



Master 2 Research Project: Modeling the thermal niche of six European tree species during early life stages

Where: BIOGECO INRAE – University of Bordeaux

When: Starting date - early 2026 (6 Months).

Application deadline: 31th November 2026

Supervisors: Marta Benito Garzón (BIOGECO – E4E), Eduardo Vicente (BIOGECO – E4E)

Contact person: marta.benito-garzon@inrae.fr

Funding:

Required skills: M1 in ecology, excellent modeling skills, very good knowledge of R environment, experience with large databases, team work capacity.

This Master 2 research project aims to investigate the thermal niche of six European tree species during the early stages of its life cycle, with a particular focus on germination and post-germination development. The research project will use empirical data from a series of translocation experiments performed from 2021 to 2026 on 15,774 seeds from 43 populations of *Abies alba* Mill., *Acer pseudoplatanus* L., *Fagus sylvatica* L., *Quercus petraea* (Matt.) Liebm., *Quercus pubescens* Willd., *Quercus suber* L. This dataset contains several phenotypic characterization monitored and measured at early tree stages (Benito Garzón et al. In press; Figure 1). It includes seed, germination, first phenology and physiological traits measured at 2 months old.

The main goal of this internship is to integrate these data into species distributions models that account for plasticity and population adaptation to project germination and regeneration capacity over the species ranges.

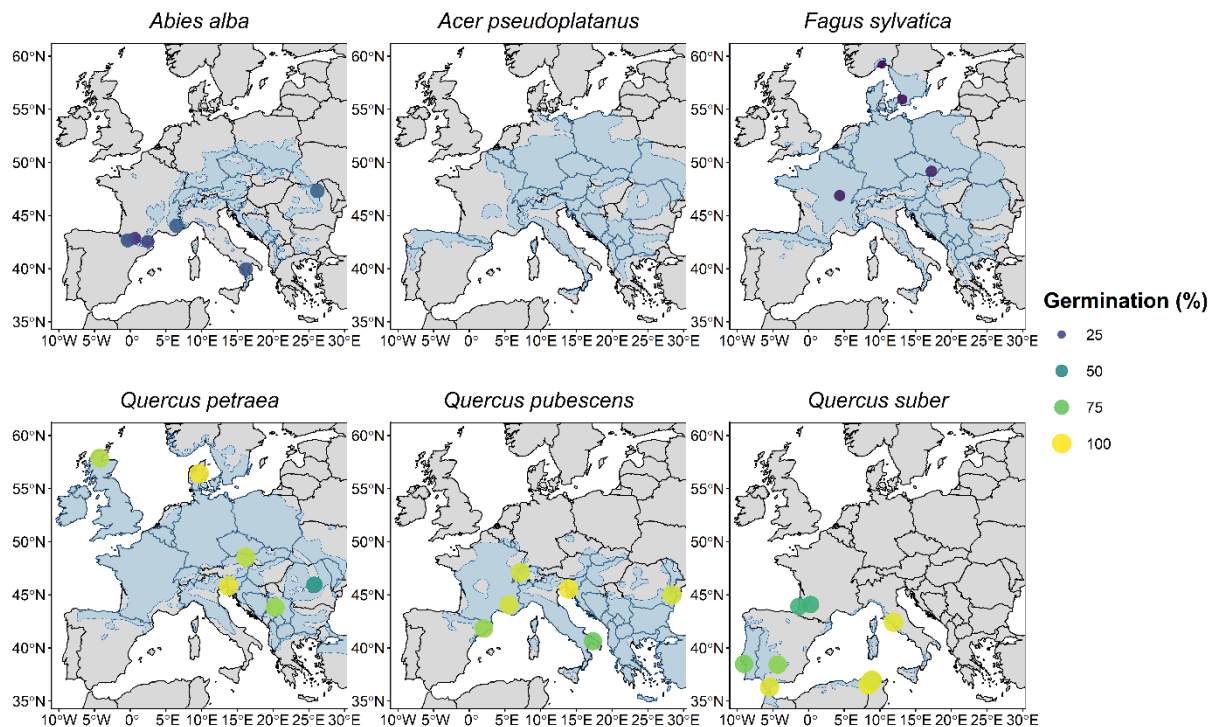


Figure 1. Percentage of germination per population within the species ranges (From Benito Garzón et al. In press). The size of the circles is proportional to the proportion of germination observed for each sampled point averaged over all treatments (sown temperature and stratification status).

STATE OF THE ART

Climate change is disrupting biological cycles, altering ecosystems and changing forests communities at an unprecedented pace. Tree populations can survive under climate change by moving towards more favorable conditions (Sunday *et al.* 2011; Chen *et al.* 2011), or persisting *in-situ* by evolutionary processes, including genetic adaptation and phenotypic plasticity (Valladares *et al.* 2014). These processes can be quantified from common gardens, where trees from different origins are planted all across the species ranges (Leites and Benito Garzón 2023). However, current knowledge on tree populations' responses to climate change at large geographical scales is mostly based on adult trees, even though early developmental stages are far more sensitive to climate than adult ones and tightly linked to fitness (Verdú and Traveset 2005). Therefore, new knowledge on the sensitivity to climate of the early phases of trees is urgently needed to assure forests persistence.

EXPERIMENTS PERFORMED

From 2021 to 2026 we germinated 15,774 seeds from 43 populations of *Abies alba* Mill., *Acer pseudoplatanus* L., *Fagus sylvatica* L., *Quercus petraea* (Matt.) Liebm., *Quercus pubescens* Willd., *Quercus suber* L. The germination experiments were performed in nursery trays distributed across three climatic chambers located at INRAE BIOGECO-University of Bordeaux (Snijder LABS, micro clima-series) set at temperatures of 15°, 20°, and 25°C to simulate at least an increase of 5°C relative to the seed origin. Relative humidity was maintained at 75%, photosynthetic photon flux density (PPFD) at 100 $\mu\text{mol}/\text{m}^2/\text{s}$, and a 13:11 h light/dark photoperiod was applied, emulating the conditions required for germination

during springtime. We watered the seeds and seedlings three days per week during the duration of the experiment. We monitored germination and first leaf emergence three days per week for five months. Post-germination traits were measured one time, one to four months after first leaf emergence, depending on the species. They mostly include above- and below-ground growth and biomass, survival and leaf pigments.

These series of experiments have been fruitfully used to address fundamental questions in ecology, biogeography and evolutionary biology. For instance, for cork oak, we observed a thermal germination cline in germination rates (Benito Garzón *et al.* 2024; Carne, Vicente, Costa e Silva, *et al.* 2026), with a more acquisitive strategy in their seedlings (Vicente *et al.* 2025). Similar results have been found for submediterranean species *Quercus pubescens* (Carne, Vicente, and Benito Garzón 2026). For the case of trees with dormant seeds, these experiments have been used to identify those populations at risk of reduced germination when stratification is not fulfilled (Poughon *et al.* 2025; Vicente and Benito Garzón 2026).

OBJECTIVE

To generate trait-based projections of the fitness-related traits gathered in the OptGERM database from germination to 4 months seedlings.

METHODS

The student will use Δ TraitSDM (Benito Garzón *et al.* 2019), mixed-effects models able to account for phenotypic plasticity and population differences in fitness-related traits to define species distribution models. The student will 1/ fit models for all the traits and species (following already developed models in Benito Garzón, M & Vicente E, Under review); 2/ project the models to ClimateDT (Marchi *et al.* 2020), high resolution climatic layers covering Europe and North Africa and 3/ predict the models result to IPCC 2080 scenarios.

OUTCOME & PERSPECTIVES

A series of high-resolution maps covering fitness-related traits distribution under current and future climate change from germination to early stages. These projections will be extremely useful to understand the forest regeneration dependence of climate across species ranges. Furthermore, they can be incorporated in assisted migration programs that, up to now, only consider juveniles and mature trees in their predictions (Chakraborty *et al.* 2024)

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