Submitted Abstract

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Abstract

Temperature extremes such as late spring frosts and droughts negatively affect productivity and tree growth in temperate beech forests. However, detailed information on how these forests recover after such event impairing leaf flushing are still missing. We investigated how late frosts affected forest cover radial growth and xylem vessel traits in European beech (Fagus sylvatica L., 1753) populations located at different elevations in the Italian Apennines and Spanish Pyrenees, where we found documented evidence of late frost events. We combined tree-ring and remote-sensing data to analyse the vulnerability and recovery capacity of beech populations to late frosts. We studied climate-growth relationships at population and individual levels to test whether trees responded consistently to climatic conditions. Using climatic records, we reconstructed late frost events and assessed their immediate and carry-over effects on growth. We assessed the key role played by spatial and structural variables as drivers of late frost rings occurrence at population and individual scales. At individual tree level we investigated how vessel trait changes under the elevational gradient and in response to late frost occurrence. We identified the characteristics of tree-rings vessel that form immediately after frost events and how they differ from the annual rings formed in non-defoliated portions of forest. Finally, using satellite images we computed Normalized Vegetation Index (NDVI), Enhanced Vegetation Index (EVI) and Leaf Area Index (LAI) to evaluate the post-late frost canopy recovery. The growth reduction in late frost-affected trees ranged from 36% to 84%. We detected a negative impact of late frost on growth only during the late frost year, with growth recovery occurring within 1-2 years after the event. We found differences in vessel size along the altitudinal gradient, with populations at high elevations showing smaller vessel diameter, vessel area and higher rates of vessel density. Water deficit during the previous and current summers and cold spring temperatures are the main factors limiting beech growth. Late frosts affected stands featuring low NDVI, EVI and LAI values until late June. Forest stands altitude can also influence frost rings formation, due to spring leaf phenology. We found a higher frost frequency at mid rather than at low or high elevations. An increasing frequency could alter the resilience of beech mountain forests, but our findings indicate a high recovery capacity and no legacy effects. Plasticity of wood anatomy traits contribute to mitigate the late frost defoliation especially in beech population located at high elevation.