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The contribution of ^{13}C isotopic tracing of soil organic matter to the reconstitution of forest–savannah successions in the coastal zone of Gabon

ROBERT NASI AND DOMINIQUE SCHWARTZ

The natural abundance of ^{13}C in higher plants is primarily determined by their photosynthetic type: the $\delta^{13}C$ defined as (sample ($^{13}C/^{12}C$)/reference ($^{13}C/^{12}C$) – 1)*1,000 of C3 plants (trees and herbaceous undergrowth) is around –26 0/00, that of C4 plants (primarily tropical Graminaceae, Cyperaceae and Chenopodiaceae) around –12 0/00. The $\delta^{13}C$ signal is transmitted with very little change to soil organic matter and the signal from a forest soil is between –26 and –28 0/00, while that from a savannah soil is more variable and depends on the degree of dominance of Graminaceae and Cyperaceae (C4) over C3-type herbaceous and woody species: from –12 to –16 0/00 (Boutton, 1996; Mariotti, 1991).

Floristic inventories and diachronic comparisons of aerial photographs or satellite images can be used to monitor the changes in forest cover in a given region over a relatively short time lapse (a few decades at most). The changes in soil organic matter $\delta^{13}C$ with depth serve to reconstitute local successions of forest and savannah vegetation over longer periods and to place contemporary patterns within a longer-term historical framework (Mariotti, 1991; Mariotti and Peterschmitt, 1994; Schwartz, 1991). Using this indirect tool to monitor forest-savannah requires above all accurate calibration of the signal so as to enable interpretation of the different values. The accuracy of the information subsequently depends on changes in the soil; as the soil is an open, bioturbated medium, the isotopic signal measured corresponds to a mean value of the types of organic matter of different ages in the soil, an increase in depth overcomes minor fluctuations in the cover.

In the coastal zone of Gabon, a comparison of aerial photographs from 1955 and 1991 revealed two forest facies considered as mature forest, which had remained stable over the period. The first was forest dominated by large *Aucoumea klaineana* and *Sacoglottis gabonensis*; the floristic composition of the second was very similar to that of the first, but there were no *Aucoumea klaineana* and very few *Sacoglottis gabonensis* (Fuhr, 1999). The $\delta^{13}C$ profiles of these two forest facies were very different (Delègue et al., 2001). That of the *Aucoumea klaineana* and *Sacoglottis gabonensis* forest was rather superficial. There was a savannah signal at a depth of around 40 cm, which proved that the forest had developed on savannah. However, the isotopic profile for the second facies was solely forest, with no signs of savannah. The area must therefore have been covered by forest for some considerable time. A plant cover that looks stable on a scale of thirty-five years may thus not be so on a longer time scale and numerous apparently primary forests are in fact old secondary forests.

In Africa, very large areas saw a fluctuation of forest fringes as a result of climatic change in the recent quaternary period (Bonvallot et Schwartz, 2002; de Foresta, 1990; Guillet et al., 2001; Maley, 1990; Youta Happi, 1998). The history of the forests in Gabon and the Congo (Schwartz et al., 1992, 1996) was marked by two main periods of retreat: the first, during which forest retreat reached a peak, around 30,000–12,000 BP (Before Present, before 1950); the second during the upper Holocene, which began between 4000 and 2000 BP, depending on the region. Just a few patches of forest, seen as 'forest refuges' remained during these periods. These two phases were separated by a period of expansion, during which the forests extended beyond their current area. After 1200 BP, a humid climate was re-established in humid tropical Africa, enabling the gradual return of forest to previous savannah areas; albeit with some halts and occasional retreats (Vincens et al., 1999). Under the current ecological conditions and without human interventions (like fire), the forest is actually spreading.

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