A brief evolutionary history of Pinus pinea L

Bruno Fady, Santiago C. Gonzalez Martinez, Giovanni G. Vendramin

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Bruno Fady*,
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AgroPine 2016
18-20 May

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Formation à pin pignon (Pinus Pinea) Var, Plaine des Maures (© F Médail IMBE)

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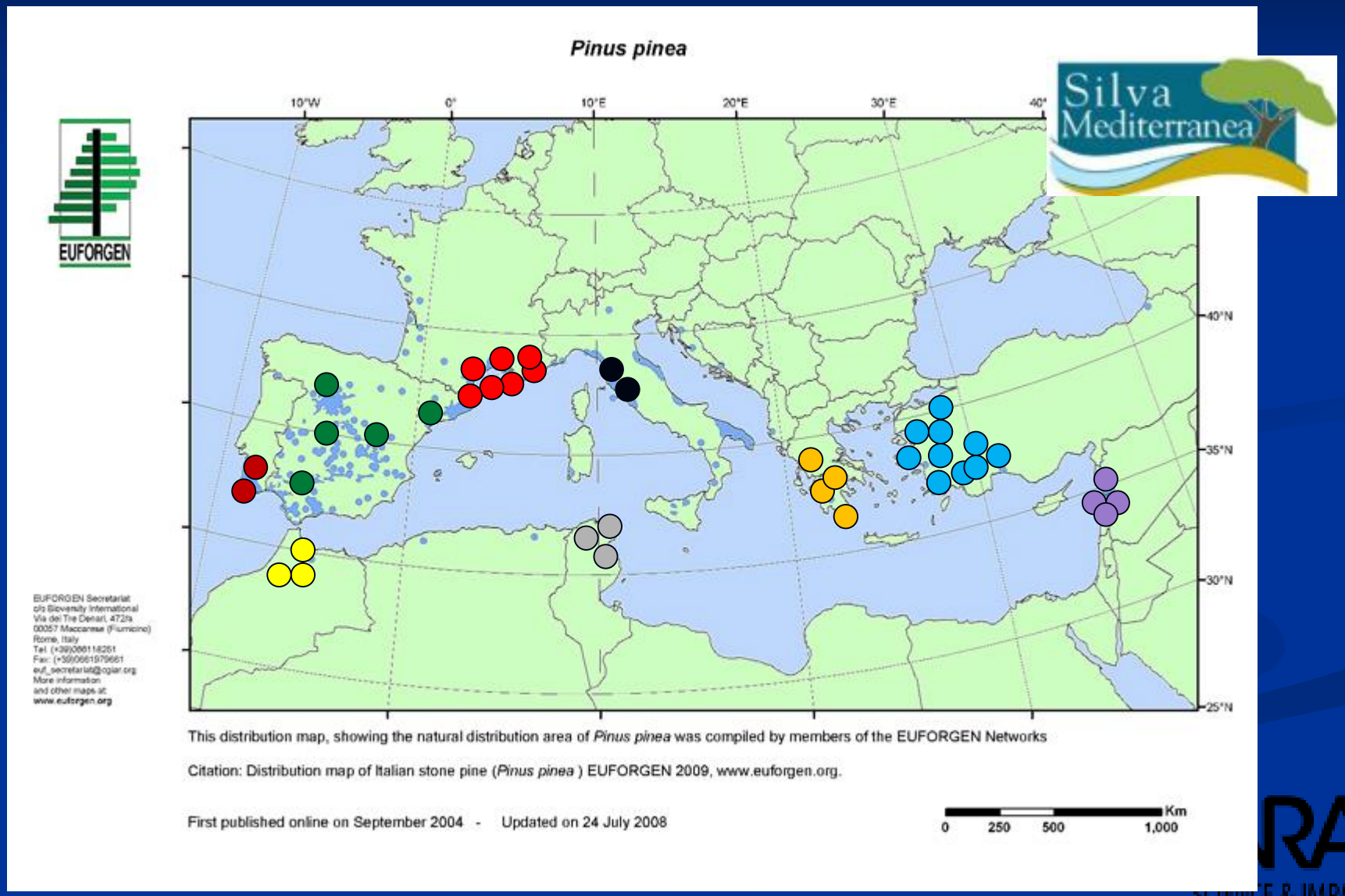
Collecting provenances from the entire geographic distribution range of Pinus pinea L.



The genetic diversity of Pinus pinea L. at isozyme loci

Study on Isozyme Variation in *Pinus pinea* L.: Evidence for Low Polymorphism

Fallour et al. (*Silvae Genet.*) 1997

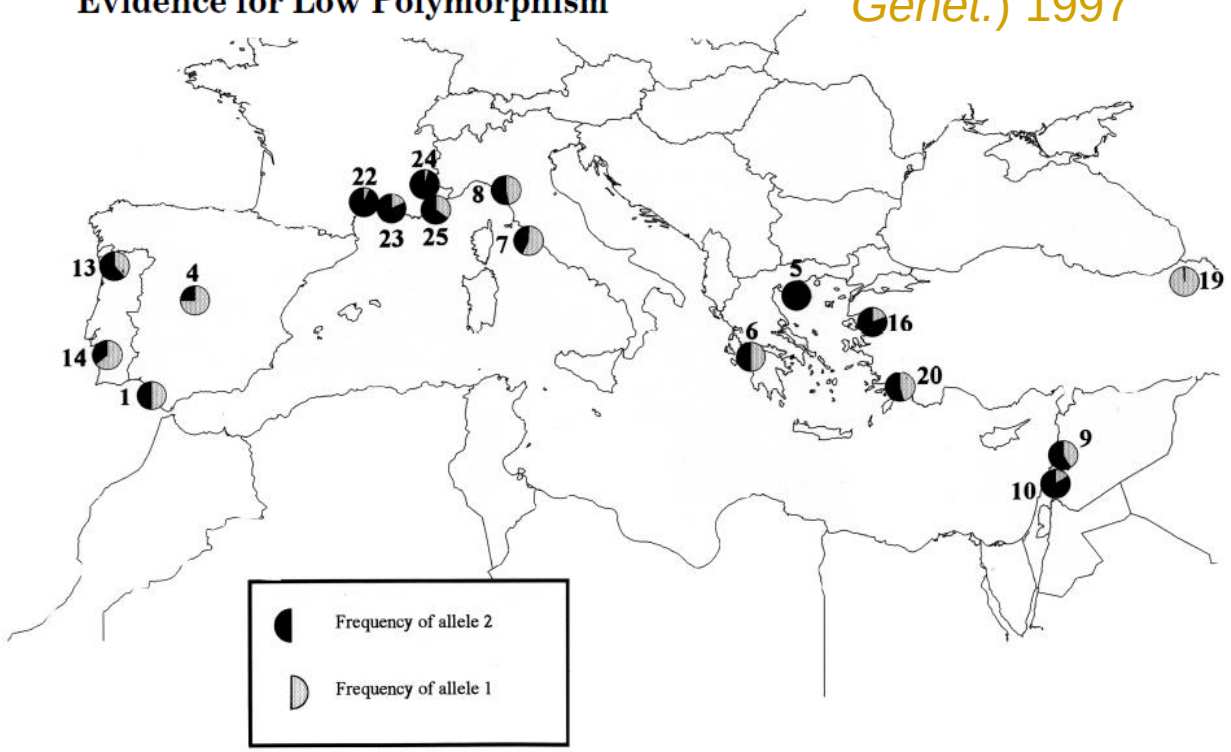


Figure 3. – Localization of the studied populations with their allele frequencies at the ME locus.

P. nigra
He = 0.250

P. Sylvestris
He = 0.350

P. pinaster
He = 0.145

P. Halepensis
He = 0.100

He = 0.011 (31 loci, 25 populations)!!!
No spatial pattern!

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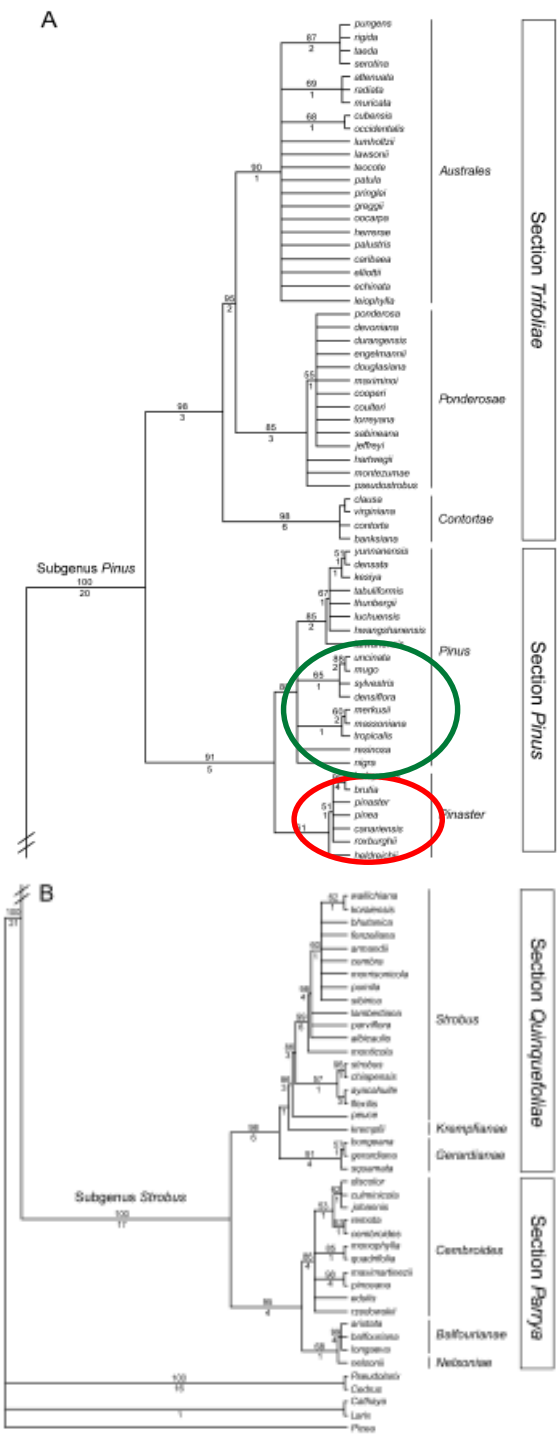
Strict consensus of 55,536 trees for the combined *rbcL* and *matK* matrix



Mediterranean pines have a common (Old World) phylogenetic origin

"True" Mediterranean pines (+ P. heldreichii): section Pinus, sub-section Pinaster

"Mountain" Mediterranean pines: section Pinus, sub-section Pinus

Gernandt et al. (*Taxon*) 2005

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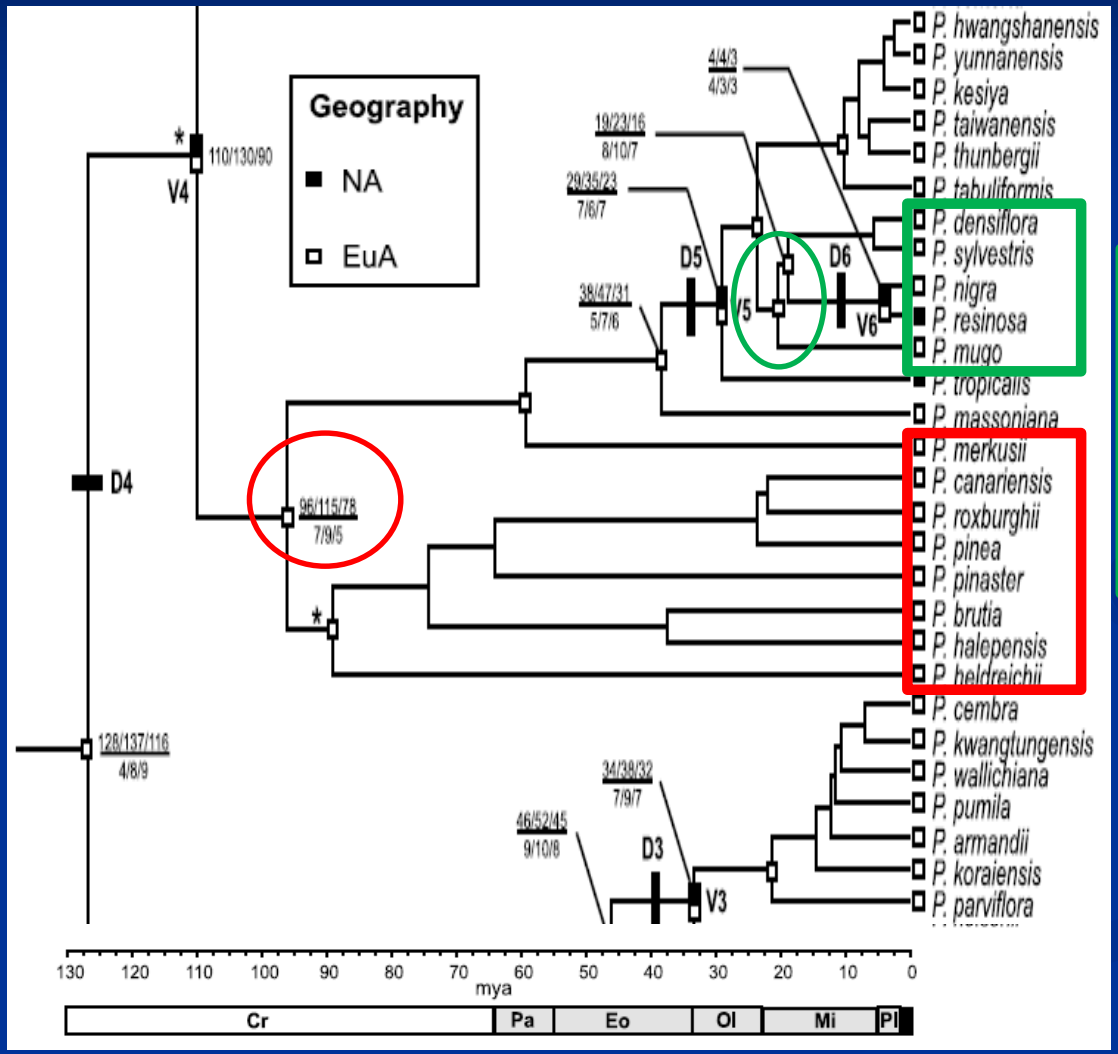
True Mediterranean pines are older than Mountain Mediterranean pines



Pines : a 128 MA-old Eurasian group

"Mountain" Mediterranean pines: a 20 MA-old Oligocene group

"True" Mediterranean pines: a 96 MA-old Cretaceous group

Eckert & Hall (*Mol Phyl Evol*) 2006 (Phylogeny made using 4 cpDNA genes)

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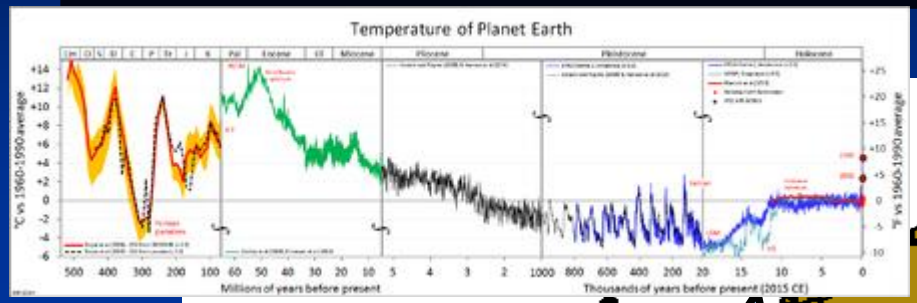
Global climate cooling and fire during the Tertiary can explain a reduced genetic diversity in "true" Mediterranean pines



Fady (AFS) 2012

See papers by Pausas et al., by Keeley et al.

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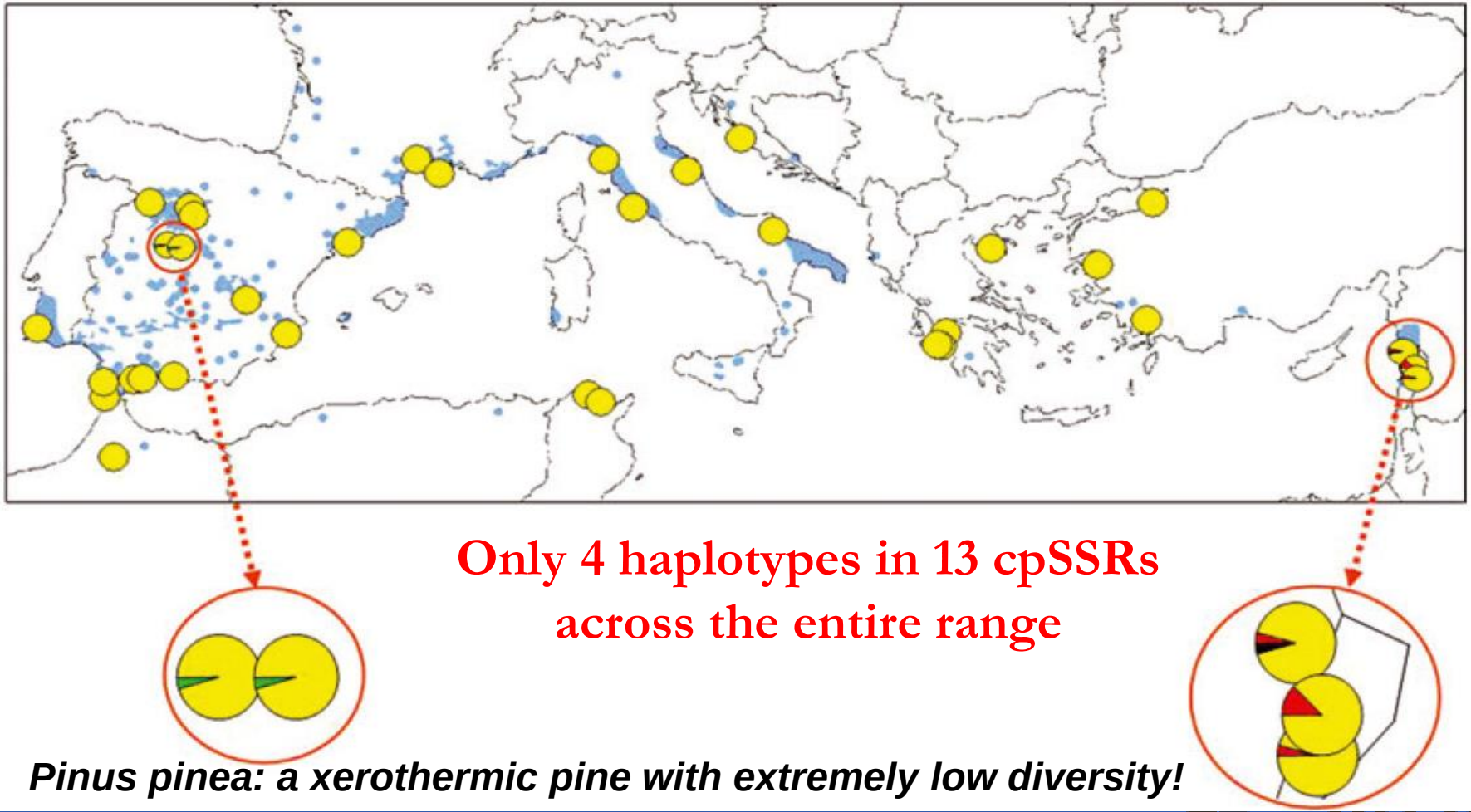
Looking for diversity in other parts of the genome of Pinus pinea*: the chloroplast genome*



Only 4 haplotypes in 13 cpSSRs across the entire range

Pinus pinea: a xerothermic pine with extremely low diversity!

Vendramin et al. (*Evolution*) 2007

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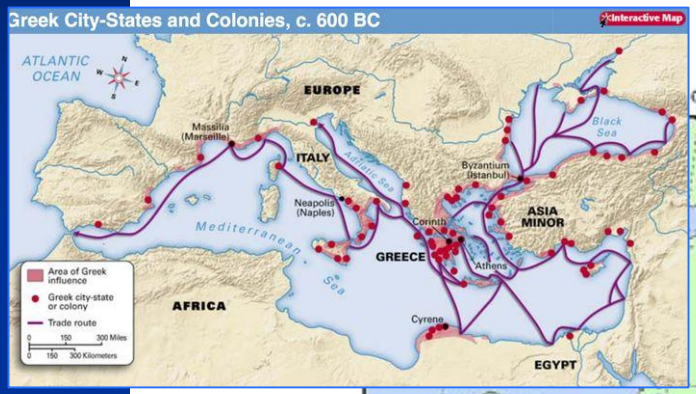
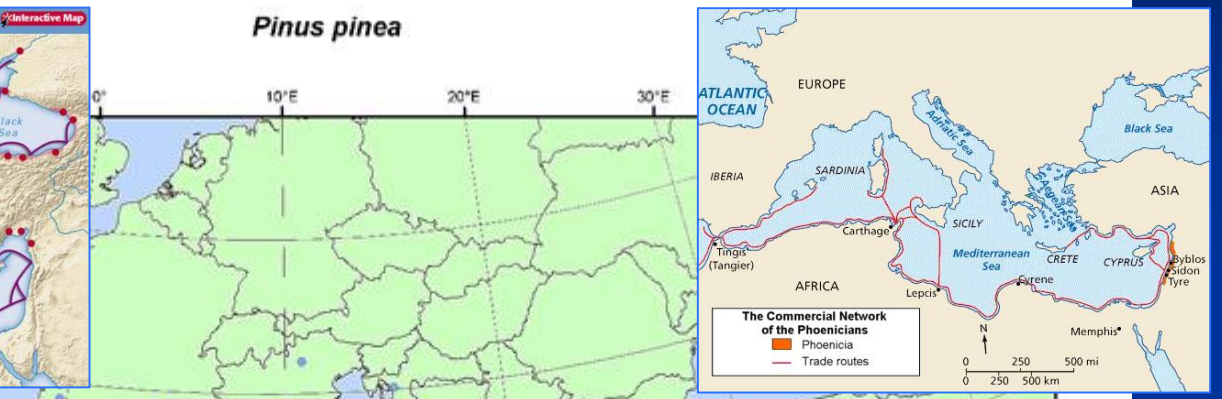
Extreme low diversity: glacial cycles and human historical trading routes. Just an explanation?





Vendramin et al. (*Evolution*) 2007

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Developing new genomic resources (still): the nuclear genome again!

American Journal of Botany

American Journal of Botany: e362–e365. 2012.

AJB Primer Notes & Protocols in the Plant Sciences

Nuclear microsatellites for *Pinus pinea* (Pinaceae), a genetically depauperate tree, and their transferability to *P. halepensis*[1]

F. Pinzauti[2], F. Sebastiani[2], K. B. Budde[3], B. Fady[4], S. C. González-Martínez[3], G. G. Vendramin[2,5]

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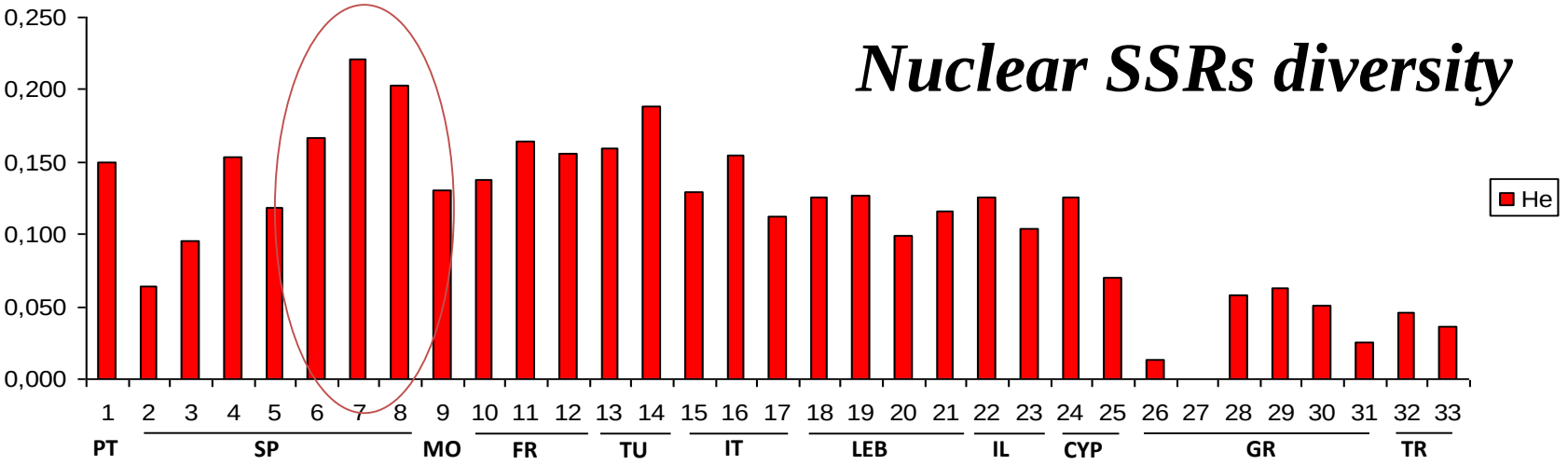
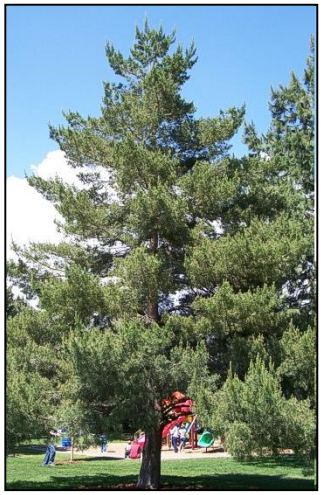
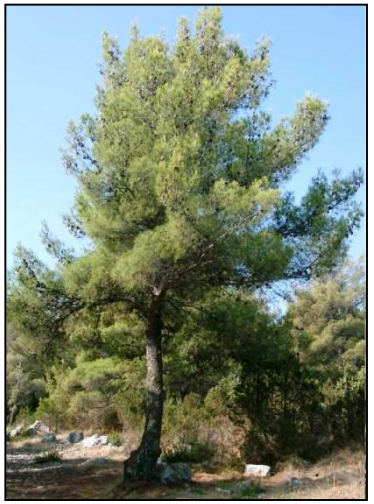
Nuclear SSRs diversity



Genetic diversity in Pinus species

Species	Heterozygosity
Pinus pinea	**0.11**
Pinus halepensis	**0.66**
Pinus pinaster	**0.82**
Pinus sylvestris	**0.88**





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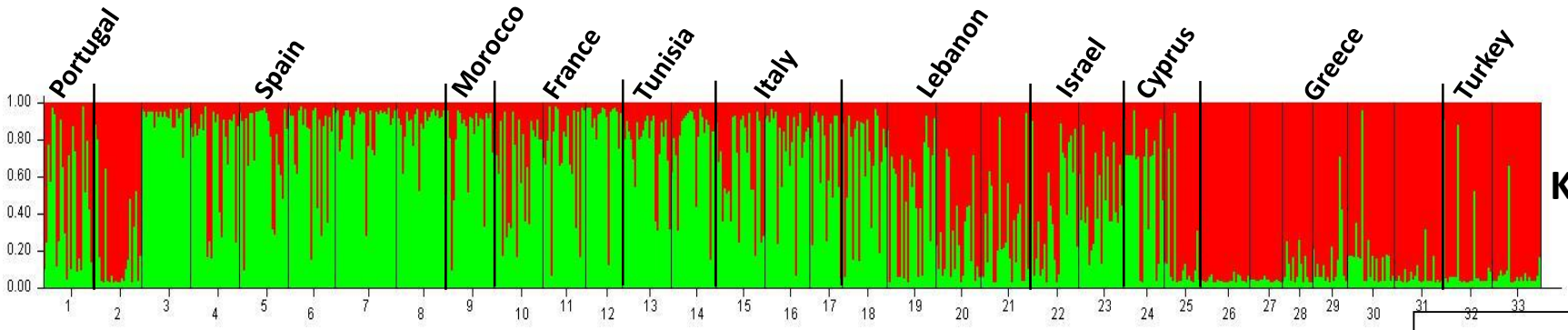
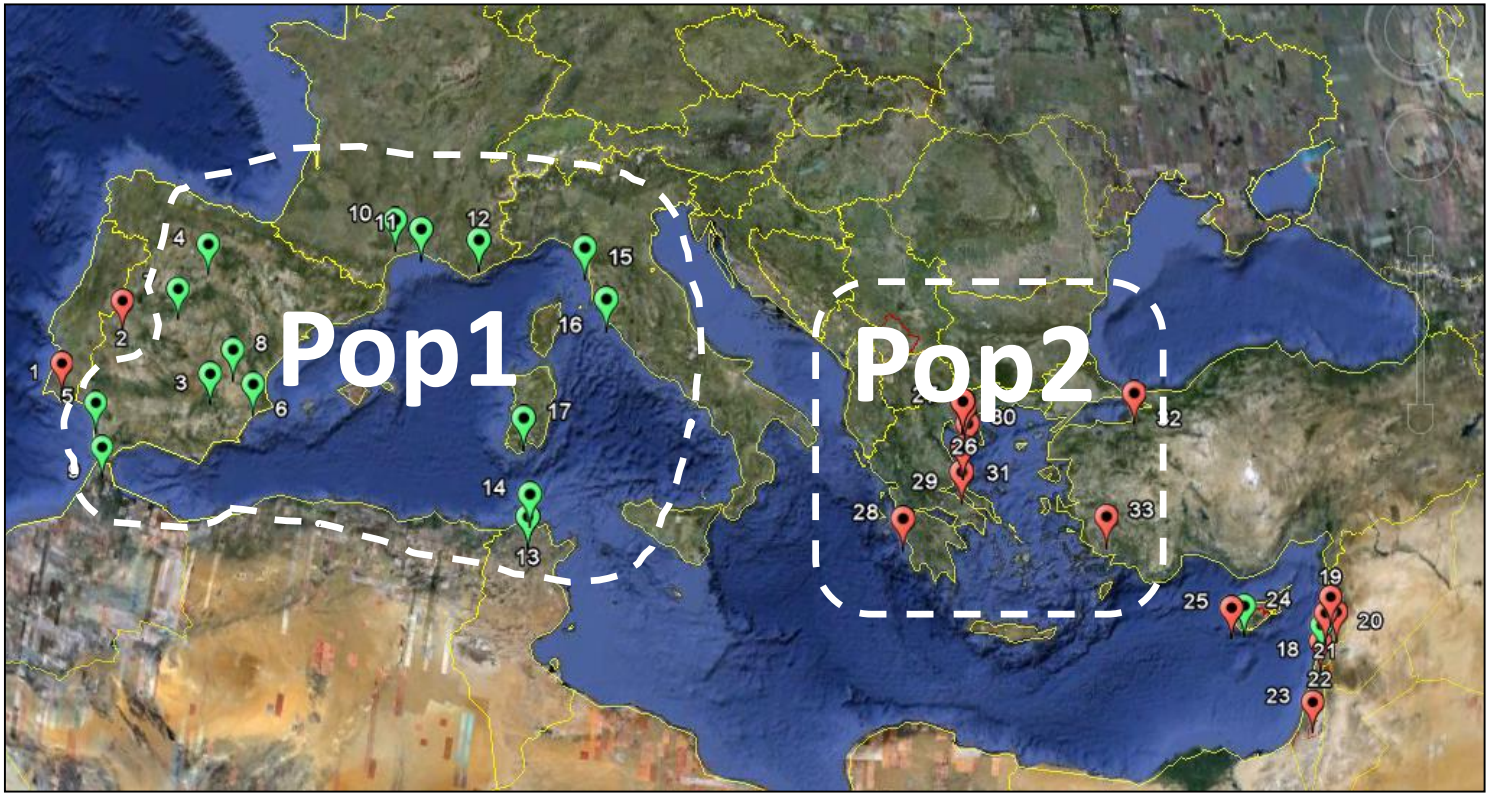
(GG Vendramin, SC Gonzalez-Martinez, et al. unpublished)



K=2

33 pop.
735 ind.



1	Quinta do Lago	Portugal
2	Garovillas	Spain
3	Bogarra	Spain
4	Palafruguell	Spain
5	Donana	Spain
6	Biar	Spain
7	San Martín de V.	Spain
8	Tarazona	Spain
9	Cap Spartel	Morocco
10	Villeneuv/Herault	France
11	Saint Maries	France
12	Saint Aygulf	France
13	Cap Bon	Tunisian
14	Rimel	Tunisian
15	Migliarino	Italy
16	Feniglia	Italy
17	Sardegna/Pula	Italy
18	Bkassine	Lebanon
19	Beit Mounzer	Lebanon
20	Kornael	Lebanon
21	Qsaibe	Lebanon
22	Masade/Golden Heights	Israel
23	Quirit/Anavin	Israel
24	Lemessos	Cyprus
25	Pafos	Cyprus
26	Chalkidiki Agios	Greek
27	Parthenonas	Greek
28	Kaiafas	Greek
29	Strofilia	Greek
30	Skopelos	Greek
31	Skiathos	Greek
32	Bursa Yalova	Turkey
33	Yatagan Katranci	Turkey

Run parameters:

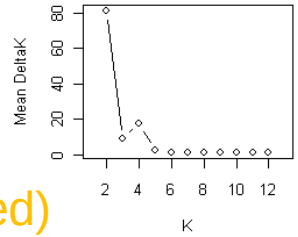
735 individuals

13 nSSR loci

K=13 populations assumed

500000 Burn-in period

100000 Reps



(GG Vendramin, SC Gonzalez-Martinez, et al. unpublished)

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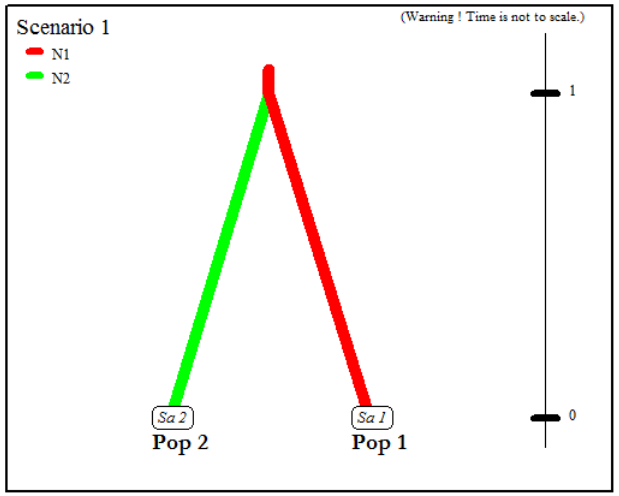
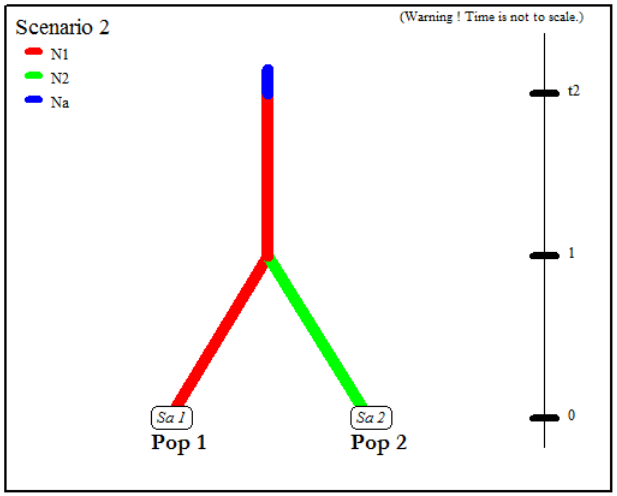
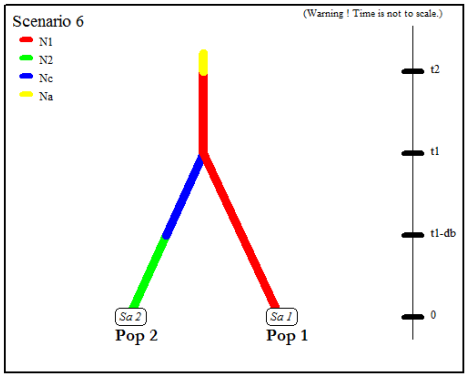
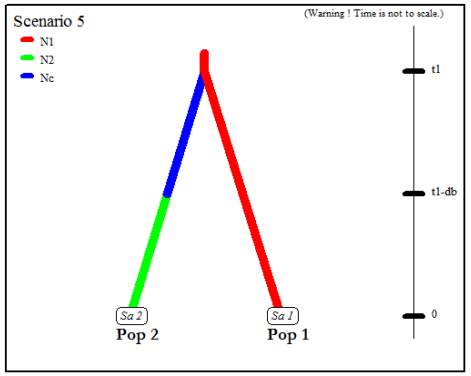






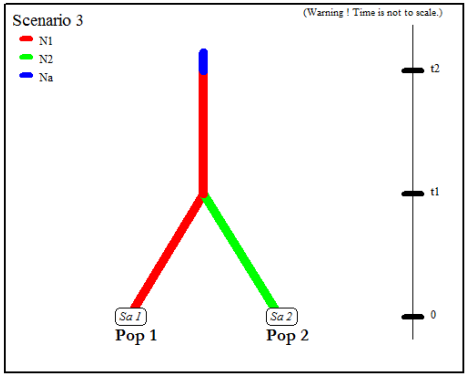


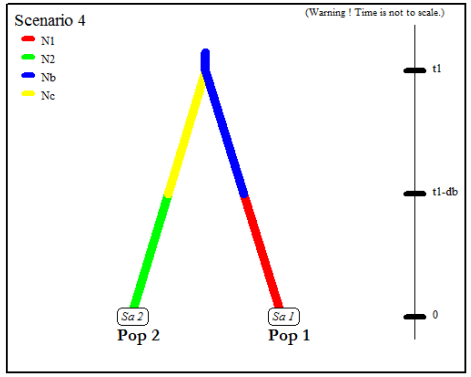
Null hypothesis I:
no genetic structure

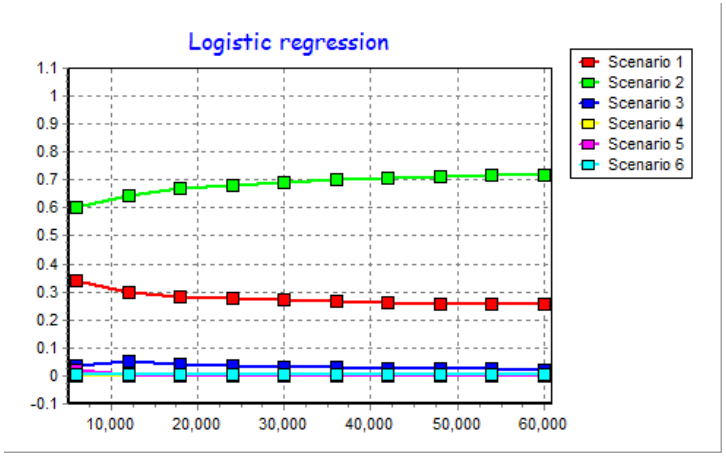
Divergence occurred just 1 generation ago

Null hypothesis II:
no genetic structure with ancient bottleneck

Divergence occurred just 1 generation ago







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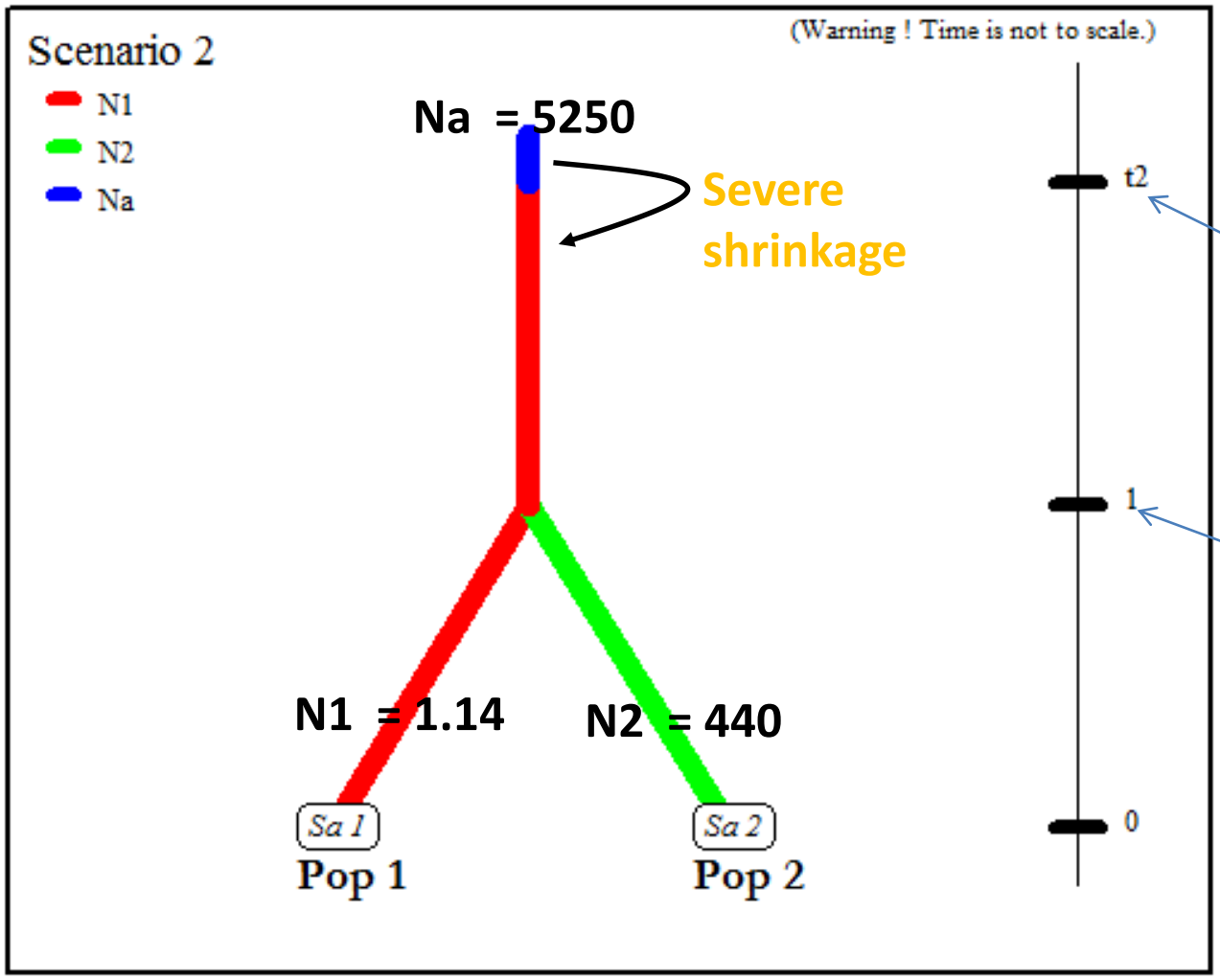
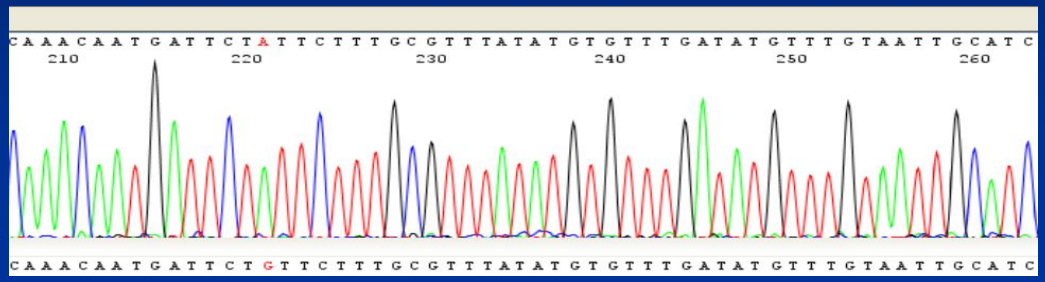
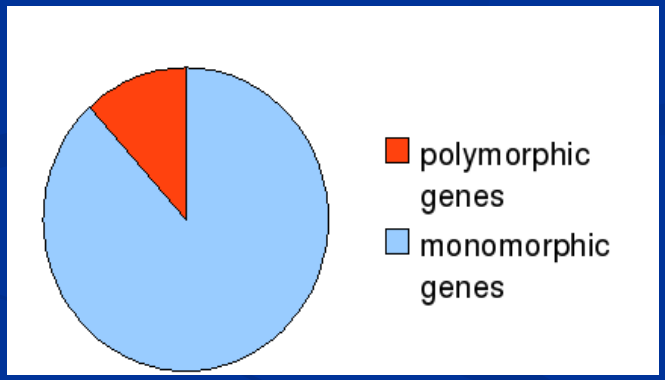
Most likely scenario;
No genetic structure with ancient population shrinkage



Developing yet new genomic resources: yet again (almost) no diversity!!



Resequencing 264 candidate genes identified in *P. taeda* => 194 gene sequences in *P. pinea*

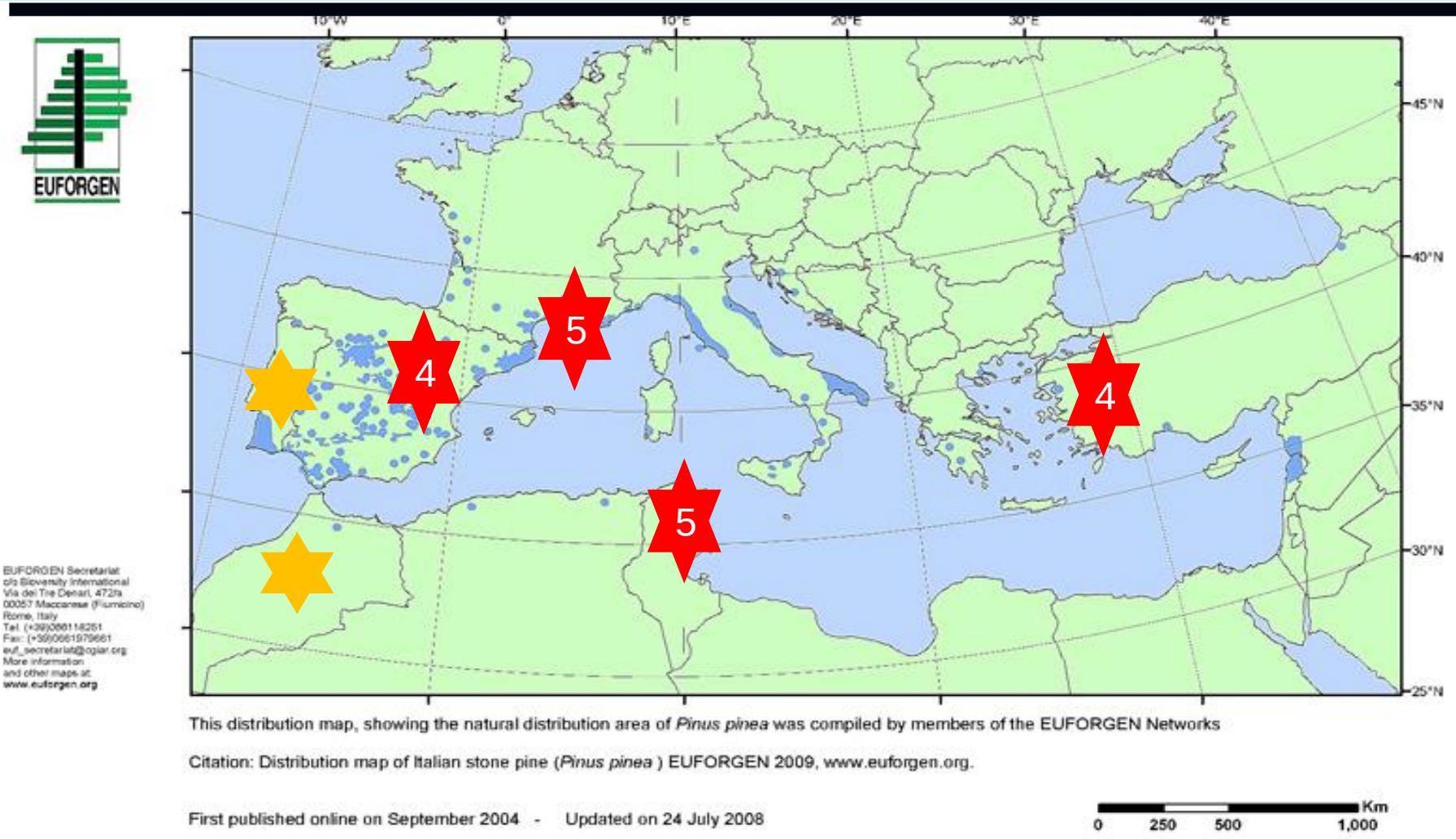


P. pinaster π = 0.0024
P. radiata π = 0.0019
P. taeda π = 0.0051
(Gonzalez-Martinez S. et al. 2006)

π = 0.000197
Total SNPs = 31
1 SNP every 1439 bases

(GG Vendramin, SC Gonzalez-Martinez, et al. unpublished)

Does (almost) no DNA diversity affects phenotypic traits? Using provenance tests with similar genetic material in the Mediterranean



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www.euforgen.org

This distribution map, showing the natural distribution area of *Pinus pinea* was compiled by members of the EUFORGEN Networks

Citation: Distribution map of Italian stone pine (*Pinus pinea*) EUFORGEN 2009, www.euforgen.org.

First published online on September 2004 - Updated on 24 July 2008

Km
0 250 500 1,000

Low genetic diversity for growth, high plasticity

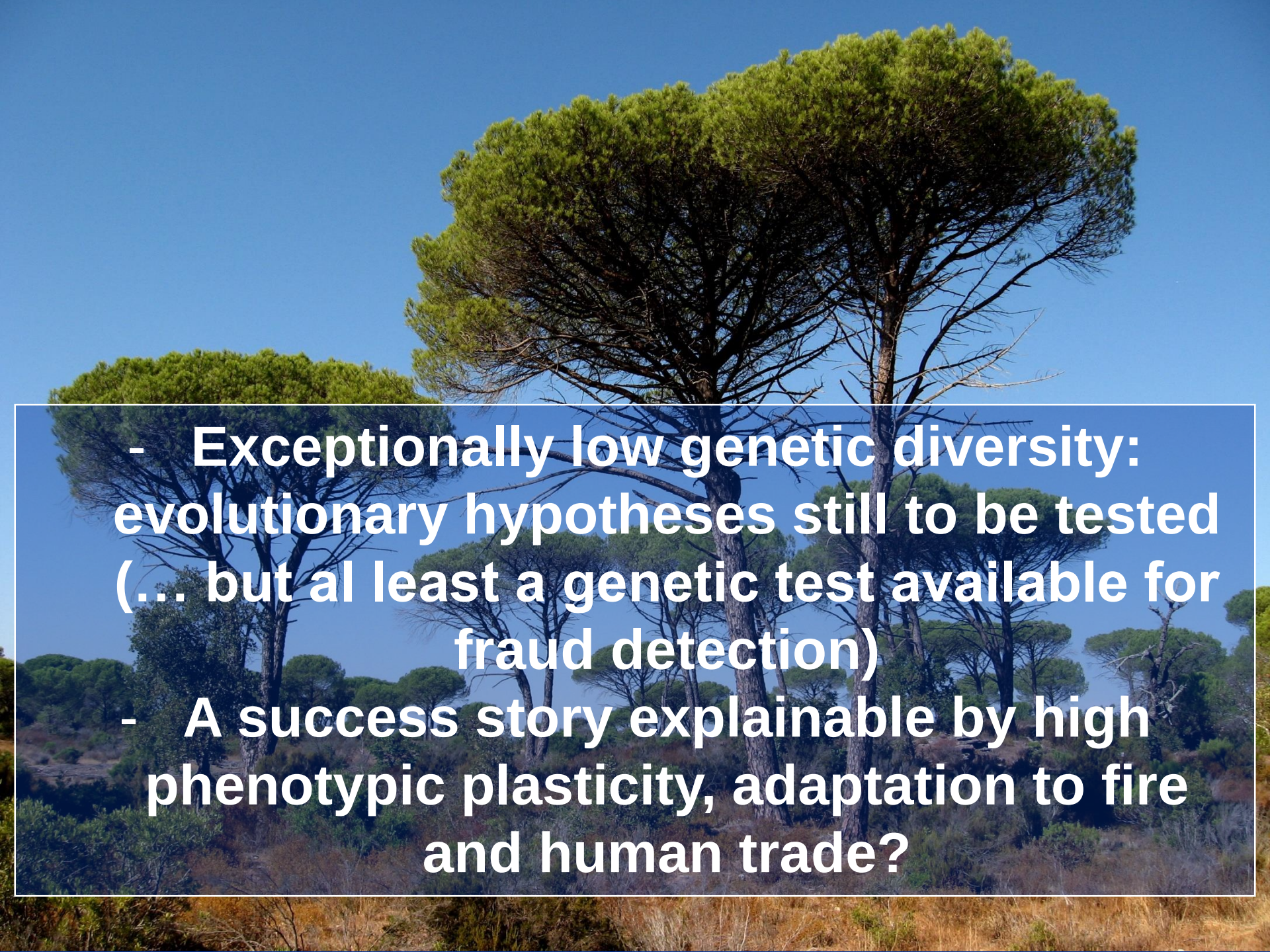
Low genetic and high environmental diversity at adaptive traits in *Pinus pinea* from provenance tests in France and Spain

Options Méditerranéennes, *A, no. 105, 2013*
Mediterranean Stone Pine for Agroforestry

S. Mutke*[1], J. Gordo **, M.L. Khouja and B. Fady****

Within site among provenance variance: 3 – 12% total variance

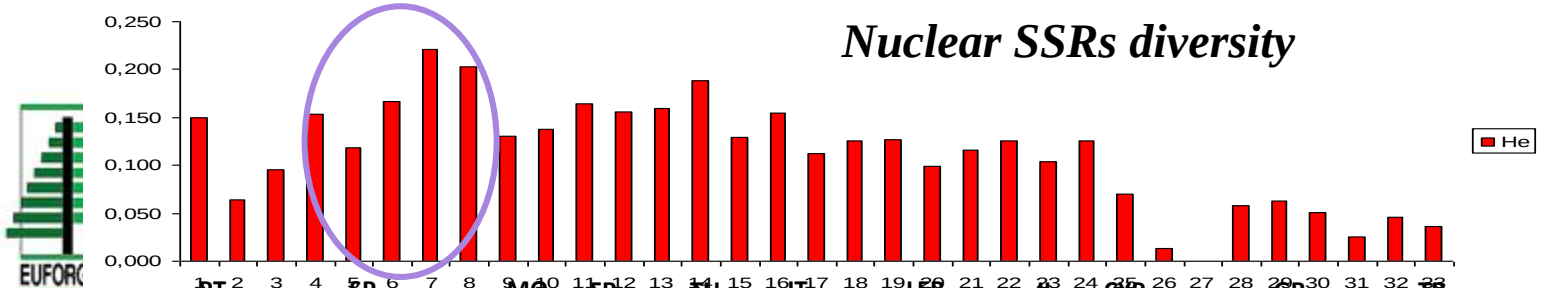
Plasticity within-provenance among sites: Up to 3 fold differences

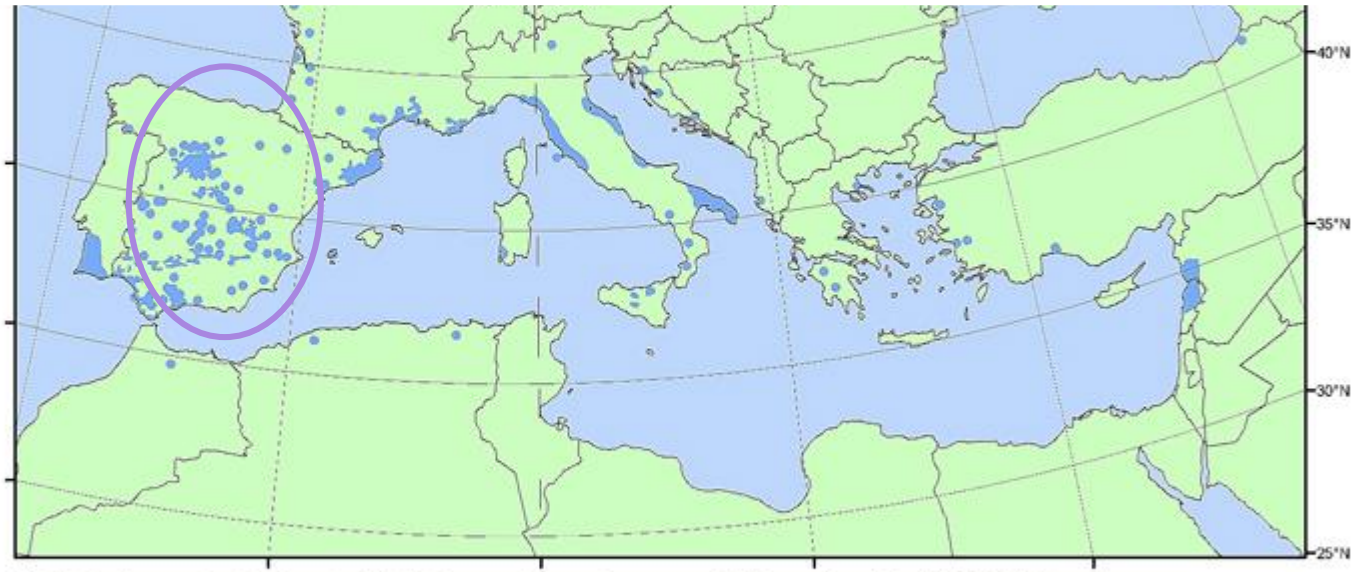


- Exceptionally low genetic diversity: evolutionary hypotheses still to be tested (… but al least a genetic test available for fraud detection)
- A success story explainable by high phenotypic plasticity, adaptation to fire and human trade?


Issues to resolve linked to exceptionally low genetic diversity :
- Conservation (of what FGR)?
- Breeding and vulnerability

Where to conserve FGR and look for useful genotypes for breeding?





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0 250 500 1000 km

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Thank you for your attention

Issues to resolve linked to *Pinus pinea*'s exceptionally low genetic diversity :

- **Conservation (of what FGR)?**
- **Breeding : possible for what traits?**