Hydraulic efficiency and safety of conifer needles

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Leaves, representing the distal section of the soil-plant-atmosphere-continuum, are exposed to lowest water potentials and thus highest drought stress intensities within the plant. In contrast to angiosperm leaves, insight into the hydraulic architecture of conifer needles is poor.

Methods:

Hydraulic efficiency

- **Needle xylem and stem xylem hydraulic conductivity (k_s):** Specfic hydraulic conductivity method / Cavitron method
- **Needle hydraulic conductance (k_{leaf}):** Rehydration kinetics method

Hydraulic safety

- **Needle xylem and stem xylem vulnerability (P_{50}):** Cavitron / Ultrasonic method
- **Needle vulnerability (P_{50}):** Rehydration kinetics measurement

Main results:

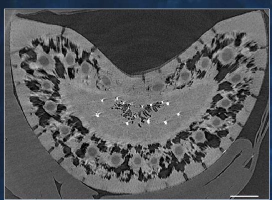
Needle xylem vs. Stem xylem

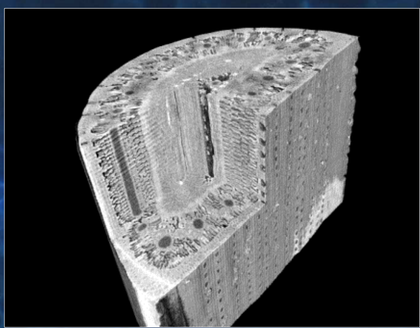
Species	**k_s axes xylem** $m^2\ s^{-1}\ MPa^{-1}\ 10^{-4}$	**k_s needle xylem** $m^2\ s^{-1}\ MPa^{-1}\ 10^{-4}$
Picea abies	5.11 ± 0.27	3.50 ± 0.66
Pinus pinaster	7.74 ± 0.56	2.03 ± 0.08
Pinus mugo	3.98 ± 0.26	0.90 ± 0.15

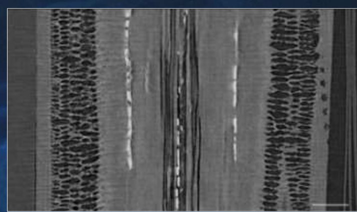
Needle k_s < Stem k_s

	P_{50} axes (MPa)	**P_{50} needles (MPa)**
Pinus pinaster	-3.15 ± 0.09	-1.54 ± 0.06
Picea abies	-3.45 ± 0.03	-2.67 ± 0.03
Pinus mugo	-3.03 ± 0.03	-1.25 ± 0.02
Pinus nigra	-3.08 ± 0.25	-1.39 ± 0.12
Pinus ponderosa	-3.11 ± 0.32	-1.94 ± 0.04

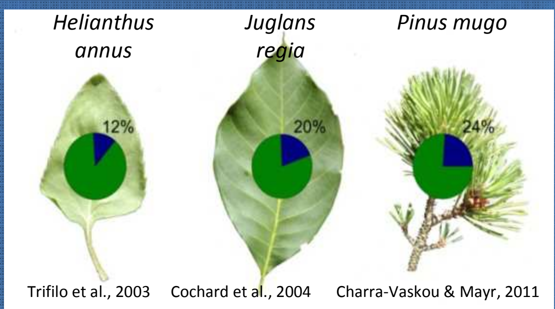
Needles: more vulnerable to dysfunction than axes





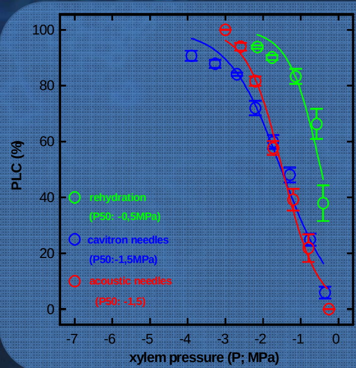


Within needle: Xylem vs. extra-vascular pathway



Extra vascular hydraulic resistance
Xylem hydraulic resistance

Xylem resistance < extra-vascular resistance



Pinus pinaster:

P_{50} needles = -0.5 MPa

P_{50} needles xylem = -1.5 MPa

Xylem: more safety than extra vascular pathway

Conclusion:

Hydraulic pathways in needles contribute a major part to the overall hydraulic resistance of conifers and exhibit a low hydraulic safety. Within needles, the extra-vascular pathway probably has lowest efficiency and safety so that the risk of conductivity losses is highest at the most distal sections of the transport pathway.