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Transport of root-derived CO_2 via the transpiration stream affects aboveground tree physiology

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Recent research on soil CO_2 efflux has shown that belowground autotrophic respiration is largely underestimated using classical net CO_2 flux measurements. Aubrey & Teskey (2009) found that in forest ecosystems a substantial portion of the CO_2 released from root respiration remained within the root system and was transported aboveground in the stem via the transpiration stream. The magnitude of this upward movement of CO_2 from belowground tissues suggested important implications for how we measure above- and belowground respiration. If a considerable fraction of root-respired CO_2 is transported aboveground, where it might be fixed in woody and leaf tissues, then we are routinely underestimating the amount of C needed to sustain belowground tissues.

In this study, we infused ^{13}C labeled water into the base of field-grown poplar trees as a surrogate for root-respired CO_2 to investigate the possible role of root-derived CO_2 as substrate for carbon fixation. The label was transported upwards from the base of the tree toward the top. During its ascent, the ^{13}C label was removed from the transpiration stream and fixed by chlorophyll-containing woody (young bark and xylem) and leaf (petiole) tissues. Moreover, based on ^{13}C analysis of gas samples, we observed that up to 88 $\pm$ 0.10 % of the label applied was lost to the atmosphere by stem and branch efflux higher in the trees. Given that one-half of root-respired CO_2 may follow this internal flux pathway (Aubrey & Teskey, 2009), we calculated that up to 44% of the root-respired CO_2 could diffuse to the atmosphere once transported to the stem and branches. Thus, a large portion of CO_2 that diffuses out of aboveground tissues may actually result from root respiration.

Our results show that CO_2 originating belowground can be transported internally to aboveground parts of trees, where it will have an important impact on tree physiology. Internal transport of CO_2 indicates that the gas exchange approach to estimating above- and belowground autotrophic respiration is inadequate. Accurate quantification of this internal carbon flux is necessary to understand plant physiological mechanisms and to explain variations in above-and belowground respiratory patterns, but these results do not imply the necessity for a reevaluation of net CO_2 flux at the ecosystem level.

Reference:

Aubrey DP, Teskey RO (2009) Root-derived CO_2 efflux via xylem stream rivals soil CO_2 efflux. New Phytologist 184: 35-40.