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Altered herb assemblages in fragments of the Brazilian Atlantic forest

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ABSTRACT

Understanding the response of tropical plant communities to human disturbance is critical for conserving biodiversity in a changing world. Here we examine the shifts experienced by understory herb assemblages while inhabiting small forest fragments in a fragmented Atlantic forest landscape to infer about community-level shifts imposed by either habitat loss or fragmentation. We established 100 25-m^2 plots, placed randomly in 10 forest fragments and 10 forest interior patches, in which all herb species were recorded, litter accumulation, soil temperature and moisture were estimated. We recorded a total of 6027 herbs belonging to 134 species, with a predominance of ferns, grasses, aroids, sedges and calatheas. Forest fragments and forest interior exhibited similar densities of herbs: 64.4 ± 57.8 herbs/25 m^2 vs. 56.1 ± 44.1, respectively. Species richness was reduced by a half in forest fragments at plot and habitat spatial scales. Fragments were particularly impoverished in terms of ferns, aroids and calatheas, but supported a subset of proliferating native herbs and indicator/exclusive species; i.e. a taxonomically and ecologically distinct herb flora. Fragments also supported less humid soils covered by a thicker litter layer and these attributes correlated to species distributions in both forest habitats. Our results suggest that habitat loss and fragmentation, particularly the establishment of illuminated and desiccated forest edges, result in the extirpation of particular ecological groups with a few species/ecological groups experiencing proliferation, such as light-demanding species. Collectively, these processes result in impoverished/altered assemblages at multiple spatial scales, potentially limiting the conservation services provided by human-modified landscapes.

1. Introduction

Understory herbaceous plants, or ground herbs (sensu Poulsen, 1996), comprise an ecologically and taxonomically diverse group in both tropical and temperate forests (Costa et al., 2005; Gillian, 2007; Poulsen and Balslev, 1991; Whigham, 2004). In fact, this group includes a wide spectrum of life forms, or life-history strategies, including (1) ferns, monocots and dicots, (2) annual and perennial species, and (3) proto and facultative terrestrial, scandents and climbers (Cicuzza et al., 2013; Poulsen and Balslev, 1991). Even in tropical forests, in which tree species account for the majority of plant species diversity, understory herbs can represent 10–20% of local plant species richness (Cicuzza et al., 2013; Linares-Palomino et al., 2009 for a review). Herbs also contribute to nutrient uptake and cycling (Lalji and Singh, 1993; Pande, 2004), ecosystem productivity and are vital for the maintenance of many animal populations, such as herbivores, pollinators and frugivores that inhabit forest understorey, including ants, birds, and small mammals (Gillian, 2007; Richards, 1996; Whigham, 2004). Understory herbs are recognized to provide particular microhabitats (e.g. shaded patches) and enhance habitat heterogeneity (Costa et al., 2005; Maraschin-Silva et al., 2009; Whigham, 2004); e.g. dense patches dominated by palmettos, calatheas and Zingiberaceae species (Cicuzza et al., 2013; Richards, 1996).

In tropical forests, habitat loss and fragmentation have been considered major sources disturbance (Melo et al., 2013), with most studies on plant responses to these threats focusing on tree species, because of their remarkable role as ecosystem engineers that characterize forest ecosystems (see Laurance et al., 2002, 2011). Tree species may be negatively affected by (1) habitat desiccation imposed by edge-effects (e.g. increased wind turbulence and luminosity), (2) altered soil conditions (e.g. a thicker litter layer), (3) disruptions in plant–animal interactions such as herbivory, seed dispersal and pollination, (4) competition with light-demanding plant species (i.e. winner species sensu Tabarelli et al., 2012) and (5) increased incidence of diseases (Laurance et al., 2006b; Tabarelli et al., 2010b; Vasconcelos and Luizão, 2004). Particularly in the case of the Amazonian and Atlantic forests, tree species bearing large seeds with supra-annual reproduction, those depending on specialized pollination vectors and with a large stature may experience population collapse (Laurance et al., 2006a; Lopes et al., 2009; Oliveira et al., 2008), resulting in impoverished tree assemblages at multiple spatial scales (Laurance et al., 2006b; Lôbo et al., 2011). In contrast to

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the comprehensive picture provided for tree species, little information has been offered for herb species, particularly in tropical forests. Like tree species, many ecological groups of herb species may be negatively affected by conversion of natural landscapes into relictual landscapes dominated by edge-affected habitats, such as those herb species experiencing reduced seed germination and seedling survivorship and increased incidence of foliar diseases (Bruna, 1999; Bruna et al., 2005; Santos and Benítez-Malvido, 2012).

The Brazilian Atlantic forest is one of the most important global biodiversity hotspots, which includes a diverse herb flora (Giulietti et al., 2005; Myers et al., 2000). Originally, it covered around 150 million ha, but recent estimations indicate that less than 16% of the forest remains (Ribeiro et al., 2009). In addition to being poorly protected (nature reserves only account for 1% of the original forest), the remaining forest cover is distributed in ca. 250 000 forest fragments, 80% of which are smaller than 50 ha and the average distance between fragments is ca. 1500 m (Ribeiro et al., 2009). Furthermore, almost half of the remaining vegetation is less than 100 m from the nearest edge (Ribeiro et al., 2009). Certainly, such human-modified landscapes offer an interesting opportunity to examine the potential effects of habitat loss and fragmentation on herb assemblages.

Here we examine the shifts experienced by understory herb assemblages while inhabiting small forest fragments in a typical Atlantic forest landscape dominated by edge-affected habitats in order to infer about community-level shifts imposed by either habitat loss or fragmentation. Accordingly, herb assemblages inhabiting fragments and forest interior patches were described and compared in terms of structure (plant density and species richness), taxonomic/ecological composition and the presence of indicator species. We also investigated the influence of some patch metrics and soil conditions on these community-level attributes. We expected that herb assemblage shifts were congruent with those exhibited by other plant groups such as trees; i.e. impoverished and taxonomic/ecologically distinct assemblages in response to edge creation (see Laurance et al., 2006a,b; Santos et al., 2008).

2. Materials and methods

2.1. Study landscape

The study was carried out at Usina Serra Grande, owned by a large, private sugar company of the same name located in the state of Alagoas, northeastern Brazil (8°30′S, 35°50′W; Fig. 1). Information on the climate, soil, fauna and flora of this region is available in Santos et al. (2008). This landholding still retains ca. 9000 ha (9.2%) of the forest cover assigned to a unique biogeographic region of the Atlantic forest: the Pernambuco Center of Endemism (Santos et al., 2007). We selected a large (667 km^2), severely fragmented landscape containing 109 forest fragments (ranging from 1.7 to 3500 ha), all of which are entirely surrounded by a uniform, stable and inhospitable matrix of sugarcane monoculture.

Sugarcane cultivation at Serra Grande dates back to the 19th century, and provides a rare opportunity for Atlantic forest fragmentation studies. The old-growth forest interior areas of Coimbra, the largest fragment (3500 ha) remaining in the landscape, still retain a full complement of plant species typical of vast undisturbed tracts of Atlantic forest, such as large-seeded (Santos et al., 2008). However, populations of large-fruit eating birds and mammals such as guans, chachalacas, toucans, aracaris, cotingas and howler monkeys are declining or have already been extirpated locally and regionally due to overhunting and other human threats (see Chiarello, 1999; Galetti et al., 2006; Melo et al., 2006; Silva and Tabarelli, 2000). To our knowledge, there is no information on the ecology of herbs in the Serra Grande landscape.

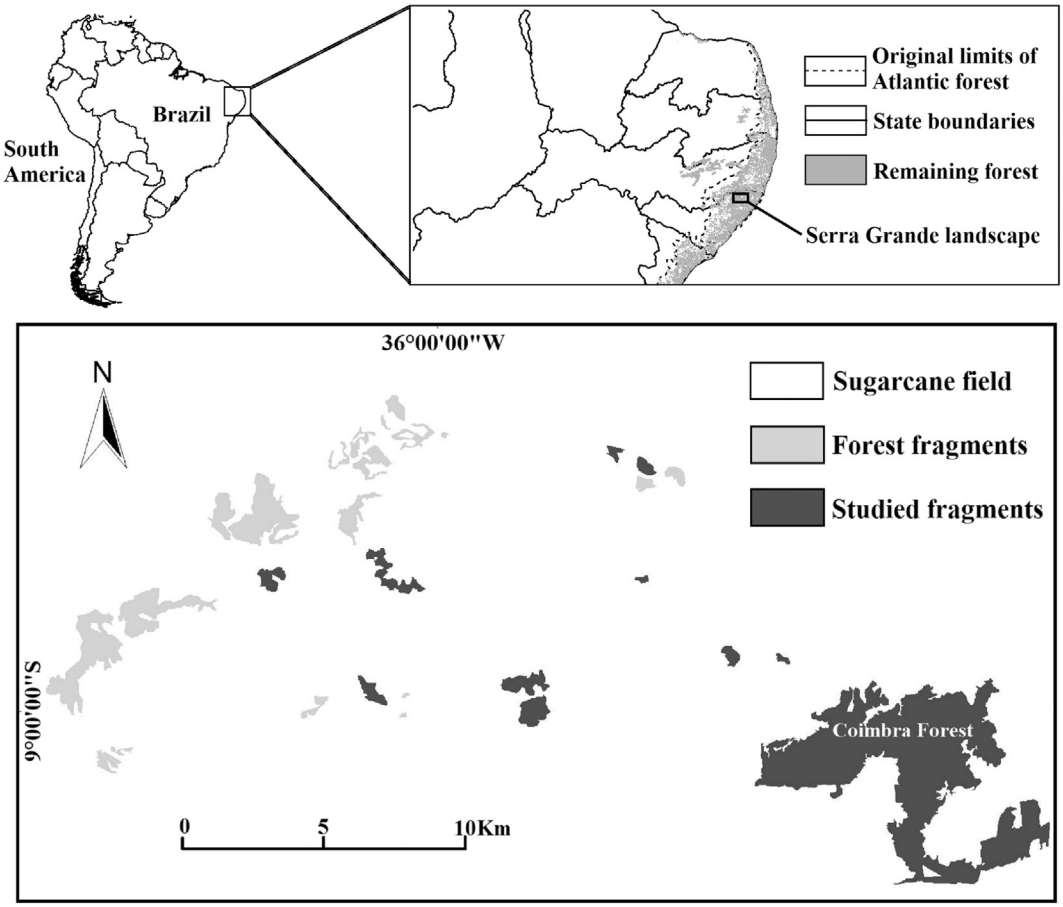

Fig. 1. The Serra Grande landscape map indicating small forest fragments and the Coimbra forest (forest interior stands) in which herb assemblages were recorded.