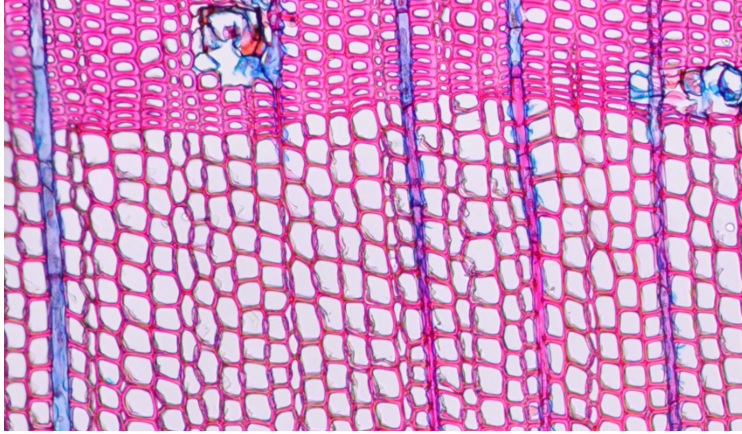


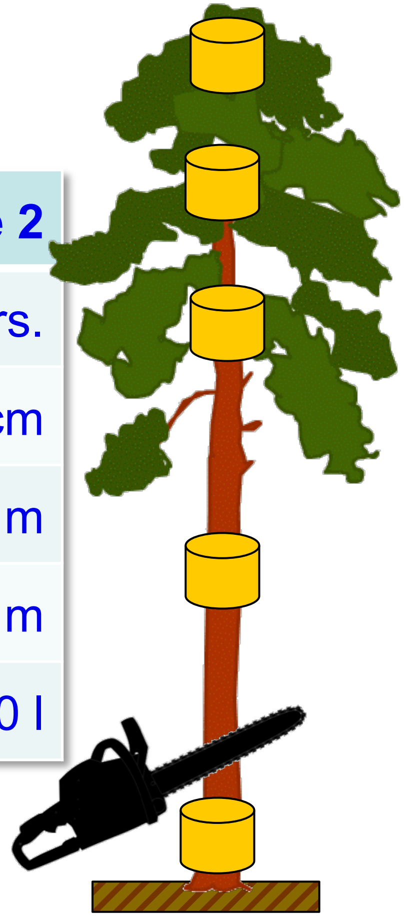
Form fits function – linking hydraulics and xylem anatomy along the stem axis

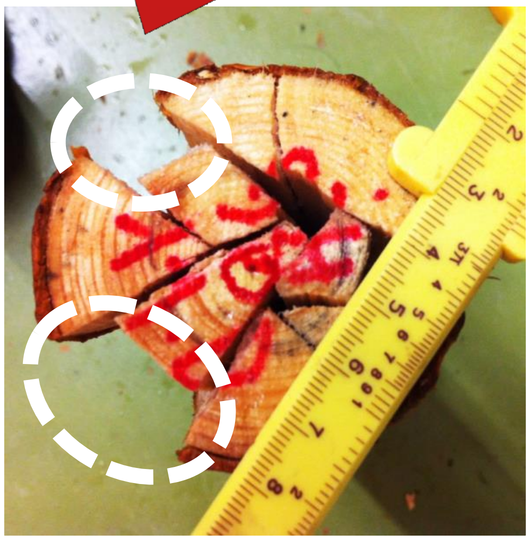
Georg von Arx, Barbara Beikircher, Stefan Mayr, Patrick Fonti

Swiss Federal Institute for Forest, Snow and Landscape Research WSL

The two poor guys … (*Pinus sylvestris*)

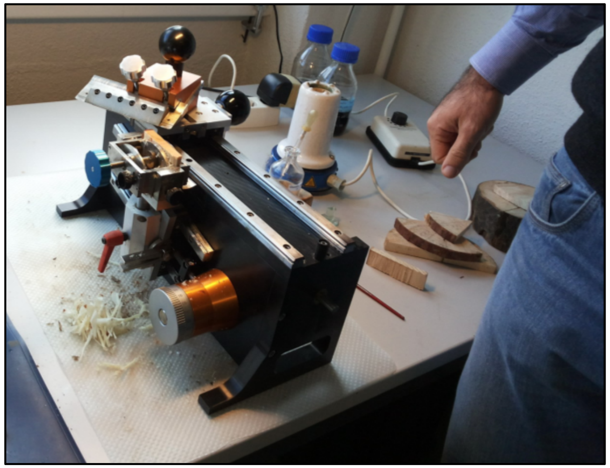
	Tree 1	Tree 2
Age	55 yrs.	110 yrs.
Dbh	24 cm	29 cm
Height	12.0 m	12.5 m
Crown	>7.5 m	>7.5 m
Needle volume	~200 l	~440 l



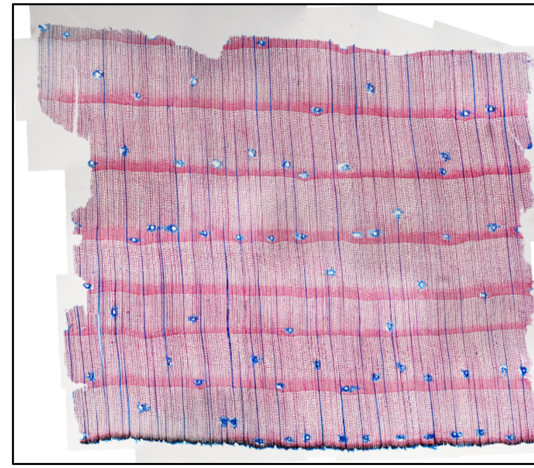


Split axial sticks with an ax (5-7 yrs.)

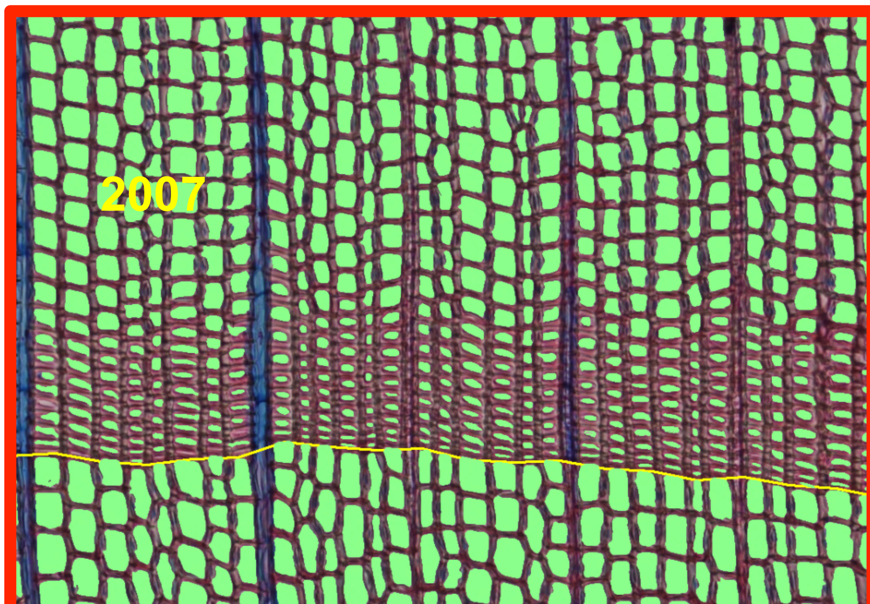
Quantifying lumina of all tracheids in axial sticks

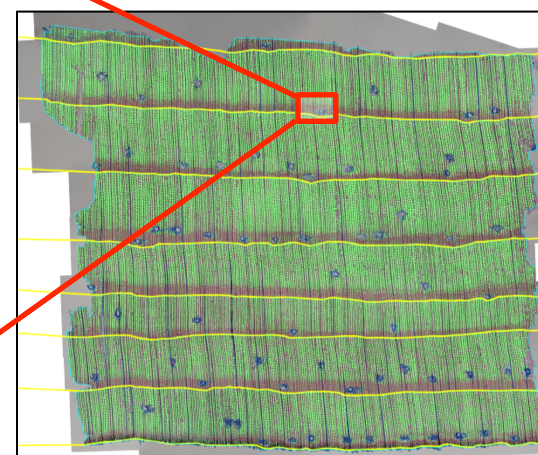


Thin sections from axial sticks



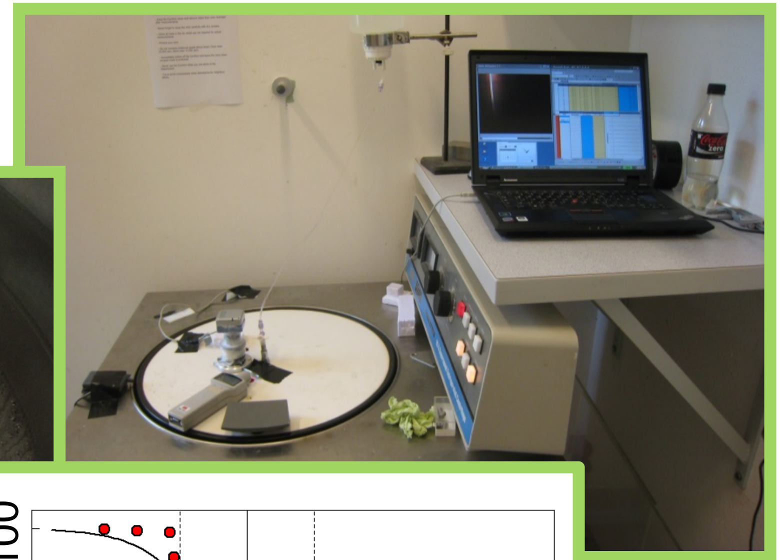
ROXAS

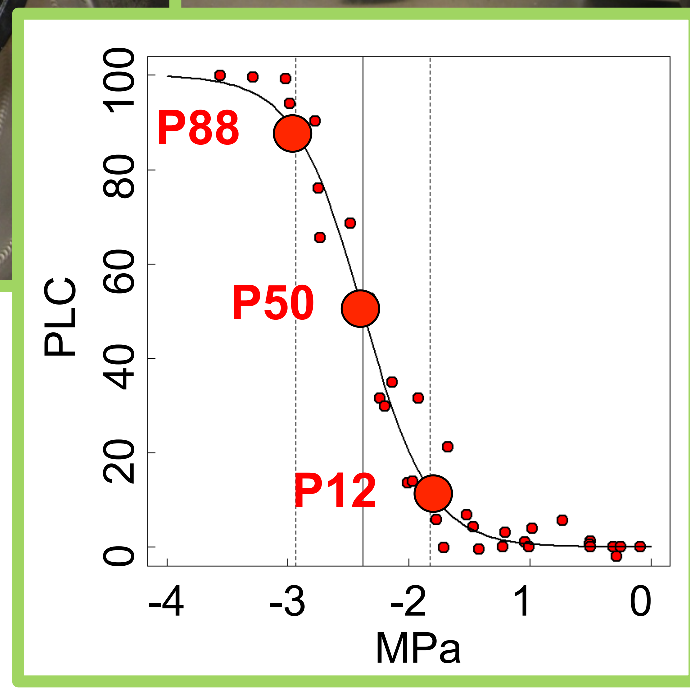




Vulnerability curves / hydraulic conductivity

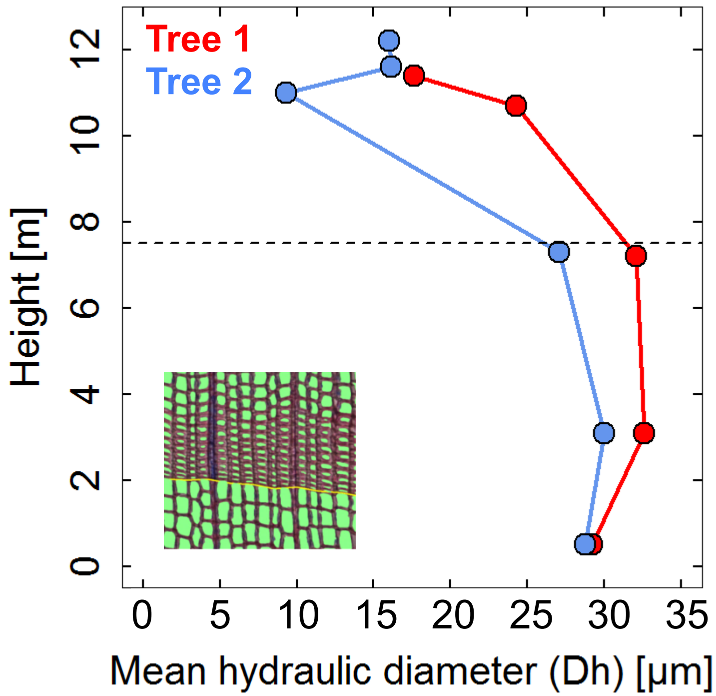
Cavitron

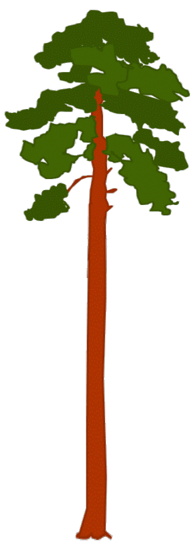


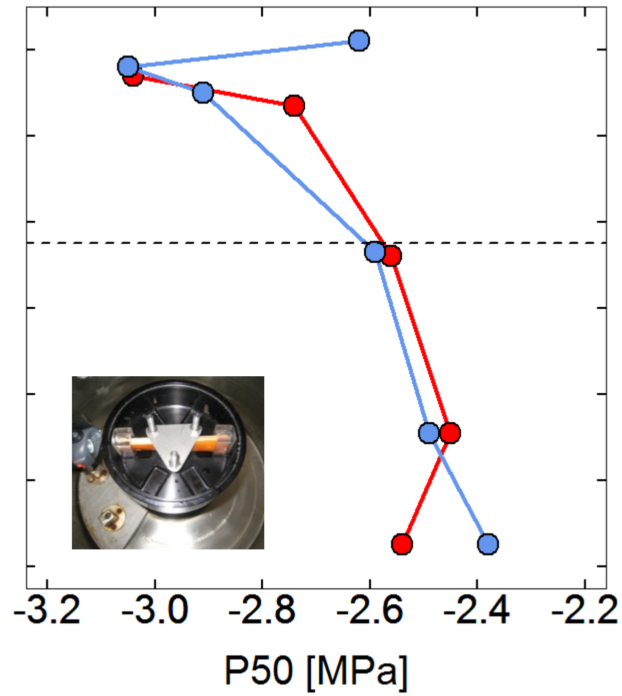


How much hydraulic conductivity is lost due to cavitation (PLC) as the water potential decreases?

Tracheid size and vulnerability to cavitation increase with distance from apex







Conduit widening!

Vulnerability tracks conduit widening!

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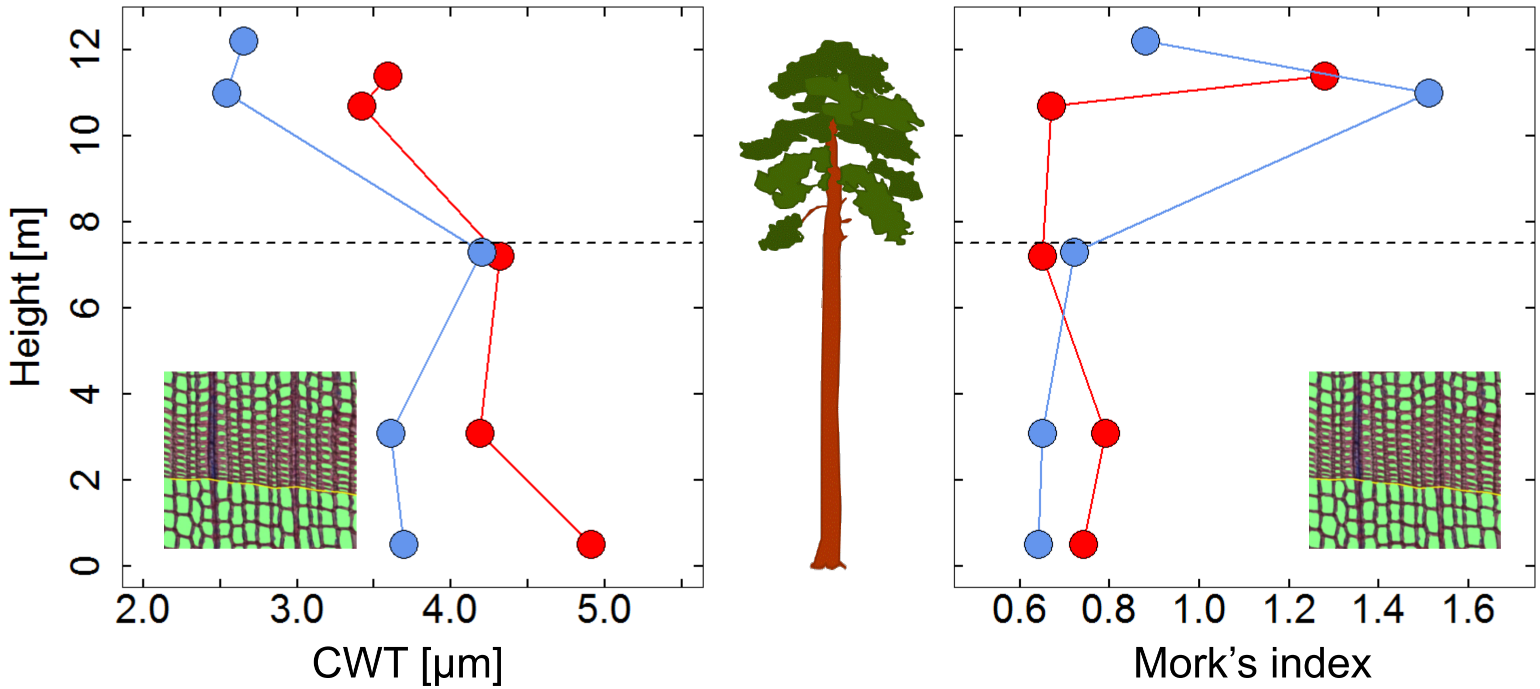
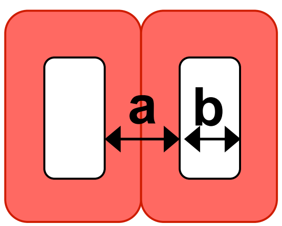
Cell wall thickness (CWT), but not anatomical wood density* increase with distance from apex



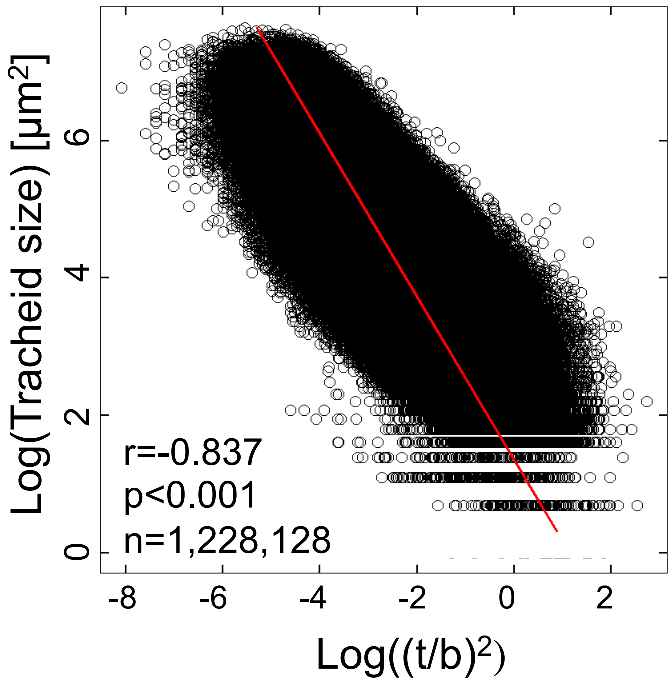


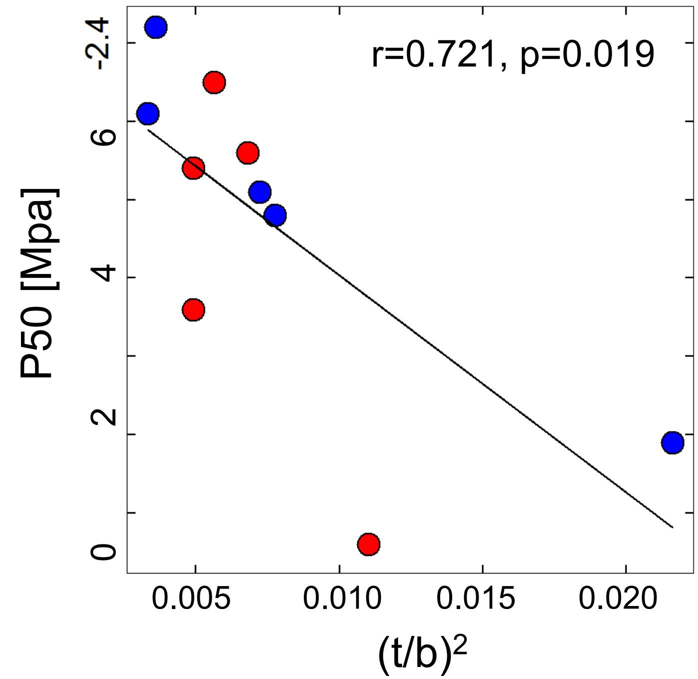
* Mork's index = 2a / b

➔ **«Anatomical wood density»**

(Denne, 1988, IAWA)

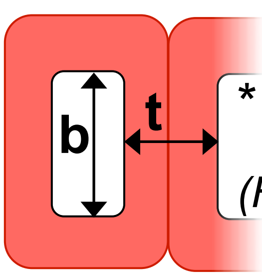
Tracheid stability* relates to tracheid size and P50





Larger tracheids are more prone to implosion

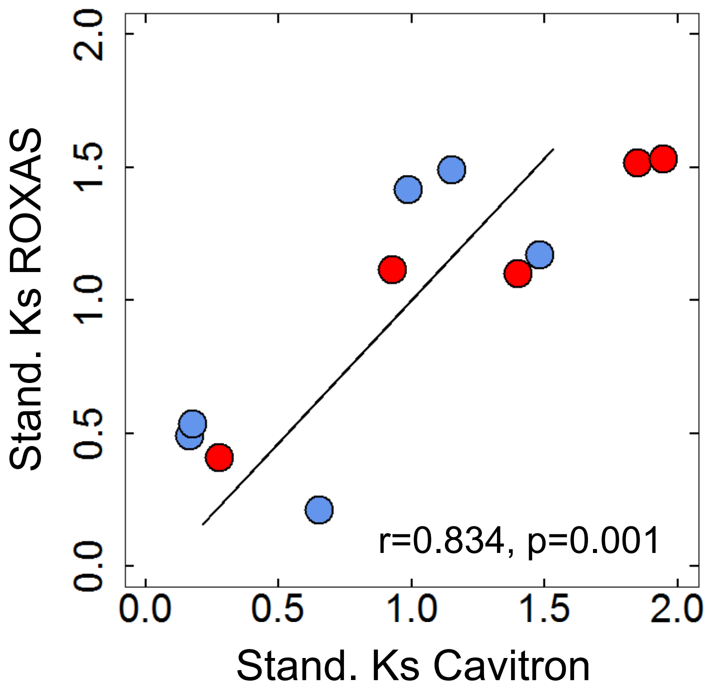
Mechanical and hydraulic safety are positively linked

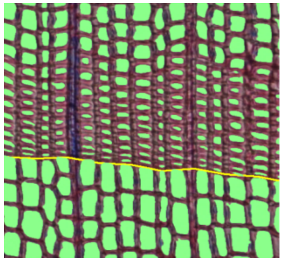


* «Bending resistance index» = $(t/b)^2$

(Hacke et al., 2001, Oecologia)

Specific conductivity (Ks) based on anatomy and Cavitron measurements match closely



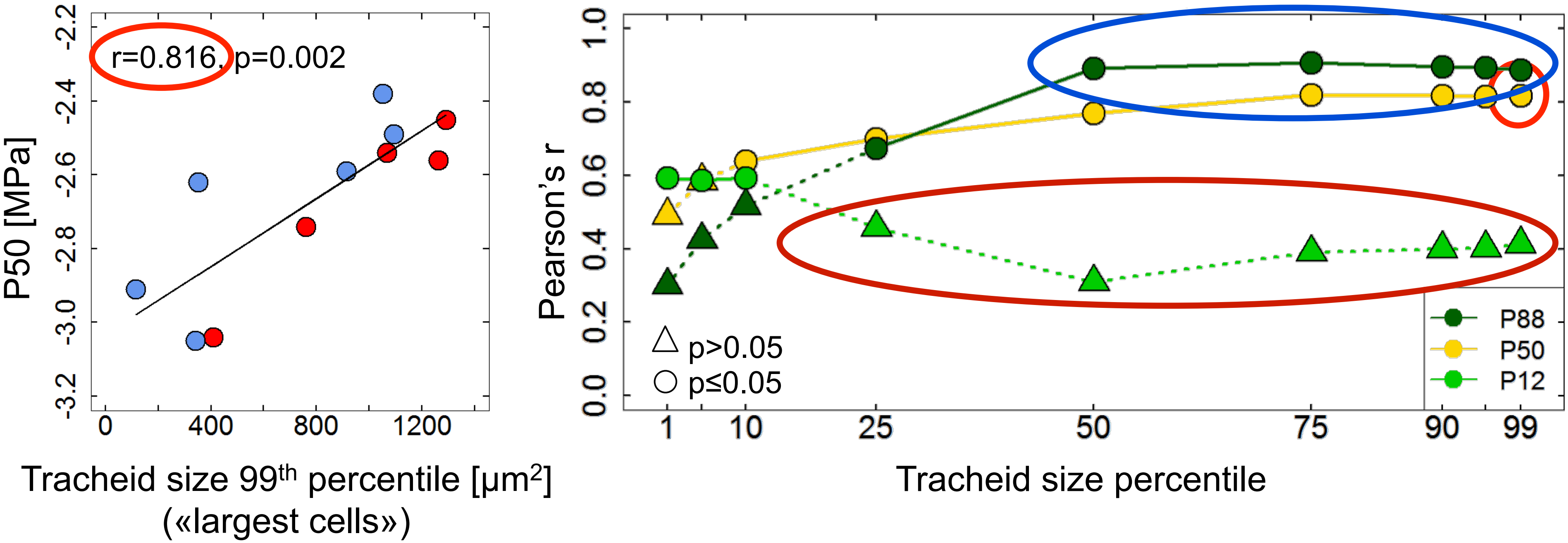


Hagen-Poiseuille:

$$\Phi = \frac{dV}{dt} = \frac{\pi \cdot r^4 \cdot |\Delta P|}{8 \cdot \eta \cdot L}$$

Cavitron

How is tracheid size related to vulnerability?



When only little conductivity is lost (P12),
the largest conduits seem still functional (r↓, $p>0.05$)

When almost all conductivity is lost (P88),
the largest tracheids seem cavitated (r↑, $p<0.05$)

Some points to remember

(1) Axial trends: tracheid size, CWT, and P50 (all related to hydraulics!) generally increased from the upper to the lower stem, while the Mork’s index (related to wood density) did not show clear axial trends.

(2) Form fits function: several anatomical and hydraulic features showed a close correspondence. The close relationship provides a long-term perspective on tree functioning (tree rings!).

(3) Only compare apples with apples: since hydraulic and anatomical properties change along the stem axis, it is important to standardize methods (=distance from apex) when comparing properties between trees and populations!

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Acknowledgements

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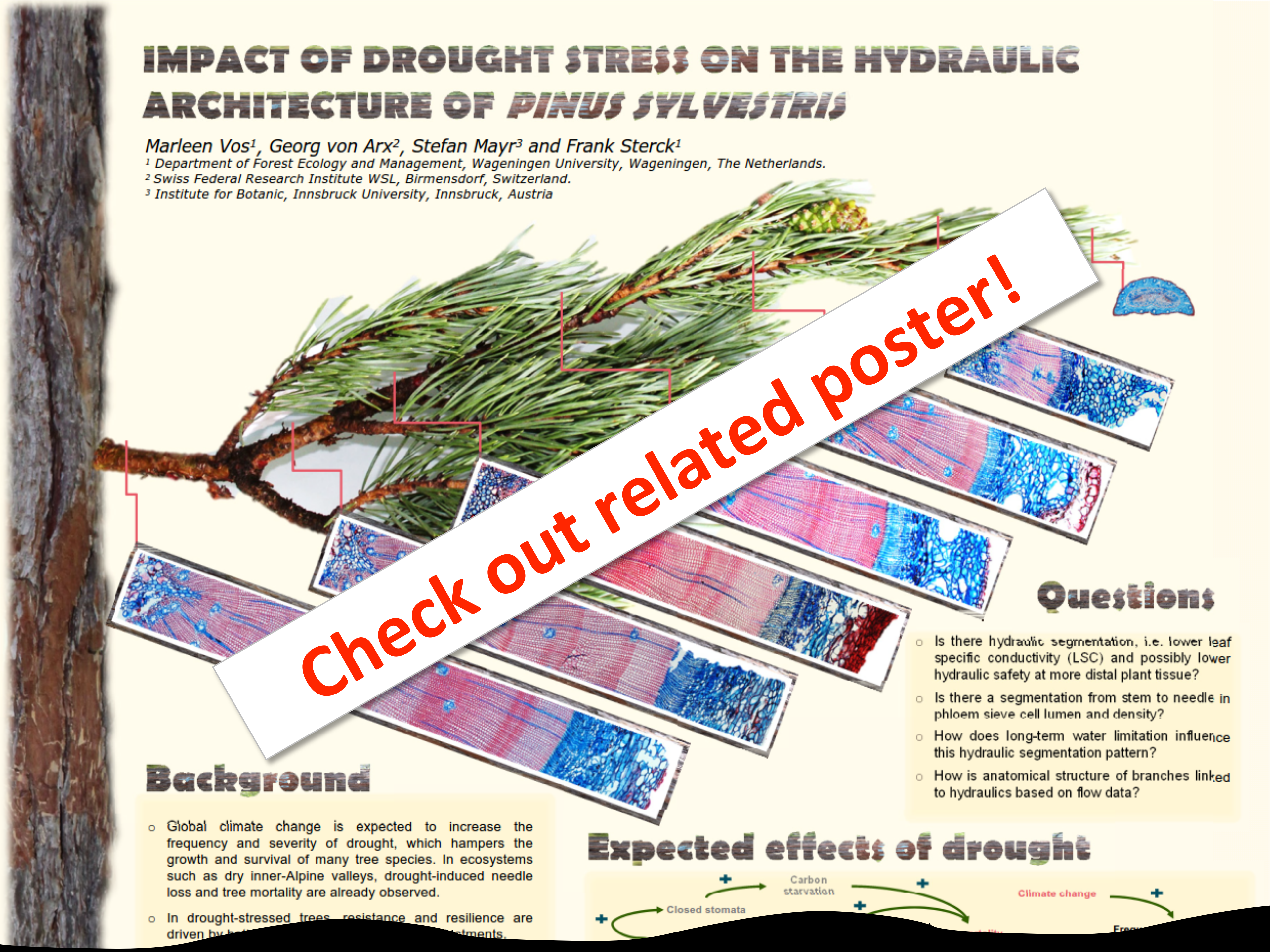
IMPACT OF DROUGHT STRESS ON THE HYDRAULIC ARCHITECTURE OF PINUS SYLVESTRIS
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Check out related poster!
Questions
Is there hydraulic segmentation, i.e. lower leaf specific conductivity (LSC) and possibly lower hydraulic safety at more distal plant tissue?
Is there a segmentation from stem to needle in phloem sieve cell lumen and density?
How does long-term water limitation influence this hydraulic segmentation pattern?
How is anatomical structure of branches linked to hydraulics based on flow data?
Background
Global climate change is expected to increase the frequency and severity of drought, which hampers the growth and survival of many tree species. In ecosystems such as dry inner-Alpine valleys, drought-induced needle loss and tree mortality are already observed.
In drought-stressed trees
Expected effects of drought
Carbon starvation
Closed stomata
Climate change