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Post-respiratory fate of CO_2 in tree stems

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CO_2 released from tree stems and branches makes up 14–30% of the total CO_2 flux in forest ecosystems. Stem CO_2 efflux is often taken as a proxy for stem respiration but recent evidence shows that several processes influence emission rates of stem-respired CO_2. Respiratory CO_2 may be dissolved and transported in the xylem, or refixed and metabolized by stem photosynthesis or via the enzyme phosphoenolpyruvatcarboxylase (PEPC). Stem CO_2 emission are thus not equal to stem respiration but the proportion of CO_2 that is transported, dissolved or refixed is likely highly variable across stem sections and over time. During aerobic respiration O_2 serves as electron acceptor and O_2 consumption may thus be a better metric of respiration rates than CO_2 emissions, in particular because O_2 is not affected by post-respiratory mechanisms the same way as CO_2. In addition, the ratio of CO_2 emission to O_2 uptake (respiratory quotient) also allows quantifying the effects of post-respiratory processes on CO_2 emissions. For a carbohydrate metabolism (carbohydrates are the dominant respiratory substrates), this ratio is expected to be 1. Recent findings report an average ratio in trees of 0.59, i.e. significantly lower than 1. Values as low as 0.7 could theoretically be explained when assuming a pure lipid metabolism, which is very unlikely for trees. A more likely explanation are reduced CO_2 emission due to post-respiratory processes, thus indicating that up to 41% of CO_2 respired by stems was not locally emitted. CO_2 refixation by the enzyme PEPC in stem parenchyma cells, woody tissue photosynthesis, and/or transport of dissolved CO_2 must have also been involved but the individual contributions are currently largely unknown. Despite their potential, measurements of O_2 concentrations at stem, tree or ecosystem-level have been rarely measured to date because the high background of O_2 in ambient air (21%) makes the detection of O_2 concentration changes in the range caused by plant respiration (a few 100 ppm) difficult and technically challenging. Here we propose a research agenda that allows the partitioning of individual contributions via the mass balance method that builds on already existing modelling approaches. We highlight a new field-tested device for autonomous long-term measurements of both CO_2 and O_2 concentrations at the trunk and describe tools and experimental approaches required for a better understanding of the post-respiratory fate of CO_2 in tree stems.