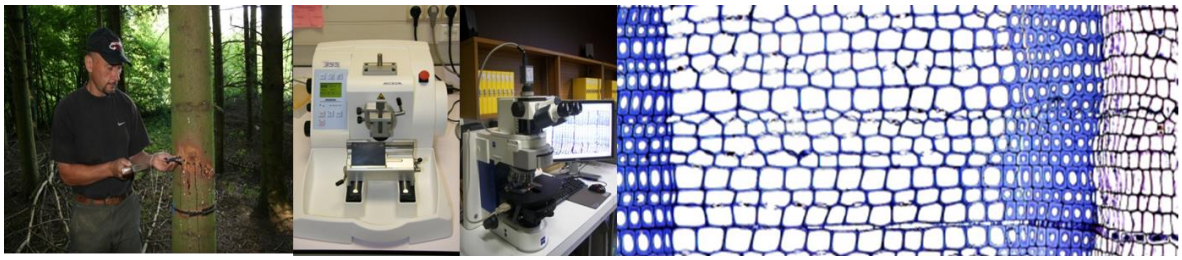
WADE



Prélèvement des micro-carottes microtome microscope coupe issue de la micro-carotte *Photos Julien Ruelle et Cyrille Rathgeber*

Wood Acclimation to Disturbed Environments

Principle investigator: *Meriem Fournier*

Partners: EEF, LERMaB

Collaboration: RDI ONF, B. Lachenbruch (Oregon State University), R. Sierra de Grado (Universidad de Valladolid), M.P. Laborie (Université de Freiburg), équipe de E.A. Vaganov (Institute of Forest SB RAS, Krasnoyarsk, Russia), D. Frank et P. Fonti (WSL, Suisse), E. Badel et B. Moulia (PIAF INRA Université Blaise Pascal U. Clermont Ferrand), T. Alméras (LMGC, CNRS Université de Montpellier II), B. Clair et G. Jaouen (UMR ECOFOG, Guyane).

Context — WADE analyses how wood properties vary in response to environmental distirbances. WADE is based on integrative modeling of functions and functionalities of wood in trees, from cell wall to tissues and the whole organism. WADE uses wood characterization techniques on Xylosciences and PTEF platforms.

Objectives — WADE aims at linking mechanistic and biophysical modeling to empirical approaches of wood quality, in order to understand and predict how micro-climate changes (of light, mechanical environment …) trigger wood patterns.

Approach —Task 1 aims at delivering the general wood framework, involving strongly the Xylosciences platform, with links with the PTEF one, for technical aspects. The three following tasks use this framework to answer biological questions linked to silvicultural or technological issues: Task 2 studies how wood responds to mechanical constraints in natural environments using recent advances made by integrative biology in this field, Task 3 characterizes wood of branches, especially its chemical properties with relation with diversity and ontogeny, enlarging the point of view developed in Scandinavian industrial studies on *Picea abies*, and Task 4 develops new markers of growth history and canopy disturbances in saplings, as this development stage, poorly understood in growth models, impacts greatly the ability of forests to regenerate under changed climatic conditions. A last task organizes synthesis and dissemination of results to i) phenomenological growth and yield forest models with forest R&D, ii) wood industries through parallel industrial projects, iii) teaching at master level.

Key results —

- Task 1: Henri Cuny's post-doc work lead to a letter published in Nature Plants sur about wood formation kinetics related to carbon storage in forest ecosystems (cf main conclusions).
- Task 1: The paper submitted to Am. J. Bot about "how universal physics explains some observed worldwide correlations between wood traits" was rejected but strongly encouraged to be submitted again. The message is important but not easy to communicate to biologists.
- Task 1: Félix Hartmann 's thesis (june 2015) about a biophysical model of wood formation showed that reaction-diffusion of morphogenetic chemical signals can explain the growth

kinetics (in volume) but not the anatomical pattern from early wood made of large cells to late wood made of small cells.

- Task 1: Wood biophysics provides help to improve discussion and valorization of datas obtained before 2014 in ANR EMERGE project (Longuetaud F., Mothe F, Santenoise Ph, Dlouhà J., Fournier M., Deleuze C. "Patterns of within-stem variations in wood specific gravity and water content for four temperate tree species" re-submitted to Annals of Forest Science)
- Task 3: Works about knot chemistry have been published (phD Z. Kebbi Benkeder LERFoB LERMaB). Firsts results about J. Song thesis (QTL of epicormic formation, supervision F. Colin LERFoB and O. Brendel EEF, collaboration with A. Kremer BIOGECO Bordeaux).
- Task 4: All data have been collected for Estelle Noyer phD about « individual response of trees to gap opening: growth and wood variations », cosupervisors C. Collet ecology/silviculture et J. Dlouha biomechanics, wood physics, with ONF's help (project "sapling reactivity"). Citra Purba's Master 2 (master FAGE BFD, double diploma with Bogor University, Indonesia) has been published. E. Noyer spent 3 months in Oregon State University where she worked with B. Lachenbruch about wood hydraulics, analyse data and decides a dissemination strategy for the phD publication.
- Task 5: WADE is valorized in several courses in AgroParisTech master of engineering and Master FAGE.

Main conclusions including key points of discussion — The main result 2015 belongs to Henri Cuny's post doc work (Nature Plants, 26 October 2015) : Trees show that growing is not putting on weight!

Our careful (and sometimes cumbersome) methodologies developed by C. Rathgeber, H. Cuny, M. Harroué, E. Cornu in LERFoB for studying intra-annual kinetics of wood formation processes have shown that mechanisms involved in tree growth are in action at different times. Stem-girth increase and woody biomass production are two key processes of forest ecosystems, driving respectively stand growth in volume and carbon sequestration into wood. Until now these two processes were considered as totally synchronous. The study demonstrated that in coniferous forests of the northern Hemisphere, woody biomass production lagged behind stem-girth increase by about one month over the growing season. It also showed that these two biological processes exhibited differential sensitivities to climatic conditions. Indeed, the seasonal dynamics of stem-girth increase matched the photoperiod cycle (change in daytime and nighttime lengths), whereas those of woody biomass production closely followed the seasonal course of temperature.

These new results show how difficult it is to properly infer the seasonal dynamics of carbon sequestration from external measurements of stem size change (e.g., dendrometer records). The amount of biomass produced from photosynthetic carbon cannot be approximated through changes in tree size on the short term. Even though stem size doesn't evolve in the fall, the forest can still capture carbon, thus increasing the wood mass at an even volume. This work helps to better quantify the seasonal balance of terrestrial carbon, providing insights and methods to link forest–atmosphere exchanges and woody carbon sequestration at weekly time scales.

Future perspectives — The WADE project is ending in 2015 (excepted Estelle Noyer's phD that will be defended at the end of 2016). The Designed to support innovative and crossed between disciplines visions of wood formation and qualities, the project has stimulated new LABEX projects or enhanced consistency between several LABEX projects (WOOD-EP-N2, WIND-IN-WOOD, WOOD ForMS, WOODCAP, EVAQB, Wood@nat transformed into a MOOC of Université de Lorraine). It reinforced attractiveness of our community in this topic: for example, Cyrille Rathgeber and Henri Cuny participate in international networks and projects, Jana Dlouhà is preparing an ANR project with Eric Badel (PIAF Clermont Ferrand) and she supervises a phD thesis with Eric, financed by INRA EFPA Department. Concerning more industrial research, we will use WADE experience to develop withThierry Constant some technological projects about non-destructive assessment of wood quality in standing trees.

Valorisation —

Publications

Cuny H. E., Rathgeber C.B.K., Frank D., Fonti F., Mäkinen H., Prislan P., Rossi S., Martinez del Castillo E., Campelo F., Vavrčík H., Camarero J.J., Bryukhanova M.V., Jyske T., Gričar J., Gryc V., De Luis M., Joana Vieira J., Čufar K., Kirdyanov A.V., Oberhuber W., Treml, V., Huan J.G., Li X., Swidrak I., Deslauriers A., Liang E., Nöjd P., Gruber A., Nabais C., Morin H., Krause C ., King G., Fournier M. (2015). Woody biomass production lags stem-girth increase by over one month in coniferous forests. Letter. Nature Plants. 2015/10/26/online

Purba C. Y. C., Noyer E., Ruelle J., Dlouhá J., Karlinasari L., and Fournier M. (2015) "Growth stresses in old beech poles after thinning: distribution and relation with wood anatomy," J. Indian Acad. Wood Sci., vol. 12, no. 1, pp. 37–43.

Kebbi-Benkeder Z., Colin F., Dumarçay S., Gérardin P. 2015. Quantification and characterization of knotwood extractives of 12 European softwood and hardwood species" . Annals of Forest Science vol 72 pp 277-284

Communications at international level

Kebbi-Benkeder Z., Touhari N., Colin F., Dumarçay S., Gérardin P. (2015) Valuable phenolic derivatives from knotwood of various tree species. Conference: MESMAP-2015, Antalya-Turkey

Noyer E. and Constant T. (2015) Analysis of the motion induced by tree growth from T-LiDAR measurements: a case of study for beechpoles (Fagus sylvatica L.). Silvilaser 2015 - Montpellier, France

Noyer E., Lachenbruch B., Dlouhá J., Collet C., Ningre F. and Fournier M. (2015) Capacity of old suppressed beech trees to adjust xylem anatomy and theoretical hydraulic properties after thinning. 63rd Annual Western International Forest Disease work conference - Newport, OR, USA

Noyer E., Dlouhá J., Collet C., Constant T., Ningre F. and Fournier M. (2015) Are old beech poles able to react to heavy thinning? And how does growth response affects pole biomechanics? 8th Plant Biomechanics International Conference 2015 - Nagoya, Japan

Hartmann F.P., C.B.K. Rathgeber, M. Fournier, B. Moulia. (2015). Control of wood formation by a morphogenetic gradient. 8th Plant Biomechanics International Conference 2015 - Nagoya, Japan

Communications at national level

Breda N. (2015). Réponse des arbres aux aléas biotiques et abiotiques : les fonctions écophysiologiques du bois. GDR 3544 « Sciences du bois » 2015 - Clermont-Ferrand, France

Kebbi-Benkeder Z., Touhari N., Colin F., Dumarçay S., Gérardin P (2015) . Biodiversité interspécifique des extractibles nodaux. GDR 3544 « Sciences du bois » 2015 - Clermont-Ferrand, France (poster primé)

Kebbi Benkeder Z. "Les extractibles dans les nœuds des arbres, quel avenir?" Séminaire de l'école doctorale RP2E. Janvier 2015.

Song J., Brendel O., Bodenes C., Kremer A., Colin F. (2015) Effet de l'environnement sur l'analyse QTL de la ramification du chêne pédonculé. GDR 3544 « Sciences du bois » 2015 - Clermont-Ferrand, France (poster primé)

Courses

Cours et TD de l'UE "Biphysique des tissus végétaux". Master 1 FAGE https://tice.agroparistech.fr/coursenligne/courses/UE817BIOPHYSIQUEDEST/

Cours "biomécanique" de l'UE Mécanique des milieux continus de la 2A Ingénieurs AgroParisTech

https://tice.agroparistech.fr/coursenligne/main/document/document.php?cidReq=RESSOURCESUEMECANIQU

Media

"Les arbres grossissent et prennent du poids mais pas en même temps" INRA et AgroParisTech le 27 octobre 2015 (à propos de l'article Cuny et a. Nature plants)

http://presse.inra.fr/Ressources/Communiques-de-presse/Les-arbres-grossissent-et-prennent-du-poids-mais-pas-en-meme-temps