HOLOCENE VEGETATION DYNAMICS AND CLIMATE INFERENCES AT NORTHERN COAST OF ESPÍRITO SANTO STATE (BRAZIL) BASED ON CARBON ISOTOPES OF SOIL ORGANIC MATTER

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1. INTRODUCTION

Holocene vegetation changes and climate fluctuations at southeastern Brazil have been investigated by distinct methodologies and proxies. According to a model derived from these studies the climate at southeastern Brazil during early to mid Holocene was drier than the late Holocene (Servant et al., 1989; Ledru, 1993; Ledru et al., 1998, 2009; Pessenda et al., 2004; Pessenda et al., 2009).

Carbon isotopes from soil organic matter have been used to characterize vegetation changes in the past in order to infer the paleoclimate (Boutton, 1996; Pessenda et al., 2004, 2009). This methodology is based on the distinct carbon isotope fractionation by C3 and C4 plants that are preserved in the organic matter in the soil profile (Boutton, 1996). Organic matter derived from C3 plants, which are represented mainly by trees and herbs from humid environments, have a carbon isotopic composition ($\delta^{13}C$) from -33‰ to -22‰. Organic matter derived from C4 plants, represented mainly by herbs from Poaceae and Cyperaceae families, species adapted to drier environmental conditions, show $\delta^{13}C$ values from -17‰ to -9‰. Therefore, the $\delta^{13}C$ of the soil profile reflects the local vegetation changes along time and may be used to infer the climate variability.

Here we present a study developed in the Vale Atlantic Rainforest Natural Reserve, northern Espírito Santo State, Brazil. Carbon isotopic composition measured in soil profiles indicates the dominance of vegetation composed mainly by C3 plants during the whole Holocene. These results suggest regional humid climate in the period, in contrast to other studies developed in the southeastern Brazil.

1.1 Study site

The Vale Natural Reserve (VNR) is constituted of an area of ca. 22000 ha of native vegetation at northern Espírito Santo State (Fig. 1). The vegetation types comprise mainly lowland Atlantic Rainforest, floodplain and gallery forests, marshes, Restinga and mussununga (Thomas, 2003). Lowland Atlantic Rainforest is placed over Dystrophic Yellow Argissol (Oxisol) (Santos et al., 2004) developed from Neogene sediments denominated

Barreiras Formation (Dominguez, 2009). Mussununga vegetation occurs interspersed among the lowland forest, placed over Spodosols (Santos et al., 2004). Sites of shallower and less drained Spodosols become water flooded during the rainy season, so distinct mussunungas present distinct physiognomies (varying from grassland to arboreal grassland) and plant species assemblages associated with the water stress resulted from the drainage system, soil depth and granulometry (Saporetti Jr, 2009). The local climate is classified as Aw in Köppen, characteristic of savannah vegetation. Field measurements carried out from 1975 to 2002, established the mean annual precipitation of 1215 mm and mean annual temperature of 23.3°C, and a dry season during the winter.

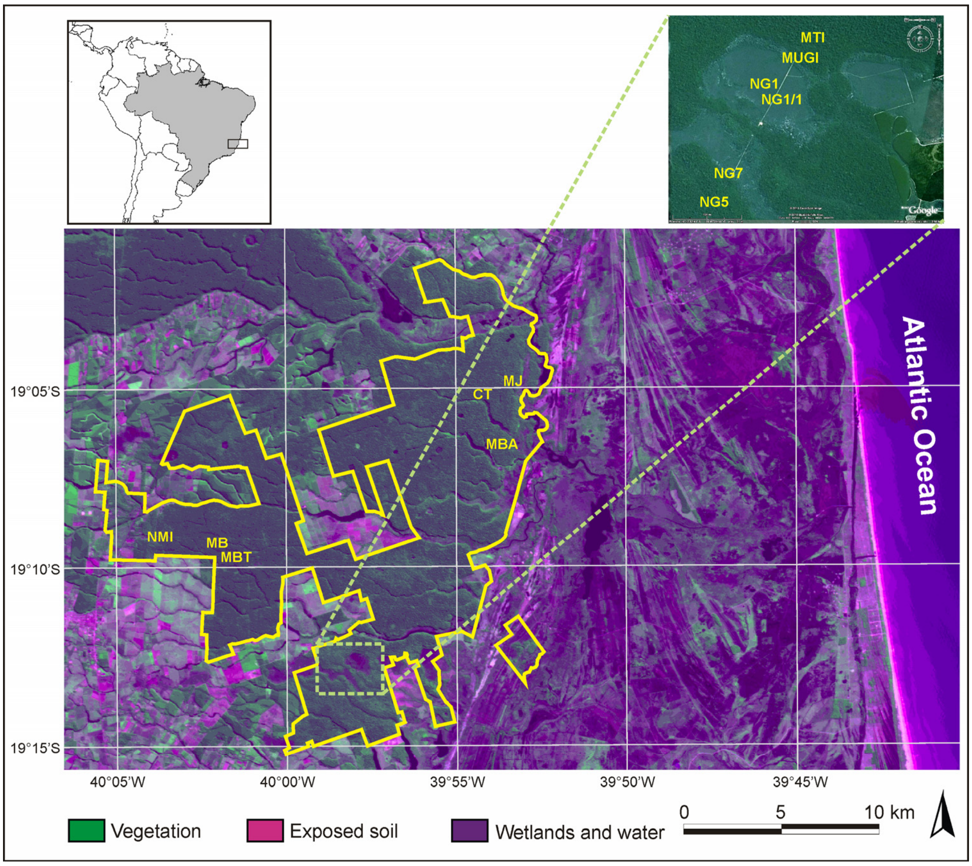

Figure 1. Study site; Land use map for the year 2005 elaborated from CBERS2 CCD bands 3, 4 and 2. The VNR area is delimited.

2. MATERIAL AND METHODS

Soil samples were collected each 10 or 20 cm in trenches or with a hand auger. Seven sampling points were located inside of lowland forest and five inside of mussununga vegetation (Fig. 1). At each site were collected dominant plant species and litter samples. $\delta^{13}C$ analyses were carried out at CENA Stable Isotopes Laboratory (Piracicaba, Brazil) using an elemental analyzer attached to an ANCA SL 2020 mass spectrometer, according to Pessenda et al. (1996b). Isotopic composition is expressed in per mil (‰) with a standard deviation of ±0.2‰, measured with respect to VPDB. Three soil samples from a trench inside a forested sample site (MBT) and one soil sample from a grassland sample site (NG1/1) were selected for ^{14}C dating of the humin fraction. These samples were treated according to Pessenda et al. (1996b) at ^{14}C Laboratory at CENA. After combustion the purified CO_2 was sent to the University of Georgia, USA, for AMS dating. The ages are expressed in years before present (yr BP) and in calibrated ages (cal. yr BP, 2σ) according to Reimer et al. (2004).

3. RESULTS AND DISCUSSION

Table 1 presents the ^{14}C ages of the humin samples. At the forested site MBT the ages range from 7856-7696 cal. yr BP at 190-200 cm to 2860-2764 cal. yr BP at 40-50 cm depth. From these results we may consider that the humin fraction of the organic matter at deeper samples of the forested sites represents at least the early Holocene (Pessenda et al., 1996a). At the grassland site NG1/1 the ^{14}C age of 16750-15584 cal. yr BP obtained for the humin sample at 350-360 cm suggests that the organic matter for the mussununga sites represents at least the late Plesitocene period.

Table 1 – ^{14}C dates obtained from humin fraction of soil organic matter

Laboratory #	Sampling site	Depth (cm)	Age (yr BP)	Calibrated age (cal. yr BP)
UGAMS4270	MBT (forest)	40-50	2720 ±25	2860-2764
UGAMS4271	MBT (forest)	90-100	6240 ±30	7254-7154
UGAMS4272	MBT (forest)	190-200	6960 ±30	7856-7696
UGAMS8195	NG1/1 (mussununga)	350-360	13280 ±60	16750-15584

*UGAMS - AMS Laboratory University of Georgia, USA.

At lowland forest sites (Fig. 2A) $\delta^{13}C$ values of dominant plant samples varied from -31‰ to -35.5‰ and litter samples varied around -30‰. These values reflect the presence of C3 plants in the forested tropical environments. All soil profiles in forest sites showed $\delta^{13}C$ values characteristic of C3 plants, varying from -24.5‰ to -28‰. The tendency to more enriched $\delta^{13}C$ values from living plants to litter and from shallow horizon to deeper soil samples is associated with the isotopic fractionation due to the organic matter decomposition (Macko and Estep, 1984).

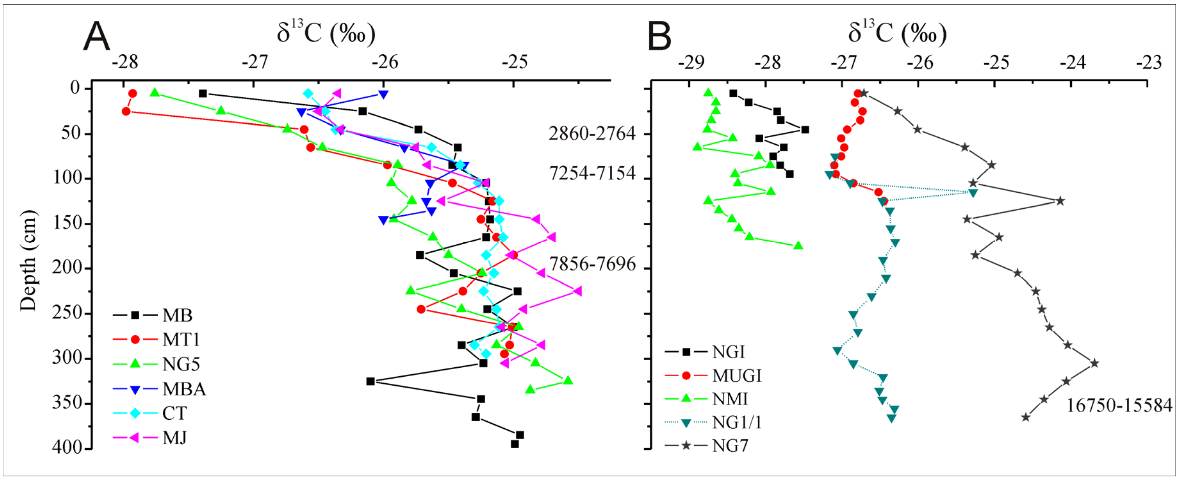

Figure 2. Carbon isotopic composition of soil organic matter and ^{14}C dates (cal. yr BP) of humin fraction; A) sites under forest; B) sites under mussununga vegetation.

At mussununga vegetation sites (Fig. 2B) $\delta^{13}C$ of plants indicates the presence of C3 and C4 species. $\delta^{13}C$ of the C3 plants, which are dominant, varied from -27.5‰ to -32.4‰. Only one C4 plant was sampled at MUGI site with $\delta^{13}C$ of -13.4‰. $\delta^{13}C$ values of soil samples at 0-10 cm ranged from -26.8‰ to -28.8‰ and represent the dominance of C3 plants. Along the soil profiles $\delta^{13}C$ values varied from -23.7‰ to -28.9‰. The $\delta^{13}C$ enrichment observed at some depths can be associated with the isotopic fractionation due to the organic matter decomposition (Macko and Estep, 1984) and/or to more significant presence of C4 plants in the past.

4. CONCLUSION

The carbon isotope composition of soil organic matter and the ^{14}C dating of the humin fraction suggest that since the late Pleistocene the vegetation cover of the Vale Natural Reserve, northern Espírito Santo State, is constituted by forest and grasslands composed mainly by C3 plants species, probably associated with the dominance of a humid climate in the study site. This result is in contrast with other studies that characterize a drier climate during the early to mid Holocene period in distinct locations in the southeastern region of Brazil.

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