Interactive climate factors restrict future increases in spring tree productivity

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Abstract

Climate warming is currently advancing spring leaf-out, enhancing net primary productivity (NPP) of temperate forests. However, it remains unclear whether this trend will continue. Using 727,401 direct phenological observations of dominant forest trees, we test for the major controls on leaf-out and forecast future trajectories of spring arrival. By representing hypothesized relationships with day-length, autumn temperature and winter-chilling, we accurately predicted reductions in the advance of leaf-out. There was a strong consensus between our empirical model and existing process-based models, revealing that the advance in leaf-out will not exceed 2 weeks over the rest of century. By incorporating these trends into a dynamic global vegetation model, we estimate that these environmental constraints reduce the expected increases in forest NPP by 0.6 Gt per year. These findings reveal important environmental constraints on the productivity of broadleaf deciduous trees and highlight that shifting spring phenology is unlikely to slow the rate of warming by offsetting anthropogenic carbon emissions.

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