



## Six years of habitat modification in a tropical rainforest margin of Indonesia do not affect bird diversity but endemic forest species

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### ABSTRACT

Studies on temporal changes of tropical bird communities in response to habitat modification are rare. We quantified changes in bird assemblages at the rainforest margin of Lore Lindu National Park, Central Sulawesi, over an interval of 6 years. Standardized bird counts were conducted in the years 2001/2002 and 2008 at 15 census points representing natural forest, secondary forest, agroforest and openland sites. Although overall species richness remained nearly identical, different species groups were affected unequally by habitat modification within the forest margin landscape. The mostly endemic forest species declined in abundance (72.0% of forest species) and were detected at fewer census points in 2008 (56.0%). In contrast, 81.8% of the solely widespread openland birds became more abundant and 63.6% of the species were recorded at a larger number of census points. Hence, recent human activities in the forest margin ecotone negatively affected species of high conservation value. Species richness turned out to be a poor indicator of habitat change, and our results underline the importance of considering species identities. Biotic homogenization as result of habitat conversion is a global phenomenon. In our study, the winners were widespread openland species, while the losers were endemic forest birds. In conclusion, our study shows that 6 years of land-use change had negative impacts on bird community structure and endangered species, but not on overall bird species richness.

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### 1. Introduction

Deforestation in tropical regions contributes substantially to global biodiversity loss (Balmford and Long, 1994; Pimm et al., 2006) and has therefore become a major issue in conservation biology (Sekercioglu and Sodhi, 2007). An increasing number of studies have focused on the effects of habitat disturbance and land-use intensification on tropical biodiversity, generally reporting a negative impact (Bawa and Seidler, 1998; Lawton et al., 1998; Marsden, 1998; Brooks et al., 2002; Lambert and Collar, 2002; Donald, 2004; Schulze et al., 2004; Waltert et al., 2004, 2005a,b; Tscharntke et al., 2005; Veddeler et al., 2005; Aratrakorn et al., 2006; Peh et al., 2006). However, many predictions of species loss caused by habitat modifications have been criticized because the potential of human-dominated habitats and secondary forests to maintain biodiversity over the long term is largely unknown (Waltert et al., 2004). Furthermore, estimated rates of loss of populations in tropical areas due to land-use changes are much higher than species extinction

rates but have received relatively little attention (Hughes et al., 1997; Marsden, 1998).

Several studies have reported a significant decrease of forest bird species at various localities within Southeast Asia as a result of deforestation (Castelletta et al., 2000; Brook et al., 2003; Peh et al., 2006) or forest replacement by commercial tree plantations (Zurita et al., 2006). This region hosts an enormous species richness and high rates of endemism, but also has one of the highest deforestation rates (Achard et al., 2002). It is thus a primary focus for conservation biology research (Brooks et al., 1997; Riley and Mole, 2001; Lambert and Collar, 2002; Waltert et al., 2004; Sodhi et al., 2005; Peh et al., 2006). Within the region, the island of Sulawesi, a global biodiversity hotspot (Myers et al., 2000), is known for its alarming rate of deforestation (Sodhi et al., 2004). The island is one of the globally most important endemic bird areas (Stattersfield et al., 1998). Mainland Sulawesi hosts 10 endemic bird genera and a resident avifauna of 224 land and freshwater species of which 41 (18%) are endemic (Coates et al., 1997). Based on data from two survey periods separated by 6 years, the aim of this study was to quantify the impact of recent land-use changes and small scale deforestation on the bird fauna at the margin of Lore Lindu National Park in Central Sulawesi.

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In particular, we addressed the following questions:

- (1) Did species richness change within a time period of 6 years in response to ongoing human activities at the forest margin?
- (2) Did land-use change facilitate species turnover or alter species composition?
- (3) Do range size (endemic vs. widespread species), habitat affiliation (understorey vs. canopy species) or feeding mode affect response to habitat modification?
- (4) What are the consequences of forest margin modification for conservation?

We expect the ongoing exploitation of the forest margin, particularly by illegal small-scale logging activities, to have a negative effect on the entire bird assemblage in the transition zone between closed forest and the adjacent human-dominated landscape. Endemic species and understorey birds are known to be particularly sensitive to habitat modification (Waltert et al., 2004; Abrahamczyk et al., 2008; Schulze and Riedl, 2008). Although a substantial number of forest species are able to utilize land-use systems such as agroforests (Greenberg et al., 1997), the value of the human-dominated countryside for forest birds may have additionally been altered due to an intensification of agroforestry system management. This could result in an increasing dominance of disturbance-tolerant birds, often represented by widespread species (Schulze and Riedl, 2008). Results of this study will help evaluate the sustainability of current land-use practices at the forest margin transition zone with respect to maintaining bird diversity within a complex mosaic of habitats at the margin of Lore Lindu National Park.

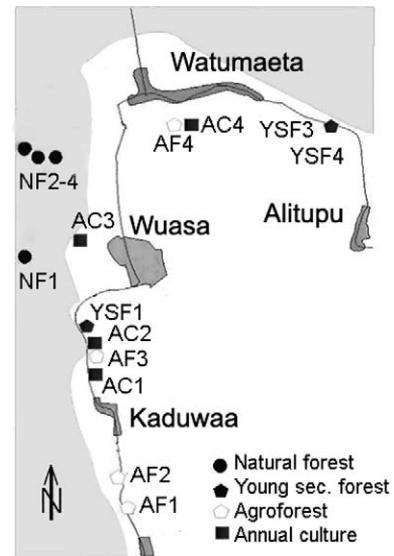
## 2. Methods

### 2.1. Study area and study sites

The study area is located in Central Sulawesi, Indonesia, approximately 75 km southeast of the province capital Palu, at the eastern margin of Lore Lindu National Park. The area was declared a UNESCO Man and Biosphere Reserve in 1977; the national park was established in 1993 and covers an area of 229,000 ha (Adiwibowo, 2005). The Lore Lindu National Park is an exceptionally species-rich area harboring approximately 78% of Sulawesi's endemic birds (Coates et al., 1997).

The forest margin landscape bordering continuous near-primary forest is characterized by a mosaic of secondary forests, young fallows, and several land-use systems with cocoa, coffee, maize and rice as the main crops (Schulze et al., 2004). Our study sites were situated at the northern tip of Napu Valley between 1100 and 1200 m ASL. This area comprises the elevational range of the lower montane forest zone (Whitten et al., 1987) with a mean annual precipitation of over 3000 mm (Schweithelm et al., 1992). Human settlement in the Napu valley is ancient, as indicated by remnants of a megalithic culture and large extensions of grasslands in the south of the region several hundreds years of age (Wibke Kirleis, personal communication). Satellite images from 1972, 1983 and 2001 (Stefan Erasmi, personal communication) show that the northern tip of the valley was dominated by a patchwork of agricultural plots and forests until the 1980s, but most forest outside of the border of the National Park was converted to other land-uses between 1983 and 2001, probably in the 1990s. Land-use conversion inside the national park mostly took place after 2001. Historical aspects of the area including land-use are covered by Burkard and Fremerey (2008).

In 2008, bird counts were conducted at 15 census points with a minimum distance of 50 m (Fig. 1), at which birds were already



**Fig. 1.** Bird census points at the margin of Lore Lindu Nationalpark in the vicinity of the villages Wuasa, Watumaeta, Alitupu and Kaduwaa which are connected by a well established road which provides relatively easy access to the forest area (indicated in grey). The white area represents several types of land use systems (e.g. rice fields, cacao plantations, coffee plantations).

surveyed in 2001/2002 (Schulze et al., 2004; Waltert et al., 2004). At that time, anthropogenic disturbance such as illegal selective logging or uncontrolled collection of rattan was already visible at the forest margin (Waltert et al., 2004). Waltert et al. (2004) selected four replicate sites for each of the four studied habitat types, near-primary forest (NF1–4), young secondary forest (YSF1–4), agroforestry system (AF1–4), and annual culture (AC1–4). However, only three YSF sites were used for further analyses because one site (YSF2) was logged during the first survey period in 2001/2002 before the bird census could be finished.

Only few sites remained in a similar condition compared to the first bird census period in 2001/2002. Habitat changes, which occurred between the first bird survey (Waltert et al., 2004) and the re-survey in 2008, are summarized in Table 1. Sites were relocated using GPS and the field experience of the last author who was involved in the initial site selection in the years 2000–2001.

### 2.2. Bird survey

We used the same survey method as in Waltert et al. (2004). To reduce seasonal effects, our second survey was conducted during a time frame (January–February 2008) similar to the first survey (December 2001–February 2002; Waltert et al., 2004). During point counts, all birds detected visually and acoustically within a radius of 50 m from the observer were recorded within 20 min. We tried to ensure that the same individual was not counted more than once. A digital rangefinder was used to measure and estimate distances. All observations beyond 50 m, including those individuals that flew over the canopy, were discarded from analysis. Census points were visited in succession between 06:00 and 09:00 am with a total of eight visits per site. Field work was conducted by BM and DDP. Identification of birds was facilitated by voice recordings (Steve Smith 1993 [“Bird recordings from Sulawesi”], and 1994 [“Bird recordings from Java, Bali and Sumatra”]) and the voice descriptions in Coates et al. (1997). Because our study focused on the temporal change of the native breeding bird community, three migrant species (*Motacilla cinerea*: one bird in 2001/2002 and five birds in 2008; *Motacilla flava*: two birds in 2001/2002; *Anthus novaehollandiae*: one bird in 2008) and the introduced *Passer*

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