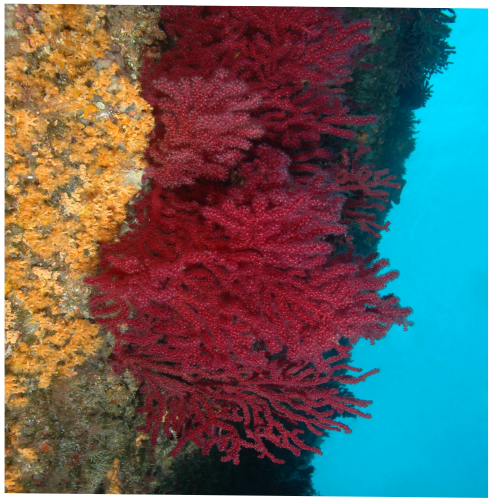
Ecological gradients as an evolutionary opportunity for Mediterranean biodiversity



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The Mediterranean paradox: High (taxonomic, genetic, functional) biodiversity despite long-term human pressure

- Land: 1.8 % of earth's land mass; 20 % of flowering plants and ferns; 5,500 endemic plant species.
- Sea: 0.8% of the surface of the global ocean; 4 to 18% of the world biodiversity

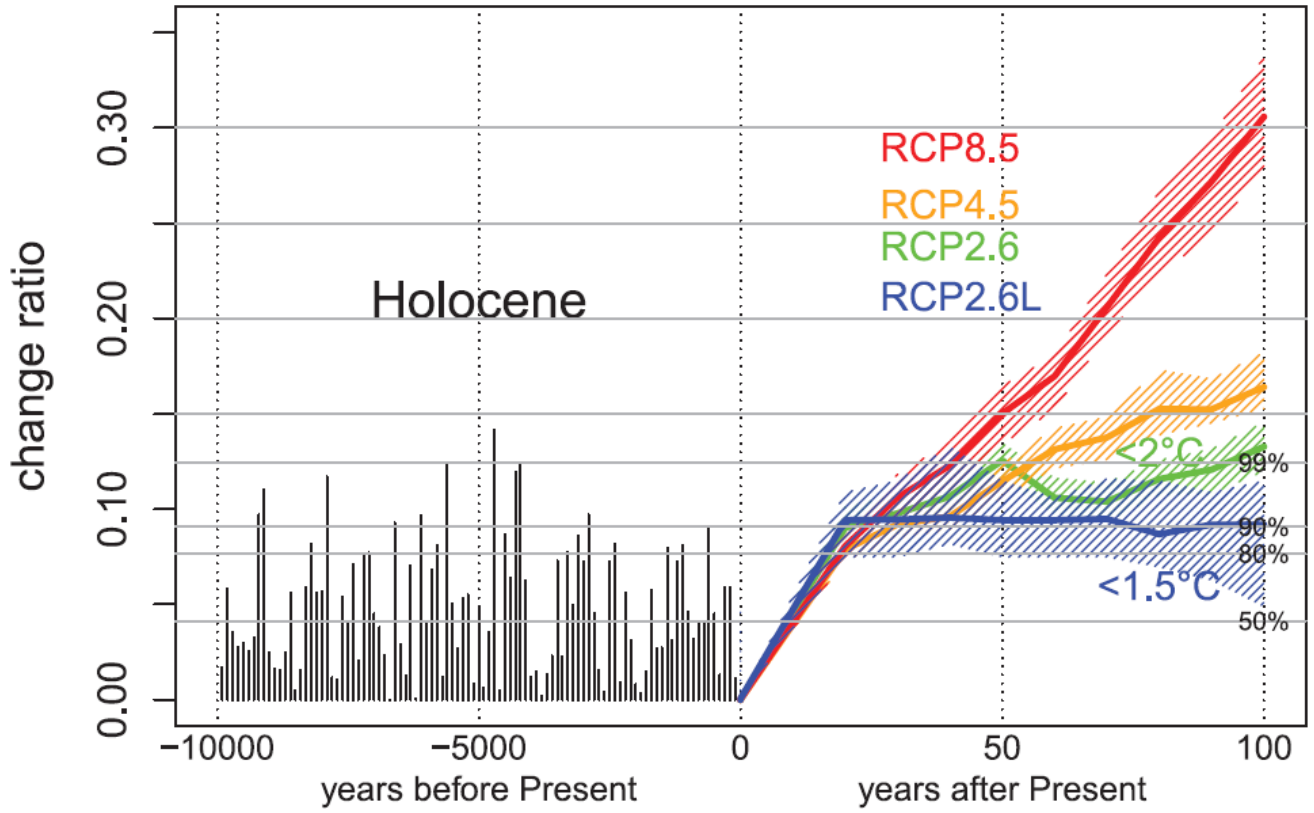
- Birth of agriculture: 10-12,000 years ago
- Total current population: 500 millions + ~270 millions tourists annually

Current climate change pattern:

~+0.2°C / decade 2nd half 20th century,

increased summer drought

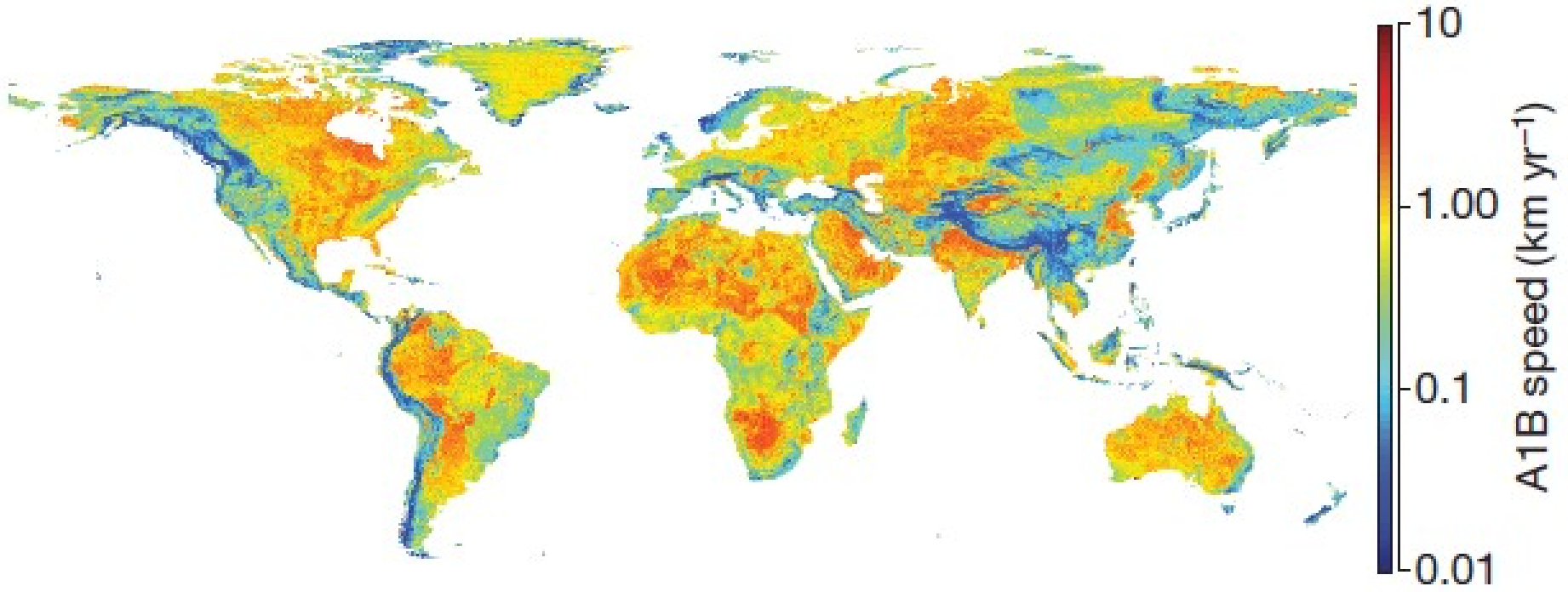
Climate change in the Mediterranean: unprecedented biome composition change is expected



Left:
Percentage of land that underwent a biome composition change during the Holocene based on pollen archives compared to present day composition.

Right:
Biome composition change that can be expected under different climate change scenarios

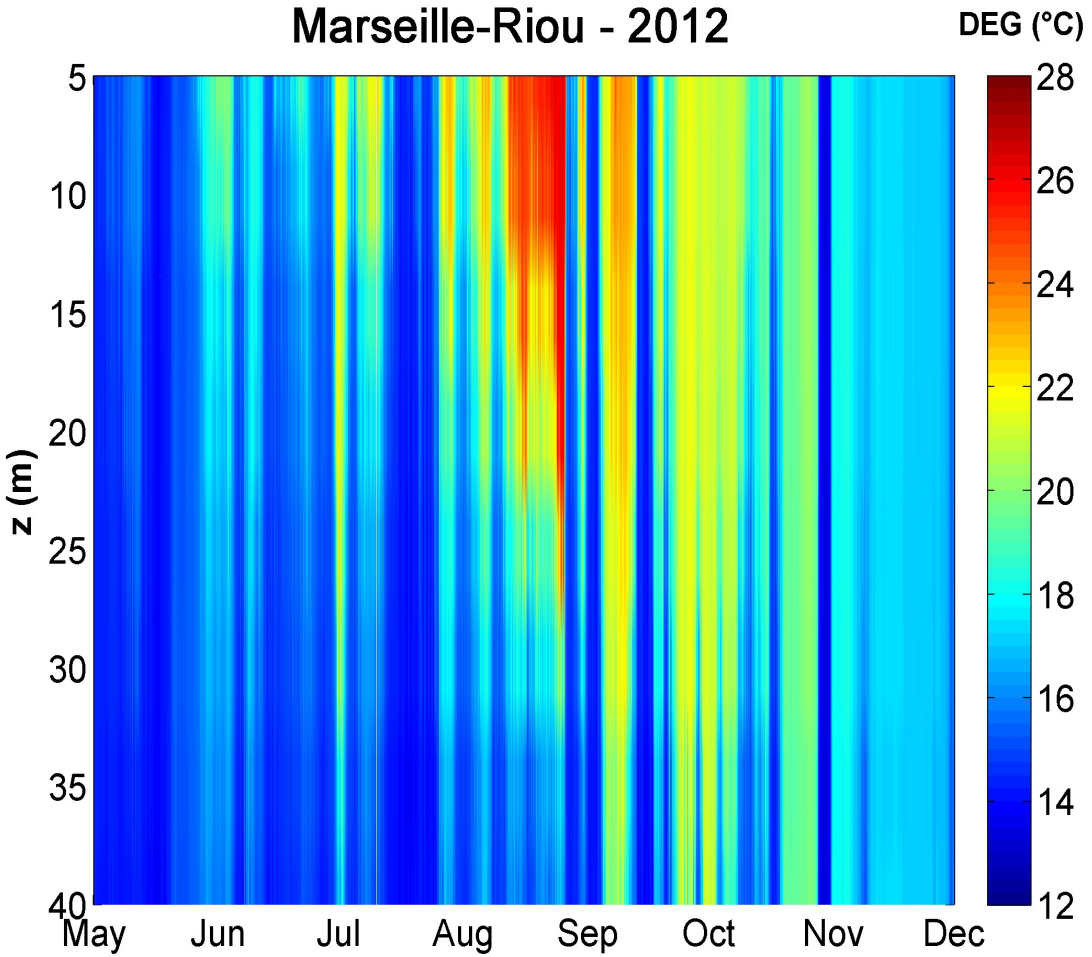
Mediterranean terrestrial forests display one of the lowest velocity of climate change worldwide.
=> a wealth of highly diverse landscapes and micro-habitats



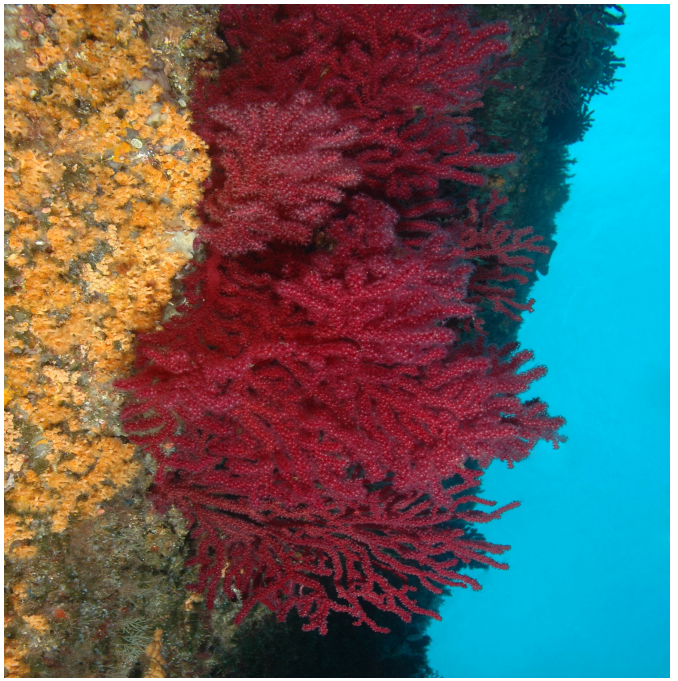
average of the global land surface. **c**, A global map of climate velocity calculated using the 2050–2100 Special Report on Emissions Scenarios (SRES) A1B emissions scenario temporal gradient.

Steep habitat / ecological gradients: also in marine systems

Strong seasonal variation and temperature stratification during the summer of shallow sea water in the north-western Mediterranean

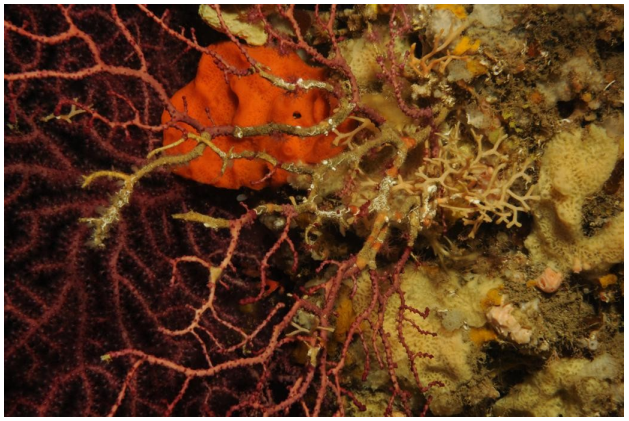


Looking for differentiation and signatures of selection in Mediterranean marine and terrestrial forests along ecological gradients



→ Mediterranean ecological gradients = strong potential for local adaptation (temperature, light, drought, etc)

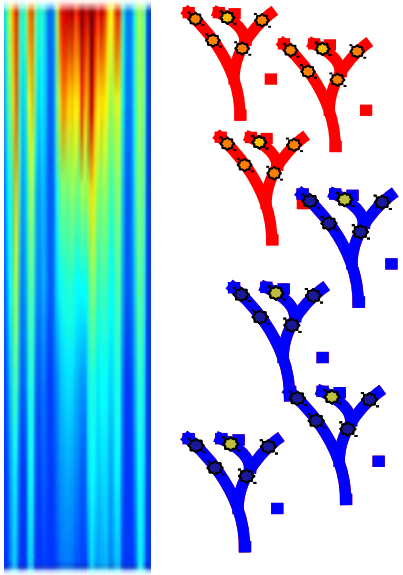
Similarities between Mediterranean marine and terrestrial forests:

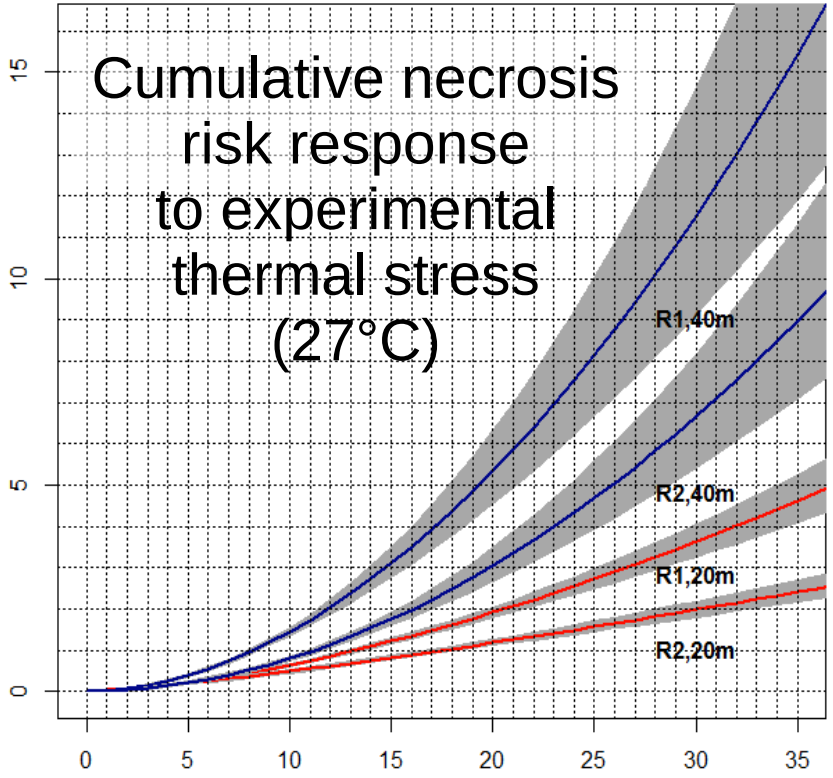


- **sessile** engineer species: long-lived anthozoans or algae, conifers and broadleaves
- “pulse like” recruitment;
- propagule dispersal possible across entire gradient;
- **range shift limitations** under climate change:
  * marine: no possibility of northward expansion in northern Medit., only downwards;
  * terrestrial: no possibility of upward expansion on low mountains;
- **mortality** linked to heat wave events (T° + pathogens).

Mediterranean marine forests : gorgonians

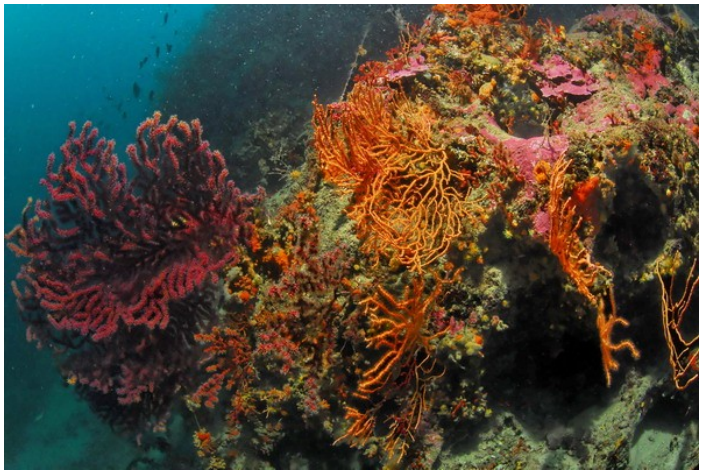
- evolution along depth / temperature gradient
- thermotolerance differences (shallow > deep)
- variable differentiation between depths





40 m depth colonies

20 m depth colonies

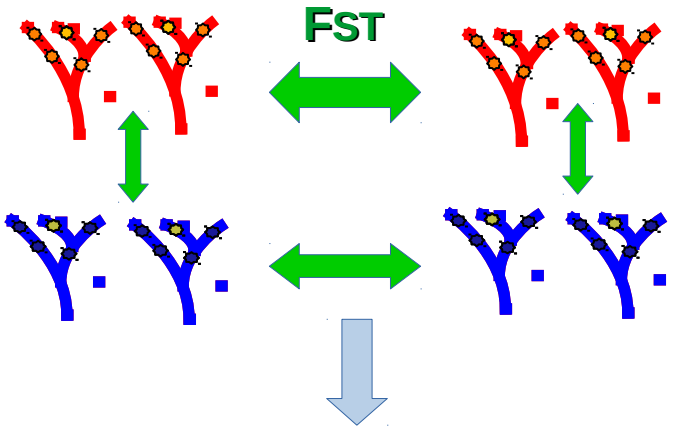


Eunicella cavolini (Yellow gorgonian)

-> determinism / heritability of fitness differences?

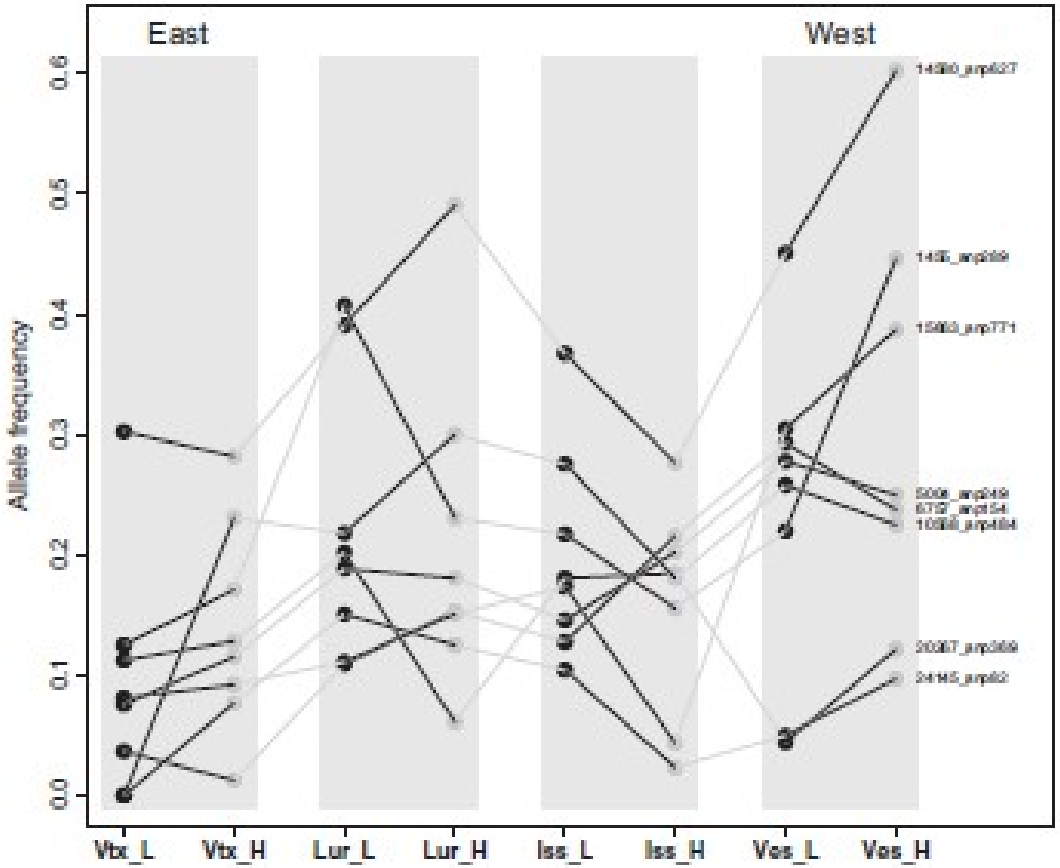
Mediterranean marine forests :

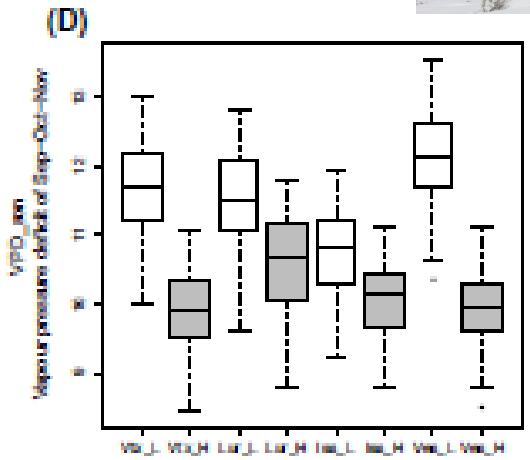
- genomic (RAD-Seq) structure along depth gradients (8-40 m) in *Corallium rubrum;*
- significant differentiation among sites (++) and different depths (+);
- Higher differentiation between shallow than between deep populations.

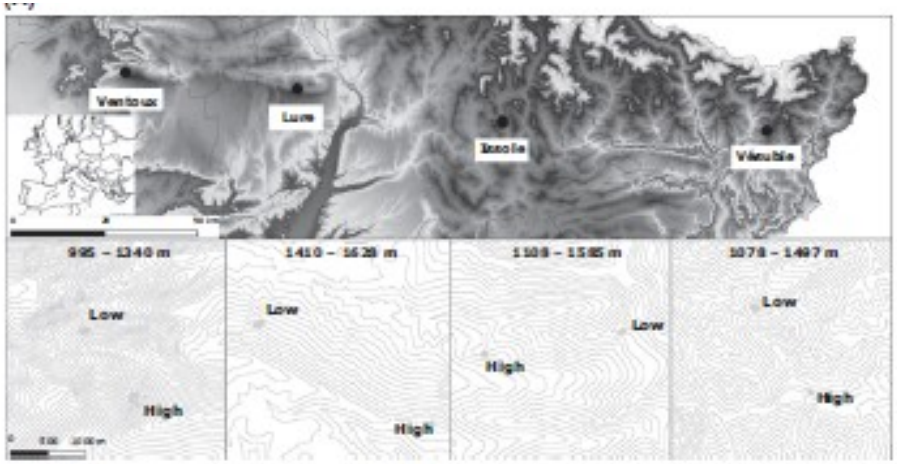


=> Barriers to gene flow in shallow populations / cryptic species?

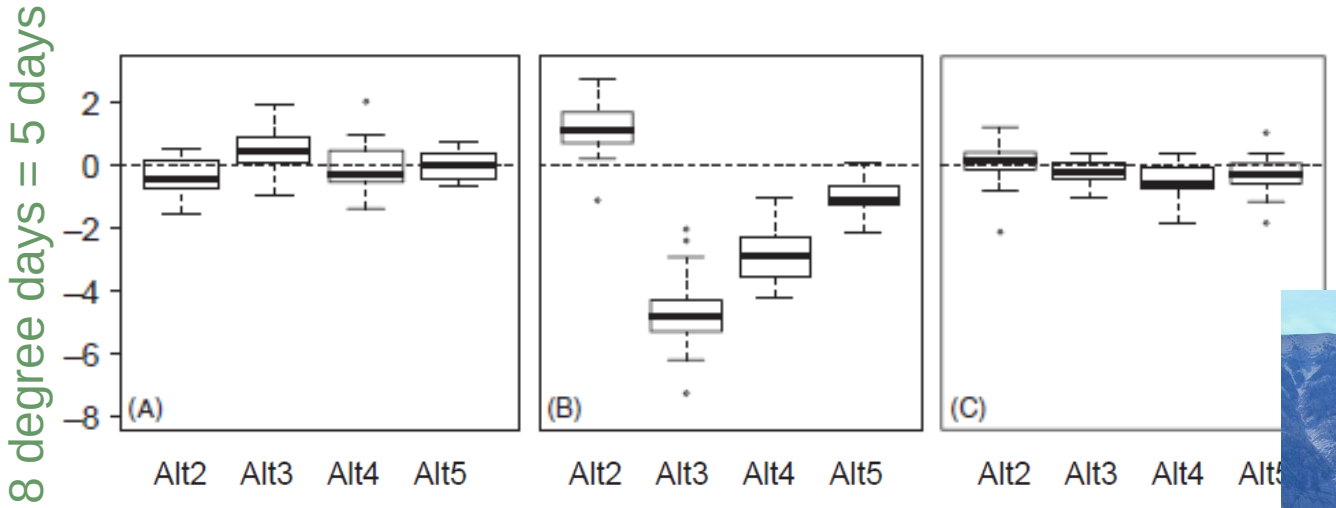
Evidence of signature of selection for drought and frost along steep ecological gradients in the conifer tree *Abies alba* in southern France







Modeling the rate of adaptive evolution of spring leaf unfolding along a steep altitudinal gradient (Fagus sylvatica): 5 generations is all it takes!



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

Conclusion (1) - Implications for biodiversity and sustainability research:

Rapid local adaptation at short spatial scale is possible along steep ecological gradients. What is the scale of local adaptation? How fast is “rapid”?

Rapid migration at short spatial scale is also possible along steep ecological gradients. What (socio-ecological) conditions favor recruitment?

Mediterranean =
Steep ecological gradients =
Ideal biome for research on local adaptation (and migration)!

Conclusion (2) – Implications for sustainable management under climate change:

The Mediterranean: a resource of and for genetic diversity

Using genetic diversity: a Nature based Solution - Conservation planning and adaptive management can prioritize areas where there are steep ecological gradients which can foster natural selection and adaptation, but also rapid habitat tracking (e.g. coastal depth gradients; mountain sides).

Evolutionary thinking needed for management to be sustainable!