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Conservation of relict and mature forests: towards an integrative approach including genetic diversity

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EUFORGEN

La Région Occitanie Pyrénées - Méditerranée

Mediterranean forests : 25.5 million hectares (FAO/FRA, 2011)

Different types of forests

Increasing complexity in size and tree arrangements in a forest ecosystem

Young forest

Mature forest

Old-growth forest

« primary forests »

Only 386 Km² (0.26 % of the Euro-Mediterranean forest area)

Sabatini et al., 2018, 2020

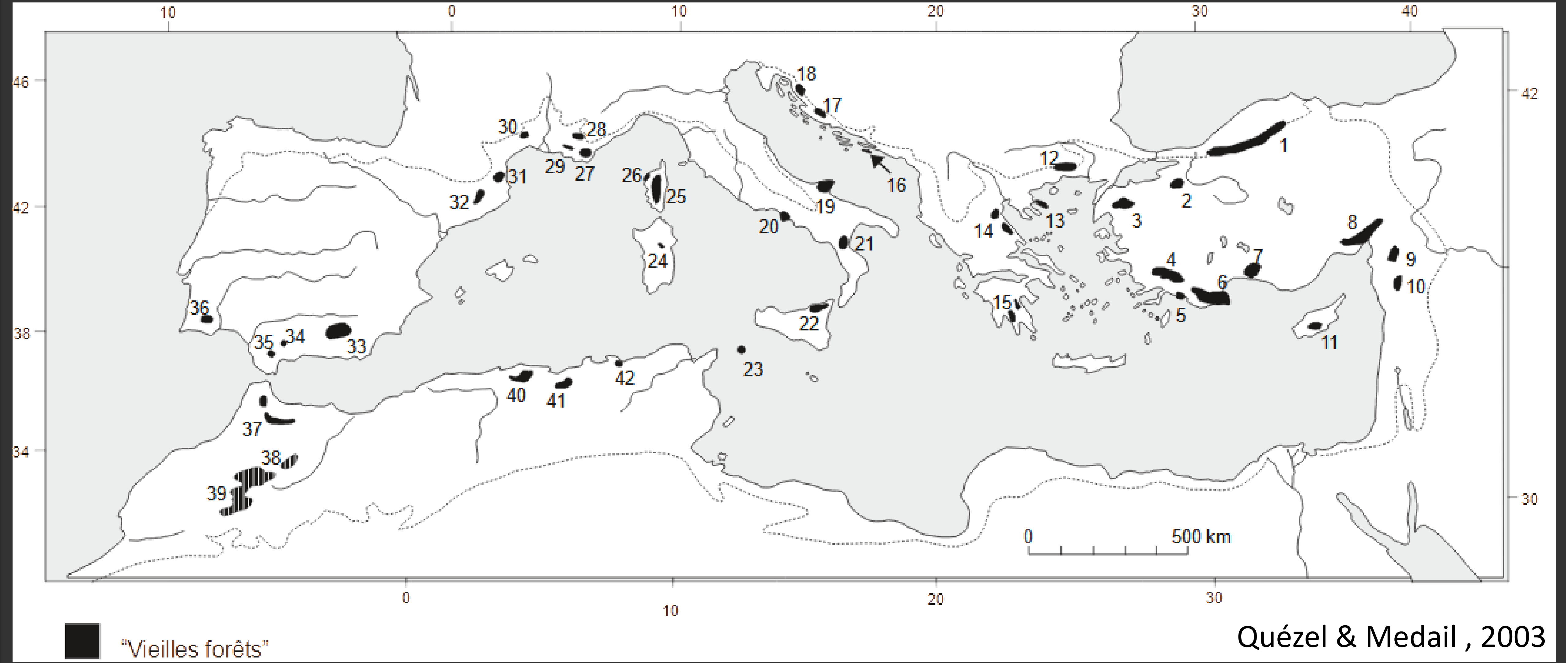
Primary forests are forests resulting from the natural regeneration of native tree species in which there are no visible traces of human activity and whose ecological processes are not significantly affected (FAO, 2015).

- **Difficult** to estimate the actual proportion of protected forest area occupied by old-growth forests. Most have been **deeply and early exploited by man**.
- Some are strongly mature (close to old-growth forest definition) in specific cases such as **sites protected** by religious congregations, sites **in rugged topographic sites** (ravines, gorges, slopes, cliffs)
- Presence of fragmented **relict forests** composed of **old trees** but habitat is often disturbed by humans (and not considered as mature forest or old-growth forest)


Sainte Baume, Beech


Gorges du Tarn,
Salzmann Pine

Probable sites of old-growth forests of the Mediterranean bassin



Quézel & Medail , 2003

Paradox of the Mediterranean forest

Strong impact of human but high level of biodiversity

Mediterranean region : Glacial refuge and endemism

52 phylogeographical refugia
50 % in hotspot of plant diversity

Médail F. & Diadema K., 2009.

Cheikh Albassatneh M. et al., 2021

Example of phylogeographic structure in oak

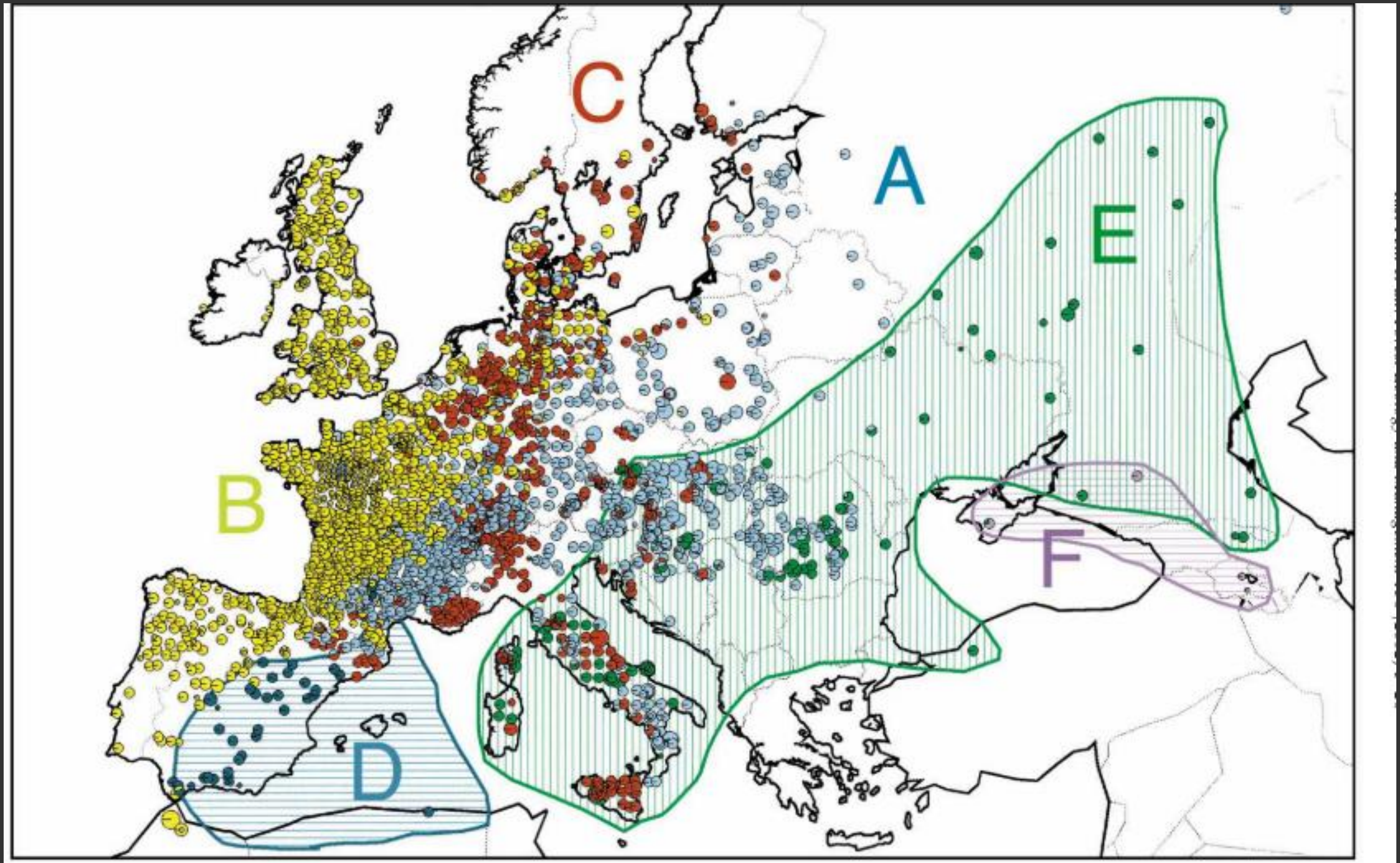


Fig. 3. Map of cpDNA lineages in Europe. The geographic distribution of the six cpDNA lineages identified (A–F) is provided. Different haplotypes belonging to the same lineage were pooled and are represented by the same colour. The limits of distribution for three of the six lineages (D–F) are shown.

Petit et al., 2002

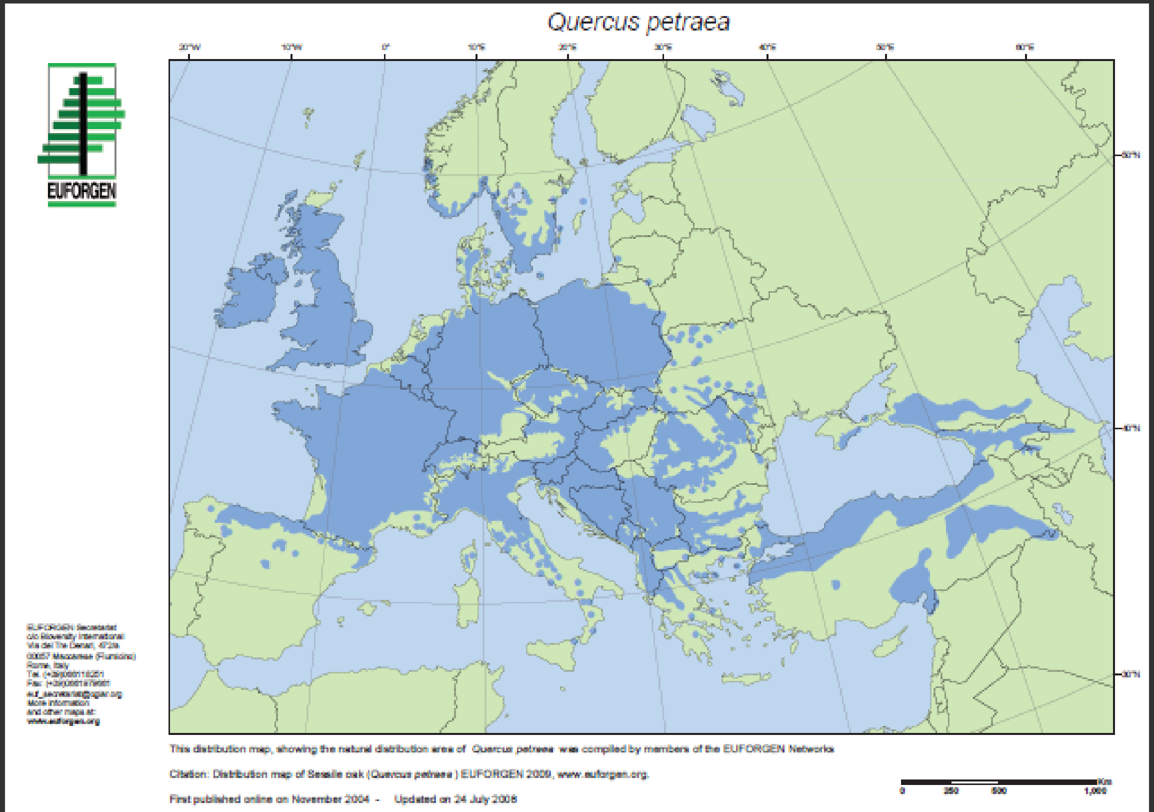
Different scales of adaptation

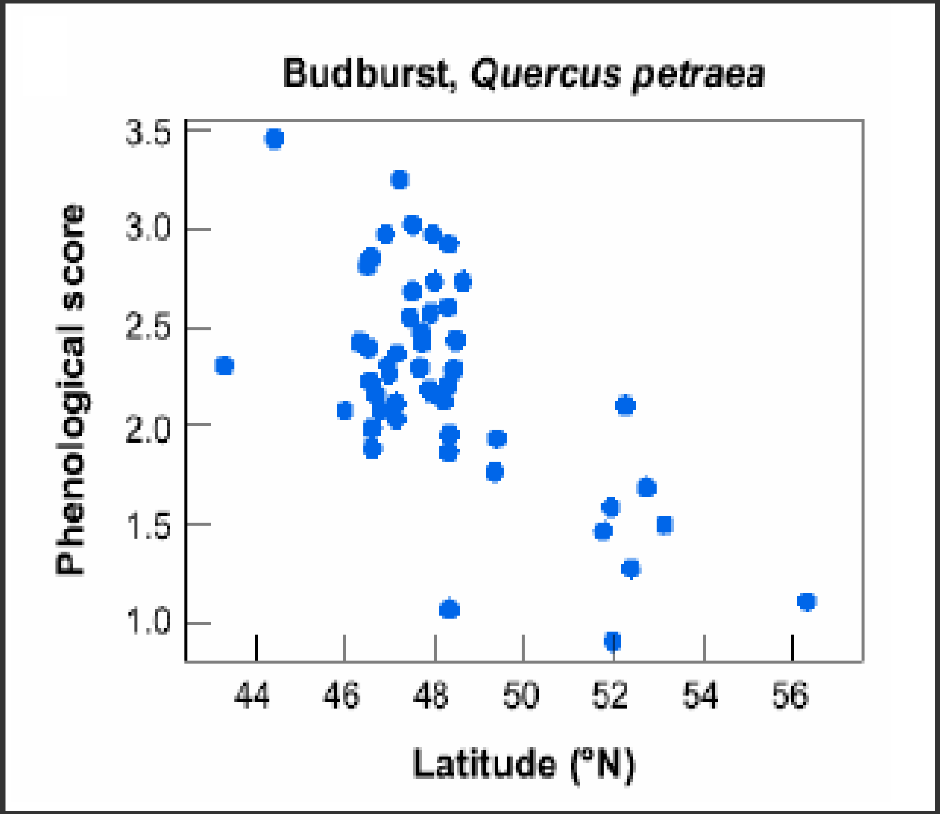
Broad biogeographical scale

Climatic & topographic heterogeneities (mountains, islands)

Micro-habitats

Populations have different adaptive properties in addition to different evolutionary histories

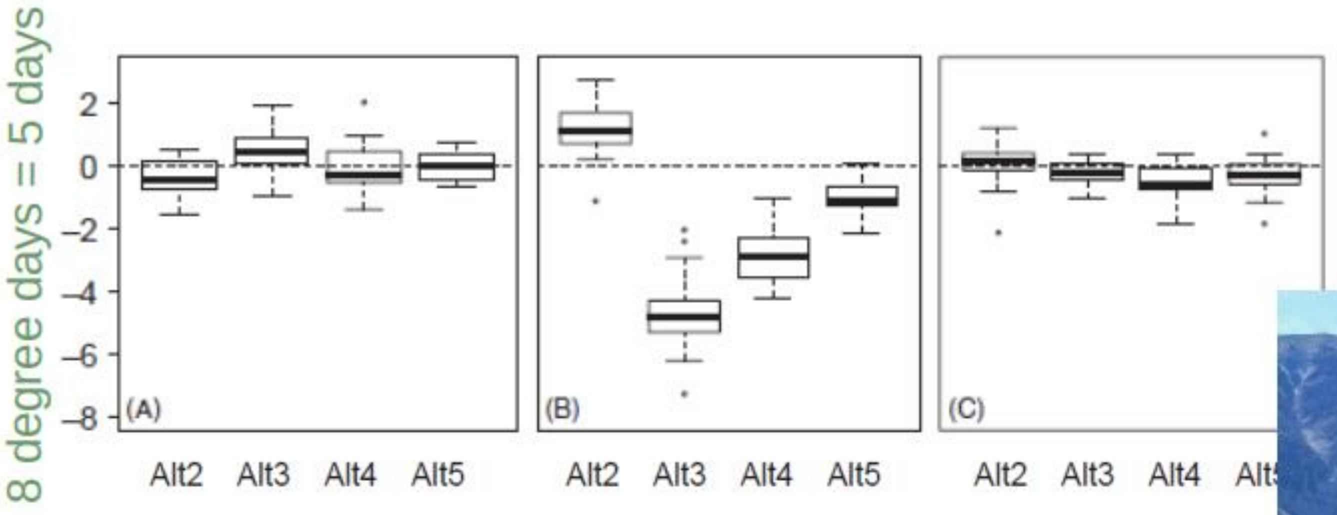




Ducousso et al. (AFS) 1996
For a review :
Savolainen et al. (2007) Ann Rev Evol Evol Syst 38: 595

A strong link between geographic origin and bud break date in the European sessile oak *Q. petraea* (4 common garden experiments)

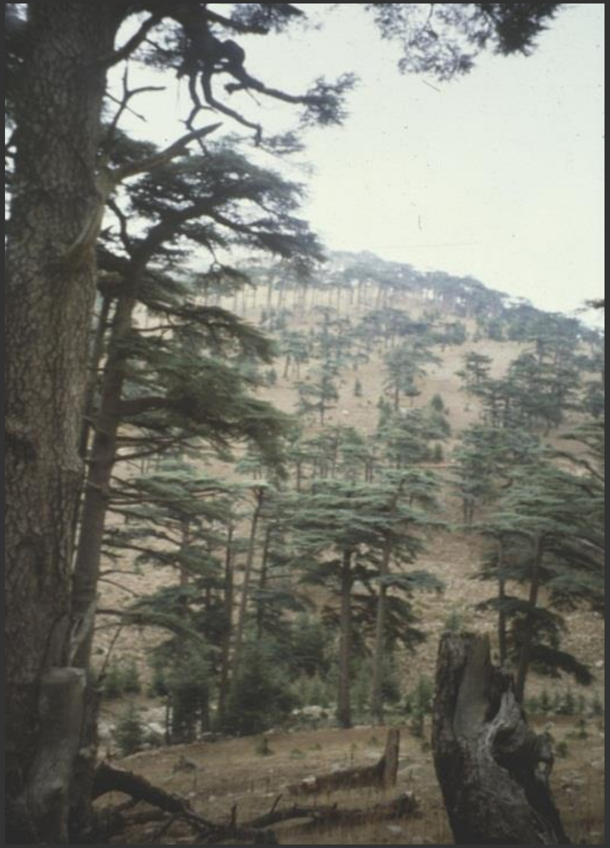
Modeling the rate of adaptive evolution of spring leaf unfolding after **5 generations** along a steep altitudinal gradient (Fagus sylvatica)



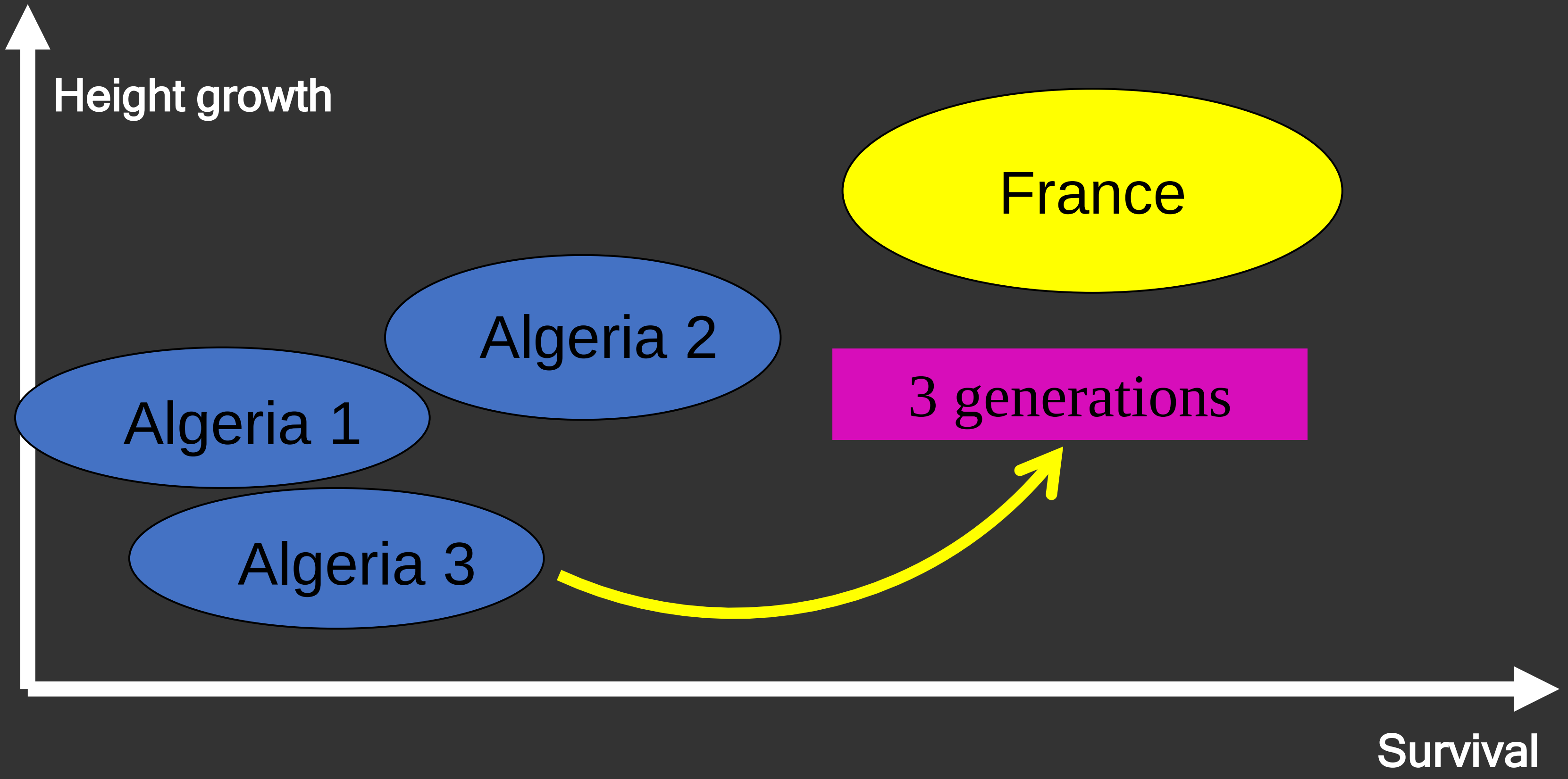
(A): Neutral
(B): adaptive evolution
(C): adaptive evolution without mortality

(Oddou-Muratorio & Davi 2014)

The introduction of cedar to France in the 19th century :
Intense natural selection and gene mixing



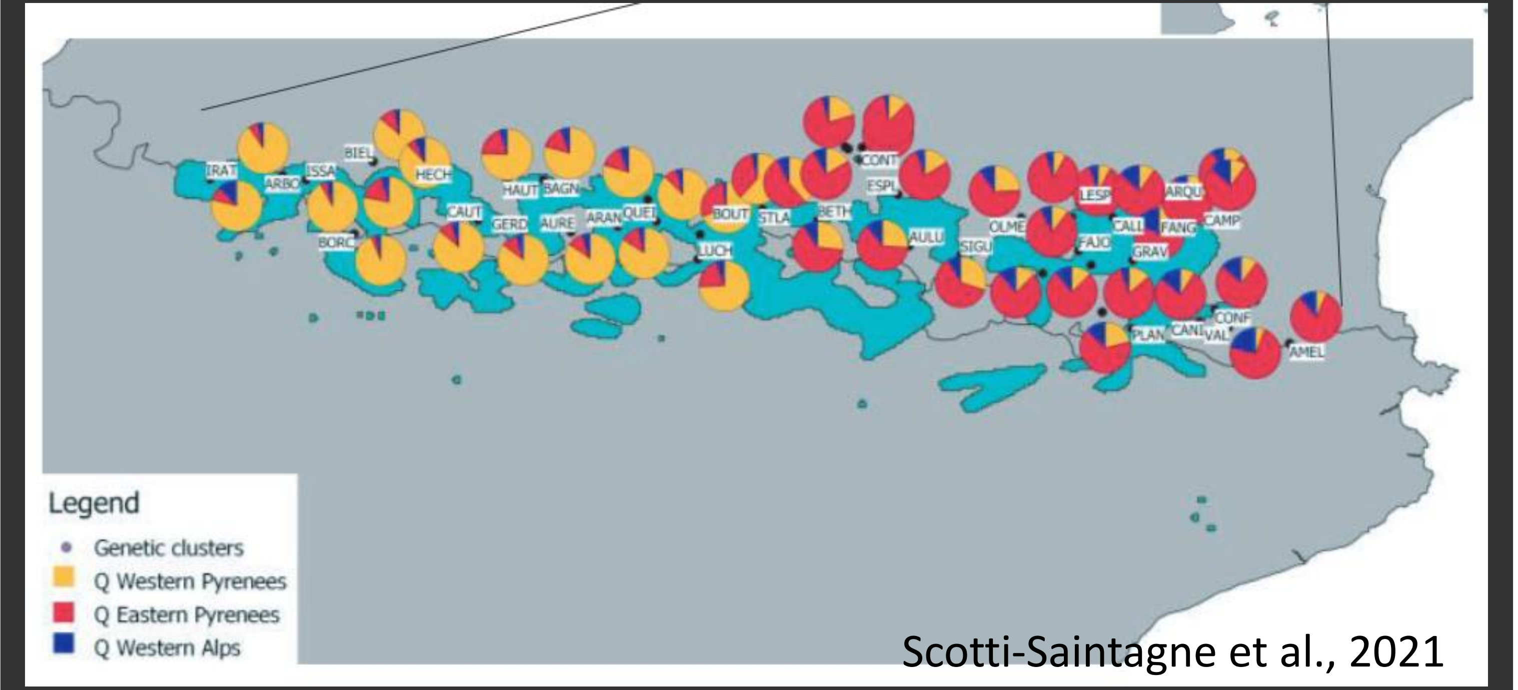
Height and Survival comparisons (common garden)



Cedars are well adapted to their new environment

Lefèvre 2020, Rendez-vous Techniques de l'ONF, 63-64, 51-53

Adaptation in silver fir at the scale of the Pyrenees mountain range



Scotti-Saintagne et al., 2021

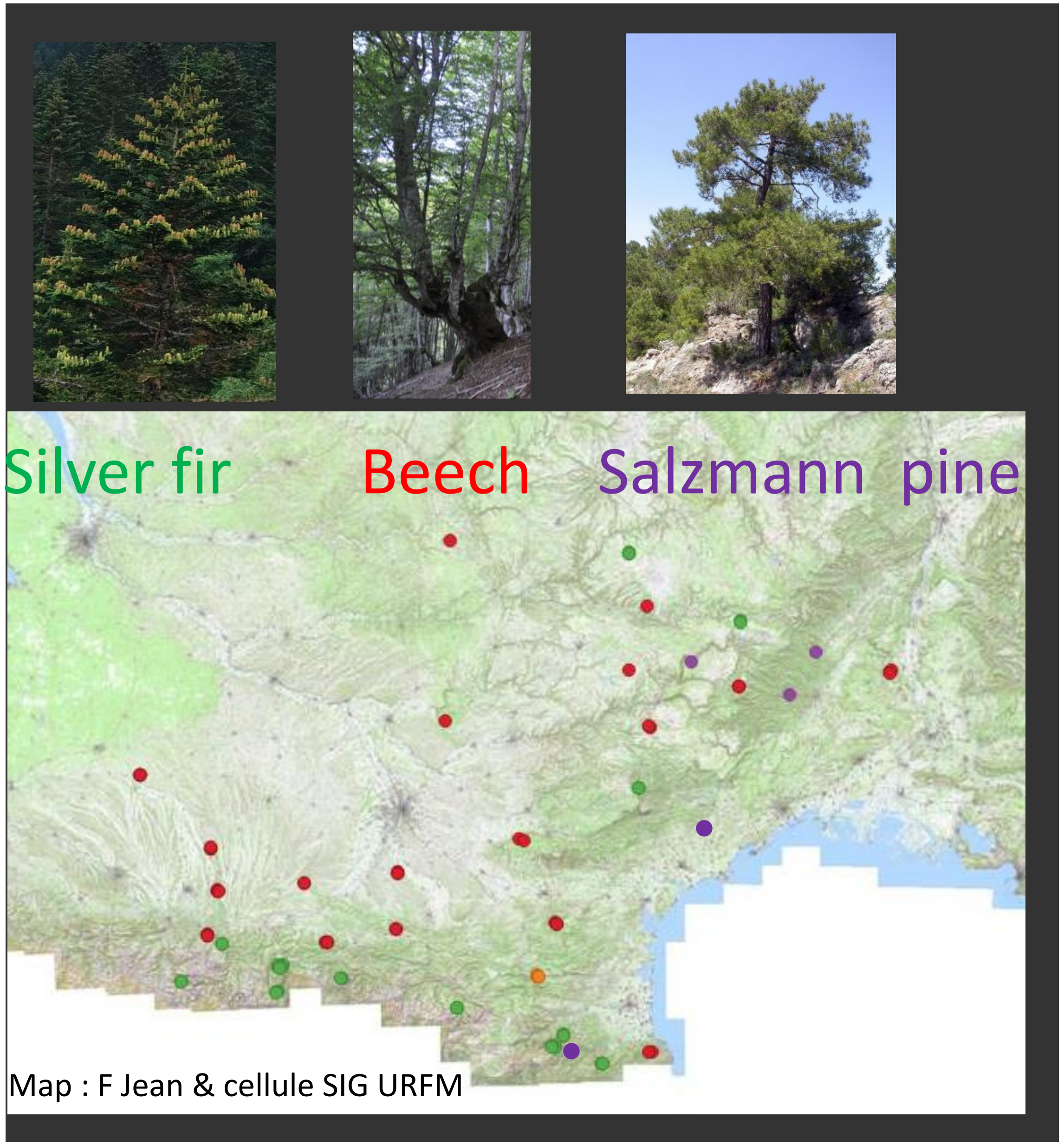
-Different adaptations between the two genetic clusters

-Trade off between growth and drought resistance

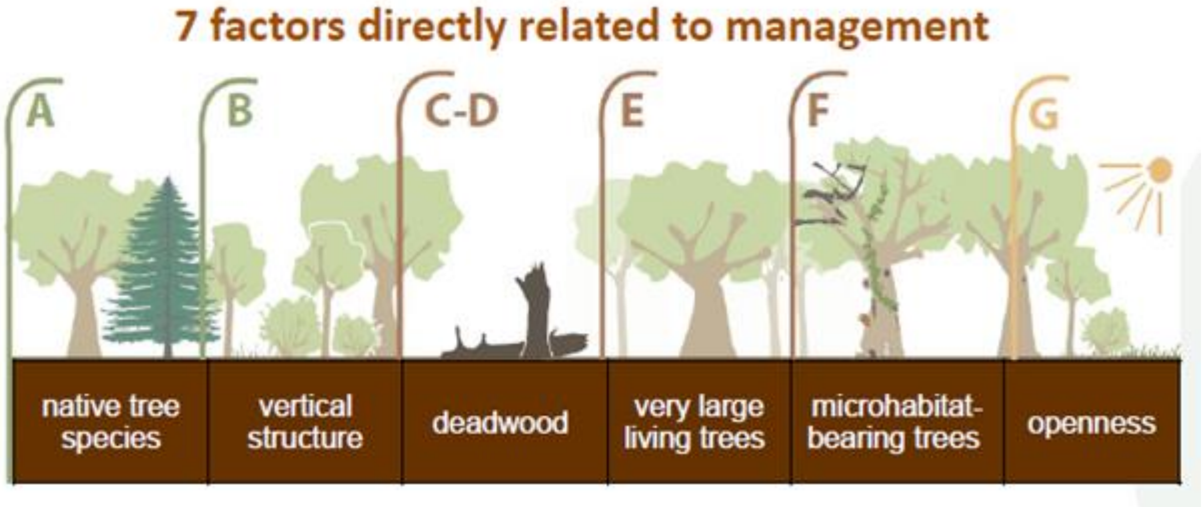
Matías et al. 2016. Tree Physiology 36

Common gardens to test responses to **temperature** and **drough**t in the two genetic clusters

Evaluate the resilience of mature and old-growth forests (OCCIGEN)



Index of Biodiversity Potential (IBP): a proxy for estimating how much biodiversity can be found in a given forest patch



Gonin et al., 2017

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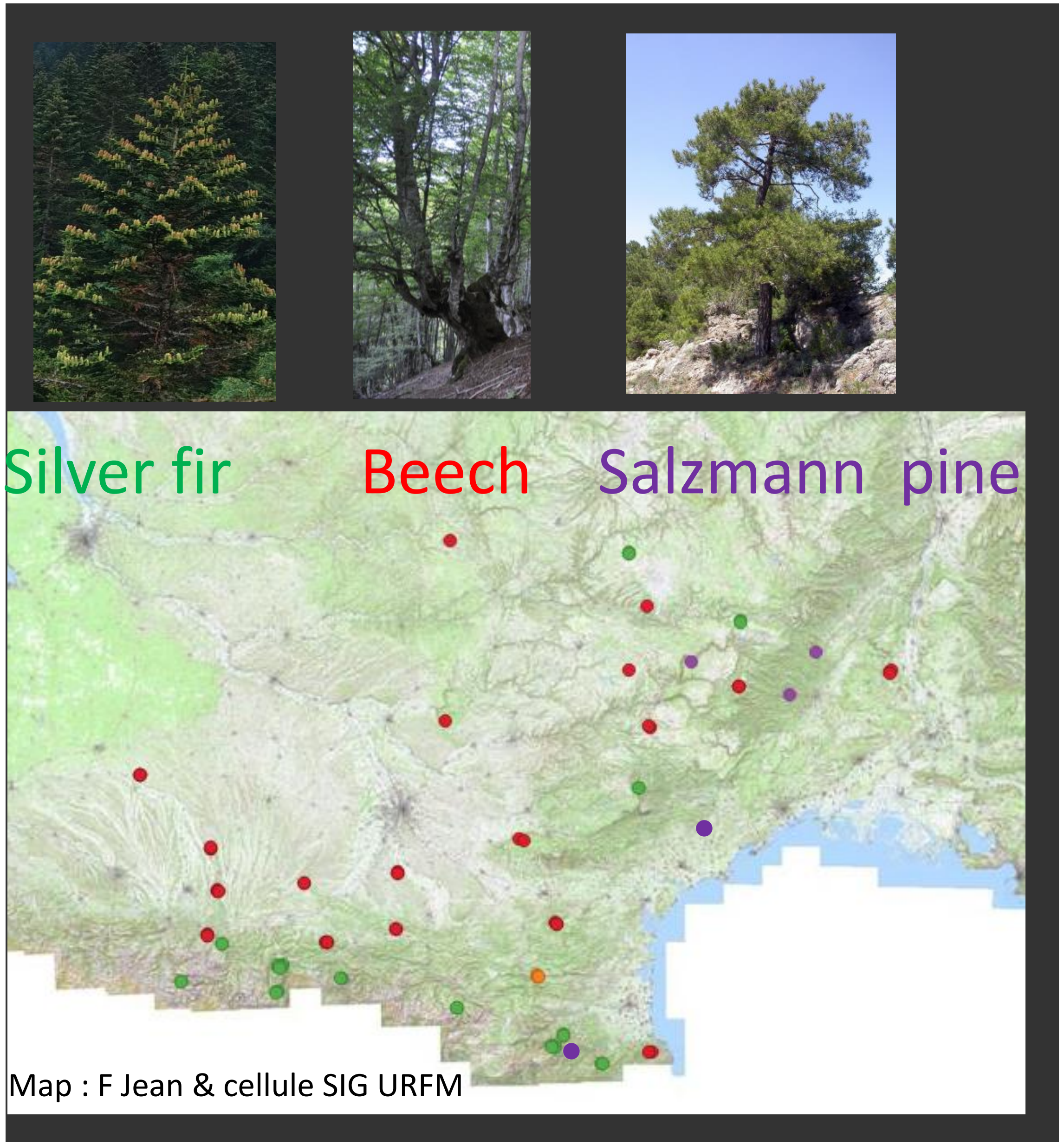
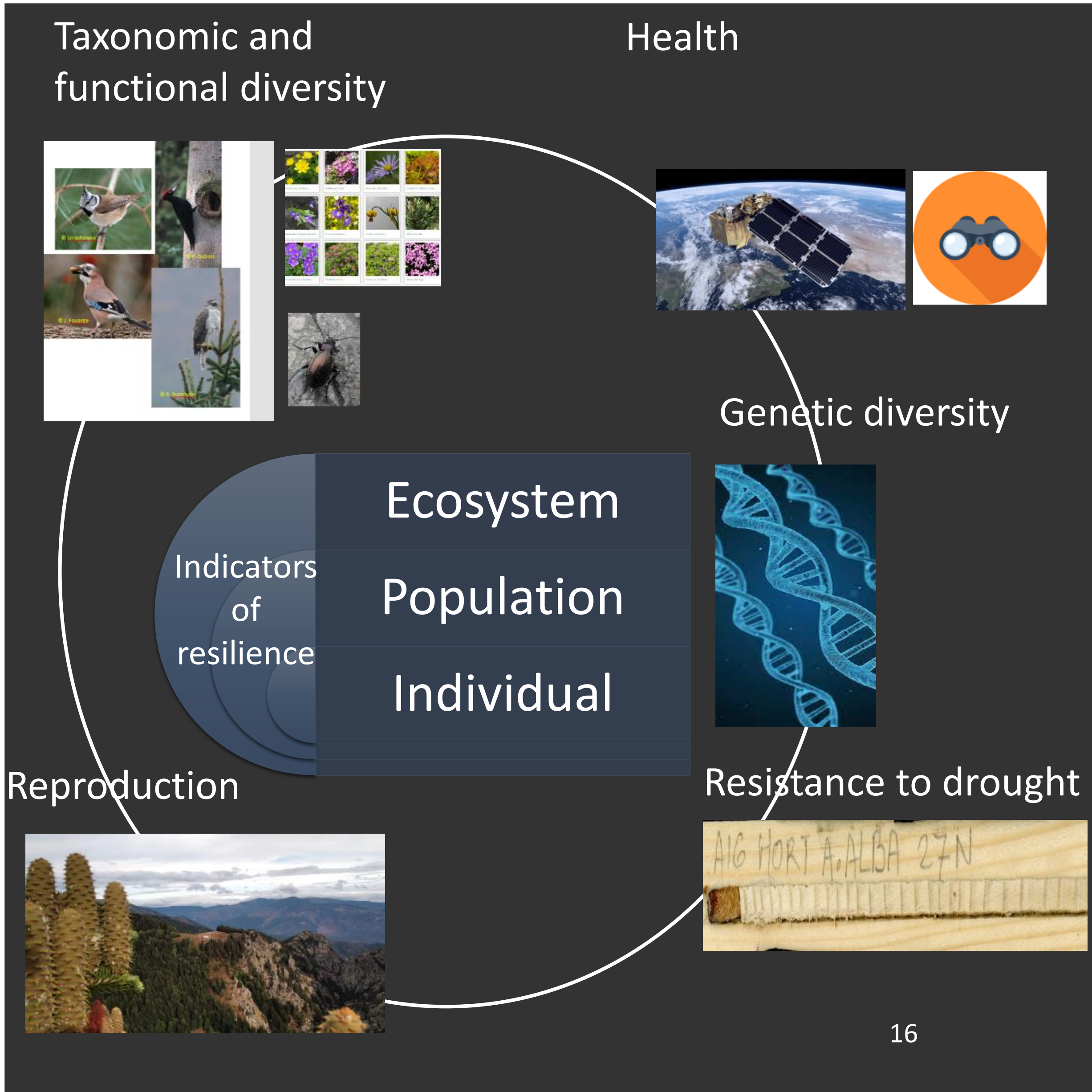
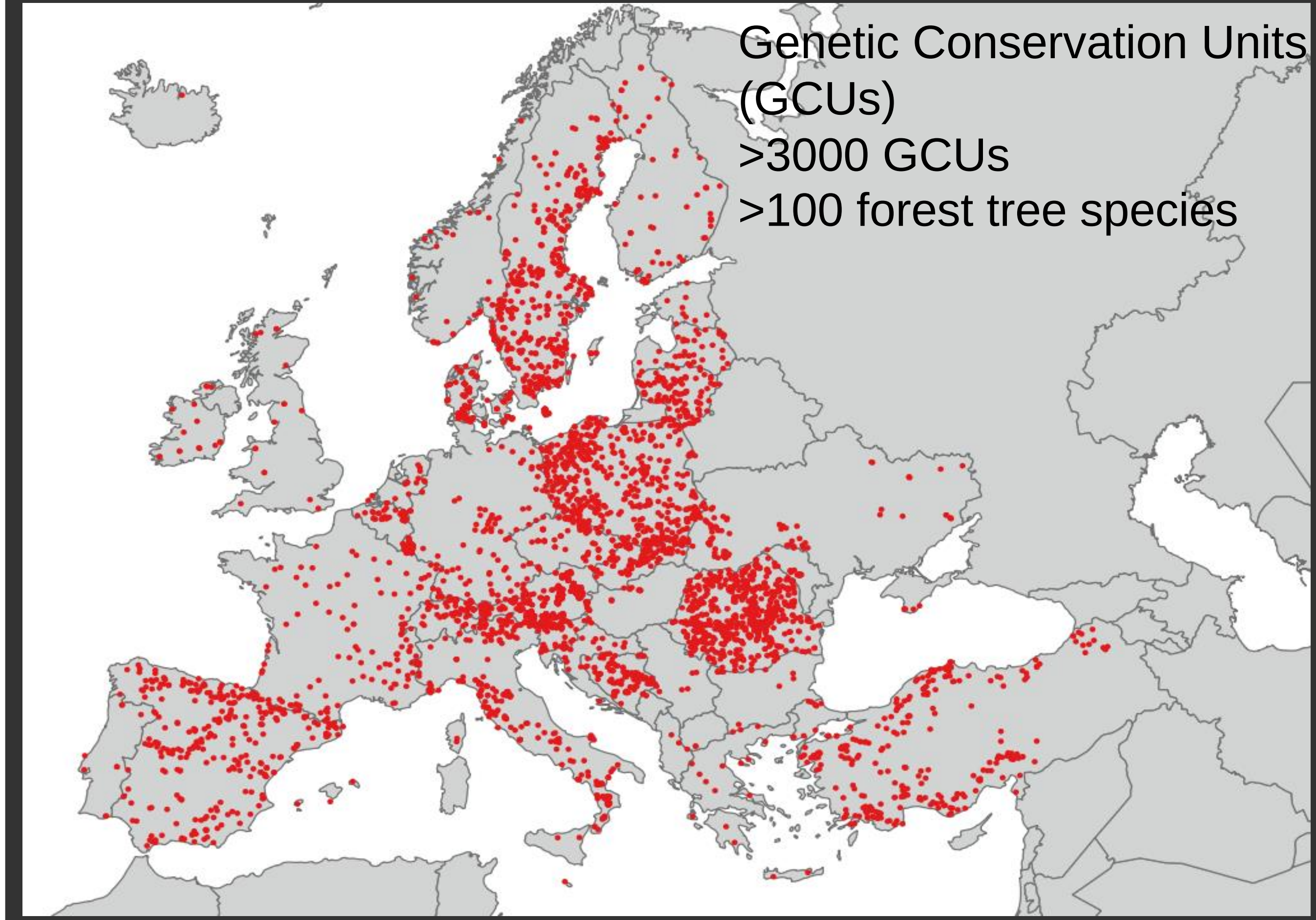


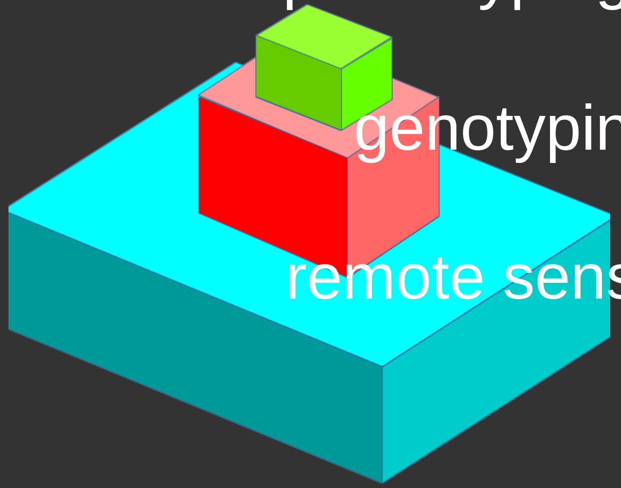


FORGENIUS

Improving access to FORest GENetic Resources Information and Services for End-USers



http://portal.eufgis.org/
(European Information System on Forest Genetic Resources)



https://www.forgenius.eu/

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Conclusions

(1) Rapid local adaptation at short spatial scale is possible along steep ecological gradients.
Conservation planning needs to focus on areas where there are steep ecological gradients which can foster natural selection and adaptation (e.g. coastal depth gradients; mountain sides)

(2) Challenges for forest managers : find a compromise between speeding up the response to selection while preserving the ability to evolve in the future.
Avoid over selecting for production traits (such as volume, straightness, density) as they may be negatively correlated with other traits important for adaptation (such as drought, pest resistance, phenology, etc).

(3) Monitoring the resilience (of mature, old-growth and relict forests) must include genetic diversity and focus on the three components of biodiversity (ecosystems, species, populations)
New tools are arriving for managers