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Severe depletion of whole-tree non-structural carbohydrates in broadleaf evergreen resprouters

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Non-structural carbohydrate (NSC) storage is crucial for trees to survive disturbances that severely diminish photosynthetic carbon assimilation, including herbivory, fire, drought and pathogens. Yet it remains unclear how much carbon is allocated to NSC storage in trees, and how NSC storage pools respond to various stressors at the whole-tree level, especially for adult trees growing in forests. As such, our understanding of when and how NSC depletions might contribute to tree mortality under stress (e.g. via carbon starvation at the organ- or tree-level) is limited. We conducted an experiment using 14-year-old trees growing in native forest to examine whole-tree NSC dynamics after a carbon-limiting disturbance. We fully defoliated or felled broadleaf, evergreen, fire-tolerant eucalypt trees to experimentally induce epicormic (stem) and basal resprouting, respectively, with control trees left intact. Trees were harvested over ten months starting when treatments were applied (early autumn), then when sprouts emerged (mid-spring), and after sprout expansion (mid-summer) to measure changes in whole-tree NSC mass by organ. Additional control trees were harvested in mid-winter to fully investigate seasonal NSC dynamics in relation to growth phenology.

NSC depletions were primarily due to starch consumption, not soluble sugars. The proportion of whole-tree starch mass depleted was severe in both defoliated trees (94% across stem, lignotuber and roots) and felled trees (85% across lignotuber and roots). The proportion of starch depleted within individual organs was similar across organs within treatments, indicating that all organs functioned as NSC storage pools. The major carbon cost during resprouting was maintenance respiration, rather than sprout production. Therefore, slow or delayed resprouting would likely lead to increasingly severe NSC depletions, potentially undermining tree resilience to subsequent disturbances. In control trees, substantial starch depletion (66%) in the stem and roots between spring and summer coincided with a period of canopy growth and drought stress. Our results indicate that NSC storage margins can be small under stress in temperate evergreen eucalypts despite their adaptation to recurrent defoliation by fire.