



Study of the beech decline in the Northeastern of France

Principle investigator: Catherine MASSONNET, UMR SILVA

LabEx partners: Nathalie BREDA, Pierre-Antoine GAERTNER, Joseph LEVILLAIN, Vincent BADEAU, Bastien GERARD, Nathalie LEROY [UMR SILVA].

Collaborations: Mathieu MIRABEL, Romaric PIERREL, Tony Larousse, François Xavier SAINTONGE [Département de la Santé des Forêts (DSF)], Hubert SCHMUCK [ONF], Correspondants-observateurs réseau hêtre DSF en Grand-Est et Franche-Comté [ONF]

Thematic action concerned: WP2

Context —

Since 2019, beech forests in the North-East of France have been showing massive decline leading to the death of some adult trees in the centre of the species' distribution area, induced by the exceptional drought episode from 2018 to 2020. Biotic attacks have also been observed on some individuals according to the typical cascade of risks. Understanding the vulnerability factors and resilience capacities of species to these extreme drought events is crucial to help foresters better manage crises, understand risks and adapt the forest management to future climate.

Objectives —

The main objective the DEP-HETRE project will be to have a better understanding the physiological dysfunctions that cause a tipping point towards death or, conversely, favour the resilience of beech trees. Particularly, the DEP-HETRE project will take the opportunity of this large-scale field decline to investigate the role of carbon reserves in the resistance and recuperation capacities of trees, their susceptibility to pathogens and their ability to defend themselves against secondary pathogen attacks.

Approaches —

Two experiments were set up:

1. Study of a stand with declining beech trees subjected to attacks by secondary pests

In 2020, a stand with declining beech trees in Bliesbruck (57) has been selected. Parameters needed to apply the Biljou© water balance model were described. Tree health status (leaf loss, branch mortality and branching deficit) and the level of fruiting of 32 hammered trees were described by the DSF (Forest Health Division). Following the felling of these trees, two agents, from ONF and DSF, described the level of biotic attacks along the trunk and branches. Wood samples of trunk, branches and roots were taken to quantify and to map the carbon reserves (starch and soluble sugars) at the whole tree scale. Cores in the heart of trees at 1m30 were also taken to determine the age of the trees and to measure the cambial growth by dendrochronological analysis.

2. Study of a network of semi-permanent plots on a large geographical scale

In 2019, a network of 30 semi-permanent plots of 15 trees with contrasted crown condition was set up by the DSF to monitor the evolution of the health status of beech stands in the GE and BFC regions for 5 years. Since 2019, the DSF has noted the annual crown condition and since 2020 we collected wood cores at the base of trees which to follow the carbon reserves of trees. At the end of 2022 we have taken also a core sample at 1.3m to know the age of trees and for dendrochronological analysis.

Key results —

1. Study of a stand with declining beech trees subjected to attacks by secondary pests

- Starch concentrations were very low in all organs of trees and the concentrations in roots and trunks were negatively correlated with the level of biotic attack. Preliminary results of the dendrochronological analysis showed a mean age of 160 years for the trees. After a standardisation of the age effect on the radial growth, the ring width and area showed a decreasing trend of the tree growth from 2003 suggesting a weakness of trees in the last twenty years. A decreasing exponential relation was observed between the leaf deficit observed in 2020 on trees and the mean ring area over the last 10 years.

2. Study of a network of semi-permanent plots on a large geographical scale

- Monitoring of tree health over a 4-year period (2019 to 2022) showed a progressive deterioration of crown condition within the network with an increase in the mean leaf deficit from 55.6% to 66.1% in GE and from 49.7% to 60.4% in BFC between 2019 and 2021. A light improvement was observed in BFC in 2022 (57.7%) whereas the deterioration went on in GE reaching a leaf deficit of 68.5%. Contrasting situations are observed depending on the trees and the plots.

- Mortality monitoring showed a mortality rate of 7.2% in GE and 9.2% in BFC over the period 2020-2022 with the highest annual mortality rate reached in 2022 in GE (3.6%) and in 2021 in BFC (5.8%).

Main conclusions including key points of discussion —

The initial results suggest a general weakening of the trees as a result of recent recurrent droughts. The low starch concentrations measured in the Bliesbruck's trees show that critical and irreversible thresholds of carbon stock shortage could be reached with a high risk of mortality. This conclusion will have to be confirmed in the multi-annual monitoring of trees in the DSF beech network.

Perspectives —

Bliesbruck stand: completion of soluble sugars, phenolic components, soil chemical analysis, and dendrochronological analyses to analyze the impact of different levels of health status and biotic attacks. The publication of these results is planned in 2023.

- DSF network: Tree health monitoring will continue in 2023 by the DSF. Pierre-Antoine Gaertner (PhD student) will go 2 months in Switzerland to complete the dendrochronological analysis using more performant methods in a high-throughput perspective (500 tree cores). Carbon reserves content is currently quantified on a subsampling of 18 plots (270 trees). Soil pits will be opened to carry out soil descriptions for the parameterization of the Biljou© water balance model, which will allow retrospective quantification of water deficits on each plot.

Valorization —

- Gaertner PA, Massonnet C, Breda N (2021) Sur-mortalités de hêtre depuis 2018 : une cascade d'aléas climatiques et biotiques ? Colloque de lancement du réseau scientifique RisqFor, Nancy.
- Massonnet *et al.* (2021) Vulnérabilité des forêts face aux changements climatiques. Colloque scientifique de la SNHF : le dérèglement climatique : un défi pour les plantes.
- Massonnet *et al.* (2022) Vulnérabilité des arbres aux événements climatiques extrêmes. Colloque AgroParisTech et ProSilva - Changement climatique : les hommes et les forêts au pied du mur ? Verdun.

Leveraging effect of the project—

- A thesis grant funded by DG INRAE (ECODIV division) has been allocated for this subject in 2021.
- Funding from DSF has been also obtained to cover the costs of this thesis work in complement of the DEP-HETRE project.
- Collaboration with researchers from the WSL (Swiss research institute, Georg Von Arx and Yann Vitasse) and obtaining grants (INRAE Ecodiv, LUE DREAM program and DEESSE Eira program) to send the PhD student for 2 months to this laboratory.
- A post-doc (Guangqi Zhang) has been recruited co-funded by the innovative RiskForBeech project (Labex project) and by the Grand-Est region to work on a complementary approach to this project.