Temperature mediates relative contribution of stomata and cuticle to leaf minimum conductance

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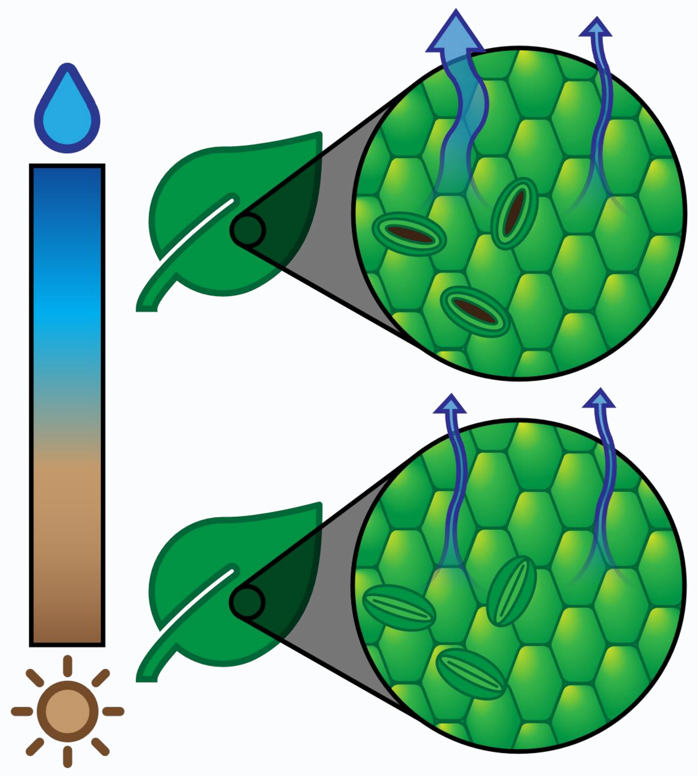
Background



Under water stress, plants close stomata to restrict water loss; water vapor may still escape through the cuticle or through incompletely closed stomata

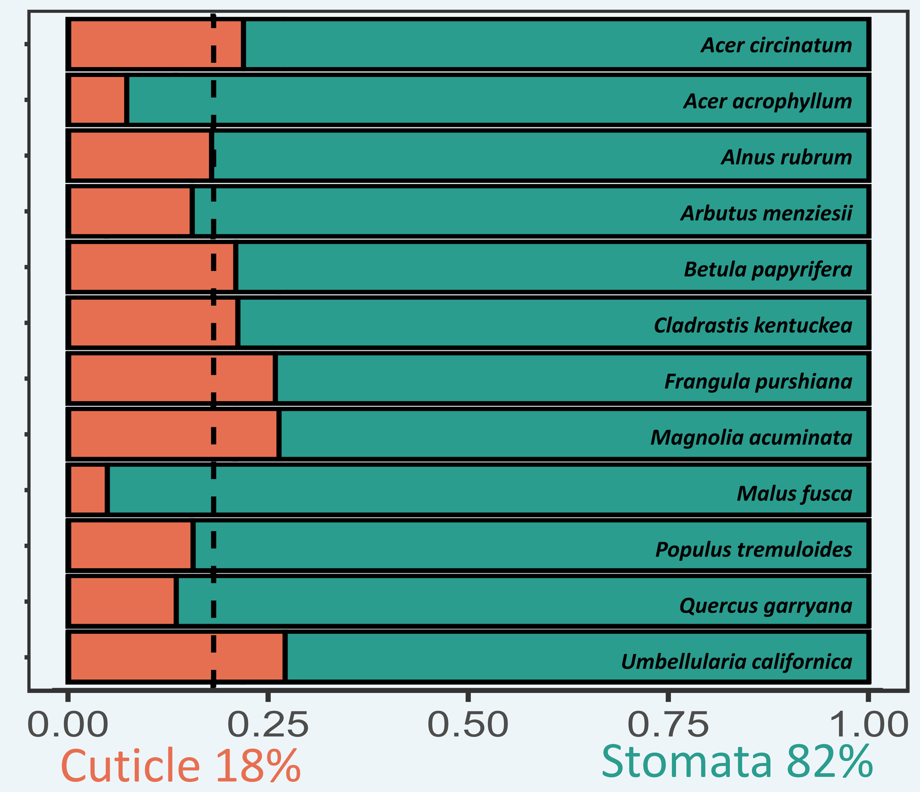
Key Questions:

Which water pathway dominates leaf minimum conductance, and what is the effect of temperature?

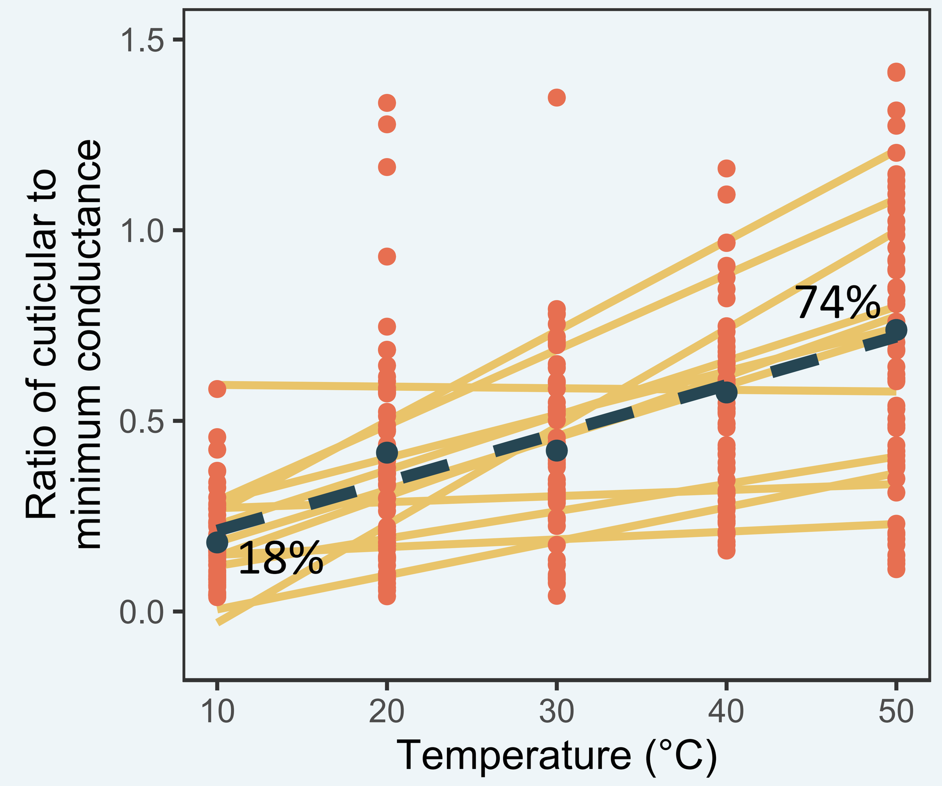
Can we predict minimum, minimum stomatal, or cuticular conductance using leaf traits?

Does temperature sensitivity of cuticular conductance affect gas exchange?

Dominant water pathway depends on temperature

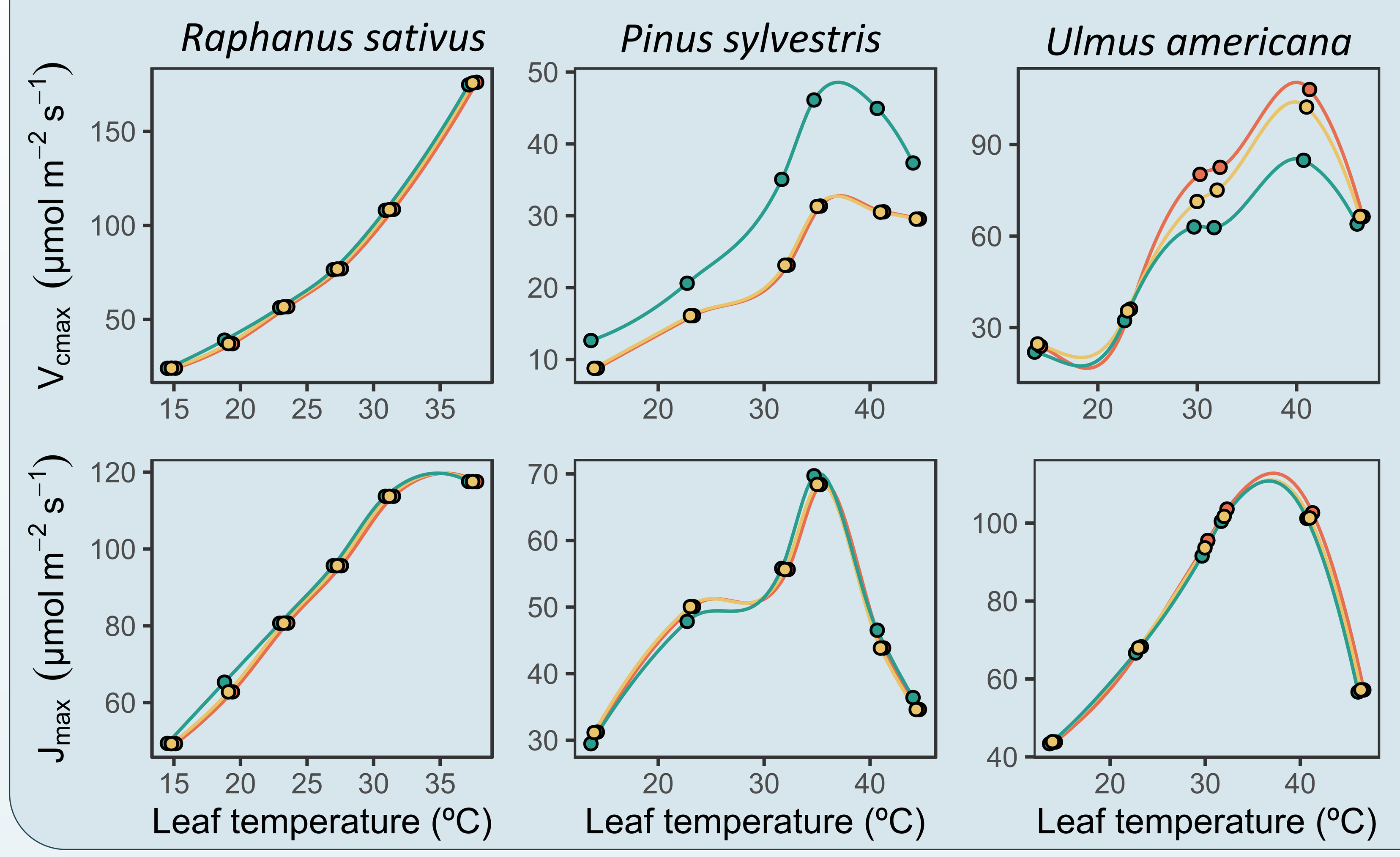


At low temperatures (10°C), stomata contribute an average of 82% of total leaf minimum conductance across species



Cuticular contribution to g_{min} increases with temperature. Temperature dependence is variable among species

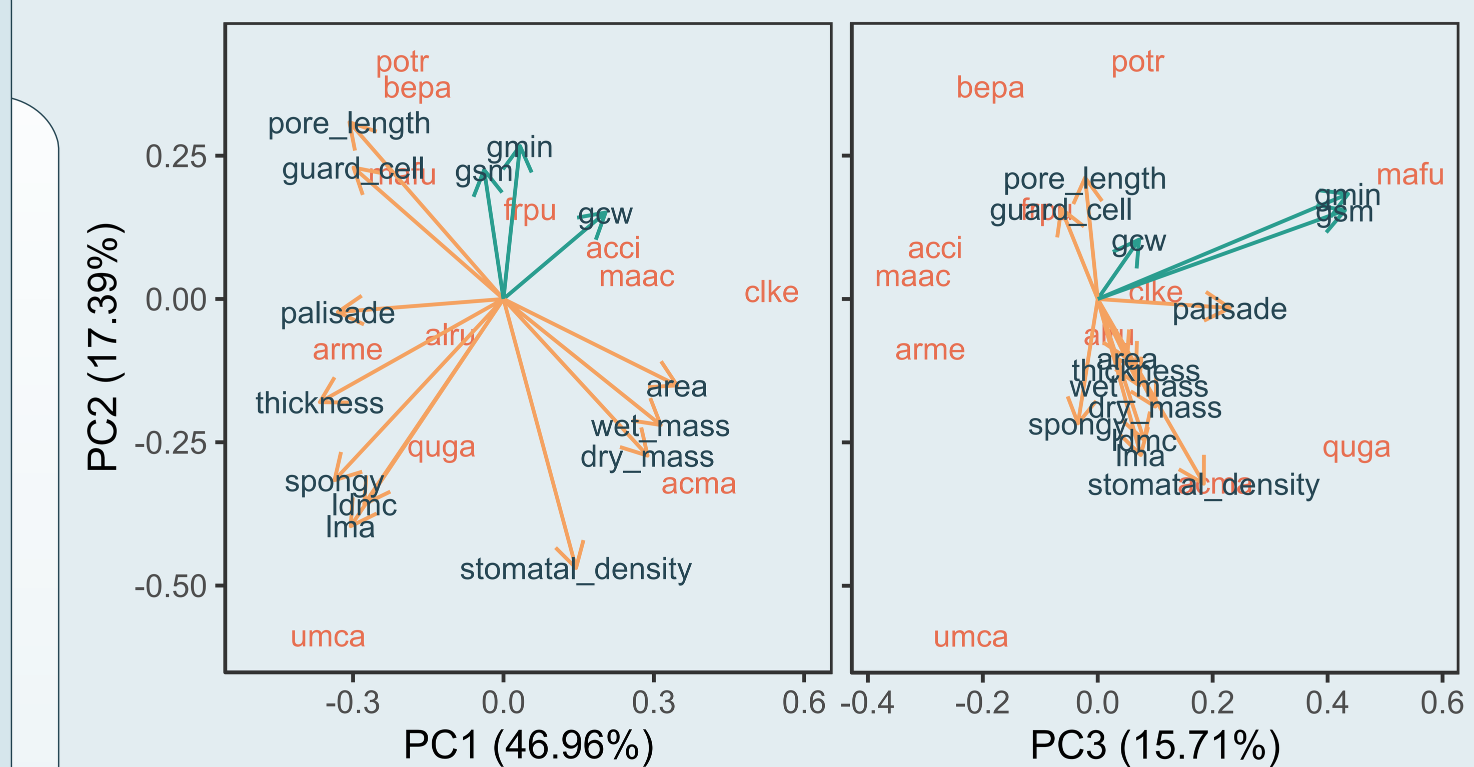
Gas exchange measurements are affected by g_{cw}



Cuticular conductance appears to affect V_{cmax} (maximum rate of Rubisco carboxylation) but not J_{max} (maximum rate of RuBP regeneration) estimates, particularly in species with low stomatal conductance. Temperature dependence of g_{cw} may also affect V_{cmax} estimates in some species

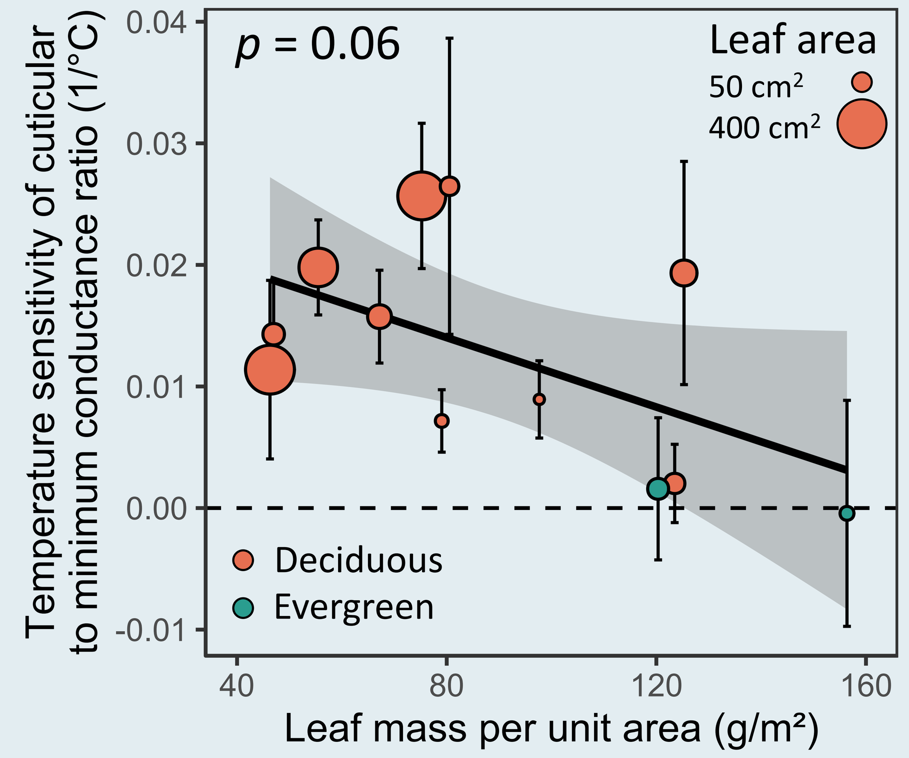
- Uncorrected (g_{cw} not considered)
- Corrected (constant g_{cw})
- Corrected (g_{cw} with temperature sensitivity)

Weak relationship between traits and conductance



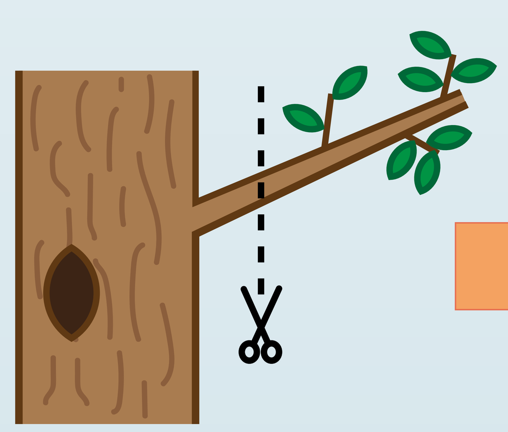
Principal components analysis reveals low coordination between conductances and leaf traits

gcw – cuticular conductance
gsm – min. stomatal conductance
gmin – minimum conductance
lma – leaf mass per unit area
ldmc – leaf dry matter content
wet_mass – fresh leaf mass
dry_mass – dry leaf mass
area – fresh leaf area
stomatal_density – stomatal density
pore_length – stomatal pore length
guard_cell – stomatal guard cell width
palisade – palisade mesophyll thickness
spongy – spongy mesophyll thickness
thickness – leaf thickness

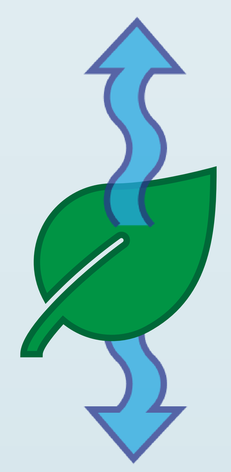


Temperature sensitivity of g_{cw}:g_{min} ratio is weakly related to leaf traits

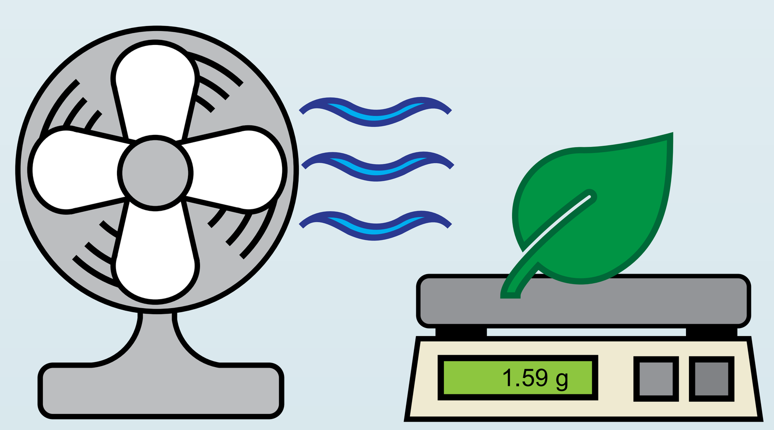
Methods



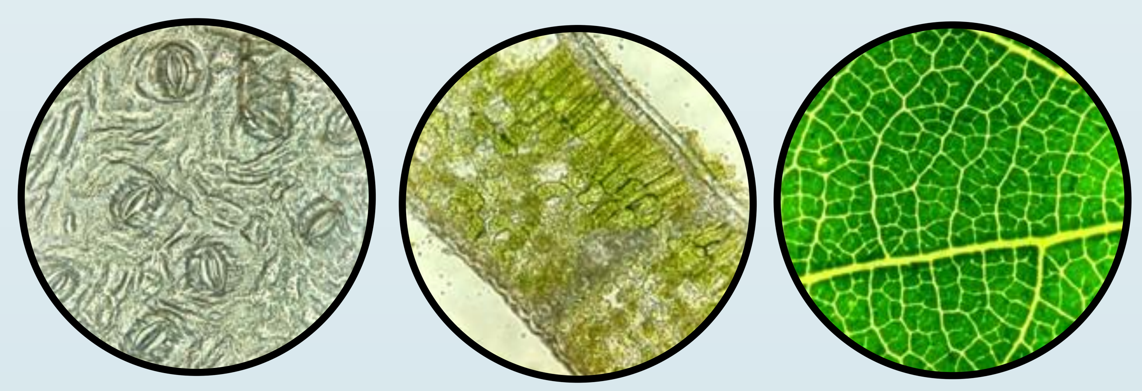
Take branch cutting



Measure cuticular conductance (g_{cw}) from adaxial and abaxial H_2O flux



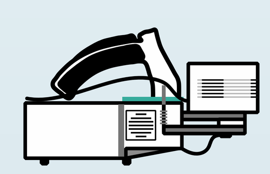
Measure minimum conductance (g_{min}) by desiccation. Estimate minimum stomatal contribution (g_{sm}) by $g_{sm} = g_{min} - g_{cw}$



12+ traits measured
12 species of broadleaf north American trees
5 temperatures 10–50 °C

Implications

Improved gas exchange measurements (g_{sw}, C_i, V_{cmax}, J_{max})



Improved representation of vegetation in land surface models

Improved forecasting of effects of heat and drought on vegetation