Climate change and the evolutionary challenge of Mediterranean biodiversity

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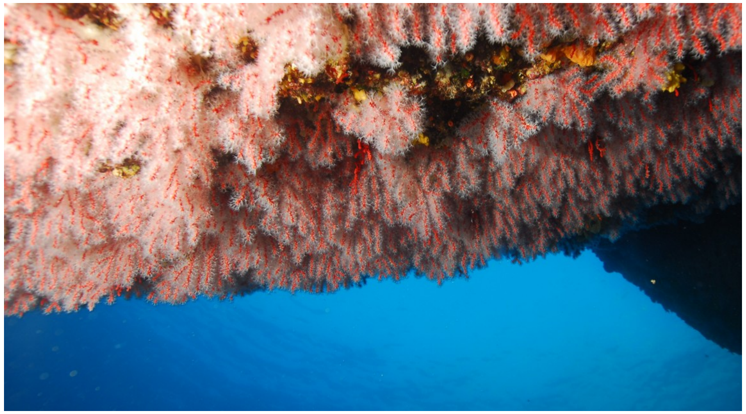

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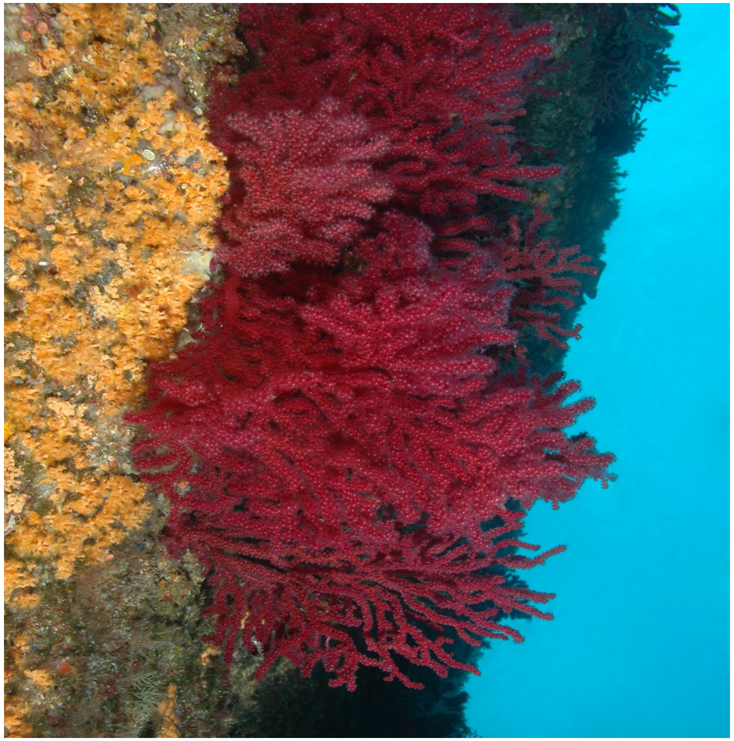


Ecological gradients and genetic adaptation to climate change in the Mediterranean

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

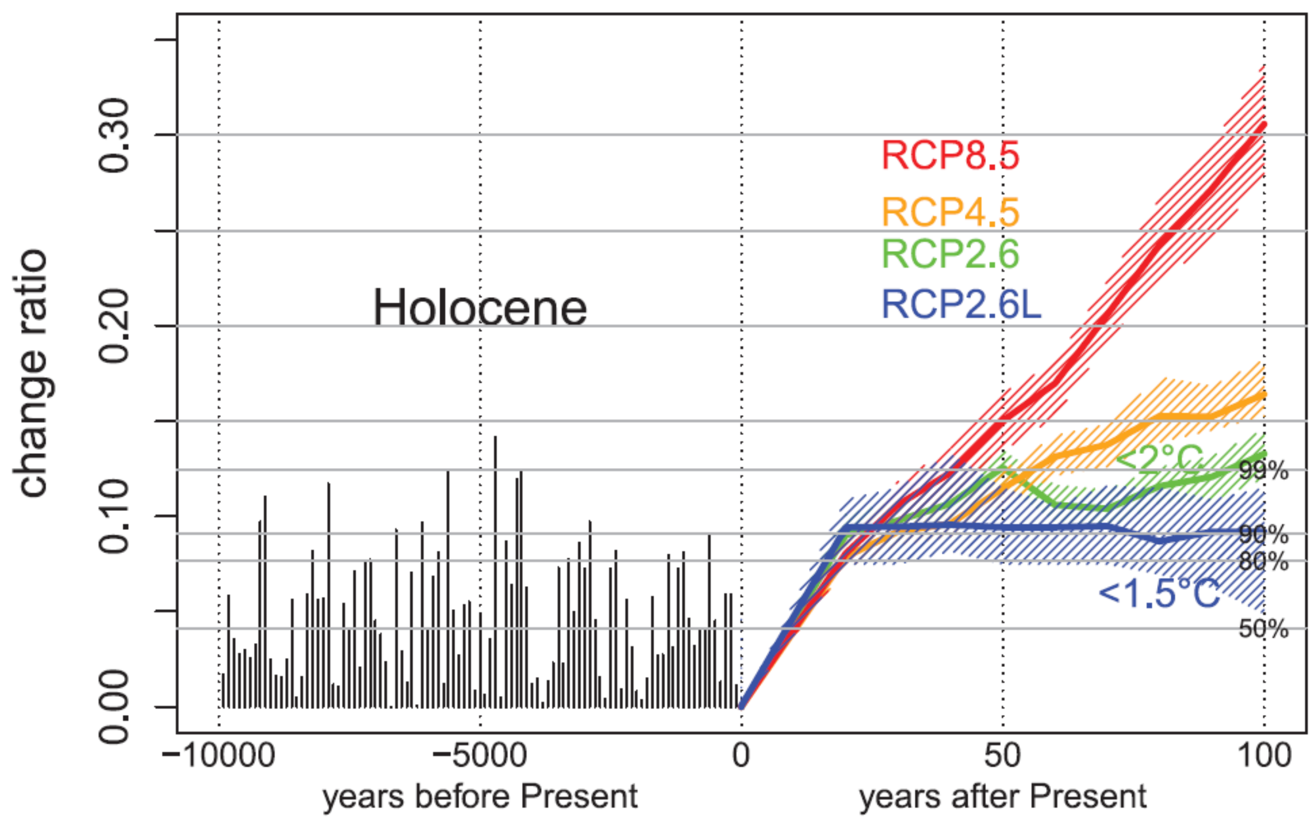
- Birth of agriculture: 10-12,000 years ago
- Total current population: 500 millions + ~270 millions tourists annually

Current climate change pattern:

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

increased summer drought

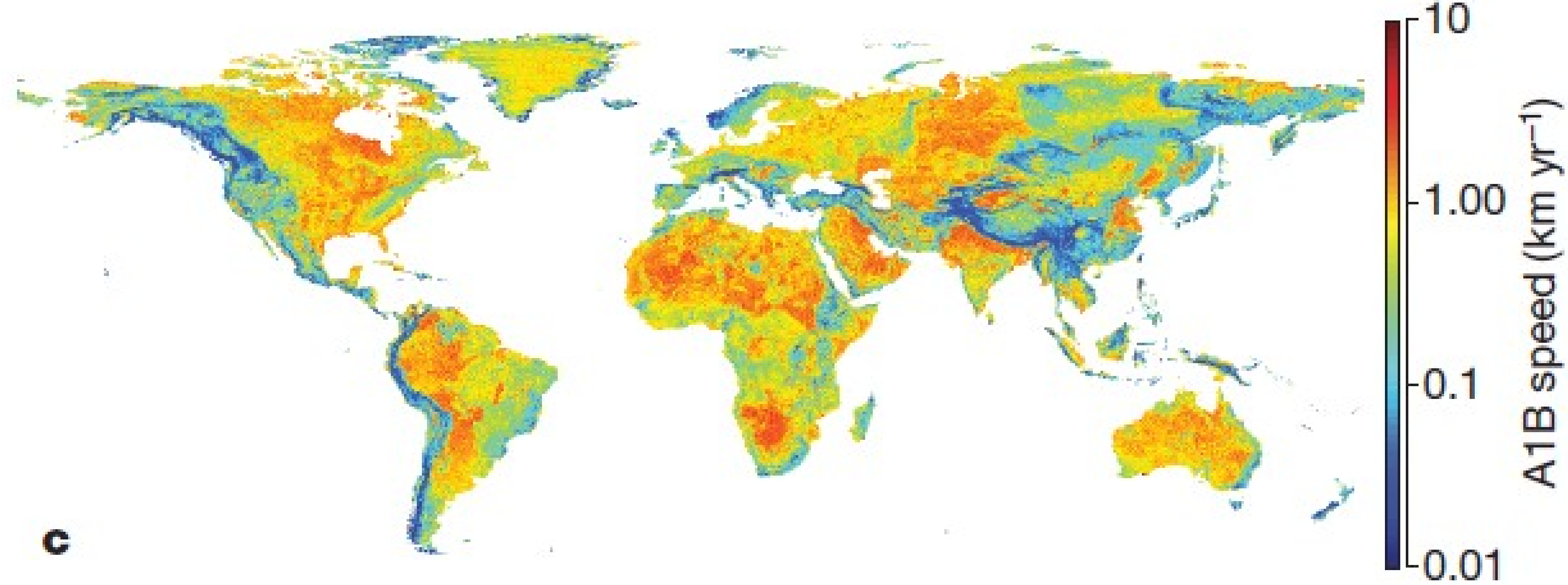
Climate change in the Mediterranean: unprecedented biome composition change is expected



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

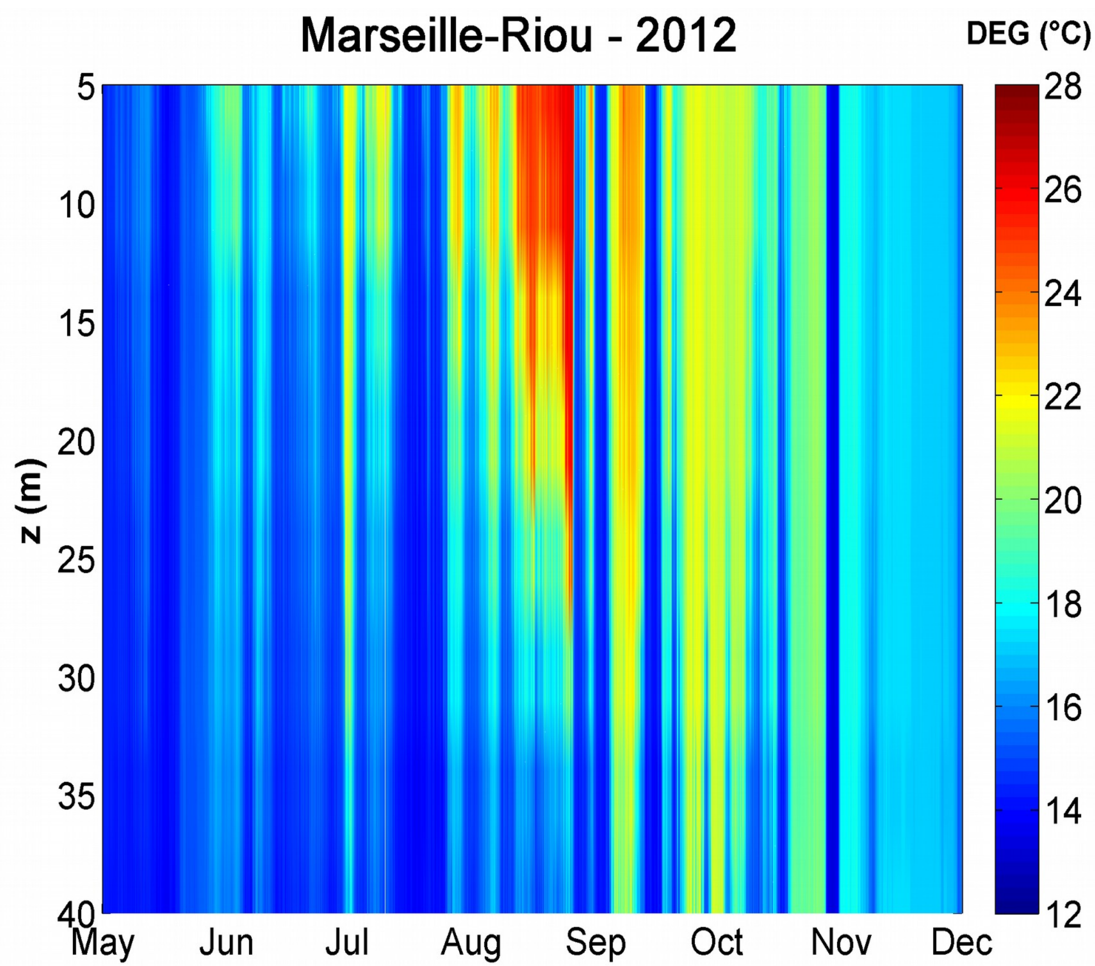
Mediterranean terrestrial forests display one of the lowest velocity of climate change worldwide.
=> a wealth of highly diverse landscapes and micro-habitats



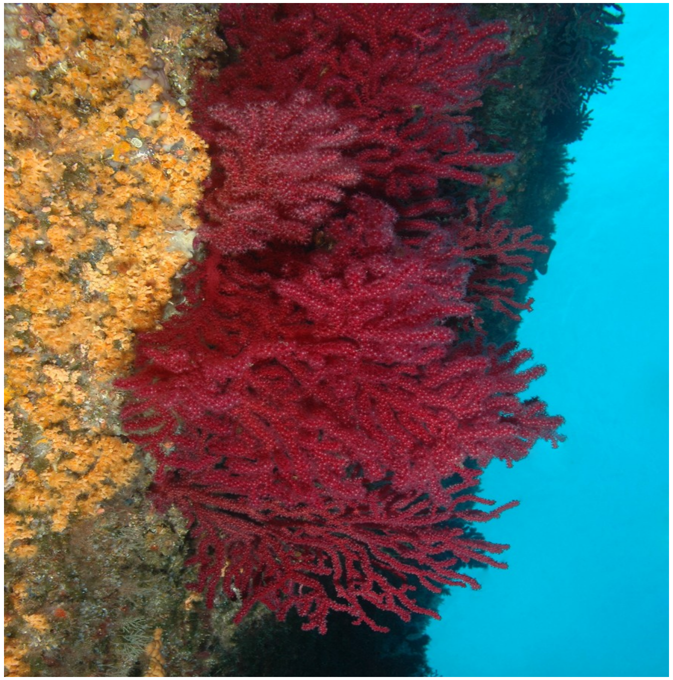
average of the global land surface. **c**, A global map of climate velocity calculated using the 2050–2100 Special Report on Emissions Scenarios (SRES) A1B emissions scenario temporal gradient.

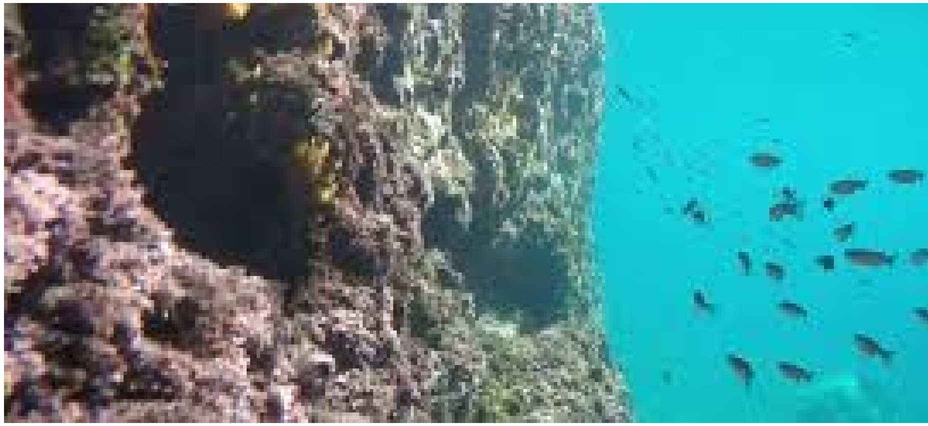
Steep habitat / ecological gradients: also in marine systems

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



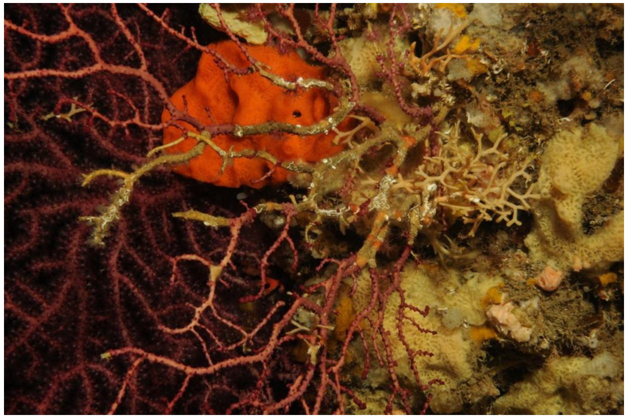
Looking for differentiation and signatures of selection in Mediterranean marine and terrestrial forests along ecological gradients





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

Similarities between Mediterranean marine and terrestrial forests:

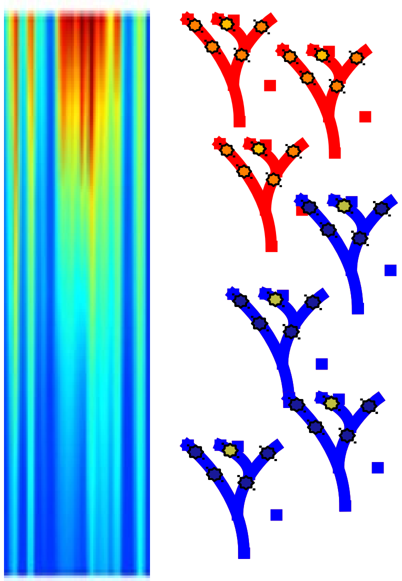


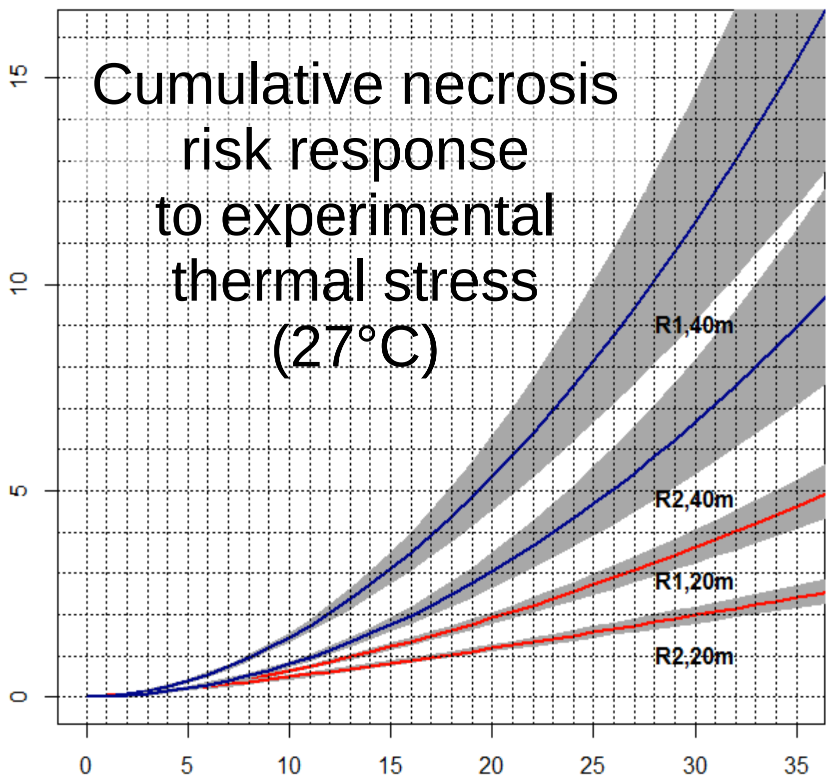
- **sessile** engineer species: long-lived anthozoans or algae, conifers and broadleaves
- “pulse like” recruitment;
- propagule dispersal possible across entire gradient;
- **range shift limitations** under climate change:
    * marine: no possibility of northward expansion;
    * terrestrial: no possibility 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

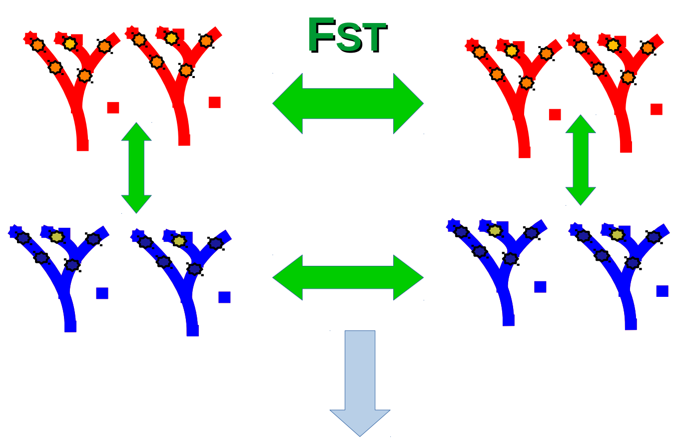
time (d)

Eunicella cavolini
(Yellow gorgonian)

-> determinism / heritability of fitness differences?

Mediterranean marine forests :

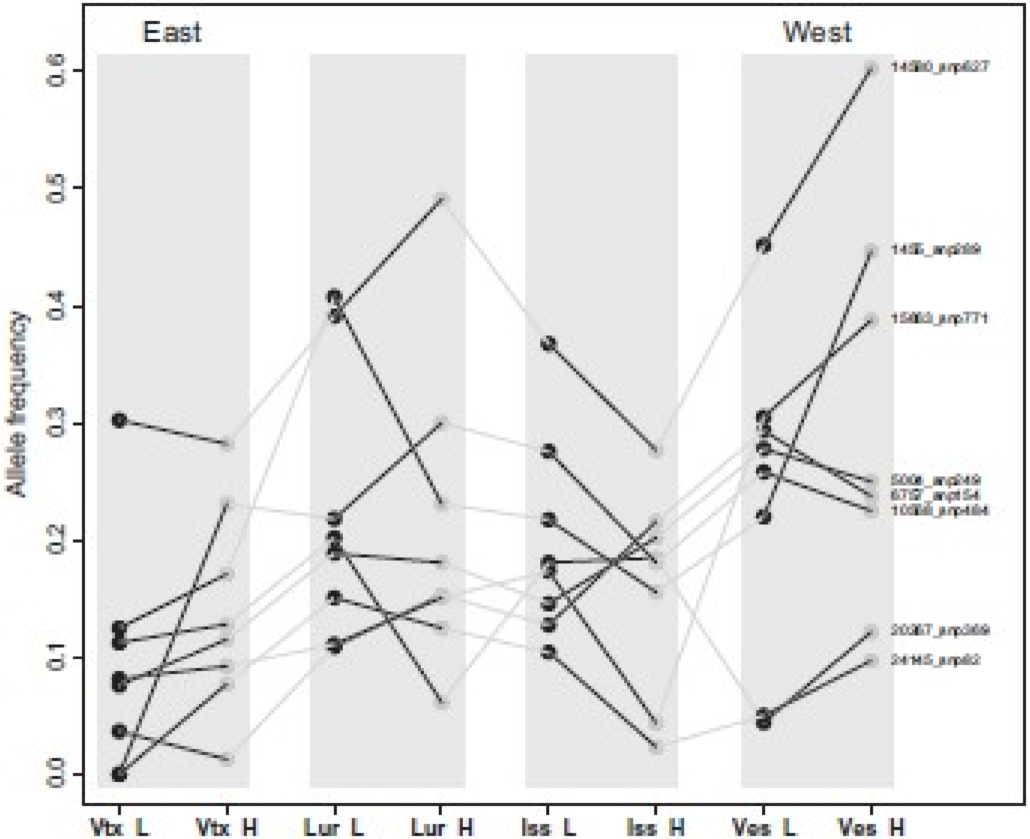
- genomic (RAD-Seq) structure along depth gradients (8-40 m) in *Corallium rubrum;*
- significant differentiation among sites (++) and different depths (+);
- Higher differentiation between shallow than between deep populations.

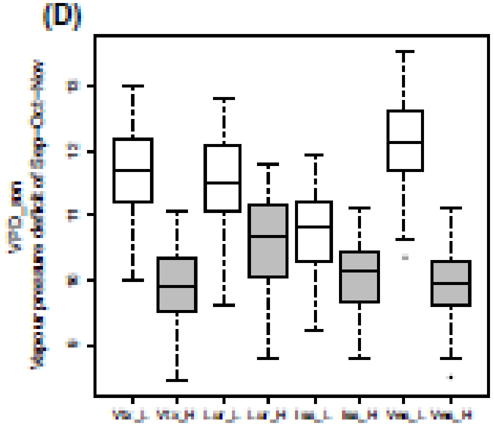


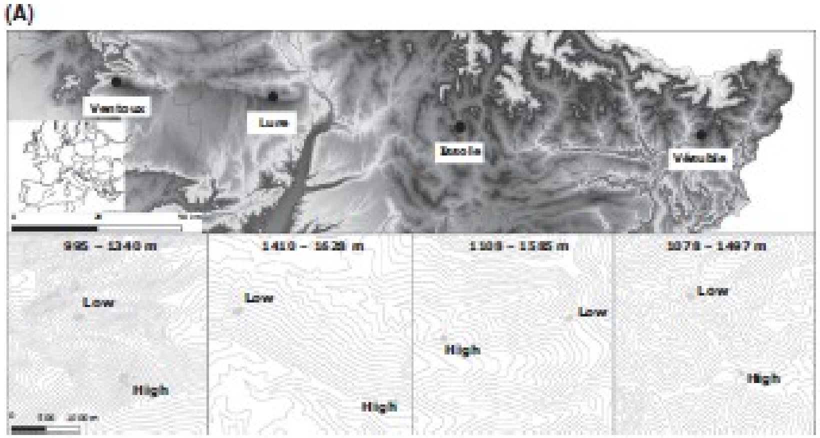
Outlier loci, see *poster S. 66 (Aurelle et al.)*

=> Barriers to gene flow in shallow populations?

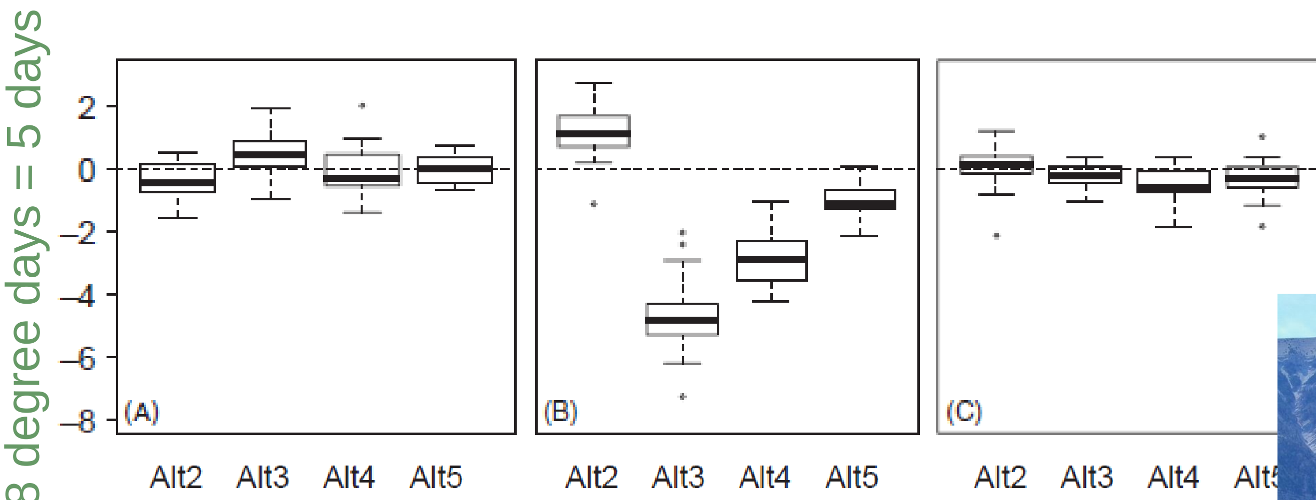
Evidence of signature of selection for drought and frost along steep ecological gradients in the conifer tree *Abies alba* in southern France







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



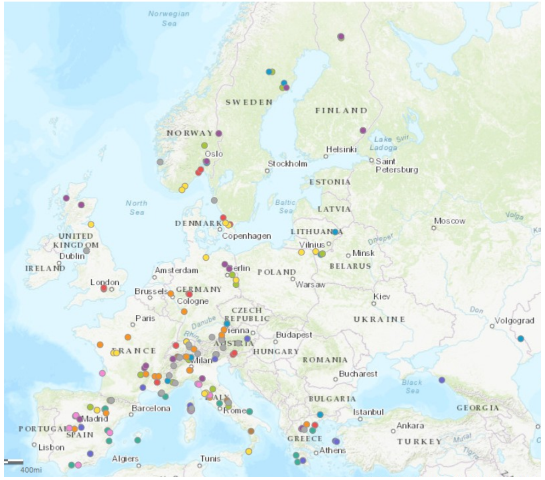
(A): Neutral
(B): adaptive evolution
(C): adaptive evolution without mortality

Conclusion (1) - implications for research:

Rapid local adaptation at short spatial scale is possible along steep ecological gradients.

Experimental design for detecting local adaptation: genome scan replicates *sensu* Lotterhos & Whitlock (MolEcol 2015) and reciprocal transplants.

See project GenTree: http://www.gentree-h2020.eu/



Mediterranean = steep ecological gradients = ideal biome for research on signatures of selection and local adaptation!

Conclusion (2) – Evolutionary application for *in situ* conservation:

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).

Include evolutionary thinking in conservation planning!

See session S76. Evolutionary management of wild populations
Wed, 22 August, starting 09:25 (Rabelais room)