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Can plant phloem properties affect the link between ecosystem assimilation and respiration?

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Phloem transport of carbohydrates in plants under field conditions is currently not well understood. This is largely the result of the lack of techniques suitable for measuring phloem physiological properties continuously under field conditions. This lack of knowledge is currently hampering our efforts to link ecosystem-level processes of carbon fixation, allocation and use, especially belowground.

On theoretical grounds, the properties of the transport pathway from canopy to roots must be important in affecting the link between carbon assimilation and respiration, but it is unclear whether their effect is partially or entirely masked by processes occurring in other parts of the ecosystem. One can also predict the characteristic time scales over which these effects should occur and, as consequence, predict whether the transfer of turgor and osmotic signals from the site of carbon assimilation to the sites of carbon use are likely to control respiration.

We will present two sources of evidence suggesting that the properties of the phloem transport system may affect processes that are dependent on the supply of carbon substrate, such as root or soil respiration.

Firstly, we will summarize the results of a literature survey on soil and ecosystem respiration where the speed of transfer of photosynthetic sugars from the plant canopy to the soil surface was determined. Estimates of the transfer speed could be grouped according to whether the study employed isotopic or canopy [U+2044] soil flux-based techniques. These two groups provided very different estimates of transfer times likely because transport of sucrose molecules, and pressure-concentration waves, in phloem differed.

Secondly, we will argue that simultaneous measurements of bark and xylem diameters provide a novel tool to determine the continuous variations of phloem turgor in vivo in the field. We will present a model that interprets these changes in xylem and live bark diameters and present data testing the model predictions for mature trees in the field. At the diurnal scale, the calculated phloem turgor signal related to patterns of photosynthetic activity and inferred phloem loading. At the seasonal scale, phloem turgor showed rapid changes during two droughts and after two rainfall events consistent with physiological predictions of phloem transport. Daily cumulative totals of calculated phloem osmotic concentrations were strongly related to daily cumulative totals of canopy photosynthesis. We propose that this method has potential for continuous field monitoring of tree phloem function.