Biological Conservation 188 (2015) 89–99

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Special Issue Article: Tropical Insectivores

Integrating life history traits and forest structure to evaluate the vulnerability of rainforest birds along gradients of deforestation and fragmentation in eastern Australia

David C. Pavlacky Jr. [a,*], Hugh P. Possingham [a,b], Anne W. Goldizen [a]

[a] School of Biological Sciences, The University of Queensland, Brisbane, Queensland 4072, Australia
[b] Centre for Biodiversity and Conservation Science, School of Biological Sciences, The University of Queensland, Brisbane, Queensland 4072, Australia

ARTICLE INFO

Article history:
Received 1 April 2014
Received in revised form 31 August 2014
Accepted 15 October 2014
Available online 22 November 2014

Keywords:
Community ecology
Deforestation
Gondwana Rainforests of Australia
Landscape ecology
Multi-species conservation
Rainforest fragmentation

ABSTRACT

The management of rainforest ecosystems for multi-species conservation must assess the impacts of habitat degradation at different spatial scales as well as determine which species are vulnerable to landscape change. Our research objectives were to (1) evaluate the effects of life history traits on the patch occupancy and vulnerability of rainforest birds, (2) determine the relative effects of stand, landscape and patch structure on species richness, and (3) evaluate the relative contributions of deforestation and fragmentation to species richness. We collected presence–absence data for 29 bird species in 46 rainforest patches in South East Queensland, Australia. We used a multi-species occupancy model that accounted for incomplete detection to evaluate hypotheses for occupancy and species richness. Avian occupancy was strongly influenced by life history traits, including population density, foraging behavior, dispersal strategy, clutch size, *body mass* and diet. Sedentary species with low population sizes, low clutch sizes, large body sizes and insectivorous diets, such as the ground-dwelling Albert's Lyrebird (*Menura alberti*) and canopy-dwelling Paradise Riflebird (*Ptiloris paradiseus*), were the most vulnerable to landscape change. After accounting for life history, the positive effect of stand basal area was the best predictor of species richness followed by the positive effects of rainforest and dry eucalypt forest in the landscape, with less support for the positive effect of patch size and negative effect of patch isolation. Deforestation was more detrimental to the bird community than rainforest fragmentation. Conservation actions that retain high stand basal area, promote unmodified landscape mosaics and maintain moderate patch sizes near large rainforest tracts are expected to be effective strategies for managing the rainforest bird community. Landscape conservation strategies to minimize habitat loss are expected to be more effective than managing the configuration of rainforest patches.

1. Introduction

The management of rainforest ecosystems must weigh the biological impacts of habitat degradation at local scales against those of regional deforestation and forest fragmentation (Gardner et al., 2010; Powell et al., 2015-a). Single-scale investigations have contributed much to our understanding of species' vulnerability in rainforest systems (e.g. Ferraz et al., 2007), but it is also important to consider the relative impacts of habitat degradation at different spatial scales (Colorado and Rodewald, 2015; Gardner et al., 2009; Moura et al., 2013). There is increasing evidence that vegetation composition at landscape scales can moderate habitat degradation at stand and patch scales (Driscoll et al., 2013; Kennedy et al., 2011). Habitat loss at the landscape scale is expected to have large negative effects on biodiversity (Ewers and Didham, 2006; Fahrig, 2003), but habitat degradation at the stand scale (Hill and Hamer, 2004) and forest fragmentation at the patch scale (Laurance, 2008) often have positive, neutral and negative effects on biodiversity. Landscape management for the conservation of biodiversity must address the requirements of the most imperilled species, and at the same time, maintain the integrity of the entire bird community (Burgman et al., 2005). However, because species show different responses to habitat loss and fragmentation, landscape conservation for a small number of indicator species may not ensure the persistence of all species in the community (Lindenmayer et al., 2002). Maximizing species richness is another approach for conserving multiple species, but simply counting the number of species in a community does not

* Corresponding author at: Rocky Mountain Bird Observatory, 14500 Lark Bunting Lane, Brighton, Colorado 80603, USA.
E-mail address: david.pavlacky@uqconnect.edu.au (D.C. Pavlacky Jr.).

http://dx.doi.org/10.1016/j.biocon.2014.10.020

provide information about species composition (Hill and Hamer, 2004).

Determining which species and life history traits are vulnerable to landscape change within species-rich assemblages is another important challenge for the management of rainforest ecosystems (Newbold et al., 2013; Powell et al., 2015-a). Species from subtropical and tropical rainforests are particularly vulnerable to the degradation, fragmentation and deforestation (Bregman et al., 2014; Sodhi et al., 2008; Stratford and Robinson, 2005). Many rainforest bird species possess a suite of life history traits related to extinction proneness (Sodhi et al., 2004), including low abundance, specialized habitat, low dispersal ability, low reproductive potential, high area requirements, restricted ranges and specialized diets (Henle et al., 2004; Lee and Jetz, 2011). In many rainforest ecosystems, understory and terrestrial species with insectivorous diets are particularly vulnerable to landscape change (Cordeiro et al., 2015; Sekercioglu et al., 2002). This set of life history traits has led to the hypothesis that rainforest birds may be more sensitive to habitat fragmentation than habitat loss (Fahrig, 2003; Sodhi et al., 2008), with important implications for the management of landscapes for conservation (Fischer and Lindenmayer, 2007; Laurance, 2008). When species are impacted by forest fragmentation to a greater extent than the absolute loss of forest cover, then managing the configuration of forest patches can mitigate against the negative effects of deforestation (Kareiva and Wennergen, 1995).

Modeling life history variation within species richness models can advance multi-species conservation by providing additional information on species composition and vulnerability. Life history traits are thought to influence the fundamental distributions of species prior to environmental effects on the realized distributions (McGill et al., 2006). Because patch occupancy is directly related to metapopulation viability (Schnell et al., 2013), we suggest the effects of life history traits on patch occupancy can provide a metric of species' vulnerability to landscape change. Our research objectives were to (1) evaluate the effects of life history traits on the patch occupancy and vulnerability of rainforest birds, (2) determine the relative effects of stand, landscape and patch structure on avian species richness and (3) evaluate the relative contributions of deforestation and fragmentation to species richness in rainforests of South East Queensland, Australia. We developed multi-species occupancy models to represent multiple working hypotheses (Burnham and Anderson, 2002) for processes affecting detection, occupancy and species richness of rainforest birds (Supplementary material).

2. Materials and methods

2.1. Study area

The study area covered ~8000 km^2 (27°30′S – 28°23′S, 152°30′E – 153°38′E) along the Border Ranges within the South East Queensland Biogeographic Region (Fig. 1). Although located south of the Tropic of Capricorn (23°26′S), the rainforests of this region share evolutionary and biogeographic history with rainforests of the Wet Tropics (Kooyman et al., 2011), with ancient origins in a previously widespread and diverse tropical (megatherm) flora (Webb et al., 1984). The mean annual temperature was 19 °C, with annual precipitation > 1700 mm and ~1100 mm for the complex notophyll and microphyll–notophyll vine forests, respectively (Webb et al., 1984). Considered to be the most important mesic refugium in the region, the rainforests of Border Ranges have the greatest rainfall, environmental stability and species endemism outside the Wet Tropics (Weber et al., 2014). The rainforests in this region are exceptionally rich in primitive and relict plant and animal species, and the avifauna is composed of species with both tropical and temperate origins (Hunter, 2004). The study area included several World Heritage sites within the Gondwana Rainforests of Australia (UNESCO, 1994). Lowland notophyll vine forest is listed as a critically endangered ecological community by the Commonwealth Environment Protection and Biodiversity Conservation Act (1999), and complex notophyll and microphyll–notophyll vine forests are listed as endangered by the Queensland Vegetation Management Act (1999).

Landscape change following European settlement began in the early 1900s, and by 1920, large areas of rainforest and eucalypt forest were converted into pasture for livestock grazing, after which many of the remaining rainforest stands were selectively logged. A comparison of current forest structure and a reconstruction of pre-European settlement forest structure (EPA, 2004) indicated rainforest cover declined by 52%, from 8% to 4% of the region. Mean rainforest patch size declined by 67%, from 221 ha to 74 ha, and patch number increased by 39%.

2.2. Sampling design and bird surveys

We used a random sample design stratified by rainforest type and patch size to select 46 rainforest patches from the study area. The rainforest patches were represented by bounded regions of discrete rainforest vegetation as measured in the New South Wales (NPWS, 1999) and the Queensland (EPA, 2004) land cover data. We

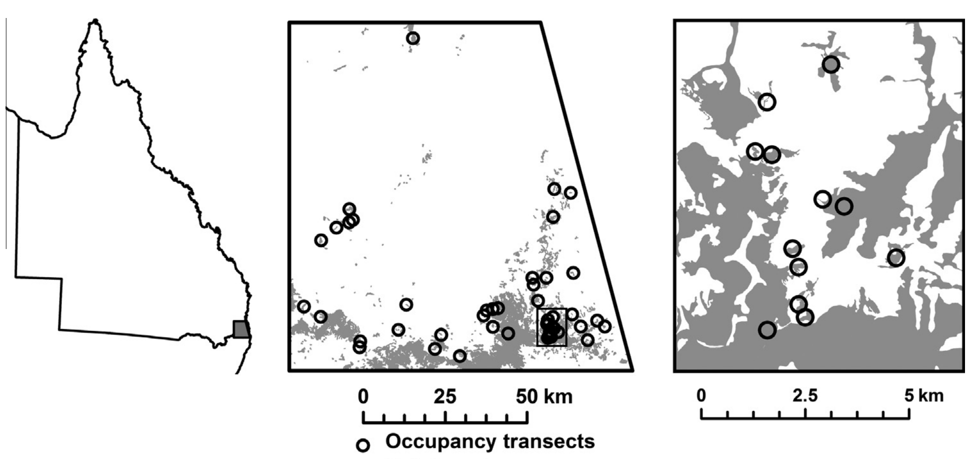

Fig. 1. Map of the regional study area in South East Queensland, Australia. The map of the regional study area depicts the location of the occupancy transects and the distribution of rainforest in the region, and the inset illustrates the location of the occupancy and distribution of rainforest on the Springbrook Plateau.