Barmah-Millewa Forest:

The 2018 Bush Bird Blitz

Technical Report to NPWS by Wayne Robinson

Online statistical consulting

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Executive Summary

The Barmah-Millewa Forest Icon site collects bushbird data to report on the condition of the woodland bird communities in the forest, as part of The Living Murray (TLM) condition monitoring program (CMP). The data can be used to assess whether the types of birds in the forest reflect a healthy forest, with particular reference to forest condition in response to environmental watering. Indices of condition based on species richness were devised in 2016 (Robinson, 2016) to provide a quantitative method of evaluating the objective.

The current project designed a large scale sampling event ('the blitz') for bushbirds in Barmah-Millewa Forest to answer two specific questions;

1. How well do the selected sites reflect the health of the entire Barmah-Millewa forest?
2. How well do sites that do not flood frequently, reflect change in forest condition in response to flooding?

The project also assessed variability in the types of bird species detected between habitats, observers, time of day and through time.

Question 1 was addressed by comparing the average scores for the TLM indices of condition - as well as some bush bird guild indices developed for the ecological thinning project[1]– between the TLM surveys in summer 2018 and the bushbird blitz surveys. Question 2 was not addressed in as much detail as planned, however inferences can be made due to the delineation provided through the site quality categories.

When the blitz and the TLM summer surveys were compared, there was similar species richness however there were fewer birds listed on the Victorian Woodland Bird Communities (VWBC) list in the Blitz surveys than the TLM surveys. Assemblages of birds differed between the two projects and habitats, for example, there were more migratory species in the surveys in summer and gradually fewer over the next three surveys. This coincided with an increase in sedentary species from summer through the three rounds of the blitz.

[1] Robinson W A (2018) Data analyses of River Red Gum ecological thinning bird data. Report to OEH May 2018.

The comparisons between projects need to be treated cautiously due to observer differences. When the same site was surveyed simultaneously, there was no significant difference in their average species richness. However, the types of birds recorded by the different observers was different even when surveying sites simultaneously, and there was a multitude of species contributing to the difference.

There was high bird species turnover temporally and spatially which is indicative of a small sampling unit. Given this high species turnover, it is no surprise that indices that use only species richness (i.e. the VWBC indices) are not very sensitive. On the other hand, indices that account for the type of species, such as guild type indices should be somewhat independent of sampling effort and this project showed that the small sampling unit was still able to find differences in bush bird communities in different site qualities.

No bird species showed a hi-fidelity with any of the different RRG habitat types. Grey shrike thrush and spotted pardolotes were identified as being slightly more abundant in red gum sites that received less water (RRG site quality 3). However these are probably spurious observations given that with so many species identified, it is likely some may come out in a statistical analysis just be chance alone. The relationships were weak and there are no obvious other potential indicator species that could be used as indicators of forest canopy health as a result form TLM watering. The difficulty in identifying suitable responses to watering regime/canopy health may also be because of the variability in species lists returned by different observers and the small sampling unit.

Overall, the project highlights the importance of standardizing identification practices between observers, the inherent temporal variation in bushbird communities over short time periods, and the limited ability of basic species richness type assessments to make inferences about forest health. A major discussion point from this project is the suitability of the 20 minute, 2 Ha sampling unit for single time surveys per season as used in the TLM. This project shows that the sampling unit does not return many of the species using the habitat. The result is that species richness type indices will be inefficient, whilst community structure or guild type measures appear more sensitive for health type assessments.

Background

The Barmah-Millewa Forest Icon site has been collecting data about the occurrence of bushbirds since 2008, and there are historical data available from 1999 -2002. The data are used to report on the condition of the woodland bird communities in the forest, as part of The Living Murray (TLM) condition monitoring program (CMP). The data can be used to assess whether the types of birds in the forest reflect a healthy forest, with reference to forest condition in response to environmental watering.

The current project is to design a large-scale sampling event (aka the blitz) for bushbirds in Barmah Millewa Forest to answer two specific questions;

1. How well do the selected sites reflect the health of the *entire* Barmah-Millewa forest?
2. How well do sites that do not flood frequently, reflect change in forest condition *in response to flooding*?

The first milestone report for this project[2] included a detailed plan and design for the blitz to collect data to address the above two primary questions as well as the following questions on assessment variability and repeatability.

Determine sites and dates of sampling for the blitz sites to;

- Represent the entire forest, including current habitat strata,
- Assess inter-operator variation in assessment,
- Assess within site (temporal) variation in assessment within a single season.

[2] Robinson W A (2018) Barmah-Millewa Forest Bush Bird Blitz. Design report to OEH, January 2018.

Methods

Sampling design and methods are detailed in the blitz design document. In summary, there are 20 sites that were sampled by the TLM survey in summer 2018 and 66 sites that were sampled in the blitz. The blitz sites are spread out over 3 rounds, across five habitats, river red gum site quality 1, 2 and 3 (hereafter referred to as RRG1, RRG2 RRG3), pine and box. The number of sites allocated to each habitat reflects relative size of the available habitat. Box was sampled less than the other sites as it is the smallest are (See design document for full details). A number of the sites were sampled 1 or 2 times within each sampling round. The sites that were sampled more than once per round, were either sampled at the same time by two different observers (concurrent), or twice on the same day by the same observer (repeated) or different (successive) observers.

In general, the analyses either; compare TLM surveys to either the first round alone of all three rounds of the blitz, or; assess just the birds collected in the three Redgum habitats in detail, as these habitats were more intensively sampled and the three categories represent 3 different levels of flooding regime. There are seven results sections, including;

Species turnover/accumulation-TLM versus Blitz

To determine if any of the habitats are more species rich requires either equal effort or adjustments for different effort in the analysis. In this report, the habitats have different effort (different numbers of sites) and species accumulation are used to compare relative abundance at the same effort. Total predicted richness is used to compare the bushbird species richness between the habitats and projects. There is no statistical test to compare the results, however, the Chao1 predicted total species richness includes a 95% confidence interval and the interval range can be used to compare richness. Further, the adequacy of the prediction can be assessed if the curve has reached an asymptote, and if the range of the confidence interval is small relative to the prediction. In these analyses, only the first survey per round at each site are used.

The TLM surveys only consist of 4 sites per habitat, so are not expected to return accumulation curves that asymptote, nor give accurate predictions of total richness. However, any obvious differences in richness to the blitz surveys would still show up in the shape of the curve.

Species turnover/accumulation-Redgum habitats across blitz

In all both the sampling programs, the box and pine habitats have had only a small number of sites surveyed as they make up the smaller relative areas compared to the Redgum forests. This meant that the three Redgum habitats were relatively well sampled throughout the three rounds

of the blitz, all having at least 13 sites per round. I took advantage of this data set to assess how the species accumulation curves differed between the three Redgum habitats and through time, using the same methods as above.

Health assessment Indices -TLM versus Blitz

The total richness and VWBC richness indices that are normally part of TLM reporting were calculated for all the survey data, including the blitz. I then added several new guild based indices (full descriptions in the ecological thinning report[3]. All indices were compared between the TLM summer samples and the Blitz round 1 as these two surveys were taken close together temporally. Only the first survey per round in each site are used to ensure comparable effort.

Comparison of TLM and Blitz bird communities in Summer 2018

I exported the full species list from the health assessment (previous section) and calculated Jaccard dissimilarity between each pair of surveys. The Jaccard similarity measure is intuitive and simple to interpret as its value is the proportion of shared species between samples. For example, a *dissimilarity* of 0.8 means the two samples had a *similarity* of 0.2, or 20 % of species in common.

A permutational (PERMANOVA) was used to compare the dissimilarity between habitats and projects. Similarity percentages (SIMPER) analysis was used to determine which bird species were associated with each habitat and/or project. I used non-metric multidimensional scaling (NMDS) to create an ordination of the relative distances between the surveys and included principal axis correlations (PCC) of individual bird species with the ordination space to look for trends in occurrence of bird species with the projects and habitats.

Comparison of TLM and Blitz assessments in Redgum forests

I performed the same assessment for all health assessment indices described above for only river Redgum forests but across the TLM and all three rounds of the blitz. This analysis included all surveys and therefore allowed for tests for differences between habitats, between the TLM and the three blitz rounds, and between observers.

Comparison of TLM and Blitz communities in Redgum forests

I performed another multivariate analyses using Jaccard dissimilarity, but only on the Redgum data, and across all surveys including repeat observations per site. This allowed for

[3] Robinson W A (2018) Data analyses of River Red Gum ecological thinning bird data. Report to OEH May 2018.

PERMANOVA tests to compare differences in bird assemblages recorded between habitats, sampling rounds (incorporating projects) and observers. I used SIMPER analysis to identify bushbird species that appeared to have associations with different surveys within each habitat, as well as differences between habitats and observers. To simplify the interpretation of the results, I calculated the distance between the centroids for each round and habitat, and separately for each round and observer and used NMDS and PCC to identify species that were associated with differences in assemblages between the habitats, observers and rounds.

This analyses allows an assessment of the relationship between bushbird communities and forest health as RRG1 habitat receives more regular flooding, RRG2 less frequent and RRG3 the least amount of flooding. Thus, differences in bird species between the habitats may lead to identification of potential indicator species for monitoring forest health in relation to watering.

Variation of bird assemblages collected within same sites

In this analyses I looked at sites that had been sampled twice on the same day. All sites in this category are from the blitz and habitats are not treated as separate because of the small sample sizes.

I performed a mixed model analysis to compare whether there was a significant difference between the observers in the total species richness observed by the different observers when performing concurrent surveys.

I calculated the Jaccard dissimilarity between each site and itself in the concurrent, repeated or successive survey taken on the same day. Histograms show the distribution of the dissimilarities between concurrent surveys and scatter plots. This shows the relationship of the dissimilarities between repeated or successive surveys with the time between surveys.

I performed a mixed model analysis to compare whether there was a significant difference relationship of the dissimilarity between repeated or successive surveys and time between surveys. This analysis included a test to compare whether there was a difference in the relationship with time between surveys, between successive or repeated surveys. This determines whether any relationship of changes in bird community assemblages is the same if it is a different observer, rather than the same observer.

Results:

1 Species turnover/accumulation-TLM versus Blitz

The TLM surveys consist of only 4 sites per habitat so are not expected to return comprehensive analyses of species turnover and accumulation but are presented here for a guide and comparison. As a comparison with standardized effort, the average number of species returned in the blitz first round after just 4 sites was very similar to the TLM surveys (Figure 1.1).

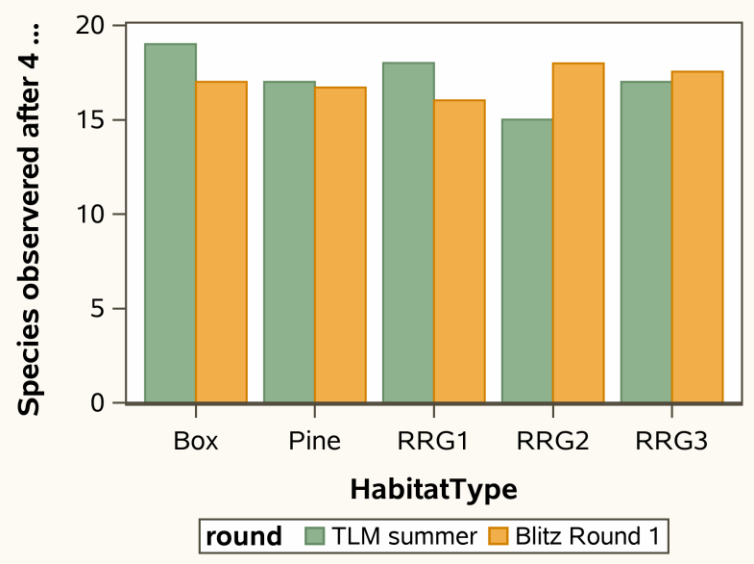


Figure 1.1 Species observed on average after just 4 sites were sampled for bushbirds in TLM summer round and first survey round of bushbird blitz in BMF. TLM only surveyed 4 sites per habitat, the blitz columns represent the average of 100 random samples of 4 sites.

The blitz round 1 surveys confidence intervals for the predicted species richness remained high even after 13 samples in RRG3, but were better in RRG1 after 18 and RRG2 after 25 sites (Figure 1.2). However, even the RRG2 and RRG3 accumulation curves had not neared an asymptote and the number of species using them could be much higher than that observed. RRG1 sites had tended to asymptote and had a narrow confidence interval, suggesting the species there were well sampled after 18 sites (Figure 1.2).

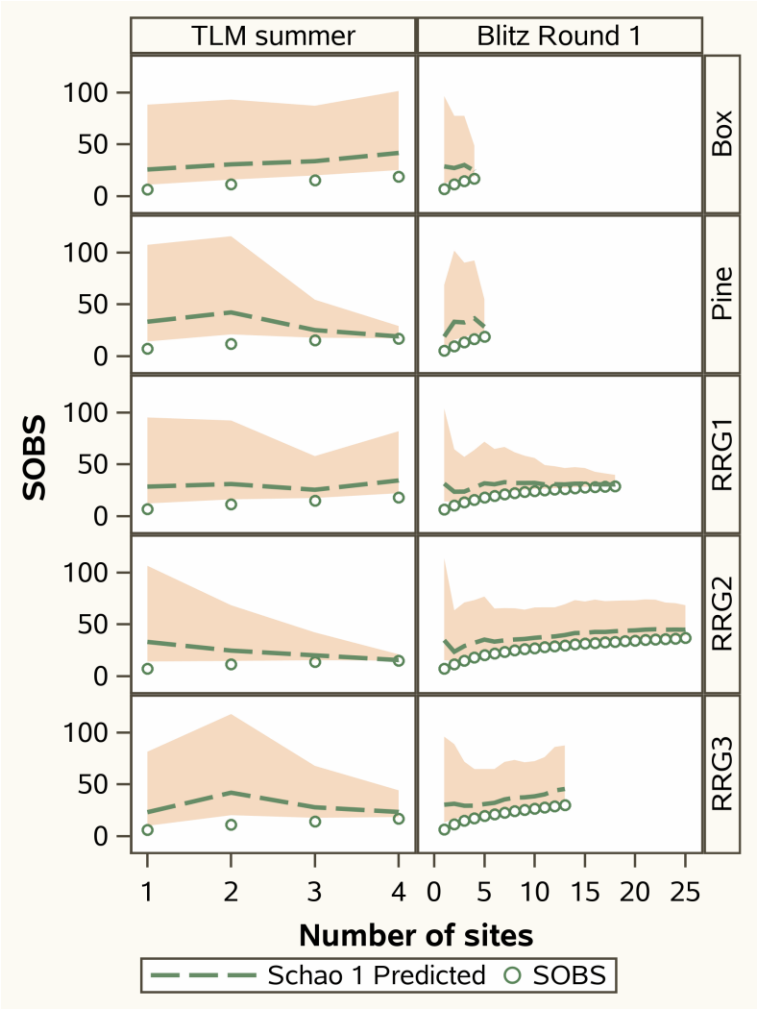


Figure 1.2 Species accumulation curves for bushbirds in TLM summer round and first survey round of bushbird blitz in BMF. Only the first survey at any site is included in the blitz curves. SOBS is Species observed. Schao 1 is the predicted total species richness in the site and the shaded region is the 95% confidence interval of the prediction.

The box and pine habitats also had only four or five sites in the blitz, so the results should be treated cautiously. Nevertheless, the narrower confidence intervals show the box habitat was better sampled in the Blitz, but the Pine habitats were better sampled in the TLM surveys (Figure 1.3). The confidence intervals were also narrower in the TLM surveys in the RRG2 and RRG3 habitats, but this appears to be a consequence of fewer species in general being collected in those sites (Figures 1.1 & 1.3). Only RRG1 sites appeared to have a similar total richness in both surveys (Figure 1.3) and as the curve was closest to asymptoting in the blitz (Figure 1.2), it was the best sampled habitat this year. We can also say that all habitats were under-sampled, and total bush bid species richness in BMF is much higher than returned in 2018.

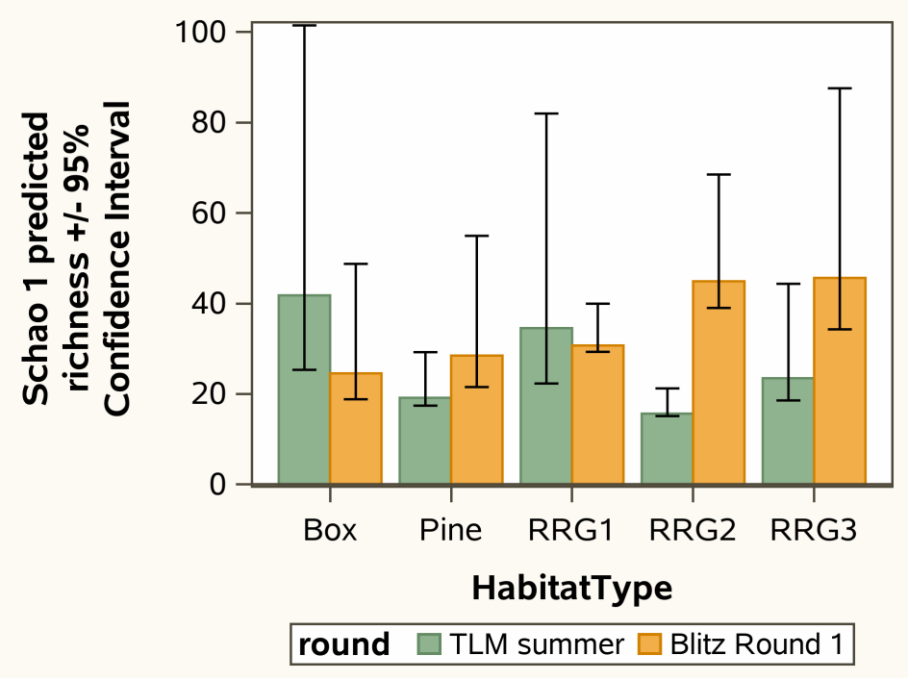


Figure 1.3 Species richness estimates based on final step of accumulation curves for bushbirds in TLM summer round and first survey round of bushbird blitz in BMF.

Take home messages

- All habitat types were under-sampled for total species richness
    - RRG 1 was the best sampled
- RRG2 and RRG3 habitats *probably* contain the most species,
    - the box habitats have been under sampled so far and may also be speciose

2 Species turnover/accumulation-Redgum habitats across blitz

There were more than 35 bushbird species collected in each river red gum habitats in every round during the blitz (Figure 2.1). RRG3 habitats had the fewest sites sampled (13), the accumulation curves did not approach an asymptote and had the widest confidence intervals (Figure 2.1). RRG sites 1 and 2 appeared better sampled as the curves were closer to the asymptote and had narrower confidence intervals (Figure 2.1).

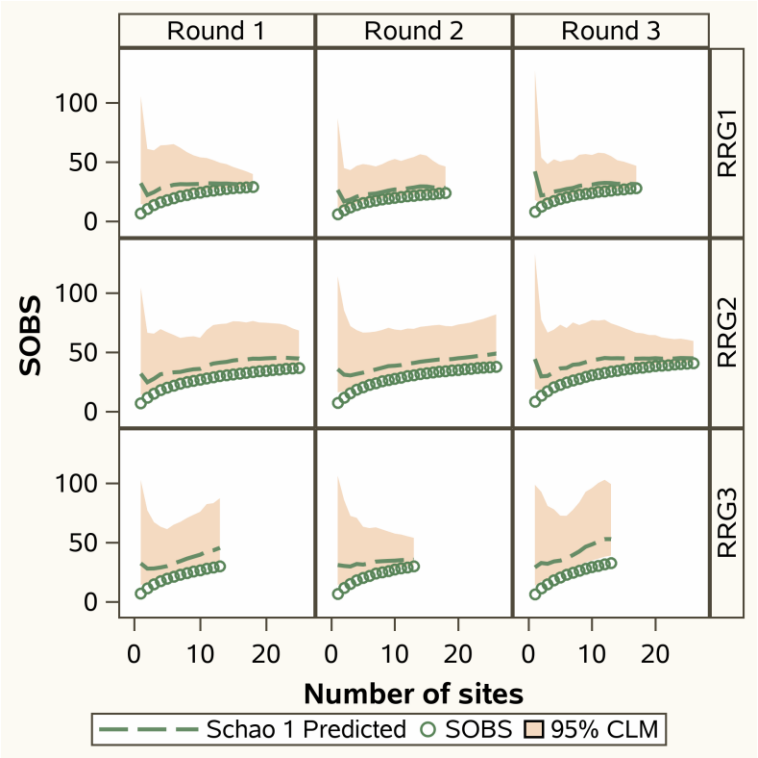


Figure 2.1 Species accumulation curves for bushbirds in Redgum forests in three surveys round of bushbird blitz in BMF. Only the first survey at any site is included in all curves. SOBS is Species observed. Schao 1 is the predicted total species richness in the site and the shaded region is the 95% confidence interval of the prediction.

RRG2 habitats had the most species predicted in every round (Figure 2.2), however this is probably a consequence of having the most sites sampled in every round as well. It is predicted that there were around 40 to 70 species in RRG2 sites in each round (Figure 2.2). RRG3 habitat had similar predicted richness, and RRG1 habitat had a lower predicted total bush bird richness during the study (Figure 2.2). All the confidence intervals for the predictions (Figure 2.2) have confidence intervals around 50% of the estimate, meaning that the predictions are not very accurate and the curves suggest that more samples are required to get more accurate estimates of total richness.

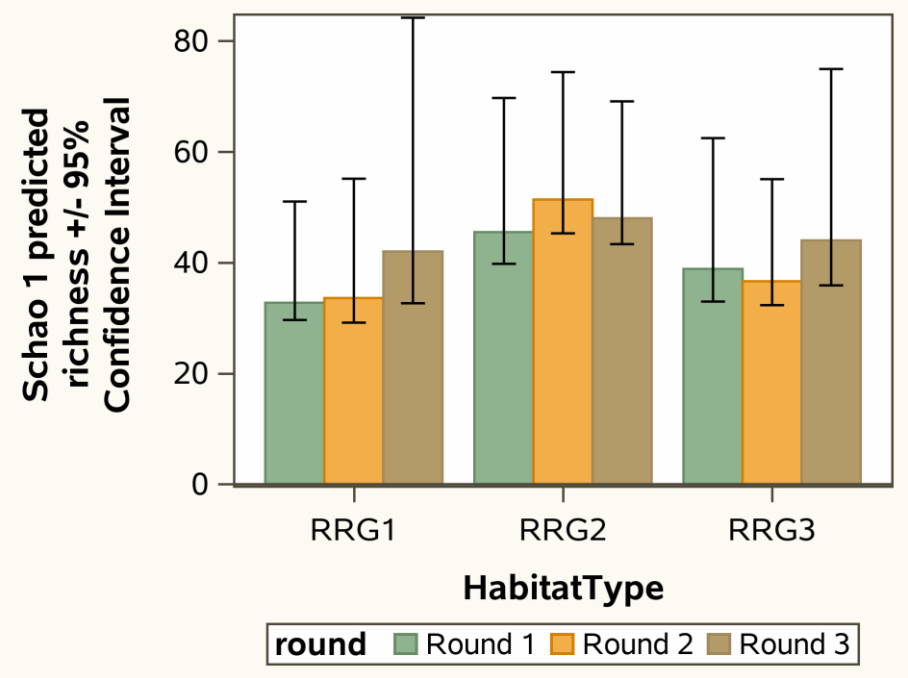


Figure 2.2 Species richness estimates based on final step of accumulation curves for bushbirds in Redgum forests across three survey rounds of bushbird blitz in BMF.

Take home messages

- The TLM surveys do not allow for accurate estimates of total richness, but in comparison with the blitz surveys, after four sites both surveys return similar species richness
- RRG 2 probably has the most bush bird species present
- It is recommended that at least 25 sites are used if it is desired to estimate total species richness, however this still leaves a confidence interval range of about 30 species, or 50 %.
- More sites are required to estimate total richness with greater precision.

3 Health assessment Indices -TLM versus Blitz

Overall there was a significant difference in the VWBC species richness ($F= 4.9$, $df=1,75$, $p<0.05$), and the proportion of VWBC species ($F= 5.2$, $df=1,75$, $p<0.05$) observed between the TLM summer surveys and the Blitz surveys in the first round. All other indices did not vary between projects and none of the indices varied between habitats or the interaction of habitats and project (Figure 3.1).

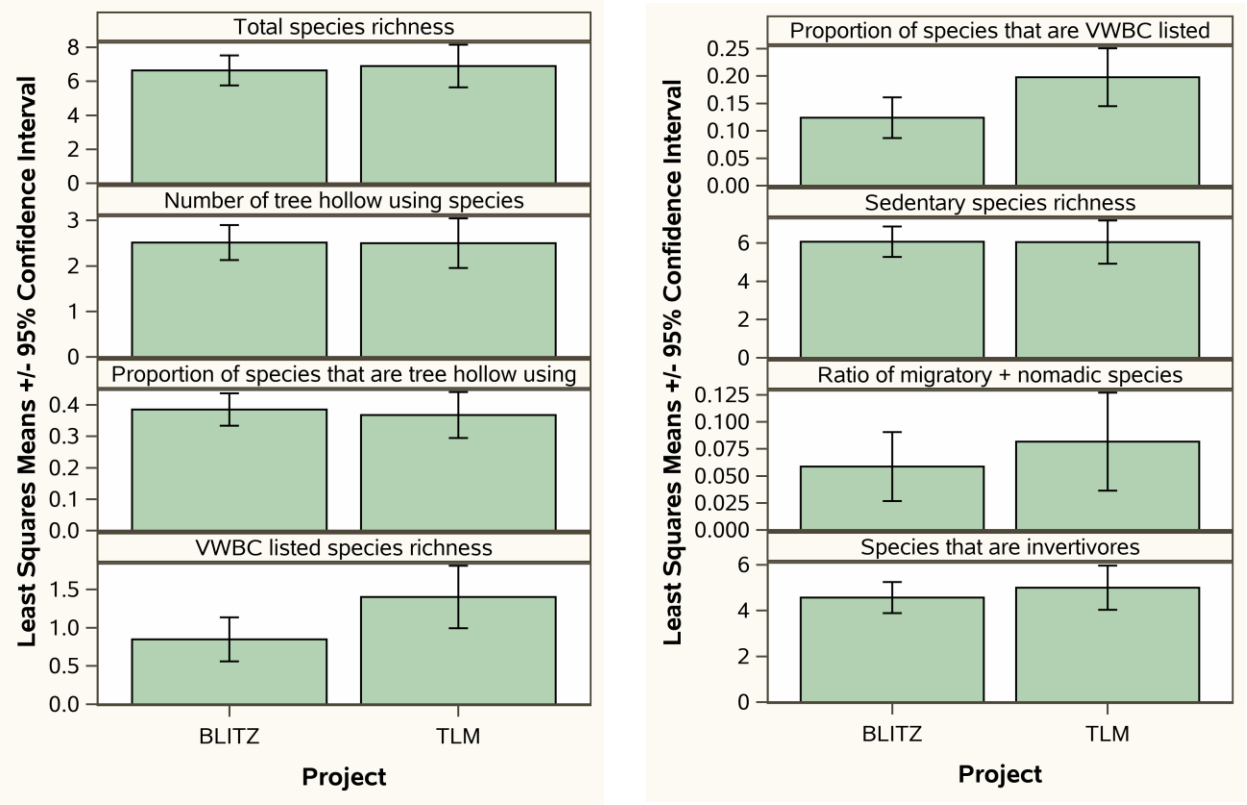


Figure 3.1. Indices (Mean+/- 95% confidence interval) describing the woodland birds surveyed in BMF surveys in 2018. Values are project means across all habitats. VWBC listed = specific or associated (See Appendix 1).

Take home messages

- There was more VWBC listed bushbird species in the TLM summer 2018 surveys than the bushbird blitz
    - This may be because of differences in birds present, or operator differences between the survey (see section 5)

4 Comparison of TLM and Blitz bird communities in Summer 2018

When looking at species assemblages across the surveys, there were significant differences between habitats (Pseudo F = 1.6, df = 4,76, p =0.002) and between the TLM and the Blitz (Pseudo F = 1.9, df = 1,76, p =0.01). Notably, the RRG1 sites held different communities to all other habitat types ($p < 0.1$), and the pine sites were also different to the RRG2 sites ($p < 0.01$).

The ordination of the surveys suffered from high stress, but showed that the pine sites tended to be more varied than the other groups (Figure 4.2). The RRG1 sites tended to align well with white-throated treecreepers, whilst box and pine sites, tended to be positioned away from that species and away from superb fairy-wrens (Figure 4.2). Nevertheless, no species had more than a medium strength association with the space (Max correlation < 0.6).

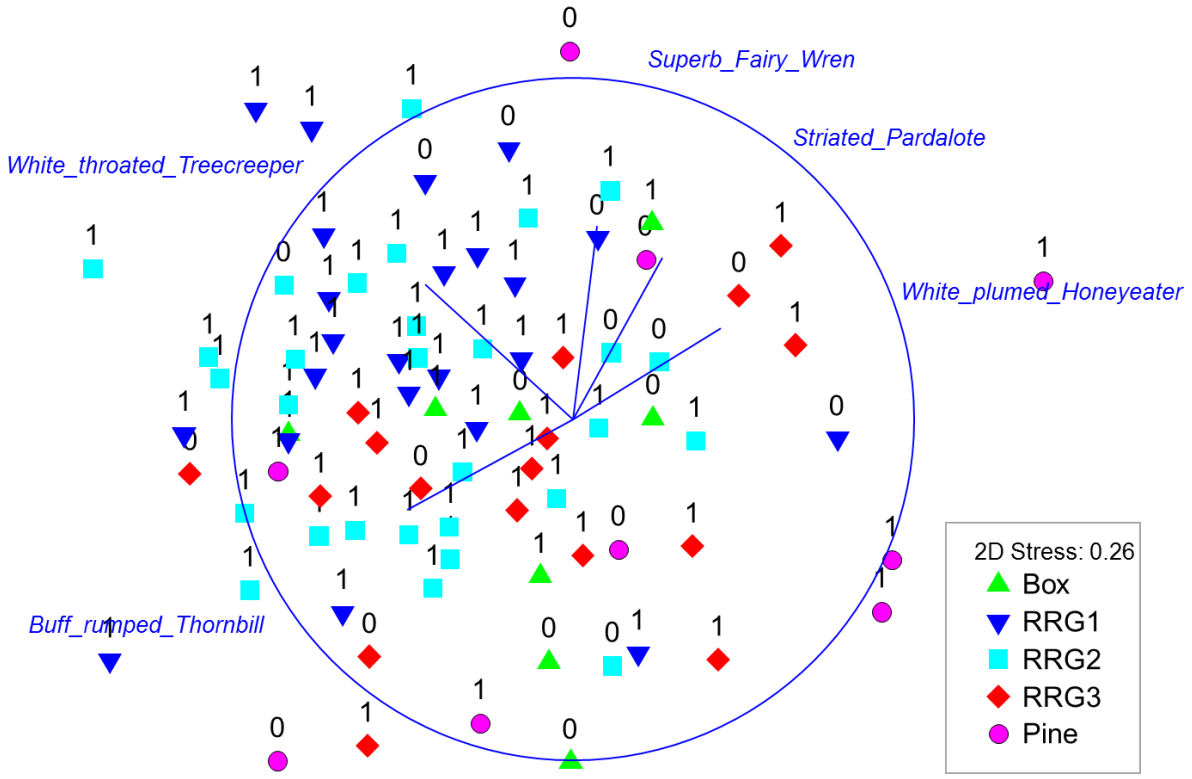


Figure 4.1. Non-metric multi-dimensional Scaling ordination of bush bird communities in TLM summer 2018 (0) and bushbird blitz round 1 (1). Vectors indicate direction of bird species associated with the ordination space. The length of the vector indicates strength of association using rank correlation and the circle indicates a maximum correlation of 1.

The Similarity Percentages (SIMPER) analysis found red-capped robins were only important in RRG1, and grey fantails only in RRG3 habitat types (Figure 4.2). White-throated treecreepers were aligned as more important in RRG3 than any other habitats and this was not apparent in the NMDS (Figure 4.1). Superb fairy-wrens were associated with RRG1 in the similarity analysis (Figure 4.2) and the ordination (Figure 4.1). Eastern rosellas were only important within Box habitat types, whilst, weebills were important in all habitats, except box (Figure 4.2). Species that contributed to between habitat differences are presented in Figure 4.3.

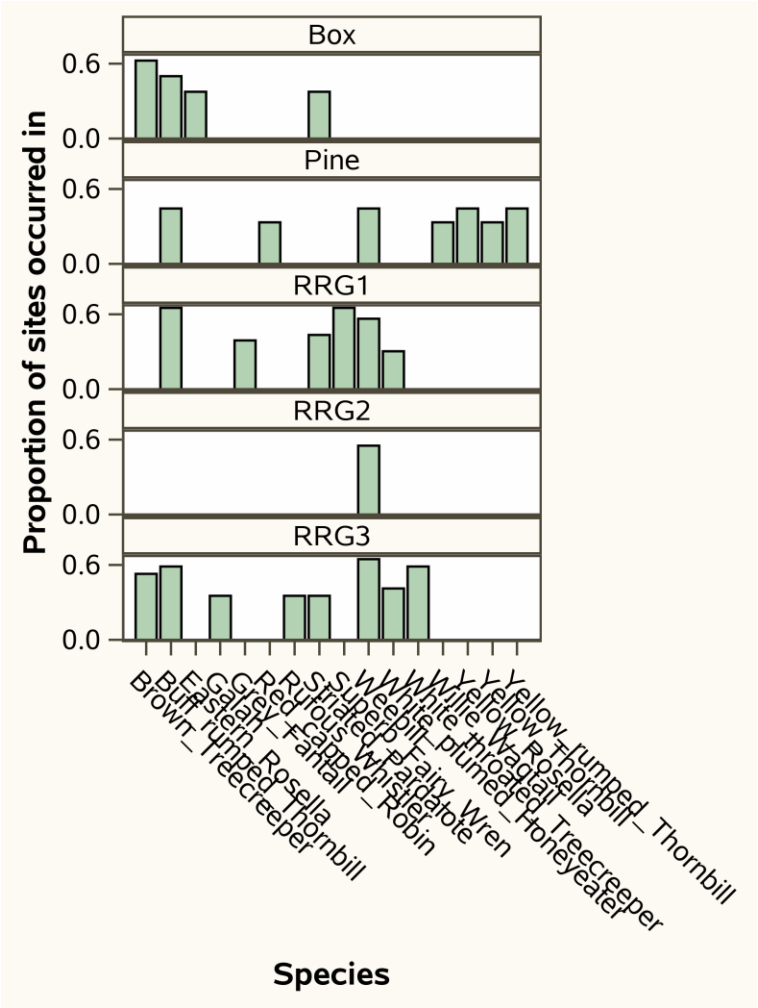
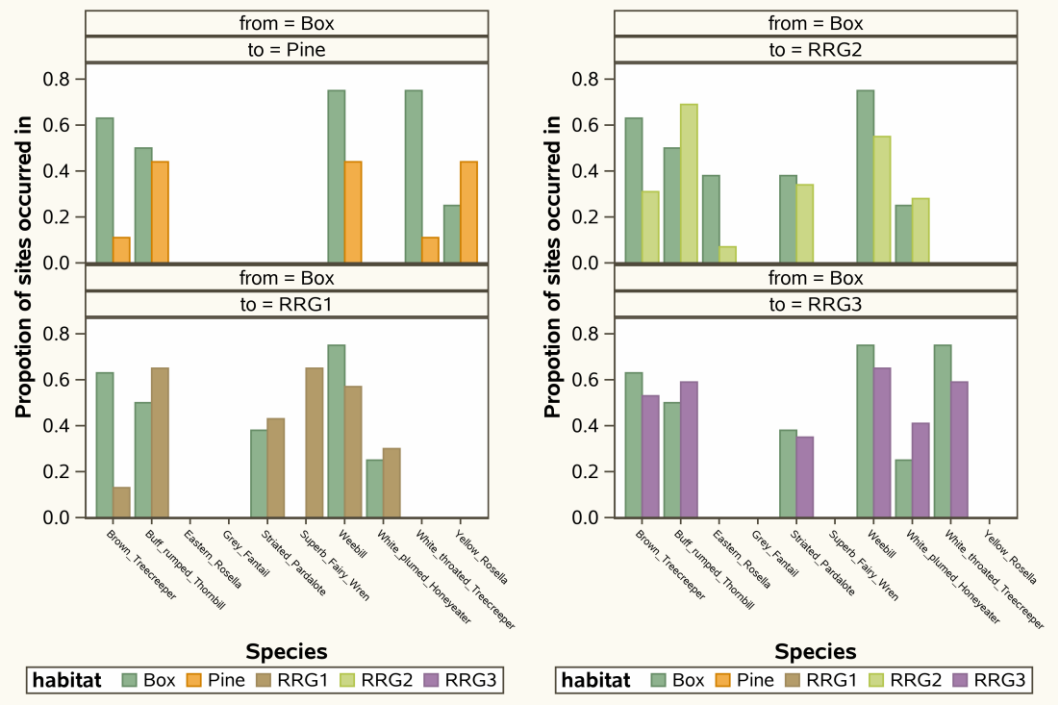
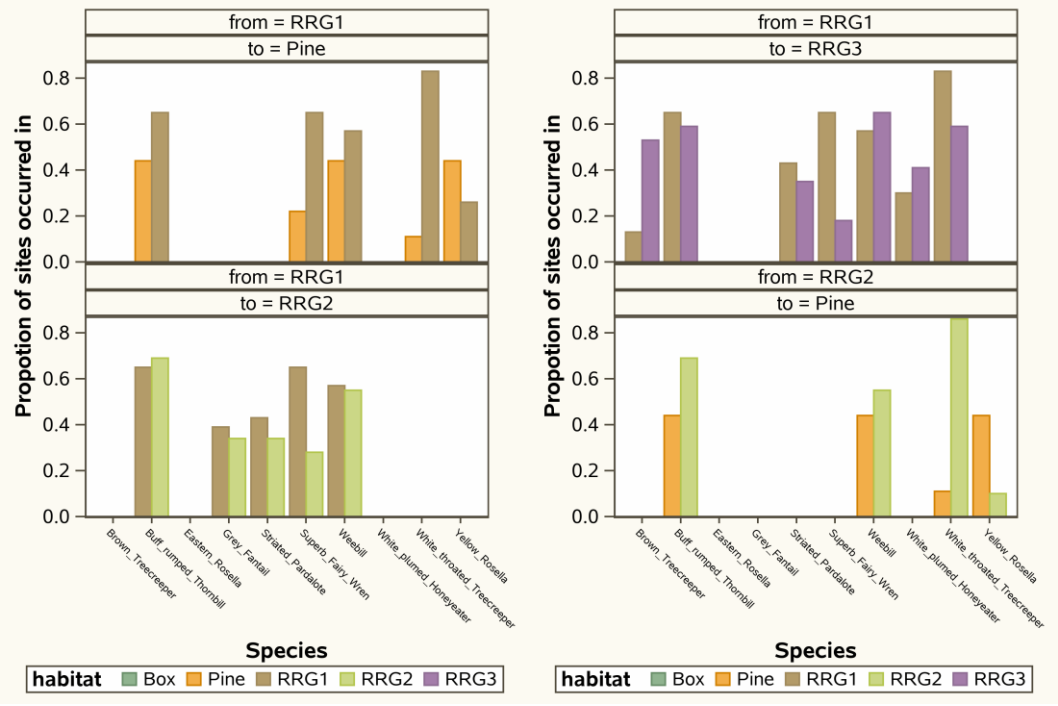


Figure 4.2. Proportion of sites occurred in for bushbird species that contribute 5% or more to *within* habitat similarity in bush bird communities in TLM summer 2018 and the bushbird blitz. Species without bars in some habitats, may occur there but do not contribute significantly to the community in that habitat.


from = Box
to = Pine
from = Box
to = RRG1
from = Box
to = RRG2
from = Box
to = RRG3
Propotion of sites occurred in
0.0
0.2
0.4
0.6
0.8
Brown_Treecreeper
Buff_rumped_Thornbill
Eastern_Rosella
Grey_Fantail
Striated_Pardalote
Superb_Fairy_Wren
Weebill
White_plumed_Honeyeater
White_throated_Treecreeper
Yellow_Rosella
Species
habitat
Box
Pine
RRG1
RRG2
RRG3


from = RRG1
to = Pine
from = RRG1
to = RRG3
from = RRG1
to = RRG2
from = RRG2
to = Pine
Propotion of sites occurred in
0.0
0.2
0.4
0.6
0.8
Brown_Treecreeper
Buff_rumped_Thornbill
Eastern_Rosella
Grey_Fantail
Striated_Pardalote
Superb_Fairy_Wren
Weebill
White_plumed_Honeyeater
White_throated_Treecreeper
Yellow_Rosella
Species
habitat
Box
Pine
RRG1
RRG2
RRG3

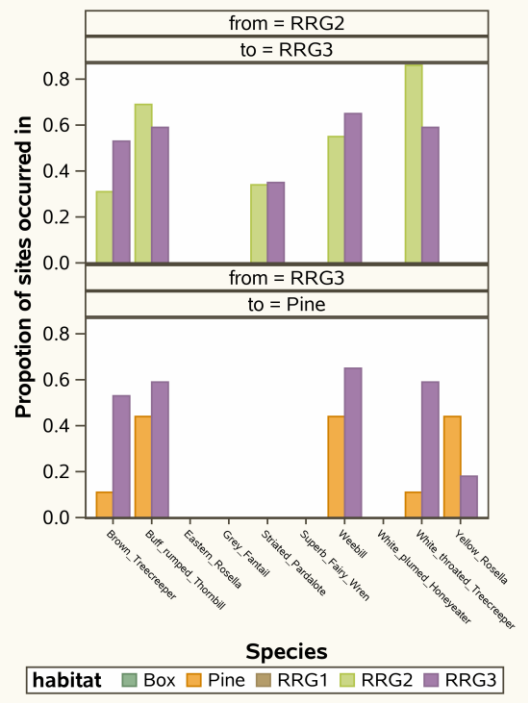


Figure 4.3. Proportion of sites occurred in for bush bird species that contribute 5% or more to *between* habitat similarity in bush bird communities in TLM summer 2018 and the bushbird blitz. Species without bars in some habitats, may occur there but do not contribute significantly to differences in the community between the habitats. For example, superb fairy-wrens do contribute to differences between Box and Redgum quality 1 sites (RRG1) but do not occur in Box sites.

Species that were important in determining differences between the TLM and Blitz rounds included buff-rumped thornbill, weebill, striated pardalote, white-plumed honeyeater, brown treecreeper, white-throated treecreeper, superb fairy-wren, rufous whistler and Australian magpie. Buff-rumped thornbill, weebill, white-throated treecreeper and Australian magpie were more common in the blitz whilst the rest were more common in the TLM surveys (Figure 4.4).

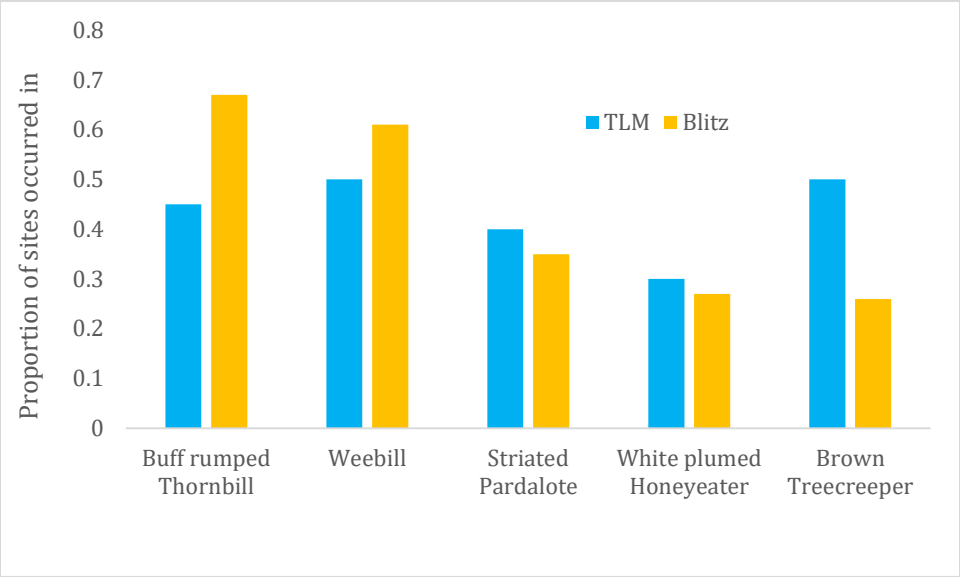


Figure 4.4. Proportion of sites occurred in for bushbird species that contributed 5% or more to the dissimilarity between the TLM summer2018 and the first round of bushbird blitz surveys. Species are ordered left to right in order of importance (6.1% to 5.0%).

Take home messages

- There were significantly different bird assemblages in the different projects and in the different habitats
- There was a suite of species associated with differences between habitats or that made surveys in different sites within habitats look similar. Some off these include;
    - Red-capped robins were only important in RRG1
    - Grey fantails only in RRG3 habitat types
    - White-throated treecreepers were most important in RRG3
    - Superb-Fairy wrens were associated with RRG1
    - Eastern Rosella were important within Box habitat sites
    - Weebills were important in all habitats, except box
- Buff-rumped thornbills and weebills occurred in up to 60% of sites in some habitats and were the most important species in delineating bird assemblages between the projects.

5 Comparison of TLM and Blitz assessments in Redgum forests

The ratio of migratory and nomadic species was significantly different between the two projects ($F = 6.2$, $df = 1, 159$, $p < 0.02$). About 9% of species in TLM and 4% of species in Blitz surveys were migratory or nomadic (Figure 5.1). There were no differences in any of the other indices between the three Redgum types or across the projects overall.

The ratio of migratory and nomadic species varied between the four rounds overall ($F = 10.9$, $df = 2, 159$, $p < 0.0001$). The 9% in TLM summer was not different to the Blitz round 1 (7%), and both these rounds were significantly higher than the round 2 and 3 blitz surveys which had only 2% migratory and nomadic species (Figure 5.2). Total species richness and sedentary species richness also varied significantly between rounds ($F=3.3$, $df = 2,161$, $p < 0.05$ & $F=3.0$, $df = 2,161$, $p = 0.05$ respectively). The average number of sedentary species in the blitz round 3 (7.1) was higher than blitz rounds 1 (6.2) or 2 (6.2), but surprisingly not significantly higher than the TLM surveys (5.9) (Figure 5.2). Similarly, total species richness varied significantly between the three Blitz rounds but none were different to the TLM round (Figure 5.2).

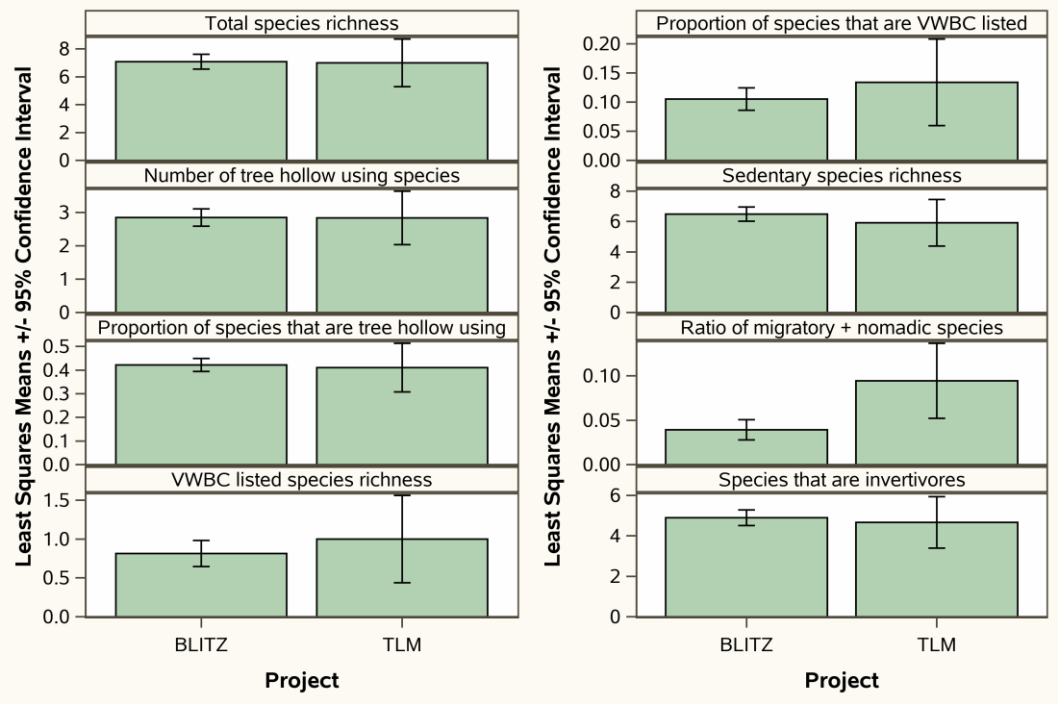


Figure 5.1. Indices (Mean+/- 95% confidence interval) describing the woodland birds surveyed in BMF surveys in 2018. Value are project means across all habitats. VWBC listed = specific or associated (See Appendix 1).

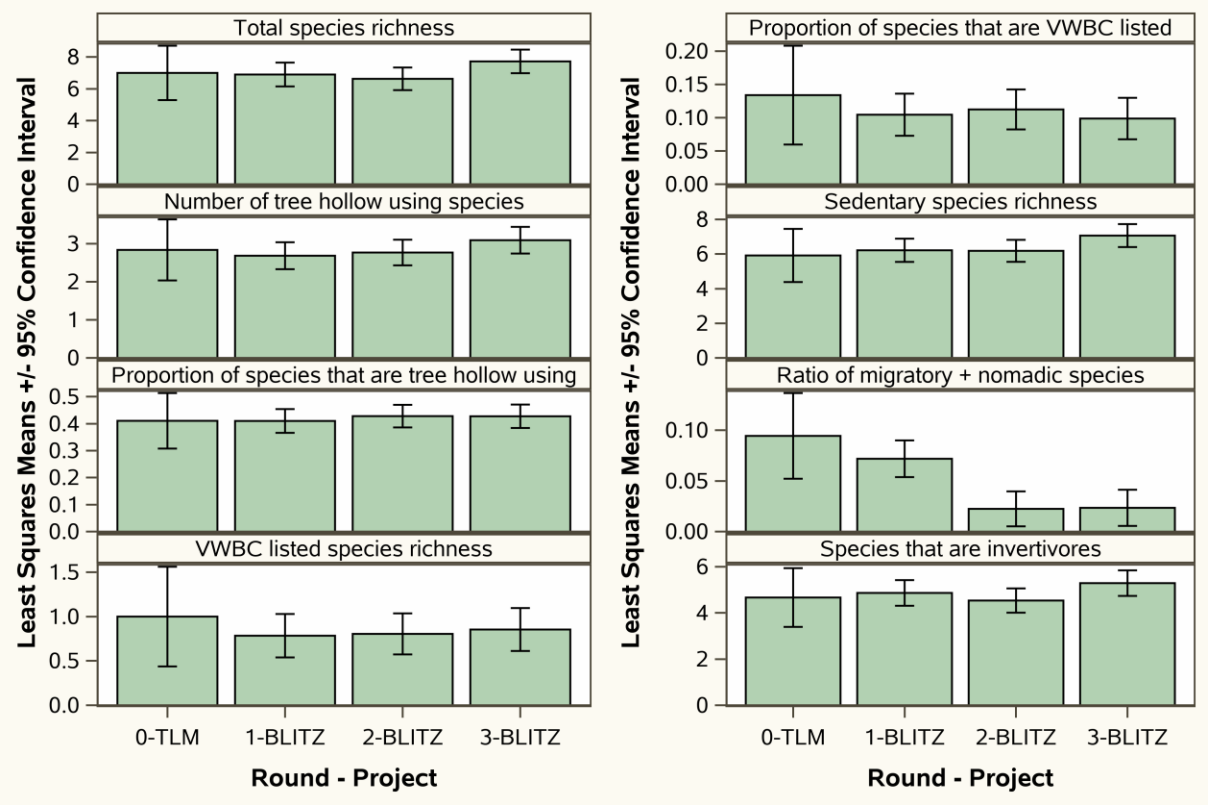


Figure 5.2. Indices (Mean+/- 95% confidence interval) describing the woodland birds surveyed in BMF surveys in 2018. Value are sampling round means across all habitats. VWBC listed = specific or associated (See Appendix 1).

There were significant differences between observes in the total species richness ($F = 14.2$, $df = 1, 161$, $p < 0.005$), the number of tree hollow using species ($F = 10.8$, $df = 1, 161$, $p < 0.005$) and the number of sedentary species ($F = 10.8$, $df = 1, 161$, $p < 0.005$).

Observer AB observed significantly fewer species (average 6.3 per site) compared to observer CB during the blitz (7.8). In the TLM surveys, observer AB (7.0) did not see more or less species than AB or CB in the blitz (Figure 5.3). The same pattern was found in the number of tree hollow users AB Blitz (2.5 species), was less than CB blitz (3.1) and neither were different to AB TLM (2.8). The same pattern was again observed in the number of sedentary species (AB Blitz = 5.89; CB blitz = 7.1; AB TLM = 5.92) (Figure 5.3).

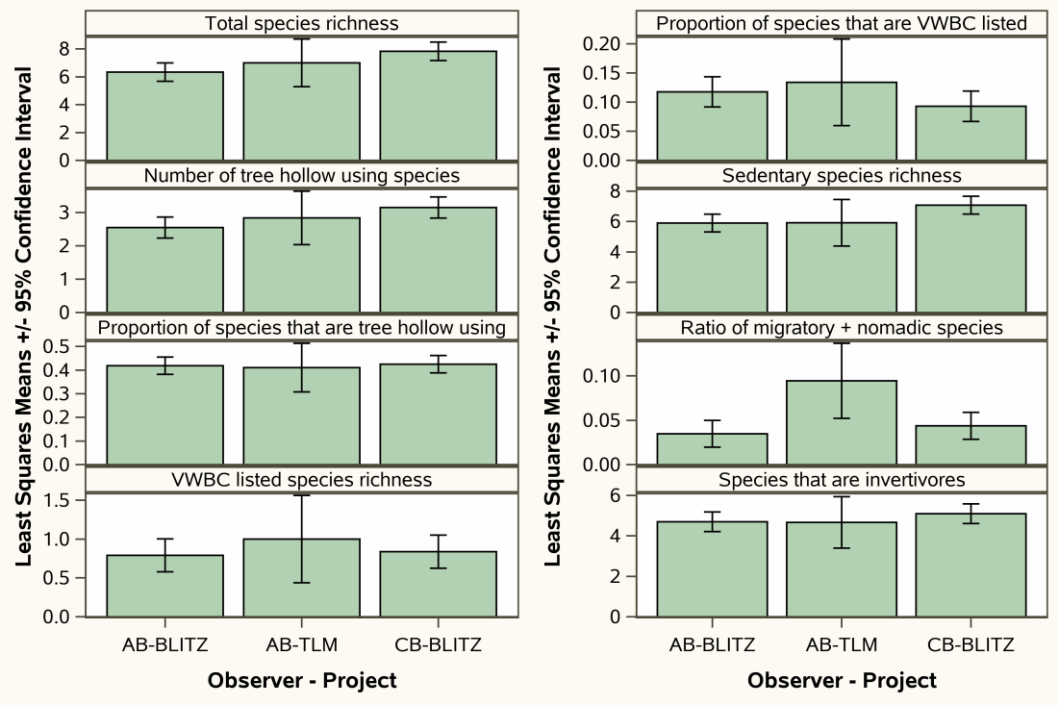


Figure 5.3. Indices (Mean+/- 95% confidence interval) describing the woodland birds surveyed in BMF surveys in 2018. Value are observer × project means across all habitats.

Take home messages

- There were more migratory species in the surveys in summer and gradually fewer over the next three surveys
    - This coincided with an increase in sedentary species from summer through the three rounds of the blitz
- Observer AB saw fewer species than observer CB during the blitz
    - This may be due to different survey sites (See section 7 for a comparison of simultaneous surveys)

6 Comparison of TLM and Blitz communities in Redgum forests

The bushbird assemblages were not significantly different between the two projects (Pseudo F = 0.7, p < 0.81). However, there were significantly different assemblages between habitats (Pseudo F = 1.7, p < 0.0005), observers (Pseudo F = 2.9, p < 0.0001) and sampling rounds (Pseudo F = 2.5, p < 0.0005). Most importantly however, the differences between observers and habitats was different between survey rounds (Pseudo F = 2.0, p < 0.001). Ordination of the centroids of the habitats and round show that the TLM surveys were more varied than the blitz surveys (Figure 6.1). Species were ubiquitous across the RRG habitats and none were identified as having fidelity to only one or two of the three RRG habitats.

The only bird species associated with the ordination space that seemed to align with a particular pattern were the grey-shrike thrush and spotted pardalote which appeared to be associated with RRG 3 surveys.

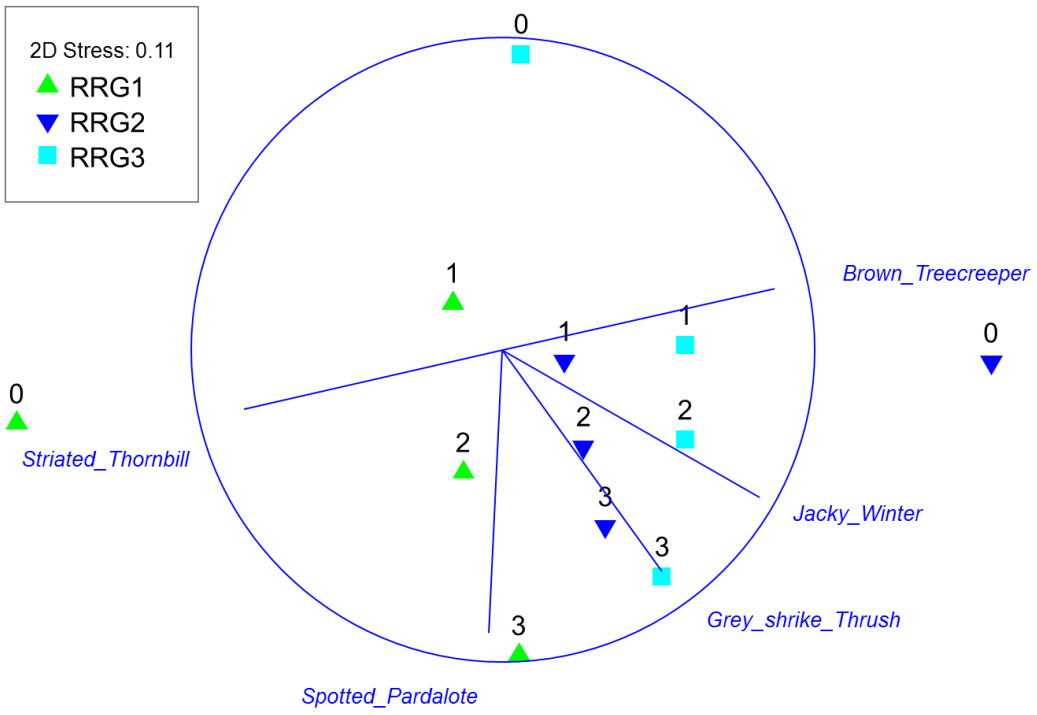


Figure 6.1. Non-metric multi-dimensional Scaling Ordination of the centroids of the bush bird communities in Redgum forests in TLM summer 2018 and bushbird blitz. Data points are the centroids of the communities in the three habitats in the TLM (0) and Blitz (1, 2, 3) sampling rounds. Vectors indicate direction of birds associated with the ordination space. The length of the vector indicates strength of association using rank correlation and the circle indicates a maximum correlation of 1.

Grey-shrike thrush are a woodland ground feeder, whilst spotted pardalotes are eucalyptus canopy feeder, and any link between their behaviour and feeding or breeding habits and why they would be associated with RRG3 habitats is difficult to elucidate. Both species are largely sedentary.

There were more than 20 species of woodland birds that were correlated with the ordination space for the centroids of the bird communities identified by the observers in the three Redgum habitats over the TLM and blitz surveys (Figure 6.2). A number of species were highly associated with observer CB in round 2, including sulphur-crested cockatoo, rufous songlark, magpie larks, yellow rosellas, white-winged choughs, red-rumped parrots, spotted pardalotes and crested shrike-tits (Figure 6.2). In the ordination space, observer AB was always positioned to the right of observer CB and this positioning was associated with fewer observation by AB for brown thornbills and white-throated treecreepers (Figure 6.2).

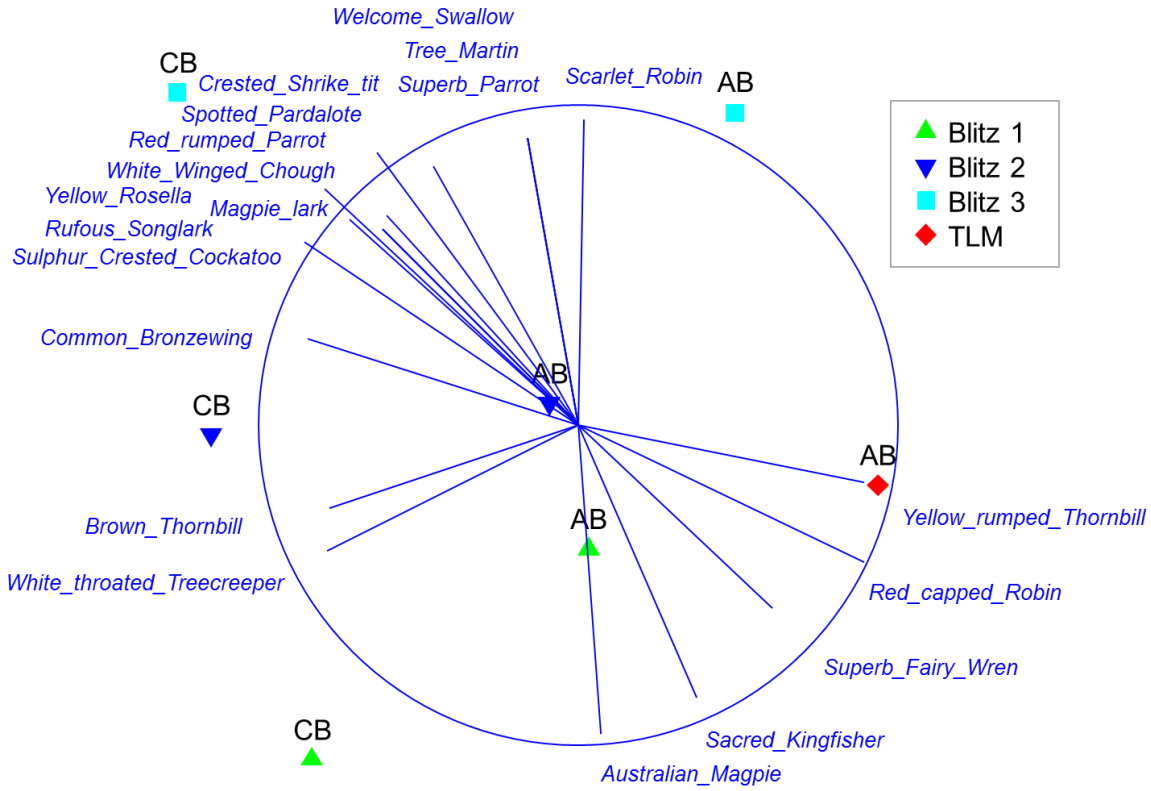


Figure 6.2. Non-metric multi-dimensional Scaling Ordination of the centroids of the bush bird communities recorded by observers (AB & CB) in Redgum forests in TLM summer 2018 and bushbird blitz. Rounds 1, 2 and 3. Vectors indicate direction of birds associated with the ordination space. The length of the vector indicates strength of association using rank correlation and the circle indicates a maximum correlation of 1.

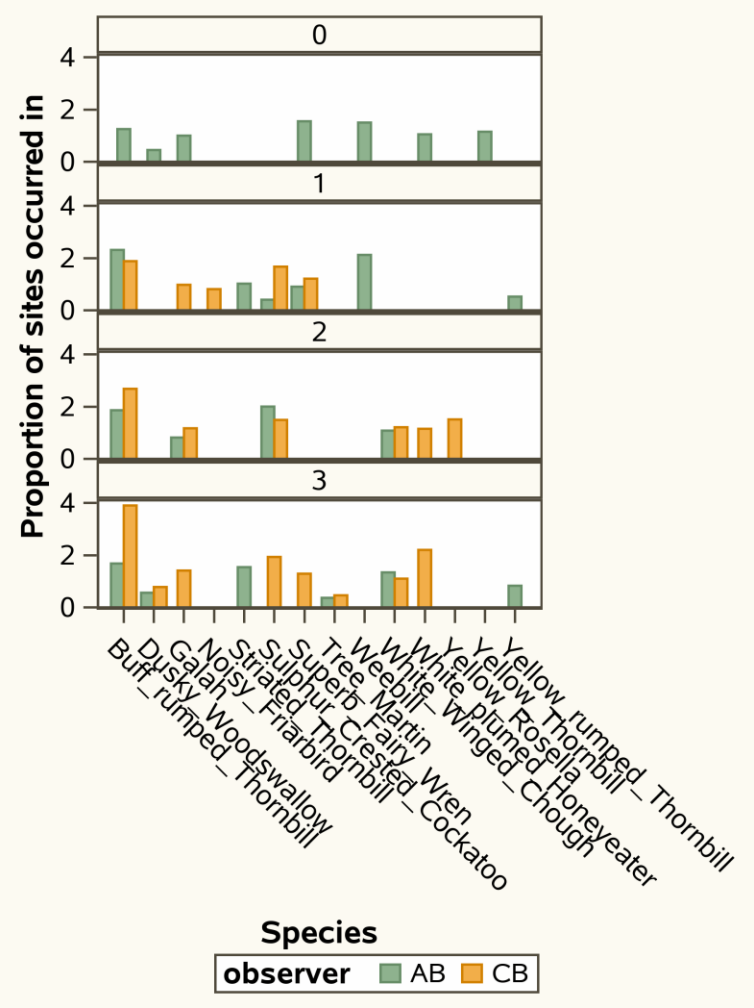


Figure 6.3. Proportion of sites occurred in for bush bird species that contribute 5% or more to *within* observer × round × habitat similarity in bush bird communities in Redgum forests in TLM summer 2018 and the bushbird blitz. Species without bars occurred in some habitats but do not contribute significantly to the community in that habitat.

Take home messages

- In Redgum habitats, the bushbird species returned by the surveys were more similar through time in the same site quality type than they were between habitat types.
- Whilst the different Redgum habitats had significantly different bird assemblages identified, there were few species that could be identified as significant in the differences.
    - Grey-shrike thrush and spotted pardalote appeared to be associated with RRG 3 surveys.

- There were significantly different assemblages recorded by the different observers, and there was a multitude of species contributing to the difference.
- Species lists for the Redgum forests changed through time, with several species, (e.g. Buff-rumped thornbill, sulphur-crested cockatoo) becoming more common in surveys through time
    - This may be because of seasonal changes in abundance, or maybe related to observer differences.

7 Variation of bird assemblages collected *within* same sites

Concurrent surveys

There was no significant difference in the species richness returned by the two observers during concurrent surveys ($F = 0.2$, $df = 1, 17$, $p = 0.66$). AB averaged 5.0 and CB averaged 5.4 species during the concurrent surveys. However, only 1 on the 19 concurrent surveys returned the same species list (Figure 7.1) and on average there was only 47% of species overlap between observers. ¾ of the surveys had less than 40% of species common, more than 0.4 dissimilarity. The differences in the species lists was not related to time of day of the surveys (Figure 7.1).

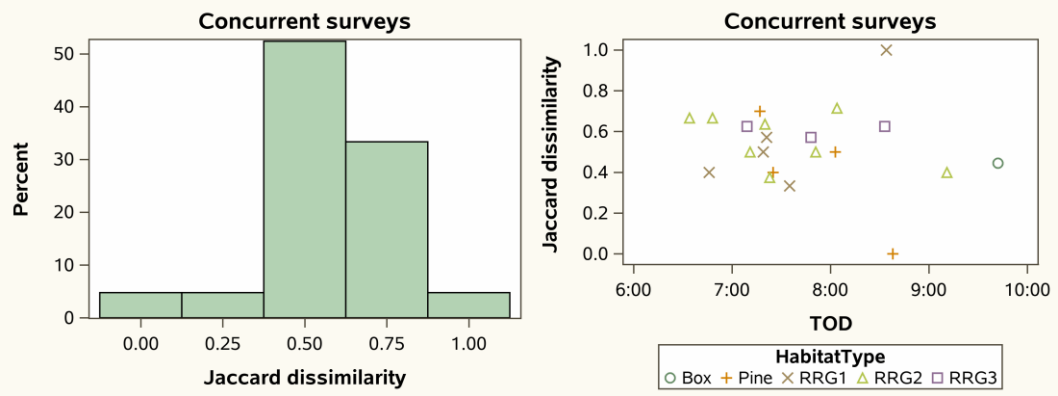


Figure 7.1 Jaccard dissimilarity between independent surveys conducted by two different observers in the same habitat at the same time (n=27). A Jaccard score of 0 indicates 100% of species shared between observers and 1 indicates no shared species. LHS = distribution across the concurrent surveys, RHS = relationship of dissimilarity with time of day surveys occurred.

Repeated and successive surveys

The difference between observers was greater when there was a gap between surveys on the same day, with an average of almost 80% different species from the same site but a different observer (Figure 7.2). Even the same observer returning to the same site later in the day had less than 40% of the same species on their list (Figure 7.2).

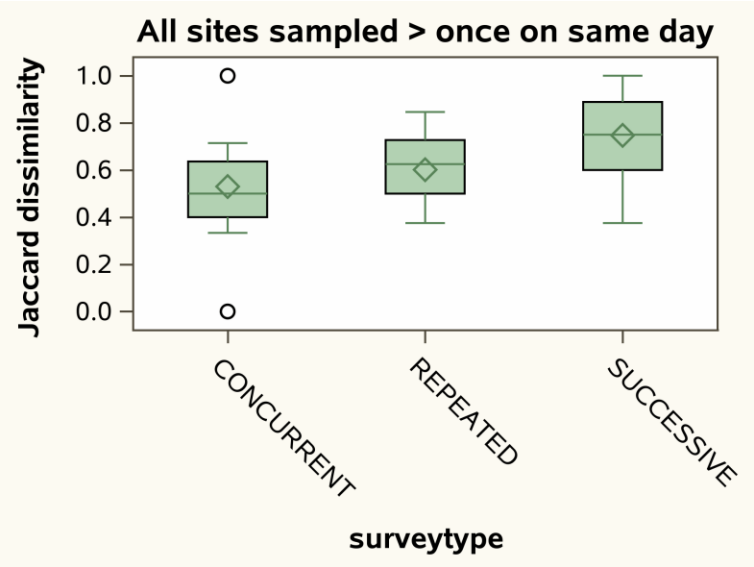


Figure 7.2 Jaccard dissimilarity between independent surveys conducted in the same habitat on the same day either at the same time by; different observers, (concurrent); the same observer later (repeated) or; different observers later (successive).

The species lists/Jaccard dissimilarity between surveys was more different if the time between surveys was greater and the observer was different (Figure 7.3) ($F = 5.8$, $df = 1, 36$, $p < 0.05$). The differences in species lists/Jaccard dissimilarity between surveys at a different time on the same day appeared less related to time between surveys if it was the same observer (Figure 7.3), however the slopes of the relationships were not significantly different ($F=2.1$, $df =1, 36$, $p = 0.16$).

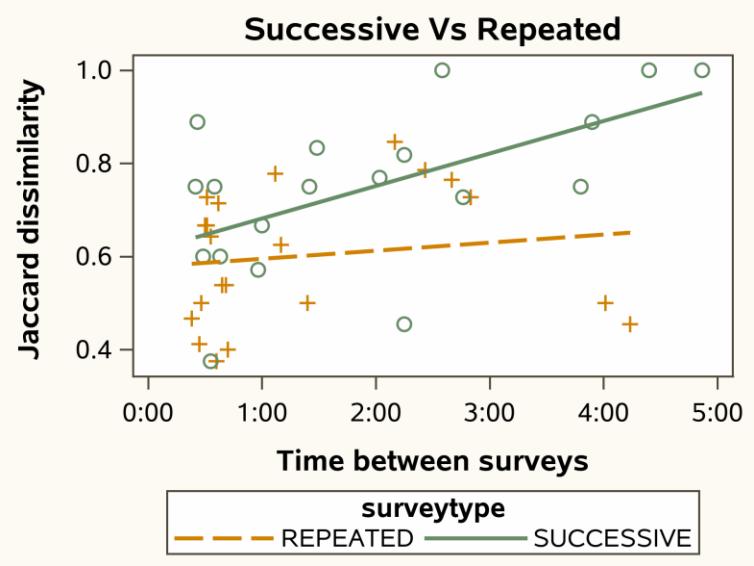


Figure 7.3. Relationship of Jaccard dissimilarity between independent surveys conducted in the same habitat on the same day by the same (repeated) or different observer (successive). Time between surveys is in hours.

Take home messages

- There was a large amount of variation in the species lists returned by the different observers, even when surveying sites simultaneously.
- Species lists in the same site differed more when the surveys were further apart
    - This is natural as the species using the plot are expected to change with time
    - However, the species lists were more similar if it was the same observer rather than a different observer making the second survey
- The time of day of the surveys was not related to the above differences

Summary of results

The Blitz surveys were intended to be more representative by sampling more sites per habitat, but also sampling using a more representative site selection strategy. This should enable more accurate assessments of bushbird condition in the forest, however the current indicators of condition are limited to total and VWBC species richness. The use of guilds is more likely to detect differences in types of species rather than just numbers of species in the habitats. All comparisons made here were somewhat limited due to the temporal difference as the TLM surveys were conducted a month before the blitz surveys. Hence, caution is required when making comparisons between programs.

Nevertheless, there is a lot of important findings and information for future surveys, including; River Redgum site quality 2 and 3 habitats probably contain the most species, but as the box habitats were under sampled, they may also be speciose. In order to determine a more complete assessment of the number of bird species using a habitat at any time would require more than the maximum 25 sites used in this project. This project found more than 35 bushbird species using each habitat type in a single season, but projections suggest that the total is more like 60 to 80 species in a single season, though these estimates have a very wide confidence interval. Across all the years and seasons and habitat types the TLM surveys have identified a total of 102 species using the forest. The within habitat totals recorded in each habitat through the 12 or so years of TLM monitoring are comparable with the estimates made here of 60 to 80 species (RRG1: 71; RRG2: 75; RRG3: 67; Pine: 69; Box: 76).

Whilst overall species richness was similar between the blitz and the TLM summer surveys, there was more VWBC listed bushbird species in the TLM surveys and this may be because of differences in the types of birds present, or operator differences between the surveys.

The entire assemblages of birds differed between the projects and habitats. For example, there were more migratory species in the surveys in summer and gradually fewer over the next three surveys and this coincided with an increase in sedentary species from summer through the three rounds of the blitz. Again, the comparisons between projects need to be treated cautiously

because of potential observer differences as observer AB was the only observer in the TLM and AB saw fewer species than observer CB during the blitz. This may be due to different survey sites as when the observers surveyed the same site simultaneously, there was no significant difference in their species richness.

Nonetheless, the types of birds recorded by the different observers was different even when surveying sites simultaneously, and there was a multitude of species contributing to the difference. Species lists in the same site on the same day differed more when there was more time between the surveys. Whilst this is natural as the species using the plot are expected to change with time, the species lists were more similar if it was the same observer rather than a different observer making the second survey. The time of day of the surveys was not related to any of the above differences.

Take home messages

- Species richness is not sensitive enough to observe changes over time.
- Guilds should be incorporated to increase sensitivity.
- Current habitats do not survey enough sites to accurately represent the species using the forest.
- Box habitat in particular is under sampled.

Recommendations

- **Incorporate a guild scoring system into the indices for condition for TLM monitoring**
  - **This may mean adjusting the reference point for each season to accommodate the types of species present at different times of the year**
- **Improve the standardization of observers or moderation of the observer effect**
  - **Aim for continuity of observers over the program**
  - **When new observers are used, attempt to include some consecutive surveys in the data collection.**
- **Continue reporting each habitat separately**
- **Review the seasonal nature of the effort. For example, 20 sites four times a year, may be better as 40 sites twice a year in order to optimize ability to detect change through time because greater effort will increase confidence in annual assessments.**

Appendix 1: VWBC species

Victorian temperate-woodland bird community species lists extracted from the Flora and Fauna Guarantee (File No. FF/54/0088).

Table A2. 1 Woodland dependent species with conservation status. All species are included in the analyses (regardless of conservation status).

Common name	Scientific name	Conservation status NRE (2000):	FFG status
Apostlebird	Struthidea cinerea	V	L
Barking Owl	Ninox connivens	E	L
Black-chinned Honeyeater	Melithreptus gularis	-	-
Brown Treecreeper sub-species *victoriae*	Climacteris picumnus victoriae	-	-
Brown-headed Honeyeater	Melithreptus brevirostris pallidiceps	-	-
Bush Stone-curlew	Burhinus grallarius	E	L
Diamond Firetail	Stagonopleura guttata	-	L
Fuscous Honeyeater	Lichenostomus fuscus	-	-
Grey-crowned Babbler	Pomatostomus temporalis	E	L
Ground Cuckoo-shrike	Coracina maxima	E	L
Hooded Robin	Melanodryas cucullata	-	L
Jacky Winter	Microeca fascinans	-	-
Little Lorikeet	Glossopsitta pusilla	-	-
Painted Button-quail	Turnix varia	-	-
Painted Honeyeater	Grantiella picta	V	L
Red-capped Robin	Petroica goodenovii	-	-
Red-tailed Black-cockatoo	Calyptorhynchus banksii	E	L
Speckled Warbler	Chthonicola sagittata	V	L
Superb Parrot	Polytelis swainsonii	E	L
Swift Parrot	Lathamus discolor	E	L
Turquoise Parrot	Neophema splendida	LR	L
Regent Honeyeater	Xanthomyza phrygia	CE	L
Western Gerygone	Gerygone fusca	-	-
Yellow-tufted Honeyeater sub-species	Lichenostomus melanops meltoni	-	-

Table A1. 2 Woodland associated bird species with conservation status. All species are included in the analyses (regardless of conservation status).

Common name	Scientific name	Conservation status NRE (2000):	FFG status
Chestnut-rumped Thornbill	Acanthiza uropygialis	-	-
Crested Bellbird	Oreoica gutturalis	-	L
Crested Shrike-tit	Falcunculus frontatus	-	-
Dusky Woodswallow	Artamus cyanopterus	-	-
Eastern Yellow Robin	Eopsaltria australis	-	-
Emu	Dromaius novaehollandiae	-	-
Gilbert's Whistler	Pachycephala inornata	-	-
Glossy Black-cockatoo	Calyptorhynchus lathami	V	L
Grey Falcon	Falco hypoleucos	E	L
Major Mitchell's Cockatoo	Cacatua leadbeateri	V	L
Malleefowl	Leipoa ocellata	E	L
Masked Owl	Tyto novaehollandiae	E	L
Powerful Owl	Ninox strenua	E	L
Regent Parrot	Polytelis anthopeplus	V	L
Restless Flycatcher	Myiagra inquieta	-	-
Rufous Whistler	Pachycephala rufiventris	-	-
Southern Whiteface	Aphelocephala leucopsis	-	-
Square-tailed Kite	Lophoictinia isura	E	L
Varied Sittella	Daphoenositta chrysoptera	-	-
White-browed Babbler	Pomatostomus superciliosus	-	-
White-browed Woodswallow	Artamus superciliosus	-	-

Appendix 2: Bushbird Guilds: Status of occurrence of common bird species in Barmah-Millewa forest

Table A2. 1 List of species and type occurrence. Se = Sedentary No = Nomadic Mi = Migratory

Species	Type	Species	Type	Species	Type	Species	Type	Species	Type
Australian Magpie	Se	Diamond Firetail	Se	Magpie-lark	Se	Sacred Kingfisher	Mi	Whistling Kite	Se
Australian Raven	Se	Dollarbird	Mi	Masked Woodswallow	No	Scarlet Robin	Se	White-backed Swallow	No
Australian Ringneck	Se	Dusky Woodswallow	Se	Mistletoebird	No	Silvereye	No	White-bellied Cuckoo-Shrike	Se
Black-chinned Honeyeater	Se	Eastern Rosella	Se	Nankeen Kestrel	Se	Singing Honeyeater	Se	White-breasted Woodswallow	Se
Black-faced Cuckoo-Shrike	Se	Emu	Se	Nankeen Night Heron	No	Southern Boobook	Se	White-browed Babbler	Se
Blue Bonnet	Se	Fairy Martin	Mi	Noisy Friarbird	Mi	Southern Whiteface	Se	White-browed Scrubwren	Se
Blue-winged Parrot	Mi	Fan-tailed Cuckoo	Mi	Noisy Miner	Se	Spiny-cheeked Honeyeater	Se	White-browed Woodswallow	No
Brown Falcon	Se	Flame Robin	No	Olive-backed Oriole	No	Spotted Pardalote	Se	White-faced Heron	No
Brown Goshawk	Se	Galah	Se	Pacific Black Duck	Se	Straw-necked Ibis	Se	White-plumed Honeyeater	Se
Brown Thornbill	Se	Gilbert's Whistler	Se	Painted Button-quail	Se	Striated Pardalote	Se	White-throated Treecreeper	Se

Brown Treecreeper	Se	Golden Whistler	No	Pallid Cuckoo	Mi	Striated Thornbill	Se	White-winged Chough	Se
Brown-headed Honeyeater	Se	Grey Butcherbird	Se	Peaceful Dove	Se	Striped Honeyeater	Se	White-winged Triller	No
Buff-rumped Thornbill	Se	Grey Fantail	Se	Peregrine Falcon	Se	Sulphur-crested Cockatoo	Se	Willie Wagtail	Se
Chestnut-crowned Babbler	Se	Grey Teal	No	Pied Butcherbird	Se	Superb Fairy-wren	Se	Yellow Thornbill	Se
Chestnut-rumped Thornbill	Se	Hooded Robin	Se	Pied Currawong	No	Superb Parrot	Se	Yellow-rumped Thornbill	Se
Clamorous Reed-warbler	Se	Horsfield's Bronze-Cuckoo	Mi	Rainbow Bee-eater	Mi	Swamp Harrier	Se	Zebra Finch	Se
Collared Sparrowhawk	Se	Jacky Winter	Se	Red-browed Finch	Se	Tree Martin	Mi		
Common Bronzewing	Se	Laughing Kookaburra	Se	Red-capped Robin	Se	Varied Sittella	Se		
Common Starling	Se	Little Eagle	Se	Red-rumped Parrot	Se	Wedge-tailed Eagle	Se		
Crested Pigeon	Se	Little Friarbird	Mi	Restless Flycatcher	Se	Weebill	Se		
Crested Shrike-tit	Se	Little Raven	Se	Rufous Songlark	No	Welcome Swallow	Se		
Crimson (Yellow) Rosella	Se	Long-billed Corella	Se	Rufous Whistler	Se	Western Gerygone	Se		

Table A2.2 Foraging guilds for common woodland bird species. Data supplied by Ricky Webster (Pers. Comm. 8/09/2015)

All levels	Aerial	Canopy	Ground	Wetland
1.1 All Levels: Invertebrates	2.1 Aerial Feeders	3.1 Canopy: Invertebrates	4.1 Ground: Invertebrates	5.1 Wetland: Animal
Fan-tailed Cuckoo	Rainbow Bee-eater	Spotted Pardalote	Yellow-rumped Thornbill	White-faced Heron
Horsfield's Bronze-Cuckoo	White-breasted Woodswallow	Striated Pardalote	Southern Whiteface	Nankeen Night Heron
Grey Shrike-thrush	Masked Woodswallow	Weebill	White-browed Babbler	Clamorous Reed-warbler
White-winged Triller	White-browed Woodswallow	Yellow Thornbill	Chestnut-crowned Babbler	
	Dusky Woodswallow	Striated Thornbill	Magpie-lark	
	Welcome Swallow	Golden Whistler	Australian Magpie	
	Tree Martin	Rufous Whistler	White-winged Chough	
	Fairy Martin	Black-faced Cuckoo-shrike	Rufous Songlark	
		White-bellied Cuckoo-shrike	Common Starling	
		Olive-backed oriole		
1.2 All Levels: Nectar	2.2: Perch Aerial Feeders	3.2 Canopy: Fruit (specialist)	4.2 Low: Invertebrates	5.2 Wetland: Vegetable
Spiny-cheeked Honeyeater	Dollarbird	Mistletoe bird	Pallid Cuckoo	Pacific Black Duck
Striped Honeyeater	Jacky Winter		Superb Fairy-wren	Grey Teal
Noisy Friarbird	Grey Fantail		White-browed Scrubwren	
Little Friarbird			Chestnut-rumped Thornbill	
Noisy Miner			Buff-rumped Thornbill	
Singing Honeyeater			Scarlet Robin	

White-plumed Honeyeater			Red-capped Robin	
Black-chinned Honeyeater			Flame Robin	
Brown-headed Honeyeater			Hooded Robin	
			Gilbert's Whistler	
			Restless Flycatcher	
			Willie Wagtail	
1.3 All Levels: Seed/Fruit	2.3 Aerial Predators	3.3 Trunks/Branches: Invertebrates	4.3 Ground: Seed/Fruit	5.3 Wetland: Predator
Sulphur-crested Cockatoo	Brown Goshawk	White-throated Treecreeper	Emu	Whistling Kite
Superb Parrot	Collared Sparrowhawk	Brown Treecreeper	Painted Button-quail	Swamp Harrier
Crimson Rosella	Wedge-tailed Eagle	Varied Sittella	Common Bronzewing	
Eastern Rosella	Brown Falcon	Crested Shrike-tit	Crested Pigeon	
Australian Ringneck	Peregrine Falcon		Peaceful Dove	
	Nankeen Kestral		Galah	
			Red-rumped Parrot	
			Blue-winged Parrot	
			Zebra Finch	
			Red-browed Finch	
			Diamond Firetail	
1.4 All Levels: Seed/Fruit (specialist)	2.4 Woodland Predators	3.4 Shrubs: Invertebrates	4.4 Ground: Seed/Fruit (specialist)	
Long-billed Corella	Little Eagle	Western Gerygone	Blue Bonnet	
	Southern Boobook	Brown Thornbill		
	Laughing Kookaburra	Silvereye		
	Sacred Kingfisher			

	Grey Butcherbird
	Pied Butcherbird
	Pied Currawong
	Australian Raven
	Little Raven

Table A2.3 List of tree hollow using woodland bird species, H = large hollow using. h = small hollow using. The two categories are not separated in the analyses.

Species	Tree Hollow Use
Australian Ringneck	H
Blue Bonnet	h
Blue-winged Parrot	h
Brown Treecreeper	h
Chestnut-rumped Thornbill	h
Crimson (Yellow) Rosella	H
Dollarbird	H
Dusky Woodswallow	h
Eastern Rosella	h
Flame Robin	h
Galah	H
Grey Teal	H
Laughing Kookaburra	H
Long-billed Corella	H
Masked Woodswallow	h
Nankeen Kestrel	H
Pacific Black Duck	H
Peregrine Falcon	H
Red-rumped Parrot	h
Sacred Kingfisher	h
Southern Boobook	H
Southern Whiteface	h
Striated Pardalote	h
Sulphur-crested Cockatoo	H
Superb Parrot	H
Tree Martin	h
Welcome Swallow	H
White-breasted Woodswallow	h
White-browed Woodswallow	h
White-throated Treecreeper	h

Appendix 3: Data notes

When a survey returned no birds, it is left in the univariate analyses but not the multivariate analyses. This included site 065 in the Blitz round 2 which returned no species for both observers in a concurrent survey, and blitz site 044 in a successive survey by observer AB also in round 2.

In abundance type calculations, the number off birds used is the sum of the GBCMA database variables 'intHeardcount' & 'intObservedcount'.

Every species is allocated to a guild and to a VWBC status and then the following rules are used to calculate the VWBC indices;

VWBC species total = VWBC Associated + VWBC Other+ VWBC Specific

VWBC species= VWBC Associated + VWBC Specific

Proportion VWBC = VWBC species ÷ VWBC species total

There are some species that are not VWBC listed and are not in the TLM database, these come up as 'VWBC missing' at the moment, so for total species richness in the surveys, there is one additional rule;

Total species = VWBC Associated + VWBC Other + VWBC Specific + vwbc Missing

Sandhill habitats in the TLM surveys are renamed as Pine habitats for the blitz Vs TLM habitat comparisons.

Grey-Shrike Thrush are not in the Atlas Australia database and are not included in guild type analyses.

The following species are not in the Ricky Webster guild tables;

Ground Cuckoo-Shrike, Little Wattlebird, Tawny Frogmouth, Yellow Rosella.

There are some inconsistencies in naming between the National Parks database and the Atlas Australia Database that need to be corrected within the analyses to allow calibration of guilds and status, etc. Several are corrected by converting all to capital letters, but the others include;

BLACK-FACED CUCKOO SHRIKE renamed as BLACK-FACED CUCKOO-SHRIKE

FANTAIL CUCKOO renamed as FAN-TAILED CUCKOO

MISTLETOE BIRD renamed as MISTLETOEBIRD

NANKEEN KESTRAL renamed as NANKEEN KESTREL

SUPERB FAIRY WREN renamed as SUPERB FAIRY-WREN

Appendix 4: Extra charts

The addition of the autumn and winter 2018 TLM data showed the continuation in trend of fewer Migratory and Nomadic species present. It also showed that total species richness tends to be lower than in the January to March period when the blitz and TLM summer surveys were taken. Another intuitive finding is that the number of insectivores dropped off after summer, which may coincide with the number off insects dropping off at the same time.

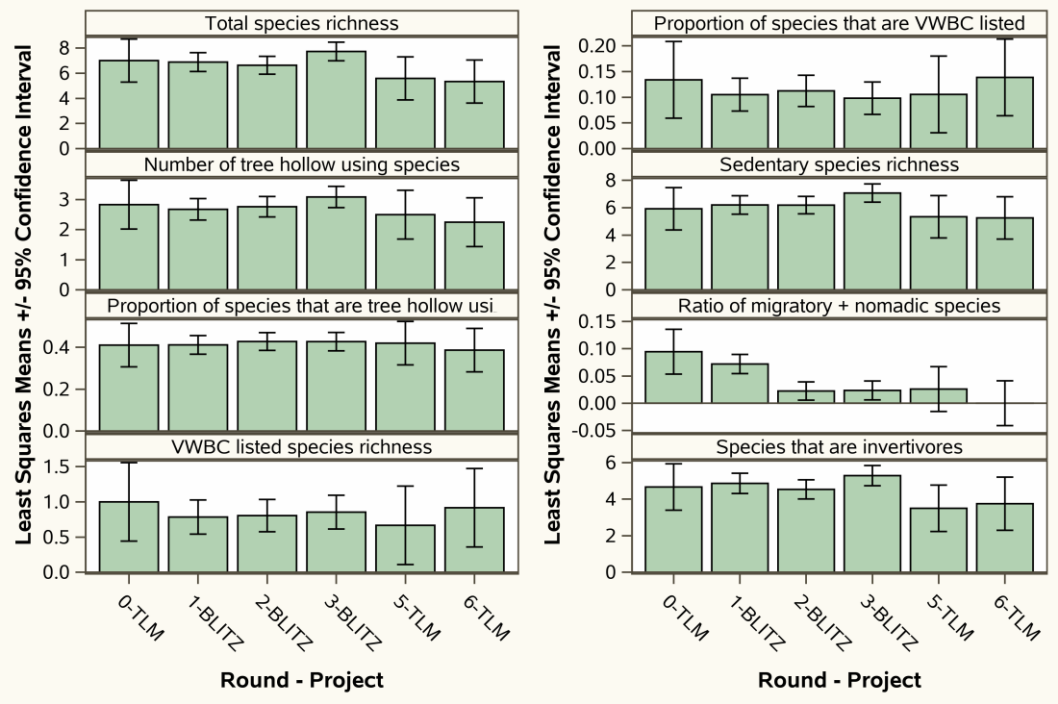


Figure A4.1 Addition on TLM Autumn (round 5) and winter (round 6) samples to the analyses.