

Acclimation of stomatal traits and leaf area under irrigation in an experimental forest

Shan Kothari

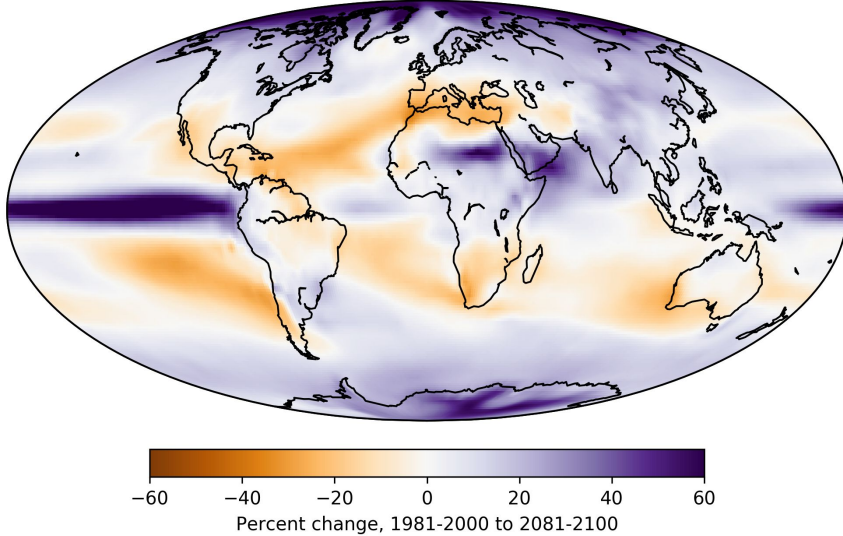
Eric Searle, Bill Parker, Morgane Urli, Alain Paquette

Colloque CEF

May 3, 2024

Forests in a drying world

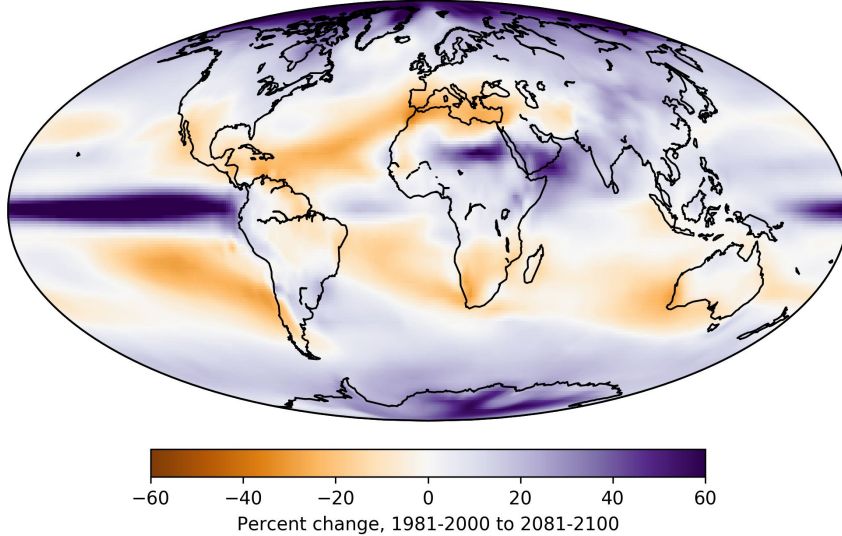
CMIP5 RCP8.5 multimodel mean all precipitation



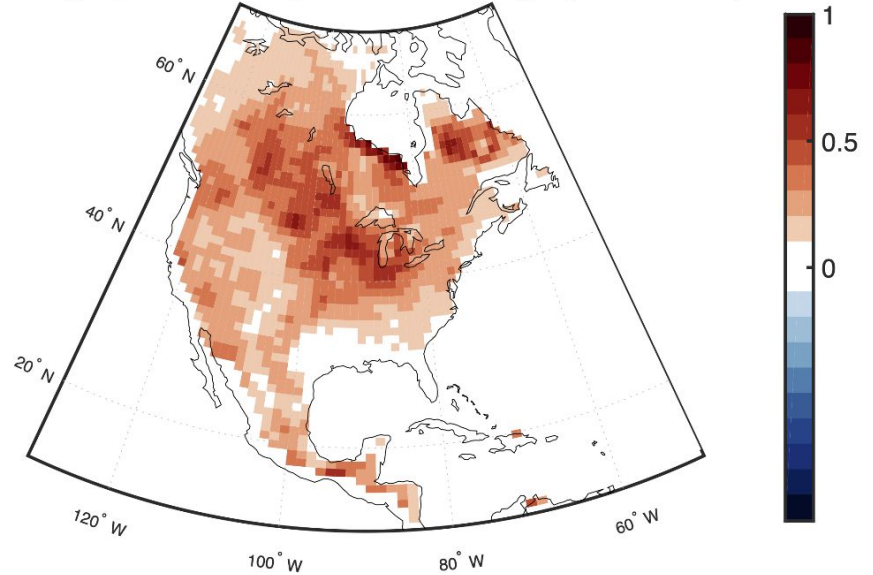
Left: Carbon Brief; Right: *in prep*

Forests in a drying world

CMIP5 RCP8.5 multimodel mean all precipitation



Vapour pressure deficit
Change produced by climate change (2050-2069)



Left: Carbon Brief; Right: *in prep*

Forests in a drying world

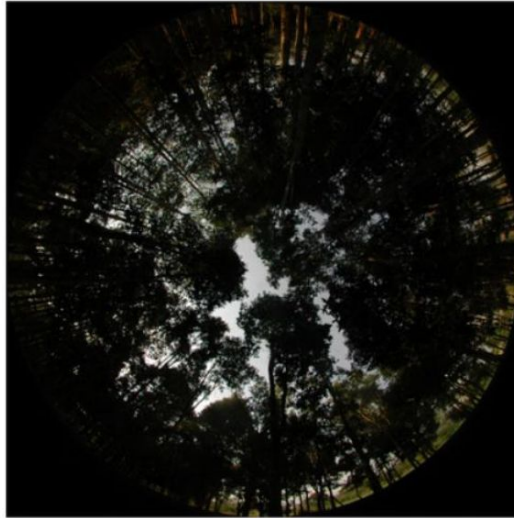
Structural overshoot: The idea that canopy dieback and mortality under drought is due to a mismatch between the *supply* and *demand* of water (Jump et al. 2017 *GCB*)



Forests in a drying world

Structural overshoot: The idea that canopy dieback and mortality under drought is due to a mismatch between the *supply* and *demand* of water (Jump et al. 2017 *GCB*)

Implies that drought should be defined relative to a historical baseline, since trees are acclimated to it



A physiological perspective on structural overshoot

Structural overshoot:

Water demand \sim LAI

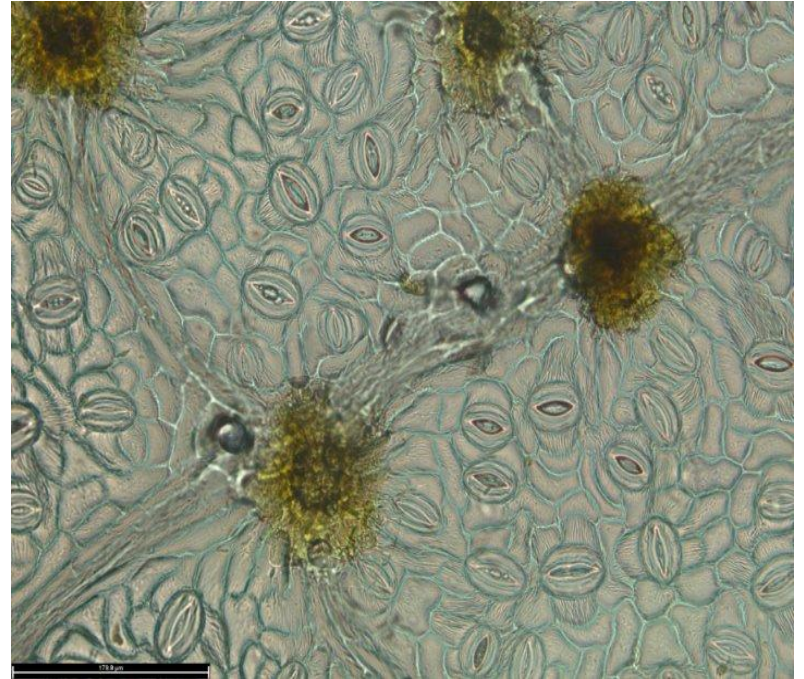
A physiological perspective on structural overshoot

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Water demand \sim LAI

Structural overshoot, version 2.0:

Water demand \sim LAI $\times g$ (\times VPD)



A physiological perspective on structural overshoot

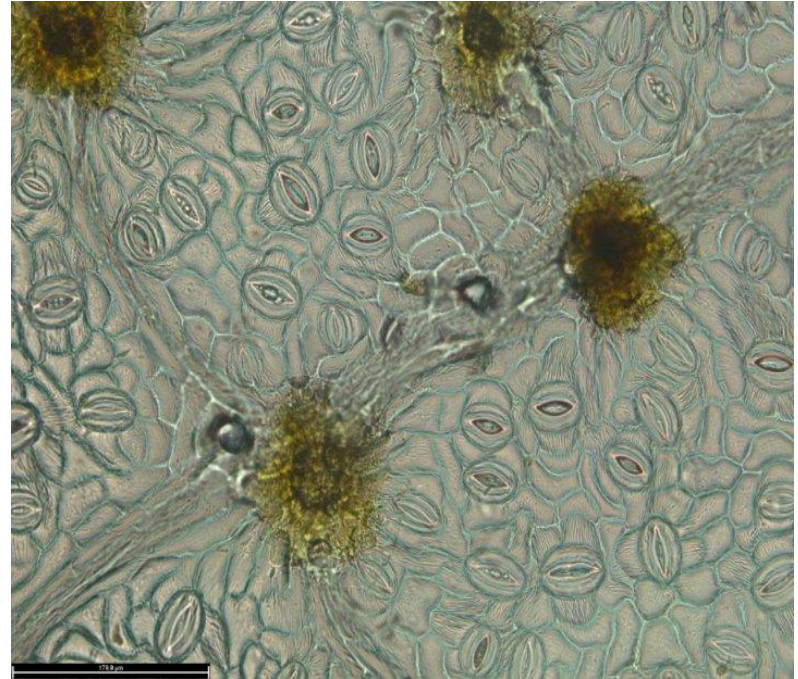
Structural overshoot:

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Structural overshoot, version 2.0:

Water demand \sim LAI $\times g$ (\times VPD)

Under a catastrophic drought, the stomatal conductance g attains its minimum value (g_{min})



Broad question: Can we predict drought mortality in advance using physiological measures?

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Narrow question: Do stomatal traits acclimate to the past abundance of water, and how much might they contribute to variation in water demand? ('leafier and leakier')

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Narrow question: Do stomatal traits acclimate to the past abundance of water, and how much might they contribute to variation in water demand? ('leafier and leakier')

Prediction: Past irrigation causes stomatal behavior to be less conservative ($\uparrow g_{max}$, $\uparrow g_{min}$, \downarrow water-use efficiency)

IDENT-Sault Ste. Marie

Plots with 1-6 species (but focusing here on monocultures)



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From 2013-2023:

- Four blocks received 230% of ambient precipitation
- Four blocks received 70% of ambient precipitation



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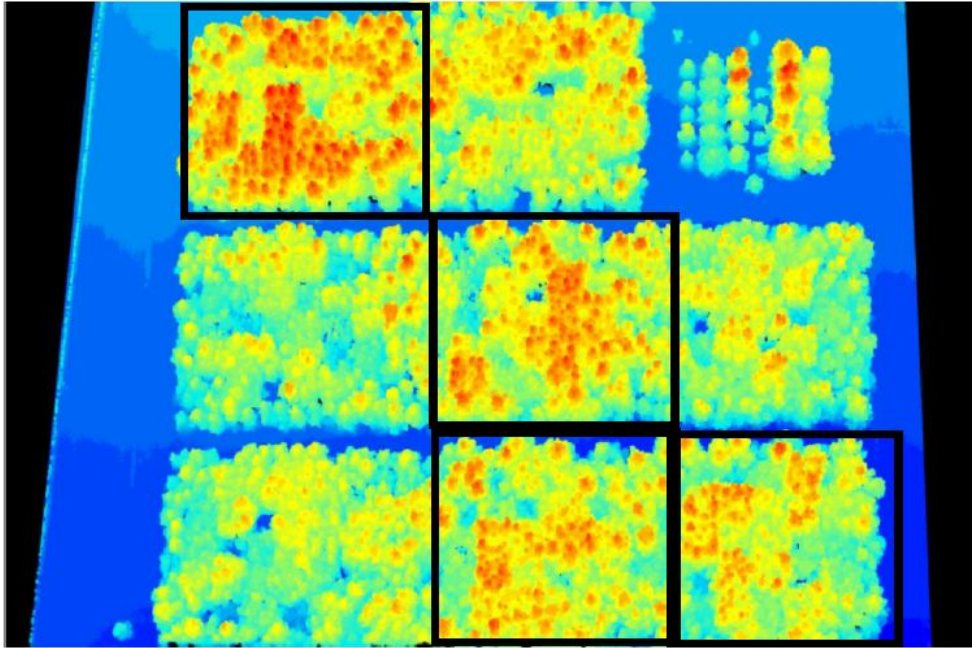
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Starting in 2024, all blocks will receive 70% of ambient precipitation



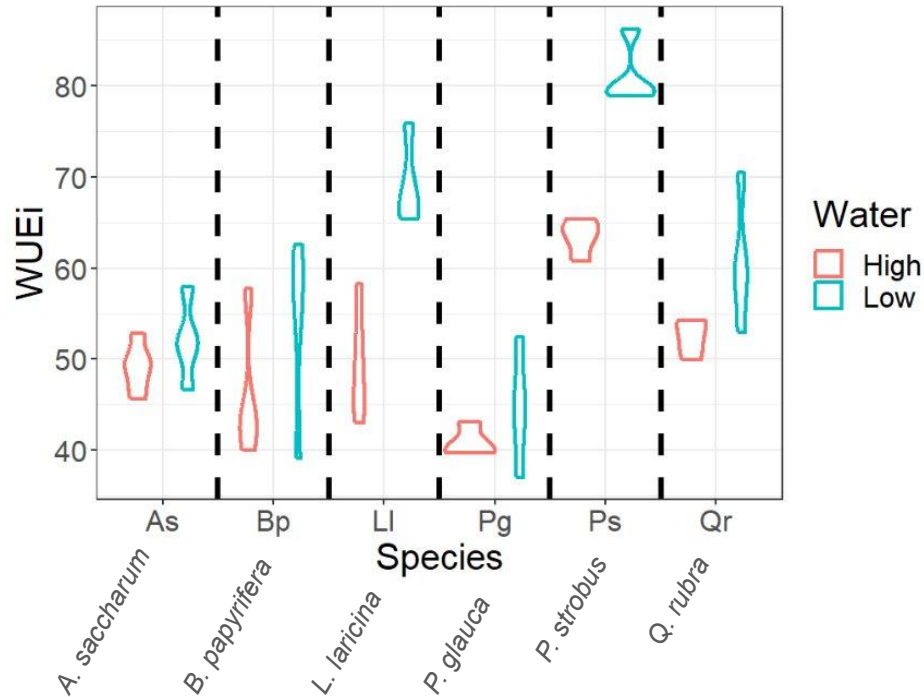
Do irrigated blocks produce more leaf area?



Apparently, yes!

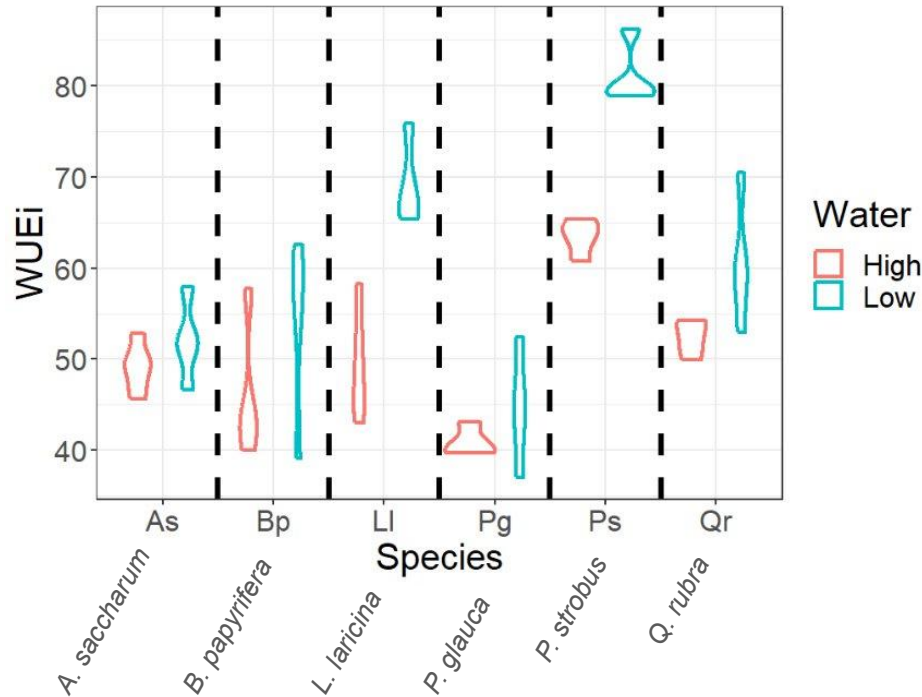
(although we are trying to quantify this more precisely using Lidar)

Do irrigated blocks have less conservative stomatal behavior?



Water-use efficiency estimated based on leaf $\delta^{13}\text{C}$ in monocultures

Do irrigated blocks have less conservative stomatal behavior?



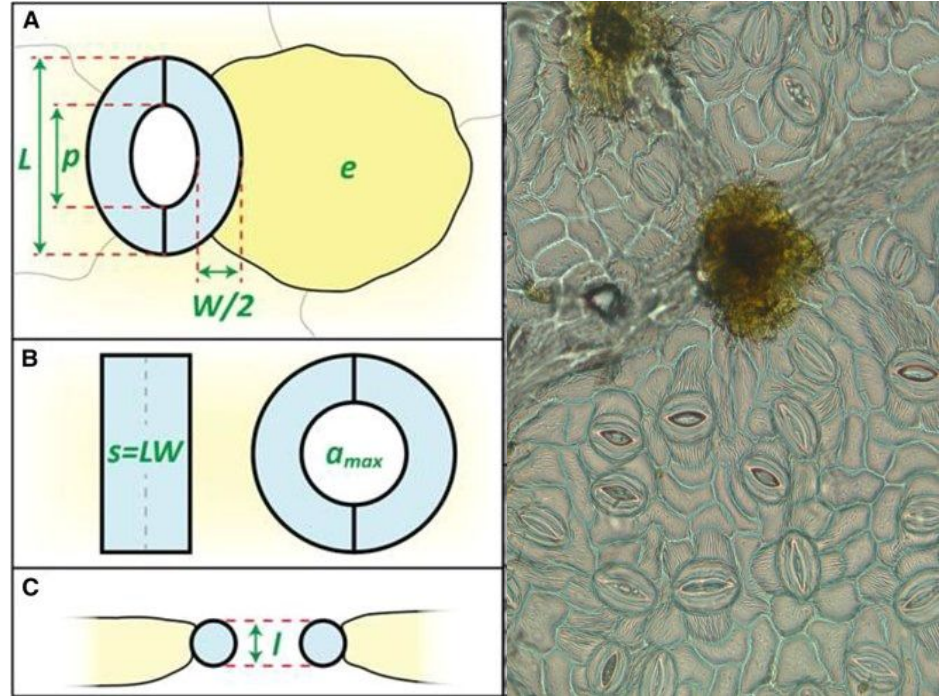
Water-use efficiency estimated based on leaf $\delta^{13}\text{C}$ in monocultures

Irrigated plots have lower water-use efficiency only in certain species (*Larix laricina*, *Pinus strobus*)

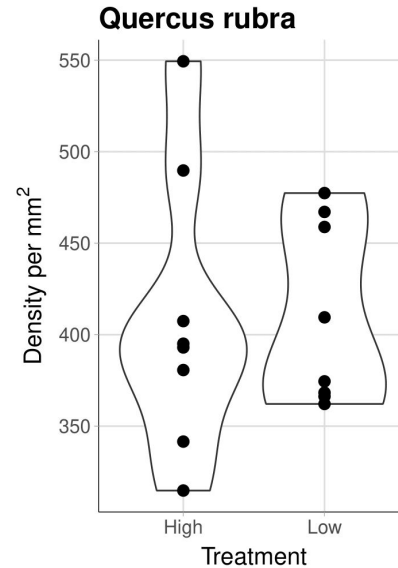
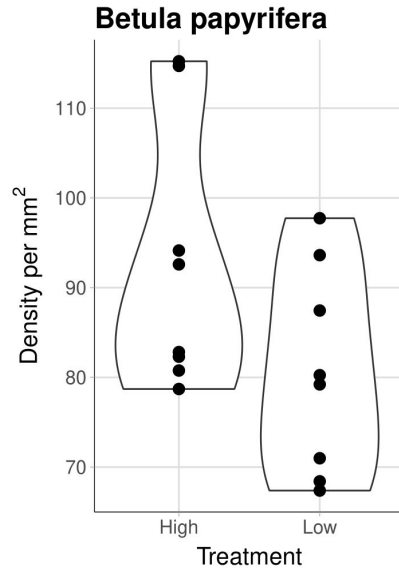
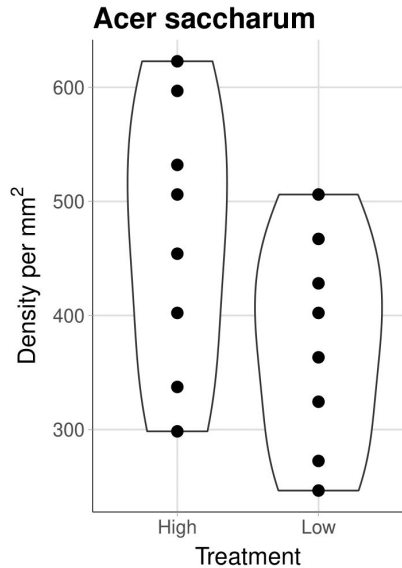
Do irrigated blocks have less conservative stomatal behavior?

Measured stomatal density and dimensions of broadleaf species based on nail polish impressions of leaf surfaces

Left: Sack & Buckley (2016)
Plant Physiology
Right: in prep

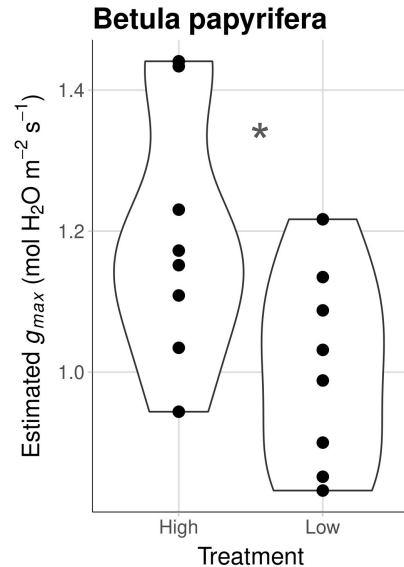


Do irrigated blocks have less conservative stomatal behavior?



Little evidence that any species adjusts its stomatal density in response to irrigation

Do irrigated blocks have less conservative stomatal behavior?



However, estimates of maximal stomatal conductance (accounting for both density and size) *are* about ~18% greater for *Betula papyrifera*

Other species pending!

The next steps

What set of variables is sufficient to yield “good enough” predictions of mortality risk?

- Leaf area index
- g_{min} and g_{max}
- Turgor loss point
- Xylem vulnerability (Urli Lab)
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Can we predict when tree diversity does and doesn't reduce the influence of drought?

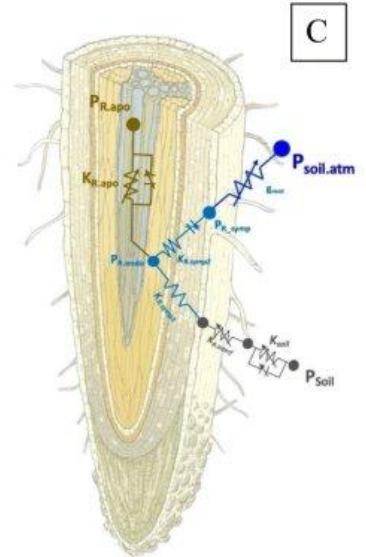
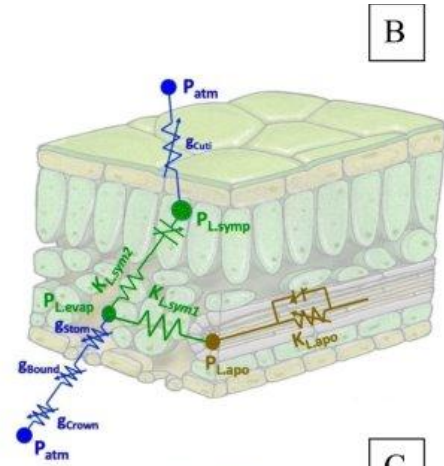
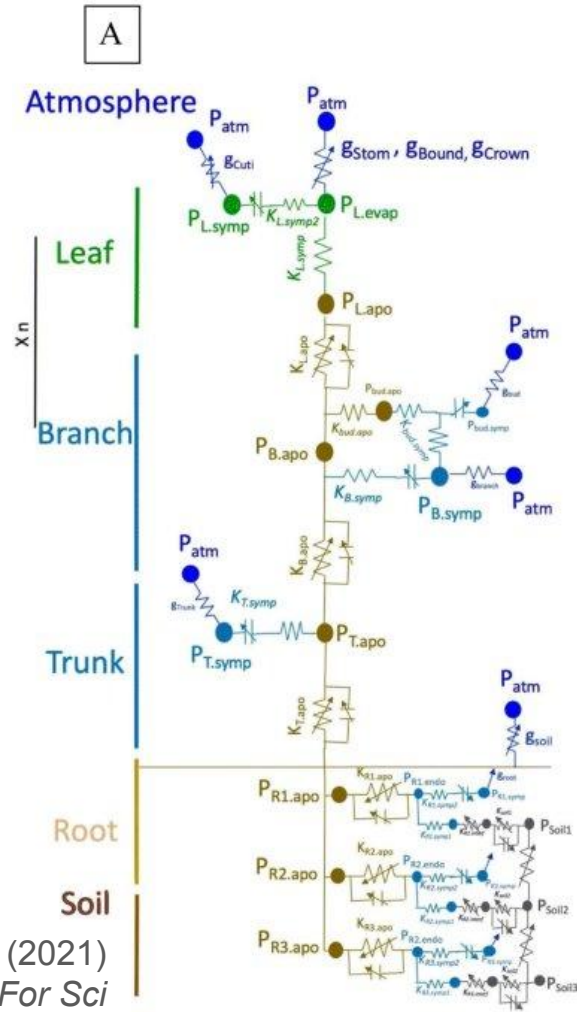
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Cochard et al. (2021)
Ann For Sci



Conclusions

There is evidence that both **leaf area index** and **stomatal traits** acclimate to past water regimes

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Both of these aspects may contribute to the adjustment of water demand that results in structural overshoot, and may be important for predicting mortality

Un grand merci à toutes et à tous !



As well as:

Bill Parker (co-author, not pictured)

Sarah Tardif and Grégoire Bonnamour for aid
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