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A novel approach to the *in situ* measurement of oxygen concentrations in the sapwood of woody plants

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Abstract:

A novel technique for the physico-chemical analysis of xylem sap by underwater access to the sapwood of trees is described. *In situ* measurements of dissolved oxygen in the sapwood are performed by combining this technique with a novel optical method for oxygen detection. In early spring, the oxygen concentration of the sapwood of *Betula pendula* was in the range of 80–230 μmol O_2 L^{-1}, corresponding to an oxygen deficit of 40–75% of air saturation. Oxygen concentration maxima and minima occurred early in the morning and in the afternoon, respectively, whereas xylem sap temperatures showed the reverse pattern. In the sapwood, hypoxia increased from the beginning of bud break until frondescence, when a deficit of 86% of air saturation marked the upper limit of oxygen depletion. There seemed to be no relationship between daily variations of oxygen concentration and xylem sap pressure. In summer, sap flow was a major determinant for the diurnal variation of dissolved oxygen concentration. Oxygen supply to the sapwood was determined by both radial influx into the trunk through intercellular gas spaces and transport of dissolved oxygen via xylem sap flow. Radial influx seemed to be favoured during night-time, when the trunk was warmer than ambient air. During daytime, the hypoxia of the sapwood rose and increased sharply in the evening, when sap flow velocity approximated zero. High temperature in the sapwood enhanced the respiratory oxygen consumption of the wood parenchyma while the supply of dissolved oxygen via the transpiration stream became ineffective.

Key-words: Betula pendula, hypoxia, phenology, sap flow, wood anatomy, xylem pressure