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Trees tolerate an extreme heatwave via sustained transpirational cooling and increased leaf thermal tolerance

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Abstract

Heatwaves are likely to increase in frequency and intensity with climate change, which may impair tree function and forest C uptake. However, we have little information regarding the impact of extreme heatwaves on the physiological performance of large trees in the field. Here, we grew *Eucalyptus parramattensis* trees for 1 year with experimental warming (+3°C) in a field setting, until they were greater than 6 m tall. We withheld irrigation for 1 month to dry the surface soils and then implemented an extreme heatwave treatment of 4 consecutive days with air temperatures exceeding 43°C, while monitoring whole-canopy exchange of CO_2 and H_2O, leaf temperatures, leaf thermal tolerance, and leaf and branch hydraulic status. The heatwave reduced midday canopy photosynthesis to near zero but transpiration persisted, maintaining canopy cooling. A standard photosynthetic model was unable to capture the observed decoupling between photosynthesis and transpiration at high temperatures, suggesting that climate models may underestimate a moderating feedback of vegetation on heatwave intensity. The heatwave also triggered a rapid increase in leaf thermal tolerance, such that leaf temperatures observed during the heatwave were maintained within the thermal limits of leaf function. All responses were equivalent for trees with a prior history of ambient and warmed (+3°C) temperatures, indicating that climate warming conferred no added tolerance of heatwaves expected in the future. This coordinated physiological response utilizing latent cooling and adjustment of thermal thresholds has implications for tree tolerance of future climate extremes as well as model predictions of future heatwave intensity at landscape and global scales.

KEYWORDS
climate change, *Eucalyptus parramattensis*, heatwave, latent cooling, photosynthesis, temperature, thermal tolerance, warming

