-thrush	Brown Honeyeater	Buff-rumped Thornbill
Striated Pardalote	Silvereye	Red Wattlebird	Yellow-faced Honeyeater
Weebill	Diamond Firetail*	White-browed Scrubwren	White-eared Honeyeater
Yellow-rumped Thornbill		Red-browed Finch	White-naped Honeyeater
Yellow Thornbill			Eastern Yellow Robin*
Fuscous Honeyeater			Hooded Robin*
White-plumed Honeyeater			Grey-crowned Babbler*
Noisy Miner			Golden Whistler
Blue-faced Honeyeater			Eastern Shrike-tit*
Little Friarbird			Grey Fantail
Noisy Friarbird			Restless Flycatcher*
Striped Honeyeater			Dusky Woodswallow*
Spiny-cheeked Honeyeater			White-winged Chough
Willy Wagtail			Apostlebird
Magpie-lark			Rufous Songlark
Grey Butcherbird			Double-barred Finch
Pied-Butcherbird			
Australian Magpie			
Pied Currawong			
Black-faced Cuckoo-shrike			
Australian Raven			
Common Starling			
Welcome Swallow			
Tree Martin			
Mistletoebird			
Little Lorikeet			
Musk Lorikeet			
Rainbow Lorikeet			
Australian King-Parrot			
Red-winged Parrot			
Red-rumped Parrot			
Plum-headed Finch			
Total number of species 38	9	10	22

* Denotes species listed as declining (Reid 1999)

6) Declining bird species

Six declining woodland bird species were recorded during the surveys of the Stock Routes (Table 5). Of these species, all but one species was recorded at a site with a habitat complexity score of more than 9. This suggests that such species have a requirement for moderate to high structural complexity. The Poplar Box Routes had the most number of declining woodland birds (Table 2) and three of these species were unique to this vegetation class.

Within the 30 Stock Reserves, eleven declining woodland bird species, including five species provisionally listed as 'Vulnerable' in NSW, were observed during the surveys (Table 7). All the Vulnerable birds were found at structurally complex sites with a habitat complexity score of at least 9. The other six declining woodland birds were found in reserves with a habitat score of at least 7 (Table 7). These birds were found only in sites with a patchy understorey of regenerating trees or shrubs and often with fallen timber.

Table 7: Declining woodland birds (Reid 1999) recorded at Stock Reserves.

Common name	Number of sites with occurrences	Minimum habitat complexity score
Brown Treecreeper *	10	9
Speckled Warbler*	2	13
Eastern Yellow Robin	2	13
Hooded Robin*	2	10
Jacky Winter	7	9
Grey-crowned Babbler*	1	10
Rufous Whistler	7	7
Eastern Shrike-tit	3	11
Restless Flycatcher	3	10
Dusky Woodswallow	1	13
Diamond Firetail*	7	9

*Provisionally listed as Vulnerable in NSW

Discussion

We conclude that many of the Travelling Stock Routes and Reserves of the Northwest Slopes and Plains have a high conservation value based on the following observations:

- Many of the TSRs have a complex structure
- Many of the TSRs are large
- Many TSRs are well connected
- A wide range of vegetation types are found within TSRs
- Many declining woodland birds are found in some of these TSRs

The significance of these four broad observations is discussed below.

The importance of structure

The structural complexity (i.e. understorey) of Stock Routes and Reserves proved to be an important factor in predicting the number of bird species at a site. The total number of bird species in complex TSRs was much greater than that of simplified TSRs with little understorey of shrubs, fallen timber and litter. The relationship between habitat structural complexity and bird presence/absence was even more marked in the case of declining woodland birds. In TSRs with simple or degraded structural complexity that were isolated from other remnant vegetation, no declining woodland birds were observed.

Habitat degradation or simplification of structure is a large scale problem facing many surviving woodland remnants. There are many factors that interact leading to an exacerbation of the problem. Over-grazing by domestic stock and feral animals, dieback, increasing salinity, rising water tables, high nutrient levels from stock and fertiliser applications, and firewood collection all contribute to the death of remaining trees, reduce recruitment of seedlings and decrease the diversity and structure of the remaining vegetation. This in turn leads to the remnant being unsuitable for many species of animal.

The value of regrowth

Regrowth of native pines and eucalypts contributes to habitat structural complexity. Like shrubs, young trees can provide dense cover and feeding niches for many woodland birds. Given time, eucalypts will self-thin and provide a more open canopy more suitable for other species. The trees that die in the self-thinning process provide habitat and rotting timber for a wide range of insects that in turn provide feed for birds such as the Brown Treecreeper. Native pines (*Callitris* spp) are very slow to self-thin and often become 'locked-up' in dense stands of small trees (2-3 m). These dense stands provide ideal habitat for some birds like whistlers, but are poor habitat for other species that find few resources in the often sparse ground cover under dense stands of native pine. Thinning of pines may be worth while in some TSRs, but should be done in patches. That is, some dense patches of pine regrowth should be left, while other areas are thinned, or burned within a TSR. Internal patchiness, or heterogeneity of a TSR provides a greater range of habitats than a TSR that is entirely shrubbed-up, or entirely dominated by an open grassy understory.

The importance of size

Surprisingly we found just as many bird species in small TSRs as in large TSRs. In many other studies, more species are found in larger sites. But the size of TSRs is important because they are all relatively large. Similar bird surveys on the Southern Tablelands (Watson *et al.* 2001) and Southwestern Slopes (Freudenberger 2001) found that patches of remnant woodland less than 10 ha in size have few woodland birds. All the TSRs surveyed in the Northwest Slopes and Plains (with the exception of site 14b at the Duri Silo) were larger than this critical size.

TSR size (area) is particularly important for declining and vulnerable woodland birds. These birds were seldom found in TSRs less than 30 ha in size. However, size alone does not provide suitable habitat for these birds. Few sensitive birds were found in TSRs, large or small, that had little understorey. It is the combination of moderate size and understorey that appears to provide occupiable habitat for so many of these birds that are seldom found in small and simplified patches of native vegetation.

The importance of connectivity

Stock Routes by their inherent design provide long strips of continuous vegetation either along roads or rivers. This study was not designed to specifically examine the effect of connectivity on bird distributions. However, similar surveys in southern NSW have shown that connectivity is important even for highly mobile species like birds. These studies showed that some declining woodland birds do not occupy patches of native vegetation that are 1-2 km away from other patches at least 10 ha in size (Watson et al. 2001, Freudenberger 2001). Corridors may be essential for some species to re-colonise areas disturbed by drought or fire. Other species likely need continuous strips of habitat to maintain genetic diversity. Isolation can lead to in-breeding depression in some species of plants and animals (Young and Clarke 2000). The ecological significance of TSRs as corridors is not well known, but it should not be underestimated.

The importance of vegetation diversity

The conservation significance of TSRs is high due the diversity of vegetation types which they contain. Each vegetation type contributed unique bird species to the overall species list. No one TSR, nor any one type of vegetation contained all bird species. For example, species such as wrens, quail, cisticolas and bushlarks were found more often at the Grassland sites than at any other vegetation type. The structural complexity of the Grassland also had a major impact on the abundance of several species. Birds such as the Zebra Finch, White-winged Fairy-wren and Superb Fairy-wren were far more abundant in Grassland TSRs with a shrubby understorey of Mimosa. Some grassland species (such as the Horsfield's Bushlark) displayed a preference for less complex areas, favouring locations where the Mimosa was absent. These findings demonstrate the complementarity of the different TSRs, with different species preferring different vegetation types and structures.

The significance of declining woodland birds

The results from this rapid assessment of habitat quality of selected TSRs strongly indicate that such sites are of significant importance for many bird species. Many of the species recorded were small insectivorous woodland birds known to be declining in the region. The presence of these woodland dependent species is known to be associated with a structurally complex understorey. The increasing absence of these species is due to loss of understorey from continuous grazing, decrease in patch size and isolation of patches of native vegetation (Reid 1999; Ford et al. 2001). TSRs with complex understorey, that are relatively large (greater than 10 ha) and are well connected have a high conservation value.

Other species

This modest study focused on birds due their ease of survey, their value to many rural and urban people, and their value as indicators of threatening processes. Birds are sensitive to threats such as habitat loss due to historical clearing, loss of understorey due to continuous grazing, and isolation of habitat due to agricultural intensification. However, birds are not sensitive to such threats as predation from foxes or the invasion of non-native weeds. Neither are birds necessarily good indicators of other species. The presence of a Vulnerable bird such as the Speckled Warbler does not necessarily indicate the likely presence of an endangered shrub or orchid. Neither does a TSR with few birds indicate that the site is poor habitat for other species. A bird poor TSR may have a patch of rare plants or unusual insects. Different surveys focussing on widely differing organisms are needed to build a better understanding of the conservation value of TSRs. The vegetation surveys and analysis being conducted by James Austen are an important complement to this bird study.

Management implications

There is an irony in our findings: many of the TSRs least suited to grazing have the highest wildlife conservation value. TSRs dominated by an understorey of shrubs and fallen timber are difficult to muster and many of the shrub species are unpalatable to stock. Yet these same shrubs provide critical habitat to a wide diversity of insectivorous song birds that do not otherwise occur in paddocks of isolated trees and low pasture cover. Ironically, as the grazing value of some TSRs declines, their habitat value increases for many threatened birds.

But conservation of biodiversity isn't that simple. TSRs with high grazing value (few encroaching shrubs) provide habitat to other birds like the Horsfield's Bushlark that were most common and abundant in open grasslands. The rich diversity of TSRs with such a wide range of vegetation types and structure is the basis for their high conservation value. This value would be diminished if all TSRs were managed similarly. There is clearly value in maintaining some TSRs in an open grassy state for those native species best adapted to those conditions. Likewise there is value in maintaining some TSRs in a 'shrub-encroached' state. Our surveys found that this shrubby kind of TSR supported many bird species that have become rare throughout the cropping country of NSW.

Grazing is both a tool, a source of income for Rural Lands Protection Boards and a drought reserve for the pastoral community. Grazing is a tool to maintain TSRs in their current wide range of states, from open grasslands to dense shrubby woodlands. It is the ability of Rural Lands Protection Boards, through their Rangers, to control the duration and intensity of grazing that has been instrumental in maintaining the high conservation value of TSRs. This control would be lost if TSRs were put under long-term grazing leases. It is the intermittent nature of grazing in TSRs that has allowed shrubs to survive and trees to regenerate. Something that rarely occurs under continuous grazing on pasture improved country.

This project has focused on examining the relationships between structural complexity of native vegetation and bird species diversity across a comprehensive range of Travelling Stock Routes and Reserves in the Northern Slopes and Plains of NSW. These relationships have been used to gain a better understanding of the habitat value of TSRs for wildlife, particularly birds. We hope this research and these insights will assist the Rural Lands Protection Board in their sustainable management of their lands for both conservation and production.

Acknowledgments

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Reference List

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

Catling, P.C. and Burt, R.J. (1995) Studies of ground-dwelling mammals of Eucalypt forests in south eastern NSW: the effect of habitat variables on distribution and abundance. *Wildlife Research* **22**, 271-288.

Ford, H. (1986) Birds and Eucalypt Dieback in north-eastern NSW. In: Ford, H. and Paton, D.C., (Eds.) *The Dynamic Partnership: Birds and Plants in Southern Australia.*, pp. 150-154. South Australia: Government Printer.

Ford, H.A., Barrett, G.W., Saunders, D.A. and Recher, H.F. (2001). Why have birds in the woodlands of Southern Australia declined? *Biological Conservation* **97**: 71-88.

Freudenberger, D. (2001) Bush for the Birds: the Saltshaker Report. A report commissioned by Greening Australia, ACT &SE NSW. Canberra: CSIRO Wildlife and Ecology.

Freudenberger, D. (1999) Guidelines for enhancing grassy woodlands for the Vegetation Investment Project. A report commissioned by greening Australia, ACT & SE NSW. CSIRO Wildlife and Ecology.

Loyn, R.H. (1986) The 20 minute search - a simple method for counting forest birds. *Corella,* **10**, 58-60.

Lumsden, L.F., Bennett, A.F., Krasna, S.P. and Silins, J.E. (1995) The conservation of insectivorous bats in rural landscapes of northern Victoria. In: Bennett, A.F., Backhouse, G. and Clark, T., (Eds.) *People and Nature Conservation: Perspectives on Private Land Use and Endangered Species Recovery*, pp. 142-158. Sydney: Royal Zoological Society of New South Wales.]

McIntyre, S. and Lavorel, S. (1994) Predicting richness of Native Rare and Exotic Plants in Response to Habitat and Disturbance Variable Across a Variegated Landscape. *Conservation Biology* **8**, 521-531.

Murray Darling Basin Ministerial Council. (1987) *Murray Darling environmental resources study*, Sydney: SPCC.

Newsome, A.E. and Catling, P.C. (1979) Habitat preferences of mammals inhabiting heathlands of warm temperate coastal, montane and alpine regions of southeast Australia. In: Specht, R.L., (Ed.) *Heathlands and Related Shrublands of the World: Descriptive Studies.*, 1st edn. pp. 301-316. Amsterdam: Elsevier

Prober, S. and Thiele, K. (1996) Reserve Concepts and Conceptual Reserves: The Grassy White Box Woodlands and Beyond. (A discussion paper). *CSIRO Division of Plant Industry*

Reid, J.R.W. (1999) *Threatened and declining birds in the New South Wales sheep-wheat belt: 1 Diagnosis, characteristics and management.*, Canberra: CSIRO Wildlife and Ecology.

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

Siversten, D. (1994) The native vegetation crisis in the wheatbelt of NSW. *Search* **24**, 5-8.

Sivertsen, D. and Clarke, P.J. (1999) Temperate woodlands in NSW: a brief overview of distribution, composition and conservation. In: Hobbs, R.J. and Yates, C.J., (Eds.) *Temperate Eucalypt Woodlands in Australia: Biology, Conservation, Management and Restoration.*, pp. 6-16. Chipping Norton: Surrey, Beatty and Sons

Watson, J., Freudenberger, D. and Paull, D. (in press) An assessment of the focal species approach for conserving birds in variegated landscapes in southeastern Australia. *Conservation Biology*

Weins, J.A. (1989) *The Ecology of Bird Communities.*, Cambridge: Cambridge University Press.

Young, A.G. and Clarke, G.M. (2000) *Genetics, Demography and Viability of Fragmented Populations. Conservation Biology 4.*, Cambridge: Cambridge University Press.

Appendix 2: *Habitat Complexity Score sheet*

Site: Date:

Observer:

Habitat complexity Score	0	1	2	3	
Canopy layer	0-10%	10-20%	20-50%	>50%	
Tall shrub layer	0-10%	10-20%	20-50%	>50%	
Low shrub layer	0-10%	10-20%	20-50%	>50%	
Ground layer	0-10%	10-40%	40-70%	>70%	
Logs and fallen branches	0-10%	10-40%	40-70%	>70%	
Litter layer	0-10%	10-40%	40-70%	>70%	
Total					

Canopy layer: Estimated percentage foliage cover of trees > 4m high

Tall shrub layer: Estimated percentage foliage cover of shrubs 2-4m high

Low shrub layer: Estimated percentage foliage cover of shrubs 0.5-2m high

Ground layer: Estimated percentage foliage cover of flora <0.5m

Logs and fallen branches: Estimated percentage of ground covered by logs and fallen branches

Litter layer: Estimated percentage of ground covered by dead leaves, sticks and twigs.

Appendix 3: *Site attributes and number of bird species recorded.*

Site ID	Site Type	Structure	Habitat Complexity Score	Number of species recorded
1	Grassland	simple	2	19
2	Grassland	simple	4	10
3	Grassland	simple	2	15
4	Grassland	simple	4	9
5	Grassland	complex	6	10
6	Grassland	complex	6	12
7	Grassland	complex	6	14
8	Grassland	complex	7	13
9	Red Gum	simple	5	29
10	Red Gum	simple	5	28
11	Red Gum	simple	7	26
12	Red Gum	simple	4	25
13	Red Gum	complex	9	35
14	Red Gum	complex	12	42
15	Red Gum	complex	10	38
16	Red Gum	complex	11	35
17	Poplar Box	simple	6	26
18	Poplar Box	simple	5	13
19	Poplar Box	simple	4	11
20	Poplar Box	simple	5	13
21	Poplar Box	complex	12	32
22	Poplar Box	complex	11	18
23	Poplar Box	complex	12	29
24	Poplar Box	complex	12	33
25	Coolibah	simple	6	23
26	Coolibah	simple	5	23
27	Coolibah	simple	5	15
28	Coolibah	simple	7	20
29	Coolibah	complex	9	25
30	Coolibah	complex	8	18
31	Coolibah	complex	11	41
32	Coolibah	complex	10	19
33	Reserve	complex	11	35
34	Reserve	complex	13	42
35	Reserve	complex	10	30

Site ID	Site Type	Structure	Habitat Complexity Score	Number of species recorded
36	Reserve	complex	11	32
37	Reserve	complex	9	26
38	Reserve	complex	10	24
39	Reserve	complex	10	32
40	Reserve	complex	14	29
41	Reserve	complex	7	22
42	Reserve	complex	12	25
43	Reserve	complex	12	27
44	Reserve	complex	10	28
45	Reserve	complex	13	29
46	Reserve	complex	8	28
47	Reserve	complex	10	33
48	Reserve	simple	6	38
49	Reserve	simple	6	17
50	Reserve	simple	3	24
51	Reserve	simple	3	20
52	Reserve	simple	1	12
53	Reserve	simple	3	27
54	Reserve	simple	5	18
55	Reserve	simple	3	20
56	Reserve	simple	4	21
57	Reserve	simple	4	16
58	Reserve	simple	4	28
59	Reserve	simple	4	26
60	Reserve	simple	4	27
61	Reserve	simple	2	20
62	Reserve	simple	5	25

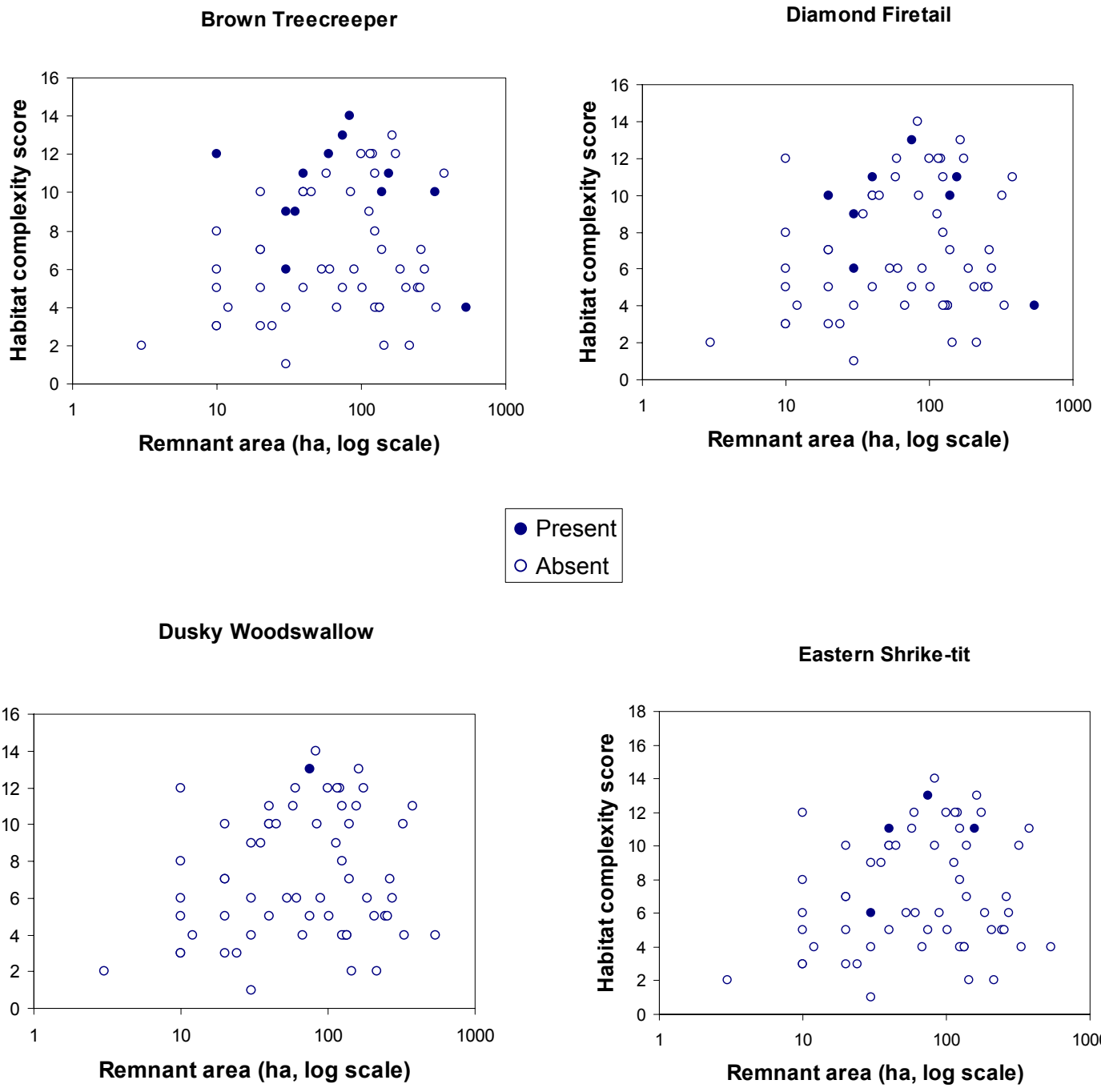
Appendix 4: *Overall species list for all sites surveyed*

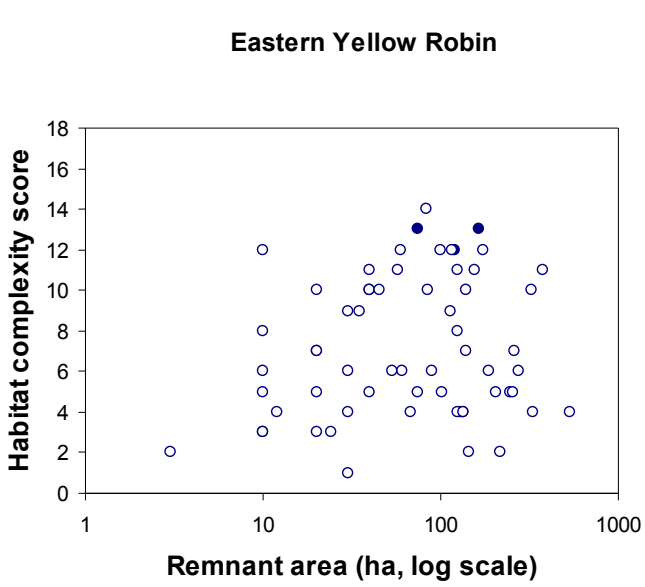
Common Name	Scientific Name	Woodland/Grassland Bird	Declining Bird
Stubble Quail	*Coturnix pectoralis*	G	
Brown Quail	*Coturnix ypsilophora*	W	
Plumed Whistling-Duck	*Dendrocygna eytoni*		
Australian Wood Duck	*Chenonetta jubata*		
Pacific Black Duck	*Anas superciliosa*		
Grey Teal	*Anas gracilis*		
Pink-eared Duck	*Malacorhynchus membranaceus*		
Australasian Grebe	*Tachybaptus novaehollandiae*		
Darter	*Anhinga melanogaster*		
Little Pied Cormorant	*Phalacrocorax melanoleucos*		
Little Black Cormorant	*Phalacrocorax sulcirostris*		
Great Cormorant	*Phalacrocorax carbo*		
White-faced Heron	*Egretta novaehollandiae*		
White-necked Heron	*Ardea pacifica*		
Great Egret	*Ardea alba*		
Cattle Egret	*Ardea ibis*		
Australian White Ibis	*Threskiornis molucca*		
Straw-necked Ibis	*Threskiornis spinicollis*	G	
Royal Spoonbill	*Platalea regia*		
Yellow-billed Spoonbill	*Platalea flavipes*		
Black-shouldered Kite	*Elanus axillaris*		
Black Kite	*Milvus migrans*		
Whistling Kite	*Haliastur sphenurus*	W	
Spotted Harrier	*Circus assimilis*	G	
Brown Goshawk	*Accipiter fasciatus*	W	
Collared Sparrowhawk	*Accipiter cirrocephalus*	W	
Wedge-tailed Eagle	*Aquila audax*		
Little Eagle	*Hieraaetus morphnoides*		
Brown Falcon	*Falco berigora*		
Australian Hobby	*Falco longipennis*		
Black Falcon	*Falco subniger*		
Peregrine Falcon	*Falco peregrinus*		
Nankeen Kestrel	*Falco cenchroides*		
Black-fronted Dotterel	*Elseyornis melanops*		
Little Button-quail	*Turnix velox*	G	
Masked Lapwing	*Vanellus miles*	G	
Rock Dove	*Columba livia*	W	
Common Bronzewing	*Phaps chalcoptera*	W	
Crested Pigeon	*Ocyphaps lophotes*	W	
Peaceful Dove	*Geopelia placida*	W	
Bar-shouldered Dove	*Geopelia humeralis*	W	
Galah	*Eolophus roseicapillus*	W	
Little Corella	*Cacatua sanguinea*	W	
Sulphur-crested Cockatoo	*Cacatua galerita*	W	
Cockatiel	*Nymphicus hollandicus*	W	
Rainbow Lorikeet	*Trichoglossus haematodus*	W	

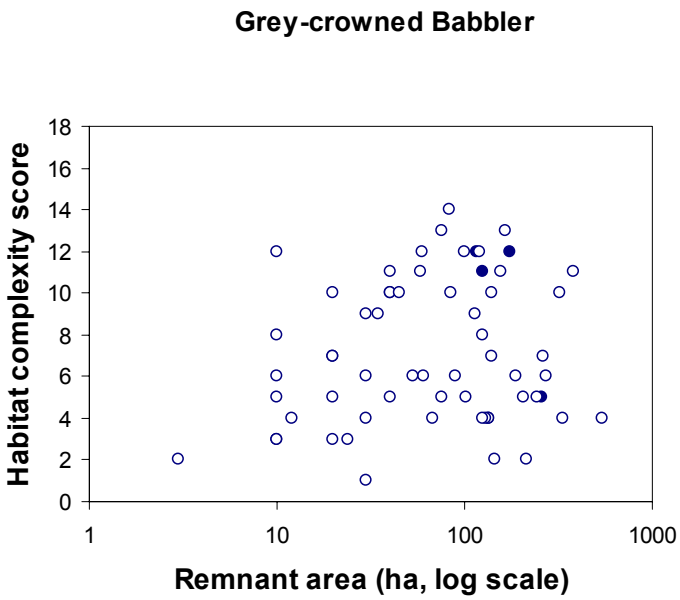
Common Name	Scientific Name	Woodland/Grassland Bird	Declining Bird
Musk Lorikeet	*Glossopsitta concinna*	W	
Little Lorikeet	*Glossopsitta pusilla*	W	
Australian King-Parrot	*Alisterus scapularis*	W	
Red-winged Parrot	*Aprosmictus erythropterus*	W	
Eastern Rosella	*Platycercus adscitus*	W	
Australian Ringneck	*Barnardius zonarius*	W	
Bluebonnet	*Northiella haematogaster*	W	
Red-rumped Parrot	*Psephotus haematonotus*	W	
Southern Boobook	*Ninox boobook*	W	
Australian Owlet-nightjar	*Aegotheles cristatus*	W	
Laughing Kookaburra	*Dacelo novaeguineae*	W	
Sacred Kingfisher	*Todiramphus sanctus*	W	
White-throated Treecreeper	*Cormobates leucophaeus*	W	
Brown Treecreeper	*Climacteris picumnus*	W	d
Variegated Fairy-wren	*Malurus lamberti*	G	
Superb Fairy-wren	*Malurus cyaneus*	W	
White-winged Fairy-wren	*Malurus leucopterus*	G	
Spotted Pardalote	*Pardalotus punctatus*	W	
Striated Pardalote	*Pardalotus striatus*	W	
Speckled Warbler	*Pyrrholaemus sagittatus*	W	d
White-browed Scrubwren	*Sericornis frontalis*	W	
Weebill	*Smicrornis brevirostris*	W	
Western Gerygone	*Gerygone fusca*	W	
Inland Thornbill	*Acanthiza apicalis*	W	
Buff-rumped Thornbill	*Acanthiza reguloides*	W	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	W	
Yellow Thornbill	*Acanthiza nana*	W	
Singing Honeyeater	*Lichenostomus virescens*	W	
Yellow-faced Honeyeater	*Lichenostomus chrysops*	W	
White-eared Honeyeater	*Lichenostomus leucotis*	W	
Fuscous Honeyeater	*Lichenostomus fuscus*	W	
White-plumed Honeyeater	*Lichenostomus penicillatus*	W	
Noisy Miner	*Manorina melanocephala*	W	
Yellow-throated Miner	*Manorina flavigula*	W	
Blue-faced Honeyeater	*Entomyzon cyanotis*	W	
Black-chinned Honeyeater	*Melithreptus gularis*	W	
Brown-headed Honeyeater	*Melithreptus brevirostris*	W	
White-naped Honeyeater	*Melithreptus lunatus*	W	
Little Friarbird	*Philemon citreogularis*	W	
Noisy Friarbird	*Philemon corniculatus*	W	
Striped Honeyeater	*Plectorhyncha lanceolata*	W	
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	W	
Red Wattlebird	*Anthochaera carunculata*	W	
Brown Honeyeater	*Lichmera indistincta*	W	
Eastern Yellow Robin	*Eopsaltria australis*	W	d
Hooded Robin	*Melanodryas cucullata*	W	d
Jacky Winter	*Microeca fascinans*	W	d
Grey-crowned Babbler	*Pomatostomus temporalis*	W	d
Golden Whistler	*Pachycephala pectoralis*	W	
Rufous Whistler	*Pachycephala rufiventris*	W	d

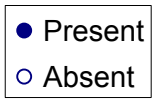
Common Name	Scientific Name	Woodland/Grassland Bird	Declining Bird
Grey Shrike-thrush	*Colluricincla harmonica*	W	
Eastern Shrike-tit	*Falcunculus frontatus*	W	d
Grey Fantail	*Rhipidura albiscapa*	W	
Willie Wagtail	*Rhipidura leucophrys*	W	
Magpie-lark	*Grallina cyanoleuca*	W	
Restless Flycatcher	*Myiagra inquieta*	W	d
Grey Butcherbird	*Cracticus torquatus*	W	
Pied Butcherbird	*Cracticus nigrogularis*	W	
Australian Magpie	*Gymnorhina tibicen*	W	
Pied Currawong	*Strepera graculina*	W	
Black-faced Woodswallow	*Artamus cinereus*		
Dusky Woodswallow	*Artamus cyanopterus*	W	d
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	W	
White-bellied Cuckoo-shrike	*Coracina papuensis*	W	
Olive-backed Oriole	*Oriolus sagittatus*	W	
Torresian Crow	*Corvus orru*	W	
Little Crow	*Corvus bennetti*		
Australian Raven	*Corvus coronoides*	W	
White-winged Chough	*Corcorax melanorhamphos*	W	
Apostlebird	*Struthidea cinerea*	W	
Common Starling	*Sturnus vulgaris*	W	
Welcome Swallow	*Hirundo neoxena*	W	
Tree Martin	*Petrochelidon nigricans*	W	
Silvereye	*Zosterops lateralis*	W	
Rufous Songlark	*Cincloramphus mathewsi*	W	
Brown Songlark	*Cincloramphus cruralis*	G	
Golden-headed Cisticola	*Cisticola exilis*	G	
Horsfield's Bushlark	*Mirafra javanica*	G	
Mistletoebird	*Dicaeum hirundinaceum*	W	
Diamond Firetail	*Stagonopleura guttata*	W	d
Red-browed Finch	*Neochmia temporalis*	W	
Plum-headed Finch	*Neochmia modesta*	W	
Zebra Finch	*Taeniopygia guttata*	G	
Double-barred Finch	*Taeniopygia bichenovii*	W	

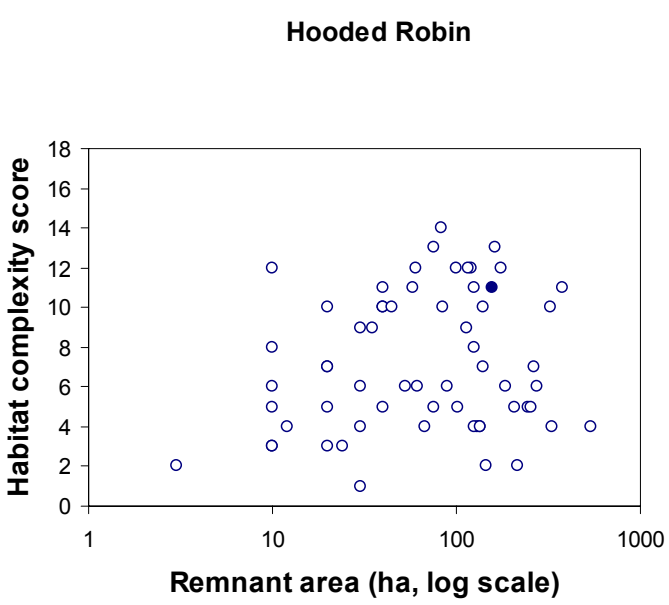
Appendix 5: The presence and absence of declining woodlands birds in relationship to TSR size and habitat structural complexity. Declining woodland birds are those recognised by Reid (1999) as becoming increasingly uncommon in the cropping zone of NSW

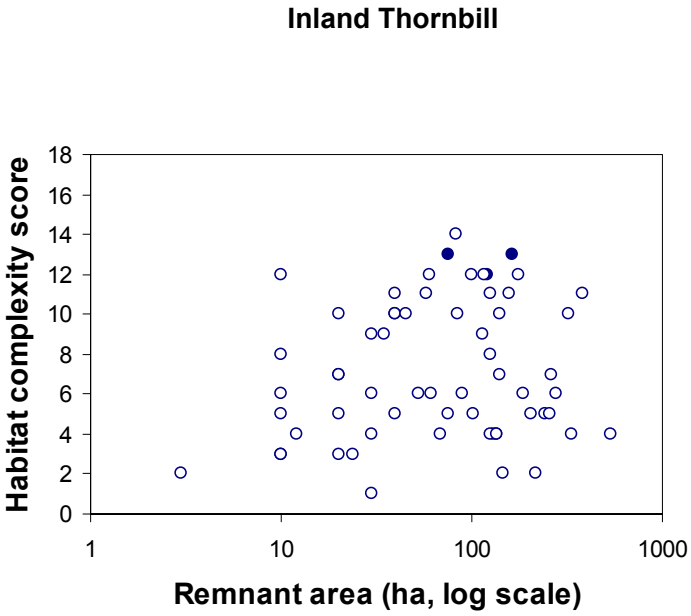


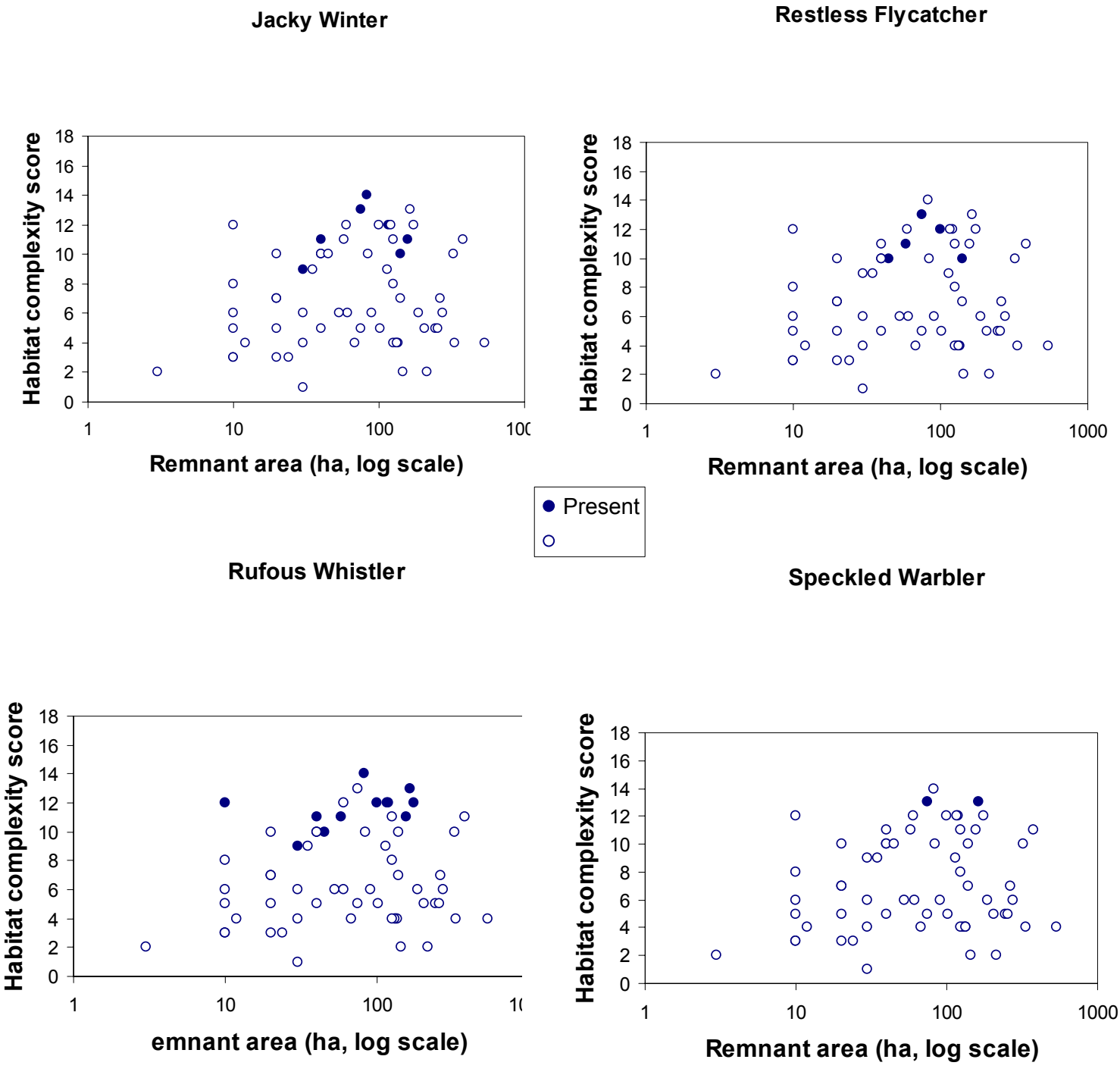

Eastern Yellow Robin
Habitat complexity score
0
2
4
6
8
10
12
14
16
18
1
10
100
1000
Remnant area (ha, log scale)


Grey-crowned Babbler
Habitat complexity score
0
2
4
6
8
10
12
14
16
18
1
10
100
1000
Remnant area (ha, log scale)


Present
Absent


Hooded Robin
Habitat complexity score
0
2
4
6
8
10
12
14
16
18
1
10
100
1000
Remnant area (ha, log scale)


Inland Thornbill
Habitat complexity score
0
2
4
6
8
10
12
14
16
18
1
10
100
1000
Remnant area (ha, log scale)


Jacky Winter
Restless Flycatcher
Habitat complexity score
Remnant area (ha, log scale)
Present
Rufous Whistler
Speckled Warbler
emnant area (ha, log scale)