Design Project – SIE 2026

Identification of the Natural Regeneration Potential of Tree Species Adapted to Climate Change in Mountain Forests

Students: Anna Istepanyan, Noemi Montelaghi

EPFL supervisor: Charlotte Grossiord

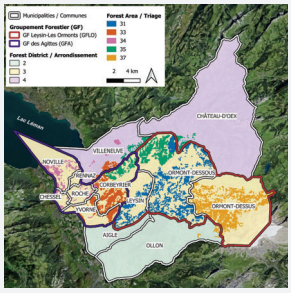
Company: DGE-FORÊT, Canton de Vaud, Marina Beck

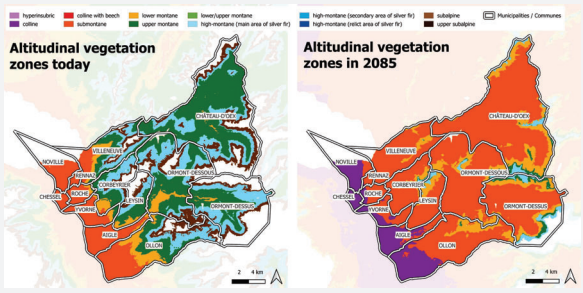
1 Motivation and Context

Swiss forests face a **projected 500-700 m upward shift** of vegetation zones by 2085. As a consequence, tree species today at high altitudes will lose their habitat and **climate-resilient species** at lower altitudes must migrate upward to ensure long-term forest stability and ecosystem services.

Whether **natural regeneration** can support this migration depends on the **location and density of seed trees** of climate-resilient species, their **seed dispersal capacity**, and the availability of **suitable environmental conditions** (in particular light) for seedling establishment.

Therefore, mapping where natural regeneration is already viable is essential to identify if and where silvicultural interventions are needed to bridge potential migration lags. This project addresses this challenge for the forests of the **3rd Forest District** of the **Canton of Vaud**, an area spanning an elevation gradient from 372 to 3,210 m a.s.l.





Key data

- **2 individual tree inventories** (2013-2015 and 2022-2023), collected on 1 point/ha, recording species, hectare location and Diameter at Breast Height (DBH) of **155,311 trees**
- **6,933 ha** of forest assessed
- **14** target tree **species**

2 The objective

To develop a **Decision Support System** (DSS) to help forest managers map the **natural regeneration potential** of climate-resilient tree species — both under current conditions and in the near future — and to determine **where** and **what type** of **silvicultural interventions** are needed to ensure forest adaptation to shifting habitats.

Current situation for maple

Near-future scenario (~2050) for maple

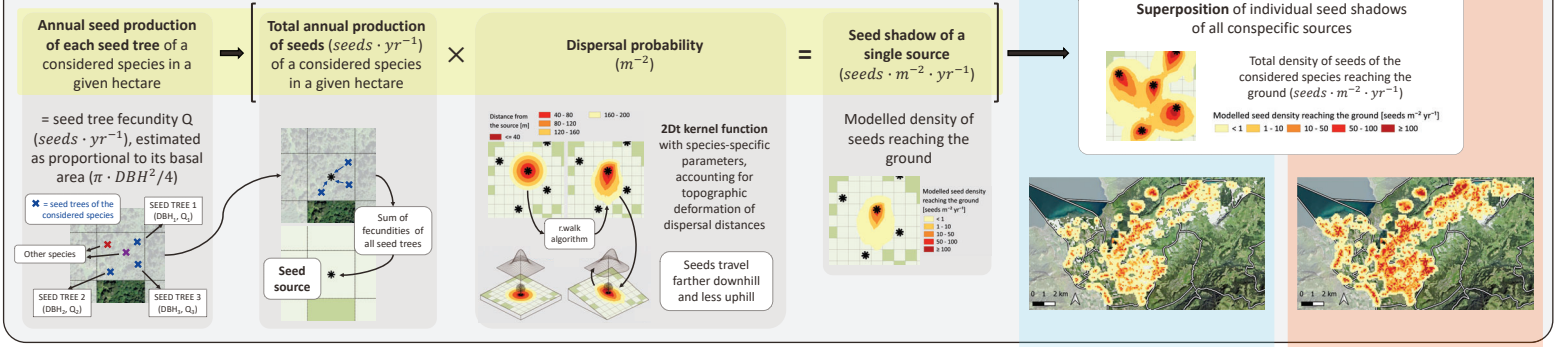
3 Location and density of seed trees

Based on its DBH, each tree was classified as a current or a future seed tree.

- **Current seed trees** = mature trees already producing seeds (DBH ≥ 30 cm)
- **Future seed trees** = trees not yet mature but expected to start producing seeds within 20-30 years (10 cm ≤ DBH < 30 cm)

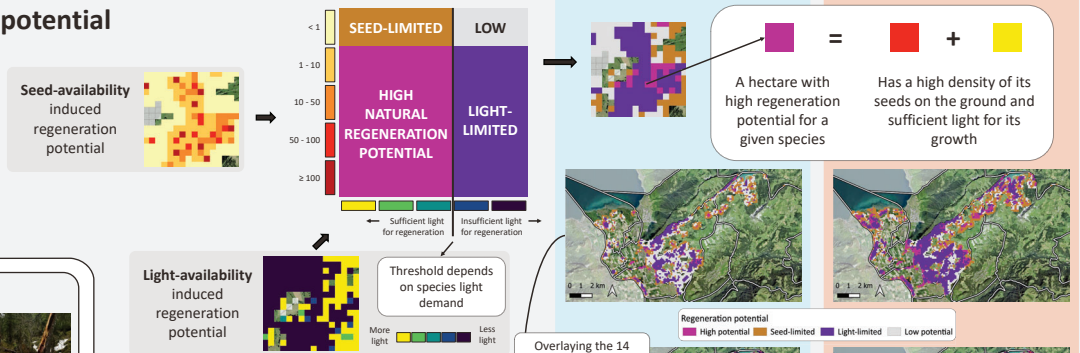
14 species-specific maps of seed tree density per hectare were produced considering two scenarios.

4 Modelling of species-specific seed dispersal



5 Mapping of natural regeneration potential

- Seed availability is only the first condition required for natural regeneration. Once a seed reaches the ground, **seedling establishment** depends on **additional environmental factors**
- The most critical factor is **light availability**
- **Light-induced regeneration potential** modelled by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) was combined with species-specific seed availability maps to obtain a final regeneration potential map for each of the 14 target species

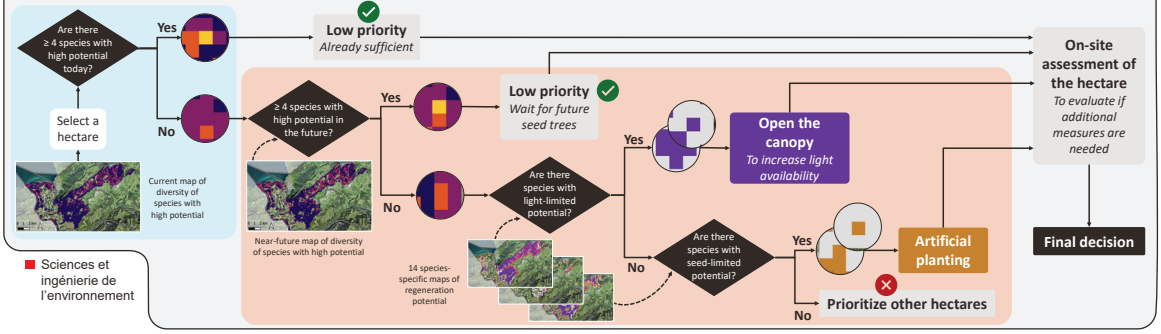


- Since the **natural adaptation** of the forest requires a **high diversity of species with high regeneration potential**, the 14 species-specific maps were overlaid to assess the number of species with high potential per hectare
- Where < 4 target species show high regeneration potential, silvicultural interventions (e.g. canopy opening, artificial planting) are recommended to support forest transition

6 Field validation of the model

- **Additional unmodelled factors** such as wildlife pressure (**browsing**) and **bramble competition** can limit seedling establishment even in hectares with high regeneration potential
- **On-site assessment** is necessary to evaluate the need for **additional measures** (such as browsing protection)

7 Final result: practical use of the DSS from maps to interventions



Sciences et ingénierie de l'environnement

8 Conclusions

- The DSS maps the natural regeneration potential of 14 target tree species under current and near-future conditions across the 3rd Forest District
- Combining seed dispersal modelling with WSL's light-induced regeneration potential provides a spatially explicit tool to identify where and what type of silvicultural interventions are needed
- Field validation showed that on-site assessment remains necessary to account for unmodelled factors, and to evaluate the need for additional measures
- The DSS represents a practical decision-support tool for forest managers to prioritize interventions and bridge potential migration lags of climate-resilient species