



Reducing the impacts of Neotropical oil palm development on functional diversity



Graham W. Prescott^{a,*}, James J. Gilroy^{b,c}, Torbjørn Haugaasen^c, Claudia A. Medina Uribe^d, William A. Foster^a, David P. Edwards^e

^a Department of Zoology, University of Cambridge, Cambridge CB2 3EJ, UK

^b School of Environmental Science, University of East Anglia, Norwich NR4 7JT, UK

^c Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, 1430 Ås, Norway

^d Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Calle 28A # 15-09, Bogotá, Colombia

^e Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK

ARTICLE INFO

Article history:

Received 7 December 2015

Accepted 9 February 2016

Available online xxxx

Keywords:

Tropical agriculture expansion

Oil palm

Functional diversity

Birds

Landscape configuration

ABSTRACT

Large-scale conversion of natural habitats to agriculture reduces species richness and functional diversity, with important implications for the provision of many ecosystem services. We investigated possible solutions to minimise loss of functional diversity: retaining forest fragments to enhance functional diversity within agricultural lands, and restricting future expansion of tropical crops to degraded lands or low-productivity farmlands to conserve functional diversity at a landscape level. We focused on birds, which play key functional roles and have well-known functional ecology, and oil palm, a rapidly expanding tropical crop. We did so in the Colombian Llanos, a region highlighted for the planting of sustainable oil palm, where plantations are currently replacing two main habitat types: forest remnants and improved cattle pasture. We found that levels of functional diversity (FD) and richness (FRic) were highest in remnant forests. Furthermore, levels of functional diversity and richness in oil palm and improved pasture were positively related to the proportion of forest in a 250 m radius surrounding each sample point. Frugivorous and canopy foraging species were particularly associated with remnant forests, while aquatic and terrestrial foragers were associated with pasture. This suggests that retaining forest remnants in agricultural landscapes is important in preventing large losses of functional diversity, and might also play a role in maintaining avifaunal functional richness within farmland.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

We live in an era of rapid global change. One of the biggest changes is the rapid conversion of natural habitats, particularly forests, for agriculture (Ellis et al., 2010). The conversion of forest to farmland has led to large-scale declines in species richness and abundance (Foster et al., 2011; Gibson et al., 2011), and replacement of specialist species with widespread generalist species (Clavel et al., 2010; Sekercioglu, 2012). Given that many of the ecosystem services underpinning the production of food, such as pest control and pollination, are regulated by wild species (Garibaldi et al., 2013; Power, 2010), habitat loss could have important negative consequences not only for the survival of global biodiversity, but also for our ability to increase food production in line with rapidly increasing population and per capita consumption (Ehrlich and Ehrlich, 2013).

The importance of conserving species not only for what they are, but for what they do (Loreau et al., 2001; Tilman et al., 1997), has highlighted the need to assess communities in terms of the roles that their

constituent species play in shaping ecological processes, rather than simply how many species they contain. Functional diversity is a concept developed to encapsulate the variety of functional roles played by the constituent species within a community (Magurran and McGill, 2010; Petchey and Gaston, 2002). It has the advantage over approaches that compare abundances of members of different functional guilds (Azhar et al., 2013; Gilroy et al., 2015a) in being less arbitrary and able to account for intra-guild differences between species (such as concurrent differences in body size and beak morphology; Edwards et al., 2013). Higher functional diversity is expected to increase the provision of ecosystem services via a variety of mechanisms (Cardinale et al., 2012; Hooper et al., 2005). For example, functional diversity was a better predictor of variation in above-ground biomass (and hence carbon storage) than species richness in a series of manipulative experiments in European grasslands (Petchey et al., 2004).

Previous studies have found a decline in functional diversity for an array of taxa following conversion of natural habitats to agriculture. For example, the functional diversity of dung beetles is reduced by conversion of forest to pasture (Barragán et al., 2011) or oil palm (F.A. Edwards et al., 2014a,b). Similarly, conversion of forest to oil palm in Sabah (Edwards et al., 2013) and to monocultures of *Eucalyptus camaldulensis* or exotic

* Corresponding author.

E-mail address: grahamprescott@gmail.com (G.W. Prescott).

pinus in Australia (Luck et al., 2013) reduced the functional diversity of birds. Conversion of forest to coconut plantations and cattle pastures in the Solomon Islands reduced the functional diversity of understory plants (Katovai et al., 2012). Given the link between functional diversity and ecosystem services, it is important to understand how agriculture can be managed to prevent severe losses of functional diversity and to optimise functional diversity within farmed landscapes.

One potential method for conserving functional diversity within agricultural land is to retain areas of adjacent natural habitats to allow functionally important species to “spill-over” into farmland (Gilroy et al., 2014). Most of the work on functional spill-over from forest to farmland has so far focused on specific functions or services. For example, forest insect pollinators increased coffee yield by ~20% within ~1 km of contiguous forest (Ricketts et al., 2004), and proximity to forests has been correlated with increased levels of pollination in other studies (Blanche et al., 2006; Gemmill-Herren and Ochieng', 2008; Klein et al., 2003). Forest fragments in areas of coffee cultivation in Costa Rica doubled the levels of pest control (through insectivorous birds consuming coffee borer beetles *Hyothenemus hampei*), providing an ecosystem service worth \$US75–\$US310 per hectare per year (Karp et al., 2013). However, bird predation of model caterpillars (considered a proxy of natural pest control by insectivorous birds) was not affected by the presence of riparian forest reserves (Gray and Lewis, 2014). Despite these studies, there remains no assessment of the impacts of forest retention on functional diversity within farmland (Blitzer et al., 2012).

In addition to enhancing functional diversity within agricultural lands, we also need to look at ways to conserve functional diversity at the wider landscape level. The most damaging effects of agricultural expansion on species, phylogenetic, and functional diversity have been due to the conversion of high biodiversity habitats, especially tropical forest (Edwards et al., 2015; Flynn et al., 2009; Gibson et al., 2011; Laurance et al., 2014). Directing future conversion to lower biodiversity habitats—including degraded areas that previously lost their natural vegetation (e.g., burned) or areas already converted to less productive forms of agriculture (Garcia-Ulloa et al., 2012; Koh and Ghazoul, 2010; Smit et al., 2013)—could be a means of mitigating some of these negative impacts. While research indicates that such low-biodiversity habitats represent golden opportunities for farmland expansion at minimal cost to species (Gilroy et al., 2015b) and phylogenetic diversity (Prescott et al., 2016), there remains no assessment of the impacts of their conversion on functional diversity.

In this study, we focus on oil palm (*Elaeis guineensis*) cultivation, which is one of the most rapidly expanding tropical crops (now covering over 16 million hectares globally) as a result of increasing demand for vegetable oils for food, pharmaceuticals, and biofuels, with expansion largely at the expense of tropical forests (Gunarso et al., 2013). This conversion drives declines in species richness and abundance, and changes in community composition for most taxa (D.P. Edwards et al., 2014; Foster et al., 2011; Savilaakso et al., 2014), as well as loss of functional diversity of birds and dung beetles (Edwards et al., 2013; F.A. Edwards et al., 2014a,b). Spatial modelling for Indonesia (Koh and Ghazoul, 2010) and Colombia (Garcia-Ulloa et al., 2012) suggests that directing oil palm expansion to regions with degraded lands and less productive forms of agriculture could reduce biodiversity loss from forest conversion. In Colombia, the main form of agriculture suitable for conversion to oil palm is cattle pasture. In particular, the western Llanos has been highlighted for conversion (Garcia-Ulloa et al., 2012). This region contains a diverse mixture of improved cattle pasturelands and remnant forest patches and corridors, both of which have been converted to intensive cattle pasture in the past (Etter et al., 2008).

To determine the impacts of oil palm expansion and landscape configuration in the Colombian Llanos, we focus on the functional diversity of birds. Birds perform important functions as pollinators, seed dispersers, scavengers, and predators (Sekercioglu, 2006). Experimental exclusion of birds led to an increase in herbivory rates in young oil palms (Koh, 2008), and an increase in the abundance of herbivorous insects and a

decrease in yield in cacao plantations (Maas et al., 2013). Their importance to ecosystem function and the widespread availability of functional trait information in the literature (del Hoyo et al., 2014; Dunning, 2007) makes them an excellent taxon with which to study functional diversity. Previous studies in the Llanos have revealed that the species richness (Gilroy et al., 2015b; see also D.P. Edwards et al., 2014) and phylogenetic diversity (Prescott et al., 2016) of birds was highest in forest but that the conversion of improved pasture to oil palm would result in minimal change. These studies also found that the amount of forest within a 250 m radius surrounding sampling points in oil palm and pasture increased the occupancy probability (Gilroy et al., 2015b) and the phylogenetic diversity (Prescott et al., 2016) of birds, suggesting the potential for spill-over of functional diversity from neighbouring forests.

In this study we therefore test the following hypotheses:

- i) the conversion of forest to oil palm reduces functional diversity at the point and landscape level, but conversion of improved cattle pasture to oil palm does not.
- ii) Retaining forest remnants close to agricultural land increases avian functional diversity in oil palm plantations and pasture.

2. Methods

2.1. Study sites

The study was based in the *Llanos Orientales* ecoregion of Colombia. This is a semi-natural open savanna system with a pronounced dry season from December–March. It contains a network of gallery forests along the rivers that ultimately drain into the Orinoco (Jiménez et al., 2012). Extensive cattle grazing has historically been the dominant agricultural land use (Etter et al., 2008; Van Ausdal, 2009). Agricultural production has intensified, and the region now has 2.5 million hectares of improved and intensive pastures (with *Brachiaria* sp. grasses introduced from Africa) and 140,000 ha of oil palm plantations (Romero-Ruiz et al., 2010). It is therefore a good place to test the relative biodiversity value of oil palm plantations and cattle pastures with a view to optimising future agricultural production in Colombia with regards to biodiversity conservation and the production of food and biofuels.

The study was conducted at three field sites – Palumea (4°20'15.2" N, 73°11'47.8"W), La Carolina (4°17'44.9"N, 72°58'35.9"W), and Guaicaramo (4°27'34.8"N, 72°57'40.0"W) – in the municipalities of Medina (Cundinamarca), Cabuyaro (Meta), and Barranco de Upía (Meta) respectively. Each of these three sites contained a mixture of improved pasture, oil palm mature enough to produce fruit (5–28 years old), and forest fragments. The forest fragments included riparian forest strips, dry forest fragments, and wet forest fragments dominated by *moriche* palm (*Mauritia flexuosa*). These sites were sampled between January–March 2013.

2.2. Bird surveys

An experienced ornithologist (JJG) conducted ten-minute point counts on four successive days at each sampling point in our study sites (106 sampling points in total) (Gilroy et al., 2015b). Fixed radius (100 m) point counts were conducted between 05:45–11:00, and the order in which they were sampled was switched between days so that all points were visited during both the earlier and later parts of the sampling window. Sampling points were organised into transects with between one and four points per transect (transects only had fewer than four points if a forest fragment was too small to have more points), and 300 m between each sampling point within a transect. In total, we sampled 36 oil palm, 36 pasture, and 34 forest points. Unfamiliar vocalisations were recorded with a Sennheiser ME66 shotgun microphone and Olympus LS11, and compared to an online database (www.birds.org).

Download English Version:

<https://daneshyari.com/en/article/6298411>

Download Persian Version:

<https://daneshyari.com/article/6298411>

[Daneshyari.com](https://daneshyari.com)