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Dendrometric measurements reveal stages leading to tree mortality in a semiarid pine forest

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Increasing frequency and intensity of climatic extreme events, such as droughts may lead to increasing vulnerability of forests, especially in semi-arid regions. In the spring of 2016 mortality was observed among trees used for sap flow (SF) and dendrometry measurements in the semi-arid Fluxnet pine forest site of Yatir in Israel (280mm annual mean precipitation). This was accompanied by bark-beetle attack, and with visual drying of needles starting in April 2016. Comparative analysis of dendrometry and sap flux (SF) measurements in 31 trees of which 7 died and 24 survived permitted identification of the stages leading to tree mortality.

Distinction between dying and surviving trees was identified in the dendrometric measurements from Nov. 2015, about five months before visual mortality signs: First, clear decline in diameter (DBH) was observed in all dying trees, whereas DBH of living trees remained constant until the first rain in January 2016 followed by growth. Second, the diurnal patterns in DBH showed a gradual shift of the diurnal DBH maximum from noon-time to early morning from the summer of 2015 to the spring of 2016 in surviving trees, whereas in dying trees it remained stable around noontime. Third, the diurnal swelling/shrinkage dynamics, assumed to reflect water use and storage dynamics, showed clear decline in magnitude, down to near zero, in the dying trees while regular daily cycle continued in the surviving trees. In September 2015 Shoot measurements showed midnight minimum of leaf water potential, lower than in living trees (-4.5 vs. -3.6 MPa respectively). Sap flow measurements were not sufficiently sensitive during the non-active season (fall and early winter) and indicated changes only after the first rain in January 2016. At this time, SF showed dramatic increase in SF with typical midday maximum in the surviving trees, whereas in dying trees SF remained low and irregular.

The results show that indicators of mortality can be detected at least 5 months before visual signs are observed, and demonstrate the interacting effects of carbon economy (growth) and tree water management (radial water movement and storage) on the development of mortality in Aleppo pine trees.