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A 30-year study of the effects of selective logging on a stem-less palm (*Astrocaryum sociale*) in a central-Amazon forest

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ABSTRACT

We studied the long-term effects of different selective-logging intensities on the stem-less palm *Astrocaryum sociale* in a central Amazonian forest 90 km north of Manaus. The experiment consisted of three blocks of 24 ha, each divided into six 4 ha plots in which the treatments were allocated randomly. Each block had a control plot. Within each block, commercial timber was logged with intensities of 44%, 50% and 67% of basal area in 1987, 1988 and 1993 respectively. Stem-less palms in each plot were measured in 1996 and 2016. The number of individuals decreased slightly from 3229 in 1996 to 2997 in 2016, and there was an increase in the proportion of large palms. The degree of change in size structure was related to time since logging ($p = 0.012$), which also affected the total number of leaves ($p = 0.0001$), the sum of all leaf lengths ($p = 0.01$) and the number of adults ($p = 0.056$). The volume of timber extracted and in standing dead trees was not related to size-structure change. In the control block, the number of individuals changed slightly during the study period. As the different cutting intensities had little, if any, effect of the size-structure of this understory palm up to 30 years after logging, management concessions can contribute to the conservation of some elements of palm biodiversity.

1. Introduction

Well-planned forest management can contribute to global biodiversity conservation (Chaudhary et al., 2016). Reduced-impact logging (RIL) techniques are considered useful tools for decreasing the rate of tropical-forest deforestation (Darrigo et al., 2016; Putz et al., 2012; Schwartz et al, 2012), can produce more profit than conventional logging (Barreto et al., 1998; Boltz et al., 2001; Holmes et al., 2002, Johns et al., 1996) and purportedly guarantee wood for the next logging cycle (Holmes et al., 2002; Johns et al., 1996; Verissimo et al., 1992). There are many studies concerning the effects of RIL on regeneration of commercial trees (Darrigo et al., 2016; de Carvalho et al., 2017; Doucet et al., 2009; Karsten et al., 2013; Rivett et al., 2016; Schwartz et al., 2012, 2013; 2017; Soriano et al., 2011), but few studies of regeneration of species with little commercial value in selectively logged areas (Clark et al., 2001; Costa et al., 2002; Dekker and De Graaf, 2003; Magnusson et al., 1999) and fewer studies evaluating the effects of logging techniques on palms (Arevalo et al., 2016).

Palms are an abundant and distinctive element in the central Amazon, found from sub-canopy to canopy, in all types of soil and topography and they exhibit a large range of growth forms (Kahn and Castro, 1985). The stem-less palm, *Astrocaryum sociale*, is endemic to the central Amazon region. It occurs on well drained, flat to slightly sloping areas (Kahn and Castro, 1985); the types of areas that are usually selected for logging. In these areas, stem-less palms are often the dominant component of the forest sub-canopy (Guillaumet, 1987; Kahn, 1986).

Several studies have evaluated the effects of selective logging on commercial and non-commercial species in the Manaus region (Costa and Magnusson, 2003; Limaet al., 2002; Magnusson et al., 1999). However, there are no studies of the effects of selective logging on *A. sociale*. The aim of this study was evaluate the effects of different logging intensities on *A. sociale* in an area that was selectively logged in 1987, 1988 and 1993 (Higuchi et al., 1985).

2. Material and methods

2.1. Study site

The study was carried out in the ZF2 Forest-Management Station (2°37′S latitude, 60°11′W longitude) of the Instituto Nacional de Pesquisas da Amazônia, 90 km north of Manaus, Brazil. The site is covered by *terra firme* dense tropical rainforest (Braga, 1979), with an average altitude of 124 m above sea level and undulating topography. The Bionte project was initiated in 1985 to evaluate the effects of different intensities of basal-area reduction due to selective logging. The

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experiment was carried out in three blocks of 24 ha, each with 6 plots of 4 ha, where treatments were allocated randomly. Each block had one control plot.

The projected logging intensities were 44% (1987), 50% (1988) and 67% (1993) of the basal area of commercial timber. Chainsaws, a bulldozer with a front blade and a tree-pusher, a winch and a truck with a crane were used for logging. The bulldozer was used for extracting the logged timber, because the truck did not function, resulting in more damage to the remaining forest. In this paper, we used the reduction in volume of all tree species with dbh ≥ 10 cm as our index of logging disturbance (Magnusson et al., 1999) and not the predicted logging intensities.

2.2. Data collection

The data were collected from each 4-ha plot by walking along 8 straight parallel 200-m walking trails spaced 25 m apart that are used for ongoing tree inventories (Higuchi et al., 1985). On each trail, 4 sub-plots (5 × 25 m) spaced 25 m apart were selected for collecting data on the number of individuals, total number of leaves, longest leaf length, individual position in the plot and the presence of reproductive parts. The collected data is from the same plots, but not necessarily the same individuals measured in 1996. Data were collected in 1996 by Maria Marcela Ortiz Brasil (Brasil, 1997). Data collection in 2006 was carried out by EMH. Individuals with longest leaf length of less than 3.5 m were

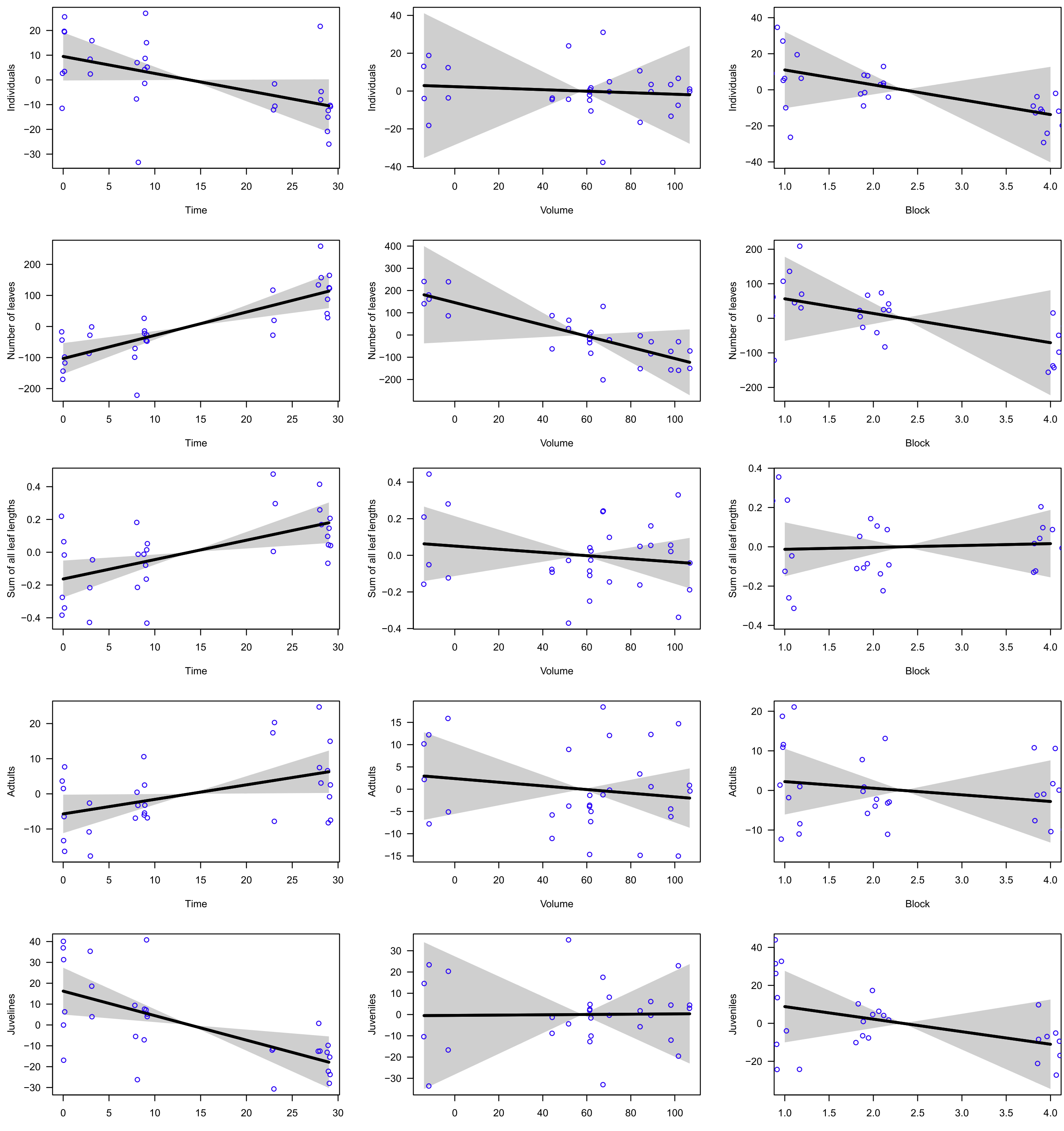

Fig. 1. Partial graphs from the fitted model presenting the effects of Time after logging, damaged Volume and Block on each characteristic analyzed.