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Consistent temperature-dependent patterns of leaf lifespan across spatial and temporal gradients for deciduous trees in Europe

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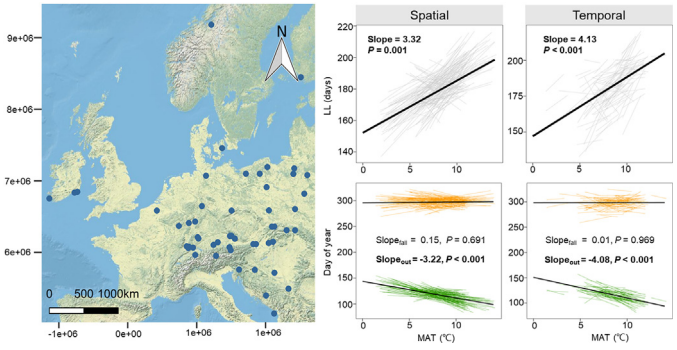
HIGHLIGHTS

- Leaf lifespan of deciduous trees extends with increasing temperature in central Europe between 1971 and 2000.
- The positive relationships between leaf lifespan and temperature are not significantly different along spatial and temporal gradients.
- Spring leaf-out is the key force shaping the relationship between leaf lifespan and temperature in the six deciduous tree species of this study.

GRAPHICAL ABSTRACT



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ABSTRACT

Temperature affects leaf lifespan (LL) across either space or time, driving long-term adaptation and short-term thermal acclimation, respectively. However, a comprehensive understanding of the phenomenon and the underlying phenological mechanisms remain poorly understood. The present study investigated the relationship between LL and temperature in six common deciduous trees across both spatial and temporal gradients, then explained the LL variation patterns based on phenological shifts. Using long-term (1971–2000) phenological records of six deciduous tree species at 54 sites across central Europe, we analyzed spatial and temporal variations of LL and leaf phenology along temperature gradients. We assessed the relative contribution of phenological shifts to LL variations by comparing absolute changes in leaf-out and leaf fall. We reported positive LL-temperature relationships across all observations along both spatial (+3.32 days/°C) and temporal (+4.43 days/°C) gradients. The paired *t*-test of the six deciduous tree species showed no significant difference in regression slopes of LL- temperature between the two gradients ($t = -1.50$, $df = 5$, $P = 0.194$). Prolonged LL can be explained mainly by earlier leaf-out induced by warmer temperatures both spatially (−3.22 days/°C) and temporally (−4.08 days/°C). The converging temperature-dependent patterns of LL across time and space indicate that short-term thermal acclimation keeps pace with long-term genetic adaptation for deciduous trees in Europe. Earlier leaf-out is the key force shaping the LL-temperature relationship. These results provide insights for predicting future vegetation dynamics under global warming.

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