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Unravelling carbon allocation dynamics in an evergreen temperate forest

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Eucalypt trees have the potential to sequester carbon from the atmosphere year-round by maintaining evergreen leaves with a prolonged multi-year lifetime. Unlike deciduous trees, eucalypts are generally known to grow opportunistic resulting in a lack of defined growth rings and no distinct seasonal crown turnover events. Stem expansion has been successfully measured with micro-dendrometers, however, it remains challenging to monitor crown dynamics at a similarly high temporal resolution. Hence, carbon allocation dynamics and seasonal variations of carbon distribution between stem and crown biomass remain largely unknown for evergreen species.

Ecosystem scale observations of net ecosystem exchange (NEE) from a flux tower located in a predominantly temperature and moisture regulated environment in south-eastern Australia have demonstrated that the ecosystem is a constant terrestrial sink for carbon. Intra-annual variations in temperature and moisture and prolonged heat waves and dry spells result in a wide range of annual sums (e.g. 2013: NEE∼4 t C ha-1yr-1, 2012: NEE∼12 t C ha-1yr-1). Newly developed low-cost terrestrial lidar sensors (VEGNET) now allow for automated daily monitoring of crown dynamics, enabling more detailed observations on the duration of crown biomass changes. In addition to leaf area index (LAI), VEGNET sensors define the location within the crown strata of the gains and losses in plant volume across the vertical forest structure. With the development of VEGNET sensors, combined with ecosystem carbon fluxes from eddy covariance measurements and with micro-dendrometers, we are able to quantify the dynamics of carbon allocation to above ground biomass pools.

Our results demonstrate that stem growth dominates in spring and in autumn, and is strongly associated with water availability. Leaf turnover predominantly takes place in summer and is initiated by prolonged heat stress and isolated storm events, yet crown biomass remains stable throughout the year. Leaf shedding and replacement happens concurrently over a period of days with leaves being mainly discarded from the bottom of the crown and replaced in the top strata. Due to the high temporal resolution and our multi-instrument approach we found that above ground carbon allocation to stem and crown pools follow different seasonal dynamics. Our ability to detect changes at a daily scale will ultimately improve our understanding of the effects of short and long term variability in temperature and moisture on carbon allocation dynamics.