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LETTER TO THE EDITOR

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The excellent paper by Grootes et al. (1988) on the incorporation of atmospheric "bomb" ^{14}C into tree-ring cellulose brings together studies from several disciplines, and serves to spotlight two inter-disciplinary questions in which differences of opinion emerge from the literature. The questions have relevance in understanding the physiological dynamics of carbon assimilation in trees and to the (often unquestioning) use of tree material in palaeo-environmental reconstructions.

The two questions: (i) to what degree does a tree assimilate locally respired CO_2 as distinct from free-atmosphere CO_2?; (ii) what are the pathways within a tree which determine the origin of carbon in a selected tree-ring section?

Grootes et al. (1988) conclude that between 13 and 28% of the trunk cellulose in Sitka spruce from the US Pacific coast was obtained from "biospheric CO_2". They also make the related inference that a major portion of the lower trunk cellulose comes from sub-canopy leaves adjacent to the sampled section.

My experience in these areas comes from stable isotope ($\delta^{13}C$) and physiological measurements on Huon pine in a Tasmanian rain forest, including measurements of the CO_2 concentration and isotopic composition in sub-canopy air (Francey et al., 1985). While the generalisation of results from one complex system to another requires considerable knowledge of both, in the absence of detailed knowledge, it is sometimes useful to speculate in the hope of identifying major common influences. Our conclusions differ from those of Grootes et al. (1988) in suggesting: (i) the reassimilation of respired CO_2 was negligible, (certainly less than 5%); and this is related to the contention that: (ii) the bulk of carbon in tree rings represents "an assimilation weighted average", with most of the carbon coming from the well-lit and well-ventilated canopy top.

This latter point is obviously the fundamental difference between the two interpretations, but appears amenable to resolution. Since the opportunity for me to experiment is currently very limited, the rationale is advanced here.

Grootes et al. (1988) attribute the depression of $\Delta^{14}C$ in the trunk compared to that estimated for the atmosphere above the canopy largely in terms of the assimilation, low in the canopy, of respired CO_2 from decaying (old) biological material. Support is drawn from concepts of limited translocation of photosynthate derived from ^{14}C tracer measurements. Francey et al. (1985) used the combined physiological and isotopic measurements to demonstrate that light was a major influence on $\delta^{13}C$ of photosynthate, and preferred an explanation involving considerable translocation and mixing to get quantitative agreement with a physiological model for ^{13}C fractionation. (The model identifies the major influence on $\delta^{13}C$ of photosynthate as being the kinetic rate of assimilation; environmental influences such as temperature, water availability, humidity, etc., are important only in so far as they affect this rate.)

For both studies, a measurement which could have been made (but was not) was a vertical profile of the ^{13}C or ^{14}C isotope ratios in the trunk. These potentially simple measurements would have commented directly on the interpretations advanced. The two isotopes give slightly different information. For $\delta^{13}C$, the direct influence of light is important, and must be considered if this influence is to be separated from a sub-canopy $\delta^{13}C$ profile in the air. For a tree with some sub-canopy foliage, a definitive result would be *no* measured vertical $\delta^{13}C$ gradient in a ring; a measured gradient would comment on the mixing but would not resolve the cause. For ^{14}C, there is no complicating influence of light, as the $\Delta^{14}C$ are corrected using $\delta^{13}C$; however, the "age" of the sub-canopy biospheric CO_2 in the air would have to be determined.

Of course, it may turn out that the two species/ecosystems are sufficiently different that both interpretations are confirmed, i.e., the Sitka spruce will have appreciable $\delta^{13}C$ and $\Delta^{14}C$ vertical gradients, and the Huon pine no such gradients!

REFERENCES

Grootes, P. M., Farwell, G. M., Schmidt, F. H., Leach, D. D. and Stuiver, M. 1989. Rapid response of tree cellulose radiocarbon content to changes in atmospheric $^{14}CO_2$ concentration. *Tellus 41B*, 134–148.

Francey, R. J., Gifford, R. M., Sharkey, T. D. and Weir, B. 1985. Physiological influences on carbon isotope discrimination in huon pine (Lagarostrobus franklinii). *Oecologia 66*, 211–218.