CHAPTER 7: GENERAL DISCUSSION

7.1 OVERVIEW OF RESULTS

The present thesis has provided valuable information regarding habitat selection of the Eastern Yellow Robin and the Scarlet Robin at multiple spatial and temporal scales. Furthermore, the thesis has also presented an alternative approach to the hierarchical nature of habitat selection in birds; presenting evidence of a 'bottom-up' model approach rather than a traditional 'top-down' model.

7.1.1 Invertebrate habitat association

The purpose of Chapter 2, apart from investigating the association of microhabitat structure with the abundance of different invertebrate orders, was to provide information that might explain why particular foraging microhabitat was selected in Chapters 3 and 4. The results showed that epigeic invertebrates from all major orders were more abundant in spring than in winter. The results also suggested that the abundance of epigeic invertebrate order was associated with various components of the mesohabitat. This association was more pronounced in spring than in winter, although in both seasons, woodiness was the most important variable, representing the highest weight of evidence in ten of the 16 (62.5%) response variable models from both seasons (see Tables 2.4 and 2.6). Specifically, in five of the seven response variable models, the relationships between woodiness and total invertebrate dry weight (one of the seven models) and epigeic invertebrate order abundance (four of the seven models) was positive (see Tables 2.3 and 2.5). The importance of a greater degree of woodiness may reflect the favourable microhabitats provided

to epigeic invertebrates by a greater cover of leaf litter, logs and canopy, and a reduced cover of ground plant material (e.g., herbaceous plants and weeds). While the ground substrate component of the woodiness variable may represent the greatest influence on this association, the canopy element of this composite variable could also play an indirect role, with a denser canopy contributing more leaf litter and reducing ground vegetation due to shading. In addition, Williams (1959) suggested that the canopy can buffer the ground from climatic fluctuations. During winter, a dense canopy cover can maintain higher overnight temperatures allowing epigeic invertebrates to survive better. As the degree of woodiness and elements contributing to this composite variable (e.g., leaf litter, logs, plant material etc) represented important attributes selected for by the Eastern Yellow Robin and Scarlet Robin at the foraging microhabitat and larger spatial scales, the results of Chapter 2 provided invaluable insights into the factors possibly driving habitat selection in these species.

7.1.2 Eastern Yellow Robin selection

Eastern Yellow Robins selected different habitat attributes at different spatial and temporal scales (Table 7.1). Generally, microhabitat and territory habitat selected by Eastern Yellow Robins was characterised by a relatively dense midstorey (sapling and subcanopy trees) and understorey (shrubs) and a ground substrate composition represented by a greater cover of leaf litter and logs and a reduced cover of ground plant material (see Plate 7.1). Selection at the landscape scale for remnants with a reduced remnant perimeter to area ratio reflects avoidance of remnants with a large proportion of edge habitat, which is typically characterised by habitat attributes in direct conflict with those shown to be selected for by the Eastern Yellow Robin at smaller spatial scales.

Table 7.1 Summary of attributes governing habitat selection of the Eastern Yellow Robin at each spatial scale.

Results are collated from chapters 3 and 5. + refers to positive association with attribute, – refers to negative association with attribute.

	Microplot	*Mesoplot*	*Territory*	*Landscape*
Winter	+ Logs	+ Woodiness + Number of sapling and subcanopy trees	+ Number of sapling and subcanopy trees + Number of shrubs	– Remnant perimeter to area ratio
Spring	+ Leaf litter	+ Woodiness		

Foraging microplot and mesoplot scale selection appear to be driven by a complex set of attributes that vary seasonally. The woodiness index appears to represent an important attribute governing selection at the mesoplot scale in both seasons. This result could reflect the importance of woodiness in harbouring an elevated abundance of some epigeic invertebrate prey orders (see Chapter 2). Furthermore, given that the invertebrate community composition at pounce and random sites were not that different, it is possible that selection of foraging mesohabitat may be governed by structural attributes of the woodiness variable (e.g., areas dominated by leaf litter) affording greater detectability of epigeic invertebrate prey. A shift in the importance of sapling and subcanopy trees at the mesoplot scale, and a shift in selection from logs to leaf litter at the microplot scale from winter to spring reflect seasonal changes in abundance and thus the detectability of epigeic invertebrates (see Chapter 3). Interestingly, the positive association with the number of sapling and subcanopy trees extends into the territory scale (Table 7.1). Apart from the continued importance of this structural attribute assisting in the detectability of epigeic prey,

selection for an elevated density of sapling and subcanopy trees as well as shrubs at this scale probably reflects breeding habitat selection, as the additional structure provided by sapling trees, subcanopy trees and shrubs provides nest sites and fledgling shelter (Debus 2006b).

Habitat selection at the territory scale for sites with a high density of shrubs appears in contrast to selection at the foraging microplot and mesoplot scales for greater degrees of woodiness, and a greater cover of leaf litter and logs. This reflects the importance of heterogeneous habitat in territory selection by Eastern Yellow Robins (pers. obs.), with territories often represented by sites harbouring aggregations of shrubs (providing nest and fledgling shelter sites) as well as open areas comprising leaf litter and logs (representing ideal foraging sites).

Selection at the landscape scale for remnants with smaller remnant perimeter to area ratios probably reflects the detrimental processes affecting those structural attributes selected for at smaller spatial scales. Edge habitat in agricultural landscapes is typically afflicted by processes such as higher grazing intensity, nutrient input, more extreme microclimates and invasions by introduced species (Murcia 1995; Ford *et al.* 2001). These processes simplify vegetation structure through a reduction in the recruitment of tree saplings and shrubs (Yates *et al.* 2000a; Yates *et al.* 2000b), and result in a reduction in leaf litter cover and logs (Abensperg-Traun *et al.* 1996; Belsky and Blumenthal 1997). Furthermore, a combination of increased nutrients at remnant edges (Weathers *et al.* 2001) and the increase in nutrients associated with grazing results in an increased density of exotic perennial weeds (Yates *et al.* 2000b). Thus, the occupation of

remnants with minimal remnant perimeter to area ratios may reflect favourable microplot, mesoplot and territory structural attributes provided in such remnants. The implications of such a hierarchical selection process will be discussed further in section 7.2.

Plate 7.1 Representative habitat of the Eastern Yellow Robin showing relatively dense midstorey and understorey vegetation and a predominant ground cover of leaf litter and logs.

7.1.3 Scarlet Robin selection

At the microplot, mesoplot and territory scales, Scarlet Robins generally selected sites with a high cover of leaf litter and a low cover of ground plant material (Table 7.2 and Plate 7.2). At the landscape scale, Scarlet Robins tended to occupy larger remnants, possibly as a result of the degraded conditions typically associated with small remnants. Ground substrate attributes selected by Scarlet Robins at the microplot, mesoplot and territory scale are those attributes most severely compromised in small remnants.

Table 7.2 Summary of attributes governing habitat selection of the Scarlet Robin at each spatial scale.

Results are collated from chapters 4 and 6. + refers to positive association with attribute, – refers to negative association with attribute.

	Microplot	*Mesoplot*	*Territory*	*Landscape*
Winter	+ Leaf litter	+ Woodiness		
			+ Leaf litter	+ Remnant size
Spring	——	– Shrub		

Selection at the foraging microplot and mesoplot scales appeared to be driven by leaf litter ground substrate, although this pattern was somewhat restricted to winter. In spring, there was no apparent selection for microplot attributes but at the mesoplot scale, sites with a reduced cover of shrubs were selected. These attributes reflect selection for sites maximising detectability of epigeic invertebrates in their respective seasons. Selection for the woodiness index in winter may reflect the structural role of this variable in maximising epigeic invertebrate detectability as well as the abundance of some epigeic invertebrate prey orders, especially in winter, where epigeic prey were in low abundance (see Chapter 2). During spring, when epigeic invertebrates were more abundant,

foraging site selection was only governed by mesohabitat with a lower density of shrubs, which may also maximise detectability of epigeic invertebrates (see Chapter 4). Selection by the Scarlet Robin at the mesohabitat scale extended into the territory scale, with a positive association of the leaf litter component of the woodiness mesohabitat variable repeated in the selection for leaf litter at the territory scale.

Selection at the landscape scale for larger remnants could reflect the avoidance of degraded remnants, as small remnants are typically afflicted by grazing, logging, understorey clearing of vegetation and logs (Barrett *et al.* 1994; Bennett 1999; Seddon *et al.* 2003), are believed to harbour a reduced availability and quality of food, and are typically afflicted by elevated levels of nest predation (Wilcove 1985; Keyser *et al.* 1998; Chalfoun *et al.* 2002) and competition from aggressive species such as Noisy Miners (Loyn 1987; Watson *et al.* 2000; Major *et al.* 2001; Mac Nally and Horrocks 2002; Mac Nally *et al.* 2002). Many of these alterations associated with small remnants detrimentally impact the ground ecosystem on which the Scarlet Robin depends. Thus, the tendency for Scarlet Robins to occupy larger remnants appeared to reflect favourable microplot, mesoplot and territory structural attributes provided in larger remnants compared to small remnants. The implications of such a hierarchical selection process will be discussed further in section 7.2.

Plate 7.2 Representative habitat of the Scarlet Robin showing a relatively open understorey structure and a high cover of leaf litter and a low cover of ground plant material.

7.1.4 Comparison of the two species

The Eastern Yellow Robin and Scarlet Robin are two ecologically similar species; both being open-cup nesting, ground-pouncing insectivores. However, the results of the present thesis suggest that different attributes govern habitat selection in the two species at various spatial scales. While both species selected leaf litter at the two foraging microhabitat scales (microplot and mesoplot), which may maximise detectability and capture of epigeic invertebrate prey, above ground habitat structure differs between the two species. The Eastern Yellow Robin appeared to occupy heterogeneous habitat characterised by dense sapling trees, subcanopy trees and shrubs (see also Debus 2006b), while also requiring more open habitat for foraging, while the Scarlet Robin appeared to select more open habitat, characterised by sites with low shrub density (see also Robinson 1992) and greater cover of leaf litter.

Selection at the landscape scale also differed between the two species, with landscape scale selection in Eastern Yellow Robins characterised by occupation of remnants with low perimeter to area ratios while Scarlet Robins occupied larger remnants. The results of the present thesis therefore suggest that Eastern Yellow Robins appear to be edge-sensitive, while Scarlet Robins appear to be area-sensitive. Previous research has suggested that Eastern Yellow Robins are area-sensitive, although the justification provided by Zanette and Jenkins (2000, pp. 446) that "Eastern Yellow Robins are area-sensitive songbirds that typically occur more than 25 m from the forest edge" [from Howe (1984) and Barrett (1995)] more accurately reflects an edge-sensitivity response rather than an area-sensitivity response. However, Barrett (1995) also noted that Eastern Yellow Robins were not found in remnants < 20 ha in size,

although separating area and edge sensitivity is difficult in small remnants (Villard 1998; Brand and George 2001), and depends not only on the shape of the remnant, but also on the individual species' response to perceived extent of edge habitat and the response to altered species assemblage interactions associated with small remnants and edge habitat (see Mac Nally *et al.* 2000). Further support for a potential edge-sensitive response is provided by Debus (2006b), who found that Eastern Yellow Robins always nested at least 40 m from the woodland edge. The area-sensitive response of the Scarlet Robin, as defined in the present study, refers to a tendency for robins to occupy large remnants more often than small remnants (Winter and Faaborg 1999) rather than a minimum area threshold, given that Scarlet Robins were still located in remnants as small as 6.9 ha in the present study. Apart from research presented by Barrett *et al.* (1994) who showed that Scarlet Robins, in a similar area to the present study, were more common in large remnants (>400 ha) compared to small remnants (defined as 6 – 20 ha), and research by Watson *et al.* (2003) suggesting that Scarlet Robins were one of seven species significantly affected by woodland remnant size and habitat complexity, the present research is, to my knowledge, one of the first to explicitly suggest area-sensitivity in the Scarlet Robin.

In the New England Tablelands, the Scarlet Robin has seriously declined in abundance, while the Eastern Yellow Robin has actually increased in abundance (Barrett *et al.* 2003). While Debus (2006a) attributes this disparate response to the ability of Eastern Yellow Robin populations to cope better with nest predation than the Scarlet Robin, the results of the present study also sheds light on additional mechanisms possibly influencing these different

responses. While the Eastern Yellow Robin appears to occupy territories with a heterogeneous structure characterised by areas of dense sapling trees, subcanopy trees and shrubs as well as areas of leaf litter for foraging, the Scarlet Robin tends to occupy more homogenous habitat primarily characterised by an open understorey, but more importantly, a dense cover of leaf litter. Large remnants comprising open habitat structure with dense leaf litter cover, representing ideal habitat for Scarlet Robins, appear limiting in the New England Tablelands (pers. obs), while heterogeneously vegetated remnants of various sizes are relatively more abundant for Eastern Yellow Robins.

7.2 HIERARCHICAL HABITAT SELECTION

7.2.1 'Top-down' and 'bottom-up' selection

Recognition of the importance of scale in ecological research is a relatively recent phenomenon (Wiens 1989; Schneider 2001), and one key advancement has been the understanding of the need for examining habitat selection of species at multiple spatial and temporal scales (e.g., Orians and Wittenberger 1991; Thogmartin 1999; Hatten and Paradzick 2003; Holland *et al.* 2004), such as in the present study. Specifically, habitat selection in birds is assumed to be hierarchical in nature (George and Zack 2001; Jones 2001), with the inevitable consequence that habitat selection at a given spatial scale is constrained by habitat selection at other spatial scales (Wiens 1989; Kristan 2006). One of the earliest researchers to examine the hierarchical nature of habitat selection was Johnson (1980), who outlined what he referred to as the natural ordering of selection processes. In this paper, Johnson divided habitat selection between first-order and fourth-order selection:

"First order selection can be defined as the selection of physical or geographical range

of a species. Within that range, second-order selection determines the home range of

an individual or social group. Third-order selection pertains to the usage made of

various habitat components within the home range. Finally, if third-order selection

determines a feeding site, the actual procurement of food items from those available at

that site can be termed fourth-order selection."

(Johnson 1980, pp. 69)

This definition of hierarchical ordering in habitat selection decisions assumes that selection operates in a 'top-down' manner (Kristan 2006); with selection at coarser spatial scales constraining selection at finer spatial scales. Hutto (1985) used the specific example of a migratory bird which first chooses a region to settle, then a particular vegetation type within that region, then selection of a particular microhabitat to search for food, and finally the selection of a foraging site and acquisition of prey. While this hierarchical ordering of habitat selection represents the processes outlined by Johnson (1980), it may be best exemplified by, and relevant to migratory bird species (see Bergin 1992 for an outline of 'top-down' hierarchical habitat selection in the migratory Western Kingbird). However, this perspective does not take into account the potential for a 'bottom-up' model of hierarchical habitat selection, with finer spatial scale selection constraining habitat selection at coarser spatial scales. In this model of hierarchical habitat selection, a bird first chooses optimal foraging sites, then selects a territory incorporating favourable foraging microhabitat, and finally occupies remnants (within dispersal range) based on assessment and provision of favourable foraging microhabitat. Given that the majority of Australian woodland birds such as the Eastern Yellow Robin and Scarlet Robin are

resident and sedentary, it is more logical to suspect selection to operate first at finer spatial scales. This is especially relevant to ground-foraging insectivorous birds such as the Eastern Yellow Robin and the Scarlet Robin, given that the scale at which a species most strongly interacts with its environment (in this case the foraging microhabitat), is thought to represent the spatial scale at which environmental variables affect it most strongly (Cushman and McGarigal 2004).

7.2.2 Evidence of 'bottom-up' habitat selection in the present study

In the present study, I suggest hierarchical habitat selection in the Eastern Yellow Robin and Scarlet Robin potentially operates in a 'bottom-up' fashion, with selection at the foraging microhabitat scale (governed by selection of habitat attributes maximising detectability of epigeic invertebrates at the microplot scale) constraining habitat selection at coarser spatial scales (e.g., territory and landscape). Although I suggest this mode of habitat selection in both species, I believe that the factors governing the strength of this selection differ between the two species.

Eastern Yellow Robin

In the Eastern Yellow Robin, selection for foraging mesoplot and microplot appear to be driven by habitat attributes maximising the detectability of invertebrates at the microplot scale (see Chapter 3). Selection for sites with a greater density of sapling trees, subcanopy trees and shrubs at the mesoplot and territory scale (see Chapters 3 and 5) reflects the important roles these habitat structural attributes play in providing perches from which robins pounce, as well as in maximising breeding success (Debus 2006b), given that this

species nests low in the vegetation in saplings, subcanopy trees and shrubs (pers. obs., Marchant 1984). Furthermore, selection at the landscape scale for remnants with a low perimeter to area ratio (Chapter 5) reflects the inappropriate structural elements associated with edges, characterised by a reduced cover of leaf litter and logs, and an elevated cover of ground plants and weeds (Abensperg-Traun *et al.* 1996; Belsky and Blumenthal 1997); attributes associated with foraging microplot and mesoplot selection. Furthermore, edge habitat is also typically characterised by reduced tree and shrub recruitment (Yates *et al.* 2000a; Yates *et al.* 2000b); structural attributes important as perching substrates and breeding habitat of the Eastern Yellow Robin. Thus, I believe that selection at the landscape scale is constrained by appropriate habitat attributes associated with foraging site selection and breeding territory selection simultaneously (see Figure 7.1).
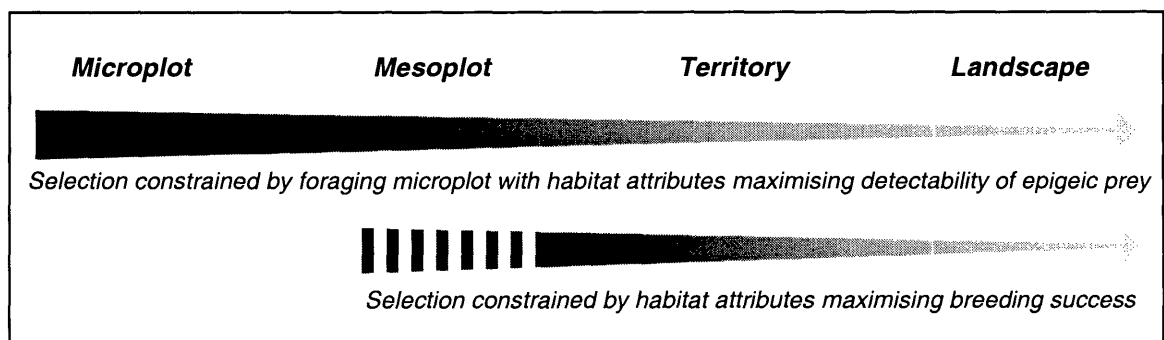

Figure 7.1 Schematic representation of the 'bottom-up' nature of hierarchical habitat selection in the Eastern Yellow Robin.

Includes a description of the factors underlying the 'bottom-up' hierarchical models (see text).

Scarlet Robin

Like the Eastern Yellow Robin, selection for foraging mesoplot and microplot in the Scarlet Robin appears to be driven by habitat attributes maximising the detectability of invertebrates at the microplot scale (see Chapter 4). However, I

believe that selection at the territory and landscape scale is also constrained by selection at the foraging microhabitat (microplot and mesoplot) scale. In contrast to Eastern Yellow Robins, Scarlet Robins primarily nest higher in trees (pers. obs., Higgins and Peter 2002), and the present study suggested no understorey or midstorey vegetation attributes are selected for at the territory scale. Instead, I believe that territory scale selection for leaf litter suggests selection at this scale is constrained by the role of leaf litter maximising detectability of epigeic invertebrates at the microplot and mesoplot scales (see Figure 7.2). Lastly, while landscape scale selection by the Scarlet Robin for larger remnants may be partly due to the elevated nest predation rates in small remnants (Keyser *et al.* 1998; Chalfoun *et al.* 2002) and increased numbers of large aggressive species such as Noisy Miners in small remnants (Loyn 1987; Watson *et al.* 2000; Major *et al.* 2001; Mac Nally and Horrocks 2002; Mac Nally *et al.* 2002), there is normally a positive association between small remnants and habitat degradation (Barrett *et al.* 1994; Seddon *et al.* 2003). Thus selection for larger remnants may reflect the negative impact that inappropriate fire regimes, collection of firewood, grazing by domestic stock and weed invasion has on the foraging microhabitat selection of the Scarlet Robin in small remnants. Selection for larger remnants thus appears constrained by the availability of appropriate foraging microhabitat attributes maximising epigeic invertebrate detectability (see Figure 7.2).
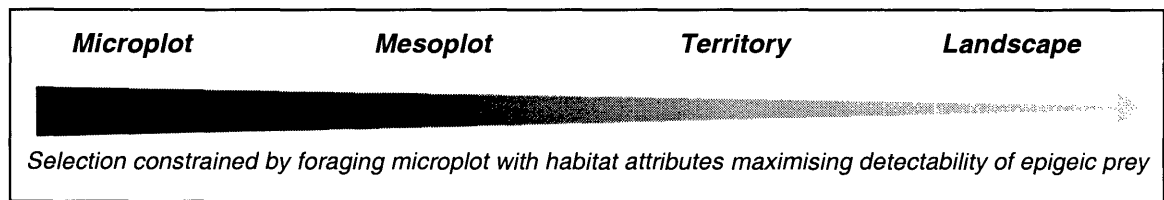
Microplot	*Mesoplot*	*Territory*	*Landscape*

Selection constrained by foraging microplot with habitat attributes maximising detectability of epigeic prey

Figure 7.2 Schematic representation of the 'bottom-up' nature of hierarchical habitat selection in the Scarlet Robin.

Includes a description of the factors underlying the 'bottom-up' hierarchical model (see text).

7.2.3 Scale of investigation influenced by 'appeal' and 'feasibility'

There are very few examples of ecologists suggesting a 'bottom-up' model of hierarchical habitat selection in the published literature. A number of studies of North American birds seem to suggest the potential for a 'bottom-up' model, though such relationships across scales are rarely discussed explicitly. For example, Sodhi *et al.* (1999) examined scale-dependent habitat selection in American Redstarts (*Setophaga ruticilla*) and concluded that forest patch and territory scale selection was constrained by the influence of the leaf and branch morphology of the vegetation on redstart foraging behaviour. However, Sodhi *et al.* (1999) merely emphasised the scale-dependent nature of habitat selection in their study and did not suggest that coarser-scale habitat selection could in general be influenced by finer-scale habitat attributes associated with foraging microhabitat selection. In a study of the avian habitat relationships of 31 species of birds in north-central New Hampshire and western Maine, USA (MacFaden and Capen 2002), microhabitat attributes were included in logistic regression models for all 31 species, with microhabitat attributes the *dominant* variable in regression models of 15 of the 31 species (48.4%), with landscape attributes dominant in only 8 of the 31 species (25.8%). MacFaden and Capen (2002) state in their conclusion that:

"Management at a coarse scale does not necessarily obviate the need for finer-scale

management; this study showed that microhabitat characteristics play a central role in

habitat selection, whether selection at the fine scale is an initial or secondary step."

(MacFaden and Capen 2002, pp. 252)

Unfortunately, this suggestion for the need to incorporate finer spatial scale management is often limited by time and money available to land managers. As a result, species and landscape management plans (e.g., regional plans, catchment management plans etc) are usually based on habitat selection studies that are not only of limited spatial scope, but are invariably focused on management units operating at 'manageable scales' such as the regional or landscape scale (see comments in Major *et al.* 2001). This is exemplified by MacFaden and Capen (2002) who, while stating the potential of fine scale habitat selection as an initial or secondary step (representing 'bottom-up' habitat selection), and who state the need to include finer-scale management, concede the 'appeal' and 'feasibility' of management at coarser spatial scales. If hierarchical habitat selection is governed by 'bottom-up' processes, management at coarser spatial scales needs to consider the role of finer spatial scale information in constraining such coarse spatial scale selection. Even when coarse spatial scale data is not obviously associated with finer spatial scale attributes (e.g., area-sensitivity of Scarlet Robins), ignoring finer spatial scale information could lead to misinterpretation of the factors governing such coarse spatial scale habitat selection.

The explosion of interest in the value of corridors and the subsequent 'corridor planting' movement at the end of the last century is an example of coarse-scale

management that underestimates the impact that coarse spatial scale management has on finer spatial scale processes. While some studies suggest corridors assist in movement of species between connected corridors (e.g., Beier and Noss 1998; Debinski and Holt 2000), many others have suggested corridors promote the spread of disease, fire or exotic species into areas connected by corridors, or lure animals to transverse corridor vegetation where risk of predation and abundance of aggressive edge species is high (see Hobbs 1992; Bennett 1999). Thus, while management at 'manageable' coarse spatial scales appears feasible and appealing, it has the effect of underestimating, or at worst rejecting attributes of fine-scale habitat selection that potentially constrain the effectiveness of coarse-scale management.

If the focus of the present study was only on landscape scale selection, management recommendations based on those results for the Scarlet Robin would have simply recognised the importance of large remnants. If hierarchical habitat selection is indeed driven by a 'bottom-up' process, this result would not have recognised the importance of leaf litter as a foraging resource ultimately influencing habitat selection at the foraging microhabitat scale, territory scale, and landscape scale. If the focus of the present study on Eastern Yellow Robins was on landscape and territory scale selection, results would have recognised the importance of remnants with a reduced ratio of edge habitat, and the importance of a dense understorey of sapling and subcanopy trees and shrubs. Without assessing foraging microhabitat selection however, such coarse-scale management would have been ineffective, unless there was concurrent management maximising the retention of logs and maintaining the leaf litter layer, while reducing ground vegetation such as weeds. This is especially

pertinent given the suggested role of these small spatial scale habitat attributes in driving territory and landscape scale selection according to the 'bottom-up' model of hierarchical habitat selection.

7.3 SPECIFIC RECOMMENDATIONS FOR MANAGEMENT

As stated by Cushman and McGarigal (2004, pp. 1091), "...the scale at which a species most strongly interacts with its environment should correspond to the organisational level at which environmental variables affect the species most strongly." In the case of ground-foraging birds such as the Petroicidae robins, environmental variables associated with the ground substrate affect the species the most. In the present study, habitat attributes such as leaf litter and logs associated with the ground substrate composition were the primary attributes governing habitat selection at the foraging microhabitat scale. Furthermore, the results of the present study, as well as previous research, suggest that modification to the ground substrate for instance by loss of leaf litter and spread of weedy vegetation has an unfavourable effect on such ground-foraging birds (Recher and Davis 1998; Recher *et al.* 2002; Cousin 2004; Antos and Bennett 2006). Given the potential role of ground substrate composition as a factor governing habitat selection at coarser spatial scales in the present study (e.g., selection for leaf litter at the territory scale for Scarlet Robins, avoidance of edge habitat by Eastern Yellow Robins harbouring unfavourable ground substrate structure), future management needs to incorporate these aspects of habitat selection at multiple spatial scales.

The ground ecosystem is that part of environment most affected by factors associated with anthropogenic land use such as agriculture and pastoralism

(Major *et al.* 1999). Inappropriate fire regimes, overgrazing, weed invasion and firewood removal are just some of the detrimental processes that can lead to altered ground microhabitat, simplification of the ground layer, and ultimately, bring about a decline in the invertebrate prey for ground-foraging birds (Recher 1991; Antos and Bennett 2006). An increase in ground vegetation also reduces the ability of robins to detect and capture prey (Marchant 1987). Ground-foraging birds, such as robins, are among the most detrimentally affected of all birds in Australian temperate woodlands and forests (Robinson and Traill 1996; Recher 1999; Garnett and Crowley 2000), and the impact of altered ground substrate appears to contribute significantly to their decline.

Therefore, given the importance of ground substrate composition in influencing habitat selection of species such as the Eastern Yellow Robin and the Scarlet Robin from the microplot scale through the territory to the landscape scale, management of these species should focus on reducing degradation of ground substrate; maintaining a heterogeneous cover including substantial leaf litter and abundant logs (Recher *et al.* 2002; Cousin 2004; Antos and Bennett 2006). Furthermore, given the suggestion in the present study of a 'bottom-up' model governing hierarchical habitat selection (especially of resident and sedentary woodland birds), coarse spatial scale management (e.g., territory, landscape or regional scale) should recognise the likelihood that habitat selection at finer spatial scales may constrain coarse spatial scale selection.

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