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Thinning after selective logging facilitates floristic composition recovery in a tropical rain forest of Central Africa

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ABSTRACT

In the Congo Basin where most timber species are light-demanding, the low logging intensities commonly implemented (1–2 trees harvested ha^{-1}) do not provide sufficient canopy gaps to ensure species regeneration. The regeneration of light-demanding timber species may therefore benefit from more intensive logging, or from post-harvest treatments such as thinning by poison girdling that increases light penetration. Little is known of the impact of post-harvest treatments on the floristic composition of tropical moist forests. This study therefore aimed to assess the effects of low and high selective logging ($\simeq$2.33 and 4.73 trees harvested ha^{-1}, and $\simeq$4.96 and 9.16 m^2 ha^{-1} of basal area removed (logging + damage), respectively) – followed or not by thinning ($\simeq$21.14 trees thinned ha^{-1}, and $\simeq$6.57 m^2 ha^{-1} of basal area removed) – on the floristic composition of a tropical moist forest in the Central African Republic, from 7 to 23 years after logging.

We analyzed abundance data for 110 tree genera recorded every year for 14 years in 25 one-hectare permanent subplots. We used multivariate analysis to detect floristic variations between treatments and we assessed changes in floristic composition throughout the period. We compared floristic composition recovery between thinned and unthinned subplots, using unlogged subplots as a reference characterizing the pre-logging floristic composition.

Logging and thinning had little impact on the floristic composition of the subplots as quantified 7 to 23 years later, though they did increase the proportion of pioneer species. Surprisingly, additional thinning at both logging levels failed to further distance floristic composition from that of the unlogged subplots, though it did increase disturbance intensity. Floristic composition recovery appeared to be facilitated when thinning was associated with logging. Thinning seemed to favor the growth and survival of non-pioneer species, to the detriment of pioneer species. These non-pioneer species could either be non-pioneer light demanders or shade-bearers. One explanation for this is that thinning by tree-poison girdling increased light availability without causing major damage to the forest, and thus increased the growth and survival of advance regeneration. The resulting enhanced competition then reduced the survival of pioneer species.

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1. Introduction

Sustainable forest management (SFM) focuses on the sustainability of many forest products and services over long periods of time (Pearce et al., 2003). One of the principal aims of SFM is to maintain timber stocks. In the Congo Basin, logging intensity is generally low, with one or two trees being harvested per hectare (Karsenty and Gourlet-Fleury, 2006). This selective logging alters the physical structure of forests, in particular by opening the canopy and the understory, and by modifying soil structure (Bawa and Seidler, 1998). Locally, this opening of the canopy changes species assemblage by modifying the prevailing conditions for species germination and establishment. Most floristic changes occur immediately after logging (Baxter and Norton, 1989), with an increase in the abundance of pioneer species (Primack and Lee, 1991). Also, the initial floristic composition generally recovers rapidly after low-intensity selective logging. For instance, Van Gemerden et al. (2003) working in Cameroon found that low-intensity logged sites were floristically similar to old growth forests 14 years after logging, and Ter Steege et al. (2002) working in Central Guyana found little change in overall species composition on a large-scale after 75 years of more or less continuous selective harvesting.

Because most timber species in these forests are light-demanding (Doucet, 2003; Hawthorne, 1995) and require high light environments at the seedling stage for survival and growth (Makana

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and Thomas, 2005, 2006), low logging intensities do not open the canopy sufficiently to ensure their regeneration (Aubréville, 1947; Foury, 1956; Hall et al., 2003). The regeneration of light-demanding timber species may therefore benefit from more intensive logging, or from additional silvicultural treatments, such as thinning, that increase light penetration (Peña-Claros et al., 2008a,b). The question then arises of the extent to which such post-harvest treatments impact the dynamics of non-timber species.

Previous studies have analyzed the impact of post-harvest treatments (i.e. liberation, thinning) on tree growth, mortality and/or recruitment, and focused on commercial species (De Graaf et al., 1999; Finegan and Camacho, 1999; Finegan et al., 1999; Forget et al., 2001; Gourlet-Fleury et al., 2004; Guariguata, 1999; Verwer et al., 2008; Villegas et al., 2009). Conversely, little is known of the impact of post-harvest treatments on floristic composition in tropical moist forests.

In this study we aimed to assess the effects of low and high selective logging (≃2.33 and 4.73 trees harvested ha^{-1}, and ≃4.96 and 9.16 $m^2\ ha^{-1}$ of basal area removed, respectively) – followed or not by post-harvest treatment – on the floristic composition of a tropical moist forest in the Central African Republic, from 7 to 23 years after logging. The post-harvest treatment performed was thinning by poison girdling (≃21.14 trees thinned ha^{-1}, and ≃6.57 $m^2\ ha^{-1}$ of basal area removed). We expected

- floristic differences with respect to unlogged subplots to increase with disturbance intensity, mainly due to an increased proportion of pioneer species;
- the highest logging intensity to have a greater effect on floristic composition, and thinning to further accentuate this effect;
- additional thinning to slow a possible return to the initial floristic composition, because it increases disturbance intensity.

2. Materials and methods

2.1. Study site

The study was conducted in the lowland semi-evergreen moist forest of M'Baïki (3.50°N and 18°E), Central African Republic (Fig. 1). Average annual rainfall is 1739 mm (1981–2008 period) with a 3-month dry season (December–February), and annual average monthly temperature is 24.9 °C (range 19.6–30.2 °C, 1981–1989 period) (Station Météorologique de Boukoko, A. Ougou pers. comm.). The forest is dominated by *Celtis zenkeri* Engl. (Ulmaceae), *Staudtia kamerunensis var. gabonensis* (Warb.) Fouilloy (Myristicaceae), *Coelocaryon preussii* Warb. (Myristicaceae), *Garcinia punctata* Oliv. (Clusiaceae), *Carapa procera* DC. (Meliaceae), and *Dasylepis seretii* De Wild. (Flacourtiaceae). Soils are Ferralsols (FAO classification), and were described by Ceccato et al. (1992) as deep soils, gravelly soils, or deep gravelly soils, depending on the subplot.

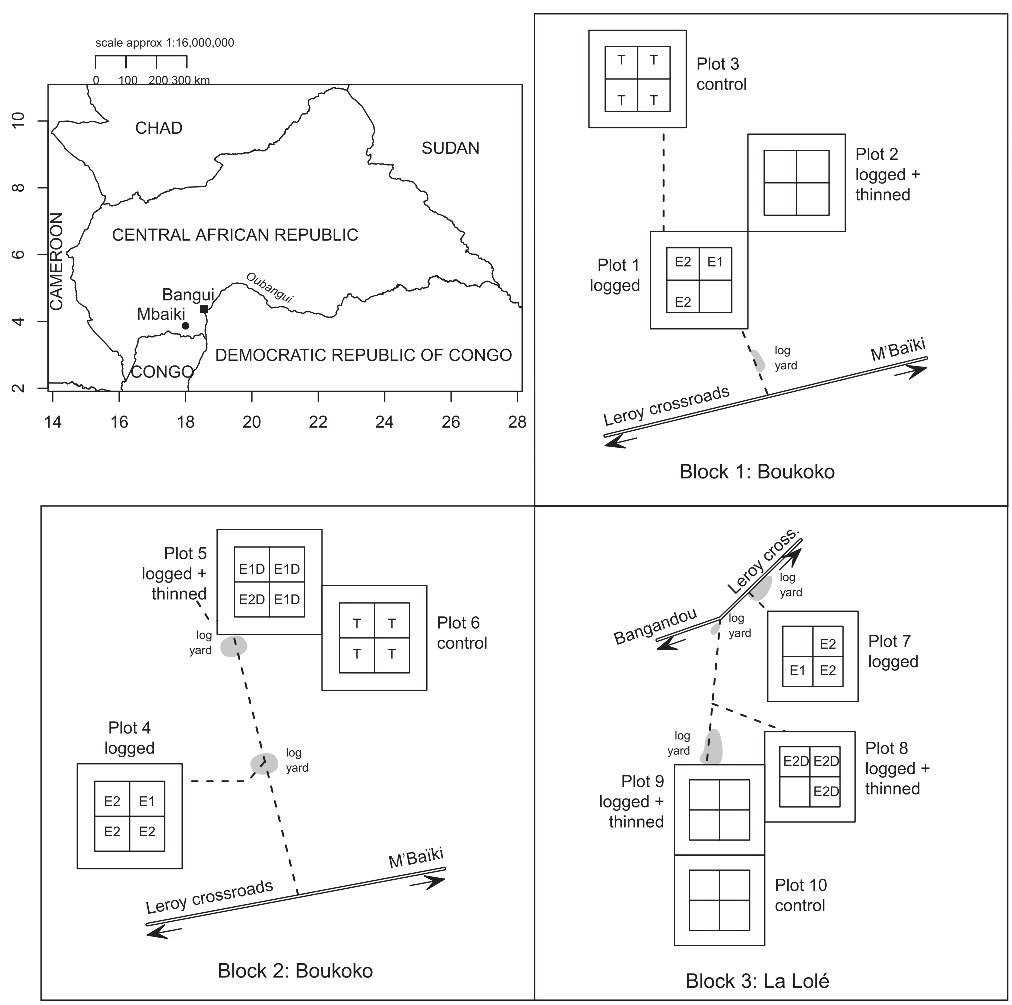

Fig. 1. Location of the study site in Central Africa and spatial distribution of the five treatments. The five treatments consisted of light logging (E1); heavy logging (E2); light logging and thinning (E1D); heavy logging and thinning (E2D); and no logging (T).

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