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Increasing important role of photoperiod in the spring leaf-out process in temperate trees

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Climatic warming has substantially advanced the timing of spring leaf-out, however the underlying mechanisms of leaf-out are still unclear. Here, based on gradient warming experiments and the long-term data series from the open-access database Pan European Phenology network, we explored the changes in the leaf-out phenology with climate warming and discussed the dynamic role of photoperiod in the leaf-out process. We found that the timing of leaf-out date was significantly advanced with an average of 10 days, from 1 May during 1951-1965 to 21 April during 2002-2016, but the temperature control on spring leaf-out was significantly reduced that may be related to an increasing important role of photoperiod. Using a gradient warming experiment in which two hours shorter photoperiod was conducted for half trees of each warm treatments, we found that the short photoperiod significantly delayed the timing of leaf-out, but only occurred when the air temperature was warmed above a threshold, in addition, large species-specific photoperiod effect was observed. These findings suggest that photoperiod likely plays more important roles in the spring leaf-out processes, but may be species-specific and interact with other environmental cues. Physiological experiments are necessary to further explain the interaction among these environmental cues for leaf-out processes.