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Demographic history of *Abies alba* Mill. in the French Pyrenees

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Thomas Boivin,
Brigitte Musch,
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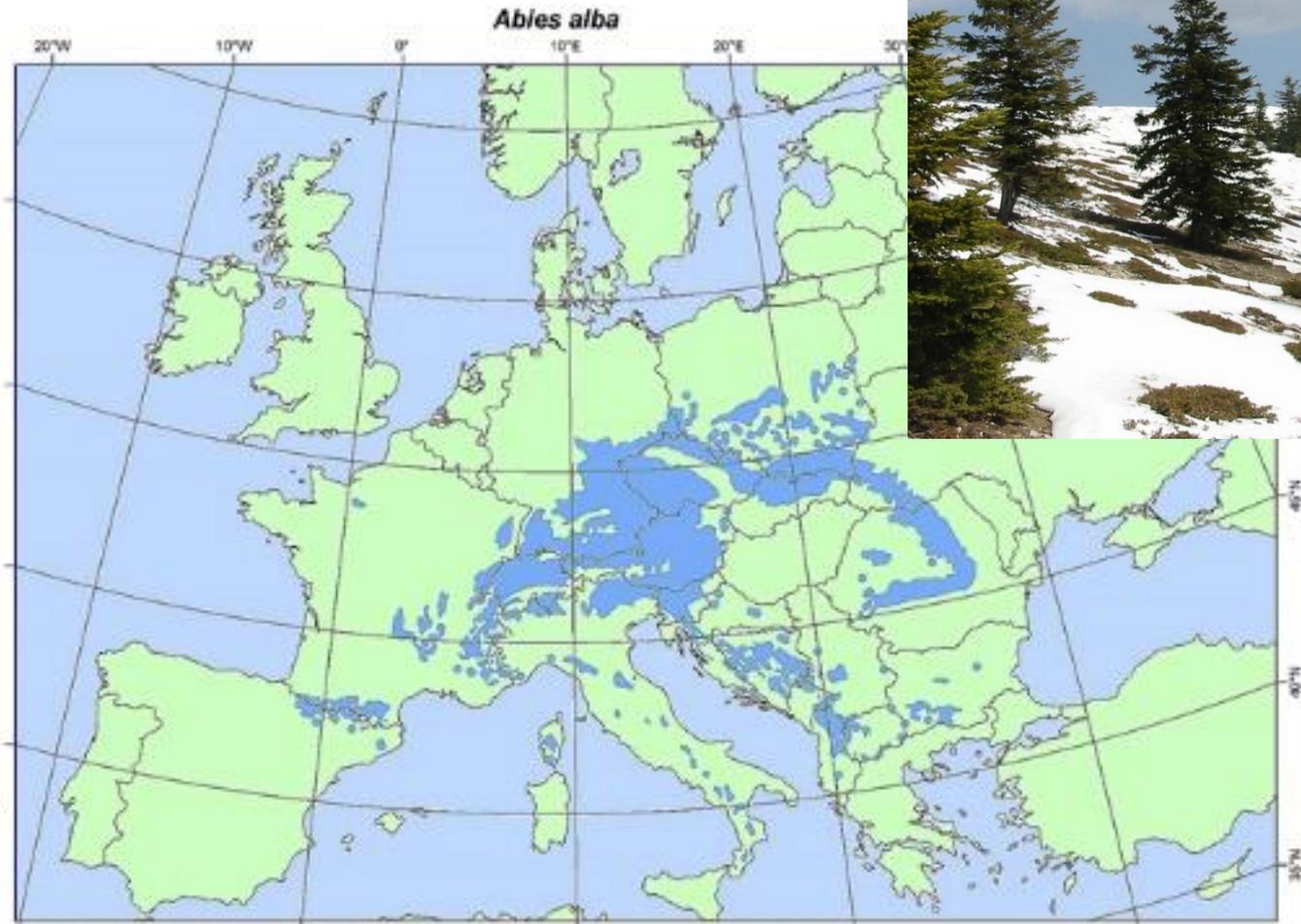
*Thanks for lab work: Anne
Roig and Matthieu Lingrand*

**“Past plant diversity changes” international
conference, Rabat, Morocco, October 1-5, 2018**

Demographic history of *Abies alba* Mill. in the French Pyrenees



Abies alba, a European mountain conifer



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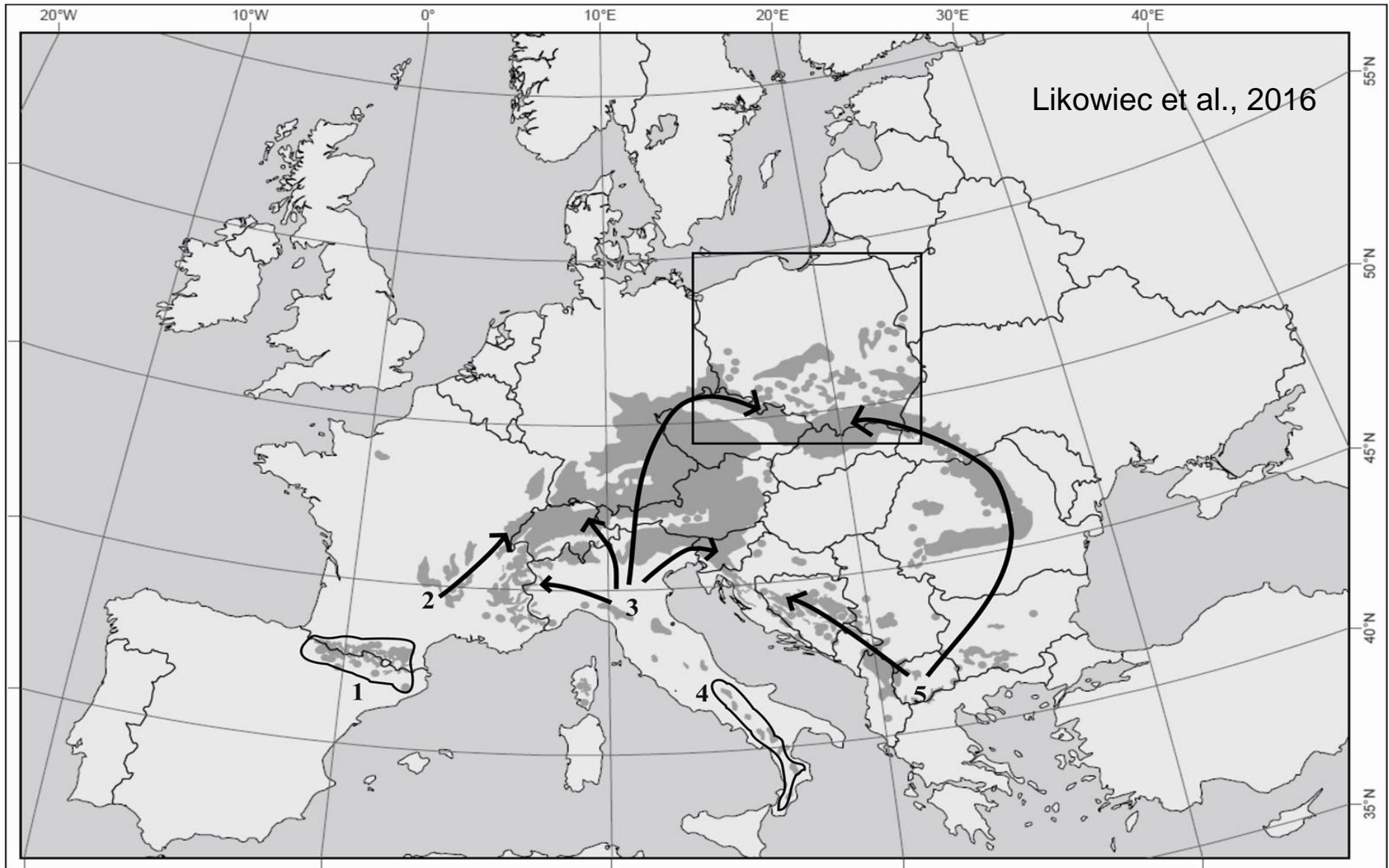
This distribution map, showing the natural distribution area of *Abies alba*, was compiled by members of the EUFORGEN Networks.

Citation: Distribution map of Silver fir (*Abies alba*) EUFORGEN 2009, www.euforgen.org.

First published online in 2009 - Updated on 25 November 2011

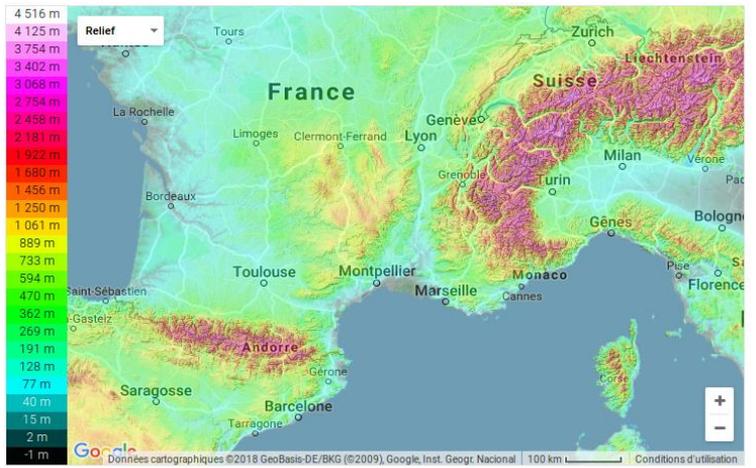


A Holocene view of *Abies alba* in Europe

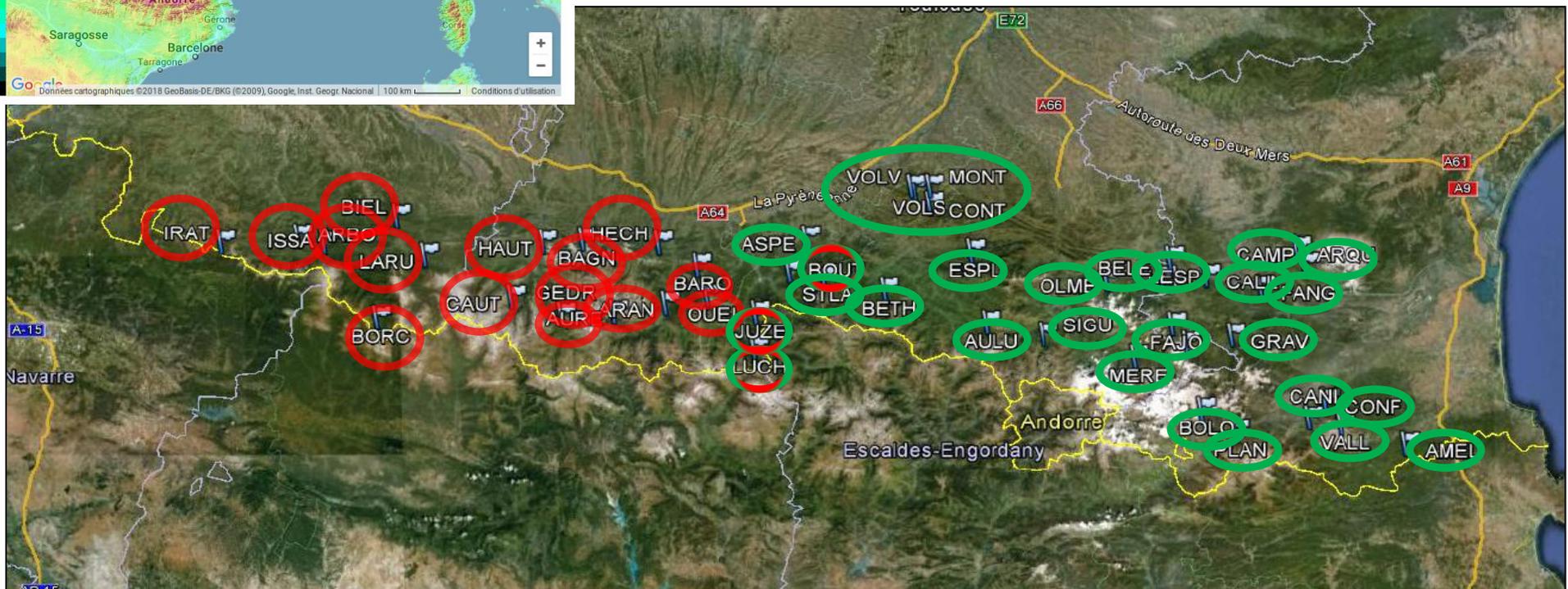


Likowiec et al., 2016 (Poland), Gomory et al., 2004 (Eastern Europe), Liepelt et al., 2009 (Europe), Sancho-Knapik et al., 2014 (Spain), Belletti et al., 2017 (Italy), Piotti et al., 2017 (Italy)

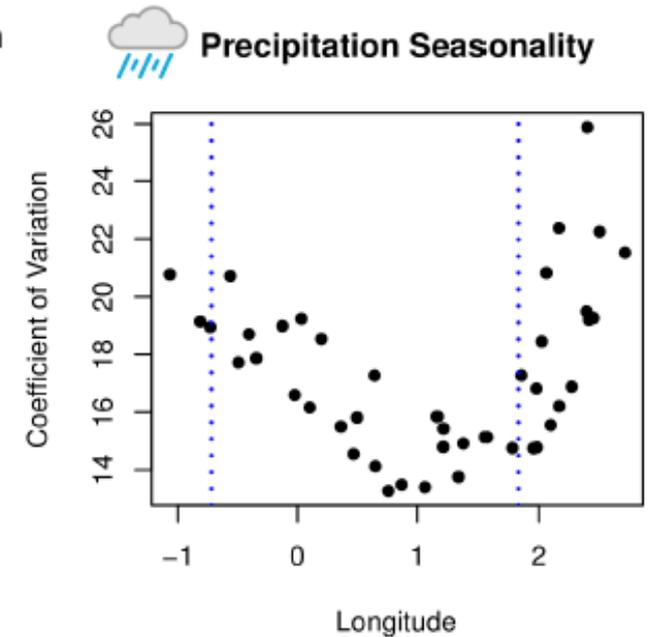
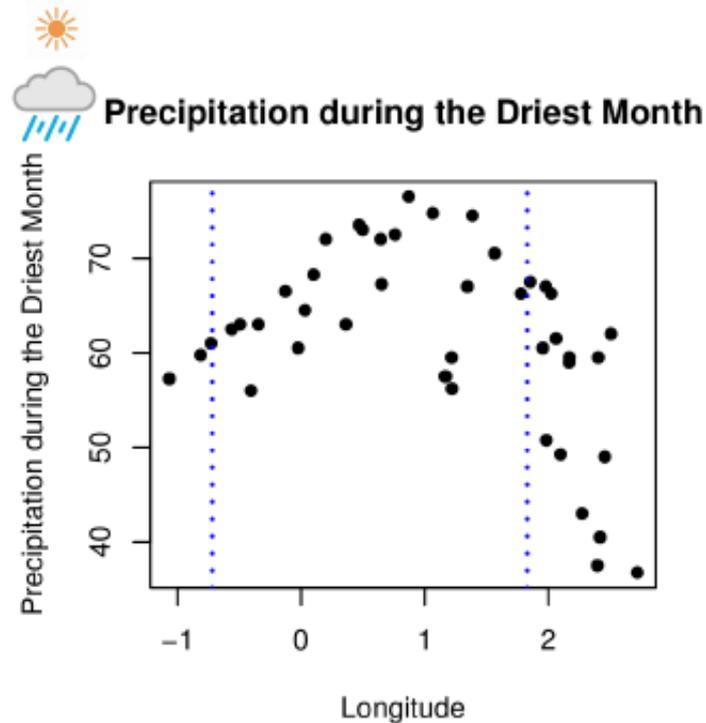
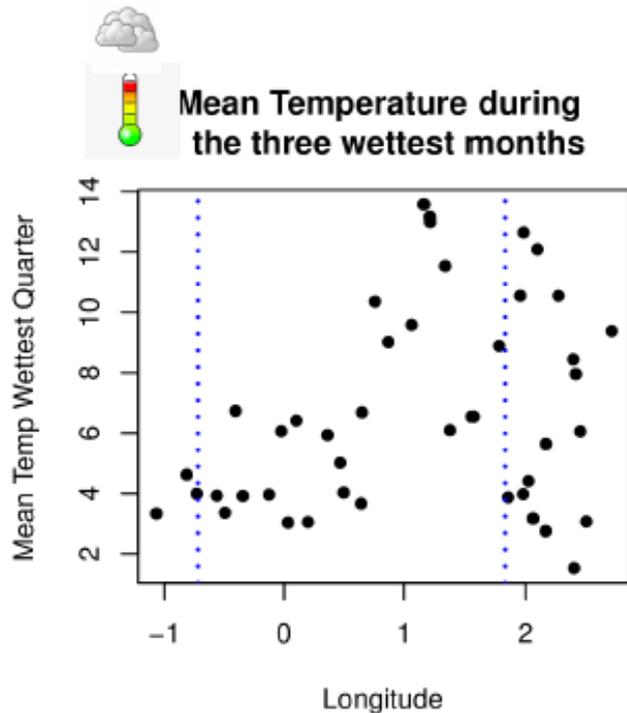
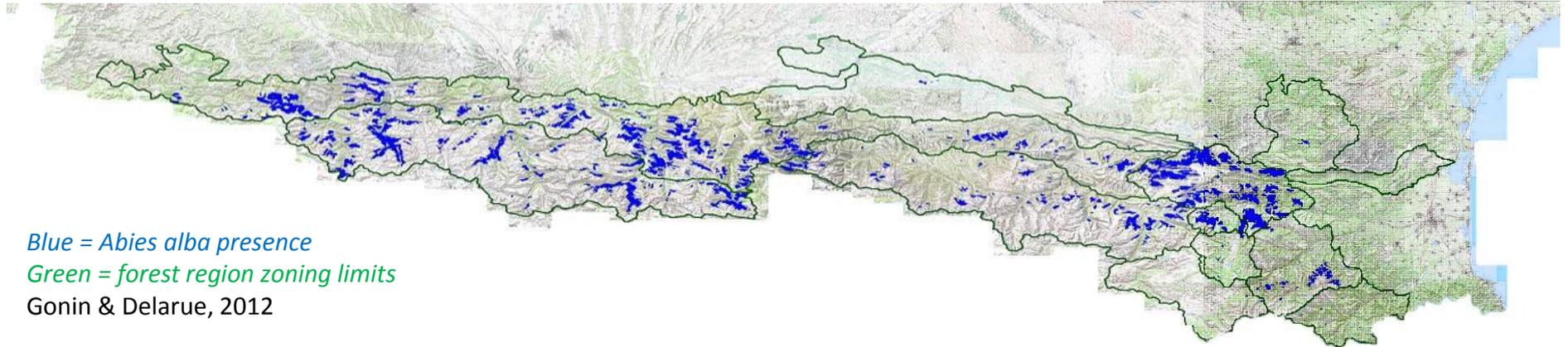
Abies alba in the Pyrenees: a more complex genetic structure than imagined?



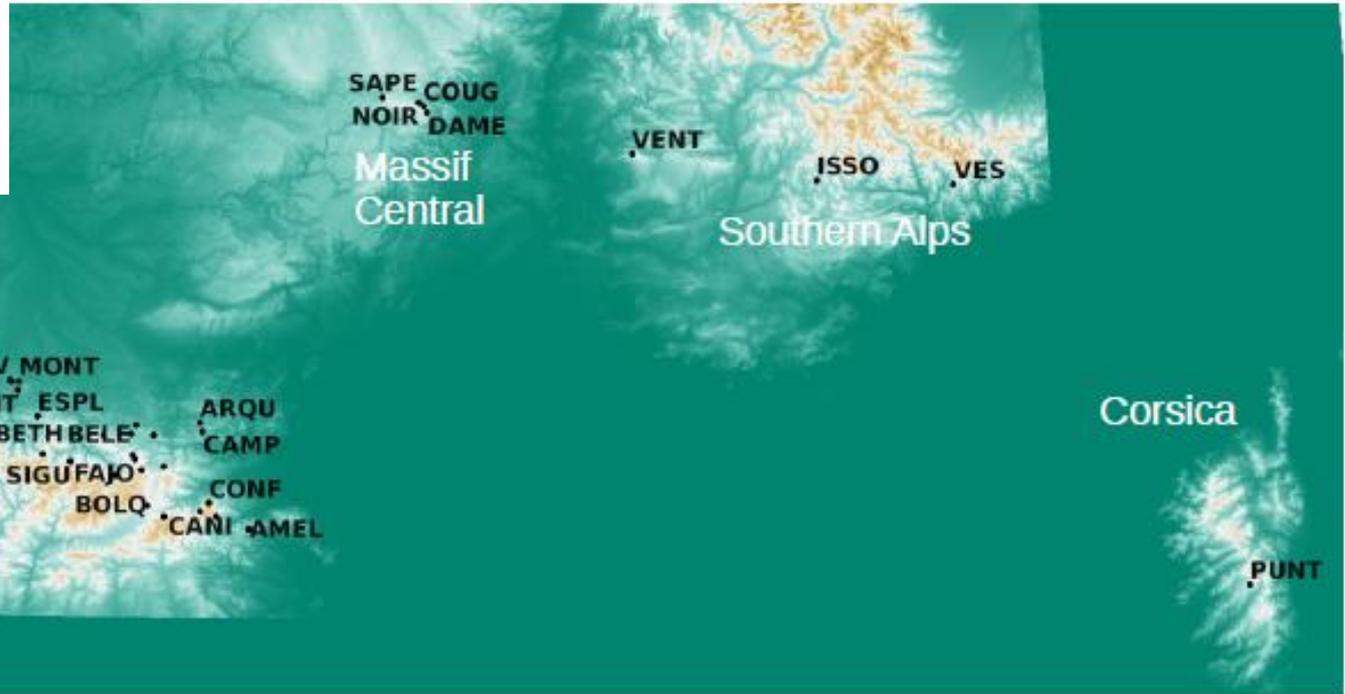
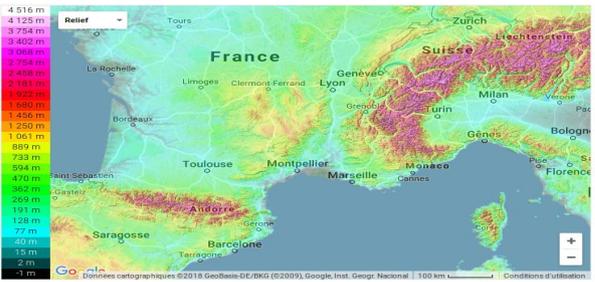
(preliminary study while addressing genetic resource conservation issues)



Abies alba in the French Pyrenees: three geomorphological and climate zones



Sampling design along ecological zones



Pyrenees : 44 natural forests x 30 samples

Central Massif : 4 sites x 30 samples

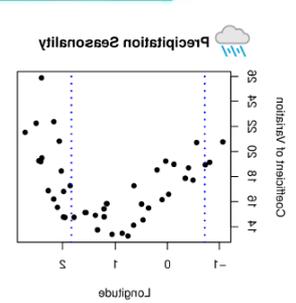
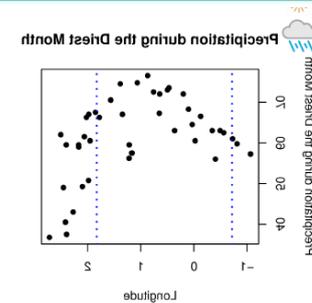
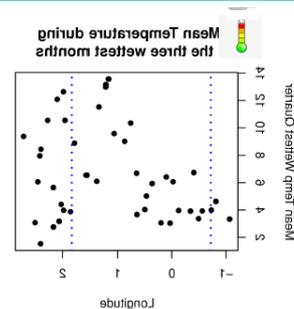
Southern Alps : 3 sites x 30 samples

Corsica : 1 sites x 30 samples

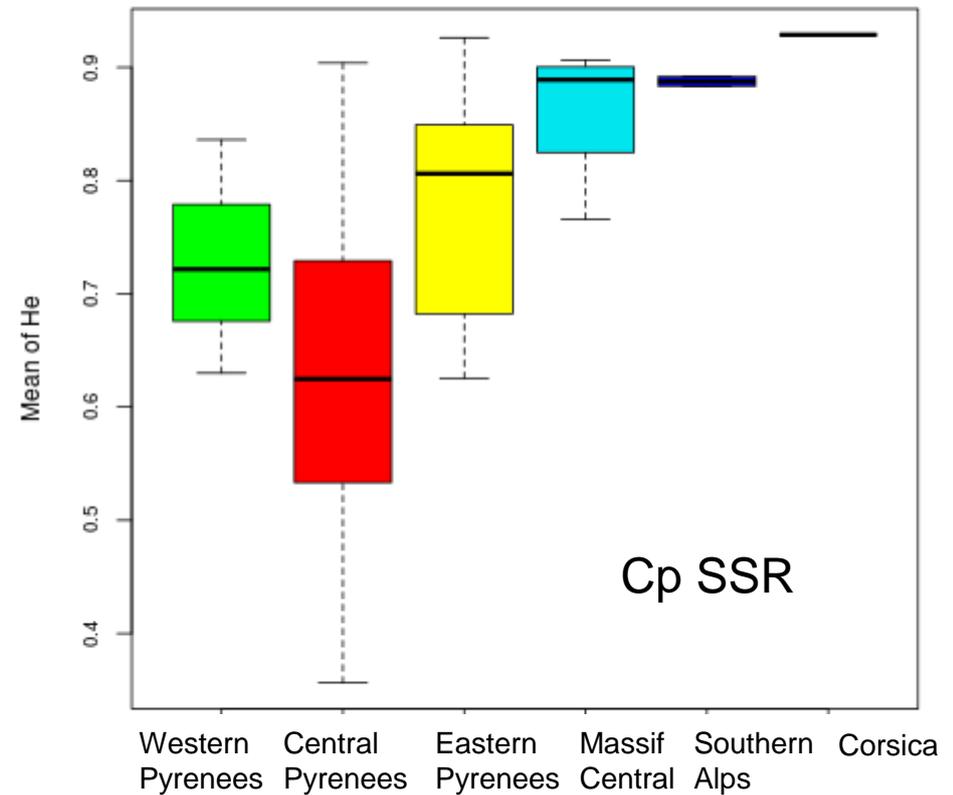
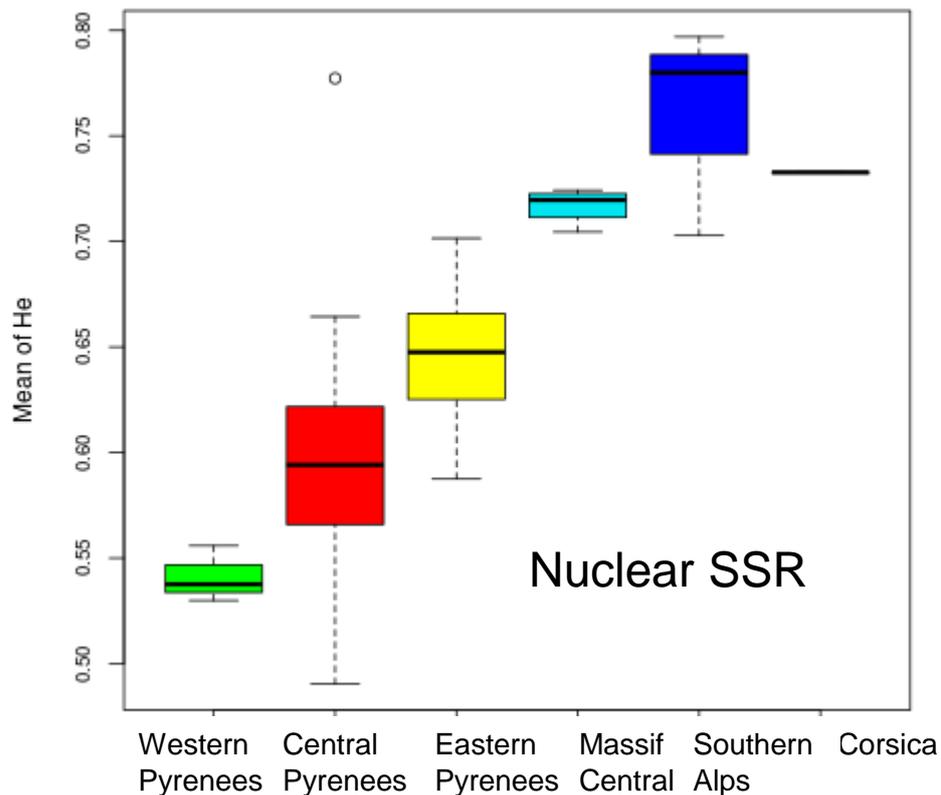
52 forests
1655 individuals



10 nSSR (Cremer et al. 2006, Hansen et al., 2005)
3 cpSSR (Liepelt et al. 2001, Vendramin & Ziegenhagen, 1997)

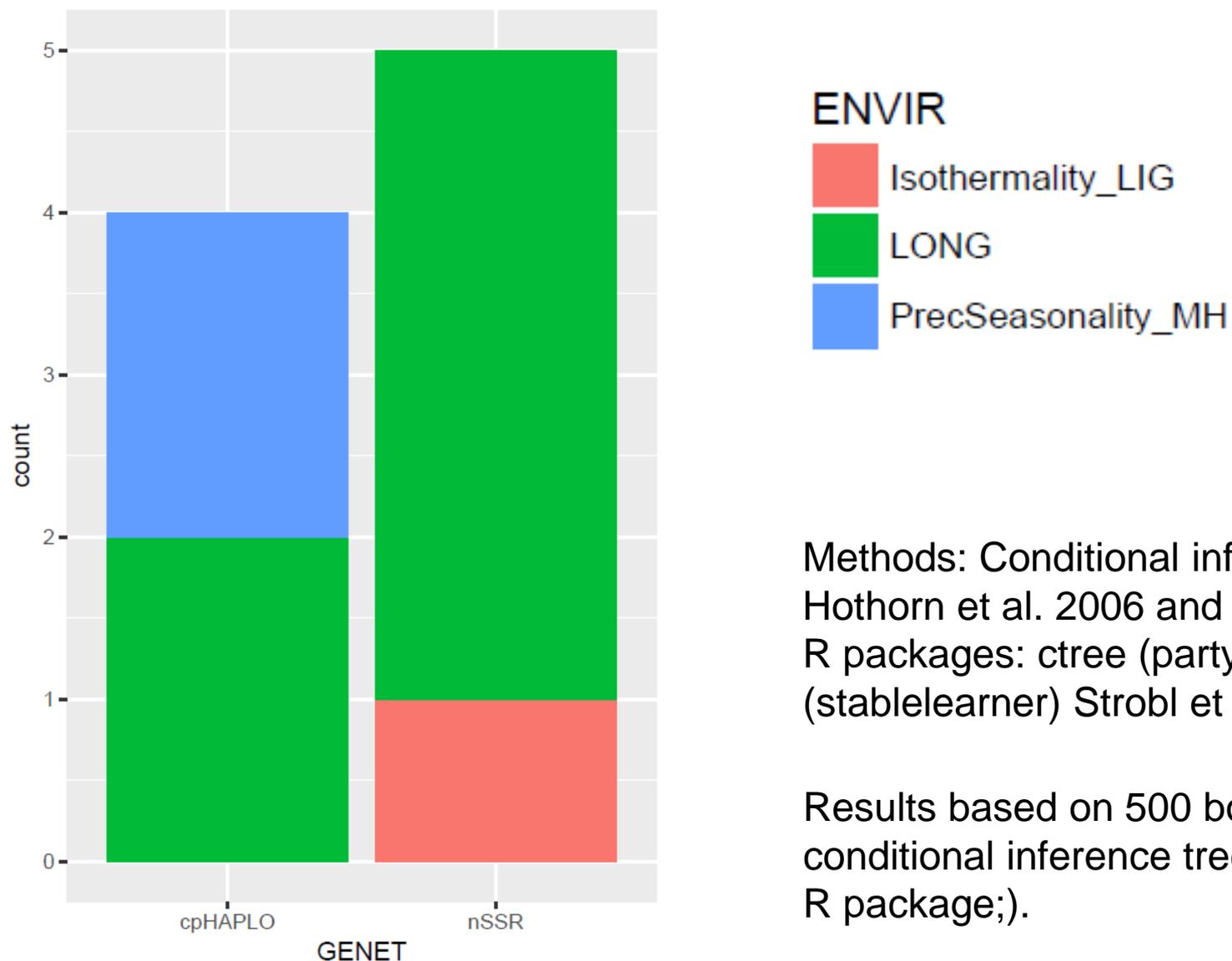


A longitudinal pattern of decreasing genetic diversity (west -> east): migration / local drift?



Genetic diversity, climate and the environment

Only three environmental and climate (WorldClim) variables (among 83 tested) have significant effects on genetic diversity (9 indicators)

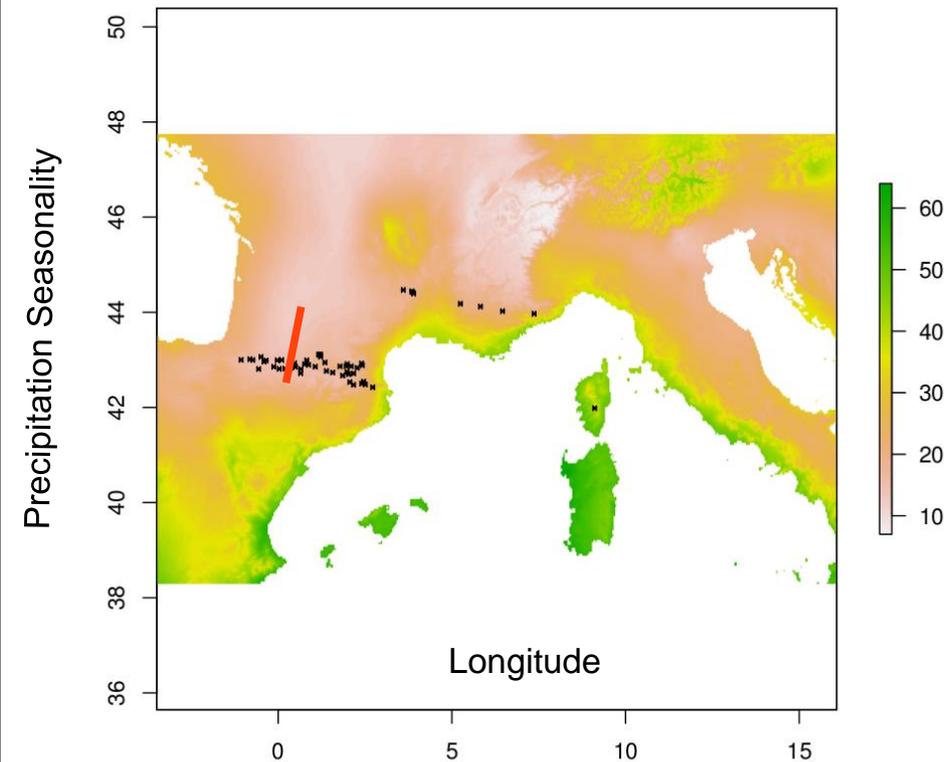
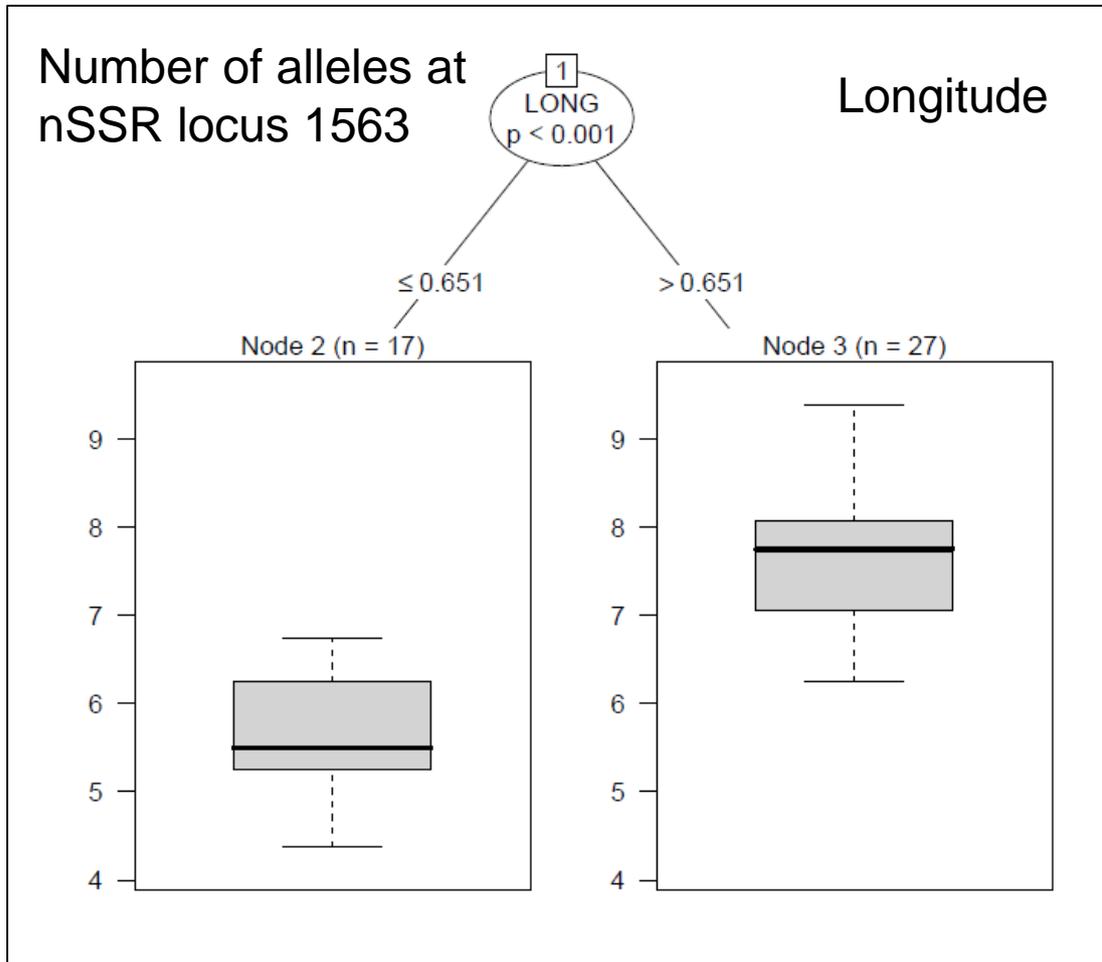


Methods: Conditional inference tree (see Hothorn et al. 2006 and Philipp et al. 2016), R packages: ctree (partykit) and stabletree (stablelearner) Strobl et al., 2008

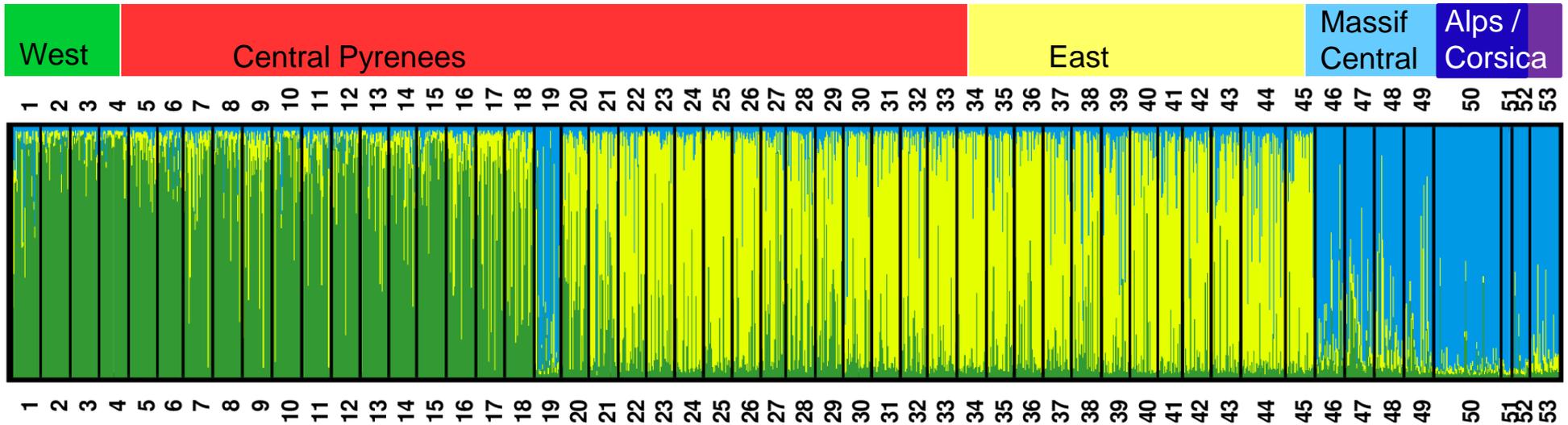
Results based on 500 bootstrapping of conditional inference trees (ctree partykit R package;).

Testing environmental and habitat effects on demography and genetic diversity

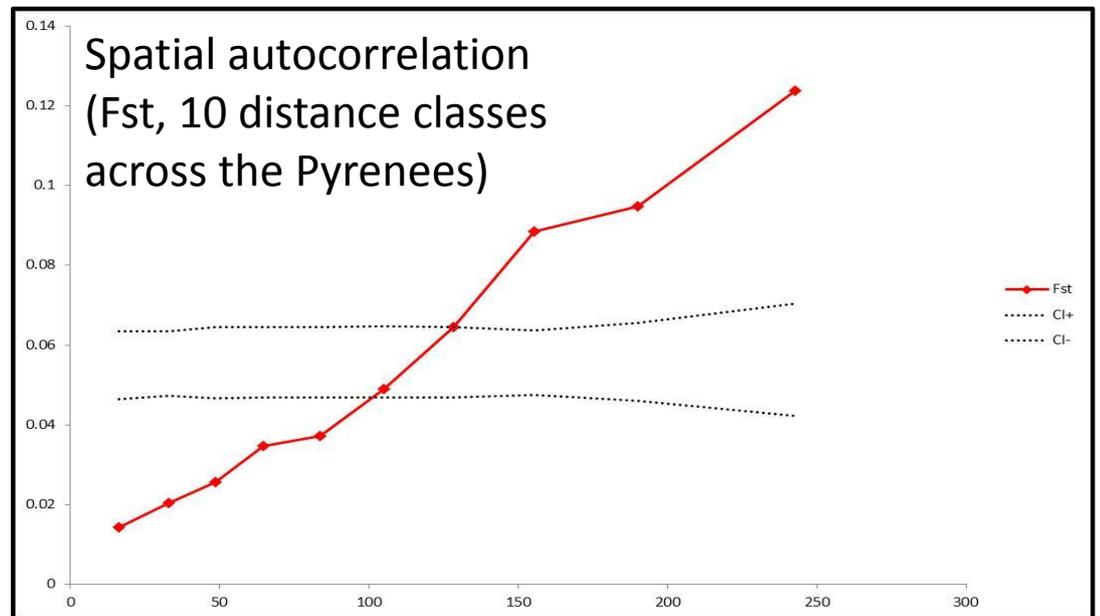
Genetic Diversity = f (Environmental variables)



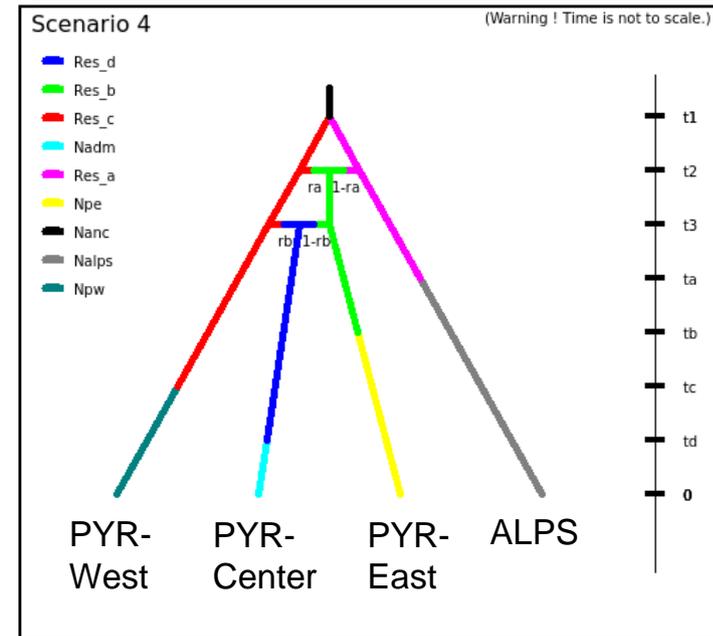
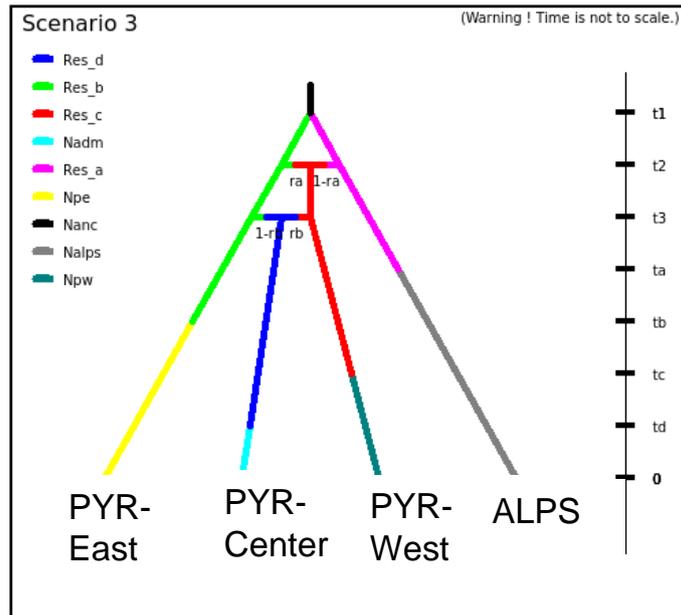
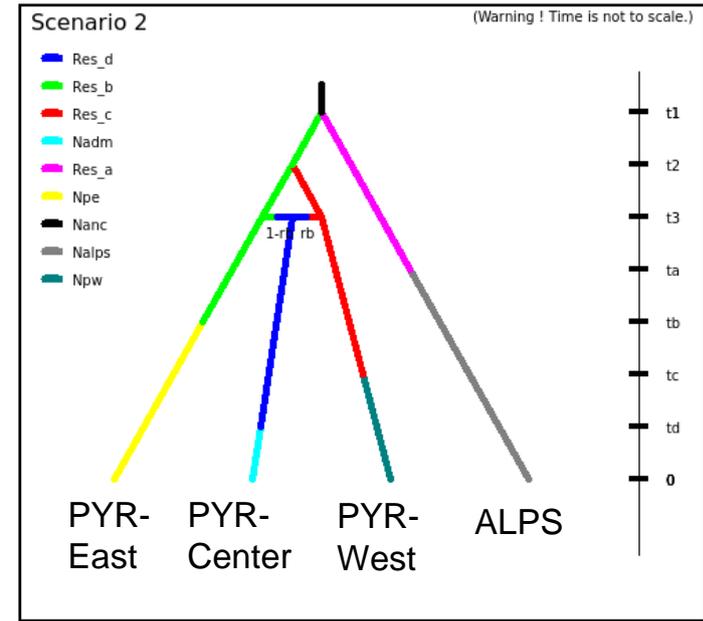
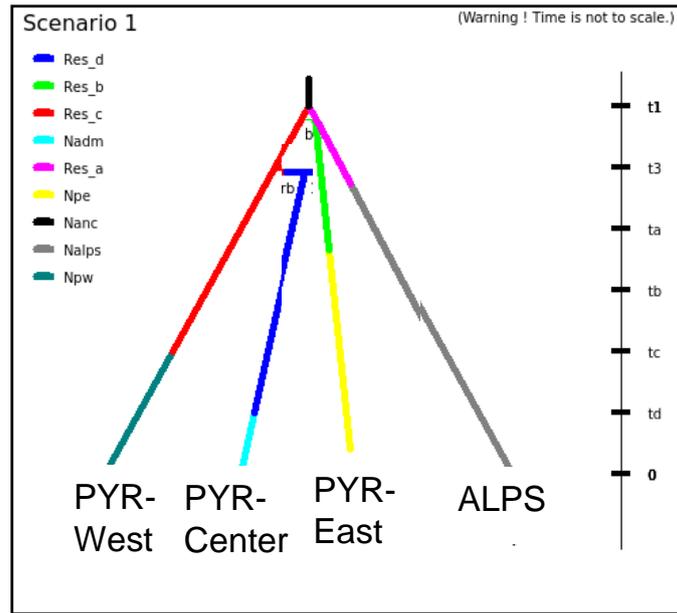
Two main genetic clusters and admixture in *A. alba* of the Pyrenees



<i>Fst</i>	Cluster	Cluster
Cluster	0.08	
Cluster	0.13	0.11

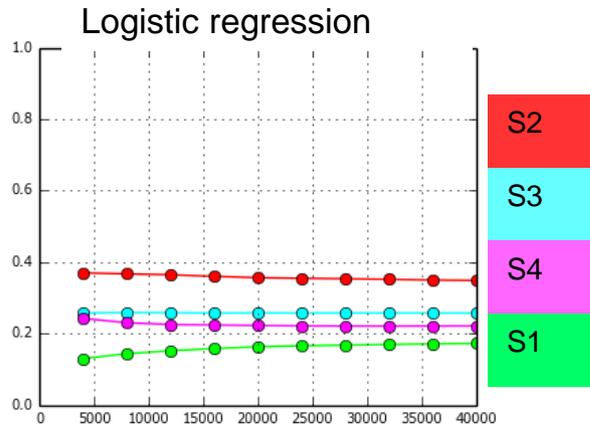


Which demographic scenario best explains the genetic data?

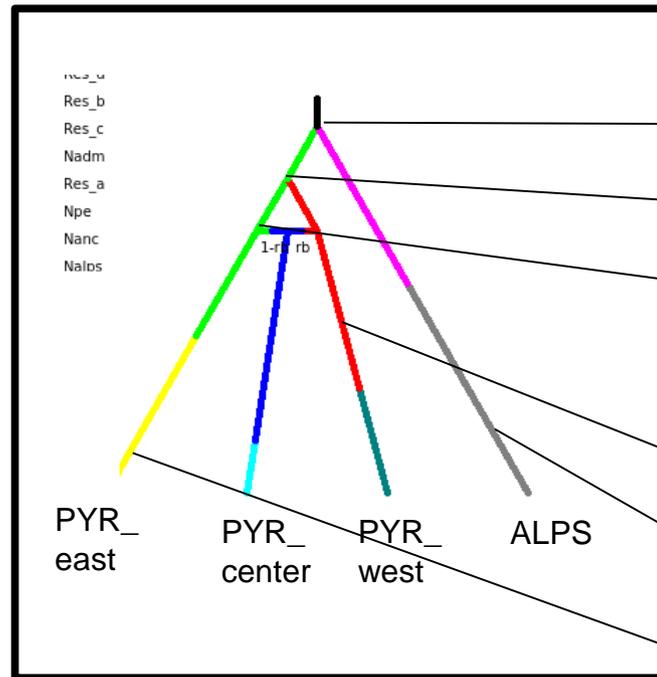


The genetic structure of *Abies alba* was shaped during the mid Quaternary in the Pyrenees

S2 : Two splits + one admixture + resizing events



Small differences
But **S2** is the best

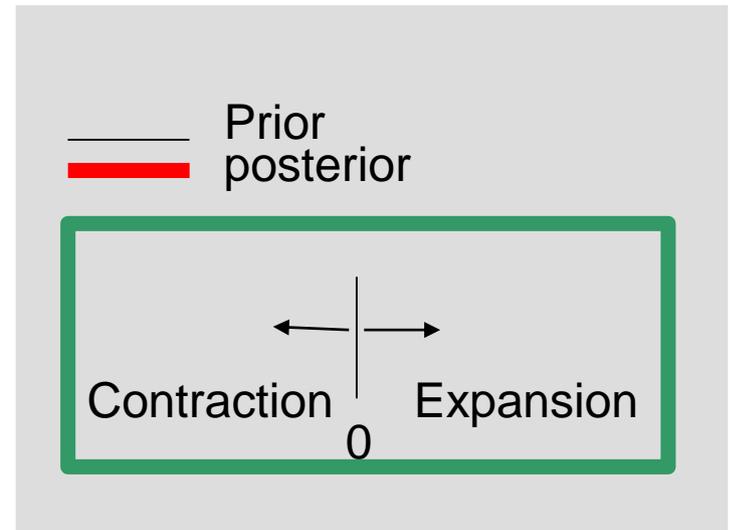
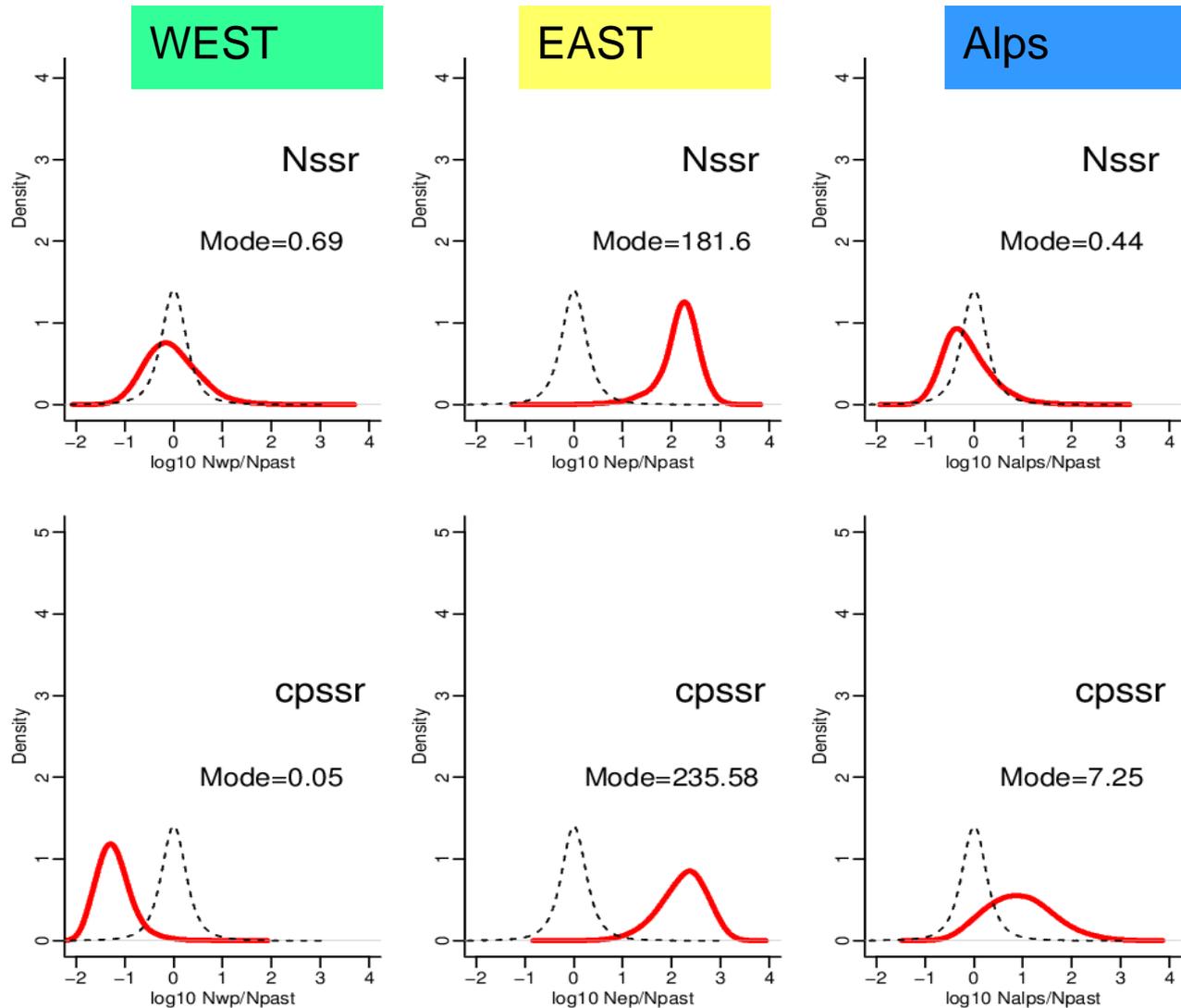


Event	Where ?	When ? generations	When ? millions years*
Split	Alps/Pyr	24253	1.2
Split	Pyr /Pyr _{w e}	21909	1.09
merge	Pyr /Pyr _{w e}	19936	0.99
Resizing	Pyr _w	14434	0.72
Resizing	Alps	13931	0.69
Resizing	Pyr _E	13707	0.68

*50 years for one generation

- Alps – Pyrenees split: >24 K generations ago (~1,2 million years BP)
- East and West Pyrenees split and admixture: 19-22K generations ago (between 0.9 and 1.1 million years BP)
- Most recent resizing: >13K generations ago (~650 000 years BP)

Demographic signatures of resizing events differ among regions



Ratio of present-to-past theta :

correctly represents ratios of effective population sizes. if constant mutation rates over time ($\mu = \mu$)

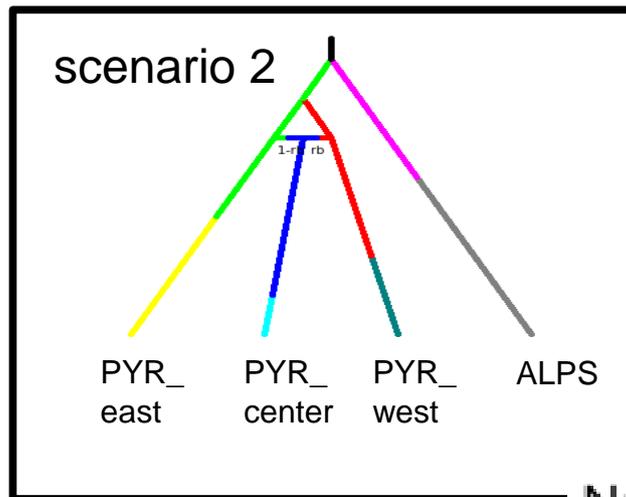
$$r = \frac{\theta_0}{\theta_1} = \frac{N_0 \mu}{N_1 \mu} = \frac{N_0}{N_1}$$

(see Barthe et al., 2017)

Conclusions and outlook



The genetic structure of *Abies alba* in the Pyrenees results from mid-Quaternary events

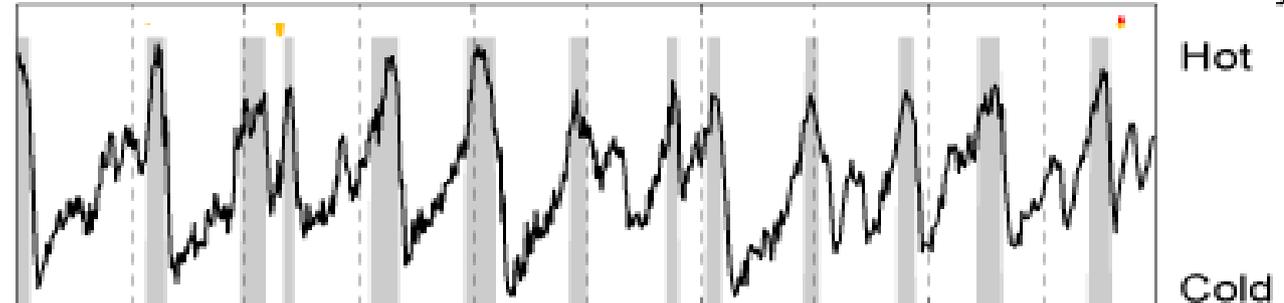
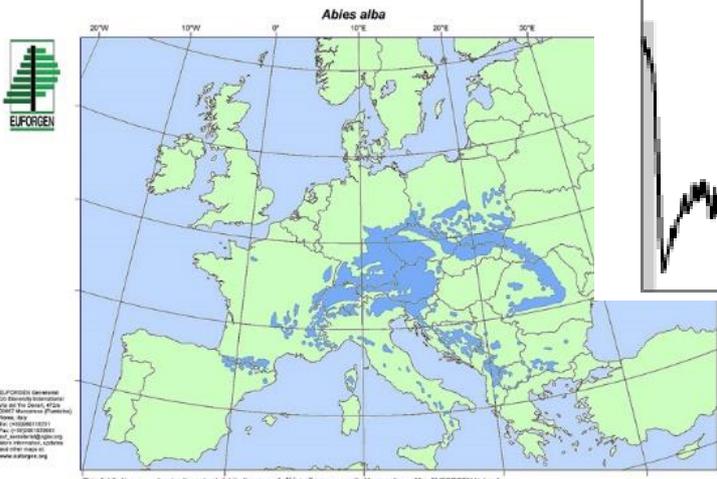


Most recent population resizing

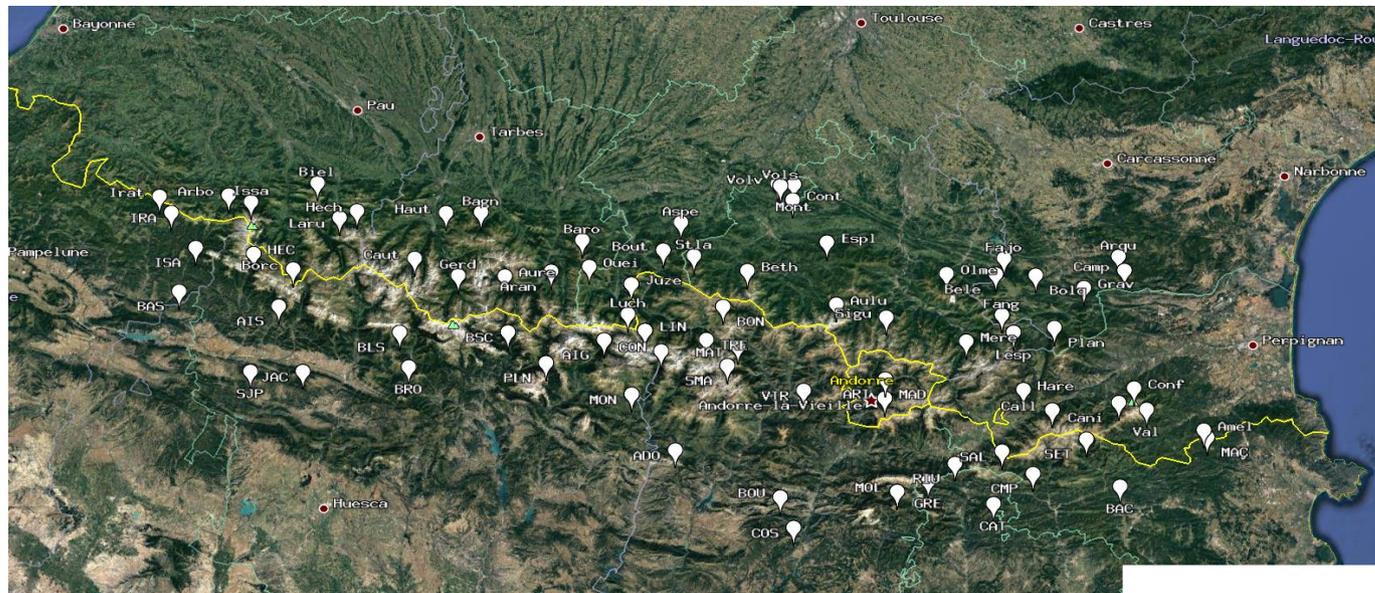
East – West Pyrenees split and admixture

Alps - Pyrenees split

Now 200 400 600 800 1000 kyr ago



Next steps : Sampling the southern, Spanish side of the Pyrenees



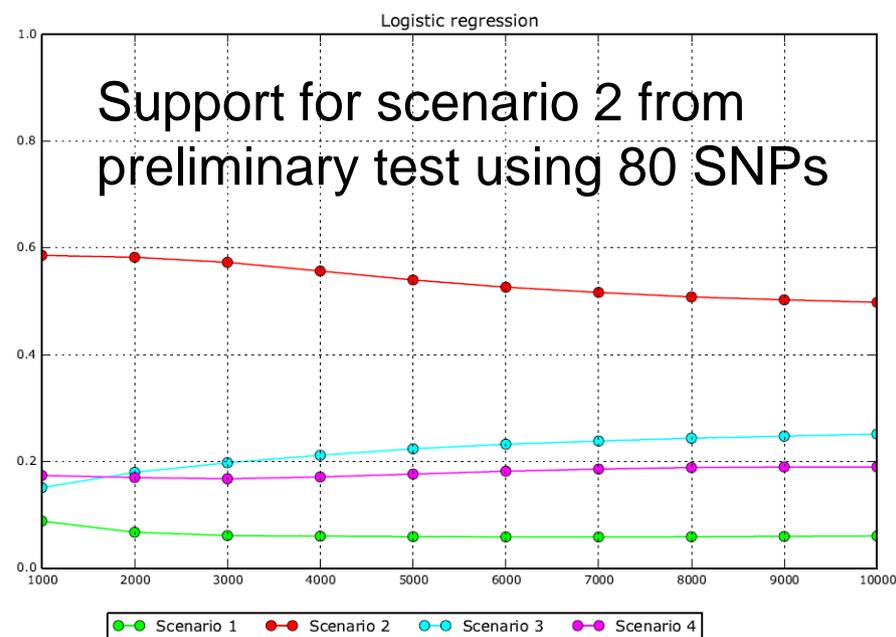
INRA,
Autonomous University
of Barcelona,
In collaboration CSIC
Zaragoza

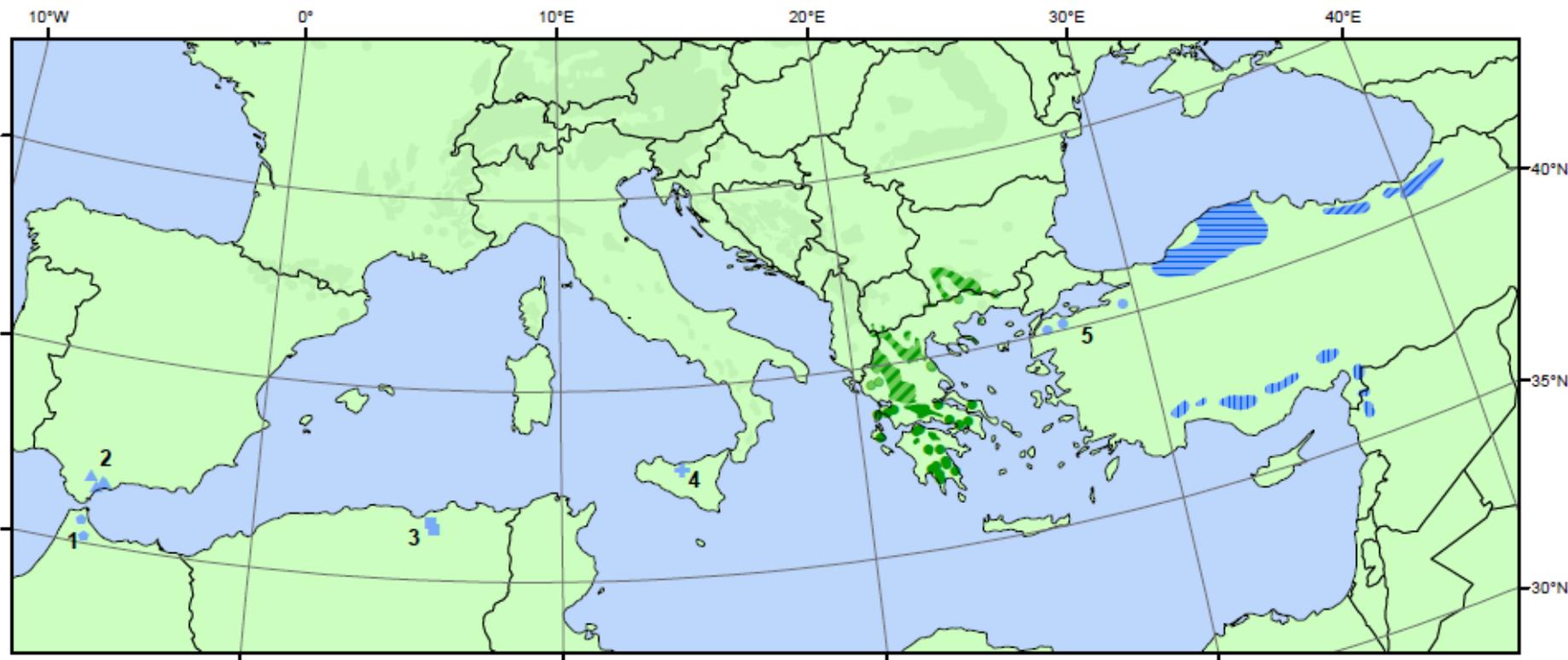
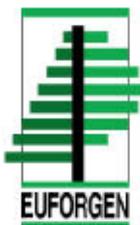
Genomic -Transcriptomic platform of
Bordeaux, Sequenom analysis



80 polymorphic SNPs

(Roschanski et al. 2013, Brousseau et al. 2016,
Roschanski et al. 2016)





- 1 *Abies marocana*
- ▲ 2 *Abies pinsapo*
- 3 *Abies numidica*
- + 4 *Abies nebrodensis*
- 5 *Abies equi-trojani*

-  *Abies borisii-regis*
-  *Abies bornmuelleriana*
-  *Abies cephalonica*
-  *Abies cilicica*
-  *Abies nordmanniana*
-  *Abies alba*

This distribution map, showing the natural distribution area of *Abies bornmuelleriana*, *Abies borisii-regis*, *Abies cephalonica*, *Abies cilicica*, *Abies equi-trojani*, *Abies marocana*, *Abies nebrodensis*, *Abies nordmanniana*, *Abies numidica*, *Abies pinsapo* in Europe is being compiled by members of the EUFORGEN Networks

Citation: Distribution map of Mediterranean firs(*Abies bornmuelleriana*, *Abies borisii-regis*, *Abies cephalonica*, *Abies cilicica*, *Abies equi-trojani*, *Abies marocana*, *Abies nebrodensis*, *Abies nordmanniana*, *Abies numidica*, *Abies pinsapo*)
EUFORGEN 2009, www.euforgen.org

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Trees move !



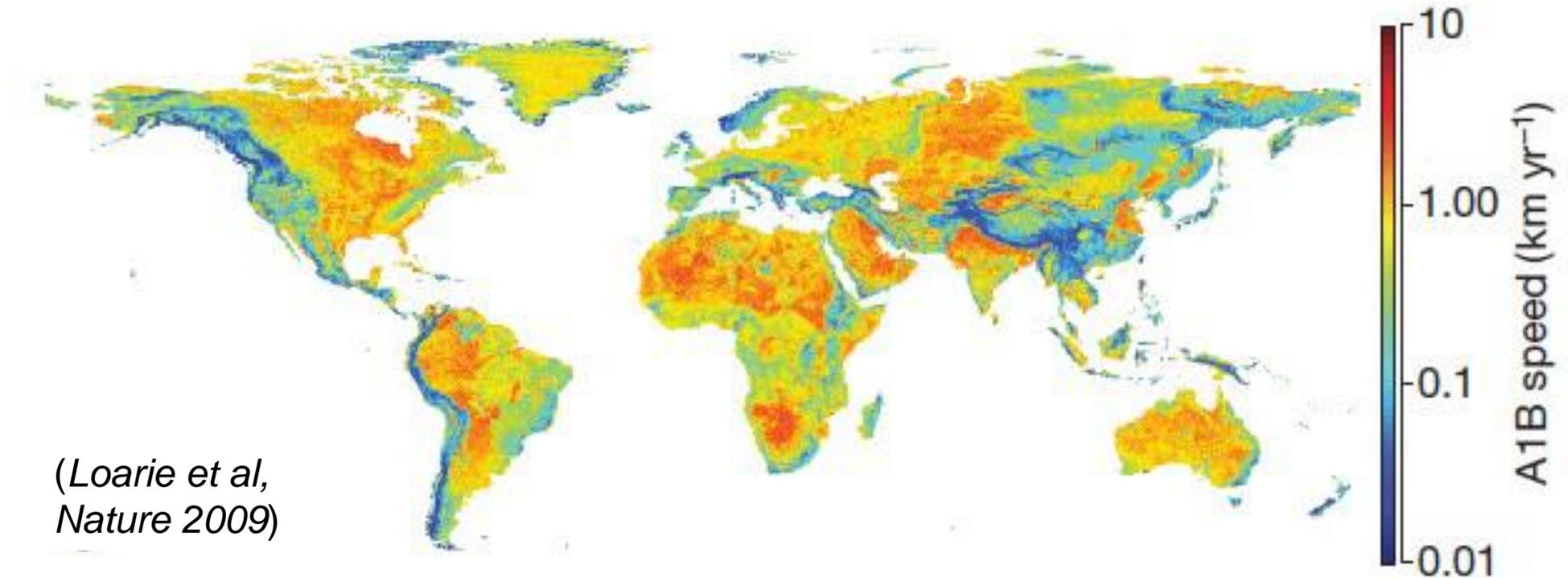
Trees move !



If we let them move...

(In situ conservation within heterogeneous landscapes)

Revisiting climate change velocity in terms of refugia

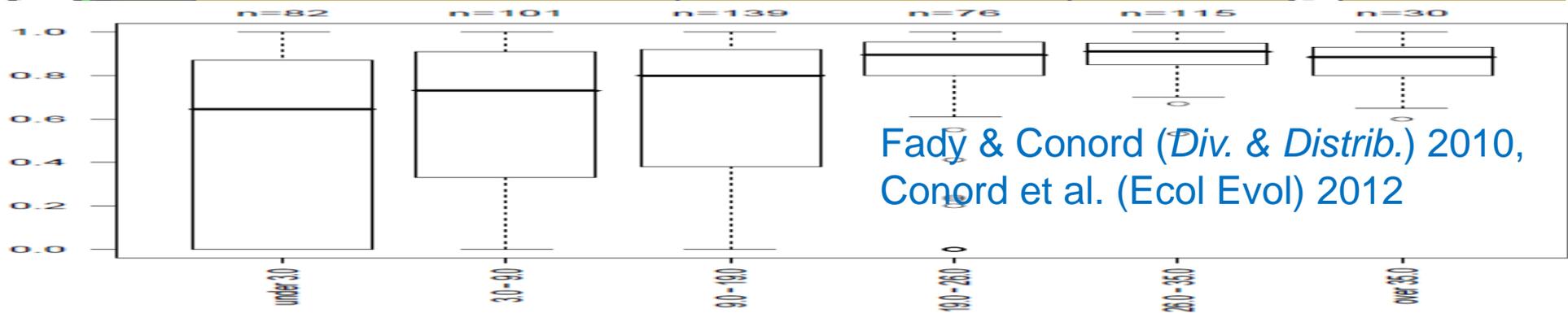
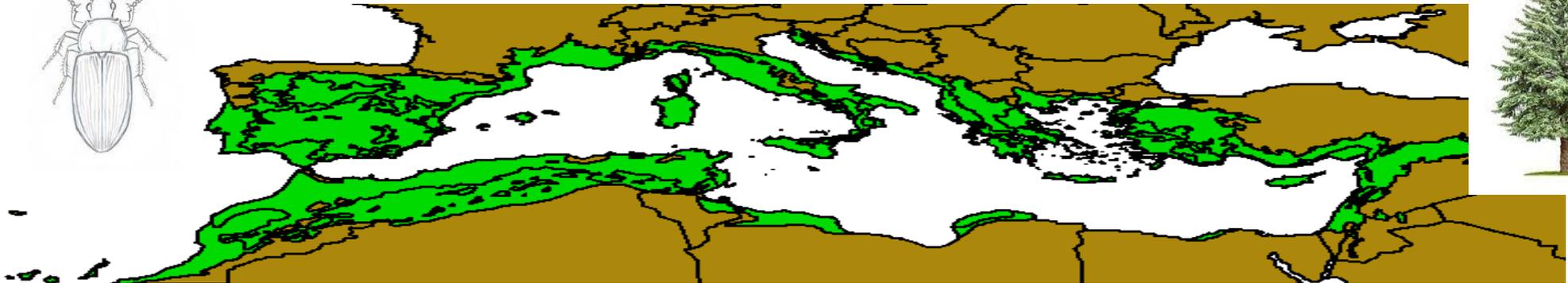
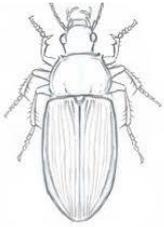


Mediterranean and mountains = hotspot of geomorphological and habitat heterogeneity (= micro-climate and habitat suitability)

⇒ no need to run fast to remain in the same habitat when climate changes

⇒ likely candidate for many altitudinal refugia (meta-population dynamics for many species)

Revisiting climate change velocity in the Mediterranean



Fady & Conord (*Div. & Distrib.*) 2010,
Conord et al. (*Ecol Evol*) 2012

Some expectations (depending on ecological requirements) for testing:

- Low-elevation = drift or extinction during long cold episodes
- Mid-elevation = admixture during cold episodes
- High-elevation = long term patterns of differentiation + drift (e.g. *Abies* sp)

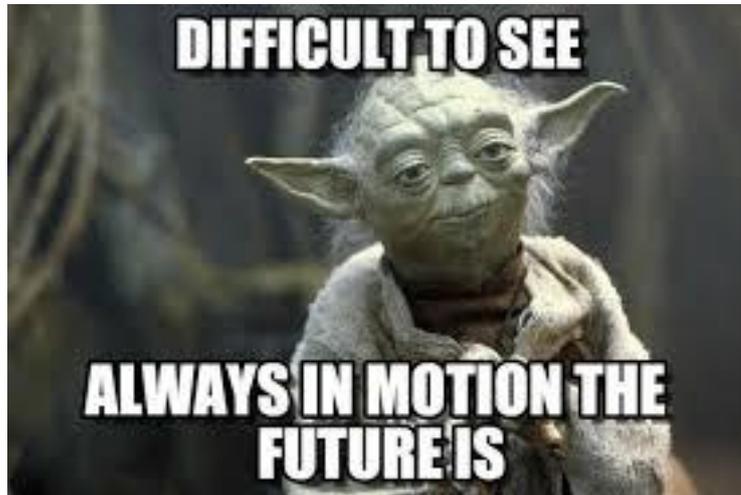


Will trees move in the future?

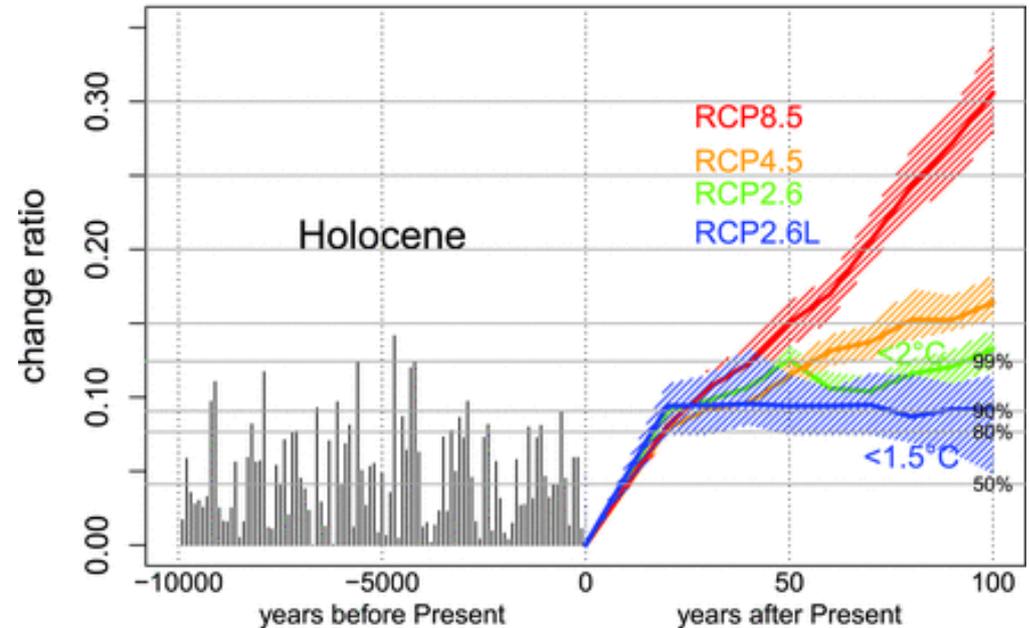


Master Yoda (1980), Star Wars: Episode V – The Empire Strikes Back, 20th Century Fox

Use the past to draw inferences for the future?



Biome type change vs Present



This is the problem!

