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ON A 50-YEAR "CLIMATE-FREE" $\delta^{13}C$ RECORD FROM JUNIPER TREE RINGS

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When used with ^{14}C records, an accurate reconstruction of the $^{13}C/^{12}C$ changes of atmospheric CO_2 may be a key constraint to determining the historic activity of the biosphere as CO_2 source or sink. We recently detailed the derivation of an atmospheric $\delta^{13}C$ record for 1930-1979 from Arizona juniper tree rings (Leavitt and Long, 1983). Each tree was close to a weather station, allowing us to account for the effects of climate on the tree-ring $\delta^{13}C$ records. The resulting atmospheric $\delta^{13}C$ trend shows an overall decrease of ca 1.3°/oo, but instead of decreasing exponentially over the whole 50-year period, the best-fit curve decreases exponentially to ca 1960 and then flattens out. The drop from 1956 to 1978 was ca 0.55°/oo, still very similar to the measured atmospheric drop over that period of 0.65 ± 0.13°/oo (Keeling, Mook, and Tans, 1979).

Although this $\delta^{13}C$ trend is not reproduced in other tree-ring studies, it suggests a change in the biosphere from net CO_2 source to sink in the early 1960's. Other studies offer evidence of the important and/or increasing role of biospheric sink activity which may support our $\delta^{13}C$ trend. Seiler and Crutzen (1980) discuss an elemental carbon (charcoal) sink from forest and grassland burning, and Walsh *et al* (1981) describe a primary production detrital sink on continental shelves. Lugo and Brown (1982) found undisturbed tropical forest lands are potentially a significant sink, enough so, that tropical forests may be in balance or even a slight CO_2 sink.

The decelerating $\delta^{13}C$ trend may be interpreted differently. If the biosphere has been approximately in balance, either this $\delta^{13}C$ trend is not globally representative or, if the trend is representative, another mechanism would have to decelerate the decreasing trend. More time and research will judge the former possibility. For the latter, we speculate on the existence of "light-carbon (^{12}C) sinks" which may increase $\delta^{13}C$ of atmospheric CO_2 and the tree-ring $\delta^{13}C$ records. Four ^{12}C sinks are: 1) Net increase of organic soils (Bohn, 1978) could lead to accumulation of relatively decay-resistant lignins and lipids which are isotopically lighter by ca 1 to 3°/oo relative to their original whole tissue (Park and Epstein, 1961); 2) The early years of tree growth (ca 50 years) are often characterized by ^{13}C depletion, ca 2°/oo less ^{13}C than that of later years (eg, Craig, 1954). With significant forest regrowth in previously-cleared areas, this young regrowth could also represent a ^{12}C sink; 3) Pyrolysis experiments (Leavitt, Donahue, and Long, 1982) indicate the char residue may be enriched in ^{12}C by ca 2.5°/oo relative to the original wood. An elemental carbon sink from forest fires may also be a potentially active light-carbon sink; 4) An increased proportion of C_3 to C_4 plants would yield a ^{12}C sink even without biomass changes. Deforestation and replacement by agriculture should generally be the reverse of such a trend: C_3 trees would be removed, and in some cases, be replaced with C_4 crops (eg, corn and sugar cane). Where fields were cleared for farming and then abandoned, "old-field succession" may take place with the opposite transition of C_4 to C_3.

The impact of the first three sinks would probably be insignificant because, 1) the carbon stored is only ca 2 to 3°/oo lighter than the average biospheric composition of ca -25°/oo, and 2) these carbon sinks are limited in size. The large difference in $\delta^{13}C$ of C_3 and C_4 plants (C_3 plants ca 14°/oo lighter) indicates a potentially more significant light-carbon sink. Per cent changes in the proportion of C_3 to C_4 plants could translate to atmospheric changes in tenths of a °/oo.

Representative or not, the unusual $\delta^{13}C$ trend should stimulate closer examination of biospheric carbon sources and sinks, including the potential influence of light-carbon sinks.

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