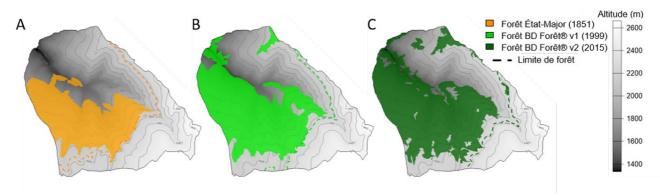# SubForDyn

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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Collaborations : Laurent Bergès (LESSEM, INRAE Grenoble)

Thematic action(s) concerned: *WP2*

Context —
The upper tree line is a major feature of Alpine landscapes, resulting from the interaction of many factors. Despite a complex determinism, the recent expansion of subalpine forest limits is largely attributed to land-use changes and global warming. Recent publications suggest that this forest expansion has a significant impact on biodiversity and ecosystem services in general.

Objectives —
In the SubForDyn 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. 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 of seizing the opportunities they represent (e.g. carbon sequestration).

Approaches —
Our knowledge of the distribution of French forests is based mainly on three separate sources (the État-Major map, old IGN maps, and BD forêt® versions 1 and 2), which we are comparing for the mountain regions (Alps, Pyrenees). Using these documents and a digital elevation model, we assess the dynamics (expansion and densification) of the subalpine forest (Figure 1). This dynamic is then analysed using economic, social, historical and environmental data.

Key results —
At this intermediate stage of our project, we have already been able to observe:
- A rise of more than 150 m in the upper limit of forests in the Alps and Pyrenees since the 1850 forest minimum;
- An acceleration in the progression of this limit in elevation over the recent period in the Pyrenees, but a slowdown in the northern Alps;
- A closure (densification) of subalpine forests at their upper limit;
- A loss of species richness in the vascular flora of subalpine forests compared toalpine grasslands.
-

Main conclusions including key points of discussion —
Our observations show that in the Alps, as in the Pyrenees, the rise in the upper limit of the forest is part of a historical context of rural abandonment that has led to a general expansion of the forest. Moreover, this expansion has been accompanied by a densification of subalpine forests, in other words a maturing of open forests into closed forests. Global warming added to this historical context to accelerate the rise of the forest to higher elevation during the 20th century. However, while the increase in forest cover is currently accelerating in the Pyrenees, it is slowing down sharply or even reversing in the Northern Alps due to strong human pressure (grazing and ski resorts). The increase in forest cover is potentially accompanied by an increase in carbon sequestration and a loss of floral biodiversity. However, we have been able to show that alpine flora can persist for several decades in subalpine forests, which opens up prospects for species conservation.

Perspectives —
This project will provide essential results on the dynamics of the upper forest limit, which is considered to be 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 envisaged, whether for the conservation of biodiversity, carbon sequestration or the maintenance of ecosystem services.

Valorization —
At this intermediate stage of our project, we can already list the following outputs:
- 2 M1 internships, 1 M2 internship (Rémi Portal), 1 thesis in progress (Noémie Delpouve);
- 1 poster presented at an international conference (IMC2022) on our results in the Pyrenees;
- 2 presentations accepted: EGU2024 (drivers), World Biodiversity Forum 2024 (biodiversity);
- 1 prize for the second-best PhD thesis presentation at ED SIRENA meeting in 2024;
- 3 scientific manuscripts in progress: 1) acceleration in the Pyrenees; 2) drivers in the Alps; 3) consequences for biodiversity in the Alps.

Leveraging effect of the project —
Thanks to the LabEx ARBRE funding obtained for this project, we were able to attract additional funding from the University of Lorraine to recruit a PhD student and an M2 student. The PhD student joined us in November 2021, and the M2 student in March 2023. This project will enable us to consolidate our structuring collaborations with the LESSEM in Grenoble (Laurent Bergès) and the WSL in Davos (Noémie Delpouve spent 3 months in Davos as part of an EIR-A course with independent funding). Finally, the SubForDyn project enabled us to write the task 4.1 of the PC MONITOR of the PEPR FORESTT (funding of 450 k€ obtained over 6-7 years).