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Intensification of shifting cultivation reduces forest resilience in the northern Amazon

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ABSTRACT

Shifting cultivation is a traditional land-use system to ensure livelihood in the Northern Amazon. Here, we evaluated how intensification of shifting cultivation (SC) affects secondary forest recovery in the northern Amazon forest. To measure intensity of shifting cultivation, we used the number of previous SC cycles. We selected three study sites containing second-growth forest (SG) with different stand ages (5 and 10 years) after one, three or six SC cycles. Furthermore, we selected old-growth forest (OG) in each study site. In each selected SG and OG, three plots of 20 × 50 m were established, totalizing 63 plots in the study area. In each plot, all trees, palms and lianas with diameter at breast height ≥ 5 cm were tagged and identified to species level. We analyzed the effects of SC intensification and soil fertility on woody species richness, species composition and basal area using mixed effect models. Species richness and basal area, lower in SG than in OG, increased with regeneration time after abandonment, but reduced with intensification of SC. Community dissimilarities (Bray-Curtis distances) between OG and SG increased with the number of shifting cultivation cycles. Soil fertility differed between SG with different regeneration stages and reduced with number of SC cycles. We found that soil fertility and management intensity, i.e., number of previous SC cycles, explained pattern observed in richness, species composition and basal area equally good. Due to nutrient exports with crops and increasing nutrient leaching, soil fertility is expected to reduce with SC intensity. Therefore, our data indicate that intensification of SC reduces recovery of species richness, composition and basal area of SGs following productive periods. Thus, the intensification of SC reduces the resilience of SGs, turning this ancient form of land-use unsustainable. Environmental sustainability of SC may be achieved by extending fallow periods, limiting the maximum yield. To attend growing demands of indigenous and non-indigenous communities, we propose other alternatives of land-use such as permanent agroforestry systems.

1. Introduction

The Amazon basin accommodates the largest tropical forest in the world (Laurance et al., 2001), holding about 11% of the world's tree biodiversity (Cardoso et al., 2017). Moreover, the Amazon plays a fundamental role in sustaining indigenous and non-indigenous people providing different goods based on biodiversity by food gathering, hunting, and shifting cultivation (SC, Arroyo-Kalin, 2012). Also known as swidden agriculture, SC represents the logging of small forest areas (slash and burn) for short-time crop plantation (Aweto, 2013). After harvest and loss of soil fertility, areas become abandoned (D'Oliveira et al., 2011; Arroyo-Kalin, 2012), and regenerate naturally, forming second growth forests (SG, Chazdon, 2014). Practiced for centuries (Bush et al., 2015), shifting cultivation is still the main agricultural system sustaining peoples' livelihoods in the Amazon (Villa et al., 2017), producing yields not only for domestic demands, but for local or

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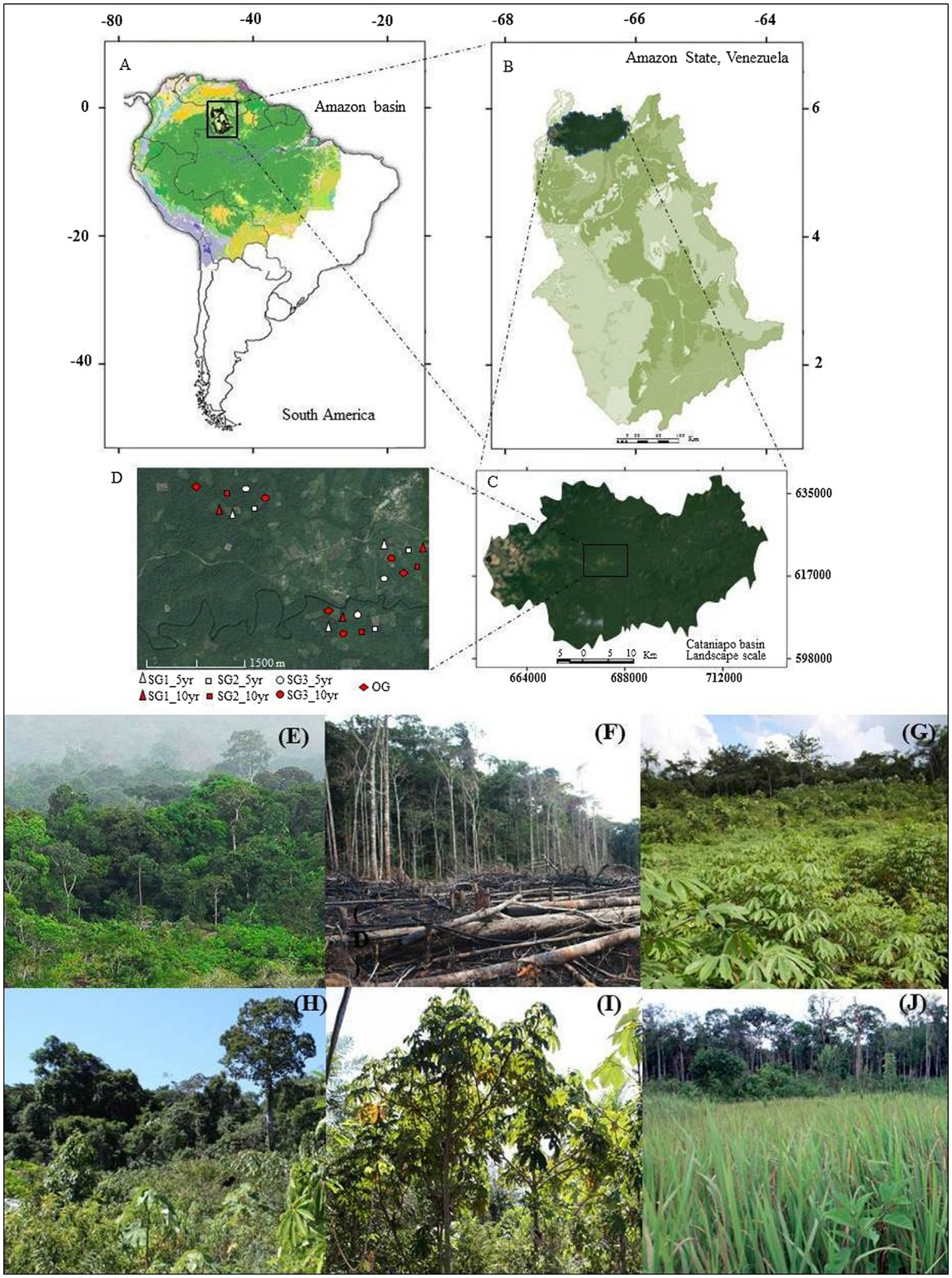

Fig. 1. Localization and general aspects of the study area. Localization of the study area in relation to South America (A), the Cataniapo basin from northern Amazonas State, Venezuela (B), and the Gavilán and Sardi villages in the Cataniapo basin (C). Satellite image of the study area (D), points indicate sampled patches. Illustrations of an old-growth forest (E), slash and burn (F), shifting cultivation with cassava (G), early second growth forest after shifting cultivation with 1–2 years (H), second growth forest with 5 years (I), and second growth forest after six SC cycles with *Imperata brasiliensis* (J).

national markets as well (van Vliet et al., 2013; Jakovac et al., 2016a). Increasing deforestation of Amazon forests due to SC by human communities seriously threatens old growth forests (OG) and their biodiversity (Barlow et al., 2016; Jakovac et al., 2016b). Furthermore, intensification of SC increases the pressure on the recovery of SG (Jakovac et al., 2015).

SC dynamics are characterized by the initial perturbations generated by the cutting and the burning of the forests (Aweto, 2013). Then, the agricultural systems' intensity and duration and the forest recovery by natural regeneration, considered as the fallow time until a new cycle

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