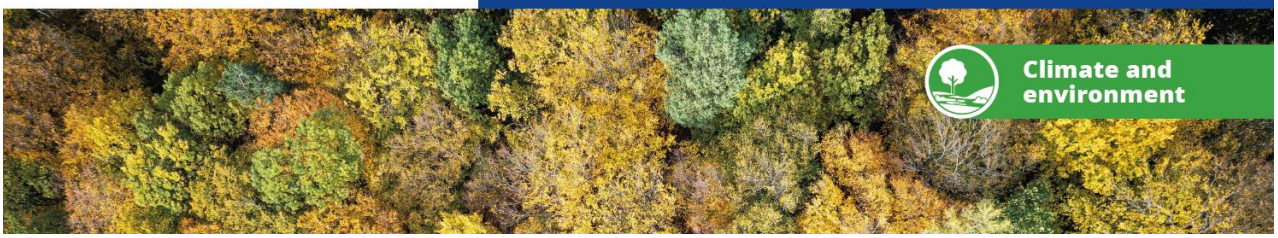
Interreg Co-funded by the European Union
North-West Europe
MigFoRest

Implementing assisted migration to increase forest resilience in North-West Europe.



MigFoRest

Work package 3

A.3.1 Sharing of experience and knowledge between forest owners/managers and nurserymen from the N and S of Europe

Report from study visit to the South of France (D. 3.1.2)

April 2025

Version	Date	Created or modified by
V1	09/04/2025	LBI, MLT, OFS
V2	24/04/2025	DDT
V3	05/05/2025	ADO, AVK, SBE

1. Program of the 2-days study visit

The six MigFoRest partners invited key stakeholders of the forest sector, namely forest managers (public and private), nurserymen and researchers in forest genetics, to learn from the experience of their peers from the South.

The study visit was an opportunity to see on the field how "southern" species which are part of the MigFoRest's selection for assisted migration are grown, from the seed orchards (collection) to the nursery (where the plantlets are grown) to young forest stands in the area. For instance, the participants learnt on specificities related to pubescent oak (*Quercus pubescens),* Greek fir (*Abies cephalonica)* or service tree *(Sorbus domestica),* which are all part of the MigFoRest selection.

March 31: (for most participants) travel and arrival in hotel in the Manosque area
April 1:
• 8:30 to 9am: meeting point and welcome in Cadarache
• 9am: general presentation on MigFoRest project and assisted migration

• 10:30 to 1pm: visit of the Office National des Forêts' experimental nursery in Cadarache, which is one the three major centres for forest genetic resources in France.
The study of the trees' ability to adapt to climate change is part of its key fields of expertise.
Two alternating tours led by ONF experts:
  • 1 focusing on the nursery's know-how with hydric stress testing
  • 1 focusing on experience with *Abies,* comparing pure native and hybrid genetic sources

• 1pm to 2pm: sandwich lunch break
• 2 to 4:30pm: visit of pubescent oak stand in the Cadarache domanial forest, managed by ONF. Explanation on specific needs, challenges and opportunities related to *Quercus pubescens*.
• 4:30pm to 7pm: travel to Salon-de-Provence area and accommodation
• 7 to 9pm: group dinner
April 2:
• 9 to 11 am: visit of Naudet private nursery in Lambesc, a reference in Mediterranean species. Naudet is one of the leading family-led nurseries in France. Discovering the realities of large-scale production of seedlings across a wide variety of species.
• 11 to 12 am: travel (1 hour driving) to Lioux (near the Southern slopes of the Ventoux).
• 12am to 1 pm: sandwich lunch break
• 1 to 3 pm: visit of Greek fir *(Abies cephalonica)* seed orchard in Lioux (Saint-Lambert woods)
• 3 pm: end of formal program

2. Participants

The group included 31 participants from Belgium, France, Germany and the Netherlands, representing a large variety of profiles and functions.

Lola Badalamenti	Project manager SRFB
Silvija Bilela-Eckert	Researcher FVA
Aurélien Blond	Head of development and innovation NEOSYLVA
Lucie Bouchereau	Public forest manager ONF
Johanna Chaillié	Researcher Bavarian Office for Forest Genetics (AWG)
Jan Coussement	Nursery manager Sylva - Van Hulle
Annelore De Ro	Researcher INBO
Sophie Dufour	Researcher CRA-W
Olivier Fabes	Communication officer SRFB
Guillaume Galet	Private forest manager UniSylva
Axel Huber	Public forest manager Regional Council Baden-Württemberg (RPF)
Rita Janssens	Nursery manager Op de Beeck
Manuel Karopka	Head of the nursery FVA
Maxime Lambinet	Project manager SRFB
Maxime Lantin	Scientific collaborator (CRA-W)
Bénédicte Le Guerroue	Public forest manager ONF
Olivier Leflon	Public forest manager ONF
David Mathy	Researcher CRA-W
Cédric Mimran	Project manager NEOSYLVA
Arjan Mostert	Public forest manager Staatsbosbeheer The Netherlands
Brigitte Musch	National coordinator forest genetic resources ONF
Charalambos Neophytou	Researcher FVA
Thierry Op de Beeck	Nursery manager Op de Beeck
Nathalie Peclers	Scientific collaborator (CRA-W)
Alexandra Robin	Nursery manager Pépinières Robin
Angelica Robin	Nursery manager Pépinières Robin
Rainer Schmid	Public forest manager Regional Council Baden-Württemberg (RPF)
Eléonore Scholzen	Public forest manager (SPW/comptoir forestier)
An Vanden Broeck	Researcher INBO
Johan Verswijvel	Scientific collaborator (CRA-W)

Two **interpretors**, one translating from French to English and one from French to German, were also present to ensure a full translation of the explanations for the visitors who were not speaking French.



3. General project presentation

Before moving to the actual site visits, the program started with a seated presentation on assisted migration in the context of the MigFoRest project:

- Objectives
- Pilot territories
- Risks and opportunities
- Species and provenances
- Planting methods
- Zooms on chosen territory specificities
    - Flanders
    - Northern France
    - Baden-Württemberg
    - Wallonia

4. Visit of the ONF experimental nursery in Cadarache

The visit was organized in two alternating groups to favour interactions and give the opportunity to ask questions.



Introducing the Cadarache nursery

The ONF has three experimental nurseries: Cadarache, Perrat-Le-Château and Guémené-Penfao.

Cadarache is dedicated to conservation, as well as experimentation. Given it is an experimental nursery, production is done manually (no automation).

The aim is not to produce seedlings for classic replanting, but to carry out various tests that can be used to help private nurserymen produce seedlings and build up collections. The Cadarache nursery carries out various experiments on drought tolerance of both deciduous and coniferous species, mainly on species considered to be more tolerant.

One of the more specific projects concerns the conservation of the Salzmann pine. This species is resistant to both drought and frost (withstanding late frost) and red band disease. It is found in the Tarn gorges above Montpellier, in the Pyrenees, which are difficult to access for seed harvesting. A conservatory collection was therefore put together, and from this collection, they recreated a seed orchard that contains 697 clones.

Another research theme concerns the drought resistance of Atlas cedar.

Techniques and tools

Containers for growing seeds

The Cadarache nurserymen work with different container sizes depending on the species and the duration of rearing in the nursery, from 200 to 400 cm^3 in plates but also an WM bucket system (like the W and M letters imbricating in each other) created by INRAe, in two parts that fit together. The pot can be opened and closed back to check on the rooting. It also promotes vertical rooting without creating a bun in the roots. The other advantage is the space saving since the buckets can be staggered together. These containers are then placed in plastic crates. The bottom of the buckets is open to allow better aeration, better drainage and root encirclement (roots that come into contact with the air stop growing).



Containers for grafting

The grafted plants are transplanted into 1.4L pots for a year before being transferred to large, perforated baskets, where they can stay 2 to 3 years.

Their final destinations are either seed orchards or conservation purposes (a good example is the work done on the Salzmann pine).

Substrate

The substrate used is a mixture of 50% blond peat, 50% sieved bark. This mixture is favourable for almost all species. Perlite is not added, but a retardant fertilizer or other additions can be made upon need. The substrate components are mixed in a machine. The pots are filled manually on a vibrating table.

Some damages from Otiorhynchus sp., which is a small beetle that preys on all species and eats roots were observed. Recently, the kM52 seeds were used against this pest as that kill their larvae. Treatments are also used against nematodes.

Greenhouses

Eight greenhouses are fully automated in terms of watering, ventilation, insect screens and heating (only used to protect frost). Rails on the floor allow the cultivation tables to be moved.

A sand layer is on top of the containers to prevent premature germination of small seeds, regulates temperature and reduces weed growth.

The plants are elevated to allow air circulation, which promotes self-pruning, preventing root spiralling. As said above, the WM containers are also designed to prevent this.

Tables

The cultivation tables are made of a metal mesh surrounded by a frame to place the trays with the buckets on top, they are at hips hight for better ergonomics. The legs are equipped with wheels that allow the tables to be moved in rails in and out the greenhouse.



The lab

The seeds are stored in a cold storage room for preservation.

Types of seeds and processing

The seeds can be of two types:

Dry seeds (*Pinus halepensis, Pinus pinea, Cupressus sempervirens*)	**Stratified seeds** (*Cedrus sp., Abies sp., Sorbus domestica*)

• multiple seeds planted per container, which can lead to multiple seedlings to cut or transplant later.	• only one germinated seed placed per container, as it is expected to grow one seedling.
	It is time-consuming at first but saves time later.
	• additional processing:
	After soaking, they are mixed with finely sieved moist peat (too much moisture causes rot, too little dries them out).
	• warm/cold treatment:
	  • Immersion in 90°C hot water
	  • Immediate cold shock
	  • Alternatively, a hot iron can be applied to each seed.
	This processus mimics the effect of fire, which seeds need to germinate.
	This process is like how birds digest and expel seeds - they require this transformation to germinate.

All seeds must go through a 24h to 48h soaking process to absorb water and activate germination, which replicates natural conditions.

Exception: *Cupressus* seeds are too small and do not require soaking.

On average, germination takes 4 to 6 weeks, but this timeframe is highly variable. Since germination is not an exact science, these estimates must be used cautiously.
Some species require even longer, such as *Pinus peuce* that can take up to 8 months.

This highlights the role of experimental nurseries, which expand knowledge by testing lesser-known species.

Each seed batch has a tracking number, ensuring full traceability from reception to field planting. In case of a sanitary problem, these seedlings can easily be tracked.



Hydric stress testing

Three species of oak renowned for their resistance to hydric stress: the holm oak – *Quercus ilex*, the pubescent oak – *Quercus pubescens* and the zean oak – *Quercus canariensis* are tested for drought resistance in the greenhouses.

Eight hundred plants per species are used, they are surrounded by cedars that serve as a screen and buffer, which prevent the plants from drying out on the periphery. Each plant is labelled accurately. All the pots are saturated with water to have the reference of 100% watering, then the plants are divided into 3 groups: one group that receives 80% of the watering, the second 60% and the last 40%. Buffer zones with plants that do not participate in the test have been installed between each group, to avoid distorting the results with the robot that carries out the automatic sprinkler watering. The test began at the beginning of March, the effects are not yet visible begin April but by the end of April, the effects of the drought will be visible on the 40% watering group. Such a test lasts 6 months.

Each plant is monitored in terms of its growth in height, diameter and bud break.

Currently, only species are compared and assessed, not provenances.

The aim of these hydric stress tests is to classify species at the juvenile stage in relation to bud break and to advise forest managers.

Comparing hybrid and native firs (*Abies)*

There are two fir tests in the greenhouse:

1. INRAE hybrid fir trials.
2. CNPF fir trials (*Abies cephalonica, A. bornmuelleriana, A. nordmanniana)* to test how they will react, in terms of productivity, in a seed orchard.

Normally, the stress effect test starts in March, but the issue with fir trees is that some have already budded while others have not. So, if they are all placed in stratification at the same time, their behaviour remains unpredictable. ONF is therefore considering conducting shorter stress tests in the summer to ensure that all trees are on equal footing.



5. Visit of pubescent oak stand in the Cadarache domanial forest

Harvest methods

Three different harvest methods can be used for oak:

Method	Advantages	Disadvantages
Climbing: climbers drop acorns onto nets on the ground.	Fresh acorns, good quality	Requires harvesting at the exact right time (3-4 days after “the purge” = fall of the bad-quality acorns) Expensive

Nets: placing nets on the ground and wait for the acorns to fall (just after the purge)	Large quantities harvested	Requires a "clean" floor to place the nets (vegetation grinding before harvest) Predation by boars, squirrels, small mammals…
Manual collection on the ground	Only good quality acorns are collected (not sprouted, no grubs)	Requires many workers and enough acorns to keep them working, time-consuming

Harvest period depends on the year (mid-September to mid-October). In case of rain, acorns sprout quickly, requiring to be responsive and to send them quickly to the drying facility.

Pre-harvest surveys are carried out during flowering (spot future acorns), then in August (confirm their formation and quantity). Fruiting frequency for pubescent oak: 1-7 years (masting: abundant, recurrent fruiting). Prospection seeks to identify different stands from different areas in a given region, promoting genetic mixing.

Seed production and seed stands

Foresters' hypothesis is that stress increases fruiting frequency (e.g., for Douglas fir: seed orchard trees are partly annulated in to increase fruiting). However, trees allocate their resources either to survival or reproduction. In case of excessive stress and low energy, it is unlikely that they invest in reproduction. Nevertheless, cold could explain the current spacing between masting events (up to 10-12 years in the East of France); thus, warmer climate could increase fruiting frequency. One might wonder where to install seed orchards to maximize seed production and adaptation to climate (epigenetic effects: trees living in dry conditions could produce more adapted seeds but in smaller quantities).

Definition of selected stands in France is planned, based on different criteria: purity, trees quality, seed production… CONQueTh project (CNPF) aimed at identifying such stands in the North of France (Loire valley). Based on selected stands, seed orchards can be established, from a minimum of 100 trees. In France, seed orchards are made up of trees from all over the country, not only from the region (genetic diversity).

Hybridization

Planting pubescent oak in the north presents a double benefit: on the one hand, enrichment increases forest diversity and resilience. On the other hand, hybridization may occur between species from the same complex. However, there is a preferential direction in hybridization: for example, sessile oak pollinates pubescent oak, the opposite is rare.

Hybridization is a controversial topic and is sometimes considered as a risk, particularly for firs. Oaks have been studied for a long time mainly by evolutionary genetics researchers. It has been shown that hybridization allowed oaks to maintain a large genetic diversity and is seen as something positive. There were less studies regarding firs, and those were mainly carried out by conservation genetics researchers. Different oaks are present in France, with overlapping distribution areas; this is not the case for firs. However, in Greece, *Abies cephalonica* is present in the South, *Abies alba* in the North, with a hybrid species (*Abies borisii-regis*) between the two; hybridization is not seen as a problem.



6. Visit of Naudet private nursery in Lambesc

Naudet's facility in Lambesc covers an area of 5 ha, with a production capacity of 2.5M plug plants (mainly forestry plants, some ornamentals).

Plug plants are produced either from 1-year bare-root seedlings which are then transplanted into containers, or from seeds sown directly in the bucket. The choice depends mainly on the species and the desire to stagger production over time, as not all species produce seed every year. For example, cedar can be sown directly in the container and produced in one year (S1) or sown in open ground before being transplanted for one more year in a container (1+1).

Dry seeds

Dry seeds (sown unsprouted) sowing in containers is done by a machine, with a production rate of 10,000 to 15,000 plants a day. In general, two seeds are sown in each container; a single seedling is then kept if both germinated. A thin layer of sand is placed on top of the soil after sowing; this prevents small seeds from being blocked by the crust that can form at the surface of the soil. Larger seeds (acorns, chestnuts) are sown manually.

Stratified seeds

Some species (cedar, maple…) require stratification to ensure gemination before being sown. Stratification consists in placing seeds in humid, cold (fridge) or warm (radiator, greenhouse) conditions; it may also involve soaking in hot water. It usually takes one season but may be longer for some species (2 years for holly, 2-4 years for juniper). Stratified seeds are controlled regularly. Sprouted seeds are sorted manually before being sown in small plugs. Once the seedlings have grown sufficiently, they are transplanted in their final container. This represents a considerable amount of work, but it ensures an even germination for the most complex species and remains attractive given the price of seeds. Due to the heterogeneity of seed lots, this operation cannot be automated.

Chemical treatments

There are very few chemical treatments, and preventive treatments are biocontrol (Bordeaux mixture...). Chemical treatments are only carried out in the event of major attacks threatening seedlings vitality. A small amount of sprout inhibitor is used, but most weeding is done by hand.



7. Visit of Greek fir *(Abies cephalonica)* seed orchard in Lioux (Saint-Lambert woods)

The *Abies cephalonica* seed orchard in France was planted by INRAe in 1979, originally for a test to compare provenances.

The Saint-Lambert woods (on the Southern slopes of the Mont Ventoux) receive on average 900mm of rain per year. Average temperature is 15,4°C.

Usually, seed orchards are based on a selection of remarkable trees in the forest or from breeding crosses. In this case, as the initial goal was to test and compare provenances, the managers know exactly what the clone is, where it comes from, and what data is collected about its growth, shape, etc. at 15 and 25 years of age.

Selective thinning is carried out by keeping only the best individuals and with a broad genetic diversity.

The Greek fir originates from Cephalonia Island, Euboea Island and several mountain areas in continental Greece.

The 3646 individual clones for this 4ha large Greek fir orchard come from the best provenances in Peloponnese and southern continental Greece.

The peripheral area of the orchard is not harvested, it serves as a buffer and barrier to the pollination of other fir trees that may be in the area, but it participates in the pollination of the central area (1684 clones).

Fruiting peaks occur every 3 to 4 years.

Why is the Greek fir interesting?

The Greek fir is more drought resistant than the silver fir, but less resistant to frost. It has prickly needles, so deer does not eat it, which is another advantage compared to the silver fir. In terms of shape, the same criteria as for the *Abies alba* (no fork or torso fibre, good straightness etc.) are considered. It can be planted above 600 m in the Mediterranean area and above 300m in the Massif Central and the Vosges. Such species can hybridize with other fir trees.

The productivity of these Greek firs in terms of wood volumes has not been evaluated. Vigorous and upright (no repeated forks), these fir trees over 45 years old can seem small for their age, due to the poverty of the soil. Planted on more fertile soil, the young trees from these seed companies grow better.

