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Response of eight bird species to woodland rehabilitation at Green Wattle Creek in the Hunter Region of New South Wales

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Summary. Habitat-management interventions may affect bird populations adversely unless conducted in an environmentally sensitive manner. This paper contrasts the occurrence of eight bird species in woodland modified by weed eradication and controlled burns at Green Wattle Creek in the Hunter Region of New South Wales. In combination, rehabilitation measures removed most of the extensive shrub-layer vegetation and initially increased the amount of bare ground, until a grass and herb layer developed. Three species arguably benefitted from the modification, at least temporarily. Speckled Warblers *Chthonicola sagittata* initially increased, taking advantage of improved ground-foraging conditions, but then declined as grass and herb cover increased. Eastern Yellow Robins *Eopsaltria australis* also appeared to benefit from more open habitat, which favoured the perch-and-pounce foraging strategy of this species. This advantage was sustained even after ground-cover increased. Although Fuscous Honeyeaters *Lichenostomus fuscus* predominantly feed in upper vegetation levels, they favour habitat lacking understorey. The rehabilitation activities increased the amount of habitat suitable for this species at Green Wattle Creek, potentially reversing their long-term decline, attributed to the removal of cattle. Although some statistically significant differences were established for the other five species—two honeyeaters, two whistlers and the Grey Fantail *Rhipidura fuliginosa*—these were not attributed primarily to changes in vegetation structure.

Introduction

Green Wattle Creek is a 90-ha area of woodland near Paterson in the Hunter Region of New South Wales (NSW) (32°39′S, 151°39′E), where monthly bird surveys have been conducted since 1996 (Newman 2009). It is now known as the Butterwick Crown Lands Reserve and is managed by Crown Lands, a division of the NSW Department of Trade and Investment. In 2008, an ongoing bush-rehabilitation project commenced involving the progressive eradication of weeds, particularly Lantana *Lantana camara*. In spring 2010, a fire-management plan, involving sequential burning of the reserve as patches up to 10 ha in size, but excluding riparian vegetation, commenced with dual objectives of hazard reduction and decreasing the weedy shrub layer and weed seed bank. A mosaic burn regime was used to create habitat diversity and hence aim to achieve increased biodiversity for all flora and fauna. The mosaic burn regime should also reduce the risk and impact of the whole reserve being burned in the event of a wildfire.

Green Wattle Creek, situated on the edge of the Butterwick floodplain, is isolated

from similar patches of remnant woodland. It is therefore important to ensure that areas of unburnt vegetation adjacent to burnt patches provide refuge for species temporarily displaced by the rehabilitation processes, particularly controlled burns. The success of this strategy may be important to sustaining avian diversity as isolation and lack of connecting vegetation corridors may limit recolonisation from external bird populations (Woinarski & Recher 1997). Green Wattle Creek supports several locally uncommon species such as the Speckled Warbler *Chthonicola sagittata* (Newman 2009, 2010), which is listed as Vulnerable under the NSW *Threatened Species Conservation Act 1995*.

Clarke (2008) has pointed out that the goal of maintaining diversity of plant communities through use of fire may conflict with the requirements of fauna species, including birds. There is a dearth of knowledge, often requiring adoption of an adaptive management approach ('learning by doing'). Woinarski & Recher (1997) drew attention to the complexity of impacts of fires on bird populations in woodland habitats. Essentially, each fire has a unique outcome based on the vegetation type, the intensity and scale of the fire and the set of bird species involved. The conflicting demands on the land manager to eradicate weeds, mitigate risks to adjacent property by hazard-reduction burns and protect biodiversity in a small woodland remnant like Green Wattle Creek are an example where adaptive management is necessary. For this approach to be credible, monitoring of fauna is essential (Clarke 2008). Fortunately, long-term monitoring of birds had been conducted at Green Wattle Creek for 16 years before the burns (Newman 2009). In the spring of 2010, additional monitoring of birds, of 20-month duration, commenced at four survey sites located in areas undergoing rehabilitation (weed eradication at all sites and burning at three sites). The primary purpose was to assess whether these modified sites still supported representative bird assemblages (e.g. species foraging in the canopy) and to determine after what period of time they could support species displaced by burning adjacent patches. An additional objective was to evaluate the efficacy of the survey design, which differed from that used during the ongoing long-term monthly surveys (Newman 2009). This paper documents the differences in occurrence of eight bird species that showed either temporal or seasonal variations, or preferences for individual survey sites.

The eight species selected for evaluation were all observed sufficiently frequently for robust statistical analysis of their seasonal and annual occurrence, as well as preference for individual survey sites. A key objective of the cool-burn strategy was to leave the canopy unaffected; six of the selected species forage extensively in the canopy, thus testing the efficacy of the burn strategy. The Eastern Yellow Robin *Eopsaltria australis* and Speckled Warbler forage in the understorey and on the ground, where habitat modification resulting from weed removal and burning was greatest. In the case of the threatened Speckled Warbler, a long-term decline at Green Wattle Creek (Newman 2010) provided incentive for detailed analysis in view of the possibility that removing ground-cover vegetation would be beneficial. Burns often provide immediate, but relatively short-term, benefits to ground-feeding species (Woinarski & Recher 1997). In the case of the Grey Fantail *Rhipidura fuliginosa*, it was possible to draw on a previous analysis of its occurrence at Green Wattle Creek (Newman 2012).

Methods

Survey method and site selection

The BirdLife Australia 2-ha–20-minute survey method (Barrett *et al*. 2003) was used to collect presence/absence data at the four sites. Presence was based on both visual and aural observations. On most occasions, all four sites were surveyed in the same sequence, commencing within 2 hours of sunrise and completed within a further 2 hours. There were occasions when weather and other factors prevented completing the survey set. The details and fire histories of the survey sites are provided in Table 1. Ideally, the 2-ha survey sites would be separated by at least 400 m and located in uniform habitat in order to maintain site independence, but this was not practicable here because site selection was constrained by the extent and locations of the burnt and rehabilitated areas. However, the necessity for independence was less important because the primary objective of this study was to determine whether the sites supported species as opposed to measuring changes in abundance of the birds. The locations of the sites, which were either square or rectangular in shape, are shown in Figure 1. Sites Postburn 1 and Postburn 2 (PB1 andPB2) were ~200 m apart at the extremities of the same patch burnt in April 2011. Site Postburn 3 (PB3) was in a patch burnt on 1 October 2010, located ~200 m south-west of Site PB2, separated by dense unburnt riparian vegetation. The unburnt Rehabilitation Site (RHB) was separated from Sites PB1 and PB2 by a track and was located midway between these sites (see Figure 1). When conducting surveys, I was careful to avoid off-site records.

Table 1. Identification and fire history of survey sites at Green Wattle Creek.

Site name	*Birdata identification*	*Fire history*
Postburn 1 (PB1)	276336	Cool burn autumn 2011
Postburn 2 (PB2)	276570	Cool burn autumn 2011
Postburn 3 (PB3)	276587	Cool burn spring 2010
Rehabilitation (RHB)	276335	Unburnt for at least 20 years

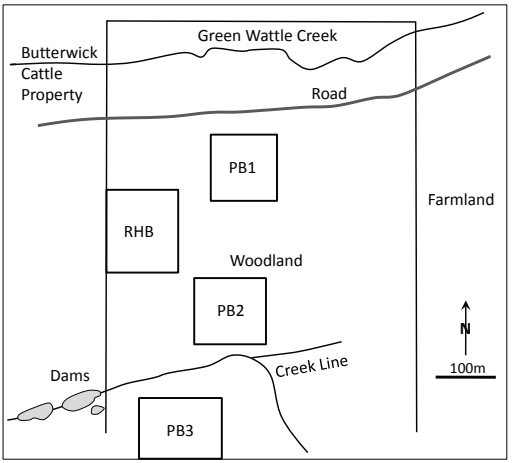

Figure 1. Locations of the four survey sites in woodland at Green Wattle Creek, Hunter Region, NSW. PB = postburn, RHB = rehabilitation.

All records were submitted to BirdLife Australia's Birdata project. Birdata site identification numbers are shown in Table 1. BirdLife Australia provided summary reports for each site, and these are the basis of the analysis reported here.

Habitat

The vegetation at Green Wattle Creek has been described previously (Newman 2009, 2010). At all survey sites, Lantana had been pulled out but left *in situ* to provide shelter for birds. Larger clumps of Lantana were poisoned. Removal of Lantana and other weeds was most comprehensive at Site RHB, but less complete at the other sites, particularly PB3.

During high rainfall conditions in spring 2011, a dense ground-cover of grass and herbs developed in the burnt areas. This died off during dry spring conditions in 2012, and by December little ground-cover remained, although bark and leaves had formed a dense cover.

Green Wattle Creek is a regrowth area involving tall (>10 m, but seldom mature) trees at all sites. The cool-to-medium-intensity burns at Sites PB1, PB2 and PB3 did not affect the canopy, including mid-storey growths of Long-flowered Mistletoe *Dendrophthoe vitellina*, which is abundant at PB1. The canopy at PB3 is more open than at the other sites. The burn strategy left small patches of shrub layer (0.5–3-m high) as shelter for birds. Remnant shrub-layer patches, mainly Blackthorn *Bursaria spinosa*, were more extensive at PB2 than at PB1 and PB3. Shrub-layer vegetation (>0.5 m tall) was absent from RHB.

The combination of burning and weed removal reduced the amount of shrub-layer vegetation and increased, at least initially, the amount of bare ground. The impact was least at the unburnt RHB Site, where drought-resistant Prickly Beard-heath *Leucopogon juniperinus* shrubs (up to 0.5 m high) continued to provide ground-cover.

Edge effects were greatest at Site PB2, where habitat with a dense shrub layer (mainly Blackthorn) was immediately adjacent to approximately half the perimeter. Similar habitat bordered only ~25% and 10% of Sites PB1 and RHB, respectively. Site PB3 was more isolated, with continuous shrub-layer vegetation present near only one boundary.

Timing of survey campaigns

The surveys were conducted in three campaigns, two in spring and one in autumn (Table 2). The composition of the bird population of Green Wattle Creek varies seasonally with a combination of resident birds, seasonal visitors and birds on passage. Seasonal factors also impact on the detection of species, particularly during the hot summer months,

Table 2. Survey effort (number of surveys) by site and season at Green Wattle Creek, Hunter Region, NSW. The time between the burn and the start of survey campaigns was 4 (S11), 11 (A12) and 17 (S12) months at Sites PB1 and PB2; 10 (S11), 17 (A12) and 23 (S12) months at Site PB3; Site RHB was not burnt; see text for site codes.

Season	*Site code*				*All sites*
	PB1	*PB2*	*PB3*	*RHB*	
Spring 2011 (S11)	17	15	13	14	59
Autumn 2012 (A12)	11	11	11	11	44
Spring 2012 (S12)	12	14	14	14	54
Total	**40**	**40**	**38**	**39**	**157**

when birds are less active and their calls are masked by the deafening noise of cicadas (Cicadidae). To minimise these biases, the period late August to early December, nominally termed 'spring', was selected for core survey effort. Most surveys were conducted after the arrival of breeding migrants in mid September, similar to the approach taken by Cameron (1985). There was typically one survey per week. Spring campaigns were conducted in both 2011 and 2012. An additional campaign between late March and early June 2012 allowed a comparison of the bird population during 'autumn' after the breeding season. The hot summer months, January and February, were avoided because previous experience monitoring Grey Fantails (Newman 2012) indicated that detection rates were low then.

Analysis of survey results

Reporting rate (RR), the frequency with which a species is recorded, can be used to determine differences in occurrence between survey sites or over time. The statistical significance of differences in RRs between individual sites and between campaigns was tested using the Chi-square test (χ^2) with Yates' Correction where comparisons involved one degree of freedom (Fowler & Cohen 1986). Differences are deemed statistically significant when the probability, P, is <0.05.

Results of surveys and observations

The eight species selected for evaluation provide examples of differences in seasonal and annual occurrence as well as preferences for individual survey sites. The three honeyeater species selected were often numerous, occurring predominantly in the canopy. Three other species, including two types of whistler, were found in the canopy, occurring as individuals or small family groups. The whistler species almost exclusively occurred in different seasons. The remaining two species exploited the lower vegetation levels. The results are summarised in Table 3.

Rufous and Golden Whistlers (Figure 2)

For both whistler species, RRs were pooled across the four survey sites. The RR for the Rufous Whistler *Pachycephala rufiventris* was higher in spring than autumn, the difference being significant ($\chi^2 = 26.9$, $P < 0.001$). In contrast, Golden Whistlers *P. pectoralis* were more frequently observed in autumn than in spring. These differences were also significant ($\chi^2 = 12.06$, $P < 0.001$). The higher RR in spring 2011 compared with spring 2012 predominantly involved Golden Whistlers at one site (PB2), where the RR was 40% (15 surveys) compared with 6.8% for the other three sites pooled (44 surveys), a significant difference ($\chi^2 = 5.55$, $P = 0.018$).

Yellow-faced, Fuscous and Scarlet Honeyeaters (Figures 3 and 4)

There were differences in occurrence of the three honeyeater species most frequently recorded during this study (Figure 3). The Yellow-faced Honeyeater *Lichenostomus chrysops* was almost invariably present, with RRs exceeding 95%. In contrast, the Fuscous Honeyeater *L. fuscus* was recorded regularly only at

Table 3. Differences in seasonal (S = spring, A = autumn) and temporal (annual) occurrence and site preferences for eight bird species at four sites in modified habitat at Green Wattle Creek, Hunter Region, NSW. *Probability significant: P <0.05, **very significant: P <0.001. See text for site codes.

Species	*Seasonal*	*Annual*	*Site preferences*
Rufous Whistler *Pachycephala rufiventris*	High in S** P <0.001		
Golden Whistler *Pachycephala pectoralis*	High in A** P <0.001		PB2, S 2011* P = 0.018
Yellow-faced Honeyeater *Lichenostomus chrysops*			
Fuscous Honeyeater *Lichenostomus fuscus*			PB1 and PB2** P <0.001
Scarlet Honeyeater *Myzomela sanguinolenta*		Decreased 2012** P <0.001	
Eastern Yellow Robin *Eopsaltria australis*	Higher in S P = 0.058	Increased 2012 P = 0.13	Favours burnt sites* P = 0.038
Grey Fantail *Rhipidura fuliginosa*			Low at PB1* P = 0.033
Speckled Warbler *Chthonicola sagittata*		Decreased 2012* P = 0.038	

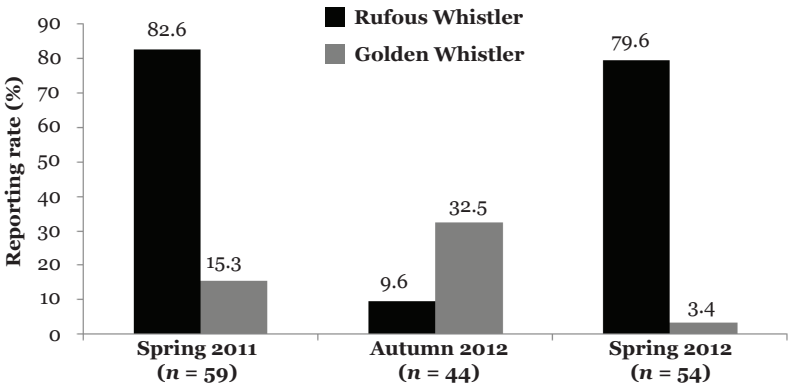

Figure 2. Comparison of the frequency of occurrence (reporting rate, %) of two whistler species—Rufous and Golden—at four pooled survey sites in woodland at Green Wattle Creek, Hunter Region, NSW, during spring and autumn surveys; n = number of surveys.

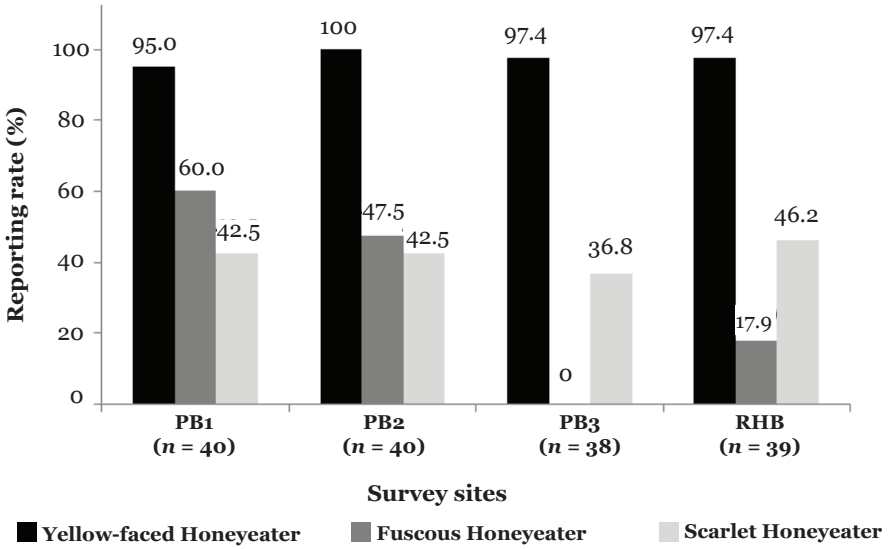

Figure 3. Comparison of reporting rates for three honeyeater species—Yellow-faced, Fuscous and Scarlet—in four modified woodland sites at Green Wattle Creek, Hunter Region, NSW, during spring and autumn surveys; *n* = number of surveys; see text for site codes.

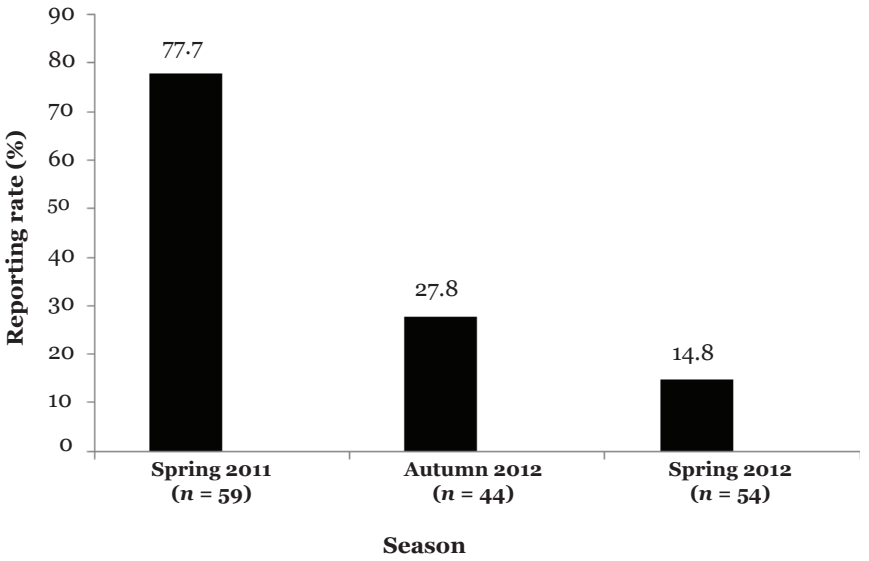

Figure 4. Temporal variation in reporting rates of Scarlet Honeyeaters in modified woodland habitat at Green Wattle Creek, Hunter Region, NSW, during spring and autumn surveys; *n* = number of surveys.

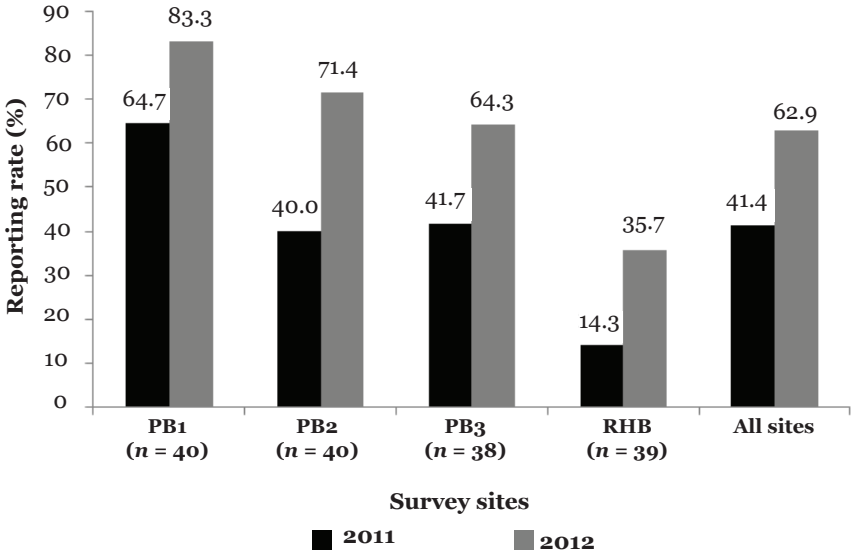

Figure 5. Comparison of spring reporting rates for Eastern Yellow Robins between four sites at Green Wattle Creek, Hunter Region, NSW, in 2011 and 2012; *n* = number of surveys.

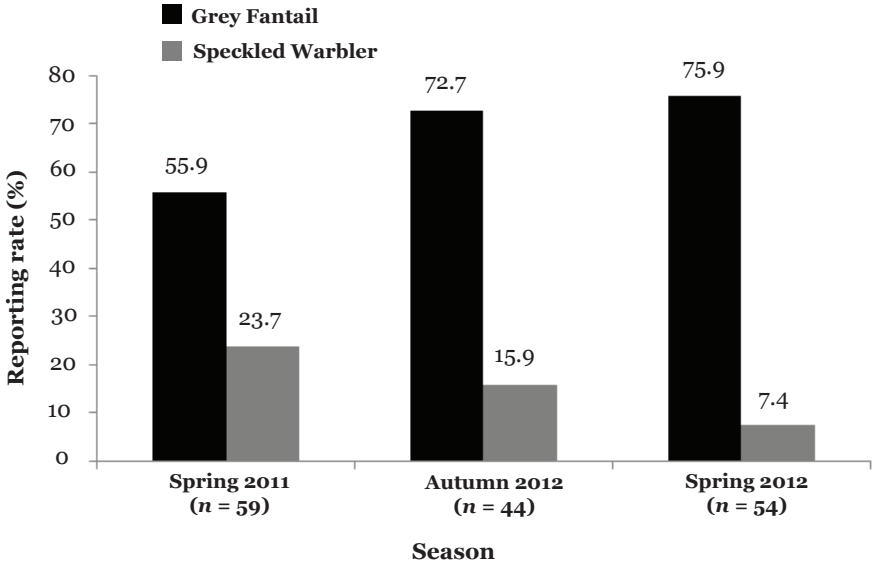

Figure 6. Comparison of seasonal reporting rates for Grey Fantails and Speckled Warblers between four sites in modified woodland at Green Wattle Creek, Hunter Region, NSW; *n* = number of surveys.

Sites PB1 and PB2, with RRs of 60% and 48%, respectively. It was less frequent at Site RHB (RR 18%) and absent from Site PB3. The preference for Sites PB1 and PB2 was significant ($\chi^2 = 23.1$, $P < 0.001$). The Scarlet Honeyeater *Myzomela sanguinolenta* was recorded at all survey sites, but less frequently, with RRs in the range 37–46%. However, as shown in Figure 4, there was a progressive drop in the RR of Scarlet Honeyeaters, with a 64% decline between the spring 2011 and autumn 2012 surveys and a further 47% decline during the spring 2012 surveys. These declines were significant ($\chi^2 = 39.7$, $P < 0.001$).

During the spring 2011 surveys, the foraging behaviour of the three honeyeater species was noted, with the Yellow-faced Honeyeater regularly present at all vegetation levels and on the ground. Fuscous Honeyeaters foraged in mid-storey and canopy vegetation, and Scarlet Honeyeaters were predominantly restricted to the canopy.

Eastern Yellow Robin (Figure 5)

Eastern Yellow Robins were observed at all four sites, with a pooled RR of 45.9% ($n = 157$). The RR in autumn was 32.8%, which was lower than for the spring surveys (41.4% and 62.9% for 2011 and 2012, respectively); differences between the campaigns were slightly above the 95% level of significance ($\chi^2 = 5.7$, $P = 0.058$). The pooled spring reporting rate in 2012 was 52% higher than the previous year ($\chi^2 = 2.3$; $P = 0.13$); the increase occurred at every site. The Robins were observed more frequently at the burnt sites than at the unburnt RHB site ($\chi^2 = 4.3$, $P = 0.038$), a significant difference.

Grey Fantail (Figure 6)

Grey Fantails occurred frequently at all sites, with a RR of 67.5% ($n = 157$). They were less frequent at Site PB1 (RR = 47.5%), compared with the other three sites (pooled RR = 74%). This difference was significant ($\chi^2 = 4.53$, $P = 0.033$). There was a 36% increase in the RR in spring 2012 compared with the previous year, but this was not significant ($\chi^2 = 1.49$, $P = 0.22$).

Speckled Warbler (Figure 6)

Although recorded at all sites, the Speckled Warbler was relatively scarce, with a pooled RR of 15.9% ($n = 157$). It was most frequent at Sites PB1 and PB3 in spring 2011 and was suspected to be breeding in, or immediately adjacent to, both sites. Speckled Warblers declined over the duration of the study, RR values being 69% lower in spring 2012 compared with the previous year. This decline was significant ($\chi^2 = 4.5$, $P = 0.038$).

Discussion

During cool burns of small patches of woodland, most birds survive by moving to adjacent habitat (Woinarski & Recher 1997). Provided that the canopy is unaffected,

the species disadvantaged in the short–medium term are predominantly those foraging in the understorey and on the ground. Impacts on these species include changes in the availability and types of food and in the structure of the vegetation. For instance, seed availability may increase and structural changes improve the foraging efficiency of some species, thus attracting open-habitat specialists like quail and finches (Woinarski & Recher 1997). The results of the present study suggest that Eastern Yellow Robins and Speckled Warblers benefitted similarly, as discussed on pp. 204–205. However, there is less shelter for skulking species, and nest-site availability may decrease following cool burns. How fast these modified conditions develop and how long they persist depend on local conditions, particularly rainfall, which is somewhat unpredictable in the Hunter Region, although spring is usually relatively dry (see Newman 2012). Nutrients released by fire often cause prolific growth of grass, as was experienced following high summer rainfall in 2011.

The occurrence of the eight species selected for analysis was generally consistent with expectations drawn from the earlier long-term study (Newman 2009), which provided a basis for comparison even though survey sites were different. This compensated for the lack of baseline data at the burnt sites. The comparison indicated that the burnt areas continued to support their bird populations at levels similar to those before the burns, particularly for the six species predominantly foraging in the canopy. The eight species showed a variety of differences in seasonal and annual occurrence, as well as site preferences (Table 3). Three seasonal and three annual differences involving five species were identified, of which four were statistically significant. Four species showed statistically significant site preferences.

Rufous and Golden Whistlers

Rufous Whistlers, breeding summer visitors to the Hunter Region, were regularly recorded at all four sites during spring. Golden Whistlers occurred approximately five to ten times more frequently during autumn than spring. In autumn, Rufous Whistlers were scarce (an occasional bird departing late or over-wintering), and it is suggested that the highly territorial and aggressive Rufous Whistler (Higgins & Peter 2002) replaces or even displaces the Golden Whistler from drier more-open woodland during the early summer breeding season. A report of a territorial dispute between the two species in which the Golden Whistler eventually withdrew supports the displacement proposition (Higgins & Peter 2002). During autumn, Golden Whistlers were recorded at all four survey sites, but 2.5 times less frequently than Rufous Whistlers in spring. However, some of this difference may reflect the Golden Whistler being less vocal in autumn, and hence less easily detected than territorial Rufous Whistlers in spring. The movements of Golden Whistlers are not well known, and it is possible that some altitudinal migration occurs (Higgins & Peter 2002; Veerman 2006). Griffioen & Clarke (2002) indicated a substantial mid-east-coast movement north along the eastern coast of Australia. Thus, the autumn population of Golden Whistlers at Green Wattle Creek may involve a combination of resident and passage birds as well as winter visitors.

Yellow-faced, Fuscous and Scarlet Honeyeaters

The ubiquitous Yellow-faced Honeyeater, observed on nearly every survey, showed no site preferences. As it foraged in the understorey and on the ground as well as in the canopy, it may have benefitted from modifications to the lower vegetation layers at the burnt sites. Yellow-faced Honeyeaters are known to undertake a mid-east-coast migration (Griffioen & Clarke 2002), and a combination of resident birds, seasonal visitors and birds on passage is possible (Wood 2008).

Scarlet Honeyeaters were abundant at all sites during spring 2011. During contemporaneous monthly surveys associated with the ongoing long-term study (Newman 2009), Scarlet Honeyeaters were as numerous as Yellow-faced Honeyeaters after compensating for the increased difficulty of detection of the former. The subsequent decline (Figure 4) is consistent with the episodic occurrence of this species at Green Wattle Creek, where it goes through cycles of abundance and absence, and shows no clear seasonal pattern (Newman 2009; MN unpublished data). Griffioen & Clarke (2002) suggested that north–south movement occurs along the mid-east coast of Australia similar to that of the Yellow-faced Honeyeater. In the suburbs of Wollongong, to the south of the Hunter Region, Scarlet Honeyeaters also occurred episodically, but primarily in spring (Wood 2008).

The Fuscous Honeyeater appears to be resident at Green Wattle Creek, but has declined over the last 15 years (Newman 2009). Recently, it has become increasingly restricted to a small area in the vicinity of Site PB1. Its disappearance from Site 3 of the long-term study (see Newman 2009) corresponded with an increase in understorey shrub layer following the removal of cattle. These observations are consistent with other studies, in which it was found that Fuscous Honeyeaters favoured eucalypt woodland away from stream beds and with a poorly developed shrub layer (Chan 1990). Higgins *et al.* (2001) suggested that this species tends to be resident with no clear migratory patterns. In contrast, around Canberra, ACT, patterns of seasonal occurrence suggest altitudinal migration, and numbers fluctuate dramatically from year to year (Veerman 2006). Therefore, the rehabilitation program at Green Wattle Creek, involving weed removal and burning the Blackthorn shrub layer, might be expected to benefit Fuscous Honeyeaters. For example, the Fuscous Honeyeater is now regularly recorded at Site PB2 (Figure 3), an area where it appeared scarce during the earlier monthly surveys. It is unclear why Fuscous Honeyeaters are less frequent at Site RHB, where the structure of the woodland is superficially similar to Sites PB1 and PB2. Their absence from Site PB3 is probably associated with differences in the mix of tree species and the more-open canopy at that site.

Eastern Yellow Robin

The combined actions of burning and weed removal at Sites PB1, PB2, and PB3 probably benefitted the Eastern Yellow Robin by making the area more open. This species often adopts a perch-and-pounce foraging strategy and favours areas with limited ground-cover (Marchant 1985). During surveys, Robins were often observed perching on the trunks and lower limbs of trees before descending to

take prey from the ground. Less frequent occurrence at Site RHB may reflect increased ground-cover as this area was unburnt. The 52% increase in the Robin's occurrence between 2011 and 2012 across all sites may be associated with the 2-year period of above-average rainfall in 2010 and 2011. In a previous study, it was found that there was a positive correlation between the occurrence of Grey Fantails at Green Wattle Creek and rainfall, which lagged by 2 years (Newman 2012). Accordingly, the impact of above-average rainfall commencing in 2010 would only be fully apparent in the breeding season of spring 2012. The observation of several pairs of Eastern Yellow Robins with dependent young in spring 2012 supports the proposition that foraging conditions were favourable despite the area having returned to below-average rainfall, with minimal precipitation during the breeding season. Marchant (1985) also found that high rainfall was important for breeding success.

Less frequent occurrence in autumn could suggest that Eastern Yellow Robins disperse outside the breeding season. However, Marchant (1984) indicated that dispersal is limited to some immature birds, with others remaining with resident pairs to act as 'helpers' in the following breeding season. Alternative and probably superior explanations of the lower reporting rate in autumn may be associated with variations in grass cover between survey campaigns and the presence of adjacent unburnt habitat. Marchant (1985) found that a wildfire of moderate intensity at Moruya, NSW, had little immediate impact on the breeding success of resident Eastern Yellow Robins, other than a shift to higher nest-sites, although the regeneration of grasses the following year had an adverse impact. In the present study, grass cover peaked during autumn 2012 and died off in the drought conditions prevalent in spring 2012.

Grey Fantail

Grey Fantails forage in most vegetation strata, but concentrate on the periphery of trees and shrubs and in the open air adjacent to them (Cameron 1985). As there was limited shrub-layer vegetation in the present study, following the removal of weeds and burning, Fantails were observed predominantly in the tree canopy. A tentative explanation of their less frequent occurrence at Site PB1 is that there was less remnant shrub layer there, and this restricted foraging opportunities.

Speckled Warbler

Speckled Warblers, which forage on the ground, declined at Green Wattle Creek, following an increase in ground-cover and shrubs after cattle were removed (Newman 2010). Increased occurrence in spring 2011 is attributed to the burns making the areas more suitable by removing ground- and shrub-layer vegetation. The subsequent decrease in 2012 is attributed to the rapid growth of grasses and other ground-cover vegetation, which decreased foraging opportunities. In summary, burning and weed removal temporarily restored the habitat to conditions structurally similar to the grazed condition in 1996 when Speckled Warblers were numerous (Newman 2010), but the advantage was less sustained than for the Eastern Yellow Robin.

Effectiveness of survey design

The results demonstrate the ability of the survey design to quantify differences in the occurrence of an eclectic set of bird species at the survey sites. For some species, e.g. Yellow-faced Honeyeater (Wood 2008) and Grey Fantail (Newman 2012), passage birds complicate the analysis of data. Spring or early summer survey campaigns would be best conducted after the peak occurrence of passage birds in September to avoid this complication. At Green Wattle Creek, an ideal design might involve 10 sets of surveys at each of five 2-ha sites conducted at approximately weekly intervals during October and November. This design would be within the capability of one person and would allow variations between campaigns to be tested for species with reporting rates exceeding 10%.

Conclusions

The main impact of weed removal and 'cool' burning was to reduce the amount of shrub-layer vegetation and increase, at least initially, the amount of bare ground. The eclectic group of eight bird species selected for analysis in this paper showed a range of styles in their continued use of the modified habitat. The six canopy-feeding species—two whistlers, three honeyeaters and Grey Fantail—were well represented during the surveys, indicating the success of the 'cool burn' strategy in protecting this foraging niche. The other two species—Speckled Warbler and Eastern Yellow Robin—arguably benefitted, at least temporarily, from structural modification of the lower vegetation layers, particularly where this increased the amount of bare ground available for foraging.

Acknowledgements

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