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Assessing the effects of forecasted climate change on the growing season length of European temperate trees species along an altitudinal gradient.

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Modelling the phenology of trees is crucial to assess the impact of climate change on the length of the growing season and the productivity of terrestrial ecosystems. A lot of models have been proposed to predict bud burst in the literature, but little has been made to predict leaf senescence and therefore to investigate how growing season length will be modified by climate change. The first aim of this study is to assess through a comparison of phenological models (i) the role of chilling and forcing temperatures on leaf flushing and (ii) the role of autumn temperature and daylength on leaf senescence for six dominant tree species in Europe (4 deciduous and 2 evergreens). We further use the best model for each species to predict shifts in growing season length for the 21st century.

Models testing and validation were done for each species on two to three years of phenological observations (flushing and senescence) acquired along a 1500 m altitudinal gradient in the Pyrénées mountains (France).

Leaf flushing phenological models were based both on forcing temperature-based (F-models) and on chilling/forcing temperature-based models (CF-models). Leaf senescence phenological models were based on photoperiod-sensitive cold-degree day sums.

We showed that most flushing models are able to accurately predict the observed flushing dates for all the species studied. However, the structural difference between F and CF models appears to influence the 21st century predicted trends in leaf flushing, especially for beech. Because global warming could lead to insufficient chilling at the rear edge of species distribution, we therefore recommend considering results from F-models with caution.

The prediction of leaf senescence appears more challenging, as the proposed model is better than the null model for only two out of four deciduous species (beech and oak).

When used in a prospective analysis under moderate warming (ARPEGE climate model, A1b IPCC scenario) for the 21st century, these models predict a stronger lengthening of the growing season for oak than for beech. On that basis, we suggest that the competitive balance between both species could be strongly modified under climate warming, and shifts in their distributions might occur: oak forests might shift upwards in elevation, progressively replacing beech forests at intermediate altitudes.