



HAL
open science

Climate change and the evolutionary challenge of Mediterranean biodiversity

Bruno Fady, Alberte Bondeau, Marc Bally, Wolfgang Cramer, Thierry Gauquelin, Jean-Pierre Féral, Anne-Christine Monnet, Séverine Thomas, France van Wambeke, Anne Chenuil, et al.

► **To cite this version:**

Bruno Fady, Alberte Bondeau, Marc Bally, Wolfgang Cramer, Thierry Gauquelin, et al.. Climate change and the evolutionary challenge of Mediterranean biodiversity. 2. Joint Congress on Evolutionary Biology (EVOLUTION 2018), Aug 2018, Montpellier, France. 2018. hal-02737804

HAL Id: hal-02737804

<https://hal.inrae.fr/hal-02737804v1>

Submitted on 2 Jun 2020

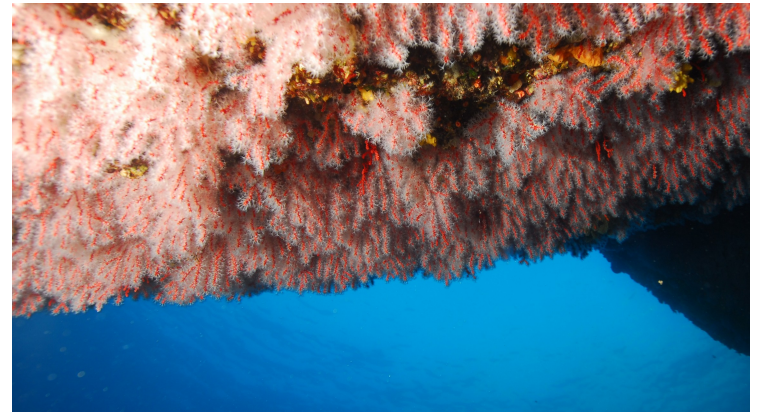
HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Climate change and the evolutionary challenge of Mediterranean biodiversity



C. Pujos / ONF



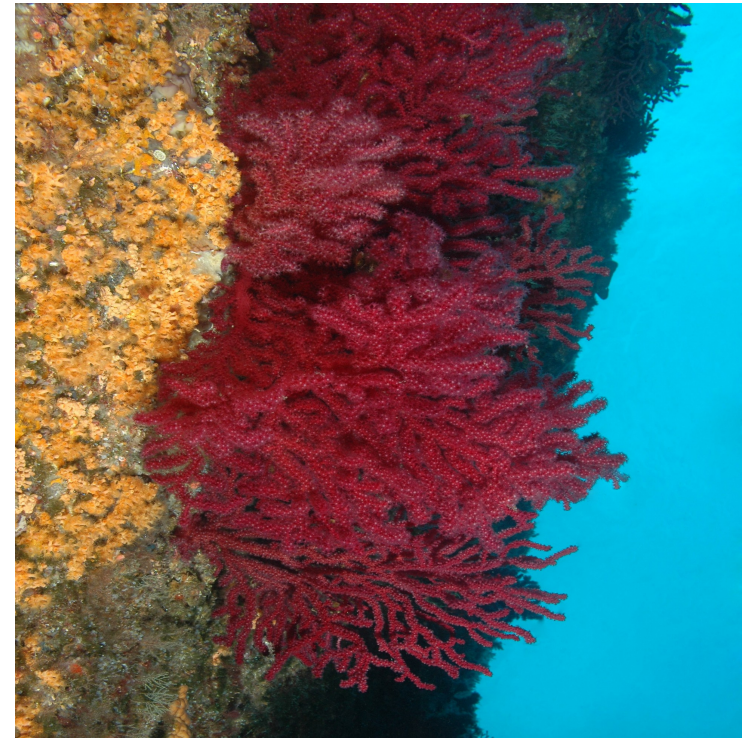
F. Zuberer / CNRS

B. Fady, M. Bally, A. Bondeau, F. Carlotti, A. Chenuil,
W. Cramer, J-P. Féral, T. Gauquelin, A-C. Monnet,
S. Thomas, F. Van Wambeke, D. Aurelle

bruno.fady@inra.fr



Climate change and the evolutionary challenge of Mediterranean biodiversity



Ecological gradients and genetic adaptation to climate change in the Mediterranean

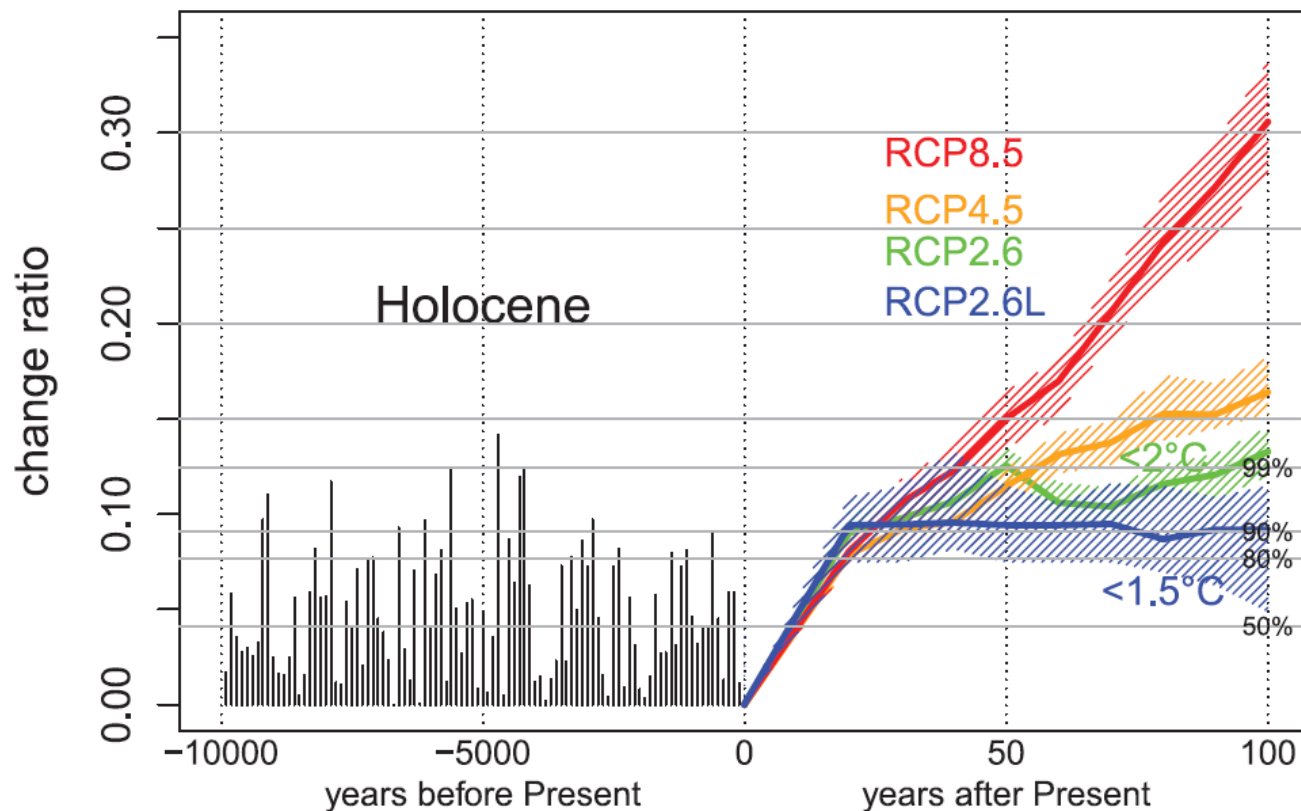
The Mediterranean paradox: High (taxonomic, genetic, functional) biodiversity despite long-term human pressure

- ✓ 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

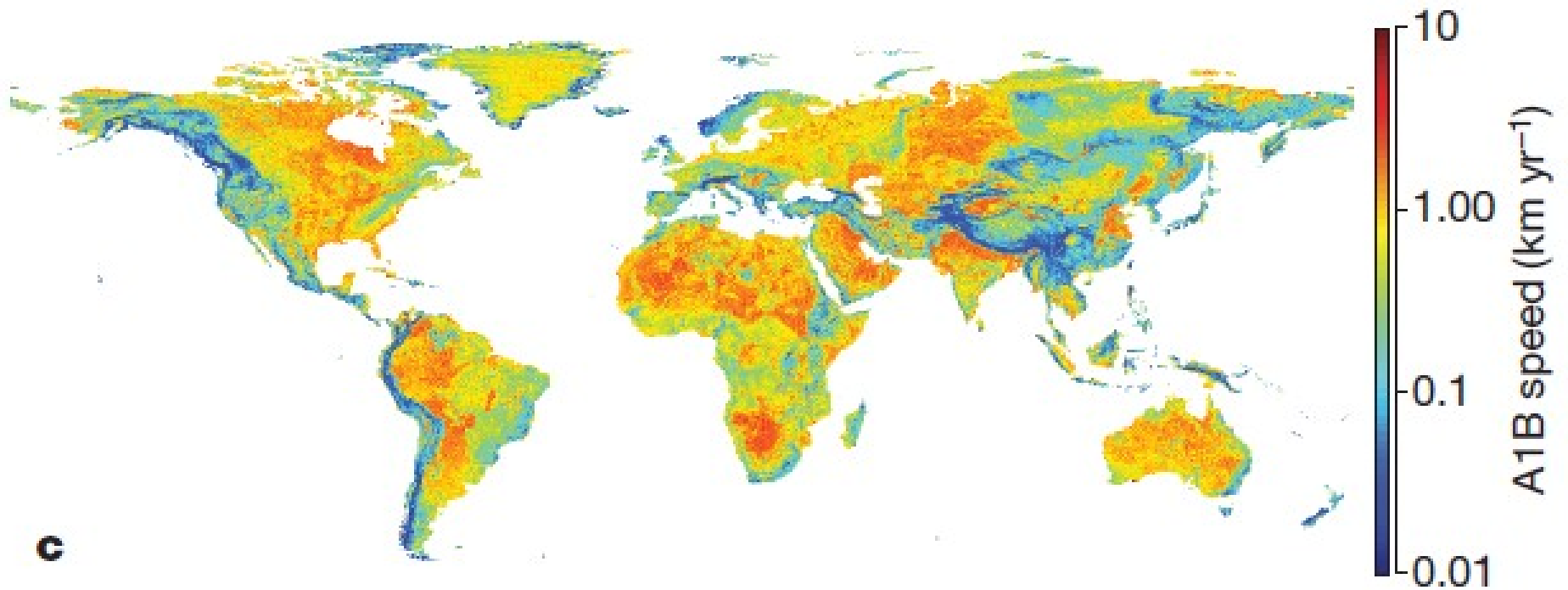
Climate change in the Mediterranean: unprecedented biome composition change is expected



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

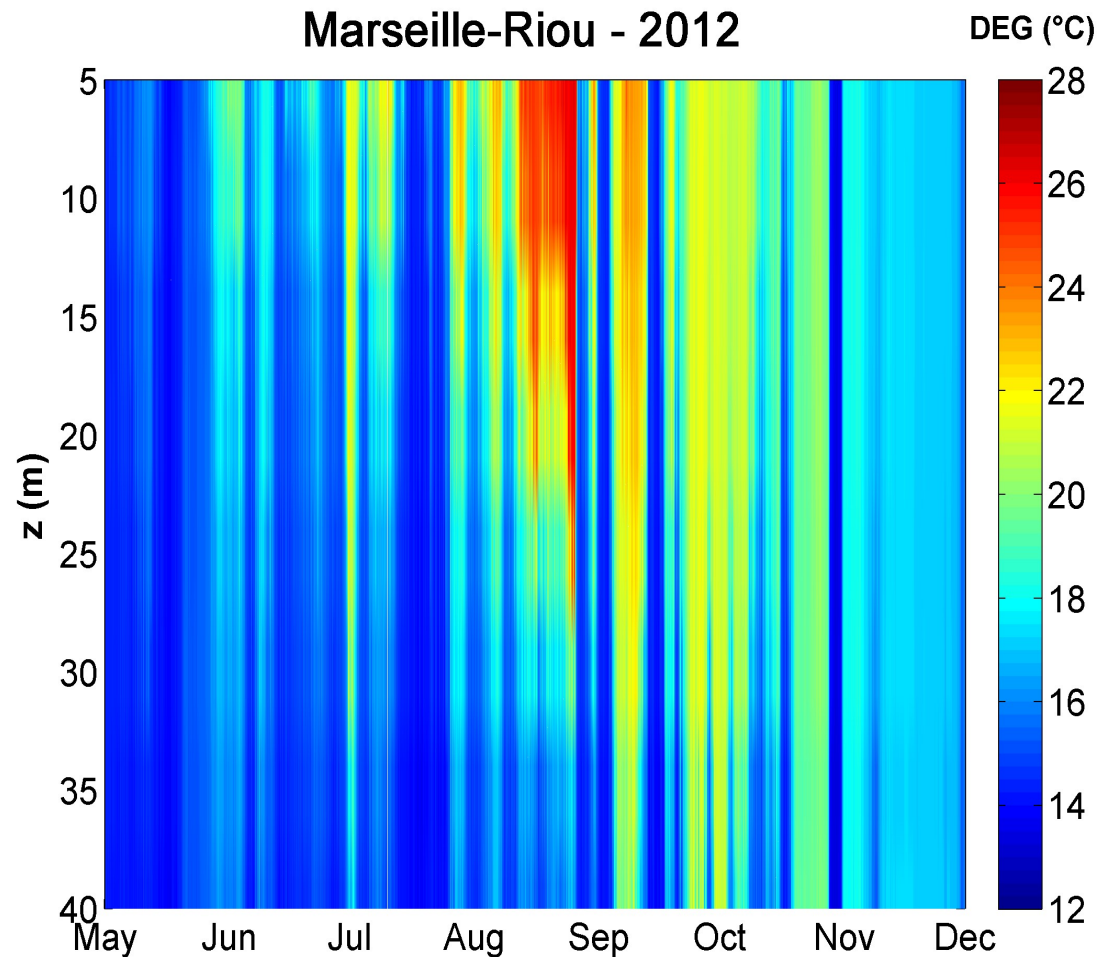
**Mediterranean terrestrial forests display one of the lowest velocity of climate change worldwide.
=> a wealth of highly diverse landscapes and micro-habitats**



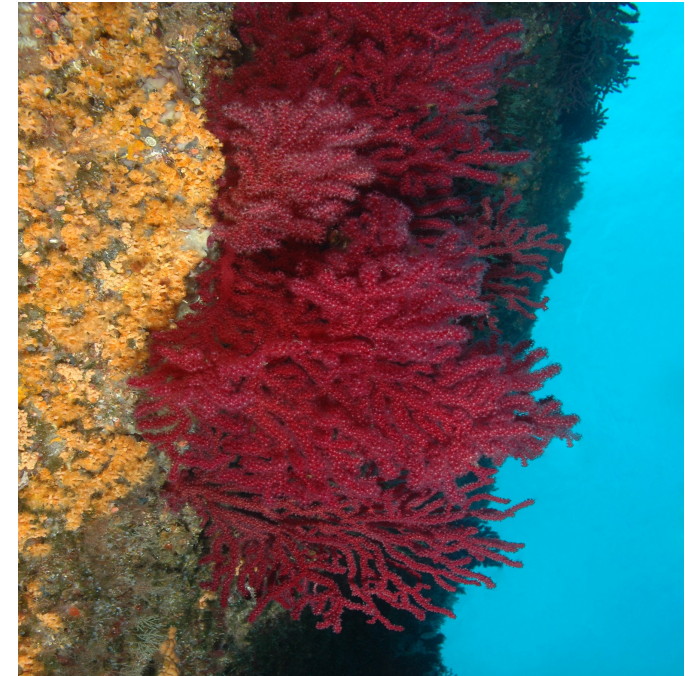
c, average of the global land surface. **c**, A global map of climate velocity calculated using the 2050–2100 Special Report on Emissions Scenarios (SRES) A1B emissions scenario temporal gradient.

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)**

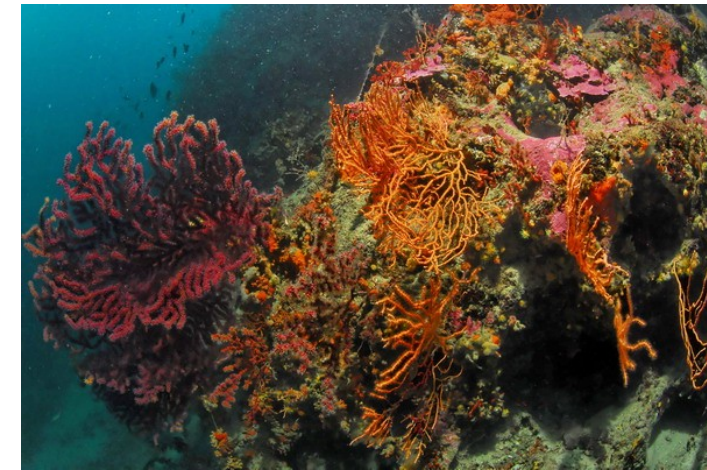
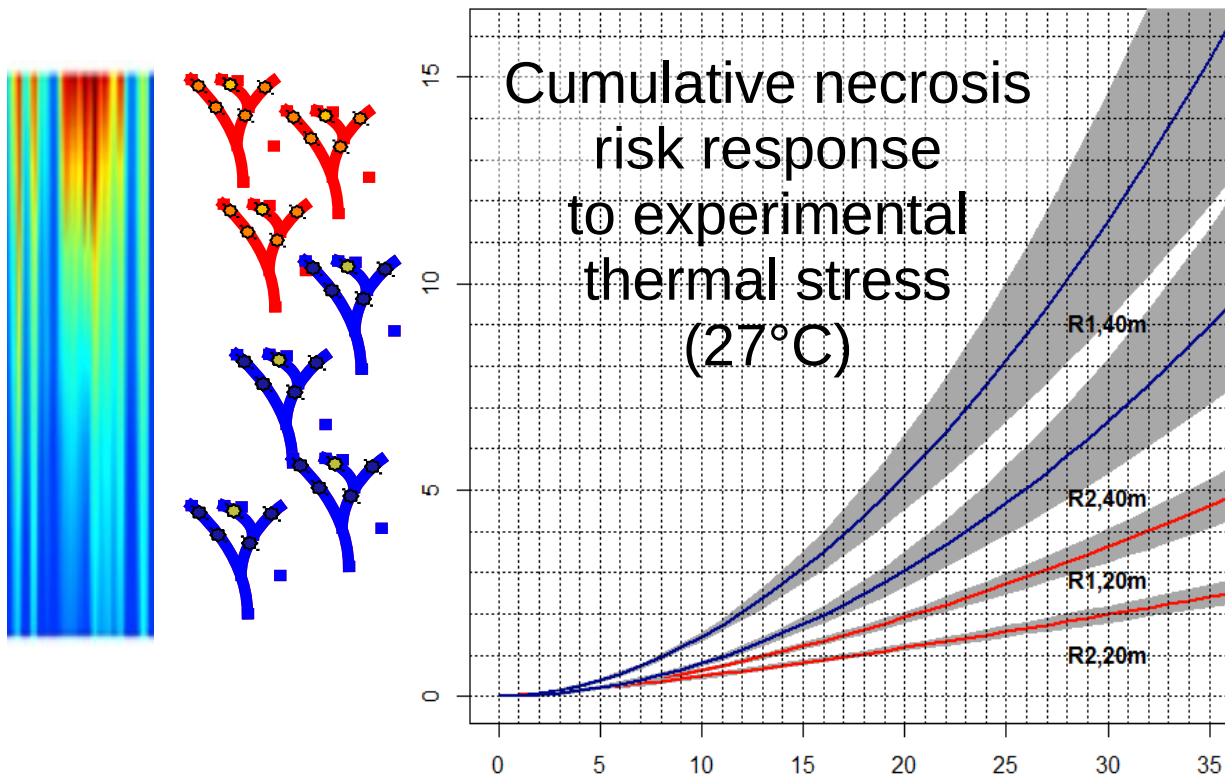
Similarities between Mediterranean marine and terrestrial forests:

- **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 ($T^{\circ} +$ pathogens).



Mediterranean marine forests : gorgonians

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



40 m depth colonies



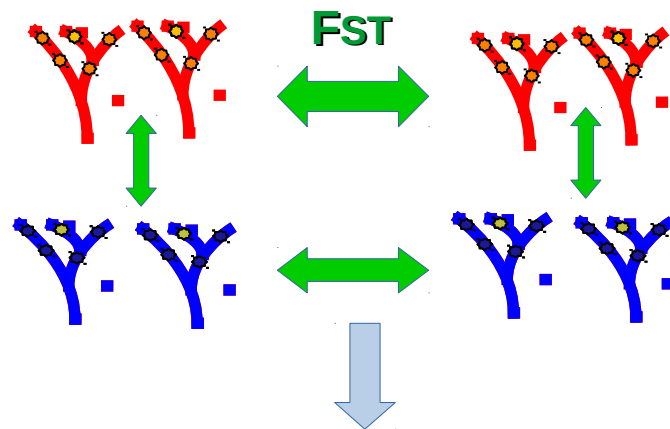
20 m depth colonies

Eunicella cavolini
(Yellow gorgonian)

-> determinism / heritability of fitness differences?

Mediterranean marine forests :

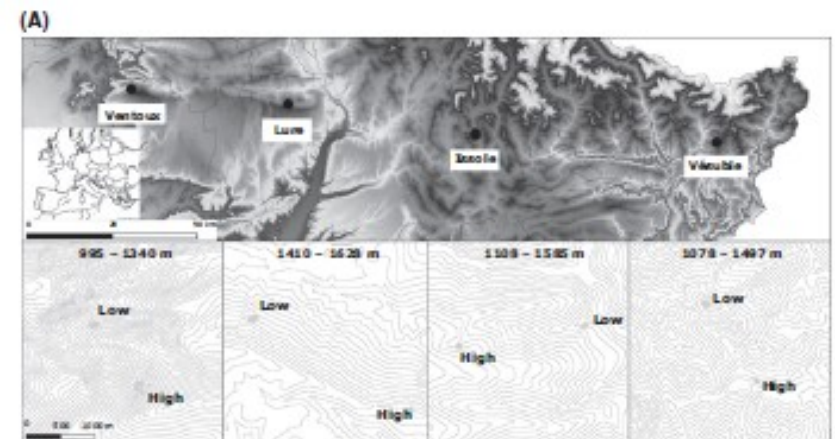
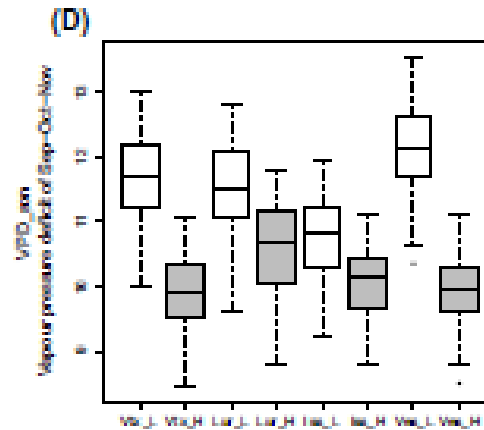
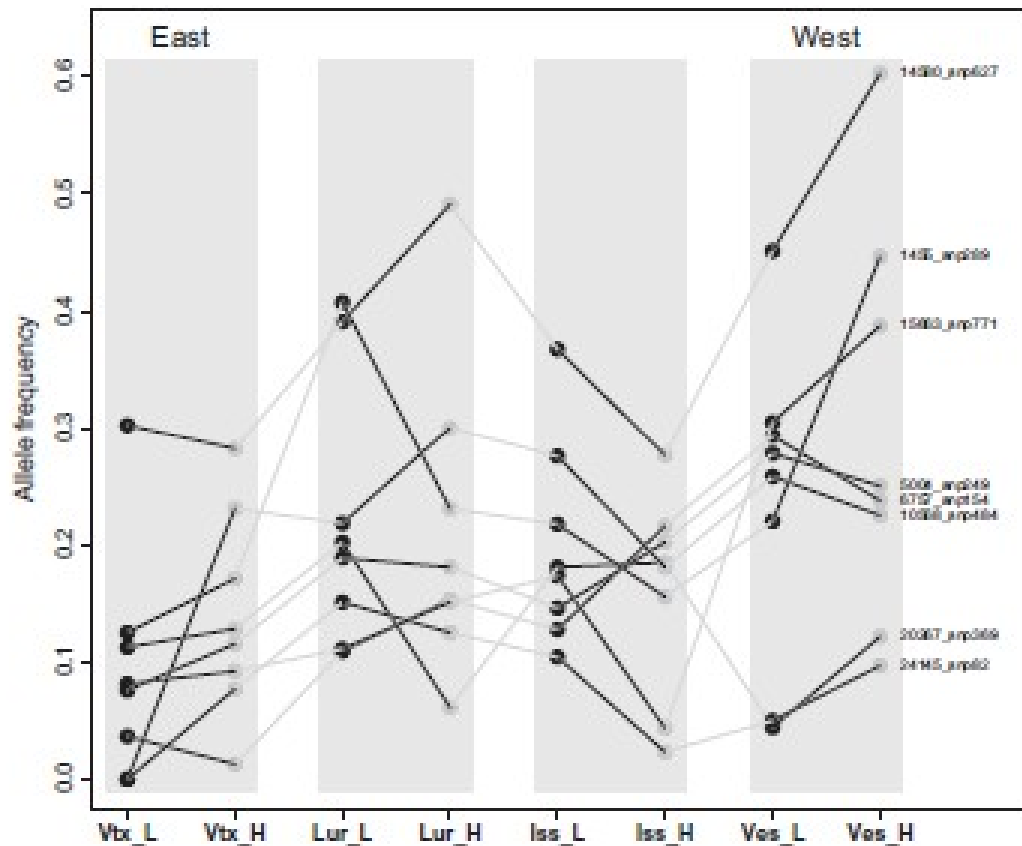
- genomic (RAD-Seq) structure along depth gradients (8-40 m) in *Corallium rubrum*;
- significant differentiation among sites (++) and different depths (+);
- Higher differentiation between shallow than between deep populations.



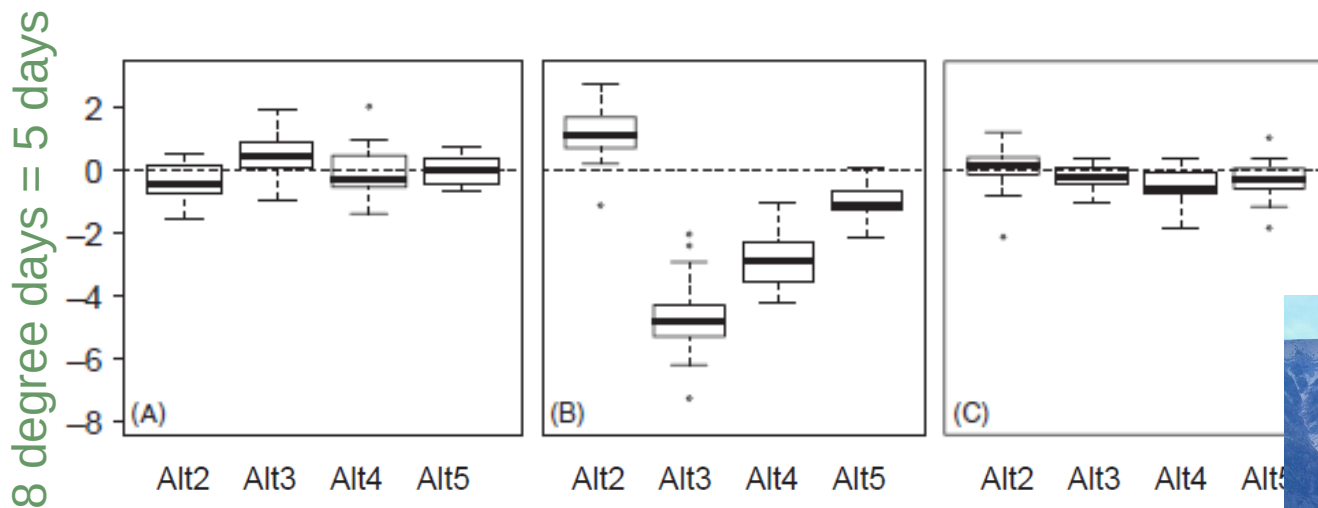
Outlier loci, see
poster P-0585, S.
66 (Aurelle et al.)
on Sunday

=> 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 after 5 generations along a steep altitudinal gradient (*Fagus sylvatica*)



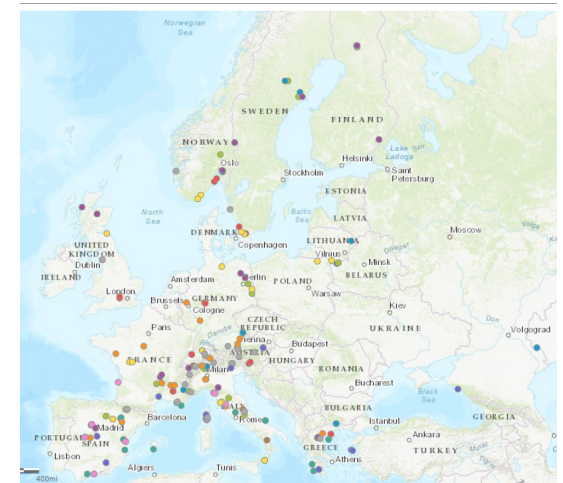
- (A): Neutral
- (B): adaptive evolution
- (C): adaptive evolution without mortality

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)