PARTITIONING SOURCES OF SOIL-RESPIRED CO_2 AND THEIR SEASONAL VARIATION USING A UNIQUE RADIOCARBON TRACER

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ABSTRACT

Soil respiration is derived from heterotrophic (decomposition of soil organic matter) and autotrophic (root/rhizosphere respiration) sources, but there is considerable uncertainty about what factors control variations in their relative contributions in space and time. We took advantage of a unique whole-ecosystem radiocarbon label in a temperate forest to partition soil respiration into three sources: (1) recently photosynthesized carbon (C), which dominates root and rhizosphere respiration; (2) leaf litter decomposition and (3) decomposition of root litter and soil organic matter >1-2 years old. Heterotrophic sources and specifically leaf litter decomposition were large contributors to total soil respiration during the growing season. Relative contributions from leaf litter decomposition ranged from a low of ~1 ±3% of total soil respiration (6 ±3 mg C m^{-2} hr^{-1}) when leaf litter was extremely dry, to a high of 42 ±16% (96 ±38 mg C m^{-2} hr^{-1}). Total soil respiration fluxes varied with the strength of the leaf litter decomposition source, indicating that moisture-dependent changes in litter decomposition drive variability in total soil respiration fluxes. Root/rhizosphere respiration accounted for 16 ±10% to 64 ±22% of total soil respiration, with highest relative contributions coinciding with low overall soil respiration fluxes. In contrast to leaf litter decomposition, root respiration fluxes did not exhibit marked temporal variation ranging from 34 ±14 to 40 ±16 mg C m^{-2} hr^{-1} at different times in the growing season with a single exception (88 ±35 mg C m^{-2} hr^{-1}). Radiocarbon signatures of root respired CO_2 changed markedly between early and late spring (March vs. May), suggesting a switch from stored nonstructural carbohydrate sources to more recent photosynthetic products.

METHODS

High and low ^{14}C-labeled leaf litter (~950‰ and ~230‰ respectively) derived from a whole-ecosystem ^{14}C labeling during the growing season in 1999, was used to establish replicated plots (49 m^2) with the labeled leaf litter replacing natural leaf litter for a period of 3 consecutive years. In order to separate the sources of soil-respired CO_2 into heterotrophic and autotrophic (as defined above), we measured the ^{14}C signatures of total soil respiration, autotrophic and heterotrophic respiration ($\Delta^{14}C_{total\ respiration}$, $\Delta^{14}C_{autotrophic}$ and $\Delta^{14}C_{heterotrophic}$ respectively) as described in Cisneros-Dozal *et al.*, [2005] and applied the isotope mass balance proposed by Trumbore *et al*., [2002]:

$$\Delta^{14}C_{total\ respiration} = \Delta^{14}C_{autotrophic} \cdot FRR + \Delta^{14}C_{heterotrophic} \cdot (1\text{-}FRR)$$

where "FRR" refers to the fractional contribution from autotrophic respiration.

Furthermore, we estimated leaf litter decomposition fluxes by contrasting the difference in $\Delta^{14}C_{total\ respiration}$ between litter treatment plots as described in Cisneros-Dozal *et al.*, [2005].

COMPONENTS OF SOIL-RESPIRED CO_2

Leaf litter decomposition was a major contributor to overall heterotrophic CO_2 fluxes, but it was also the most variable component in space and time in response to changing moisture conditions (Fig. 1). In contrast, root/rhizosphere respiration fluxes did not exhibit marked temporal variation but the ^{14}C signature of root respiration provided preliminary information on the source of C respired by roots. This source appeared to be comprised by both, recent photosynthetic products indicated by lower ^{14}C content particularly in the summer (i.e. June) and a proportion of stored C indicated by the constant difference in the ^{14}C signature of root respiration between two sites that were exposed to high (TVA) and low (Walker Branch) amounts of ^{14}C during the labeling in 1999 (Fig. 2).

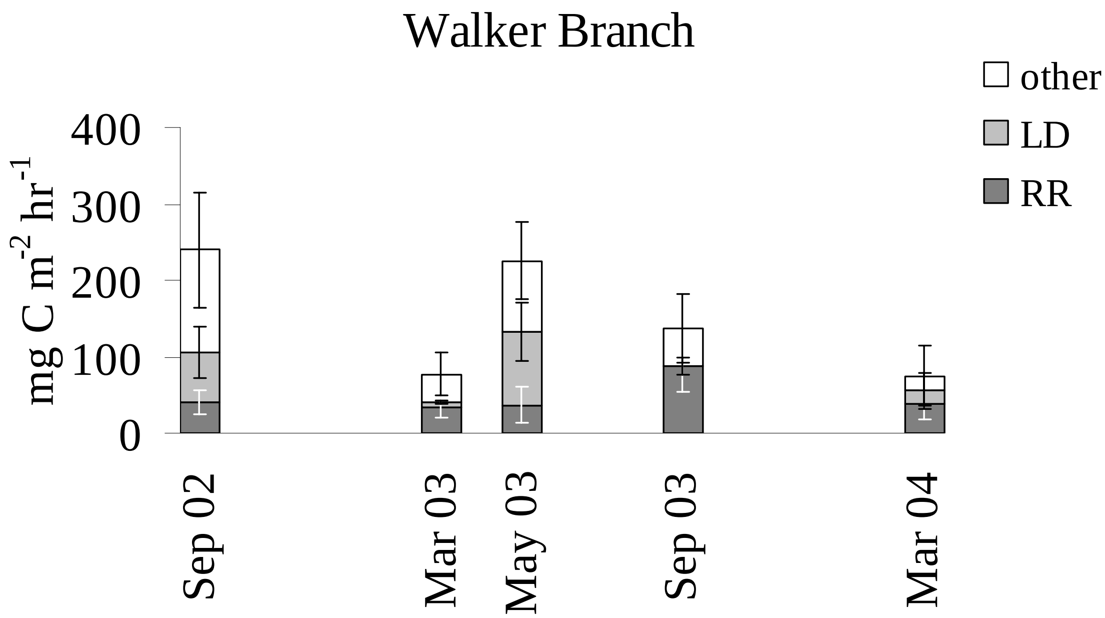

Fig. 1 Absolute contributions from leaf litter decomposition (LD), root/rhizosphere respiration (RR) and other heterotrophic sources (other) to total soil respiration at the Walker Branch site. Fluxes shown under "other" were calculated as the remaining difference and are assumed to have the isotopic signature of the incubated soil organic matter.

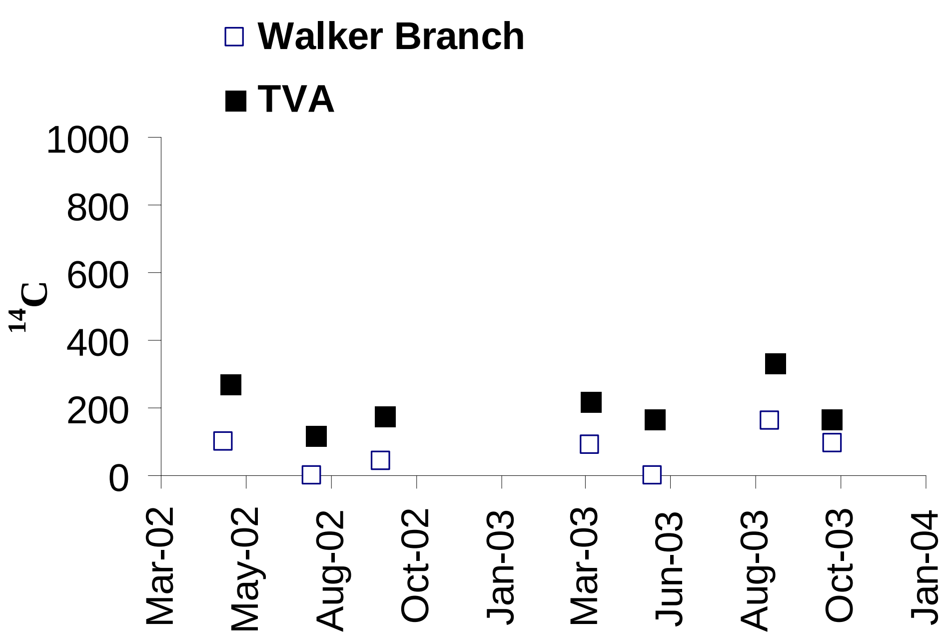

Fig. 2 ^{14}C signature (‰) of root/rhizosphere respiration at two sites exposed to high (TVA) and low (Walker Branch) levels of ^{14}C during the growing season in 1999.

REFERENCES

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