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Above-ground biomass and the fate of carbon after burning in the savannas of Roraima, Brazilian Amazonia

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Abstract

Above-ground biomass (live + dead), was estimated pre- and post-burn in eight types of savanna ecosystem in Roraima, in the extreme northern part of the Brazilian Amazon. The objective was to investigate the stock of pre-burn above-ground carbon and its fate after experimental fires that were set during the dry season (December–March). The total biomass in each ecosystem was divided into two groups (''fine-fuels'' and ''trees and shrubs''), and the combustion factor and the concentration of carbon were determined for of each of the biomass components within these groups. The ecosystems with the lowest biomasses were the grasslands (1627–4045 kg ha^{-1}), followed by parkland (6127–8038 kg ha^{-1}) and open woodland savanna (10,246–11,731 kg ha^{-1}). The percentage of ''live biomass'' was higher in the open woodland vegetation types (77.1–85.6%), and lower in the grassland and parkland types (11.4–51.4%). The total emitted carbon (''presumed release'') in each ecosystem varied from 551 to 1474 kg C ha^{-1}. These results differ from those observed in the savannas of central Brazil (2909 kg C ha^{-1} emitted), which were used as the standard in the Brazilian national inventory of greenhouse-gas emissions for the burning of non-anthropic savannas. This suggests that the calculations of Brazilian emissions for savannas should be disaggregated by region instead of using standard national values. Savanna ecosystems in Amazonia, although defined phytoecologically in the same way as those of central Brazil (despite being separated by great geographical distances), possess fire dynamics of their own, implying differences in the emissions of greenhouse gases.

Keywords: Amazonia; Biomass; Carbon; Cerrado; Savanna; Savannah

1. Introduction

Biomass and carbon contained in the different components of the vegetation are key parameters for the calculation of the emission of particulates and greenhouse gases from fires in savannas (IPCC/

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OECD, 1994; Cachier et al., 1995; Liousse et al., 1997; IPCC, 1997; Ferek et al., 1998). These parameters have been determined for different types of savannas in various parts of the world, the largest number of studies being in Africa (Crutzen and Andreae, 1990; Scholes, 1995).

In Brazil, studies to quantify plant biomass and carbon stocks in savanna ecosystems (also called "*cerrado*" in Brazil, see Eiten, 1982) have recently begun to receive greater attention. Most of the studies in Brazil have been done in the central part of the country, such as the studies by Ward et al. (1992), Kauffman et al. (1994), Miranda et al. (1996a,b), Silva et al. (1996), Sato and Miranda (1996), Abdala et al. (1998), Castro and Kauffman (1998), Miranda and Miranda (2000) and Ottmar et al. (2001). Such studies are lacking in the Amazon region, even though Amazonian savannas also are affected by frequent burning, contributing to the net emission of particulate material and greenhouse gases to the atmosphere (Nepstad et al., 1997; Barbosa and Fearnside, 2005). Although Amazonian savannas have their own dynamics in the event of fire, floristic and structural criteria lead to these emissions being estimated in the general calculations of the National Inventory of greenhouse-gas emissions from burning of non-anthropic savannas (Brazil, MCT, 2002) by use of proxy values from central Brazil that are not appropriate for the Amazon region. The present study fills this lacuna by evaluating the above-ground biomass (pre- and post-burn) and the fate of the carbon (both the stock and the release) in eight types of open (low biomass) savanna located in the Brazilian Amazon.

2. Study area

The study area is the largest continuous block of savannas in northern part of the Brazilian Amazon. The savanna area covers approximately 40,000 km^2, including islands of forest and agricultural areas. This savanna area is located in the State of Roraima, approximately between 2°30′N and 5°0′N and 59°30′W and 61°30′W (Fig. 1). It is a large mosaic of ecosystems of open vegetation that is part of the "Rio Branco-Rupununi" complex, located between Brazil and Guyana (Eden, 1970; Sarmiento and Monasterio, 1975). According to Brazil, Projeto RADAMBRASIL (1975), the vegetation types in this mosaic can be divided into two landscape groups, taking into account their position with respect to altitude, pedology and geomorphology: (1) "savannas" (S)—located in the low and mid-altitude relief (<600 m) of the Boa Vista and Surumu Formations, predominantly on latosols and podzolic soils (Oxisols and Ultisols) and (2) "steppe-like savannas" (T)—located in the high altitude relief of the Roraima Group (>600 m), established on sandy and stony soils. In both cases, vegetation types range from grassland to open woodland, according to the classification of Brazil, IBGE – Brazilian Institute of Geography and Statistics (1992), together with the definitions adopted by Coutinho (1978) and Ribeiro and Walter (1998) (Table 1). We disaggregate the data so that they can be interpreted both in terms of the IBGE vegetation code and in terms of the *campo limpo* (grassland) or "clean field" (CF) and *campo sujo* (grassland with scattered small trees) or "dirty field" (DF) distinction often employed in ecological studies of the *cerrados* (savannas) of central Brazil.

The climate of the area is Awi under the Köppen classification, with 1100–1700 mm of rainfall and 100–130 days with rain per year (Lameira and Coimbra, 1988; Barbosa, 1997). The driest months are between December and March, and the peak of the rainy season is between May and August. The relief that supports this landscape rises in altitude as one moves from the center-south to the north-northeast, beginning at an altitude of approximately 80–100 m in the Boa Vista Formation and increasing to over 600 m in the Roraima Group (Brazil, Projeto RADAMBRASIL, 1975).

3. Material and methods

Fieldwork was carried out between January 1995 and January 1998. The methodology used to identify and to quantify the above-ground plant biomass, and the corresponding carbon for each of the ecosystems studied was based on inventories that contained biomass components with the greatest uniformity possible, together with procedures of direct (cutting and weighing) and indirect analysis (by means of regression), as described below.