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Effectiveness of woodland birds as taxonomic surrogates in conservation planning for biodiversity on farms

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ABSTRACT

Woodland birds are a commonly used taxonomic surrogate for other species groups in agricultural landscapes as they are relatively diverse, easily-studied, and charismatic. Yet, other taxa can respond to native vegetation on farms differently to woodland birds, challenging the present focus on birds in agri-environmental schemes. We aimed to assess the effectiveness of woodland birds as taxonomic surrogates for biodiversity in conservation planning on farms, in comparison with reptiles and arboreal marsupials. We used a complementarity-based approach to select patches of remnant and restored vegetation that supported a priori representation targets of species occurrences. We found that the spatial locations of vegetation patches selected to meet representation targets for woodland birds were 24%–69% different from the locations of patches selected for other taxa. The vegetation patches selected to meet representation targets for woodland birds failed to incidentally meet representation targets for other taxa, although targets for a subset of threatened woodland birds were exceeded. Conservation planning for woodland birds, however, led to higher incidental representation of the other taxa, compared with conservation planning for reptiles and arboreal marsupials. This indicates that woodland birds are a more effective taxonomic surrogate for biodiversity on farms compared to reptiles and arboreal marsupials. If the conservation goal is to conserve a broad array of biodiversity on farms, then the focus on woodland birds in agri-environmental schemes is justified. However, if the conservation of particular species or taxonomic groups is a priority, then conservation plans explicitly targeting these species or groups are required.

1. Introduction

A core challenge for conservation science is the lack of complete information on biodiversity, that is, a comprehensive inventory of all species of all groups in a given area (Williams and Gaston, 1994). This challenge is difficult to address directly, given insufficient resources to survey the myriad of species in ecosystems, as well as the spatial and temporal complexity of ecosystem processes. Instead, surrogates for biodiversity are used, for instance environmental attributes or taxonomic groups, that attempt to represent the full assemblages of species to some degree (Howard et al., 1998; Andelman and Fagan, 2000; Margules and Pressey, 2000; Sarkar et al., 2006; Rodrigues and Brooks, 2007).

Birds are the most commonly used taxonomic surrogate in terrestrial ecosystems (Eglington et al., 2012; Larsen et al., 2012; Westgate et al., 2014). They are a well-studied taxon, being highly detectable, easily identifiable, and inexpensive to survey compared with other vertebrate and invertebrate taxa. Their relatively high levels of species diversity, breadth of functional attributes, and heterogeneous distributions also contribute to their effectiveness in improving the efficiency of conservation planning and management (Lewandowski et al., 2010). Further, birds are a charismatic taxon garnering high public appeal, which makes them an ideal flagship group for conservation actions (Veríssimo et al., 2009).

In agricultural landscapes, birds are often the target group for agri-environmental initiatives (Guerrero et al., 2012), including restoration plantings and the protection of remnant vegetation. In Australia, most restoration initiatives aimed at improving biodiversity conservation (e.g. Lindenmayer et al., 2013) have focused on woodland birds. Woodland birds are defined here as species that occur in temperate woodland, not excluding species that also occur in grassland (Silcocks et al., 2005). There is a vast literature on woodland birds, exploring the importance of different vegetation attributes at patch and landscape scales (e.g. Watson et al., 2003; Radford et al., 2005; Barrett et al., 2008; Haslem and Bennett, 2008; Bowen et al., 2009; Hanspach et al., 2011; Ikin et al., 2014), and in conservation planning (Thomson et al., 2009; Ikin et al., 2016). Findings from these studies contribute to the evidence-base for conserving a broad array of biodiversity on farms. However, other

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research shows that other groups of vertebrate taxa that are more difficult to survey, for example mammals and reptiles, can respond differently to vegetation composition and structure compared to woodland birds (Cunningham et al., 2007; Jellinek et al., 2014; Michael et al., 2014; Yong et al., 2016). Such a discrepancy in responses to the landscape calls into question whether woodland birds are as good taxonomic surrogates for biodiversity on farms as they are supposed.

Our study aimed to assess the effectiveness of woodland birds as taxonomic surrogates in conservation planning for biodiversity on farms, in comparison with reptiles and arboreal marsupials. Agricultural landscapes, despite their highly modified state, can support high numbers of species (Yong et al., 2016), and systematic survey data on multiple taxonomic groups are rare (underscoring the necessity of using taxonomic surrogate approaches). We took advantage of the South West Slopes Restoration Study (Cunningham et al., 2007; Lindenmayer et al., 2016), which gathers detailed multi-taxon data across an extensive agricultural region of southeastern Australia. Using a complementarity-based approach, for each taxonomic group we identified patches of restored and remnant vegetation that together met a priori representation targets of species occurrence in the landscape. We asked:

1. Are the vegetation patches selected to meet representation targets for one taxon the same as vegetation patches selected for other taxa?
2. Which taxon achieved the best incidental representation of other taxa?

Given the relatively high species diversity and functional diversity of birds in the landscape, we predicted that a large number of restored and remnant vegetation patches would be needed to meet niche requirements (Moritz et al., 2001). Consequently, we expected that spatial concordance between these patches and those selected to meet representation targets for other taxa would be high, and therefore that conservation planning for woodland birds would be effective at incidentally representing other taxa - thus indicating that woodland birds are effective surrogates. However, we did not expect that the degree of spatial concordance or incidental representation would be identical between taxa (Lentini and Wintle, 2015). For instance, we predicted that conservation planning for all woodland birds in our agricultural landscape would be: (i) less effective than conservation planning targeted at a subset of threatened woodland birds (Beger et al., 2003), and (ii) more effective at representing arboreal marsupials, which may use the landscape at similar scales to birds and thus may have similar ecological requirements, compared to reptiles, which may use the landscape at smaller scales (Yong et al., 2016).

2. Methods

2.1. Study design

We conducted our study in a 150 km × 120 km area of the wheat-sheep belt of southeastern Australia, in the South West Slopes bioregion of New South Wales (Appendix A). Farms within this region typically have between 3% and 35% native vegetation cover, including remnant temperate box-gum *Eucalyptus* woodland, natural and coppiced regrowth, and restoration plantings (Cunningham et al., 2014). For this investigation, we focused on 189 patches of native vegetation (68 remnant woodland, 61 regrowth woodland, and 60 plantings), which together covered 1437 ha across 43 farms (Appendix B).

We collected two years of occurrence data for each of our taxonomic groups along a permanent 200 m transect established in each patch. Bird surveys were conducted in spring 2008 and 2011, with each transect visited twice in any given year between sunrise and mid-morning. Each visit involved five-minute point counts at the 0 m, 100 m and 200 m transect points. All birds seen or heard within 50 m of the point, but excluding those flying overhead, were recorded as present. Reptile surveys were conducted in spring 2008 and winter 2011, with each transect visited once between mid-morning and mid-afternoon. Each visit involved a twenty-minute active search of leaf litter, grass tussocks, coarse woody debris, surface rocks, and decorticating bark, between the 0 m and 200 m transect points. All reptiles seen within 50 m were recorded as present. Visits also involved inspecting arrays of artificial refuges (four wooden railway sleepers, four terracotta roof tiles, and one double stack of 1-m^2 corrugated steel sheet) placed at the 0 m and 100 m transect points. Arboreal marsupial surveys were conducted in autumn 2008 and winter 2011, with each transect visited once between sunset and midnight. Each visit involved a twenty-minute spotlight survey between the 0 m and 200 m transect points, walking at an average speed of 3 km/h. All species seen or heard were recorded as present.

2.2. Data analysis

We restricted our analysis to species recorded at least twice over the two survey years (Table 1; Appendix C). This enabled us to exclude vagrant species. This gave 72 species of woodland birds (Silcocks et al., 2005); a subset of 10 species of listed birds (woodland birds listed as threatened in New South Wales in 2016 under the *Threatened Species Conservation Act 1995*; hereafter referred to as a separate taxon for simplicity); three species of arboreal marsupials; and 22 species of reptiles.

For each taxonomic group, our objective was to find complementary sets of patches that met a priori representation targets of species occurrences while minimizing the combined area (ha) of the patch set, irrespective of spatial configuration (note that this objective of minimizing the area of vegetation needed to meet representation targets is not intended to identify "unnecessary" vegetation patches, but instead constrain the analyses to best compare surrogate efficacy). To do this, we used Marxan, a decision-support software program that uses a simulated annealing algorithm to solve the minimum set problem (Ball et al., 2009). We created a conservation feature representing patch occurrence of each species in each survey year (two features per species, e.g. for woodland birds we created 144 conservation features in total), following Ikin et al. (2016) and Runge et al. (2016). We set representation targets of 25%, 50%, and 75% occurrence of species in every year (equivalent to 25%, 50%, and 75% of patches where each species occurred). For every combination of taxon and representation target (12 in total), we performed 100 Marxan runs to identify the best patch set. The best patch set was defined as selected patches of vegetation that represented the target of species occurrences in the landscape over the two study years (e.g. 25% representation of woodland bird species occurrences, while ignoring the occurrences of arboreal marsupials and reptiles) for the least combined area. To confirm that patch selection for woodland birds was not sensitive to the subset of listed birds, we re-ran the analyses for woodland birds excluding listed species.

To answer our first question (*Are the vegetation patches selected to meet representation targets for one taxon the same as vegetation patches selected for other taxa*?), we assessed the spatial concordance between the best patch sets for each taxon and representation target. To do this, we calculated Bray-Curtis dissimilarity (adjusted for presence-absence data) between each pair of best patch sets, with low dissimilarity indicating that the spatial locations of the selected patches were similar.

To answer our second question (*Which taxon achieved the best incidental representation of other taxa*?), we assessed how well the best patch sets selected for one taxon represented the occurrences of species in each of the other three taxa. To do this, we calculated the average minimum percent occurrence of each species per taxon that was met over the study period under each best patch set. Incidental representation is a direct measure of surrogate efficacy (Grantham et al., 2010) – the higher the incidental representation of other taxa a particular taxon achieves, the more effective that taxon is as a taxonomic surrogate.

3. Results

Woodland birds were the most species-diverse taxon of the three taxa we studied, every study patch supported at least one woodland

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