

SUMMARY

Tender category: Call for proposals.

Coordinator: Ms Ingrid SEYNAVE (INRAE UMR SILVA).

Duration: 29 months (June 1, 2023 - October 31, 2025).

Project partners: GIS Coop, CNPF, FCBA, ONF, AgroParisTech.

AFORCE grant amount: 58 000 €.

THEMES



PROJECT CONTEXT AND OBJECTIVES

In a context of climate change marked by an increase in the frequency and intensity of droughts, the adaptation of single-species forest stands constitutes a major challenge. The reduction of density through thinning is identified as a key lever to limit competition for water and mitigate edaphic drought. However, the effects of successive thinnings, corresponding to complete silvicultural pathways, remain poorly documented.

The study consisted of quantifying the dynamics of relative soil water reserves based on in situ moisture measurements, estimating the water deficit at the soil profile scale using the Biljou© model, and then analyzing the effect of density on three drought indicators. Particular attention was paid to methodological aspects (probe calibration, estimation of usable reservoirs, model parameterization).

KEY DELIVERABLES AND TARGET AUDIENCES

Category	Deliverable	Description	Target audiences
Final report 	SEYNAVE I., 2025. Technical report of the SylvEau project.	The report describes the methodology implemented both for the processing of measured data and for the implementation of the Biljou© forest water balance model. It presents the results obtained on the effects of stand density on three ecophysiological drought indicators that characterize the period during which trees significantly regulate their water consumption.	R&D Agents, Managers, Teachers, Researchers.
Communication 	Project Presentation.	This presentation was made at the RMT AFORCE symposium in March 2025. It briefly presents the general approach and the very first results.	R&D Agents, Managers, Teachers, Researchers.

PROJECT PARTNERS

■ INSTRUCTIONS FOR USE

Experimental devices

This study analyzes the effect of population density pathways on the characteristics of edaphic drought episodes (onset, duration, and intensity), by combining in situ measurements and modeling.

It is based on seven experimental sites of the GIS Coop (Fig. 1), covering three forest species with contrasting phenology, a wide range of pedoclimatic contexts, five density pathways, and a seven-year monitoring period.

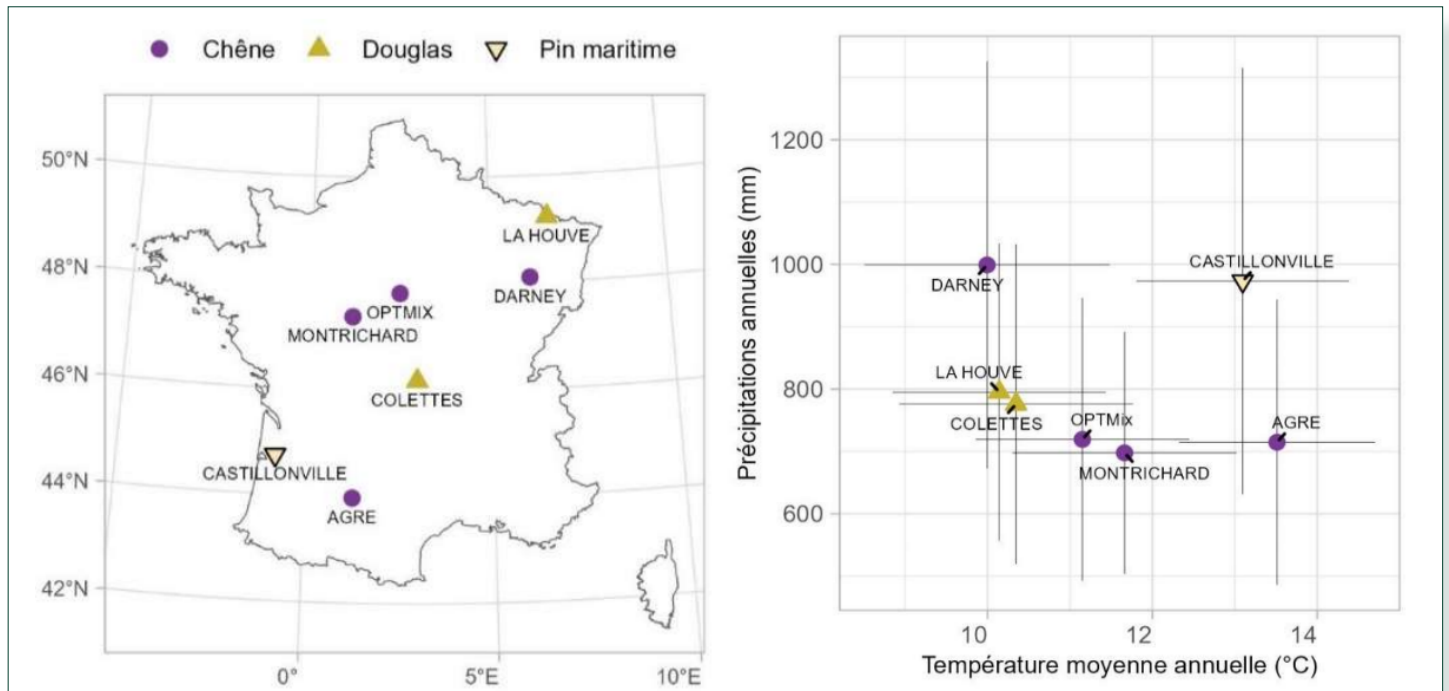


Figure 1: Location of the experimental sites. On the right, position of the sites along the gradients of mean temperature and annual cumulative precipitation. The points represent the average values over the period 1991-2020 derived from the SAFRAN model, and the vertical and horizontal lines indicate the variability of the annual values.

Approach

Quantifying the seasonal and interannual evolution of relative soil water reserves based on in situ measurements

To quantify the seasonal and interannual evolution of relative soil water reserves (REW, Relative Extractable Water) from in situ measurements, we first converted the signal from our soil moisture probes into volumetric moisture using calibration equations established on soil samples collected from our sites. Then, we determined the characteristic water contents (at field capacity and permanent wilting point) to convert from volumetric moisture to REW.

Quantifying water deficit using the daily water balance model Biljou©

To quantify the water deficit using the daily water balance model Biljou©, we determined, for each site, the required input parameters. Different estimation methods were implemented for certain parameters such as the budburst date, the soil water reservoir, the vertical distribution of roots, and the drainage parameters.

Analyze the effect of density on soil water availability

To analyze the effect of density on water deficit, we calculated three annual drought indicators from the measured and simulated REW curves: the onset, duration, and intensity of drought. These are ecophysiological indicators that characterize the period during which the relative soil water reserve is below 0.4, a threshold below which stomatal conductance (or canopy conductance at the stand scale) significantly regulates the water consumption of trees. Various statistical methods were then implemented to test the effect of density on these indicators, which are strongly dependent on weather and site conditions.

■ RESULTS

The variations in the indicators between densities are of secondary importance compared to the variations between years (weather) and between sites (water reservoir x functional type). Nevertheless, the effect of density is significant.

It appears that the duration and intensity of drought are significantly reduced in low-density stands compared to a medium-density stand. On average, the duration of drought is reduced by about fifteen days.

The effect of density also varies according to the severity of drought. Thus, for the duration and intensity of drought, there is a clear decrease in the indicator for low-density plots compared to medium-density plots, the more significant the more severe the drought. For the most severe droughts, lasting approximately 150 days, the duration is reduced by 50 days (for indicators calculated on the rooted profile) to 25 days (for measured indicators), representing a decrease of 30 to 25%. For drought intensity, the decrease is of the same order of magnitude. In contrast, few differences are observed between medium and high densities.

The results obtained from in situ measured data and from simulations made with Biljou© are very similar, which reinforces their validity.

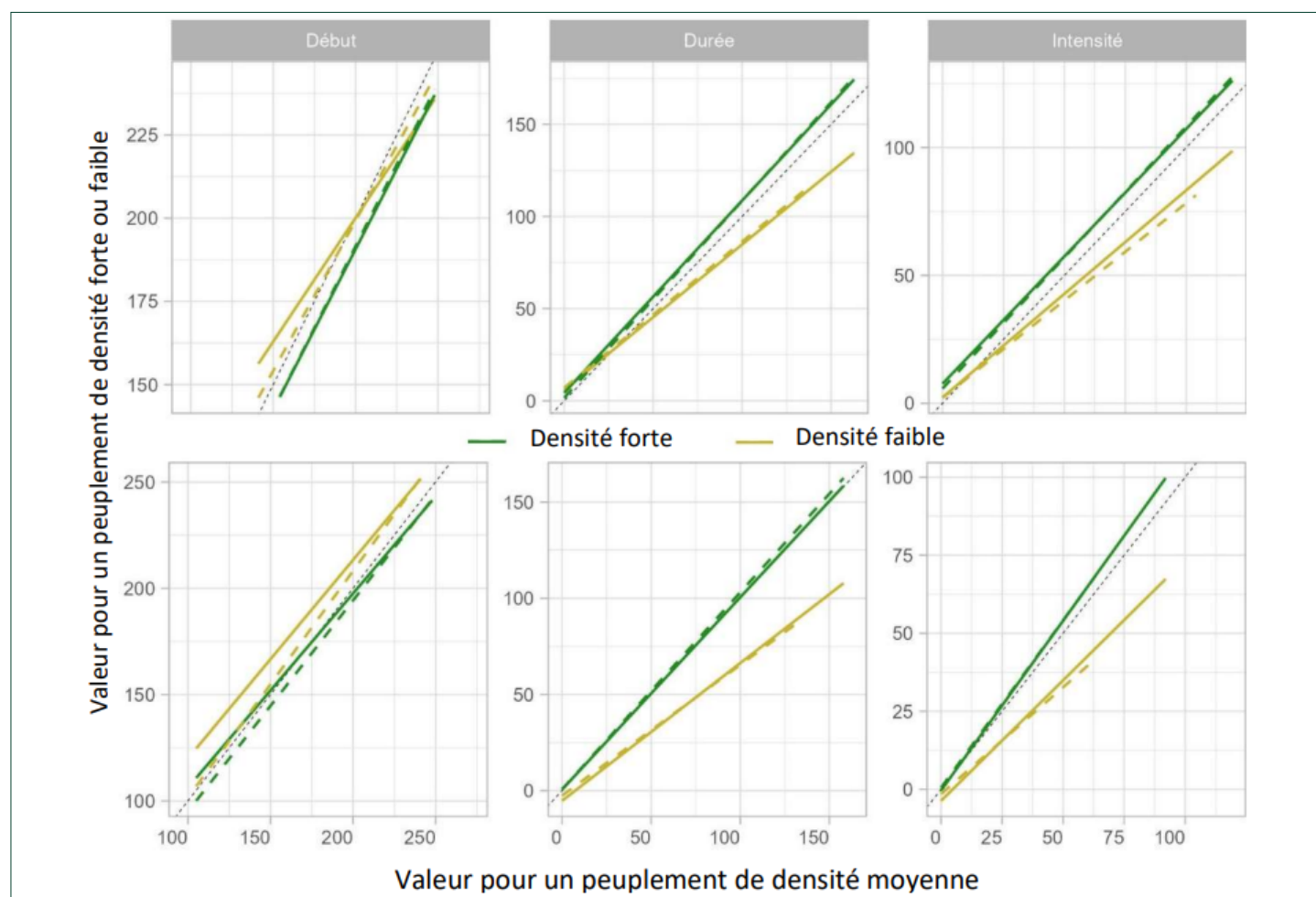


Figure 2: Comparison of indicators for high- and low-density stands relative to medium-density stands across the three drought indicators (onset, duration, and intensity). The black dashed line represents $y = x$. The top panel shows results based on in situ measurements.

■ KEY LESSONS

This work brings significant advances on methodological aspects that are generally little considered.

The work on calibration shows that the equations obtained differ from the manufacturers' equations regardless of the site and the probe model. Although all the established equations are polynomial equations, it is not possible to define a generic equation valid in all contexts. These differences may seem negligible, but they still have an impact on the calculation of volumetric moisture, which can be over- or underestimated depending on the moisture range. It therefore appears essential to calibrate the probes to estimate volumetric moisture at different depths. The work on quantifying water deficit using the daily water balance model Biljou© (simulated values) and the comparison with measured data also showed that, depending on the sets of parameters used for modeling, the estimates of different drought indicators and their consistency with measurements could vary (depending on, for example, the rooting depth of the trees). The very high variability of R^2 and RMSE observed at each site highlights the importance of this parameterization step.

Several avenues for deepening the analyses are being considered. They will be carried out in the short and medium term in order to continue the enhancement of this work. The experimental sites used for this project are also subject to hourly monitoring of tree growth. Using our results to assess the effect of water deficits on growth dynamics is also a long-term objective, whether for stands of high density, low density, or medium density.

■ CONTACT

The project leader is Mrs. [Ingrid SEYNAVE](#), Research Engineer, INRAe (UMR SILVA).

The site managers are Mrs. Sandrine PERRET, Mrs. Céline MEREDIEU, and Mrs. Lisa LAURENT.

The members of the monitoring committee are Mr. Philippe Balandier, Mrs. Nathalie Breda, Mr. Aurélien Forler, Mrs. Lisa Laurent, Mr. Joseph Levillain, Mr. Jean-Baptiste Mayet, Mrs. Céline Meredieu, Mrs. Sandrine Perret, Mr. Thomas Perrot, Mrs. Sarah Poisot, Mrs. Arivoara Rabarijaona, Mr. Raphaël Segura, Mrs. Ingrid Seynave, and Mr. Erwin Thirion.

For more information on the Biljou© daily water balance model, please contact Mrs [Nathalie BREDA](#), Research Director at INRAe (UMR SILVA) or visit the [dedicated page](#) of the RMT AFORCE.

For more information on the RUFOR project: Mr. [Joseph LEVILLAIN](#), Research Engineer at INRAe (UMR SILVA).

■ FOR MORE INFORMATION

More information is available on the SYLVEAU [project page](#) of the RMT AFORCE.



References

¹ GIS Coop site [>>>](#)

² OPTMix system. [>>>](#)

³ Daily water balance model Biljou© (site). [>>>](#)

⁴ RUFOR project on the estimation of the usable water reservoir. ADEME funding. [>>>](#)

PROJECT FUNDERS