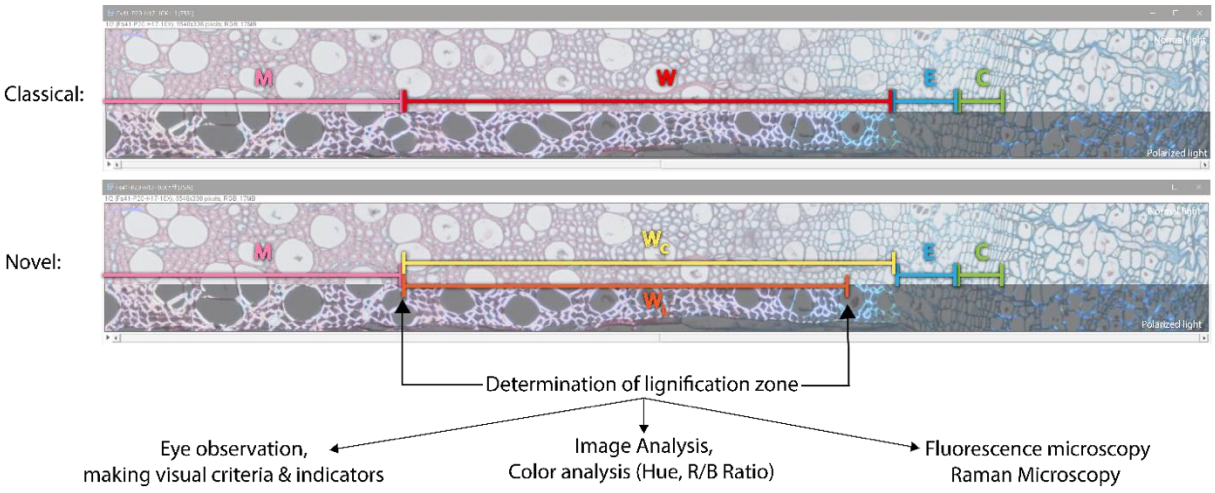
ModPhenWood



Determination of the wood formation zones and the lignification zone in particular. The top picture illustrates the classical zonation of wood formation bands: (C) Cambial division, (E) Enlargement, (W) Secondary cell wall thickening and lignification, and (M) Mature zones. Bottom picture illustrates the new proposed zonation adding lignification (W_L) to cell wall thickening.

Ecophysiological modelling of the phenology of wood formation in temperate and boreal forest trees

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Action thématique concernée : WP2

Context — Wood is the second largest stock of continental biomass on Earth. Its production by woody plants helps to mitigate the current accumulation of anthropogenic CO_2 in the atmosphere. Wood formation is, however, a complex process, the seasonality of which is now known to depend not only on carbon assimilation processes. Indeed, environmental factors and tissue development have a crucial influence on the dynamics of wood formation. These facts contradict the common representation of this process in vegetation models which assume that xylogenesis depends only on photosynthesis.

Objectives — The ModPhenWood project aims to deepen our knowledge of the roles of environmental and ontogenetic constraints on the phenology of wood formation. A set of statistical and ecophysiological models simulating the occurrence of key stages of wood formation (resumption of cambium divisions, start and end of enlargement of new xylem cells, start and end of secondary wall deposition and lignification) will be developed. These models will explore both the role of environmental factors (temperature, soil moisture, photoperiod) and the ontogenetic sequence.

Approaches — The models will be developed and tested using an existing database of over 300 site-years of weekly wood formation data for more than 20 conifer species located in the northern hemisphere. In parallel, the database will be extended to hardwoods, with a set of over 30 site-years already identified for sessile oak and European beech. The project will also aim to improve the criteria for observing the different stages of wood phenology and cell wall lignification dynamics in particular.

Key results — Improving the definition of the critical dates of wood phenology for gymnosperms and angiosperms and developing an ecophysiological model will make it possible to quantify the respective roles of environmental constraints and ontogenetic sequence on the seasonal patterns of wood formation and to assess the impact of climate change.

Main conclusions including key points of discussion — Our results, which are still very preliminary, confirm that temperatures are indeed the main determinant of wood phenology in angiosperms and gymnosperms. However, these temperatures do not control the phenology of wood formation through a simple threshold effect (as assumed in many publications), but through a more complex process that involves both warm spring temperatures (forcing) and cold winter temperatures (vernalisation), during particular periods (photoperiod effect) that depend on the species. Furthermore, our results indicate that, even in temperate forests, water stress has an important role in the cessation of cambial activity, wood formation and lignification in particular.

Perspectives — Once our work on redefining critical dates for wood formation is complete, we will apply it to our preferred study site (the Hesse forest) to assess the impact of the 2018 heat wave on wood formation and carbon sequestration in trees. We will also be able to use the data thus generated for angiosperms to develop the phenological model for this taxonomic group. In the medium term, the wood phenology model is intended to be integrated into a vegetation model (CASTANEA) in order to improve the seasonal dynamics of carbon allocation in the tree.

Valorization — This project will result in several participations in international conferences and several high-level scientific articles on the main themes of the project, which are very original (e.g., phenology of wood lignification, influence of climate (and drought) on lignification, ecophysiological model of wood phenology for gymnosperms, then for angiosperms). This project will also enable the defense of two doctoral theses, the thesis of Jianhong Lin at the University of Paris Sud and the thesis of Ignatius Adikurnia at AgroParisTech.

Leveraging effect of the project — With the help of LabEx funding, which consisted of a half thesis grant, we were able to attract additional funding from the INRAE ECODIV department, which allowed us to launch an international recruitment. We attracted two excellent candidates, including a Chinese candidate (Jianhong Lin), who through a partnership between the University of Paris Sud and the Chinese Ministry of Research was able to benefit from an individual doctoral grant. With half a thesis grant financed by the LabEx, we were thus able to launch two thesis projects in parallel.