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Are European forests currently experiencing a shift in climate-related mortality? A retrospective analysis across the last 25 years.

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European forests are an important source for timber production, human welfare, income, protection and biodiversity. During the last two decades, Europe has experienced a number of droughts which were exceptionally within the last 500 years both in terms of duration and intensity and these droughts seem to left remarkable imprints in the mortality dynamics of European forests. However, systematic observations on tree decline with emphasis on single species together with high-resolution drought data has been scarce so far so that deeper insights into mortality dynamics and drought occurrence is still limiting our understanding at continental scale.

Here we make use of the ICP Forest crown defoliation dataset, permitting us to retrospectively monitor tree mortality for four major conifers, two major broadleaves as well as a pooled dataset of nearly all minor tree species in Europe. In total, we analysed more than 3 million observations gathered during the last 25 years and employed a high-resolution drought index which is able to assess soil moisture anomaly based on a hydrological water-balance and runoff model every ten days across the continent.

We found significant overall and species-specific increasing trends in mortality rates accompanied by decreasing soil moisture. In particular, previous-year soil moisture anomaly had a stronger influence on mortality rates than current-year soil moisture, suggesting that legacy effects (either physiological or caused by secondary biotic agents) play a keyrole in actual forest decline. Remarkable peaks in mortality occurred simultaneously in Norway spruce and Scots pine (2004, 2018, 2019), but were largely asynchronous in broadleaves. Mortality rates in Norway spruce and Scots pine have increased by 60% and 40%, respectively (period 2010-2020 compared to 1995-2009). Oak (*Quercus robur and petraea*) as well as Silver-fir (*Abies alba*) showed much lower mortality and only a weak upward trend.

We conclude that mortality patterns in European forests are currently reaching a concerning upward trend which could be further accelerated by future global change-type droughts.

