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On which timescale(s) do optimal adjustments to vegetation function confer resilience? A case study in South-Eastern Australia

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Droughts have been implicated as the driver behind recent vegetation die-off across a variety of hydroclimates and are projected to drive greater mortality under future climate change. Predicting ecosystem resilience to future drought requires a predictive capacity, which is currently lacking in state-of-the-art land surface models (LSMs) that rely on simplified empirical relationships to represent the impacts of water stress on vegetation. Novel approaches that optimise stomatal conductance with respect to plant photosynthetic and hydraulic functions have been shown to reduce the biases of LSM gas exchange predictions during drought. These approaches also offer a pathway to further develop mechanistic optimality theory, e.g. pertaining to leaf drought deciduousness. But on what timescale(s) does vegetation function adjust to maximise resource investment? We explore the following timescales of optimality within a simple LSM: (i) instantaneous (regulating canopy gas exchange); (ii) monthly (regulating the investment of nitrogen in photosynthetic capacity); and (iii) seasonal to annual (water stress legacies on plant hydraulics). We use observations from a temperate woodland in South-Eastern Australia to test which optimisation timescales and processes are best supported and whether competing timescales can operate together, both under well-watered conditions and during a severe multi-year drought, and from the leaf-scale to the ecosystem-scale. The insights gained help us characterize how adjoined allocation processes, like leaf biomass adjustment, relate to leaf carbon uptake and plant water status through time (e.g. leaves can be shed to mitigate drought stress or built from structural storage pools when water is not limiting), therefore conferring additional resilience.