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Impacts of extractive forest uses on bird assemblages vary with landscape context in lowland Nepal

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ABSTRACT

Forest use practices such as logging, lopping of tree branches for fodder, and grazing do not reduce forest area but disturb forest structure and impact biodiversity. Although such forest disturbances can be key determinants of the biota occupying a site, rarely is the interaction between disturbance intensity and landscape context considered, despite its relevance to conservation management. We investigated the influence of site-and landscape-level habitat characteristics on birds, and explored whether the effects of site-level disturbance on bird richness varied with forest extent in lowland landscapes in Nepal. While extractive uses reduced forest structural complexity and altered the avifaunal community of a site, the intensity of such effects depended on the extent of forest in the surrounding landscape (19.6 km^2). The extent of forest, large tree density, and tree canopy cover were important predictors for all bird response groups. However, the effect of forest extent on bird richness was stronger for sites with greater disturbance intensity. Managing and restoring landscapes to support greater forest cover may not only have a positive direct effect on bird conservation, but may also help to compensate for site-level disturbance, such as characterises multiple-use forests worldwide.

1. Introduction

In recent decades, anthropogenic activities have been the principal cause of habitat loss and degradation worldwide (Millennium Ecosystem Assessment, 2005; Foley et al., 2005; Ellis and Ramankutty, 2008). However, anthropogenic habitat degradation is greater in areas of high population density and poverty. Such areas are mainly in developing countries (Laurance, 2010) where a significant proportion of the population live near the forests (Hegde and Enters, 2000; Millennium Ecosystem Assessment, 2005). About one billion people living in developing countries rely on forest-based products, primarily for subsistence livelihoods (Chao, 2012). This has resulted in extensive use of forest resources, for timber and firewood, cutting of tree canopy for fodder, livestock grazing and collection of non-timber forest products (Chettri et al., 2002; Shahabuddin and Kumar, 2007; Christensen et al., 2009). Thus, managing forests for biodiversity conservation while satisfying human demands for forest products is a major global conservation challenge (Chappell and LaValle, 2011).

Anthropogenic activities can reduce the forest area and also cause significant changes in forest structure and composition (Chettri et al., 2002; Sagar and Singh, 2004; Shahabuddin and Kumar, 2006). Repeated extraction of timber resources reduces tree basal area, tree height, canopy closure, and regeneration capacity (Sundriyal and Sharma, 1996; Mishra et al., 2004; Sapkota et al., 2010). For example, removal of live trees increases light levels in the forest, thereby modifying canopy structure (Sekercioglu, 2002; Villela et al., 2006), altering tree density and diversity (Moktan et al., 2009), and changing understorey characteristics (Aleixo, 1999; Moktan et al., 2009). Other forms of extraction of woody biomass such as lopping of tree branches affects canopy structure. Livestock grazing also simplifies the understory forest structure and reduces regeneration, foliage density, canopy height, and vegetation cover (Tasker and Bradstock, 2006; Piana and Marsden, 2014). Such loss of structural components in forests ultimately affects populations of many species reliant on forest habitat (Díaz et al., 2005; Lee and Carroll, 2014).

Habitat variables measured at the site-scale (<1 ha), however, may not be sufficient for meaningful prediction of species responses to disturbance type and intensity. Rather, the local effects of such anthropogenic disturbances on forest fauna may also depend on the landscape context (100–1000 s ha) in which a site is embedded. Increasingly, faunal communities are being shown to be affected strongly by the proportion of forest habitat in a landscape (McGarigal and McComb, 1995; Trzcinski et al., 1999; Radford et al., 2005; Ewers and Didham, 2006; Smith et al., 2011). It is

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therefore plausible that landscape-scale variables, such as the extent of forest, may actually moderate the effects of site-scale anthropogenic impacts on faunal communities, and vice-versa. Yet knowledge of such interactions between the extent of forest in the landscape and the impact of forest disturbances remains limited.

In this study, we first investigated the effects of anthropogenic disturbance on vegetation structure and consequences for bird communities in the lowland Terai forests of Nepal. This region is dominated by the highly productive *Sal* forests, which are facing significant anthropogenic pressure from extractive and grazing uses. The economy of rural communities in the region is based largely on subsistence agriculture, livestock rearing, and selling of firewood and non-timber forest products (Sharma, 1990). Such activities have contributed elsewhere to a decline of many forest bird species (Inskipp et al., 2013; Baral et al., 2014), particularly species with small home range and/or other ecological requirements (Inskipp, 1989).

Second, we modelled the effect of the interaction between landscape context and disturbance intensity on the bird assemblages of these forests. We hypothesized that forest disturbances will negatively affect vegetation structure and bird communities, but that disturbance intensity will interact with the extent of forest in the landscape to affect the avifauna of a site. Specifically, our main objectives were to: (1) determine whether the vegetation characteristics and species richness and abundance of forest bird assemblages varied with logging, grazing, and lopping intensity; and (2) assess the relative importance of site-and landscape-scale forest habitat characteristics on bird species richness and abundance and the existence of any interaction effects between disturbance intensity and landscape context.

2. Materials and methods

2.1. Study area

The study was conducted in southern Nepal, also called 'Terai' (80°4′30″ to 88°10′19″E 26°21′53″ to 29°7′43″N, elevation 63–330 m ASL). The Terai encompasses most of the country's tropical moist forest from the Mechi River in the east to the Narayani River in the centre. The annual rainfall decreases from 2680 mm to 1138 mm from east to west, and the mean monthly rainfall ranges from 8 mm in November to 535 mm in July (FRA/DFRS, 2014). The area is characterized by a tropical climate, with the maximum monthly mean temperature of 35–40 °C in April/May and the minimum, 14–16 °C, in January (Jackson et al., 1994). Before 1950, the region supported continuous dense tropical forest. With the eradication of malaria in the early 1950s, large tracts of the highly productive lowland forests were converted to agriculture (Hrabovszky et al., 1987). Consequently, most of the forest was destroyed and the remaining forest areas were subjected to intense human exploitation. Nearly half of Nepal's population now lives in the 17% of the country that is lowland (Central Bureau of Statistics, 2011).

2.2. Study sites and landscapes

Twenty-eight landscapes, each 5 km × 5 km, and supporting different amounts of forest cover (7.9–95.3%), were selected across south-central (Bara-Parsa forest and Chitwan forest) and south-eastern lowland Terai forests (eastern forests) (Fig. 1). Geographically, 15 landscapes were located in eastern Terai forests and 13 landscapes were located in central lowland Terai forests. Four survey sites, each measuring 200 m × 50 m, were randomly located in each landscape, resulting in a total of 112 sites (28 landscapes × 4 sites). The non-forested part of landscapes in this region is mainly comprised of a mixed land-use type that includes rural towns, agriculture and agro-forestry. All sites were located at least 500 m from roads to minimize any road-induced variation in bird assemblages. The minimum distance between sites was at least 1000 m to reduce the chance of spatial dependence.

2.3. Bird surveys

At each study site, birds were surveyed on three occasions between November 2012 and May 2013. On each visit, the observer (BRD) recorded all birds seen or heard within 25 m of the centreline of the transect while walking along its length over a 10-min period. Prior to the data collection, we tested for visibility of birds within 50 m and 25 m of the transect, and found that visibility beyond 25 m was challenging. To reduce the risk of sampling bias (Järvinen and Väisänen, 1975), we used a rangefinder to help ensure all birds counted were within the fixed belt transect.

Surveys were conducted only between 0600 and 1100 h in the morning and 1400 to 1745 in the afternoon. Although the effects

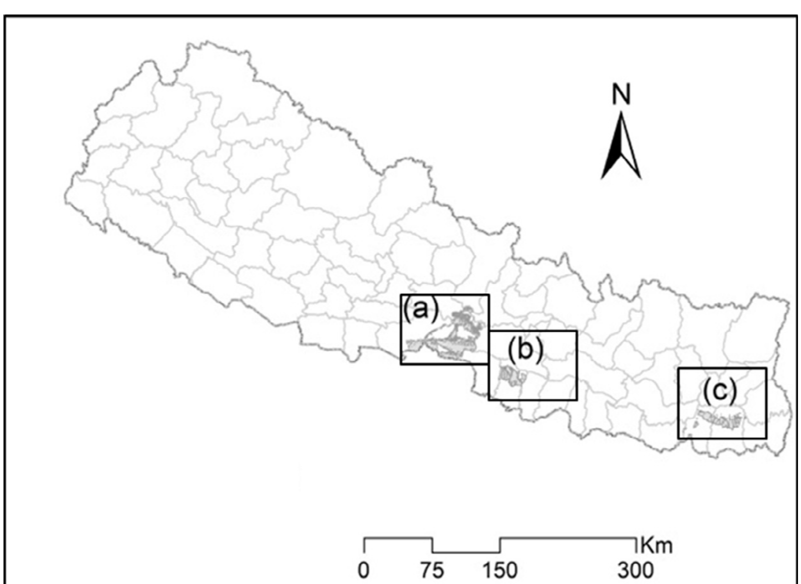

Fig. 1. Location of the three study regions in Nepal: (a) Chitwan forest, (b) Bara-Parsa forest and (c) Eastern forest.