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Avian biodiversity in multiple-use landscapes of the Brazilian Amazon

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ABSTRACT

Habitat loss and degradation is the most pervasive threat to tropical biodiversity worldwide. Amazonia sits at the frontline of efforts to both improve the productivity of tropical agriculture and prevent the loss of biodiversity. To date our understanding of the biodiversity impacts of agricultural expansion in Amazonia is restricted to findings from small scale studies that typically assess the importance of a limited number of land-use types. Here we investigate local and landscape-scale responses of Amazonian avian assemblages to land-cover changes across a gradient of land-use intensity ranging from undisturbed primary forest to mechanised agriculture in 36 drainage catchments distributed across two large regions of the eastern Brazilian Amazon. We found that species richness of forest-associated birds declined progressively along this gradient, accompanied by marked shifts in assemblage composition. We found significant changes in species composition, but not richness, between primary forests that had been subject to different levels of disturbance from logging and fire. Secondary forests retained levels of species richness intermediate between primary forests and production areas, but lacked many forest-dependent species. Production areas (arable crops, cattle pastures and plantation forests) all retained far fewer species than any forest habitat, and were largely dominated by taxa commonly associated with open areas. Diversity partitioning revealed that species composition varied the most among undisturbed forest transects, and steadily decreased with increasing forest degradation and land-use intensity. Our results emphasise the importance of protecting both remaining areas of primary forest in private lands, as well as protecting the same forests from further disturbance events.

1. Introduction

In the tropics, land-use change has been the principal driver of biodiversity loss (Sala et al., 2000; Hooper et al., 2012) and ecosystem function impairment (Cardinale et al., 2012). Understanding the impacts of land-use change on patterns of species occurrence and abundance is of fundamental importance for developing effective conservation strategies (Gardner et al., 2009; Waltert et al., 2011; Balmford et al., 2012).

In the Brazilian Amazon, despite significant reductions in deforestation, 4656 km^2 of forest were still lost in 2012 (INPE, 2013). The loss and degradation (e.g. from timber extraction, fire and over-exploitation of non-timber forest products) of primary forest remains the most important threat facing the biodiversity of the region (Peres et al., 2010), and is being driven by agricultural expansion (Davidson et al., 2012) and catalysed by major infrastructure improvements including road building and paving projects (Fearnside, 2007; Fearnside et al., 2012).

Although the impacts of forest loss, fragmentation and degradation on Amazonian biota are now increasingly understood, the majority of existing studies are limited in their spatial scale, concentrated in well-studied areas of the region, and have tended to focus on either fragmentation, forestry or fire impacts over a narrow range of land-uses (see reviews in Gardner et al., 2009; Peres et al., 2010; Laurance et al., 2011). In addition the vast majority of studies assessing the impacts of land-use change on biodiversity across the tropics have been limited to site-based assessments, despite increasing evidence indicating that landscape scale characteristics (such as the loss of total forest cover) can have a major

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influence on local species distribution patterns (e.g. Bennett et al., 2006; Pardini et al., 2010). As a consequence, insights into the impacts of multiple land-uses on Amazonian biota have up until now remained largely within the domain of meta-analyses (e.g. Barlow et al., 2006), which do not account for important differences in landscape context.

Here we evaluate avian responses to changes in forest disturbance and land-use across nearly 400 study sites distributed across 36 catchments in two different regions of the Brazilian Amazon, encompassing the full gradient of dominant Amazonian land-use types. Birds are excellent indicators of the ecological consequences of disturbance because their ecology is relatively well known, they are relatively easy to identify and cheap to survey (provided expert field observers can be sourced), and they exhibit a broad range of interspecific responses to human impacts at spatial and temporal scales that can be readily interpreted by snap-shot field assessments (Howard et al., 1998; Lees and Peres, 2006; Gardner et al., 2008).

We have three main aims. First we assess the loss of bird species (total number of species and number of primary forest-associated species separately) along a gradient of human impact from undisturbed primary forest through primary forest that has been varyingly disturbed by logging and fire, secondary re-growth, plantation forests, pastures and mechanised agriculture. This assessment contributes important information towards debates regarding the relative biodiversity value (compared to a primary forest baseline) of production areas (Peres et al., 2010; Mahood et al., 2012), secondary forests (Dent and Wright, 2009), and forests degraded by fire and logging compared to relatively undisturbed primary forest (Barlow et al., 2006). Second, we compare patterns of avian species richness across catchments (separate landscapes) distributed along a gradient of deforestation in each study region, providing the first assessment of how changes in total forest cover can influence landscape-scale patterns of diversity in multiple-use tropical forest regions. Third, we investigate how patterns of avian diversity are partitioned across multiple spatial scales and within each major land-use type, from point counts to transects to landscapes, and ask whether differences in total forest cover explain these patterns through relative contributions of the α, and β diversity components (Tylianakis et al., 2006).

2. Methods

2.1. Study regions and experimental design

This study was conducted in two regions of eastern and central Pará state (Fig. 1), Brazilian Amazonia, in the municipalities of Paragominas (PGM) between 28 July and 20 November 2010 and 18–29 May 2011 (NGM and ACL) and in Santarém/Belterra (STM) between 16 October 2010 and 8 February 2011 (NGM, ACL, CBA and BJWD). Both regions have been heavily impacted by deforestation but have significant differences in their historical trajectory of colonization and both past and present land-uses (Gardner et al., 2013). The municipality of Paragominas (1.9 Mha) is located in north-east Pará state, 300 km south-east of Belém. The average

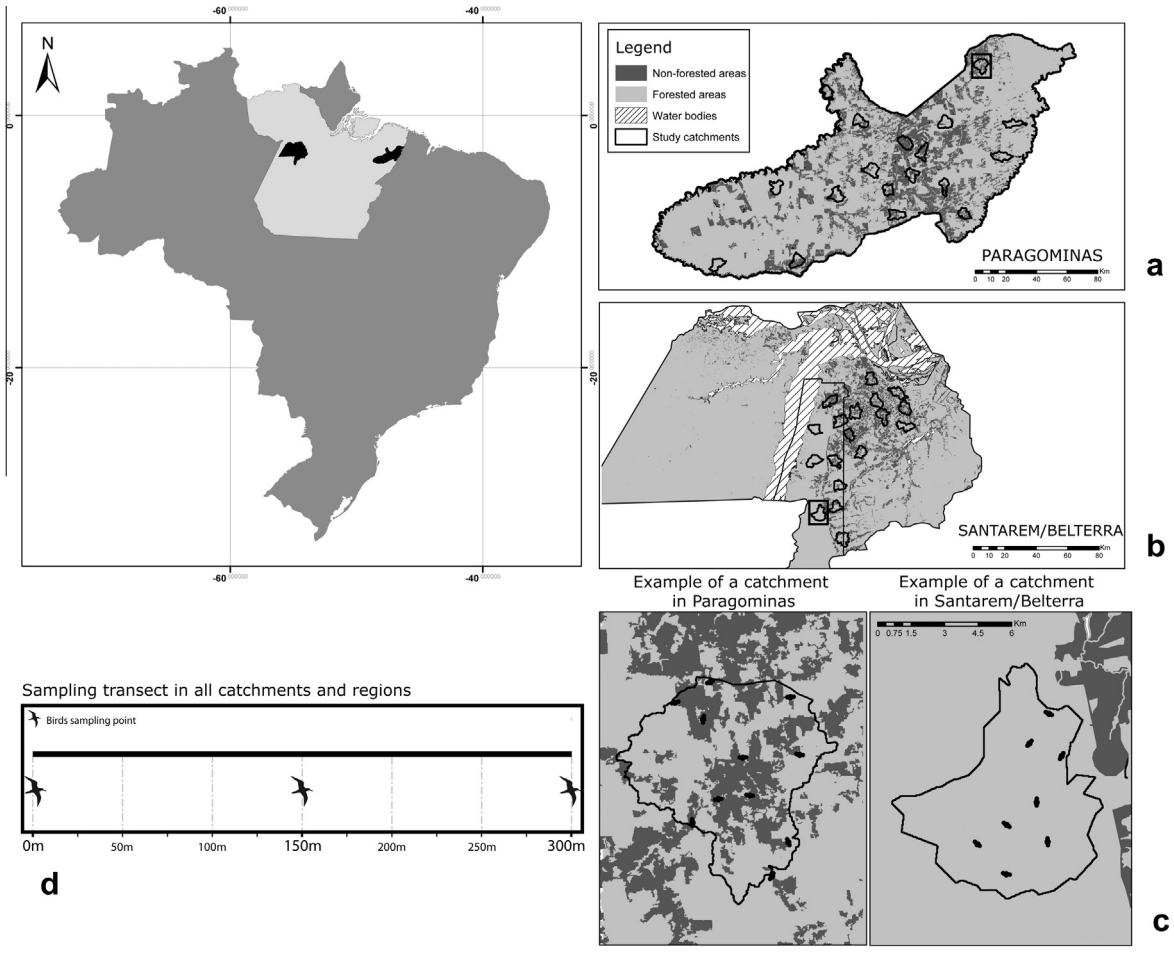

Fig. 1. Map of Paragominas (a) and Santarém/Belterra (b) showing the location of the 18 catchments surveyed in each municipality. Two example catchments are presented for each municipality in (c) showing the location of transects and transects design and positioning of point count stations (d).