



Figure 1. Dynamics of the forest distribution and its upper limit for the municipality Valcebollère in the Pyrenees. A, Forest distribution and estimation of its upper limit (2179 m) on the État-Major map (1850); B, forest distribution and estimation of its upper limit (2223 m) on the BD Forêt® v1 (1985); C, forest distribution and estimation of its upper limit (2278 m) on the BD Forêt® v2 (2015).

Reconstructing, understanding and modelling subalpine forest dynamics to support carbon sequestration, biodiversity conservation, and infrastructure protection

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Thematic action concerned: WP2

Context —

The upper tree line is a major feature of alpine landscapes, resulting from the interaction of many factors. Despite the complex determinism, the recent expansion of subalpine forest edges is largely attributed to land use change and climate warming. Recent publications suggest that climate change and the resulting forest expansion have already had a negative impact on alpine biodiversity, significantly altering functions such as carbon sequestration and nutrient cycling.

Objectives —

In this project, we plan to quantify, understand and model the evolution of French subalpine forests, from the forest minimum of 1850 to their current maximum expansion. Furthermore, we also want to quantify the ecological impacts of this evolution in order to propose actions capable of mitigating the negative consequences of these changes (e.g., loss of biodiversity), but also to seize the opportunities they represent (e.g., carbon sequestration).

Approaches —

Our knowledge of the distribution of French forests is mainly based on three distinct sources (the État-Major map, the BD forêt® versions 1 and 2, and an aerial photographic layer) that we compare for the mountain regions (Alps, Pyrenees, Corsica). Based on these documents and a digital terrain model, we evaluate the dynamics (expansion and densification) of the subalpine forest (Figure 1). This dynamic will then be analysed using economic, social, historical and environmental data.

Key results —

At this intermediate stage of our project, we have already seen:

- An increase of more than 150 m in the upper limit of subalpine forests in the Pyrenees since the 1850 forest minimum;
- An acceleration of the progression of this limit in elevation over the recent period;
- A closure (densification) of the subalpine forests at their upper limit.

Main conclusions including key points of discussion —

Our observations show that in the Pyrenees the rise in the upper forest limit is part of a historical context of rural abandonment which led to a general expansion of the forest. However, the acceleration of the rise in the upper forest limit is probably due to the global warming. But the phenomenon that seems to be more prevalent than the expansion is the densification of subalpine forests, i.e., the maturation of open forests into closed forests.

Perspectives —

We started our work in the Pyrenees for three main reasons: good experience of the team in this region, good quality data already available, high potential for collaboration. We are currently pursuing this work in the Alps thanks to a M2 internship. This project will provide essential results on the dynamics of the upper forest limit, which is considered a key element of the Alpine landscape, and a crucial marker of environmental change, but which still resists our understanding. These results will also be used to understand the influence of human and environmental factors on these dynamics, and then to predict the position of sensitive areas where specific actions could be considered, whether for biodiversity conservation, carbon sequestration, or maintenance of ecosystem services.

Valorization —

At this intermediate stage of our project, we can already list the following outputs:

- A M1 internship completed, an M2 internship in progress (Rémi Portal), a thesis in progress (Noémie Delpouve);
- A poster presented at an international conference (IMC2022) on our results in the Pyrenees;
- A scientific article being written on our results in the Pyrenees.

Leveraging effect of the project —

Thanks to the LabEx funding obtained for this project, we were able to attract additional funding from the A2F cluster of the University of Lorraine to recruit a PhD student and an M2 student. The PhD student joined us in November 2021, the M2 student in March 2023. This project allows us to consolidate our structuring collaborations with the LESSEM in Grenoble (Laurent Bergès) and the WSL in Davos (Switzerland, Ester Frei). Noémie Delpouve will carry out her fieldwork this summer in the Alps with the help of LESSEM and will spend three months this autumn in Davos as part of an EIRA course (independent funding obtained)