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Research Paper

How scattered trees matter for biodiversity conservation in active pastures

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ABSTRACT

Large areas of Tropical Forest have been cleared and deeply modified aiming at growing crops and producing livestock. Many of these areas are transformed in pastures with scattered trees. We investigated an area of 618.59 ha in Southeastern Brazil composed of active pastures of an African grass, *Urochloa decumbens*, with scattered trees and forest patches. We surveyed all the scattered trees in the active pastures and in 60 plots of 200 m^2 within eight forest patches. To identify the ecosystem services and the history of scattered trees we applied a semi-structured survey to the landowners. We assessed regeneration, distance of propagules source, grass cover, microclimate, seed rain, and soil compaction under scattered tree crowns and in samples in the pasture without scattered trees. We found the scattered tree community highly diverse and associated this to apparent lack of preference for species showed by farmers during the clearing process for pasture, choosing the trees only by their shading capability (size). We also found that the scattered trees strongly affect seed rain and sapling regeneration in the pastures, improving microclimate and attracting dispersers, although this last effect is strongly dependent of the forest proximity. We found that the major difference between the scattered tree community and forest patches is associated with small trees lost during forest clearing and not to the largest trees left in the pastures. We see the scattered trees as key factors for promoting forest recovery, as well as an important biodiversity pool per si in highly fragmented landscapes.

1. Introduction

Pastures with scattered trees are human modified ecosystems widely distributed in tropical forested biomes. With the growing conversion of natural systems into human-transformed ones – something around 83% of dry land is impacted by human activity in some degree (Hobbs et al., 2009) – ecologists and conservationists have been shifting their gaze to the role of these human modified ecosystems for biodiversity conservation and ecosystems functionality, as well as to their sustainability.

Active pastures with scattered trees and the surrounding forest patches and corridors comprise profoundly modified ecosystems, where natural elements share space with invasive and exotic species like grasses, ruderal plants, associated organisms (e.g. insects, fungi, bacteria) and cattle. In addition, their functioning is expected to be very different from the original state, being modified and mediated by human management.

Pastures with scattered trees combine meat, wool and milk production with vestiges of the original forest community that previously occupied these areas. The ecological and economic role of those scattered trees has received a wide range of studies. Economically speaking, those trees are recognized as important food source for cattle and are important for improving the microclimate conditions in the pastures. The benefits of keeping trees in pastures have been recognized a long time ago, as it is evident by the traditional use of silvopastoral systems in several parts of the world (Hartel et al., 2013, 2017). On the other hand, the importance of scattered trees for biodiversity conservation has also been investigated (Manning et al., 2006; Oellerer, 2014; Athayde et al., 2015). Scattered trees are considered stepping stones facilitating fauna locomotion among forest patches surrounded by pastures (Manning et al., 2006; Oellerer, 2014; Athayde et al., 2015). They are also considered important "regeneration nuclei" (Guevara et al., 1986; Herrera and García, 2009) for the recovery of the forest after pasture abandonment (Duarte et al., 2010). This function is linked to attraction of seed dispersers (Carlo and Morales, 2016) and to the ameliorated microclimate under their canopies.

This paper studies a community of scattered trees in active pastures in the tropical Southeastern region of Brazil. The composition and

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structure of scattered trees in a pasture are supposed to depend on different factors. On the one hand, the original community must have a strong influence on the actual composition of the tree community in a pasture, however, the original trees gradually die, mainly the ones more sensitive to the new environmental conditions, and new ones colonize the area. These new trees are supposed to be light-demanding species tough enough to be able to overcome the harsh conditions of the pastures. On the other hand, the composition and structure of the scattered trees must depend on historic factors, such as decisions of the landowner/user during forest clearing and posterior management. Therefore, because of this no-random mortality and no-random colonizing process, we expect that (i) the community of scattered trees has lower diversity than the original one and that (ii) the composition of the tree community in the pastures diverges from the original one.

Another aspect affecting the composition and structure of the scattered trees community is the way the process of forest clearing was carried out during the pasture establishment. Considering that beef and milk production increase if some shade is provided in the pastures and that timber is an important resource for farmers (Titto et al., 2011), we expect that (iii) the landowners keep remaining tree species in pastures based on shading efficiency and timber quality.

Finally, scattered trees have for a long time been recognized as facilitators of forest regeneration. These trees, mainly when close to the forest edges, are supposed to attract seed-disperser animals like birds and bats that are otherwise shy of wide open spaces characteristic of pastures (Fischer et al., 2010; Pizo and dos Santos, 2011; Hartel and Plieninger, 2014). Scattered trees also create less severe microclimate conditions under their canopies which are believed to favor regeneration of forest trees (Manning et al., 2006). Therefore, we expected that (iv) the presence of scattered trees would favor regeneration under their canopies and that this effect would be stronger closer to the edges of forest patches.

2. Methods

2.1. Study site and its history

We conducted this study in the state of Minas Gerais, in the Southeastern region of Brazil (Fig. 1A). The climate in the area was classified as CWA and CWB of Köppen, moist temperate with dry winters and hot summers. The soils in the area were Oxisols and Ultisols. The area (44°47′56″W/44°46′11″W and 21°15′07″S/21°13′19″S) of 619 ha comprises 11 patches of active pastures (total of 446.27 ha, mean size = 40.60 ha, the smallest size = 21.05 ha, the largest size = 96.12 ha) and eight patches of Semideciduous Forest partially connected among them (total area = 170 ha, mean size = 21.25 ha, the smallest size = 6.42 ha, the largest size = 63.53 ha) (Fig. 1).

After forest clearing around 30 years ago, pastures of *Urochloa decumbens*, an African grass, were planted and used for beef and milk production. Associated to those activities, we found cattle trails and manure within the forest patches, as well as sparse logging. The owners cut down shrubs and young trees in the pastures every two years to reduce competition with the grasses and increase economic returns.

2.2. Scattered tree diversity and structure

In the pastures, we surveyed all scattered trees with DBH (diameter at 1.3 m height) ≥4.8 cm (circumference of 15 cm). We called a tree a scattered tree when its crown did not overlap with the crown of another tree. We identified, mapped (using a GPS Garmin Map 76 CS) and measured (DBH and height) all trees following those criteria. We plotted each tree in a map generated from RapidEye images with 5 m resolution using ArcGis (versão 10.3) and calculated the distance between the tree the closest forest edge.

We surveyed the forest patches (FP) using 60 5 × 40 m plots (200 m^2), in a total of 1.2 ha, distributed in eight patches (FP7 = 12 plots; FP1, FP2, FP4 = 9 plots each; FP5, FP6, FP8 = 6 plots each, FP3 = 3 plots). We set the same number of plots (20 plots) for each situation of forest patches: edges, cores and intermediary position. Plots in a single forest patch and in the same situation were at least 40 m far from each other. Edge plots were set with one of their sides confronting with the pastures. Intermediary and core plots were set 40 m and 80 m from the forest edge, respectively. All sampled patches were large enough to accommodate at least one plot of each situation and all sampled patches had, individually, the same number of plots in each situation. We identified and measured all trees with DBH ≥ 4.8 cm within the

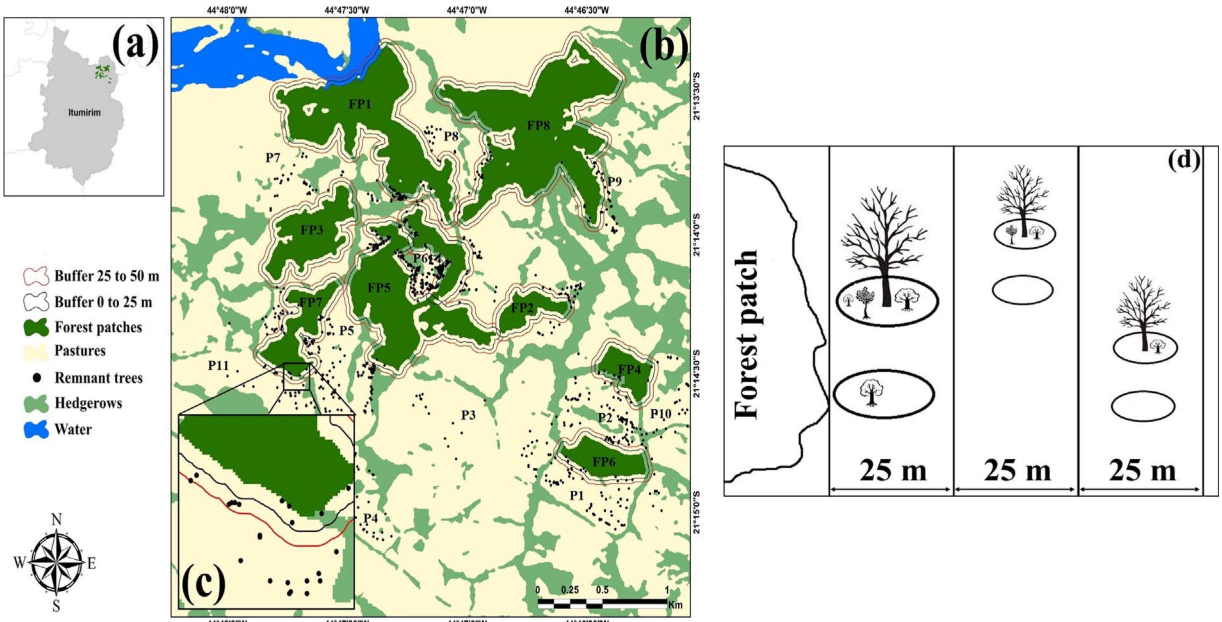

Fig. 1. (A) Municipality of Itumirim, state of Minas Gerais, Brazil and the location of the study area (green patches); (B) Study area with the forest patches (green) and scattered trees (black dots) in the pastures; (C) Detail showing the three distance buffers in the pasture close to a forest patch edge; (D) Sampling design showing the pairs of plots (with and without scattered trees) for the three buffer distances from the forest patch edge. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)