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Can inter-annual variation of tree crown condition of Fagus sylvatica explain radial growth?

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Detecting and understanding changes or trends in forest health is essential in a context of increasing frequency of extreme weather events. In addition to the climate-induced tree vulnerability, an increase in biotic attacks due to warming and phenology shifts for insects and trees, could amplify the decline of forest health.
The knowledge of the reaction of the trees to the past biotic and abiotic constraints is the key to understand their future resilience. For that purpose, we need long time-span observations to detect immediate and delayed effects of environmental factors on forest trees, and the transnational monitoring network of ICP Forest, initiated in the 80s, gives us this opportunity. Since 30 years onwards, defoliation percentages and abnormal leaves colorations are recorded each year on more than 100,000 trees over Europe in order to quantify their health. Despite a difficult interpretation and an uncertain objectivity of these criteria (because of their "expert" visual assessment) numerous studies have been conducted to interpret the interannual variations and the trends of crown conditions data, in regard to environmental constraints. However, very few studies have examined the physiological impact of these leaf losses or discolourations. Our study was launched in this spirit.
Because radial growth is a well-established indicator of tree health and physiological status, we cored to the pith 544 beech trees over 89 plots of the French ICP Forest Level I network. Climate series and soil water deficits were computed for each plot, and a classical dendroecology study was performed. To go further, we tried a joined analysis of crown deficit, radial growth signals, climatic and biotic constraints. Our questions were: i) is radial growth and leaf loss controlled by similar climatic factors; ii) can leaf loss explain part of the inter-annual variations of radial growth.
To analyse this complex spatio-temporal dataset, we used the Random Forest Regression. This new machine learning method, was applied to predict annual ring width and defoliation using climatic and water balance variables over 6 French ecological regions. Then annual defoliations with pest and disease damages were added to the potential explaining variables in order to predict annual growth.
Environmental constraints were identified to explain year-to-year variations of crown conditions and ring-widths. Nevertheless, in the case of beech, current (or lagged) crown condition was not relevant to explain radial growth. This result opens the discussion about the relevance of defoliation assessment as an indicator of tree health.