



A brief evolutionary history of *Pinus pinea* L

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

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A Brief Evolutionary History of Pinus pinea L.

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

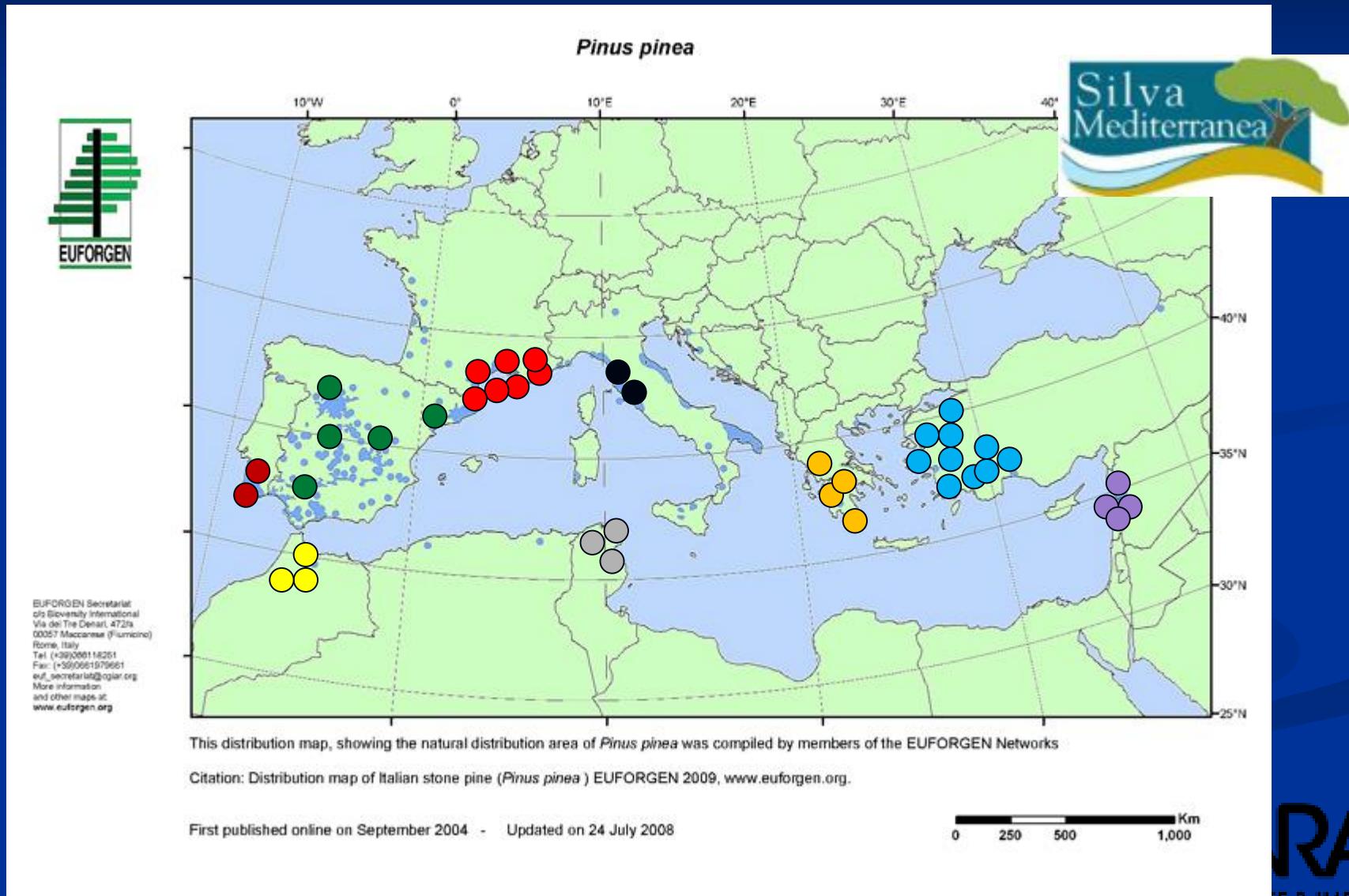


INRA – URFM, Avignon, France
** INRA – Biogeco, Bordeaux, France
*** CNR – IBBR, Florence, Italy



For me, it all started in 1992....

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

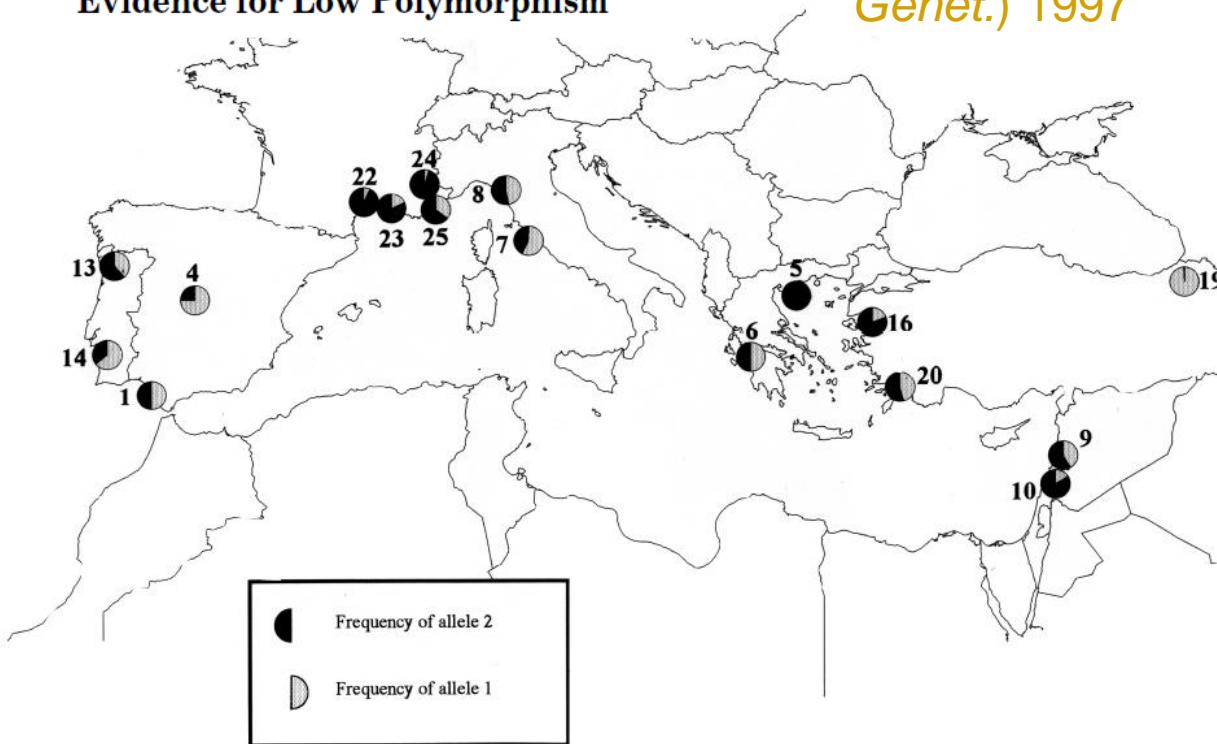


Figure 3. – Localization of the studied populations with their allele frequencies at the ME locus.

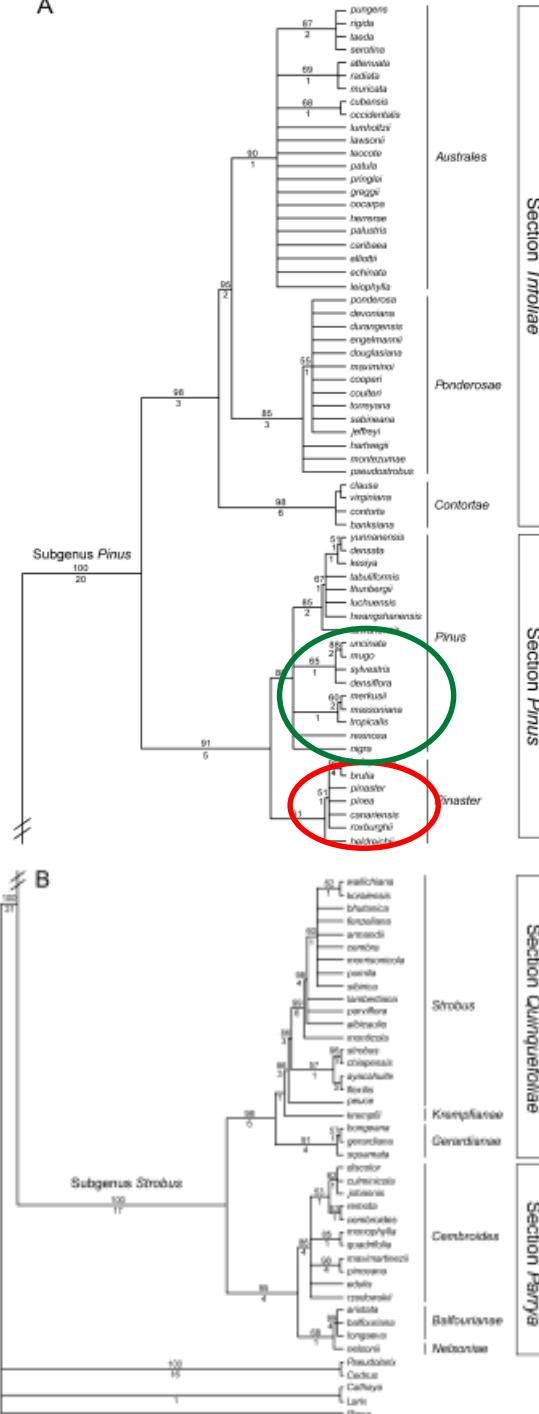
He = 0.011 (31 loci, 25 populations)!!!
No spatial pattern!

P. nigra
He = 0.250

P. Sylvestris
He = 0.350

P. pinaster
He = 0.145

P. Halepensis
He = 0.100

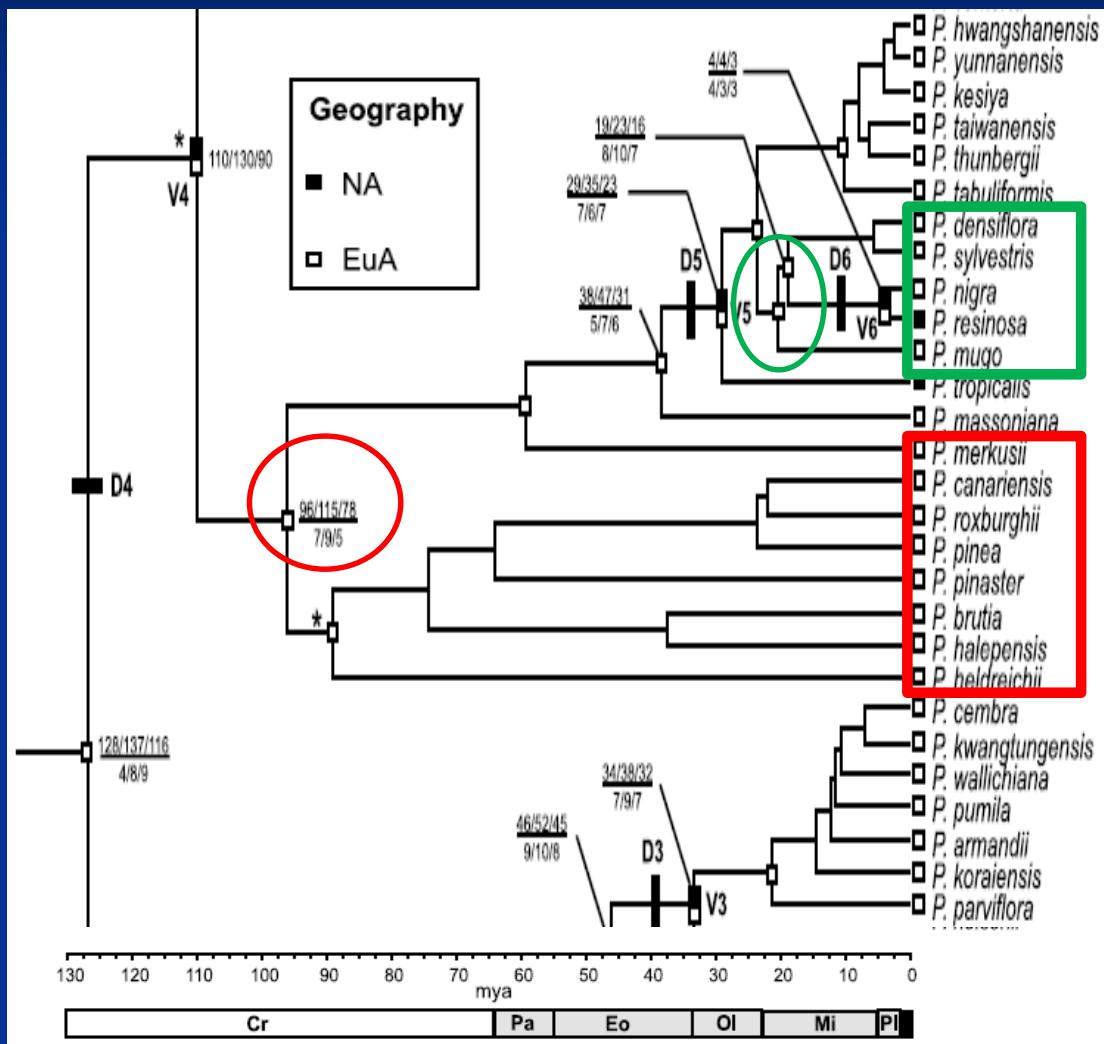


Mediterranean pines have a common (Old World) phylogenetic origin

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

“Mountain” Mediterranean pines: section *Pinus*, sub-section *Pinus*

True Mediterranean pines are older than Mountain Mediterranean pines

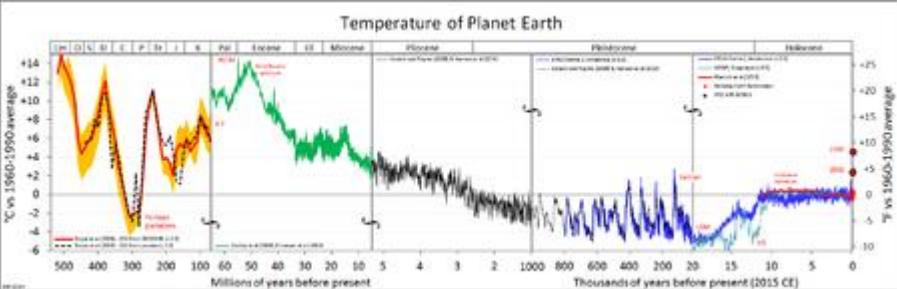


Pines : a 128 MA-old Eurasian group

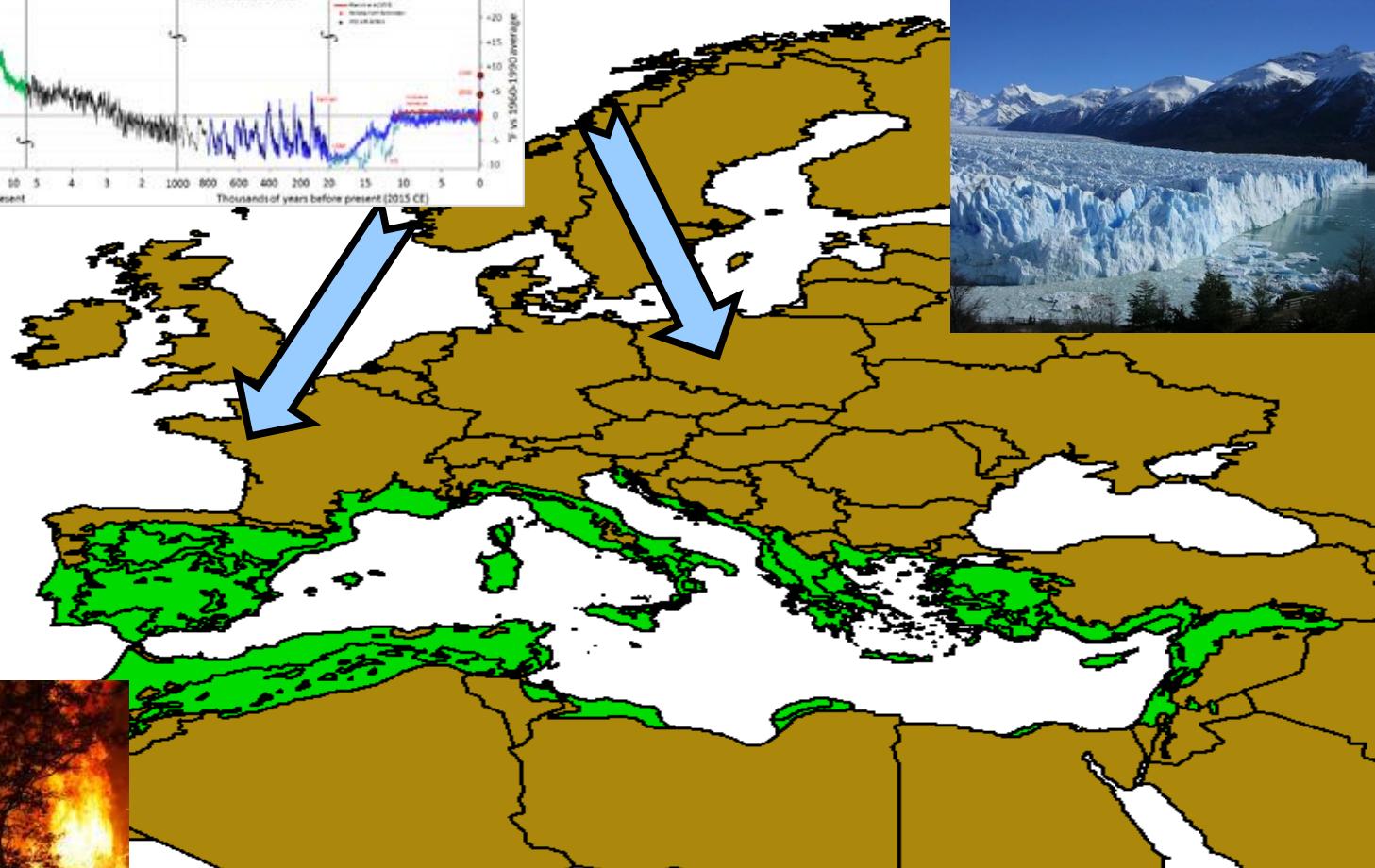
“Mountain” Mediterranean pines: a 20 MA-old Oligocene group

“True” Mediterranean pines: a 96 MA-old Cretaceous group

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

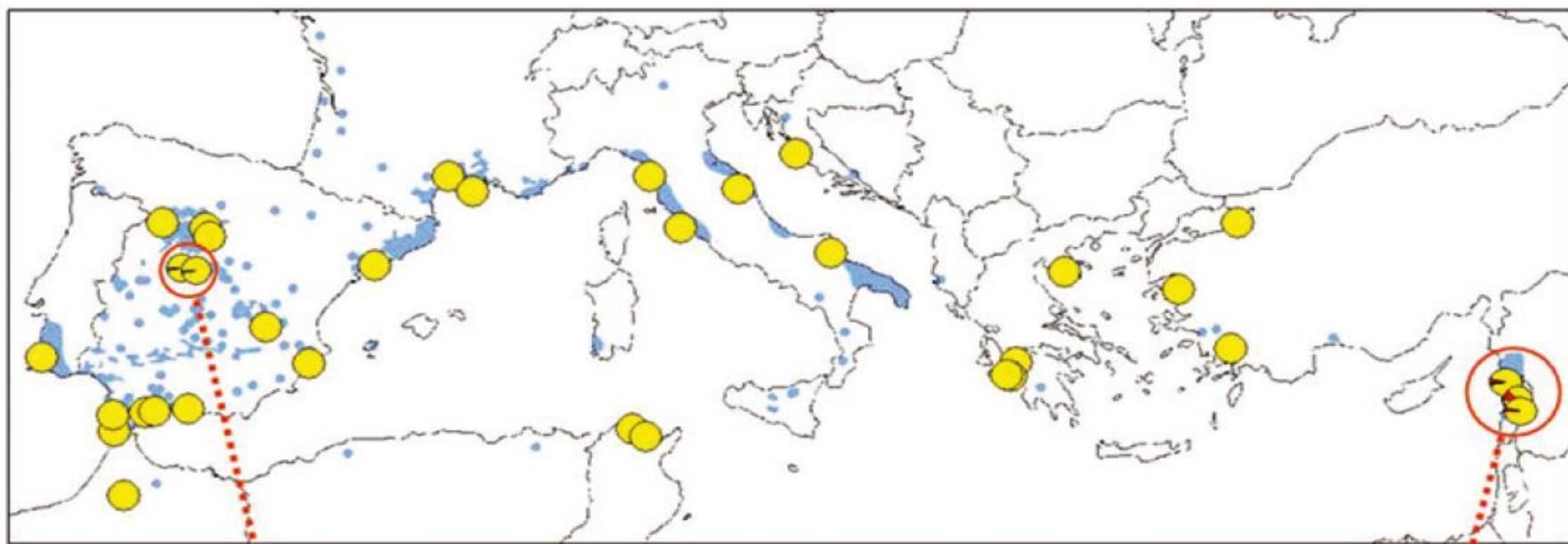


Fady (AFS) 2012

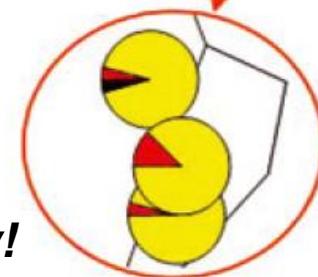
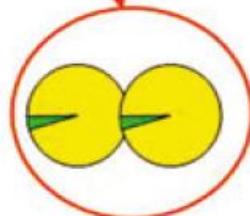


See papers by Pausas et al., by Keeley et al.

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

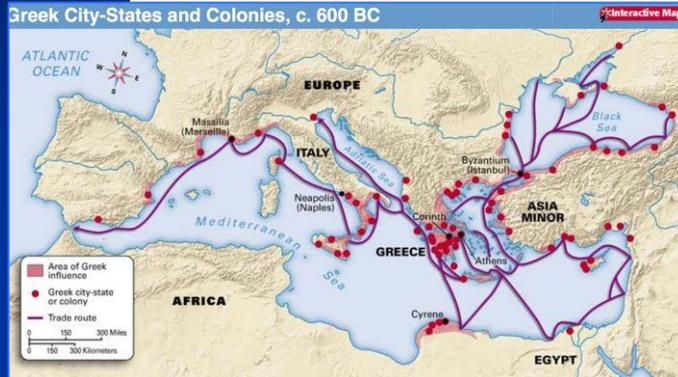


Only 4 haplotypes in 13 cpSSRs
across the entire range

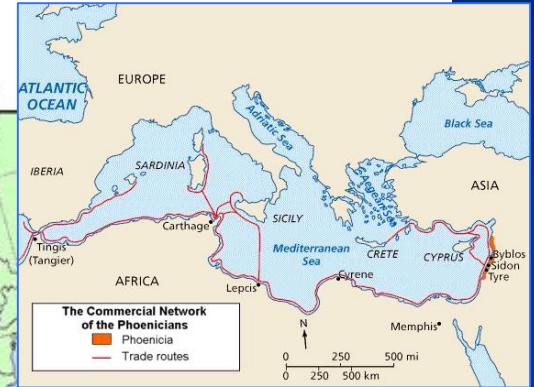


Pinus pinea: a xerothermic pine with extremely low diversity!

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



Pinus pinea



EUFORO
c/o Sileva
Via dei Trulli
00157 Roma
Italy
Tel: (+39)066116251
Fax: (+39)0661170561
e-mail: sileva@euforo.org
More information
and other maps at:
www.euforo.org



0W 200 400 600 800 1000 kyr ago

This
Cita
First

Hot
Stages of
Glaciation
Cold

INRA
SCIENCE & IMPACT

Vendramin et al. (*Evolution*) 2007

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

AMERICAN JOURNAL OF
Botany

American Journal of Botany: e362–e365. 2012.

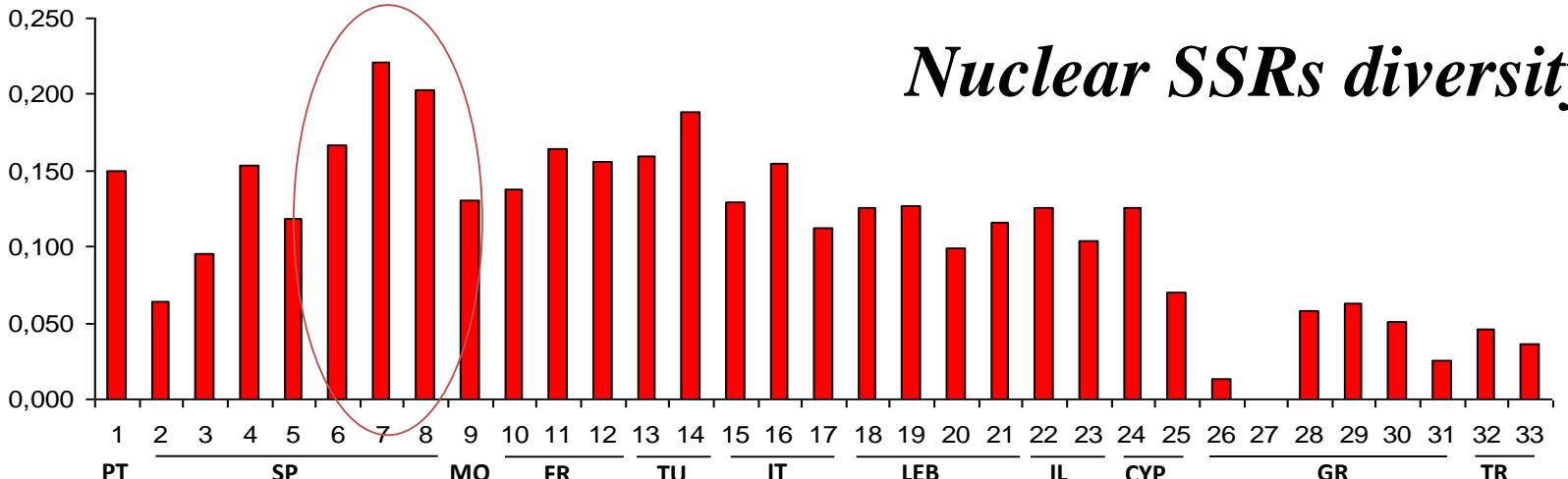
AJB PRIMER NOTES & PROTOCOLS IN THE PLANT SCIENCES

NUCLEAR MICROSATELLITES FOR *PINUS PINEA* (PINACEAE), A GENETICALLY DEPAUPERATE TREE, AND THEIR TRANSFERABILITY TO *P. HALEPENSIS*¹

F. PINZAUTI², F. SEBASTIANI², K. B. BUDDE³, B. FADY⁴, S. C. GONZÁLEZ-MARTÍNEZ³,
G. G. VENDRAMIN^{2,5}



Nuclear SSRs diversity



Genetic diversity in *Pinus* species

Species Heterozygosity
Pinus pinea 0.11

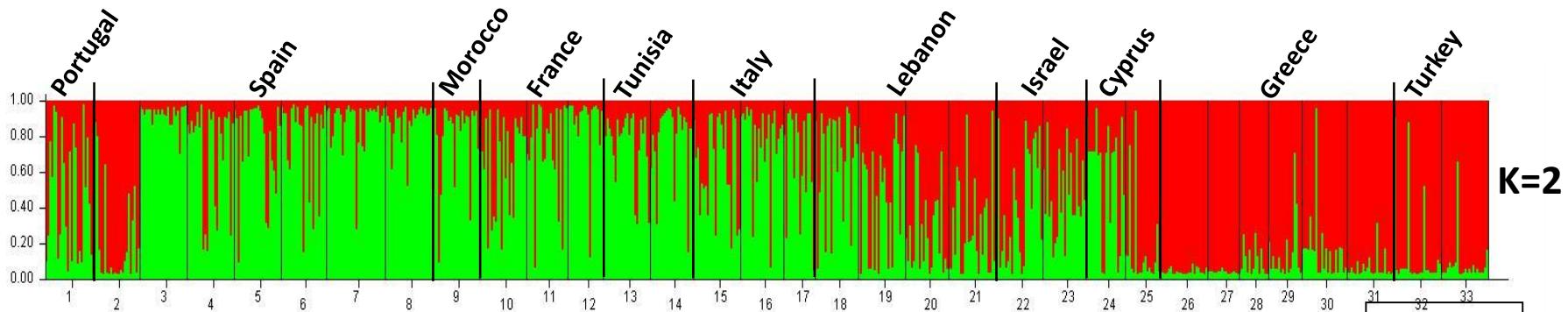
Pinus halepensis 0.66

Pinus pinaster 0.82

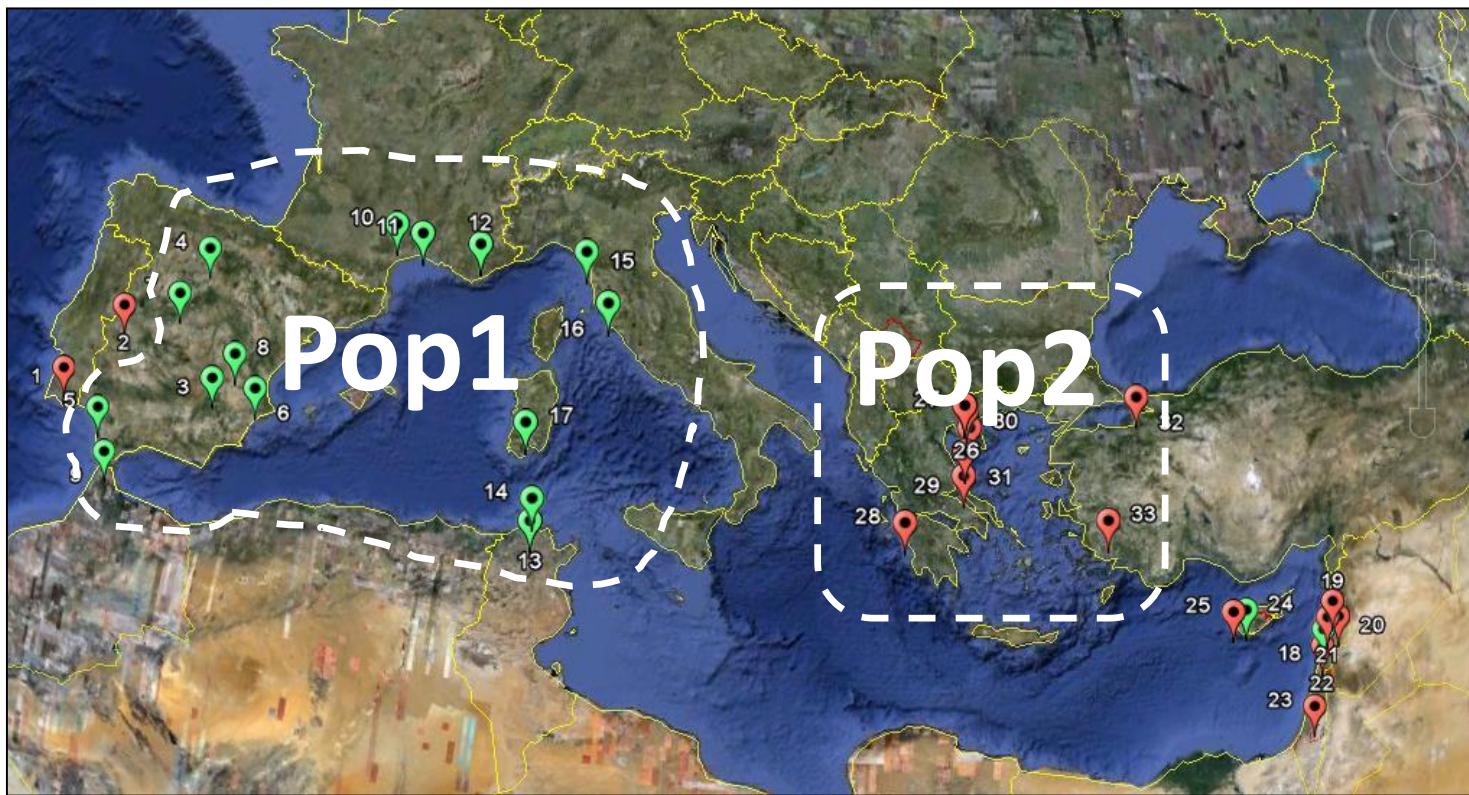
Pinus sylvestris 0.88



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



K=2



33 pop.
735 ind.

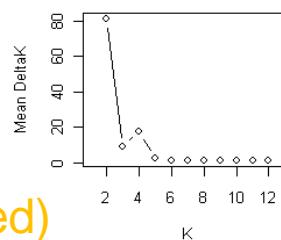
	Quinta do Lago	Portugal
1	Garovillas	Spain
2	Bogarra	Spain
3	Palafrugell	Spain
4	Donana	Spain
5	Biar	Spain
7	San Martin de V.	Spain
8	Tarazona	Spain
9	Cap Spartel	Morocco
10	Villeneuv/Herault	France
11	Saint Maries	France
12	Saint Aygulf	France
13	Cap Bon	Tunisian
14	Rimel	Tunisian
15	Migliarino	Italy
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	Kaiatas	Greek
29	Strofilia	Greek
30	Skopelos	Greek
31	Skiathos	Greek
32	Bursa Yalova	Turkey
33	Yatagan Katranci	Turkey

Run parameters:

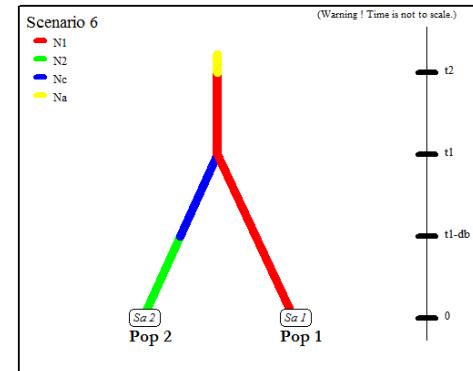
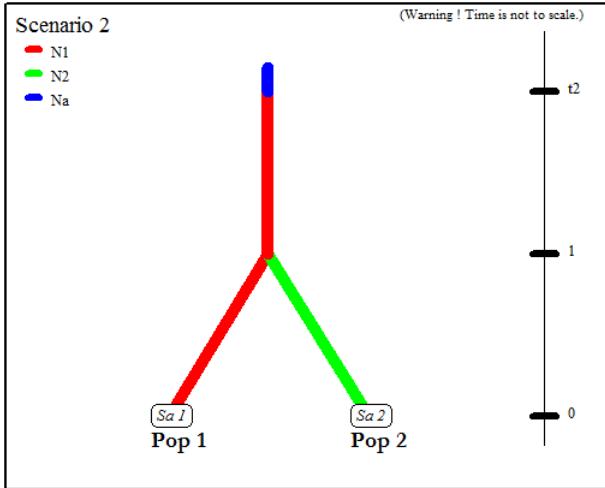
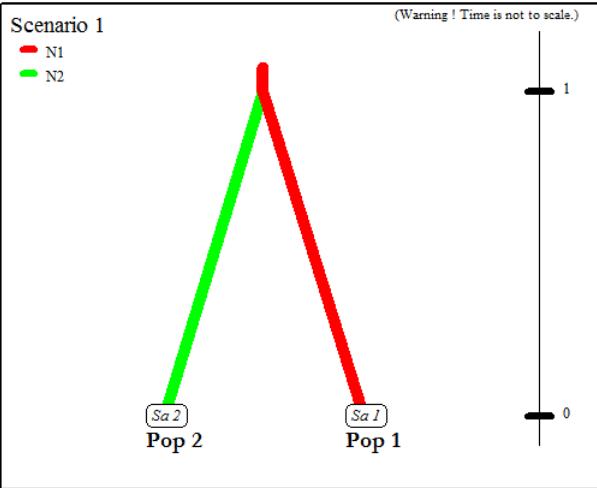
735 individuals
13 nSSR loci

K=13 populations assumed

500000 Burn-in period
100000 Reps

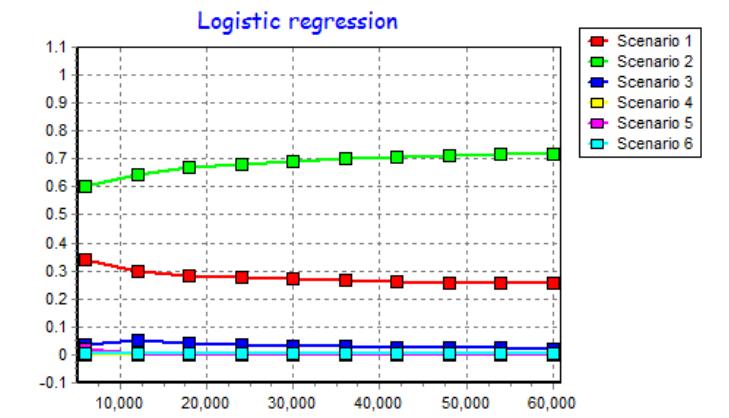
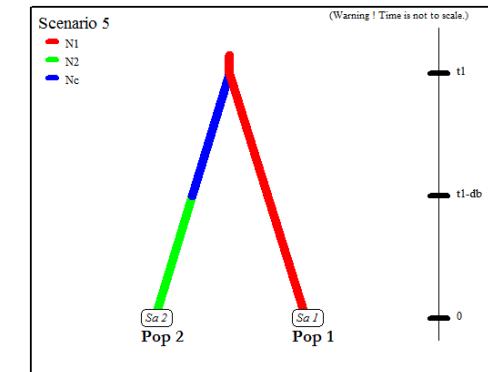
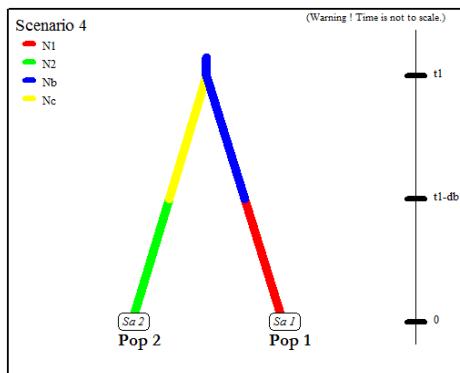
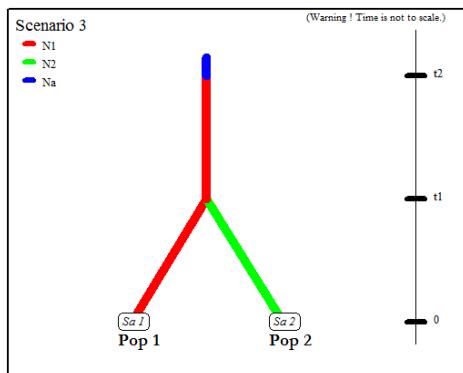


(GG Vendramin, SC Gonzalez-Martinez, et al. unpublished)



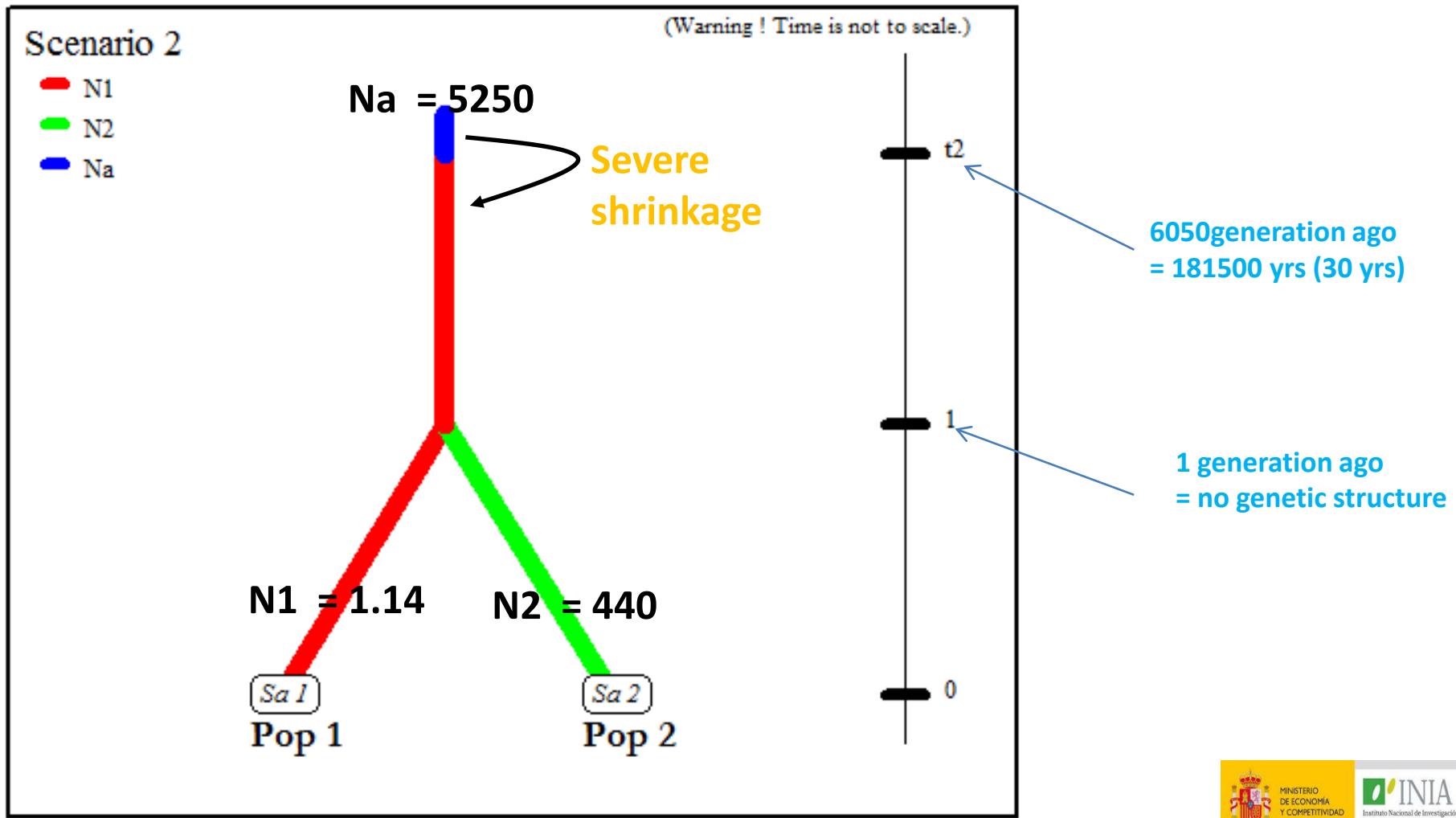
Null hypothesis I:
no genetic structure
Divergence occurred just 1 generation ago

Null hypothesis II:
no genetic structure with
ancient bottleneck
Divergence occurred just 1 generation ago

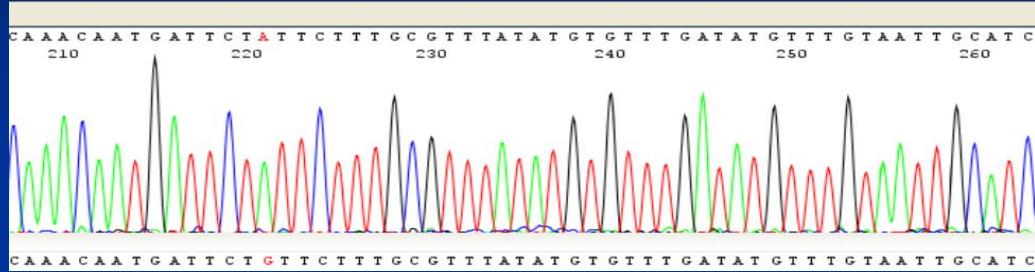


Most likely scenario;

No genetic structure with ancient population shrinkage



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



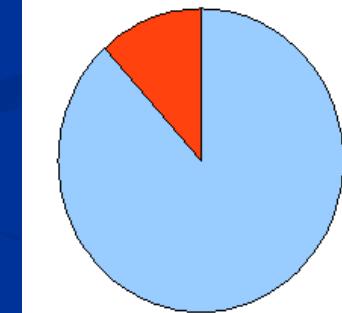
Resequencing 264 candidate genes identified in *P. taeda* => 194 gene sequences in *P. pinea*

P. pinaster $\pi = 0.0024$

P. radiata $\pi = 0.0019$

P. taeda $\pi = 0.0051$

(Gonzalez-Martinez S. et al. 2006)



■ polymorphic genes
■ monomorphic genes

$\pi = 0.000197$

Total SNPs = 31

1 SNP every 1439 bases

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

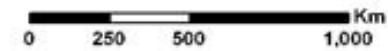
Does (almost) no DNA diversity affects phenotypic traits? Using provenance tests with similar genetic material in the Mediterranean



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



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

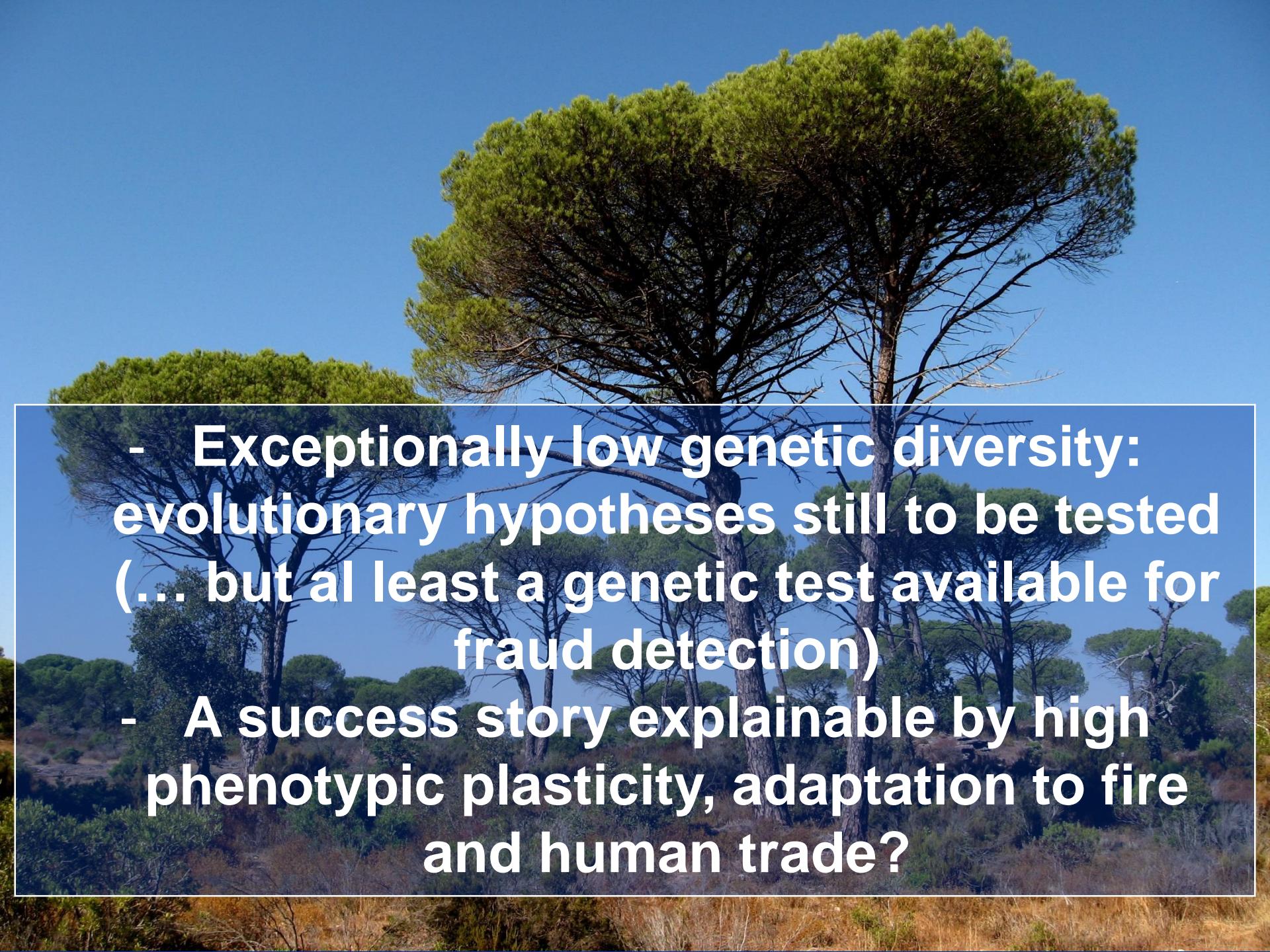
Mediterranean Stone Pine for Agroforestry

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

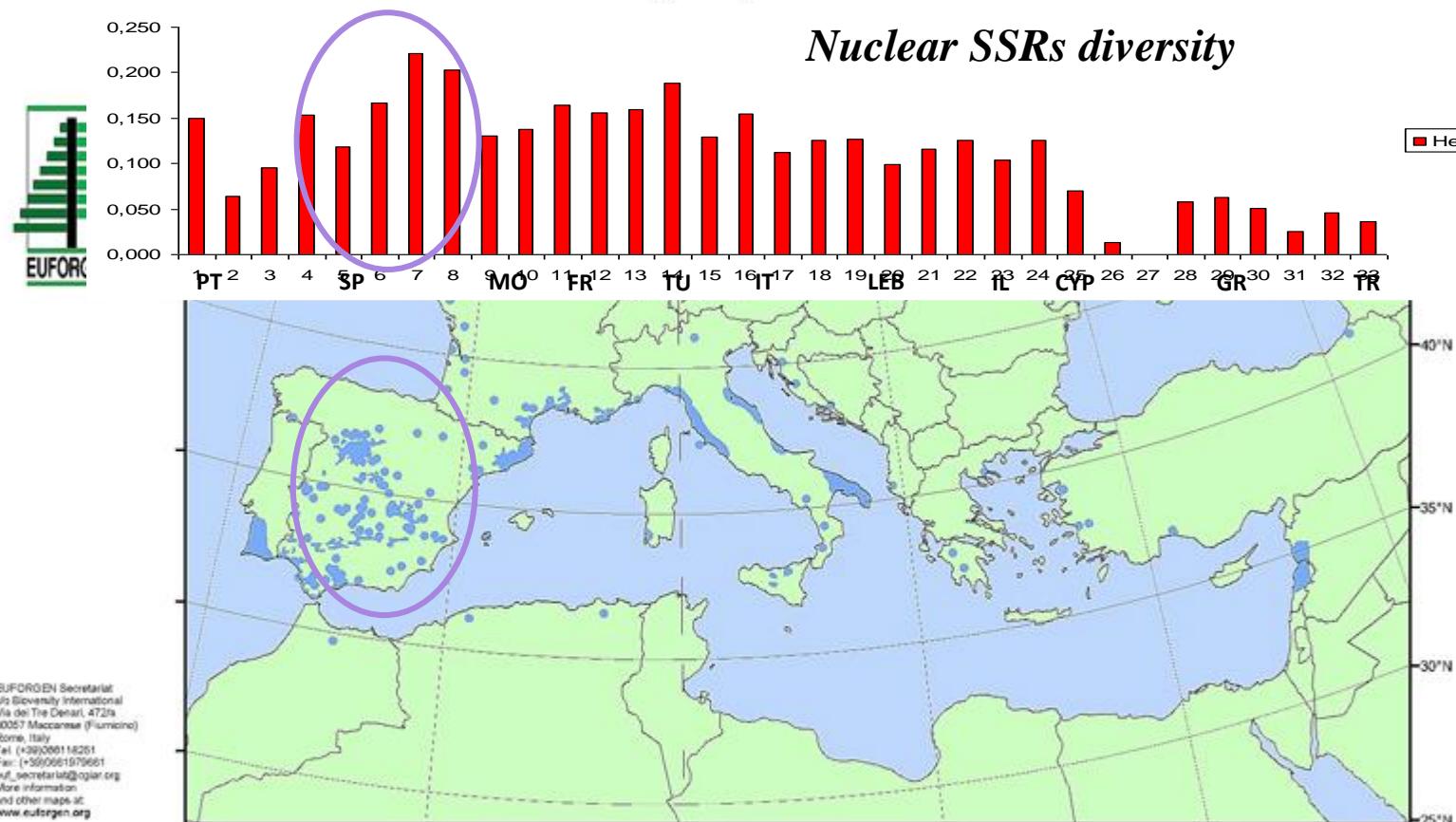
- 
- A photograph of a coastal or island landscape under a clear blue sky. In the foreground, there's dry, yellowish-brown scrubland. Behind it stands a dense forest of tall, thin pine trees with dark trunks and large, rounded green canopies. One tree in the center-right is particularly prominent, its branches reaching upwards and outwards.
- Exceptionally low genetic diversity:
evolutionary hypotheses still to be tested
(... but at 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?



EUFORGEN Secretariat
c/o Biodiversity International
Via del Te Deum, 47/29
00157 Maccarese (Fiumicino)
Rome, Italy
Tel: (+39)066116251
Fax: (+39)066116261
e-mail: euforgen@biogeo.it
More information and other maps at www.euforgen.org

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

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



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?