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Mechanisms and Control of Phloem Transport in Trees: Fast and Slow – Sink and Source

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Trees are large global stores of carbon that will be affected by increased carbon dioxide levels and climate change in the future. However, at present we cannot properly predict the carbon balance of forests as we lack knowledge on how plant physiological processes and especially the transport of carbon within the plant interact with environmental drivers and ecosystem-scale processes. The central conveyor belt for C allocation and distribution within the tree is the phloem and its functionality under environmental stress (esp. drought) is important for the avoidance of C starvation.

This paper addresses the distribution of new assimilates within the plant, and sheds light on phloem transport mechanisms and transport control using 13C pulse labelling techniques.

We provide experimental evidence that at least two mechanisms are employed to couple C sink processes to assimilation. We observed a fast increase of belowground respiration with the onset of photosynthesis, which we assume is induced by pressure concentration waves travelling through the phloem. A second, much later occurring peak in respiration is fueled by new 13C labeled assimilates.

Moreover, we relate phloem transport velocity and intensity of labelled 13C assimilates to drought stress intensity and give indication how sink rather than source control might affect phloem transport in trees. During drought, net photosynthesis, soil respiration and the allocation of recent assimilates below ground were reduced. Carbohydrates accumulated in metabolically resting roots but not in leaves, indicating sink control of the tree carbon balance. After drought release, soil respiration recovered faster than assimilation and CO_2 fluxes exceeded those in continuously watered trees for months. This stimulation was related to greater assimilate allocation to and metabolization in the rhizosphere. These findings show that trees prioritize the investment of assimilates below ground, probably to regain root functions after drought and indicate that sink activity governs carbon allocation not only during drought stress but also after stress release.