

Roots to riches

Genetics & products of stone pine & Mediterranean oaks

Mediterranean pine nuts – from forests or from plantations? New management approaches under global change



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FAO/CIHEAM Inter-regional Research Network on Nuts

IUFRO RG1.08.00 - Silviculture for production of edible fruits



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Roots to Riches

Genetics & products of stone pine & Mediterranean oaks

EFIMED Scientific Seminar

Alghero, Sardegna, September 26, 2018

Stone pine, *Pinus pinea*

Mediterranean pine nut kernels, a gourmet NWFP



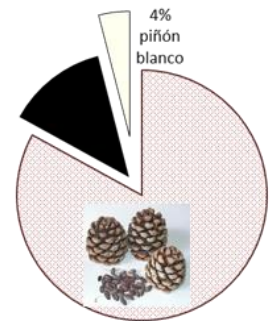
Yields (“100-2,000 kg/ha/yr cones”)

Fresh **cone** weight 250-350(-600) g

18% **pine nuts** in shell per kg cone (**1:6**)

25% kg **kernel** per kg pine nuts (**1:4**)

4% kg kernel per kg cone (**1:25**)



GLOBAL CHANGE – GLOBAL TRADE

Pine nuts traded in the European market – genuine *pignoli*?

Pinus pinea

True Mediterranean pine nuts

Deliberate confusion in retail

of genuine Mediterranean pine nuts (*P. pinea*)
with cheaper Asiatic species (*P. koraiensis*, *gerardiana*),
differed clearly in taste and nutritional values

⇒ **enforce standards, traceability, due labelling,
quality brands, consumers awareness
& molecular tools** (e.g. INIA patent, 2011)

Pinus koraiensis

Chinese pine nuts

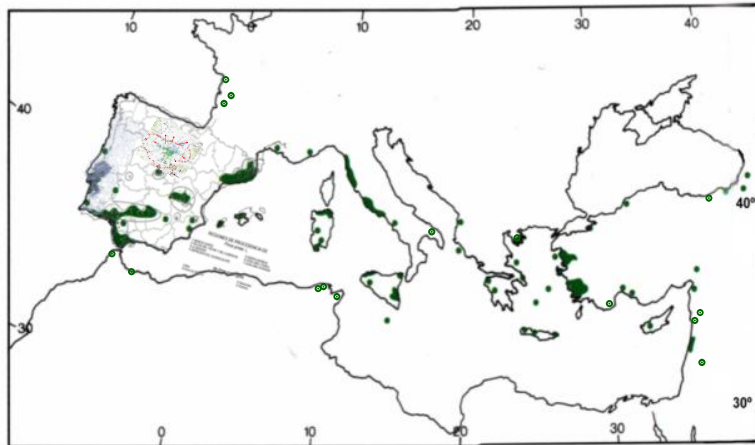
Pinus gerardiana

Pakistani *Chilgoza* pine nuts



Stone pine, *Pinus pinea*

Pan-Mediterranean distribution
 ...mostly plantations since 19th c.
 (dune fixation, or vineyards erased by *Phylloxera*)
 one-layer stands → naturalisation



Adapted from Blanco et al, 1997

& natural presence in open stand on dunes, and as secondary tree species "over" Mediterranean woodlands.

Area (ha)		
	"XIX c." (estim.)	"2018"
Spain	175,000	490,000
Turkey	30,000 ?	195,000
Portugal	35,000 ?	175,000
Italy	40,000 ?	46,000
Tunisia	"0"	21,000
France	13,000 ?	13,000
Lebanon	10,000 ?	12,000
Syria		5,500
Maroc	"0"	3,000
Israel	"0"	2,000
Greece	500 ?	1,500
Total	< 300,000	> 960,000



The Mediterranean stone pine: ecology

- **Wind-pollinated, zoochorous** pine.
- **Self-fertil?** Capable to establish from a few **kinds**.
- **Natural stand dynamics:** open, irregular woodland
- **In regular pine groves** $N_e \ll N_{total}$ (few reproducers)
- Local dispersion by birds **>1.5 km /100 yrs**



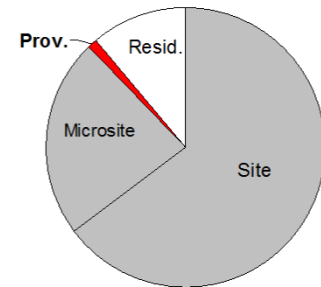
Stone pine, *Pinus pinea* – genetic resources



Quantitative genetics (phenotyping)

International Provenance trial
FAO *Silva Mediterranea* s. 1994

(Court Picon et al., 2004,
Mutke et al., 2010, 2013,
Carrasquinho & Gonçalves, 2013)



... reduced adaptative variation (growth, phenology)

Molecular genetics

Isoenzymes: only 1 polymorphism (2 alleles) out of 32 loci (Fallour et al. 1997)

cpDNA: only 3 polymorphisms (2 alleles) out of 13 loci (Vendramin et al. 2008)

"1 sole chloroplast survived"

...nearly complete absence of neutral variation

nuSSRs: 6 polymorphisms (several alleles each)

(Pinzauti et al., 2012)

...low, but significant variation

Stone pine, *Pinus pinea* – genetic resources



Hypothesis: glacial population bottleneck in SW Iberia



Broodbank, 2013

Gibraltar to Malaga

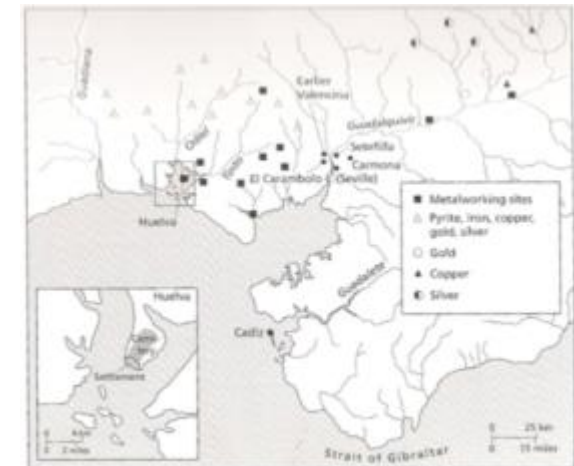
The last few Neanderthals (150-28 kyr BP), living retired at the *Costa del Sol*, eating pine nuts, sea food and snails



SW Iberia (Lisbon to Malaga)

Megalithic Copper Age, Tartessos, Phoenicians (5-0.5 kyr BCE)

Copper Age ivory vessel ~2.5 kyr BCE
(García Sanjuan et al., 2013)

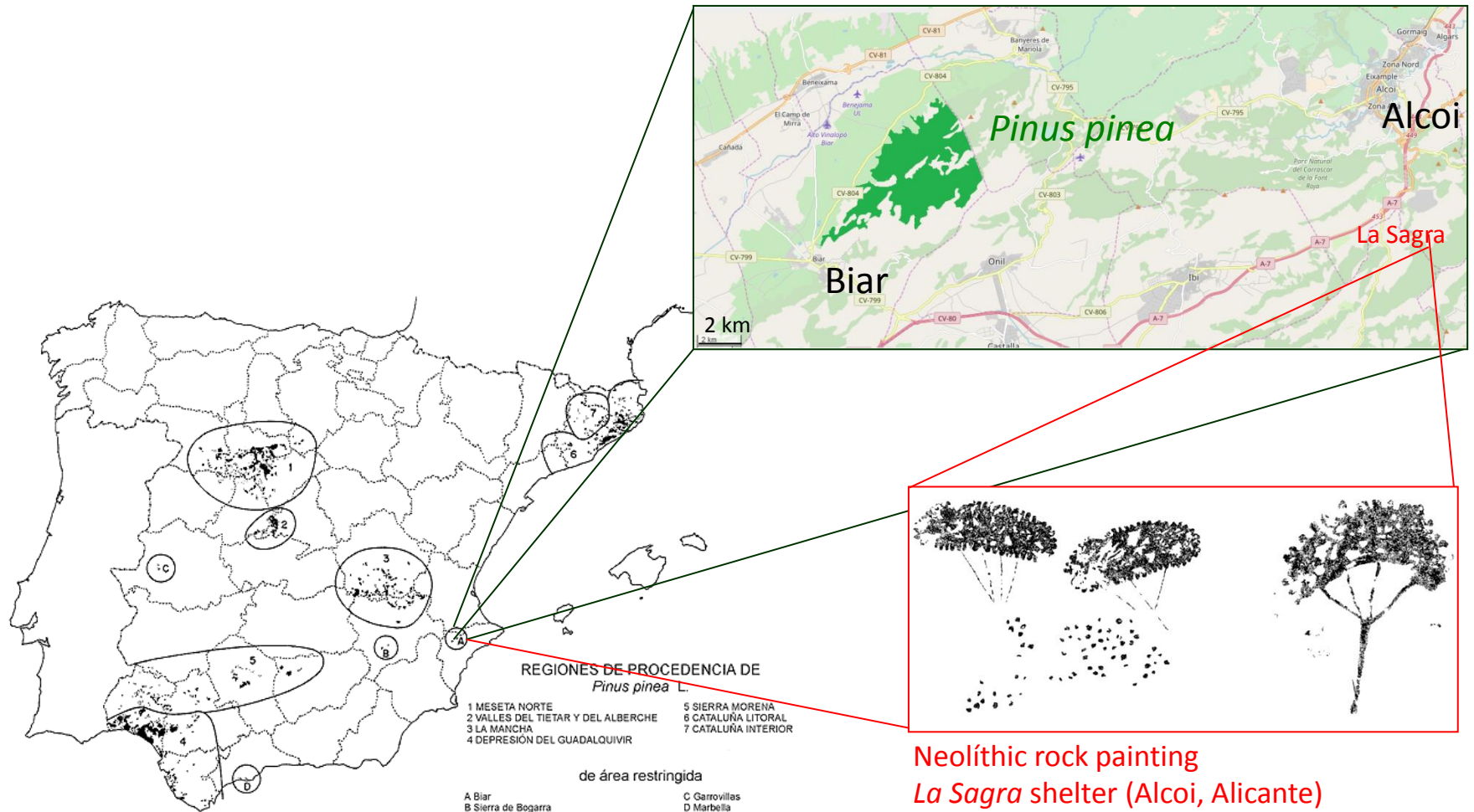


Broodbank, 2013

Archaeological findings "50,000-50 BCE"
& whole (western) Mediterranean since Iron Age (1 kyr BCE)
(Rubiales et al., 2011)

Stone pine, *Pinus pinea* – forestry

Spain 175,000 ha (1857)



Neolithic rock painting
La Sagra shelter (Alcoi, Alicante)
(Hernández et al., 2007)

Stone pine, *Pinus pinea* – forestry

Spain 175,000 ha (1857)

→ 490,000 ha (x3 since 1900), public & private afforestation (e.g. CAP >1993)
(760,000 ha 'presence' incl. mixed forests)



MULTIPURPOSE FORESTRY

Ecosystem services

Provision

- timber, biomass, cones, hunting

Regulation

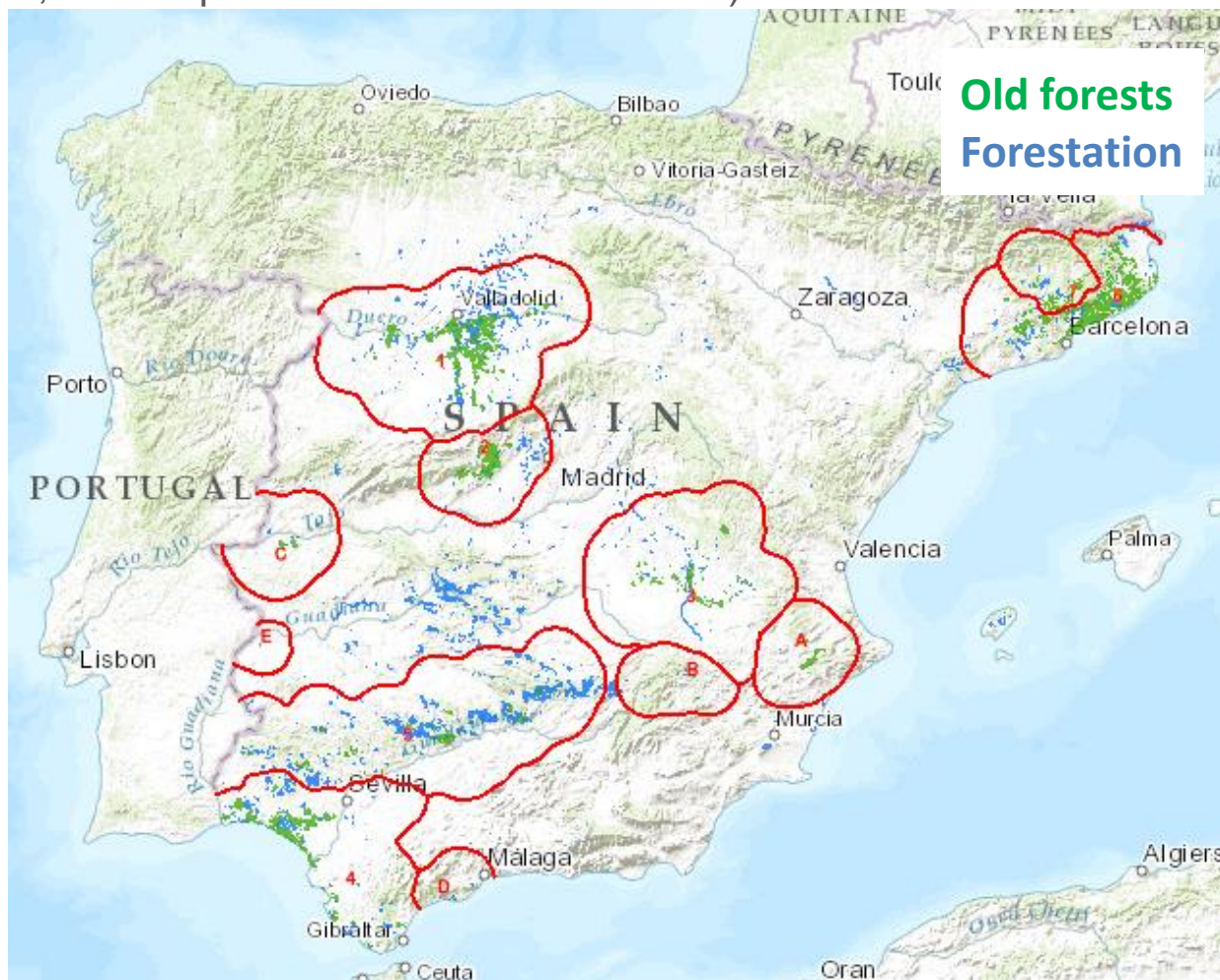
- soil and water

Support

- habitat for wildlife, flora

Culture

- recreation, landscape, amenity



http://www.genforced.es/sig_esp_forest.html

CONTEXT OF GLOBAL CHANGE

“Forests and forestry are facing at present times various environmental, social, economic and political challenges and threads

- Climate change ... *drought events*
- Loss of biodiversity
- Emerging and invasive forest pests and diseases ... *Leptoglossus seed bug*
- Land erosion and loss of soils
- Illegal logging and trade of wood ...*and of NWFP*
- LULUC - Land use changes ...*coastal pine forests tor housing areas*
- etc. “

[ERA-NET *Sumforest* conference “*Sustainable forestry: Fact or Fiction?*” Skopje, 2017]

CONTEXT OF GLOBAL CHANGE

Africanisation of the Mediterranean climate zone

CC - Climate Change (\subset Global Change)

- Weather-triggered phenology / productivity (Mutke et al., 2003, 2005; Calama et al., 2011, 2016)
- Natural disturbances, extreme events (crown diebacks)
- Forest fire risks, drought-prone pest outbreaks,...
- Exotic pests range expansion (+ diseases)

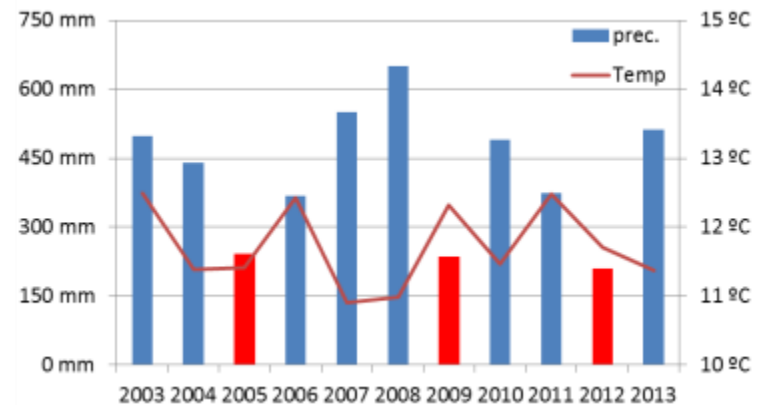


Impacts

- Species range
- Adaptation / Genetic resources
- Forest production / productivity (Pardos et al., 2015)

Adaptation & Mitigation

- Adaptative management, stand density reduction (del Río et al., 2014)



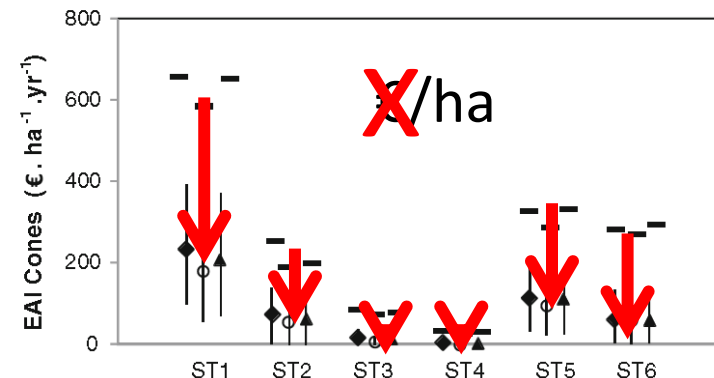
Climate scenarios (21st c. central Spain)

MAT Baseline 11-13 °C

CC +4 to +8 °C

MAR Baseline 350-500 mm/yr

CC. up to -20 %



(Pardos et al., 2015)

CONTEXT OF GLOBAL CHANGE



Pests (some of them favoured by global warming and plant stress)

Endemic needle and shoot pests (pine processionary moth, *Thaumetopoea pityocampa*,
pine shoot moth, *Rhyacionia buoliana*)

Endemic cone and seed pests (cone weevil, *Pissodes validirostris*,
cone moth, *Dioryctria mendacella*)

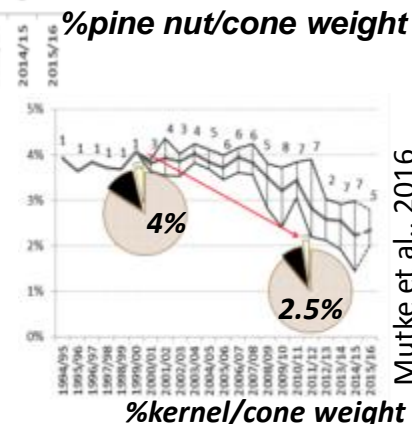
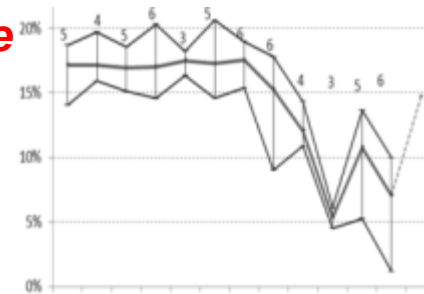
Recently introduced **exotic seed bug** *Leptoglossus occidentalis*

causing the massive **Dry Cone Syndrome**

- conelet abortion
- empty seeds (50%)
- drop in kernel yield



Leptoglossus occidentalis



Mutke et al., 2016

combined with grazing, annual crops, cork oak, fruit tree underplanting



New management approaches under global change - domestication for pine nuts

Portugal

Formerly, **35,000 ha** in open / mixed forests

→ **175,000 ha (6% forest area.pt) (x5 since 1970),**

Increasingly orchards & agroforestry, increasingly **grafted** <http://www.unac.pt/eventos/2012.html>



Turkey (42,000 ha stone pine in state forests)

“28,000 ha **forest** in good shape + 15,000 ha **degraded** (0.3% total forest area TR)”

<http://www.ogm.gov.tr/lang/en/Documents/Forest Atlas.pdf>

But actually, **195,000 ha** stone pine (**x5 since 1970**)

▷ 133,000 ha **private plantations**

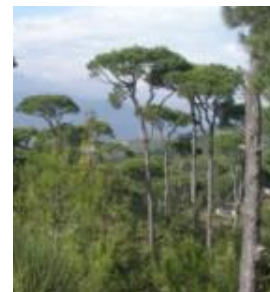
with **local economic relevance** of pine nut value chains [Kilci et al., 2014, Can 2016]

Lebanon (12,000 ha afforestation after 1860, Ottoman Empire)

still 12,000 ha today → (over-)mature evenaged stands, no regeneration

Western Mount Lebanon, at 600 to 1,000 (1,600) m a.s.l.

on steep slopes, poor soils on sandstone, but **very productive** in cones





Genetic improvement of *Pinus pinea*

- **Spain** (Ministry, Regional Gov., INIA, UPM, IRTA, CTFC): 15 qualified & tested clones
- **Portugal** (INIAV + private land owners assoc. UNAC, ANSUB): qualified clone mixture (64)
- **Tunisia** (INGREF, collab. with IRTA / CTFC/ INIA Spain)
- **Turkey** (EFRI)
- **Chile** (INFOR), Australia, New Zealand (tree growers)

⊂ **FAO-CIHEAM** Inter-regional Research Network on Nuts, Stone Pine Group

AgroPine meetings 2011, 2016 <http://networks.iamz.ciheam.org/agopine2011/>

<http://agopine2016.inia.pt/>



Guadaño & Mutke, 2016

New management approaches under global change - domestication for pine nuts



For instance, clonal Selection in Spain

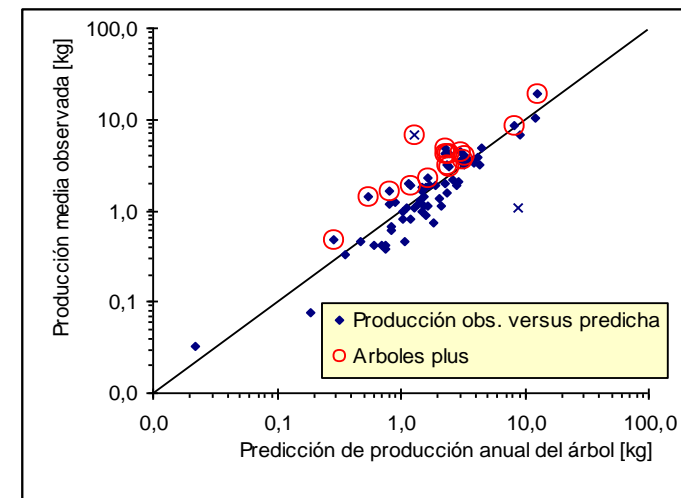
1.- Plus tree prospection in main regions (80/90ies)

3-7 year individual cone yield series, seed extraction



OBSERVACIONES SOBRE SU PRODUCCIÓN

Cierta cantidad de pinya de 4 y 5 años, muchas de ellas cerradas y atacadas por pisosodes.



(Gordo *et al.*, 2001)



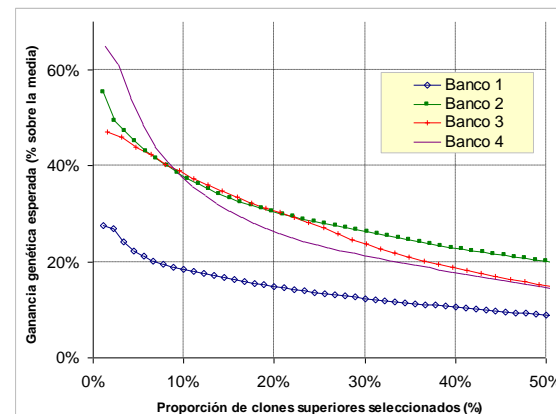
For instance, clonal Selection in Spain

1.- Plus tree prospection

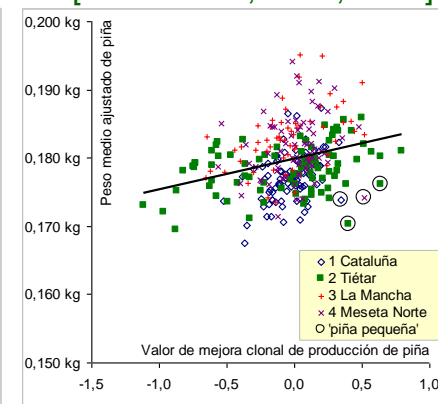
2.- Propagation by tip-cleft grafting

3.- Grafted orchards as **comparative trials** (replicates, randomisation. etc.)

- 10-20 yrs. individual yield series
- Evaluation weighted by covariates (tree size...)
- **Genetic gains +20-40%** selecting best 10%



[Mutke et al., 2005, 2007]



BUT virtually impossible to distinguish stone pine *cultivars* or even *varieties* by morphological or phenological descriptors *D.U.S.*, mandatory for their register (*“Distinctness, Uniformity and Stability”*) under standards UPOV.

*“Once you have seen an umbrella pine
all the other ones are the same”*



Nor by molecular markers with isoenzymes or cpDNA, either

Positively distinct by molecular markers *nucSSRs* (Pinzauti et al., 2012)

→ Register as **Forest Basic Materials** (*sensu* EU Regulation)

for producing **“Tested” Forest Reproductive Materials (graft scions)**

Superiority in cone yield for 5 “tested” clones [% trial mean]

Clone	Commercial name	Trial site 1	Site 2	Site 3
1011	Portillo-11	27%	-	25%
1012	Portillo-12	20%	12%	29%
1073	La Vega	12%	-	17%
1123	Íscar	-	20 %	11%
1201	Valdegalindo	-	15%	18%

(+10 “qualified” clones: 9-31% in one site)

Guadaño & Mutke, 2016

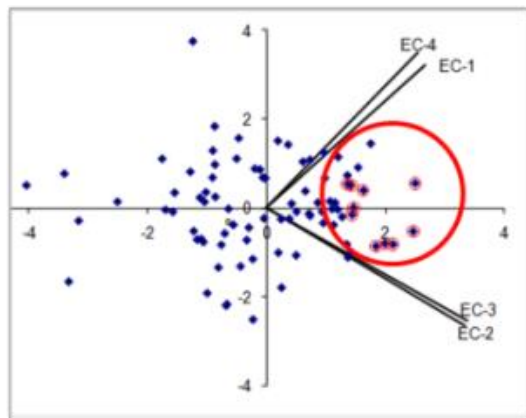


Clonal Selection in Spain

- 1.- Plus tree prospection in 5 m
- 2.- Propagation by tip-cleft **grafting** (green bud graft)
- 3.- Grafted orchards as **comparative trials**
- 4.- **Outlook:** Genotype x Environment **interactions** (~ **agroclimate** zones)

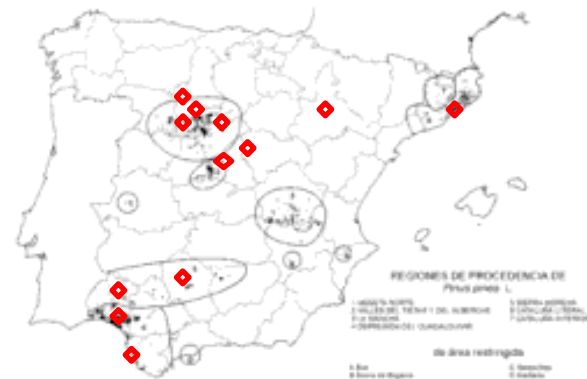
Genetic improvement (" +20% ")
versus
Integrated improvement ("x3")
(good horticultural practices)

→ **Broaden the network of reciprocal test sites**



EC-1, - 4
(Coastal plain)

EC-2, - 3
(Sierra Morena)



Last not least – fauna, soil protection, landscape, recreation



*A quien
a buen pino
se arrima...*

Not to be neglected, existing Mediterranean pine forests and woodlands still have paramount **ecological, protective and social ESS**

- (Peri)urban forestry (landscape, amenity, recreation)
- Wildlife, soil and water protection
- e.g. Tuscany, Tyrrhenian coastline, Doñana NP, Mount Somma / Vesuvius
- The only forest islands in the mostly “empty” Castilian cereal *pseudo-steppe*

Thank you for your attention

