An overview on the genetics of *Quercus suber* in the Mediterranean. Implications for management

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INIA-CIFOR

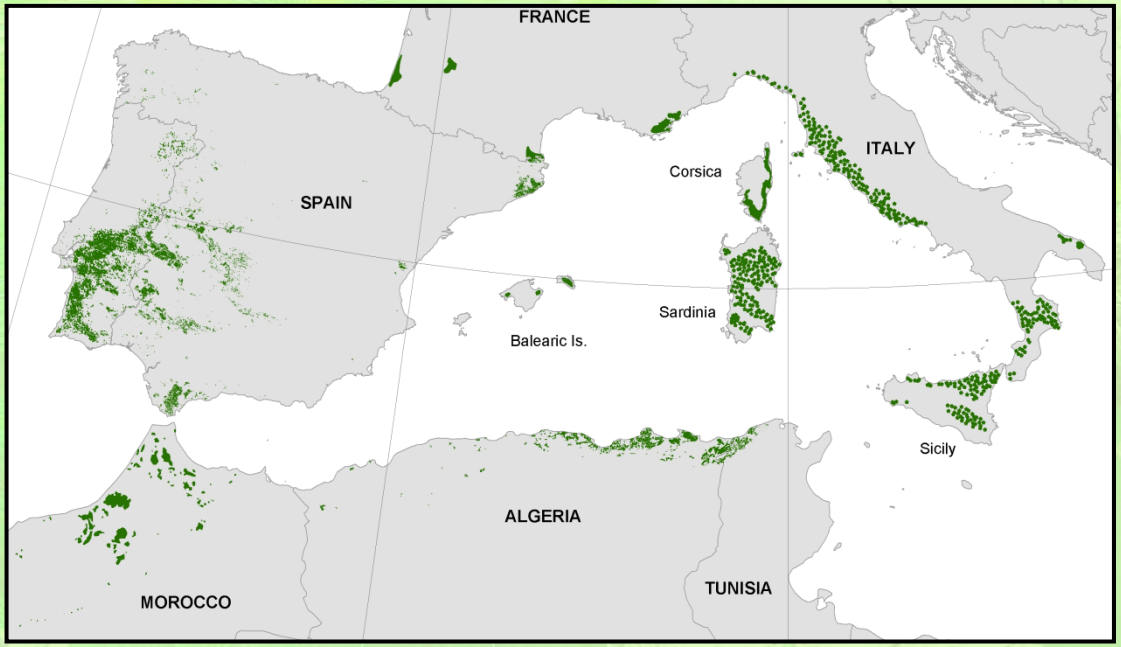
Cork oak (*Quercus suber* L.)

Leaf habit and distribution

Evergreen species

Distributed in the western Mediterranean Basin

Acidic soils



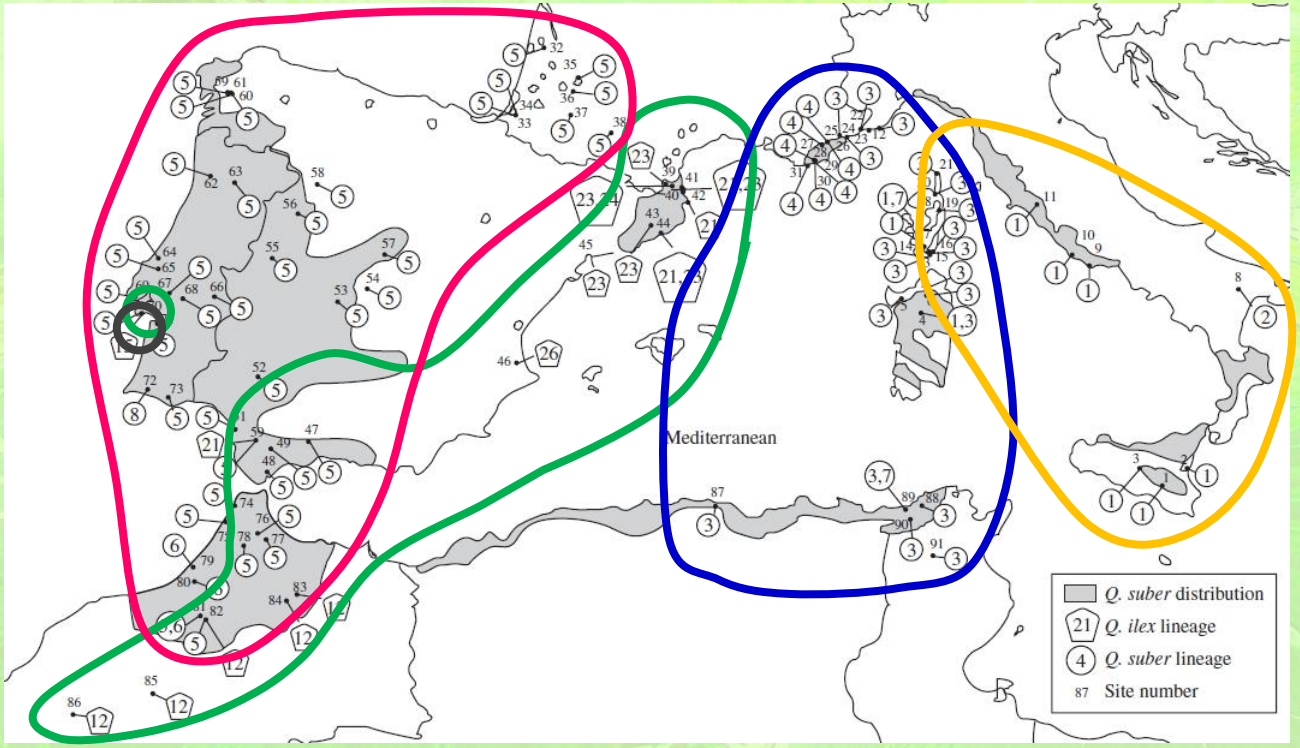
Modified from Aronson *et al.* (2009)

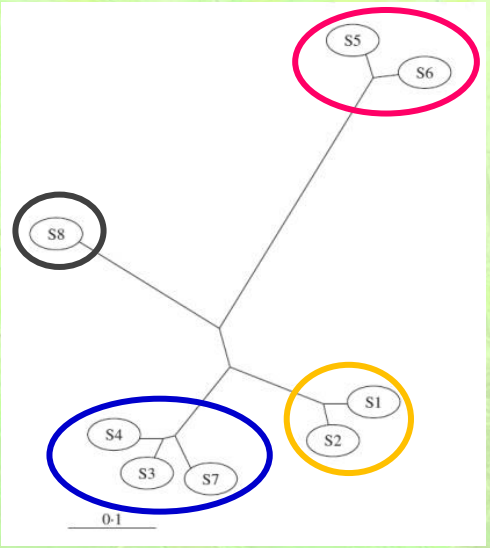
Molecular markers: Whole distribution range

cpDNA

Three main haplotypic groups: Western, Central and Eastern

One haplotypic group shared with *Quercus ilex* and *Quercus coccifera*





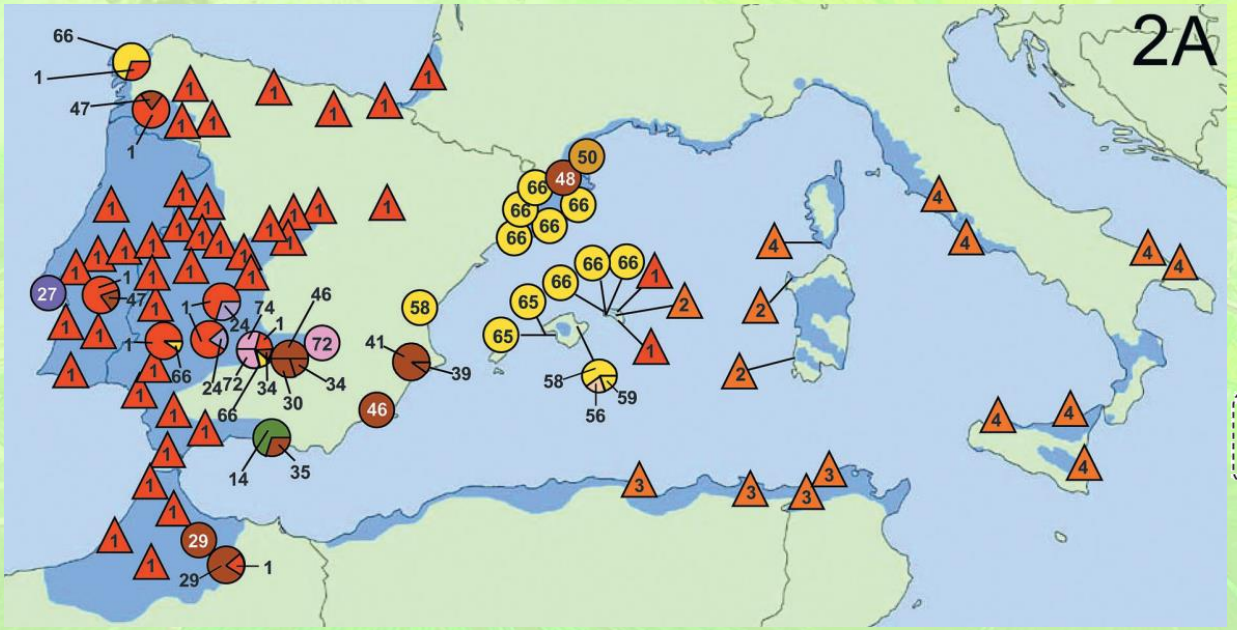
Lumaret *et al.* (2005)

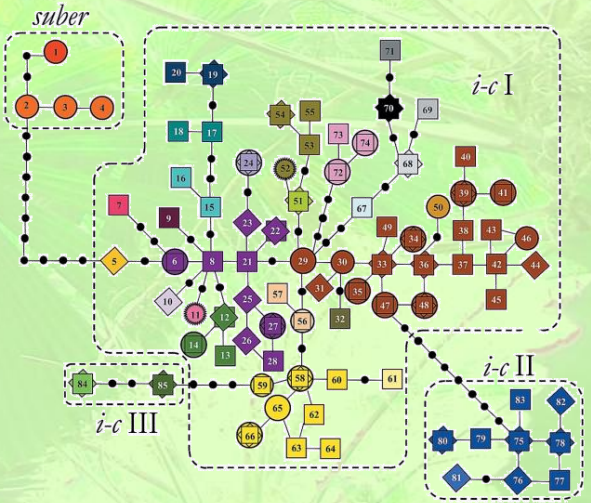
Molecular markers: Whole distribution range

cpDNA

Vicariant pattern: Eastern and Western populations

Ilex-coccifera lineage in:
Eastern Iberia, eastern Morocco and the Balearic Islands



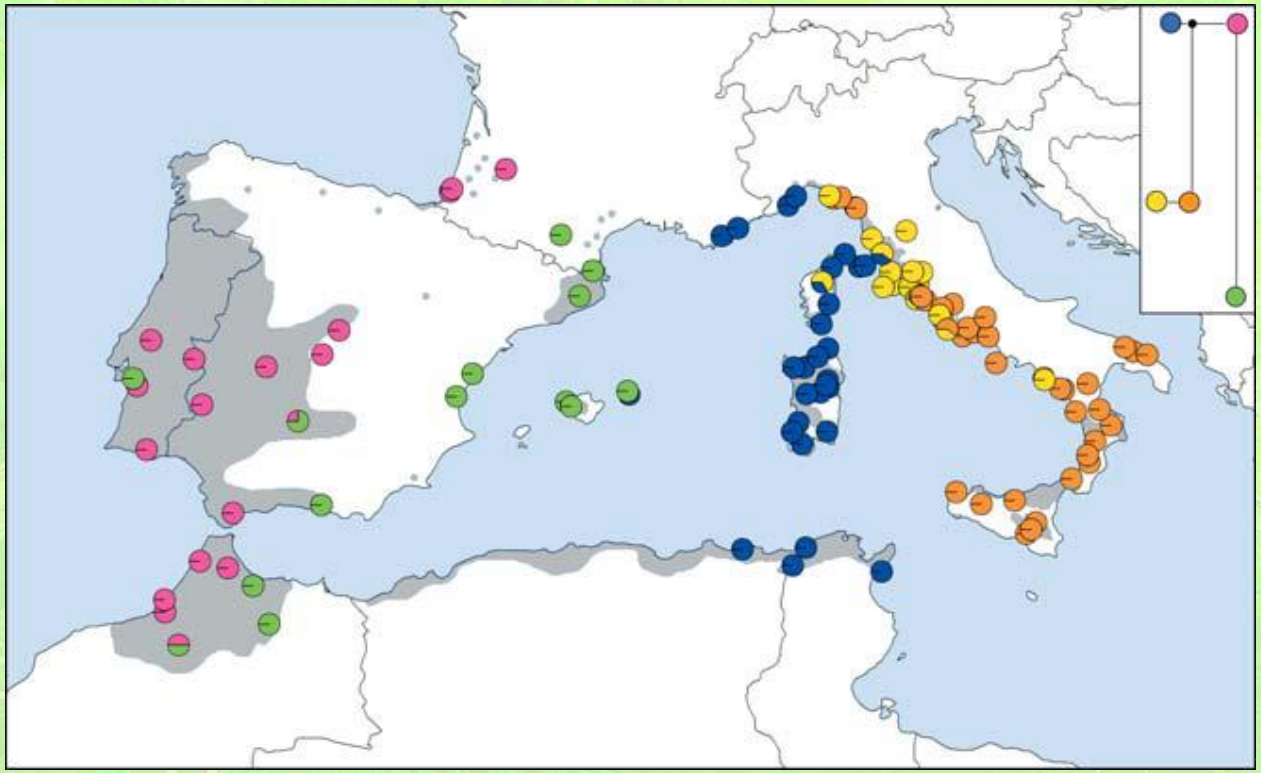


López de Heredia *et al.* (2007)

Whole distribution range

cpDNA

Five haplotypes. Longitudinal pattern of variation



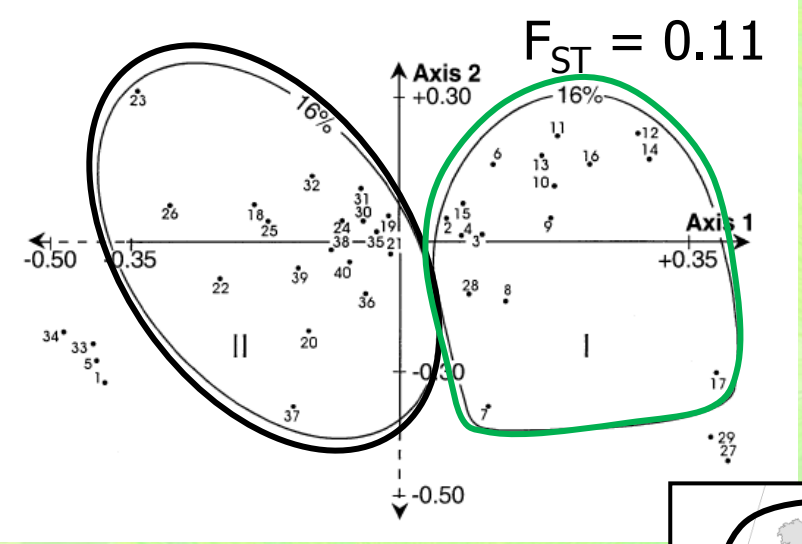
Eastern, central and western genetic clusters

Results consistent across studies

Magri *et al.* (2007)

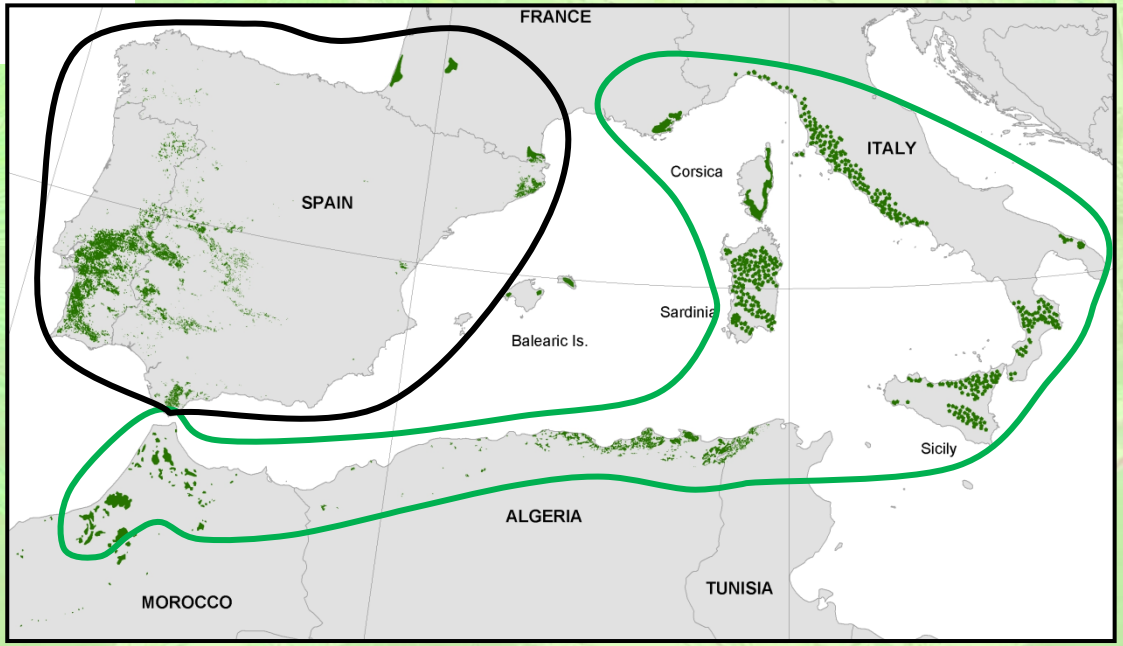
Molecular markers: Whole distribution range

Biparentally-inherited markers



Toumi & Lumaret (1998)

Iberia,
Western France
vs.
Rest of the range



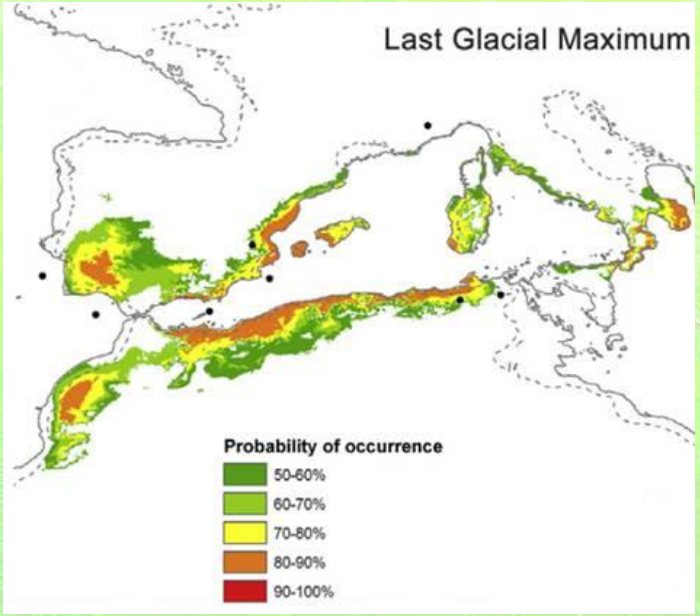
Molecular markers: Whole distribution range

Possible causes ?

Human activity

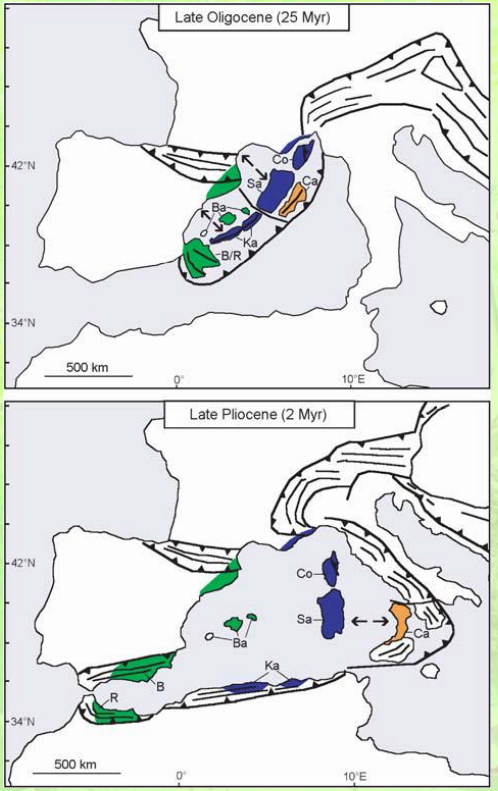
Toumi & Lumaret (1998)

Glacial refugia and post-colonization



Modified from Vessella *et al.* (2007)

Microplates evolution

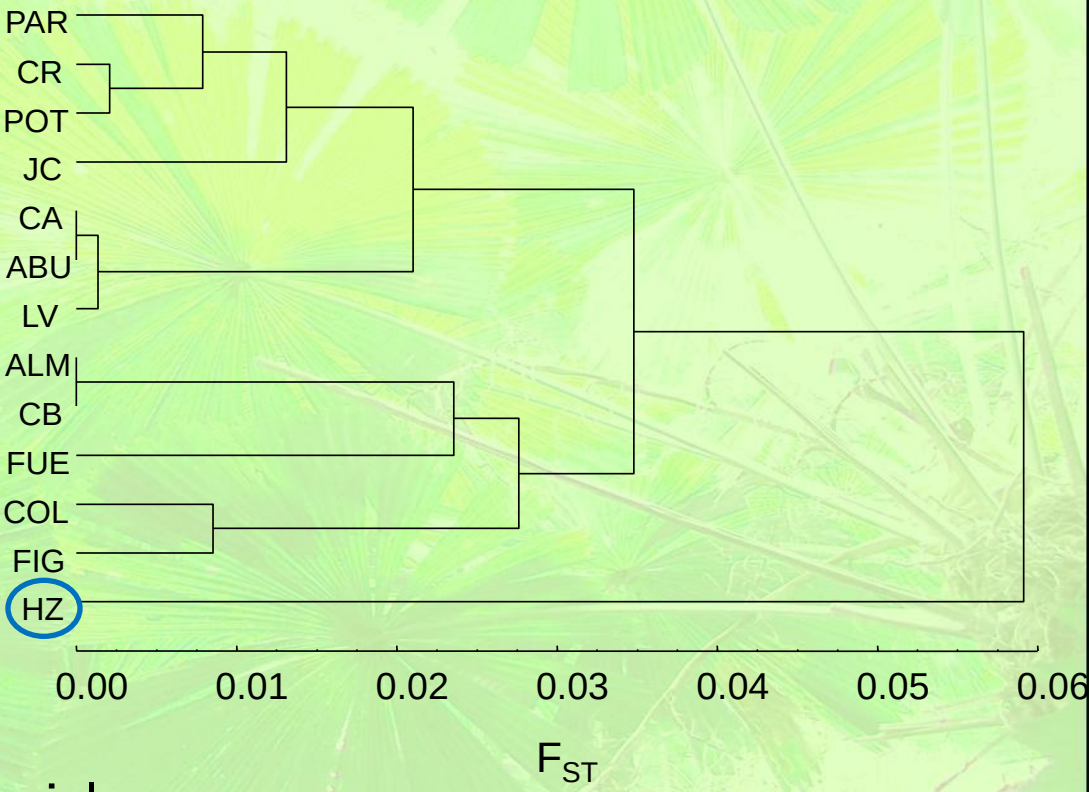


Magri *et al.* (2007)

Molecular markers: Among populations within regions

Iberian Peninsula: Spain

Low genetic differentiation (F_{ST} = 0.033)



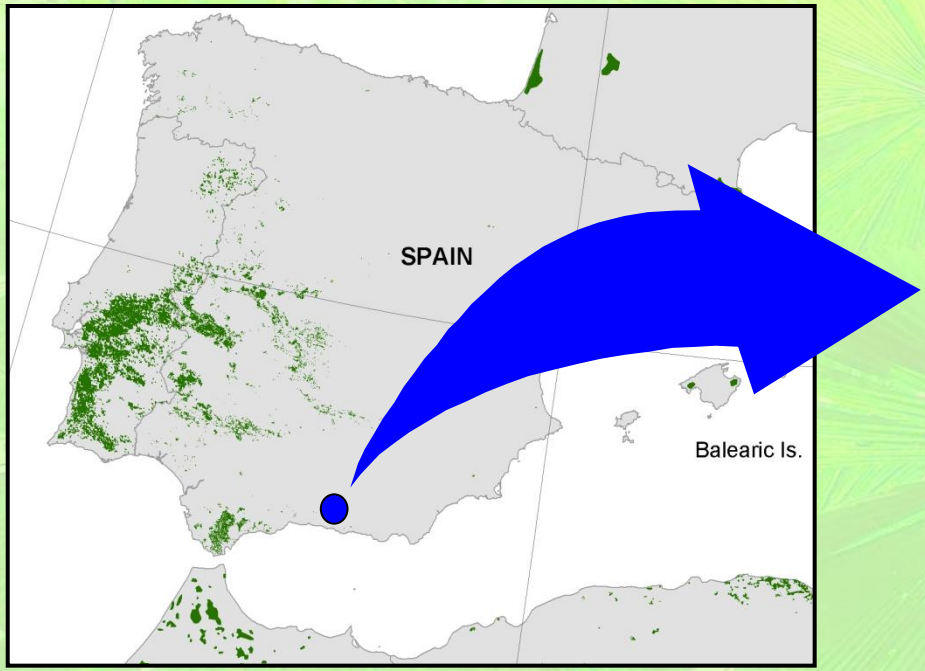
Southeastern population is special

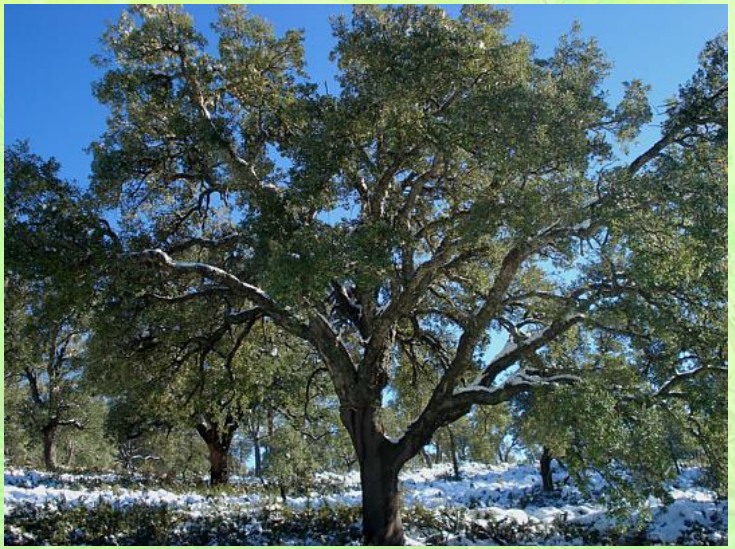
Ramírez-Valiente *et al.* (2009a)

Molecular markers: Among populations within regions

Southeastern population is different…

➡ Isolation: 1300 m a.s.l and 200 km away from closest populations



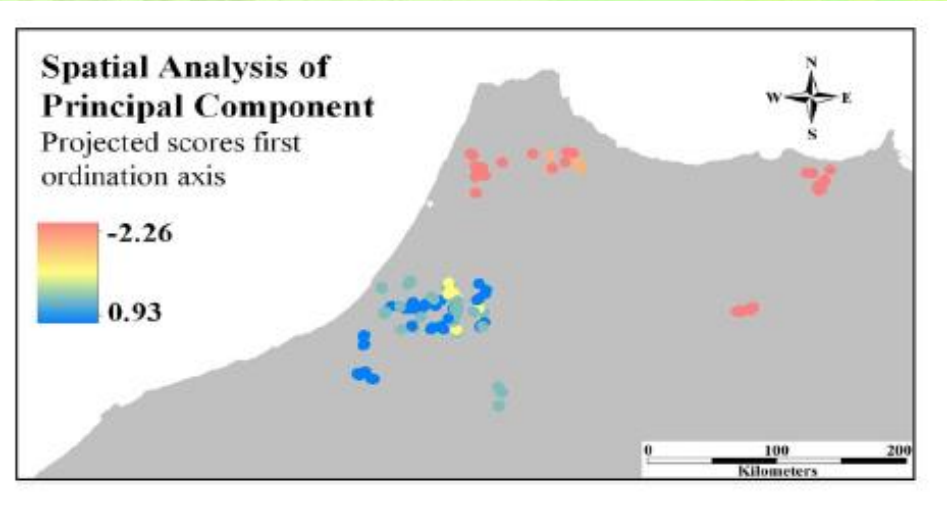


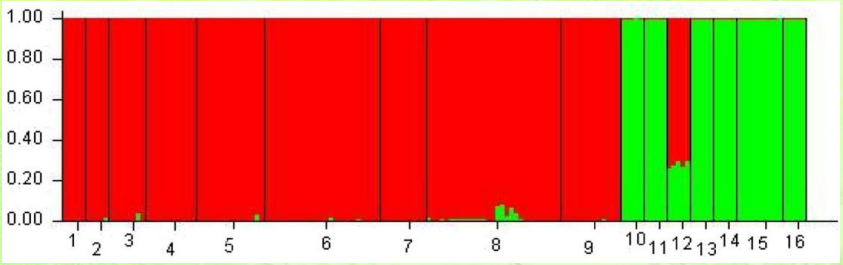
Ramírez-Valiente *et al.* (2009a)

Molecular markers: Among populations within regions

North of Africa: Morocco

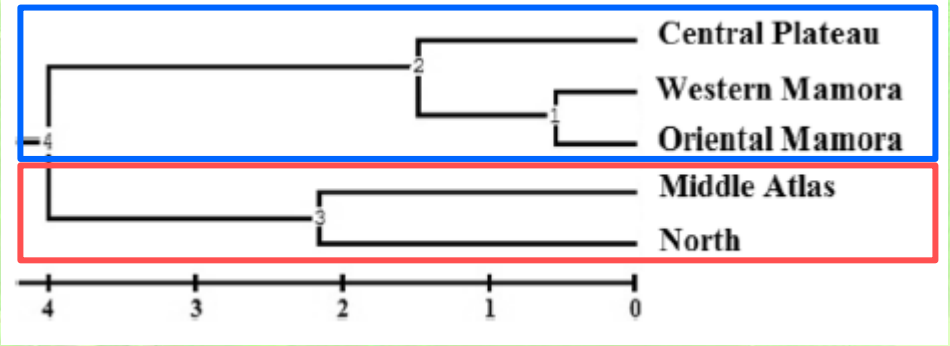
Two genetic groups: North & Eastern vs. southwestern F_{ST} = 0.06





Twenty-three ISSR

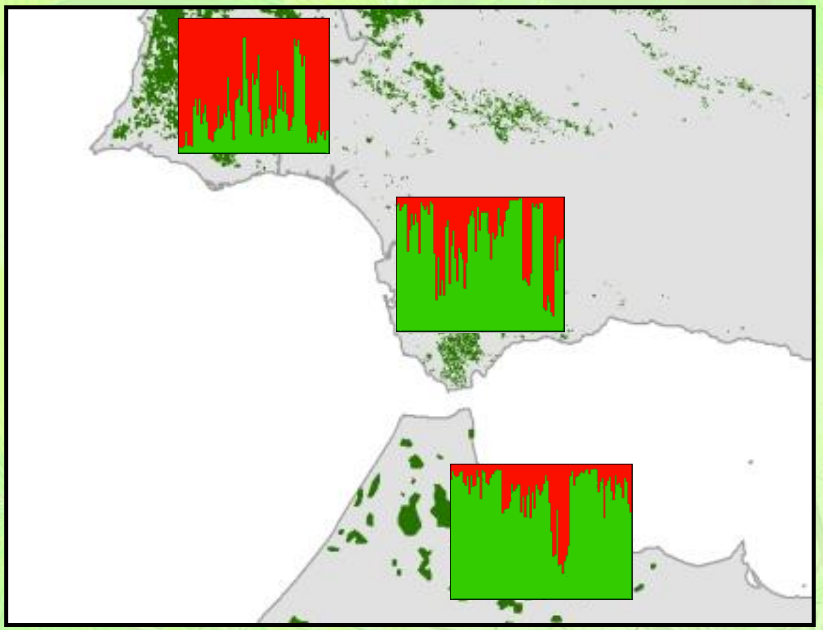
Sixteen populations

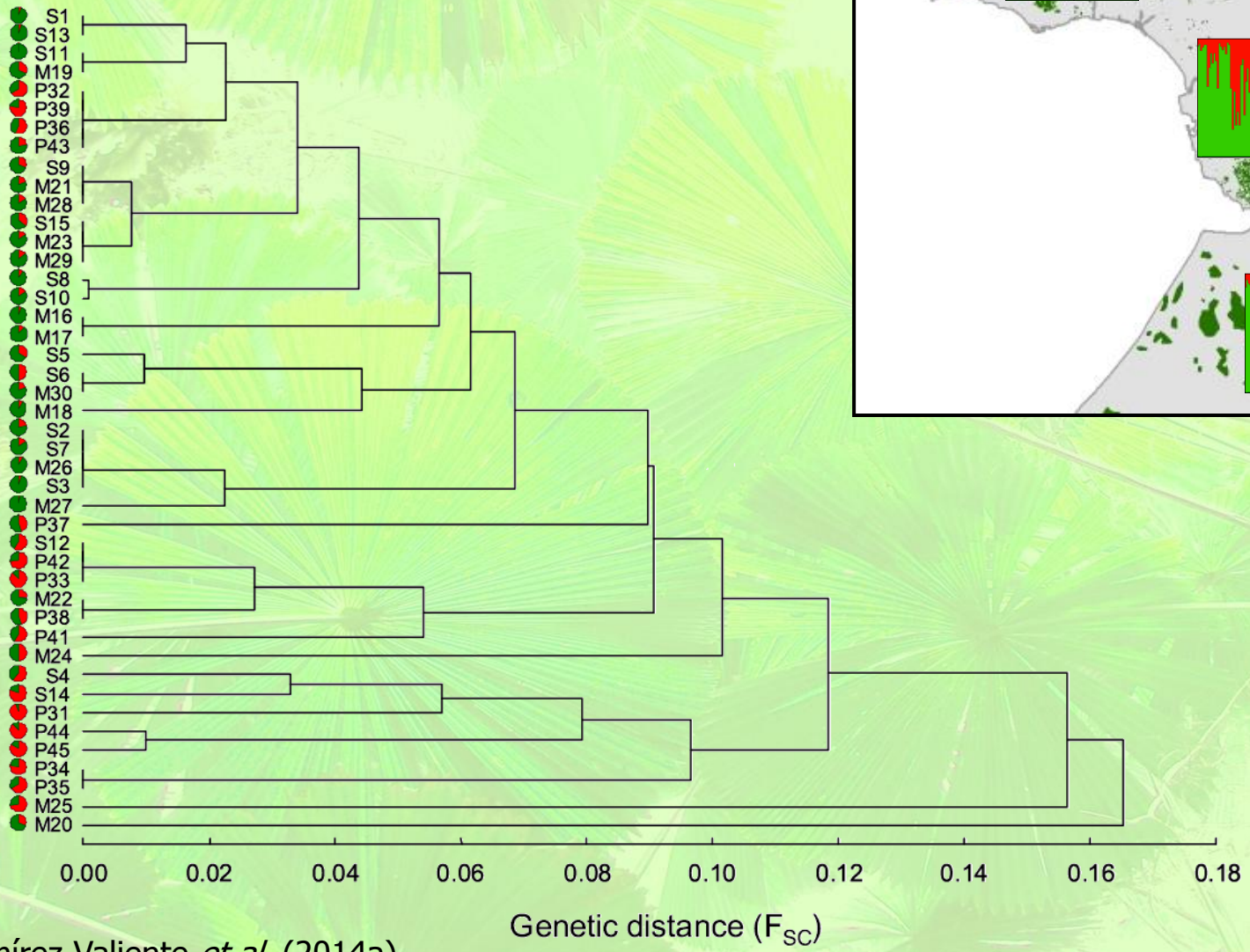


Laakili *et al.* (2018)

Molecular markers: Within populations

Differences among poulations (F_{ST} = 0.03)
Genetic among lines (F_{ST} = 0.07)





Ramírez-Valiente *et al.* (2014a)

Cork oak (*Quercus suber* L.)

Ecology

- Precipitation: 400-2000mm
- Temperature: 13-20ºC

Rainy-warm forest
P.N. los Alcornocales
Cádiz
Southern Spain

Cork oak woodland 1300 m
Haza de lino
Granada
Southeastern Spain

Mixed Mediterranean forest
Q. suber,
Q. ilex, Q. faginea
Montes de Toledo
Central Spain

Rainy atlantic forest
Les Landes
Southwestern France

Díaz-Fernández *et al.* (1995), Aronson *et al.* (2009)

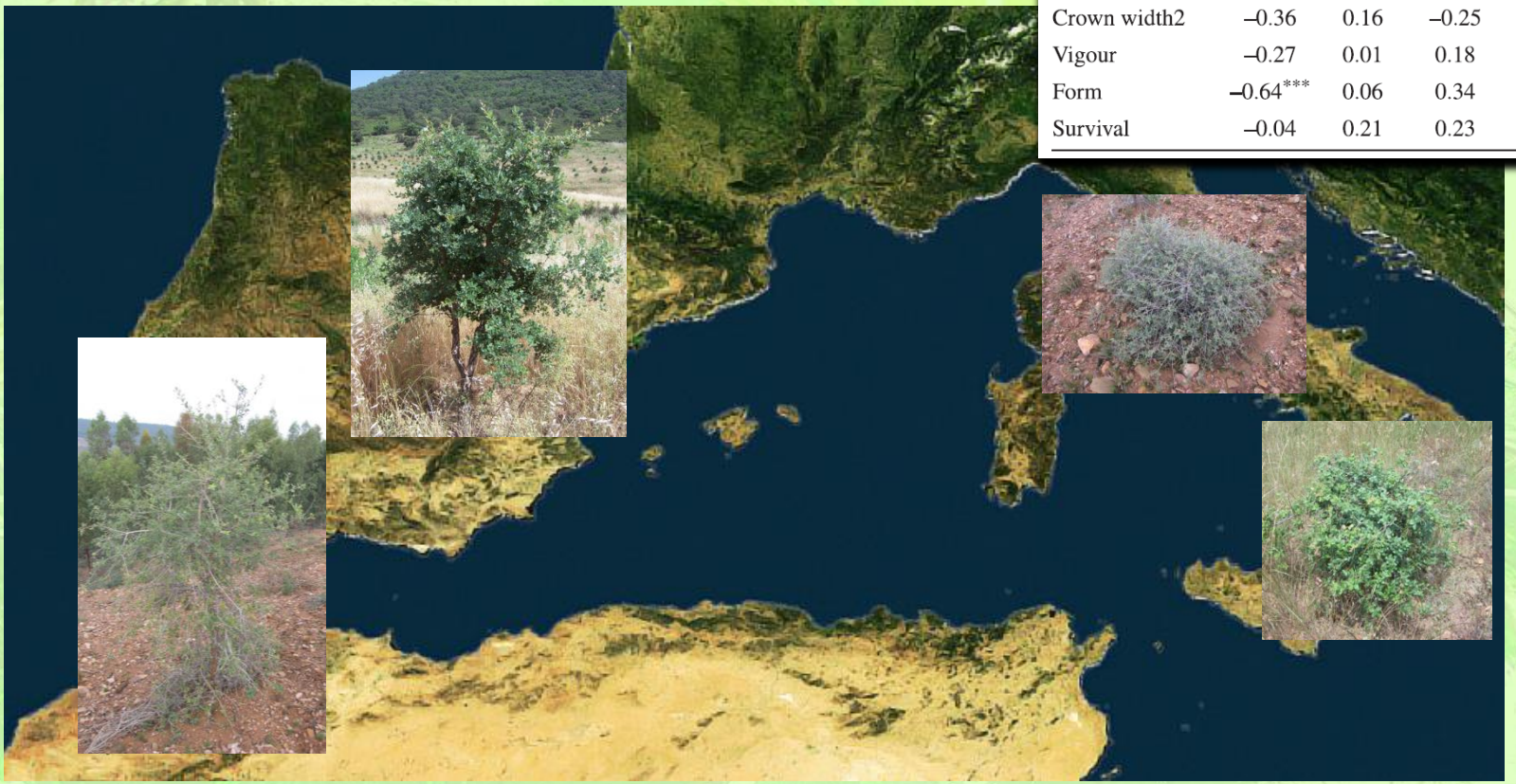
Traits and fitness: Whole distribution range

Differences among populations in height, diameter and growth architecture

Some associations with chlorotype of origin

trait conservatism?

Variable	T	P	Altitude	Longitude	Latitude
Total tree height	–0.57**	0.18	0.07	0.63***	–0.5**
Diameter at base	–0.30	0.14	0.03	0.46**	–0.28
Crown width1	–0.40**	0.20	–0.22	0.36	–0.39**
Crown width2	–0.36	0.16	–0.25	0.36	–0.39
Vigour	–0.27	0.01	0.18	0.56**	–0.16
Form	–0.64***	0.06	0.34	0.56**	–0.54**
Survival	–0.04	0.21	0.23	0.47**	0.15

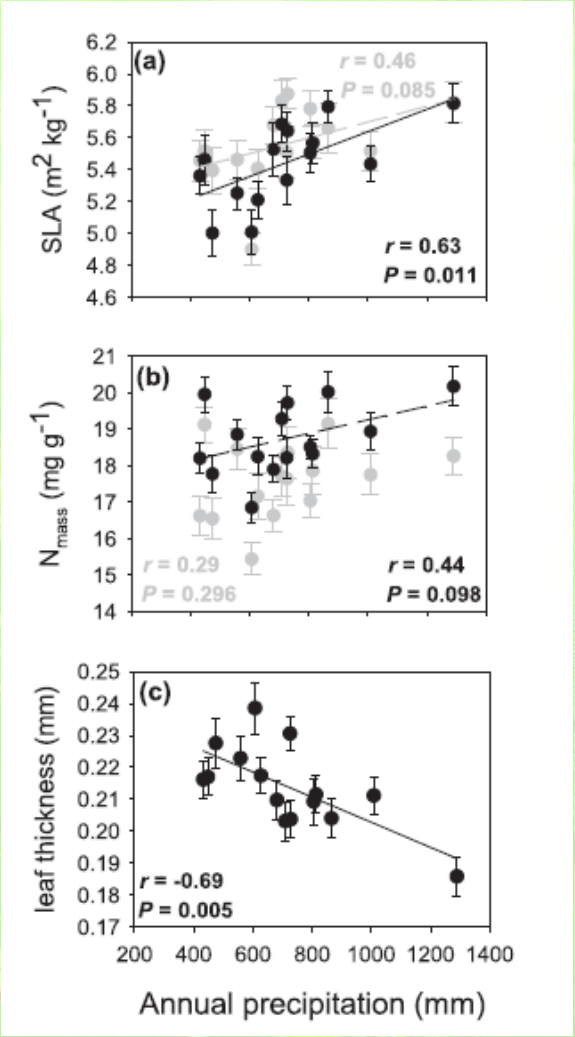


Gandour *et al.* (2007), Ramírez-Valiente *et al.* (2014b)

Traits and fitness: Whole distribution range

Traits related to drought response strategies

Differences in SLA, N content and leaf thickness

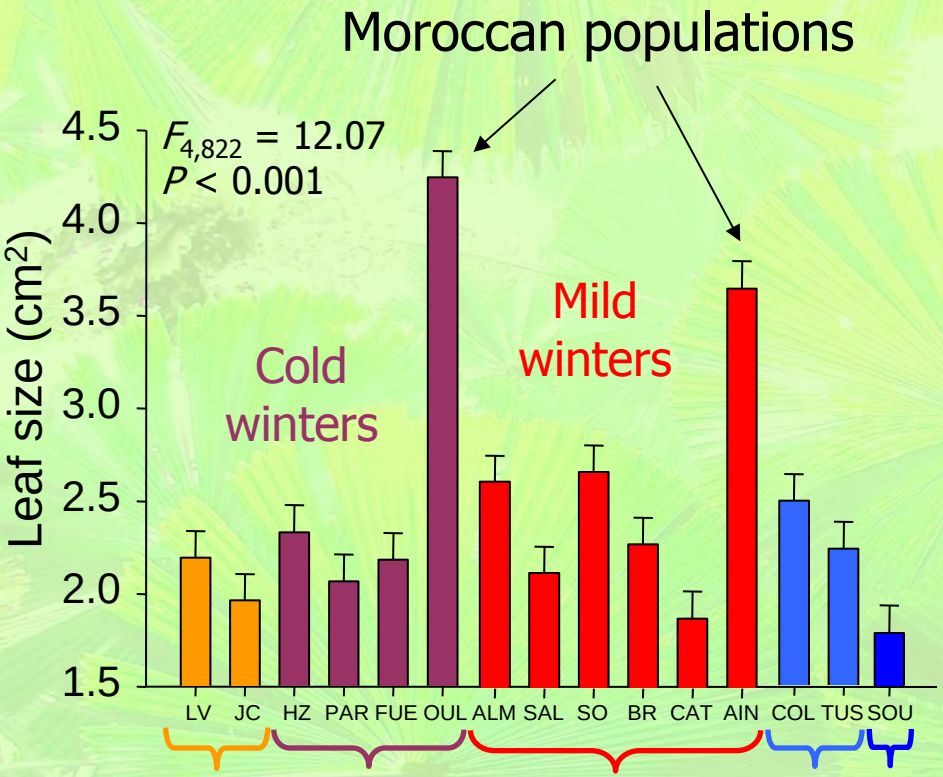


Ramírez-Valiente *et al.* (2014c)

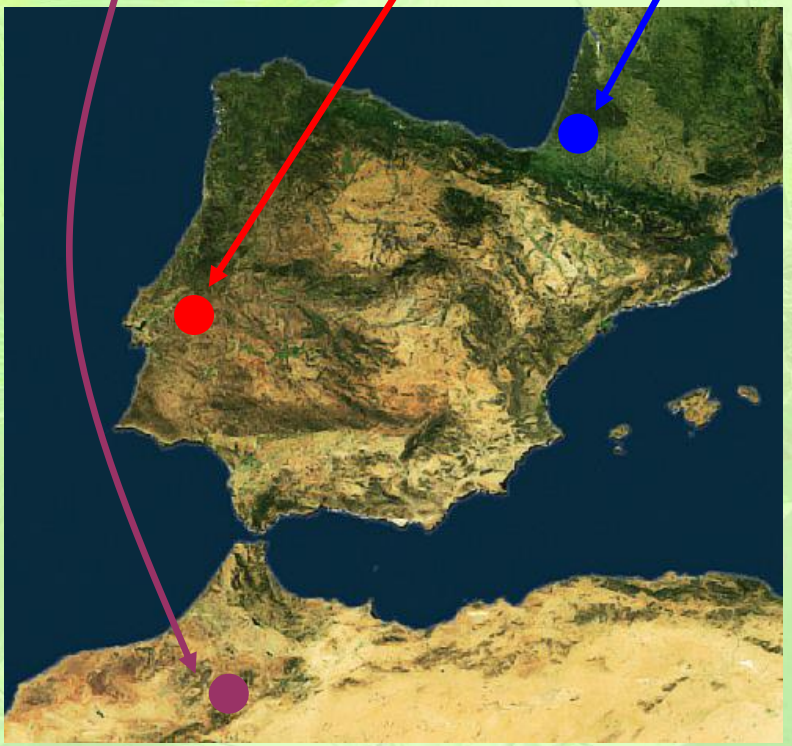
Mesic populations have thinner leaves with higher SLA and Nitrogen content

Traits and fitness: Whole distribution range

Differences among populations in leaf size



Oulmes Ponte do Sor Soustons



Large leaves in Moroccan populations

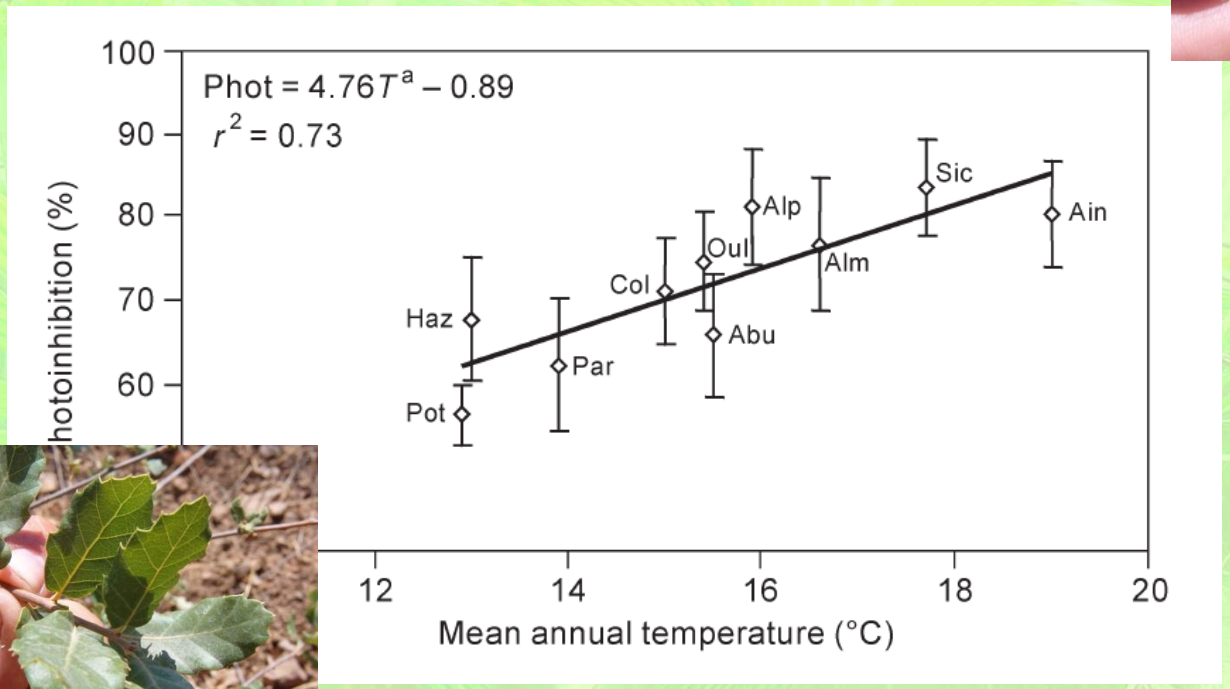
No associations with climate

Ramírez-Valiente (2010)

Traits and fitness: Whole distribution range

Differences among populations in sensitivity to low temperatures

Coldest populations lower levels of photoinhibition

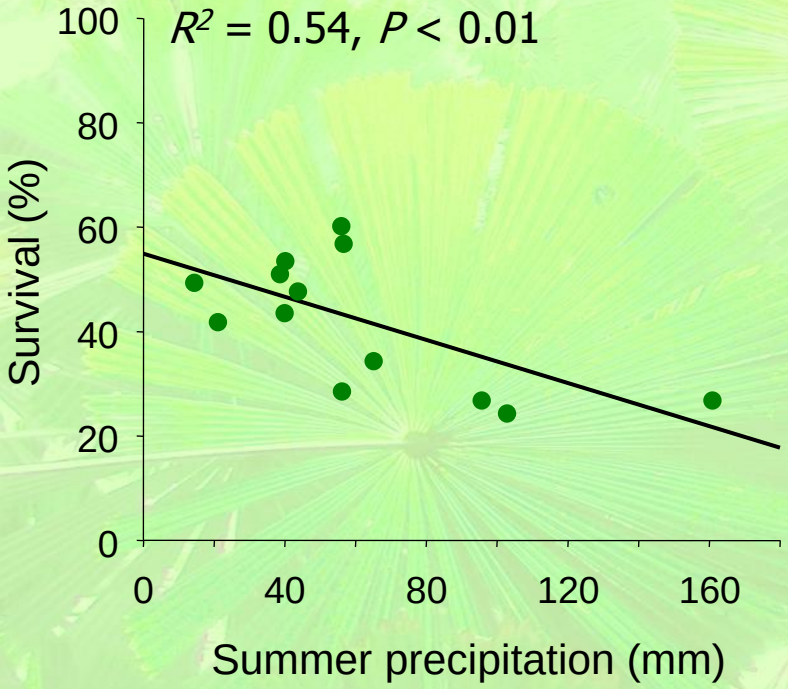


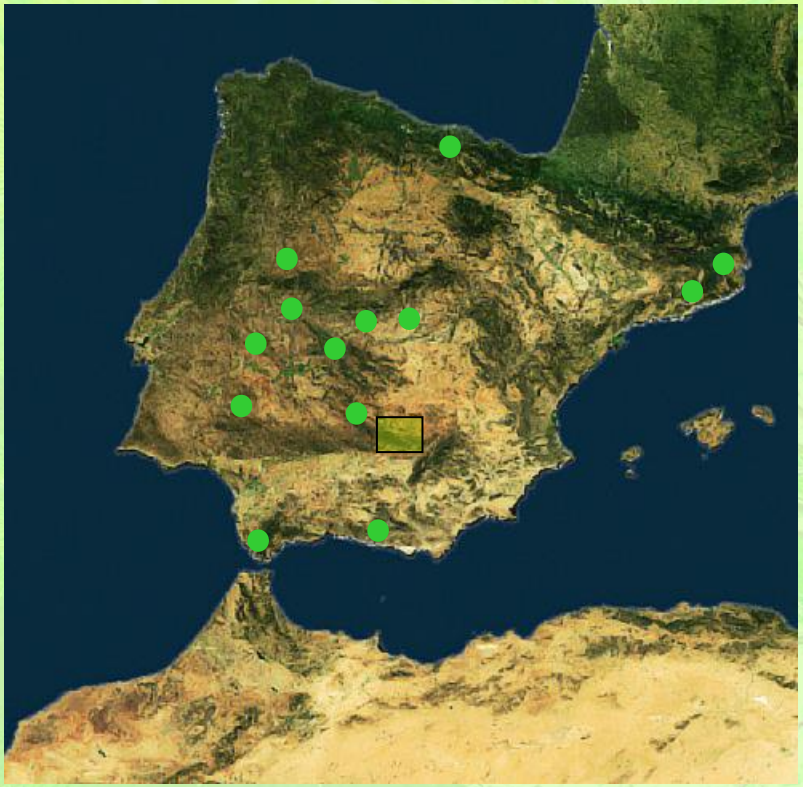
Aranda *et al.* (2005)

Traits and fitness: Among populations within regions

Differences in survival among populations from the Iberian Peninsula

Seedlings of xeric populations exhibited higher survival and larger acorns

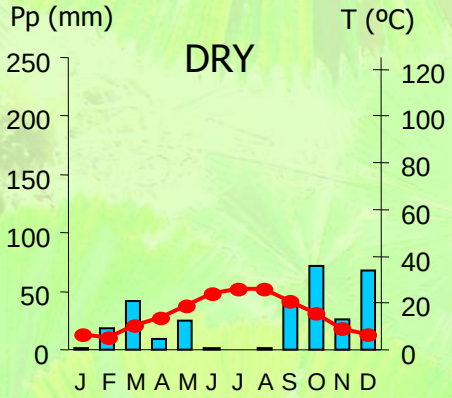


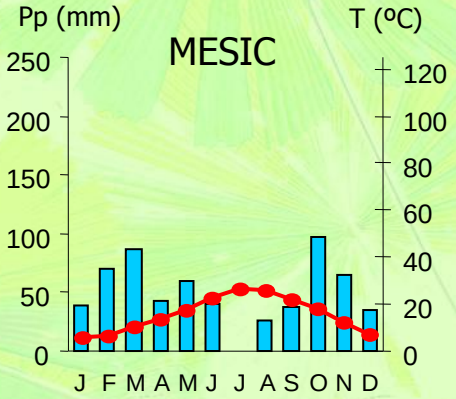


Ramirez-Valiente *et al.* (2009b)

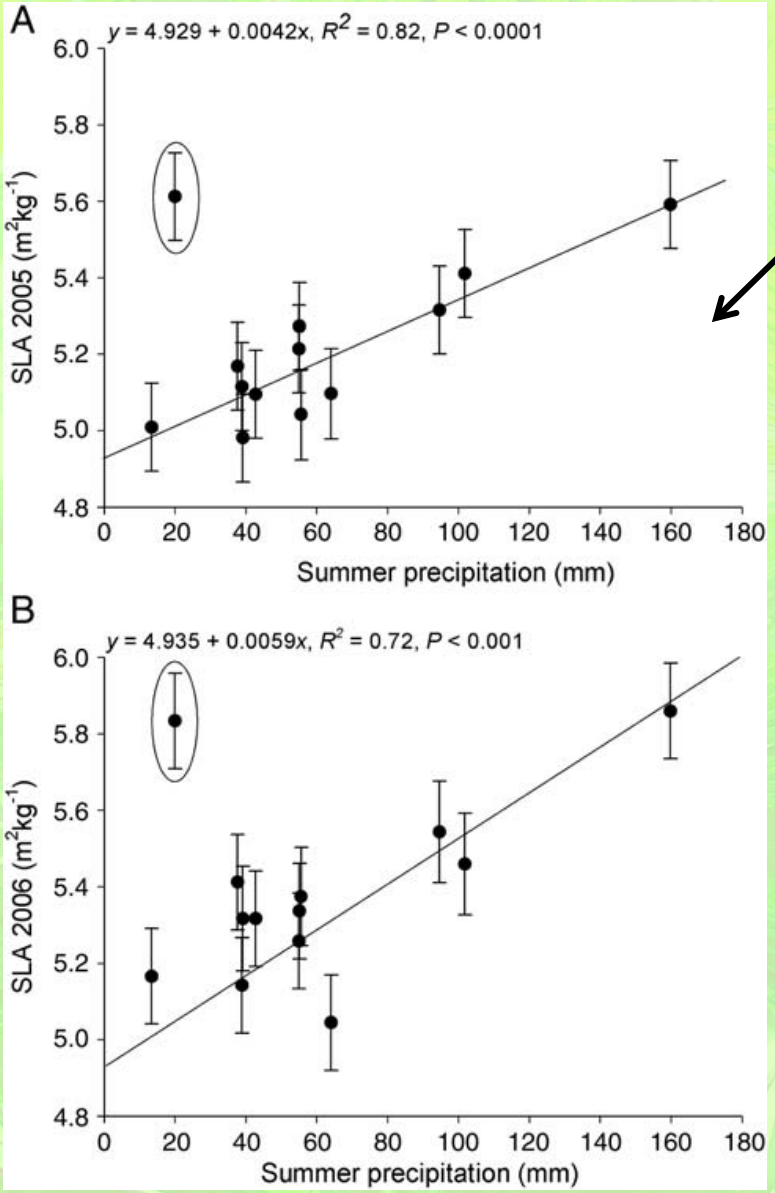
Traits and fitness: Among populations within regions

Testing for population differences in two climatically contrasting years

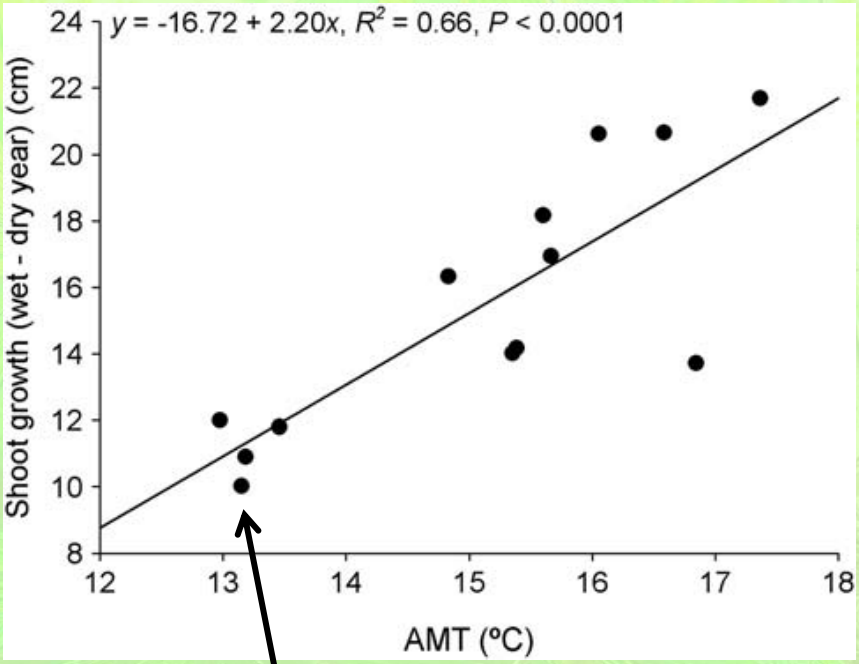




Traits and fitness: Among populations within regions



Drier populations have smaller, thicker leaves, lower SLA and N_{mass}



Population x environment interaction. Colder populations less plastic

Ramirez-Valiente *et al.* (2010)

Traits and fitness: Within populations

Differences among maternal families within populations in:

Height, diameter, $\Delta^{13}C$, SLA and leaf size.

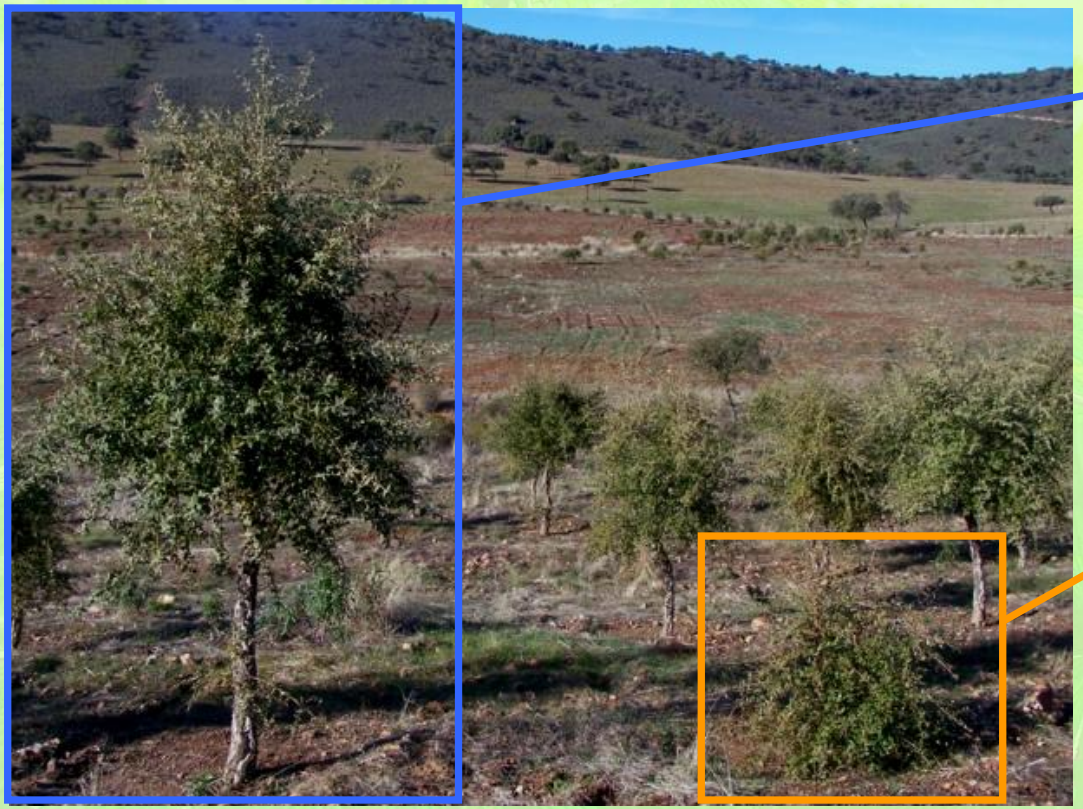


Fig. Seedlings originating from two contrasting maternal families from Alcácer do Sal (Portugal)

Ramirez-Valiente *et al.* (2011)

Traits and fitness: Within populations

% variance explained by family > population

		Height	Diameter	SLA	$\Delta^{13}C$
Population	% variance	**5.2**	0.6	1.3	1.2
Family (population)	% variance	**8.9**	**11.7**	**4.5**	**12.6**

Implications for management

Genetic patterns of variation in molecular markers and functional traits are different

To combine information from both neutral molecular markers and quantitative functional traits to define conservation units

To assess population differentiation under different environmental conditions. Genotype x Environment interactions

Analyses on intrapopulation genetic variation might be crucial to understand evolutionary potential of populations

THANK YOU VERY MUCH

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