Core sampling in the wet site by Arivoara Rabarijaona (left). Automated dendrometer newly installed in the Harth site (right)

Effect of intra-population functional diversity on the population resilience to drought

Principle investigator: Stéphane PONTON, UMR Silva

Collaborations: Oliver BRENDEL, Arivoara RABARIJAONA, Cyrille RATHGEBERr, François NINGRE, Nathalie BREDA, SILVA-TECH

Thematic actions concerned: WP1 + WP2

Context —
The rapid changes in predicted climate conditions is challenging forest managers. They have to identify the tree species and provenances that will constitute productive and sustainable forests in the future decades. Species distribution modeling could provide them guidance. However, despite significant recent improvements, the models still consider average species behavior, or, at best, among-population variations, ignoring that within-population functional diversity is usually much higher. Indeed, within-population data are extremely rare and the current knowledge failed to provide a general understanding of the impact of this functional diversity on the population performances.

Objectives —
Our main objective was to evaluate the effect of the within-population functional diversity on the population resilience to drought, focusing on water-use efficiency (WUE), a common integrative plant trait. This knowledge is necessary to evaluate the relevance of assisted migration as a solution to adapt the French managed forests to their future drier environment. Because of its ecological and economical importance, as well as for the acquired ecophysiological and genetic knowledge, we selected the sessile oak as the species model and studied it in two stands with contrasted drought exposure.

Approaches —
A retrospective approach, based on the analysis of ca 100-year tree-ring chronologies, was used to: 1) study the tree response to drought events over a period long enough to estimate their resilience, 2) characterize the trees phenotypic variability (each year/ring being considered as a phenotypic expression in relation to a particular set of environmental conditions) in relation to their fitness (relative growth will be used as a proxy), 3) analyze the trees functional trajectory with aging and its consequence at the population level.

Key results — (presented as separated bullet points)

- *The phenotypic expression of WUE of a tree integrates: (1) a genetic component, conserved over time; (2) an environmental component including (2a) the response to annual soil and climatic conditions (2b) as well as a multi-year micro-environmental signal, due to heterogeneity of access to water and light resources between trees of different social status within a population.*
- *In both study sites, having a high WUE is globally associated with higher growth in wet years, and lower growth in dry years. These relationships are more pronounced when trees are older.*
- *A high WUE in the young stage generally makes the trees in a stand more resistant and resilient to future drought events in both sites. In the wet site, having a higher WUE in the young stage allows individuals to have better productivity for about 60 years, and then the effect disappears. In the dry site, the positive relationship between young-age WUE and productivity only becomes apparent in the mature stages but then persists for more than a century.*

Main conclusions including key points of discussion —
Unraveling the nature of the link between WUE and social status is difficult, and causes and effects can be confused. One of the aims of A. Rabarijaona's thesis is to clarify this relationship. The interpretation phase of the results is not yet complete, but it appears for the moment that WUE has a genetic component associated with greater resistance and resilience to drought and better productivity. However, the intra-population variability of WUE at the mature stage appears to be more related to the variability of social status than to the initial value (i.e. its genetic component) of WUE. The relationships identified between WUE and growth variation at maturity thus seem to be mainly the effect of social status. The latter is of course the result of the cumulative growth performance of the trees throughout their life and therefore also influenced by WUE.

Perspectives — Extension of the approach to other functional traits.

Valorization —
This study corresponds to the core part of A. Rabarijaona thesis that will be defended in June 2023. An article is being written. It will be submitted to an international peer reviewed journals in the coming months.

Leveraging effect of the project— This project brought us into contact with the *Forest Dynamics Unit* (WSL), which is currently implementing a project similar to ours. A. Rabarijaona did a 3-month internship in this laboratory last spring (18/04-23/07/22) as part of this collaboration.