

Scots pine water relations in response to drought-induced defoliation and competition by Holm oak trees

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Background

- Chronic water stress and recurrent drought spells are leading to reduced growth, crown defoliation and increased mortality rates of Scots pine (*Pinus sylvestris* L.) in some populations of its southern distributional limit.
- Scots pine decline since the 1990's in the Prades Mountains (NE Spain) has been favouring Holm oak trees (*Quercus ilex* L.) growing in the understory

Questions addressed

- Do Scots pines and competing Holm oak trees differ in their seasonal patterns of water use, especially in response to summer drought?
- Are defoliated (D) Scots pine trees more sensitive to drought compared to non-defoliated (ND) pines?

Design and instrumentation

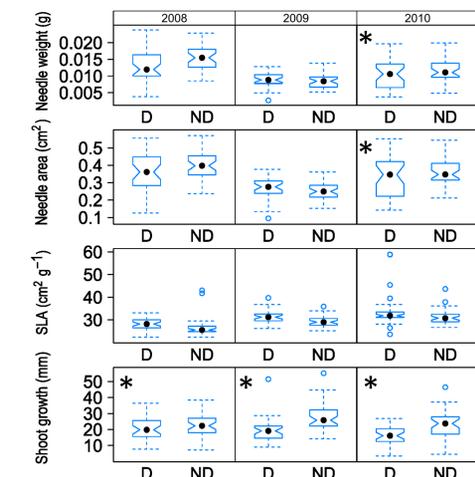
- Three plots within the same valley (facing N/NW, 1030-1080 m, slope ~35°).

Wet → Dry



- Sample size: sap flow in 10 trees per species, plot and canopy condition (only for Scots pine in the mixed plot). Two Granier sensors per pine, one per Holm oak. Soil water content (SWC, 0-30 cm) in each plot. Predawn and midday water potentials in 4 trees, 5 sampling dates.

Defoliation patterns in Scots pine

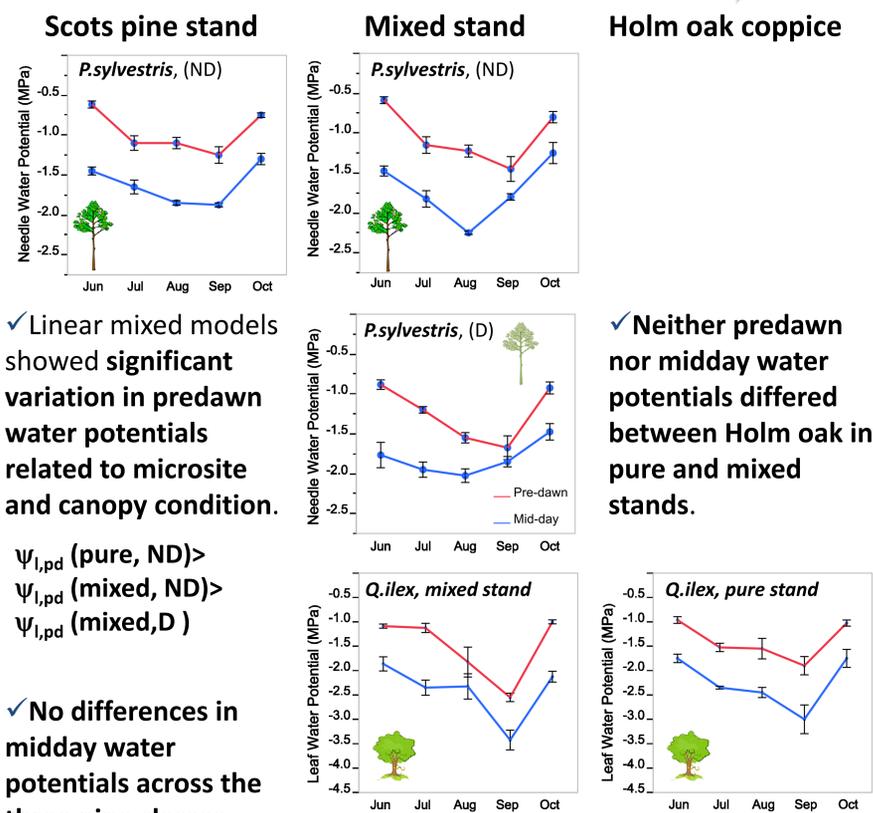


- 25 branches sampled for allometry (D & ND). Needle parameters analysed for different shoot ages.
- Needle retention is about 3 years in both classes of pine.
- Canopy defoliation largely mediated by reductions in shoot growth and leaf dimensions.

Statistical significance of differences between defoliation classes: * P < 0.05

Predawn and midday water potentials

Wet → Dry



Linear mixed models showed significant variation in predawn water potentials related to microsite and canopy condition.

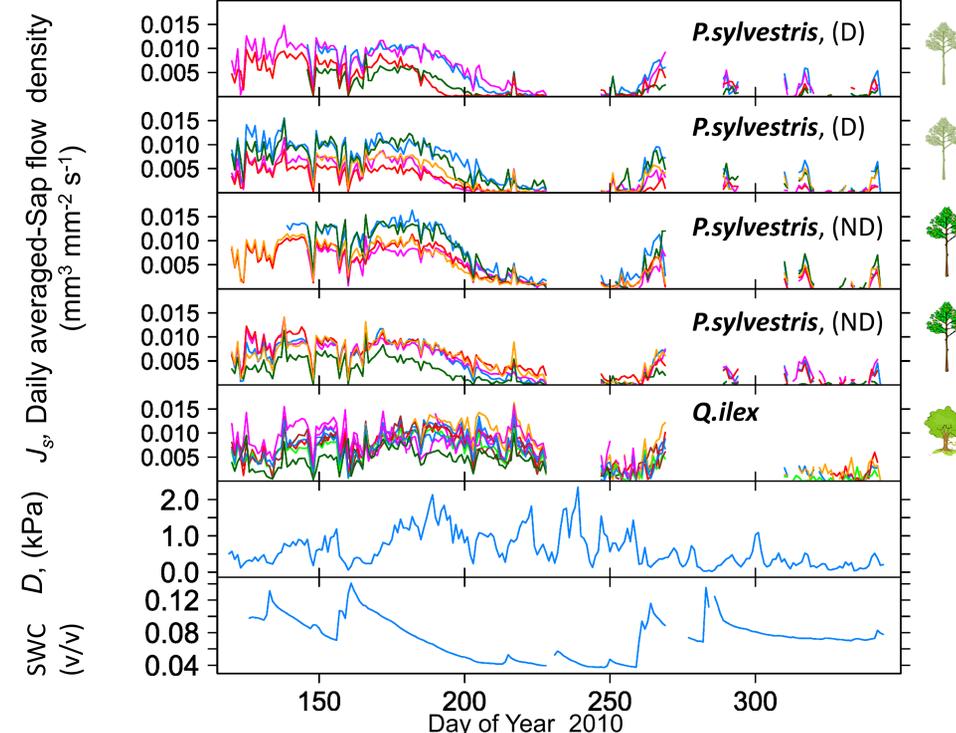
$$\psi_{l,pd}(\text{pure, ND}) > \psi_{l,pd}(\text{mixed, ND}) > \psi_{l,pd}(\text{mixed, D})$$

No differences in midday water potentials across the three pine classes.

Neither predawn nor midday water potentials differed between Holm oak in pure and mixed stands.

Seasonal course of sap flow in the mixed stand

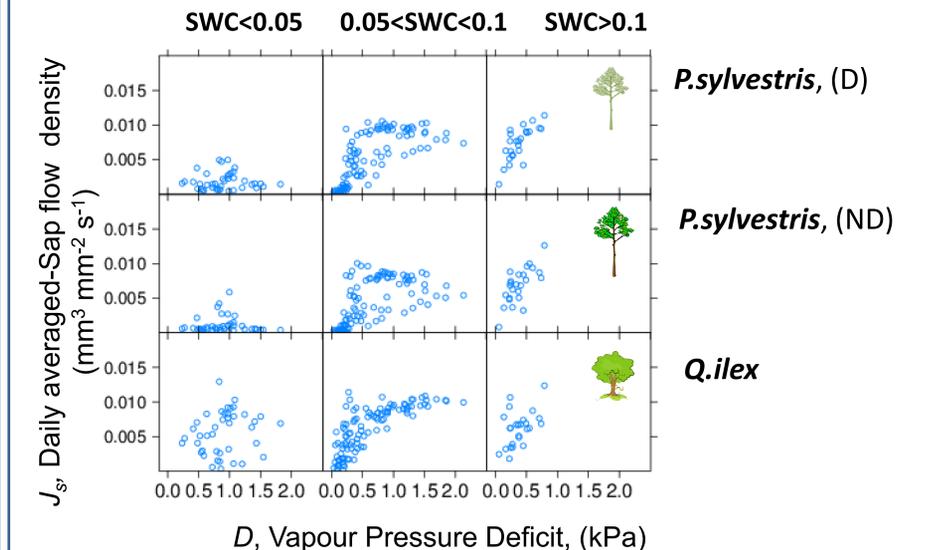
- Lines represent daily average rates for individual trees



- Scots pine sap flow is much more sensitive to drought than co-occurring Holm oak, showing very low transpiration between days 200-250 and only recovers after significant rainfall.
- Sap flow almost ceases completely after DOY 200 in some defoliated pines.

Sap flow responses to evaporative demand

- Rainfall during July and August was only 25% of the climatic mean, and therefore SWC reached very low values.



Conclusions

- Compared to Scots pine, Holm oak maintained relatively high sap flow rates under dry soil conditions, which is probably related to its recent expansion.
- Despite the reductions in transpiring area, we found some evidence that defoliated Scots pines were more sensitive to drought than non-defoliated trees.