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Shift to efficient leaf cooling through sensible heat revealed by detailed energy budget in mature pine trees in drought manipulation field experiment

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Efficient leaf-scale temperature control is instrumental to vegetation functioning and ecosystem-scale resilience to a drying and warming climate. When evaporative cooling is suppressed during drought, leaf thermal regulation requires modulation of the leaf energy budget and the balance between sensible heat (H) and latent heat (LE) fluxes.

We obtained rare leaf energy budgets under field conditions by combining measurements using a new methodology and theoretical estimates in naturally droughted and artificially irrigated plots of a dry Mediterranean pine forest, with low and high evapotranspiration rates, respectively.

The measurements revealed that under the same radiative load, leaf cooling shifted from equal contributions to heat dissipation of H and LE in irrigated trees to almost exclusively through H in droughted ones while maintaining comparable leaf-to-air temperature differences.

The results demonstrate that an assessment of the leaf energy budget in the field provides the means to identify effective leaf temperature control in pine trees under drought, enhancing their resilience to current drying trends. The shift from LE to H provides an 'air cooling' mechanism that equals the efficiency of evaporative cooling. It also provides a leaf-scale basis for the large ecosystem-scale 'convector effect' identified in semi-arid forests.