



Asymmetric effects of cooler and warmer winters on beech phenology last beyond spring

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In temperate trees, the timing of plant growth onset and cessation affect biogeochemical cycles, water and energy balance. Currently, phenological studies largely focus on specific phenophases and on their responses to warming. How differently spring phenology responds to the warming and cooling, and affects the subsequent phases, has not been well investigated. Here, we exposed saplings of *Fagus sylvatica* L. to warmer and cooler climate during the winter 2013–2014 by conducting a reciprocal transplant experiment between two elevations (1340 vs. 371 m.a.s.l., ca. 6°C difference) in the Swiss Jura mountains. To test the legacy effects of earlier or later budburst on the budset timing, saplings were moved back to their original elevation shortly after the occurrence of budburst in spring 2014. One degree decrease of air temperature resulted in a delay of 10.9 days in budburst dates, whereas one degree of warming advanced the date by 8.8 days. Interestingly, we found an asymmetric effect of the warmer winter vs. cooler winter on the budset timing in autumn: saplings experiencing a cooler winter showed a delay of 31 days in their budset timing compared to the control, whereas saplings experiencing a warmer winter showed 10 days earlier budset. The dependency of spring over autumn phenophases might be partly explained by the building up of the non-structural carbohydrate storage and suggests that the potential delay in growth cessation due to global warming might be smaller than expected. We did not find a significant correlation in budburst dates between 2014 and 2015, indicating that the legacy effects of the different phenophases might be reset during each winter. Adapting phenological models to the whole annual phenological cycle, and considering the different response to cooling and warming, would improve predictions of tree phenology under future climate warming conditions.