Shrubland & woodland restoration in Spain and the Mediterranean

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CEAM
FUNDACIÓN CENTRO DE ESTUDIOS AMBIENTALES DEL MEDITERRÁNEO

Consolider

Programa Prometeo

GENERALITAT VALENCIANA
CONSELLERIA D'EDUCACIÓ

GRACCIE

UNIVERSITAT DE BARCELONA

FUME

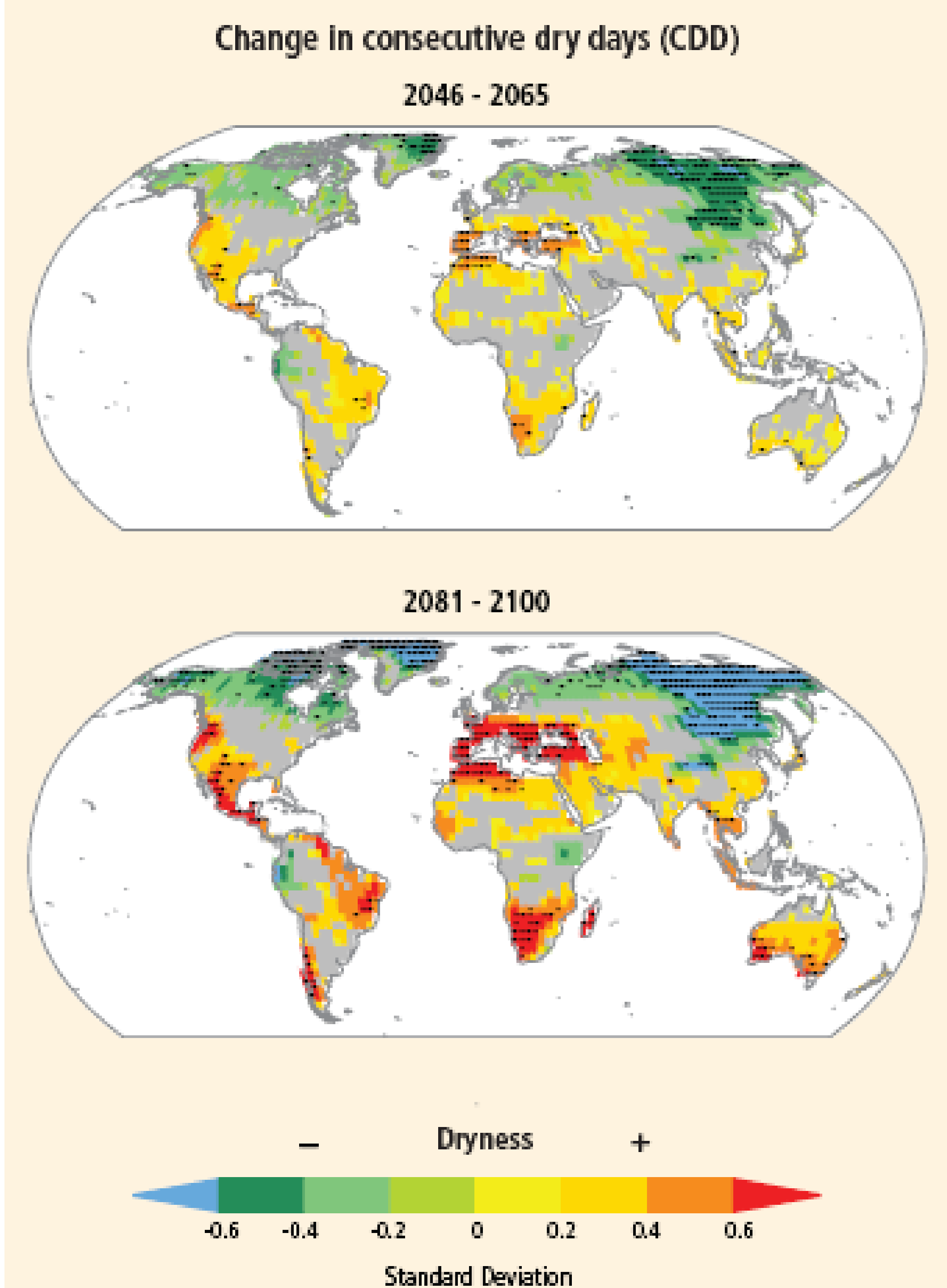
SEVENTH FRAMEWORK PROGRAMME

CLIMATE CHANGE PROJECTIONS:

fire hazard & restoration

- **LONGER AND MORE SEVERE FIRE SEASON**
- **HEAT WAVES & DROUGHT**
- **LARGER EXPOSED AREAS**

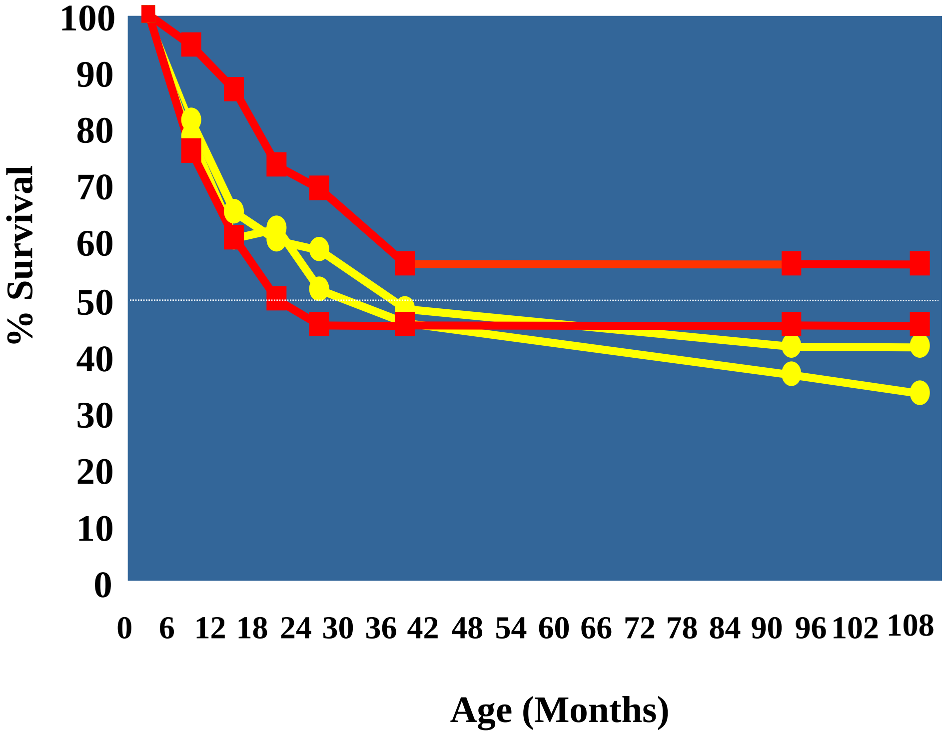
Changes in CDD interannual variability (standard deviation) in 20-year periods as compared to 1980-1999



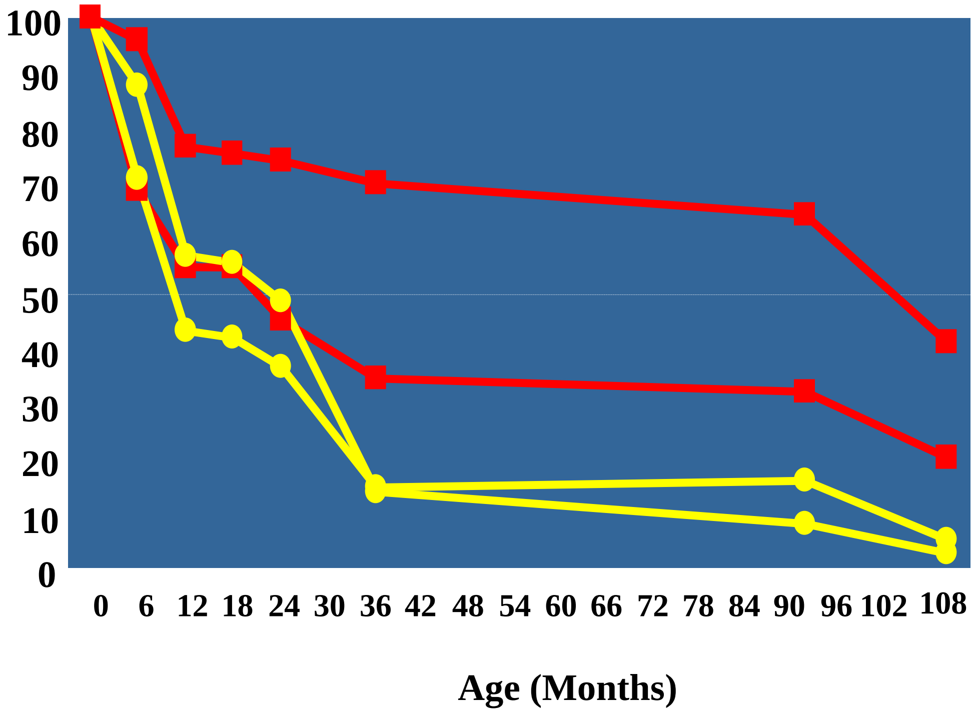
IPCC **SREX** (SMP) 2012
CCD < 1mm
SRES A2
17 GCMs

PLANTATIONS (1992)
Post-fire, south-facing slopes, degraded soils

Pinus halepensis



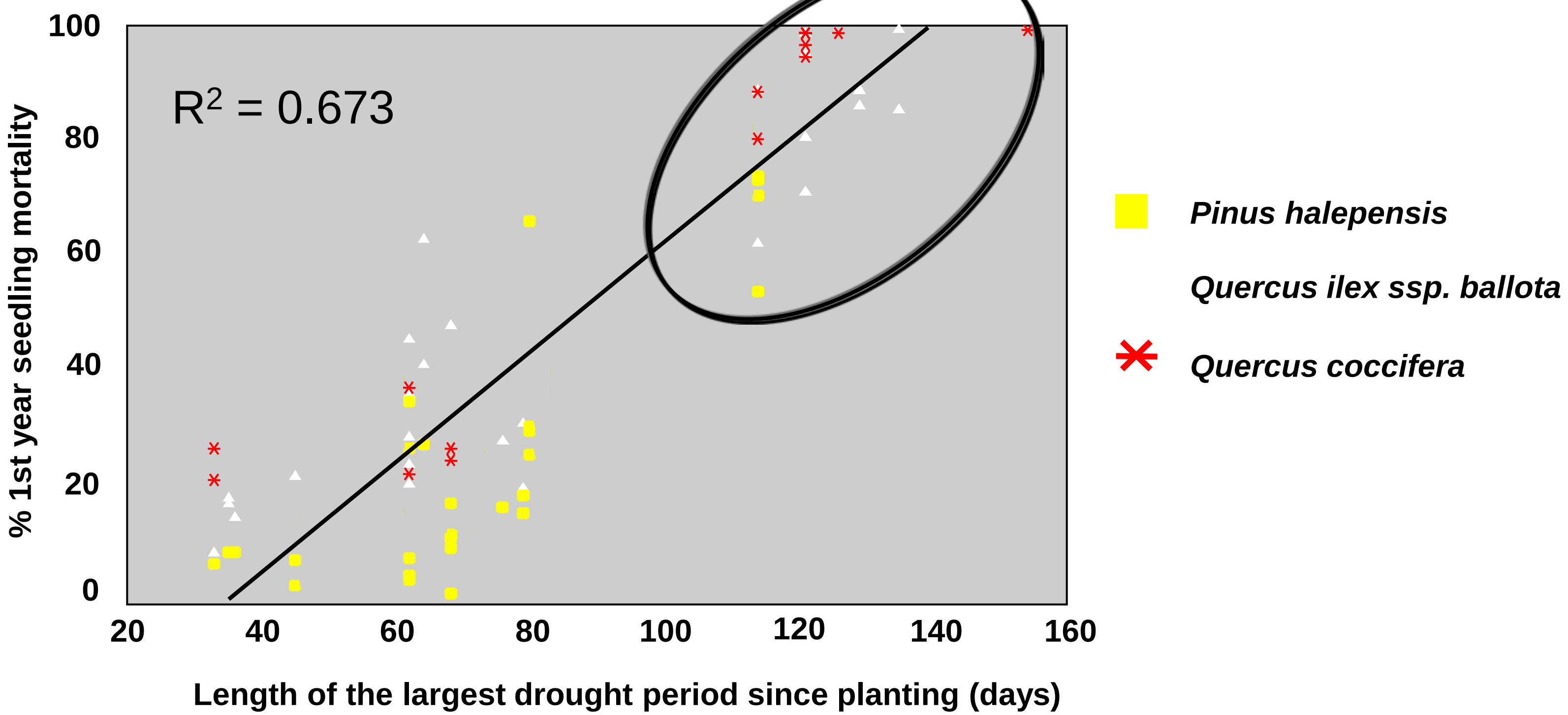
***Quercus ilex* ssp ballota**



Marls: ■ **Limestones:** ●

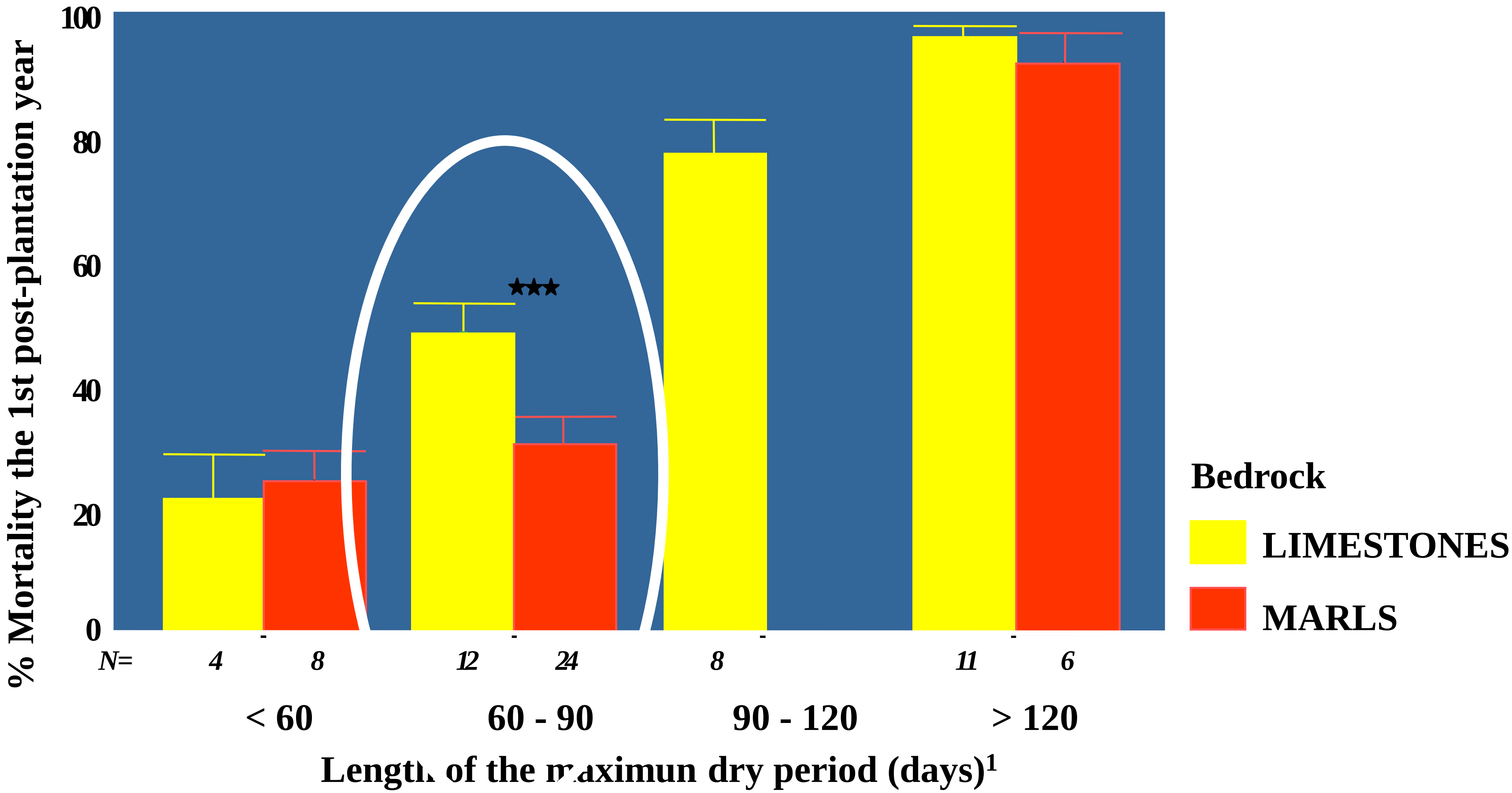
POST-FIRE SEEDLING PLANTATION

Dry subhumid and semiarid areas



(from Alloza & Vallejo, 1999)

Drought is the main cause of seedling mortality both for recruitment and in afforestation



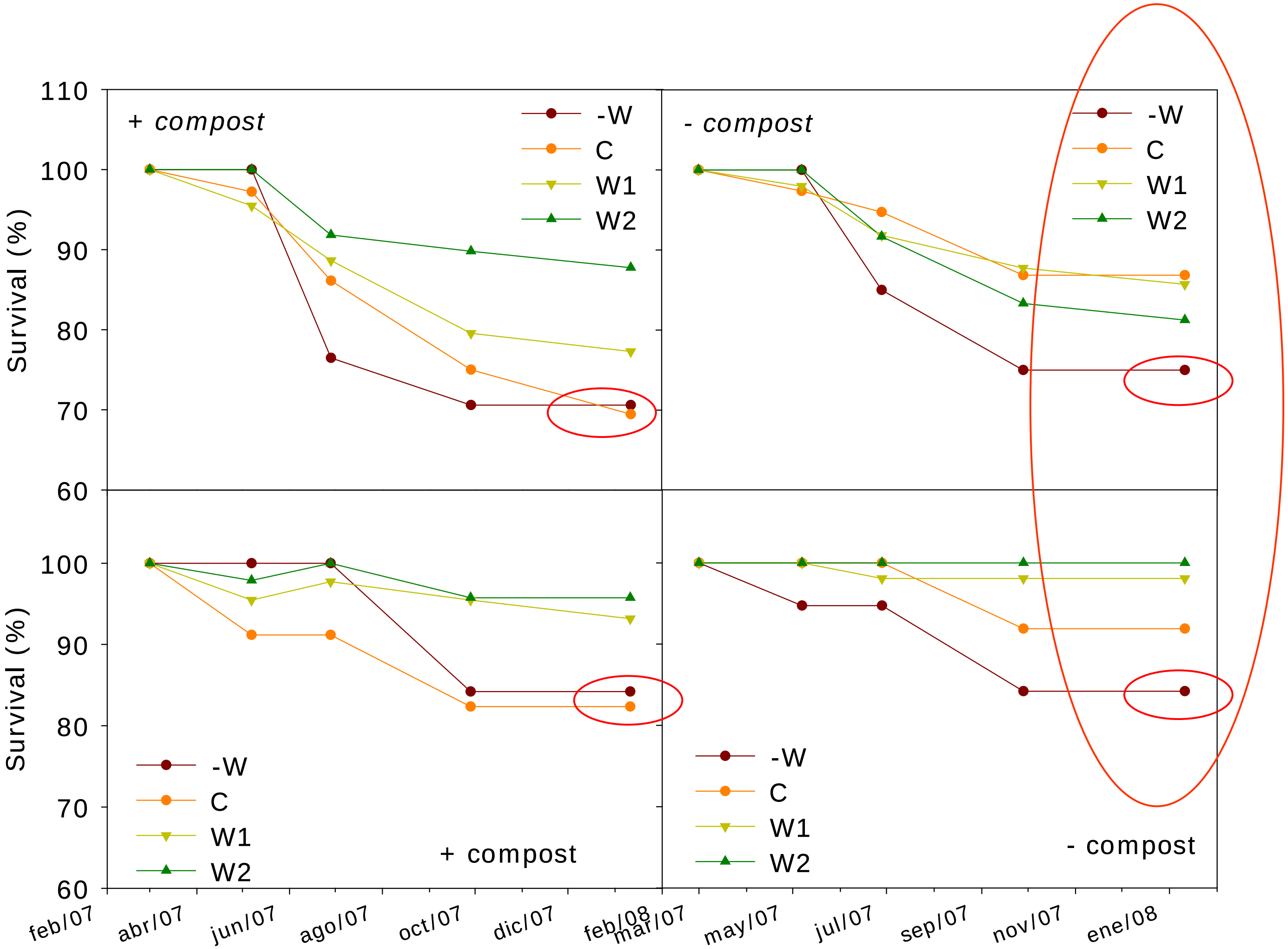
[1]*Consecutive days without any rainfall > 5 mm. *** Significant differences at p < 0.05*

SMALL CHANGES IN SOIL MOISTURE (approx. - 10%)

…. can produce increased seedling mortality and reduced growth

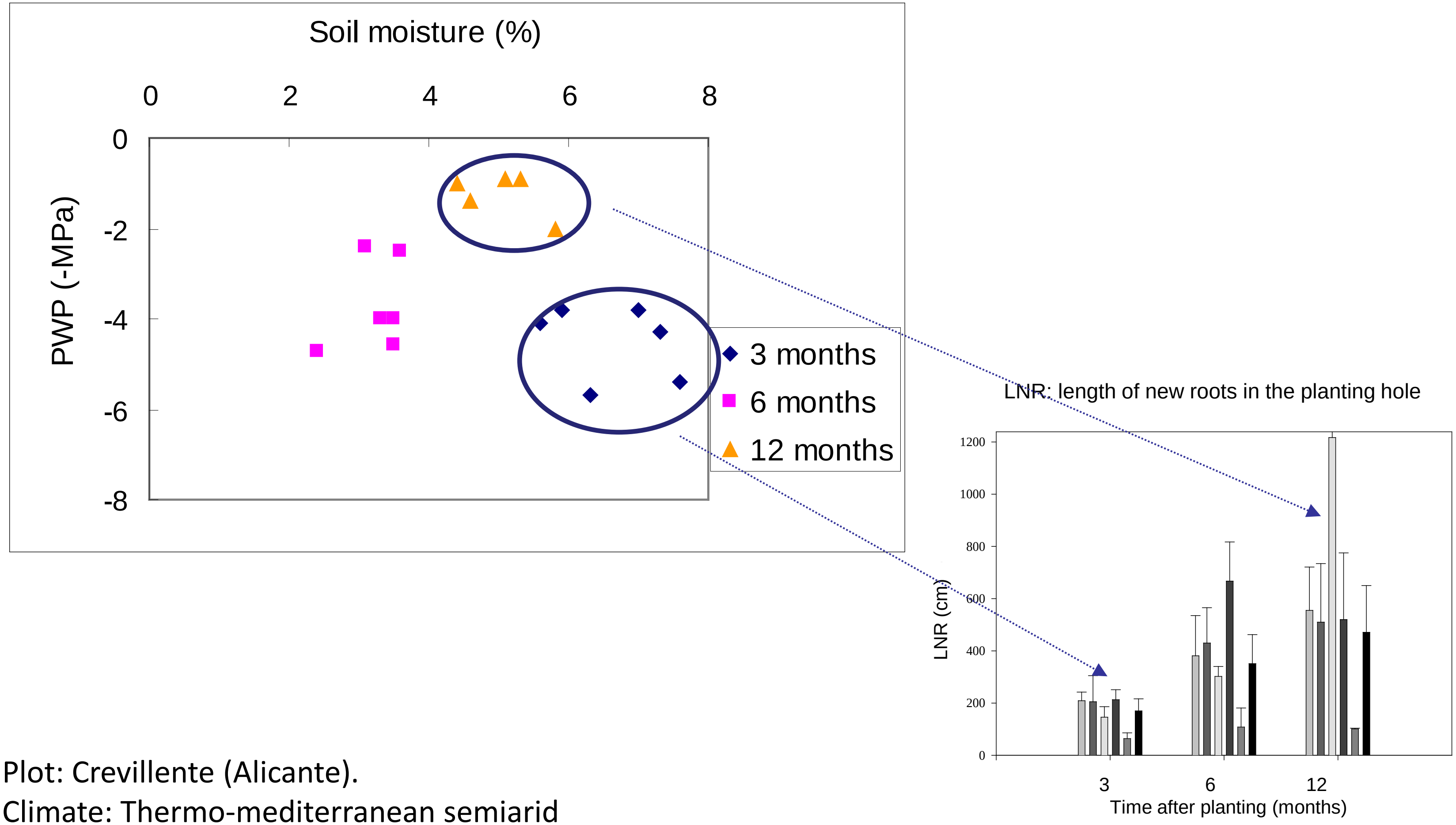
Pinus pinaster

Quercus ilex



TRANSPLANT SHOCK:

ROOT GROWTH AFTER TRANSPLANTING



Plot: Crevillente (Alicante).
Climate: Thermo-mediterranean semiarid
Species: *P. lentiscus, J. oxycedrus, Q. coccifera*

Fonseca 1999

TECHNICAL OPTIONS TO REDUCE WATER STRESS IN PLANTATIONS

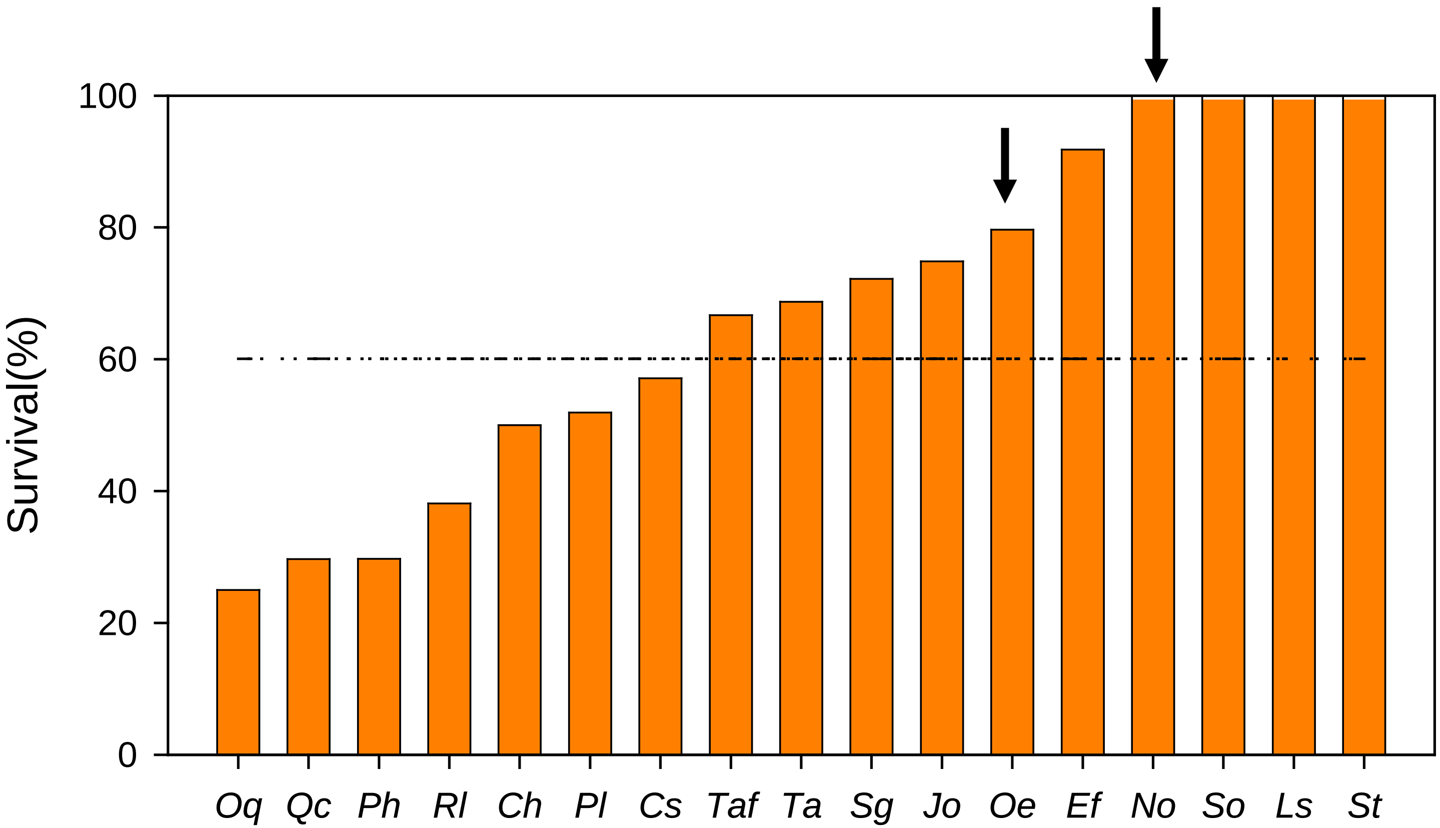
Table 11.2 Mediterranean restoration techniques concerned with water

Objective	Technique
Increase water-use efficiency	Selection of drought-tolerant species and ecotypes Seedling preconditioning Improve below-ground performance Improve nutritional status
Increase water supply	Soil preparation and amendment Irrigation Microsite selection
Reduce water losses	Tree shelters Mulching Microsite selection Control of competing species

Vallejo et al 2012

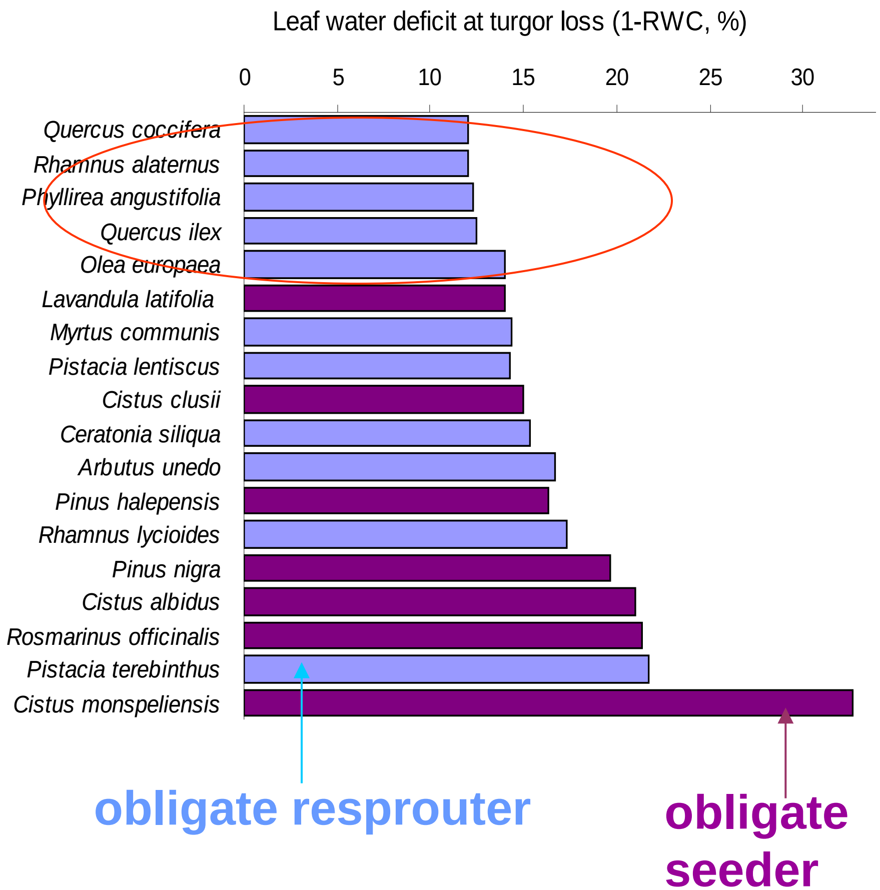
Species survival four years after outplanting

Albatera project , P 280 mm

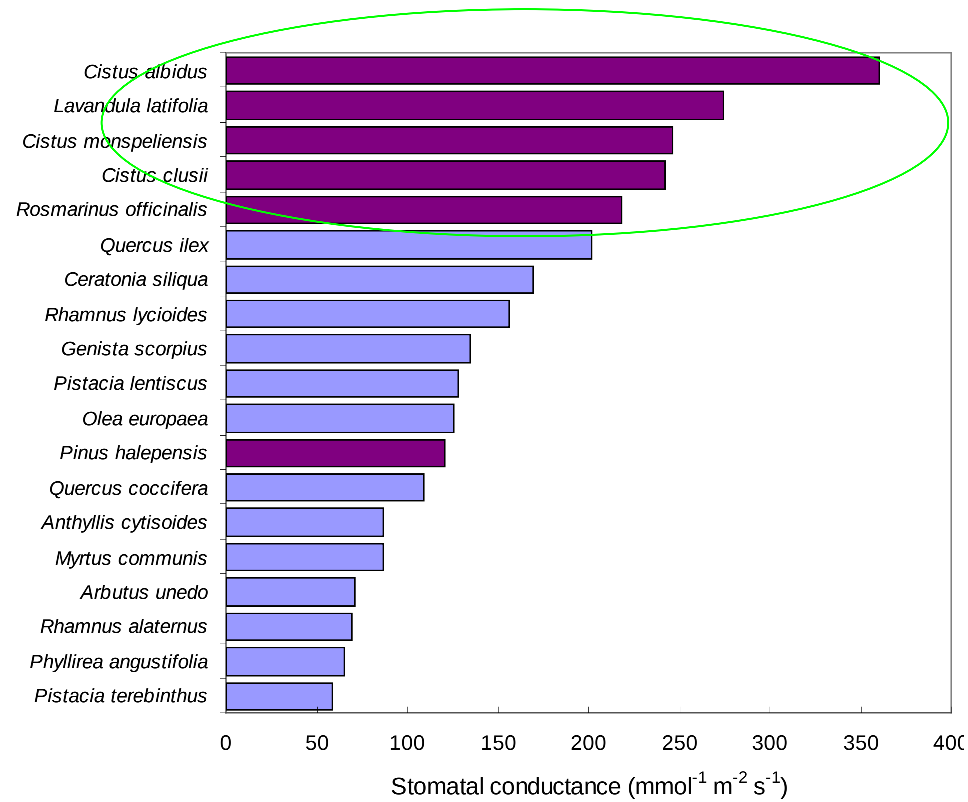


Abbreviations: *Qc: Quercus coccifera, Cs: Ceratonia siliqua, Pl: Pistacia lentiscus,* ***Ta: Tetraclinis articulata***, ***Ef: Ephedra fragilis***, *Rl: Rhamnus lycioides,* ***Oe: Olea europaea sylvestris***, *Ph Pinus halepensis, Oq: Osyris quadripartita,* ***Jo: Juniperus oxycedrus***, ***Sg: Salsola genistoides***, ***No: Nerium oleander***, ***Taf: Tamarix africana***, *Ch : Chamaerops humilis,* ***So: Salsola oppositifolia***, *Ls: Lygeum spartum, St: Stipa tenacissima.*

SPECIES SELECTION
Water-use strategies and response to drought

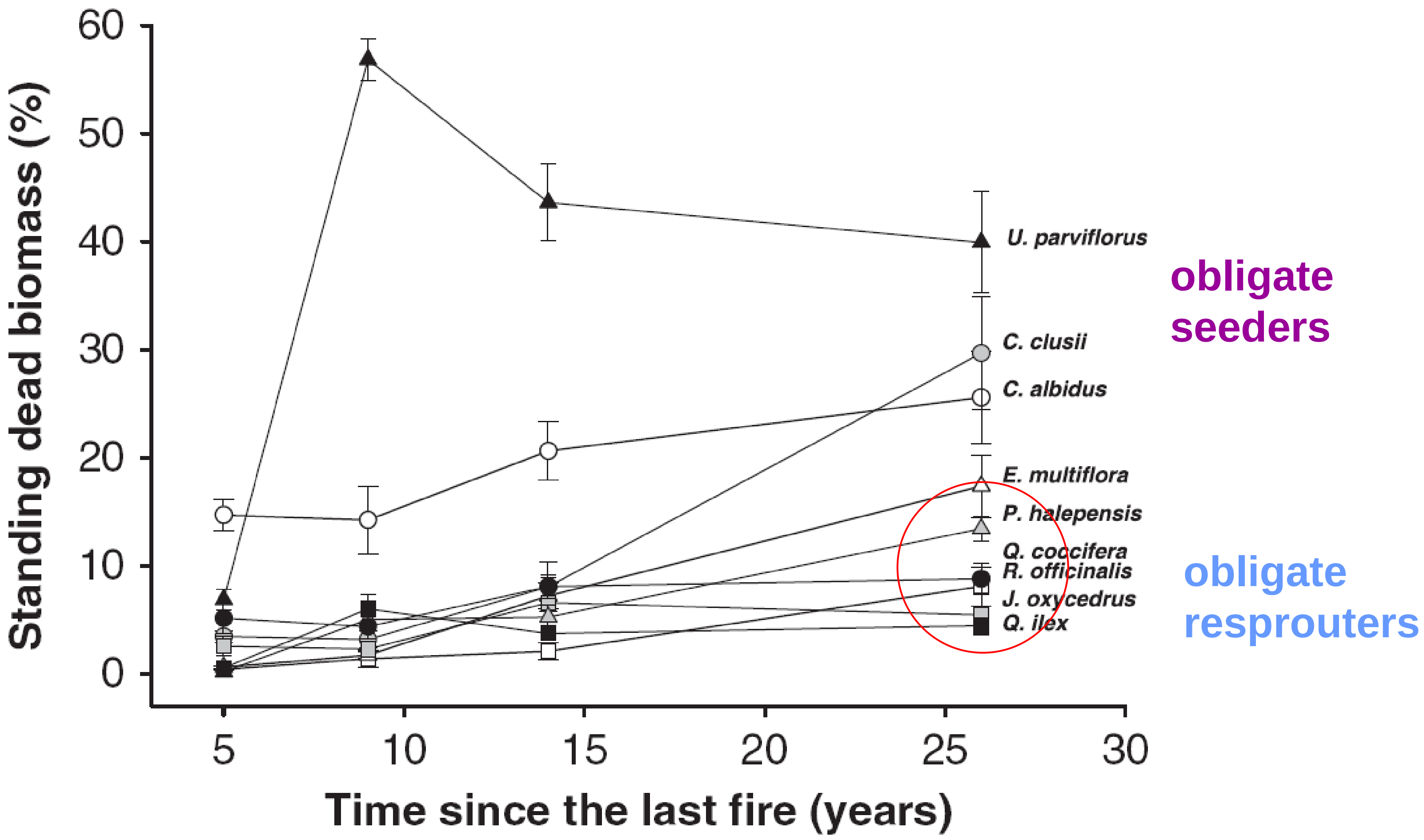


At field capacity



Vilagrosa et al., 2009; Hernández, 2010

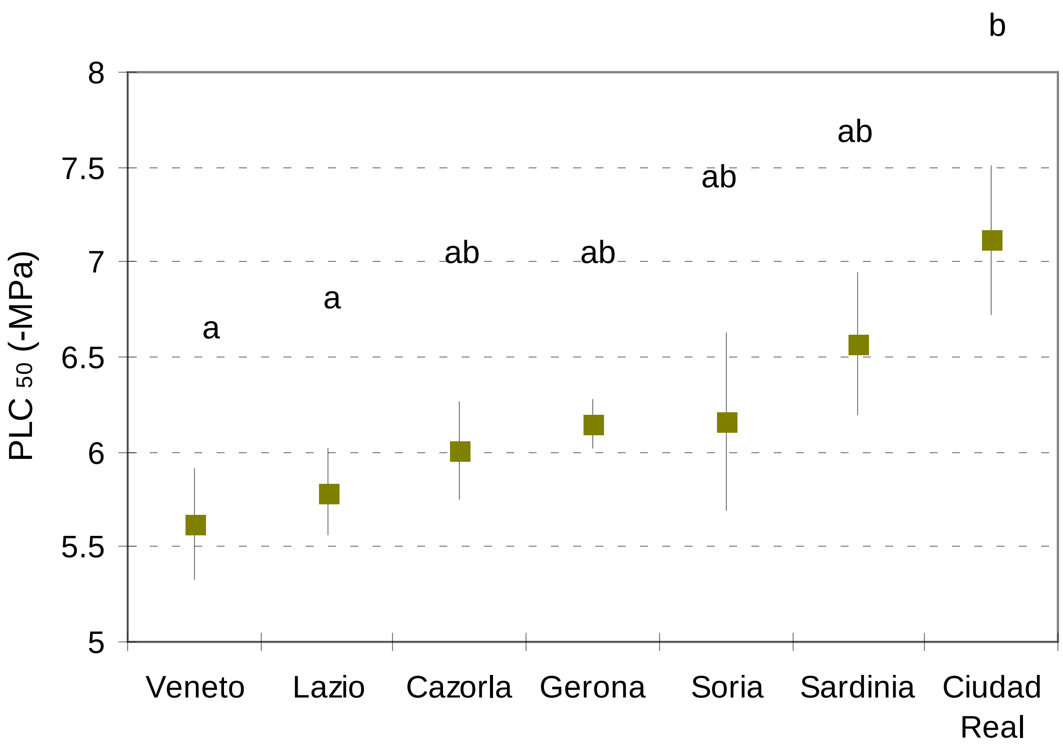
Dynamics of total standing dead fuel after fire



Baeza et al. 2011

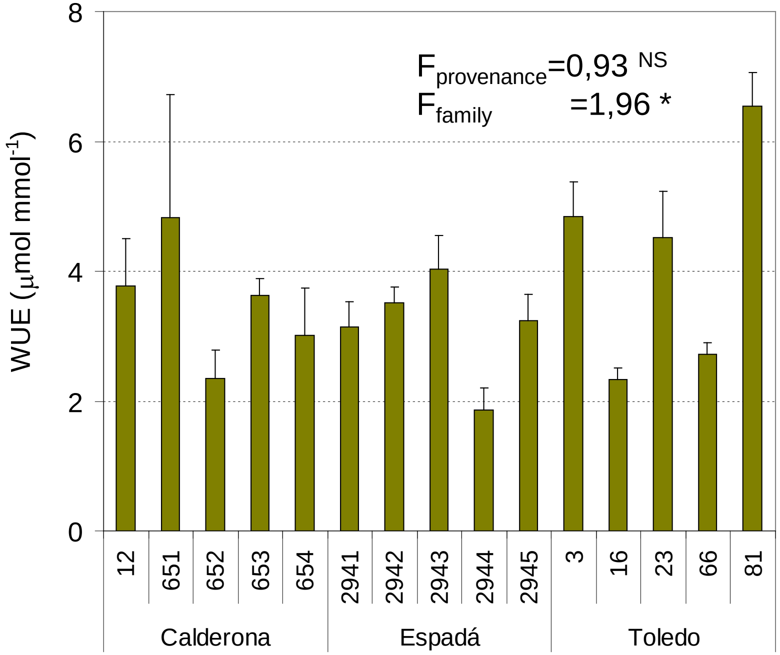
EXPLORING PROVENANCES …

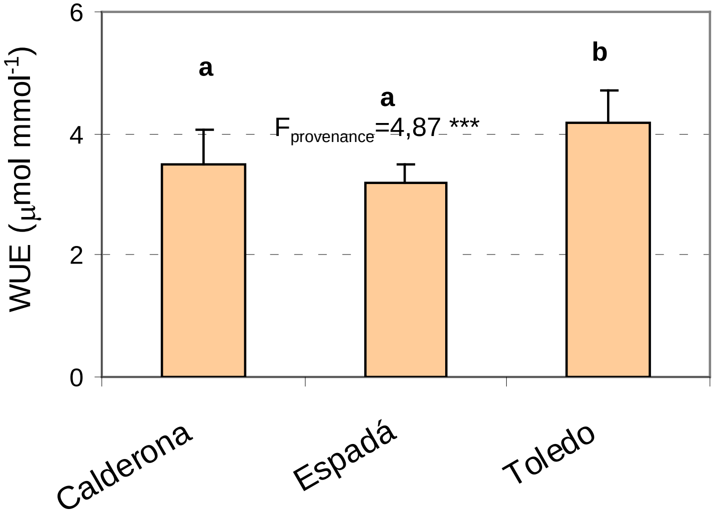
Quercus ilex: Risk of xylem cavitation among populations



Gil & Vilagrosa, unpublished

Quercus suber: Effect provenance and family/mother plant





Morcillo 2006, unpublised

SPECIES DIVERSIFICATION

Planting woody resprouters

WOODY RESPROUERS RECOVER FASTER AFTER BURNING & ARE LESS FLAMMABLE

SPECIES DIVERSIFICATION

Pistacia lentiscus

Arbutus unedo

Rhamnus alaternus

CONSTRAINTS FOR LAND RESTORATION IN DRY MEDITERRANEAN CONDITIONS

CLIMATE
- PREDICTIBLE: SUMMER DROUGHT
- LESS PREDICTIBLE: OUT-OF-SEASON DROUGHTS

SOIL
- SHALLOW/STONY/DISCONTINUOUS
- POOR STRUCTURE (PRONE TO SURFACE CRUSTING: SILTY SOILS)
- POOR BIOLOGICAL FERTILITY AND SOM
- LOW NUTRIENT CONTENT

DISTURBANCE REGIME
- FIRE (RECURRENT)
- GRAZING (FIRE-GRAZING CYCLES)
- EXTREME CLIMATIC EVENTS

TRYING TO IMPROVE SEEDLING PERFORMANCE IN THE FIELD

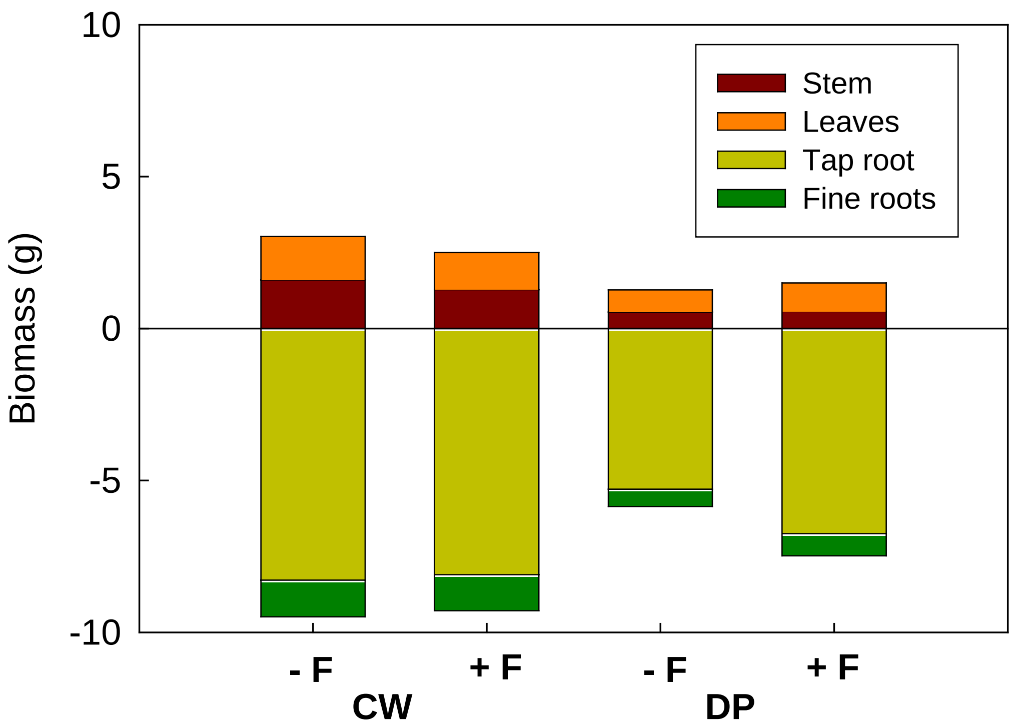
↓

Overcoming transplanting shock

SEEDLING QUALITY

Drought preconditioning
Quercus suber

Nursery



Control

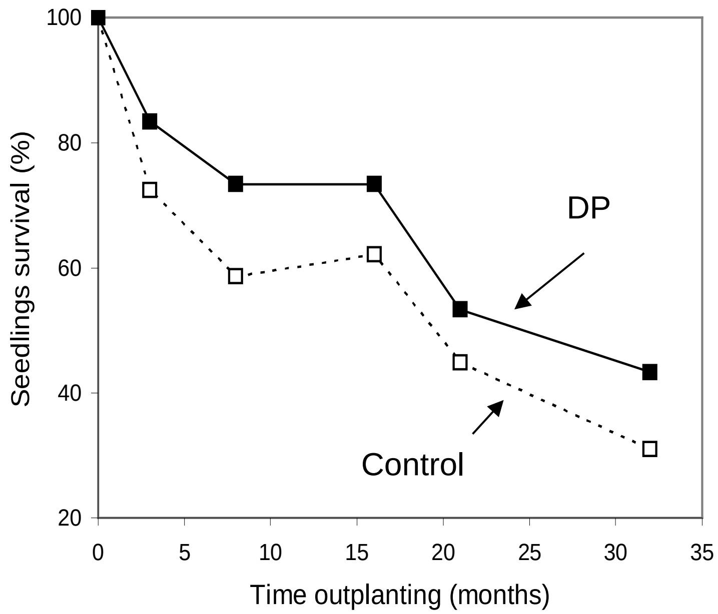
Drought-preconditioned

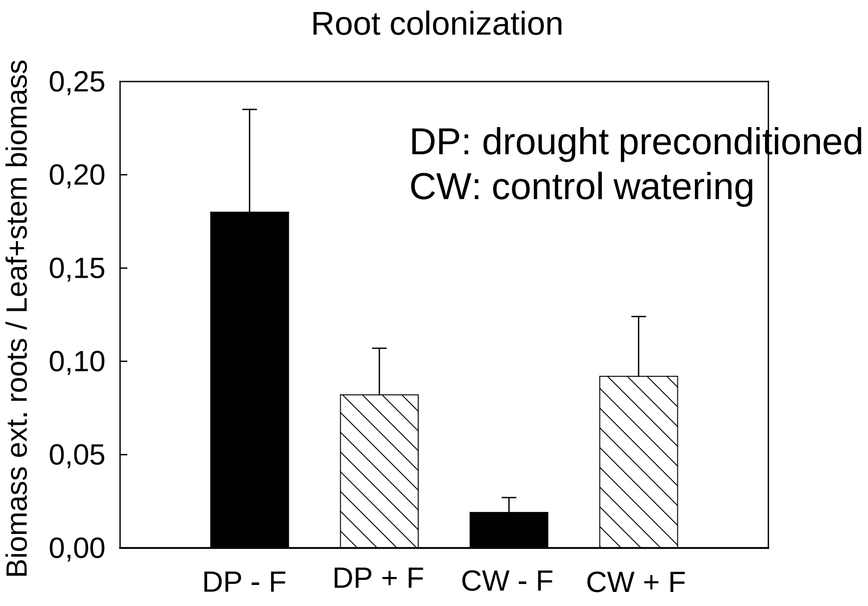
✓ **DP (drought preconditioning) produced smaller seedlings with higher R:S ratio.**

Drought preconditioning

Quercus suber

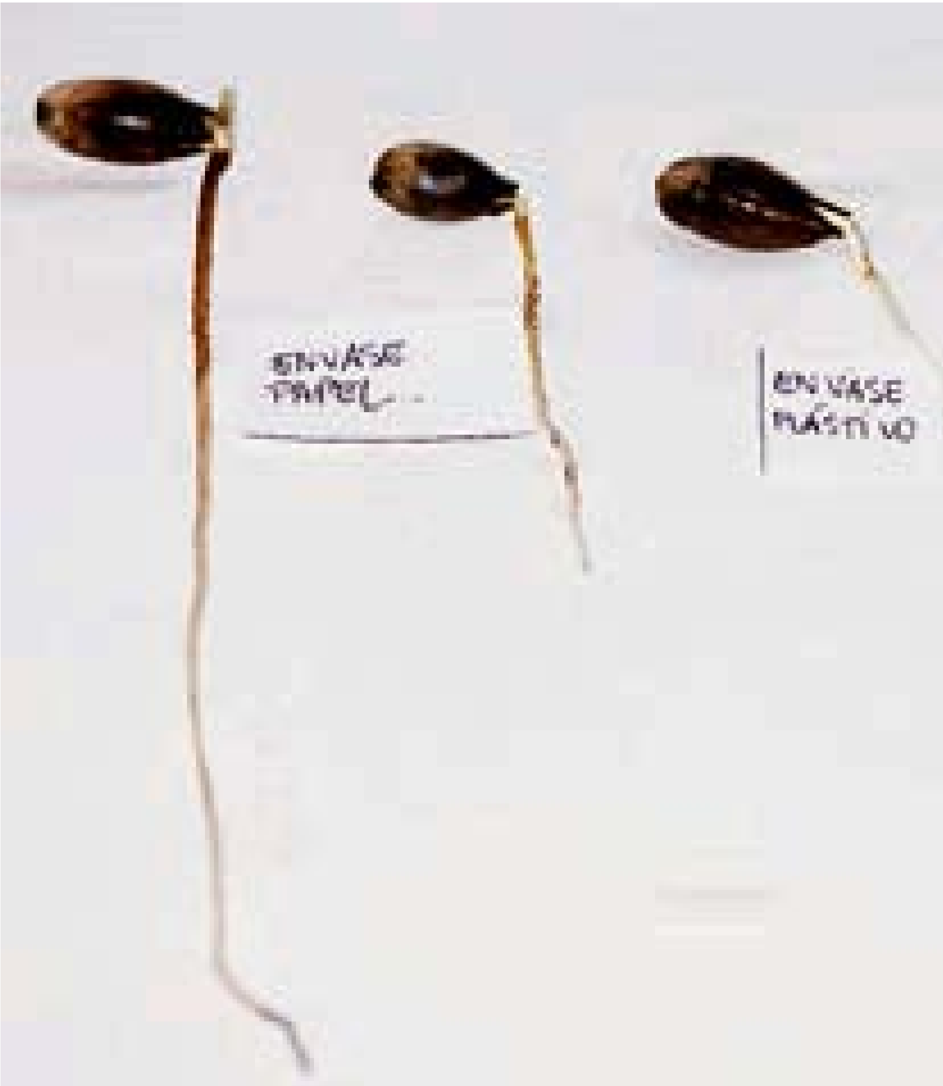
Field

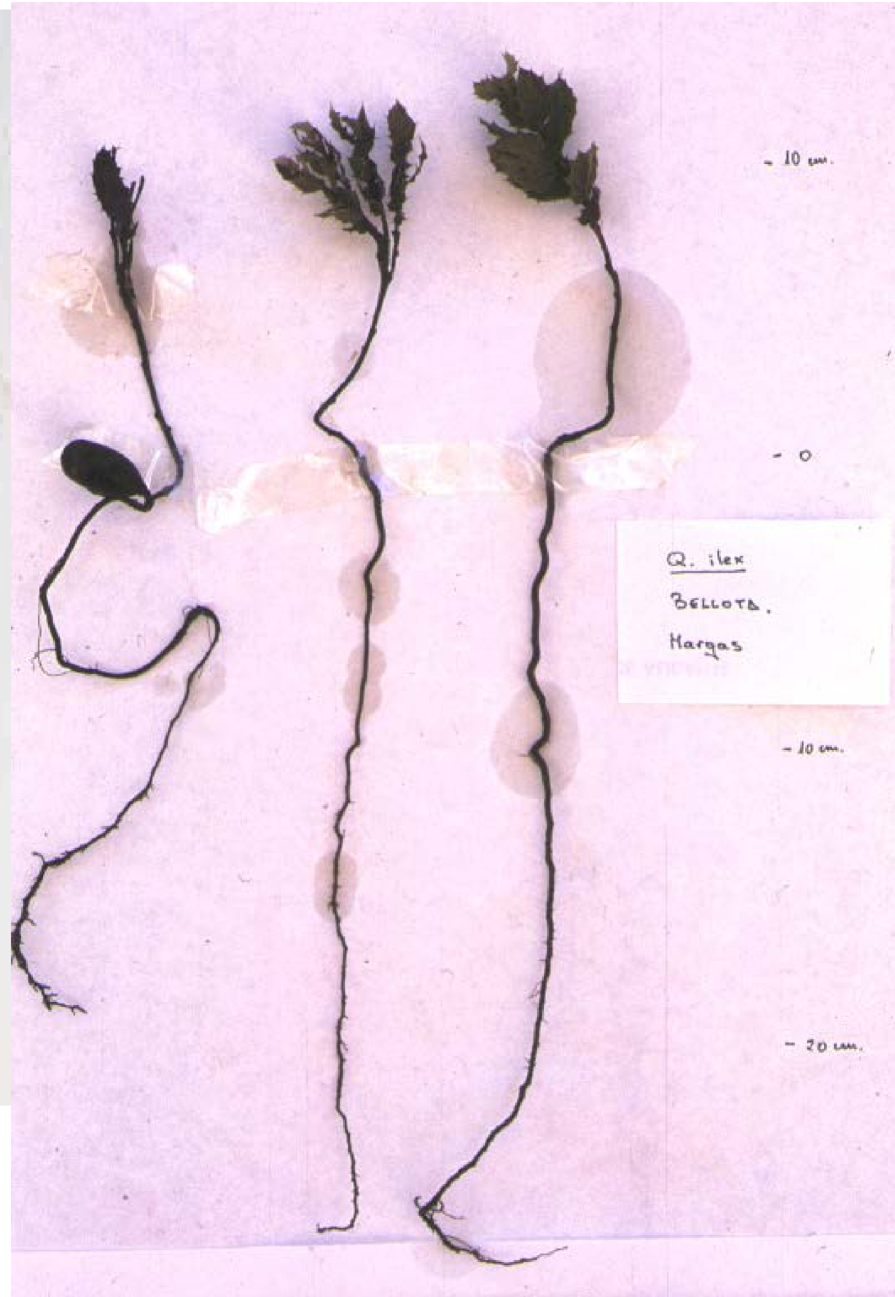




- ✓ **DP showed a tendency to improve survival.**
- ✓ **DP increased the root colonization in the field, deeper in the soil and with greater root biomass.**

Quercus spp


ENVASE
PAPEL
ENVASE
PLÁSTICO


- 10 cm.
- 0
Q. ilex
BELLOTA.
Margas
- 10 cm.
- 20 cm.

USE OF DEEP CONTAINER FOR *Quercus*

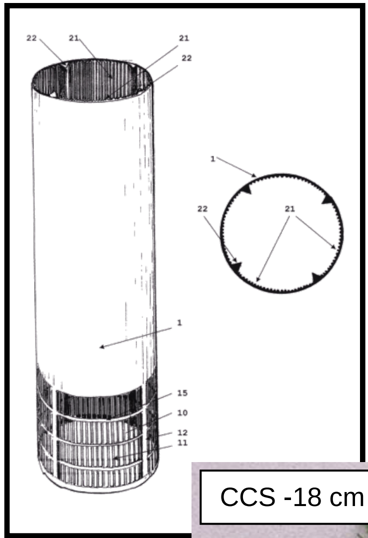
18 cm

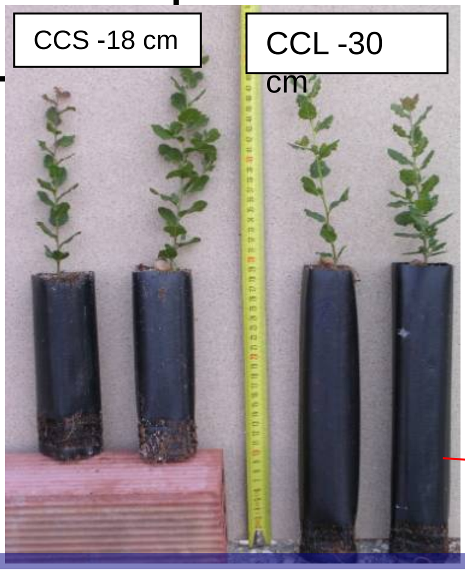
30 cm

ACCLIMATING ROOT SYSTEMS TO CC:

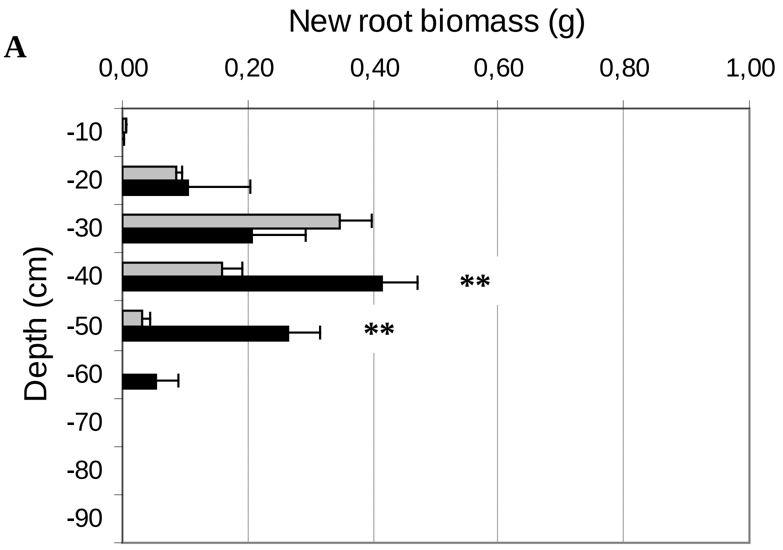
Use of deep container to improve root colonization of seedlings

Quercus ilex



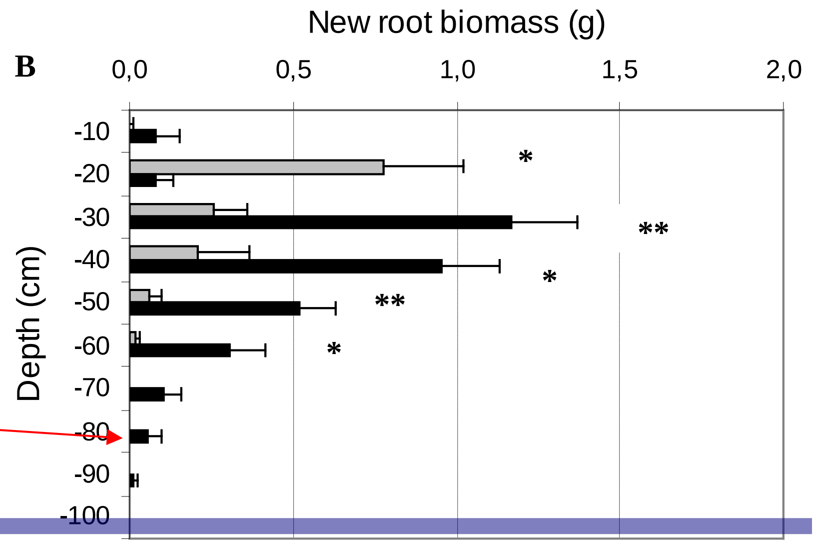


3 month



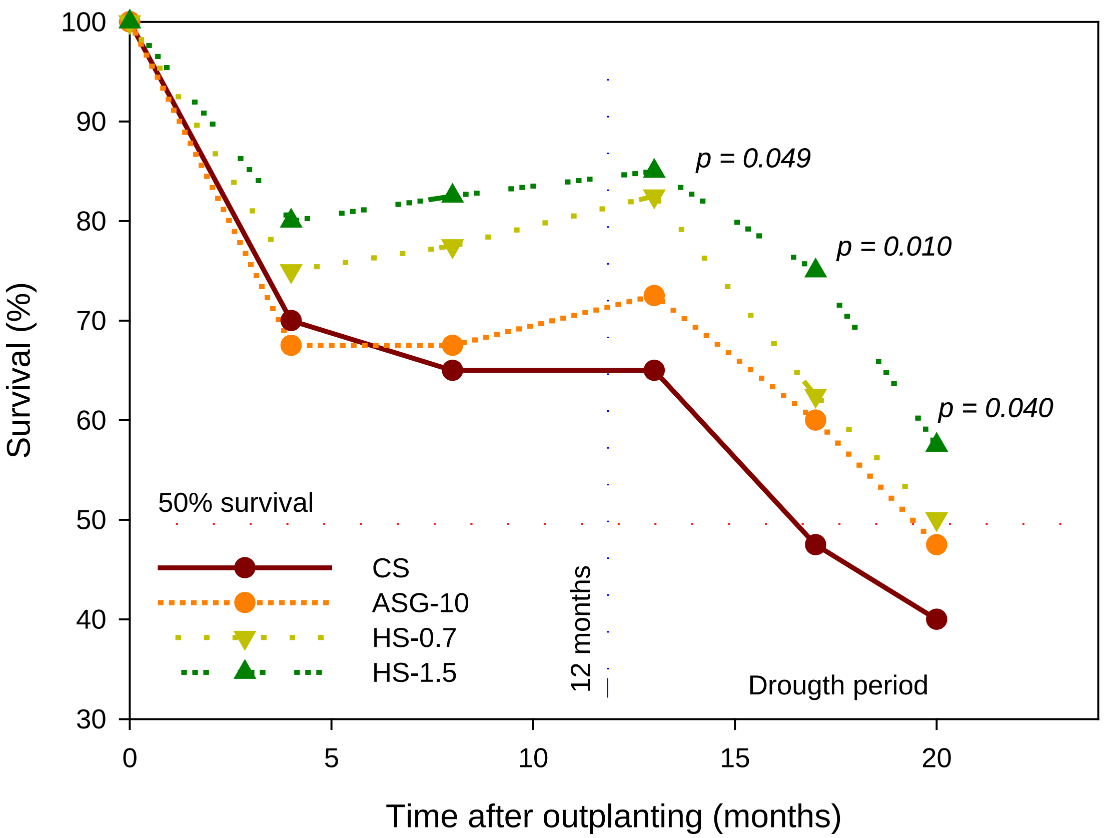
Chirino *et al*., 2009

18 month



Water manipulation of growing medium: <u>addition of hydrogel and clay in the substrate</u>

Use of hydrogel in seedlings of *Quercus suber* (cork oak)



Increase seedling survival in the field
(*Q. suber*; S. Espadán)

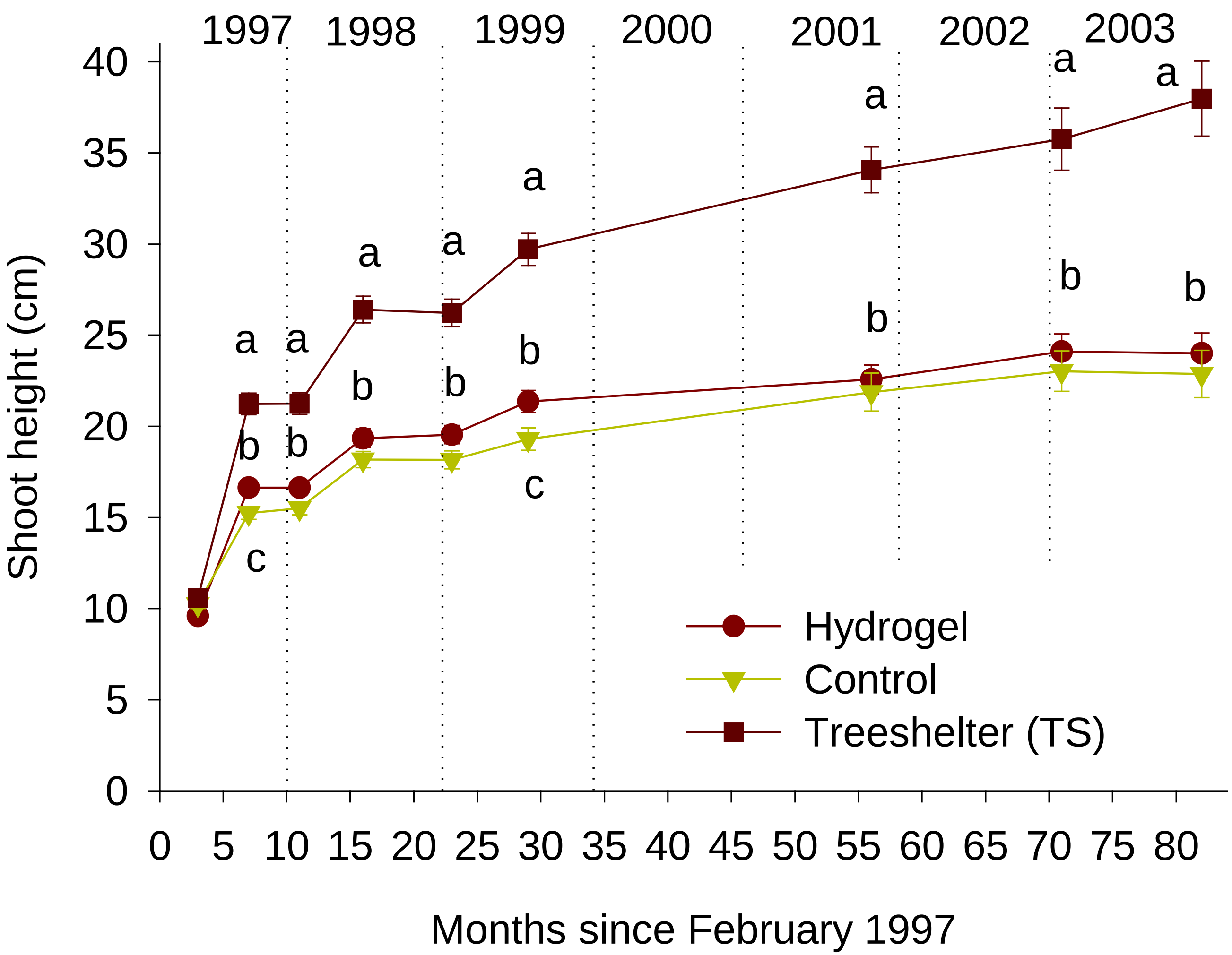
Chirino *et al.*, 2010

THE USE OF TREE-SHELTER


↓ PREDATION
↓ PAR
↓ WIND
↓ TRANSP
↑ % RH
↑ TEMPERATURE

Olea europaea
2005, 2 year

Growth dynamics of *Quercus ilex ssp ballota* seedlings and acorns in relation to some field and nursery treatments

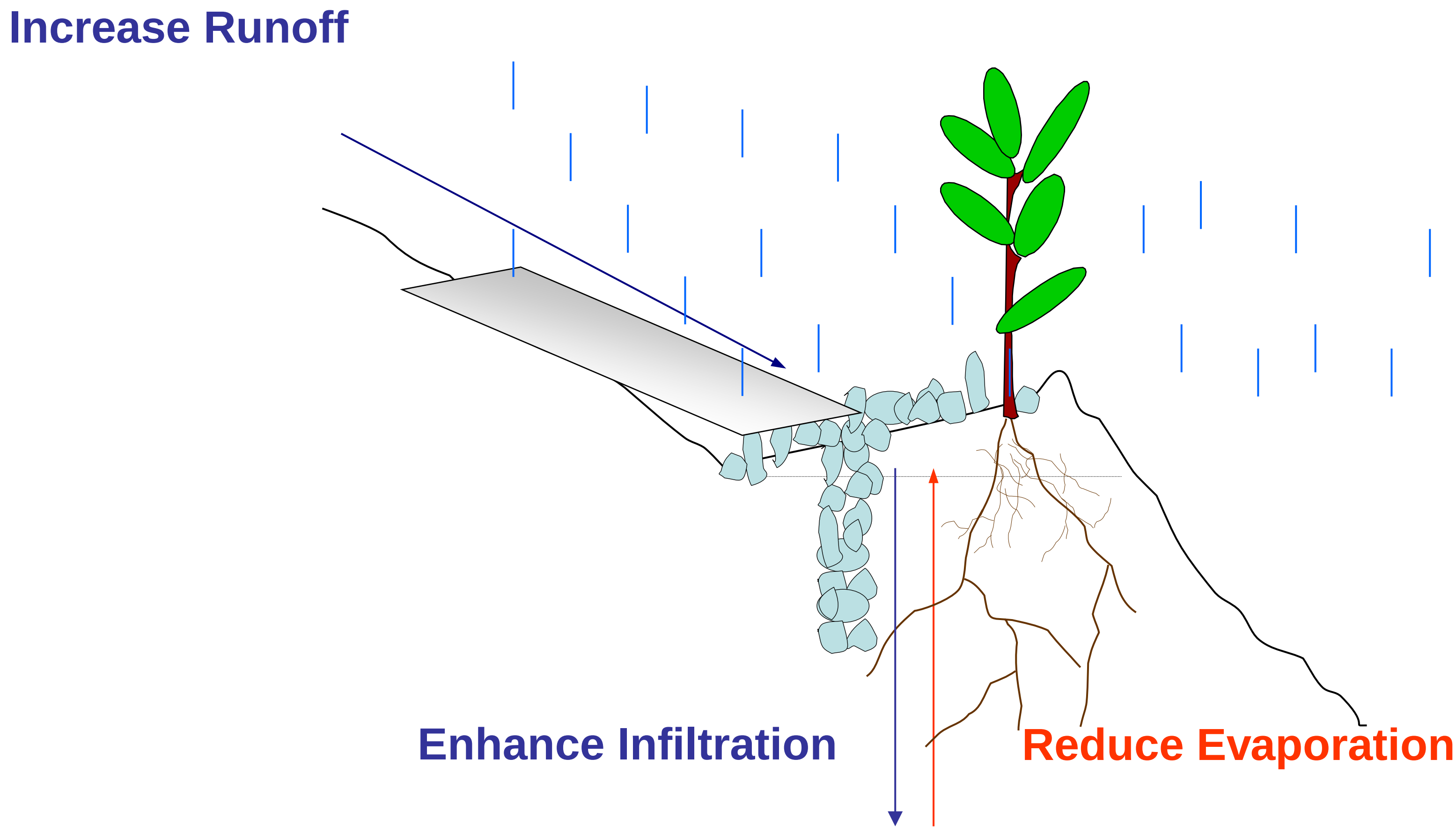


Tree-shelters limitations

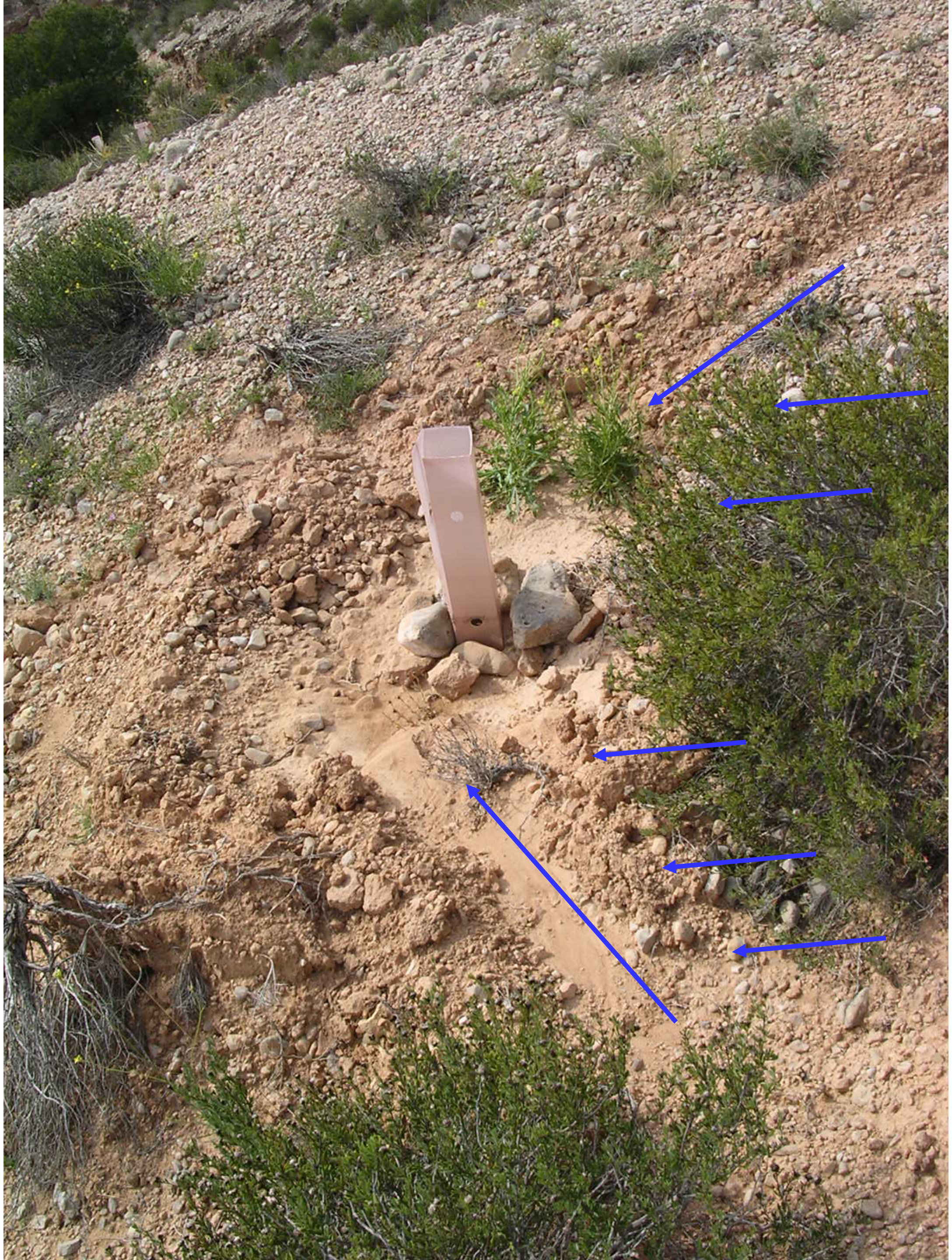
- Inside the tube, temperature increases a few ºC with respect to ambient
- for temperature > 40-45ºC PSII (Fv/Fm) efficiency decreases ⇒ stress in the photosynthetic system
- Slightly decreases R:S ratio
- In moist conditions, excessive stem elongation (etiolation) and weakening

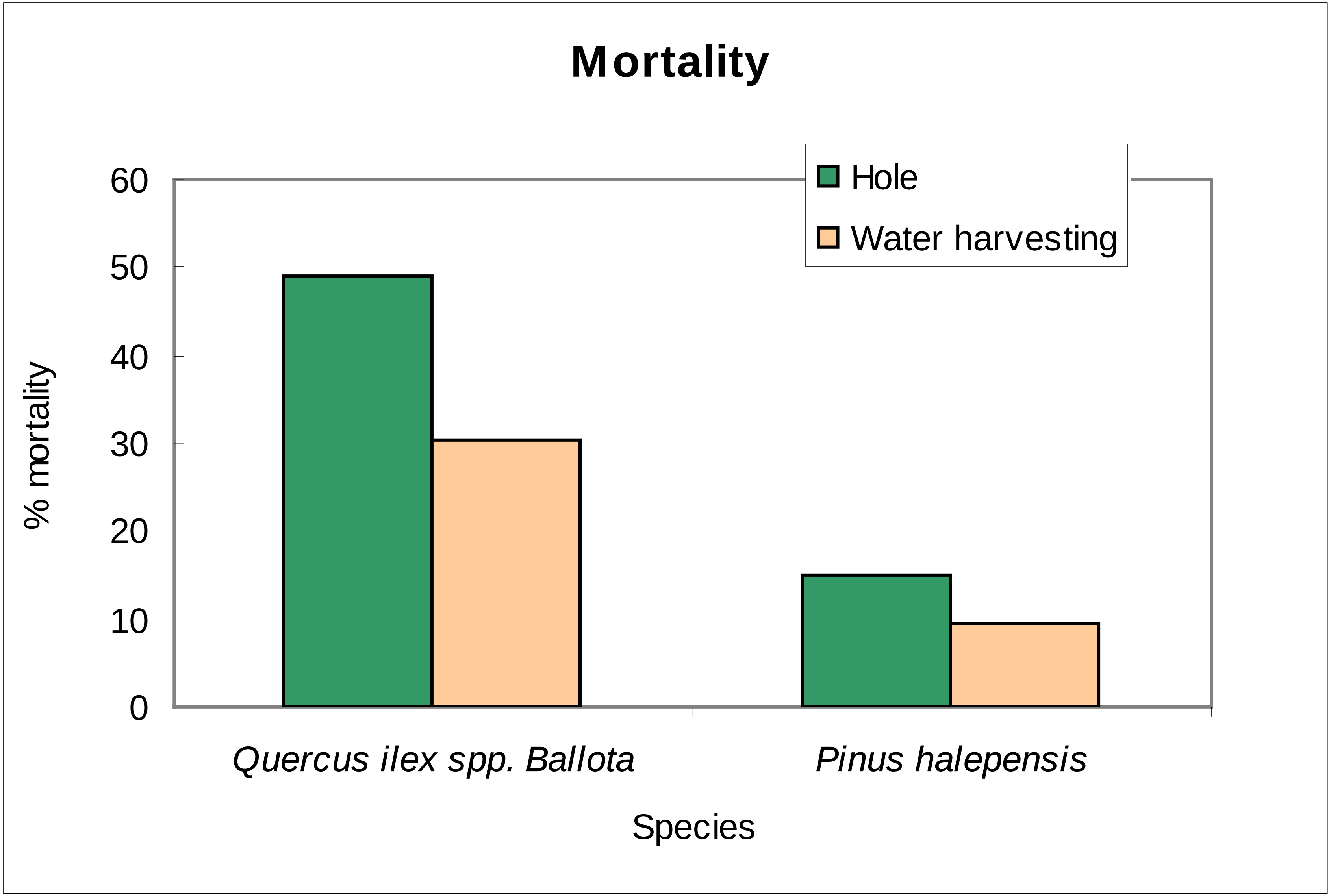
Mechanical hole with backhoe *Spider*

TECHNIQUES TO IMPROVE WATER AVAILABILITY TO SEEDLING



water harvesting

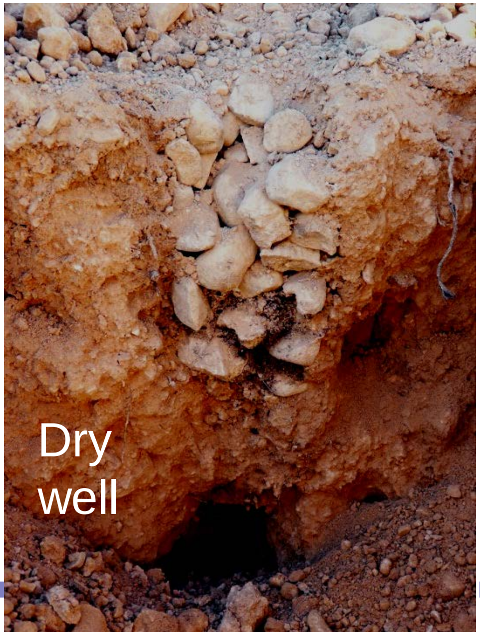



Mortality
Hole
Water harvesting
60
50
40
30
20
10
0
% mortality
Quercus ilex spp. Ballota
Pinus halepensis
Species

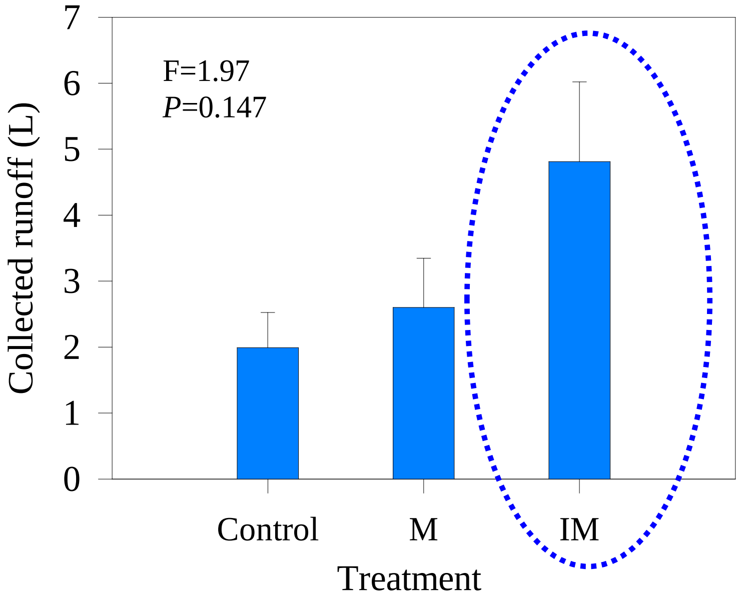

Control


Improved Microcatchment (IM)

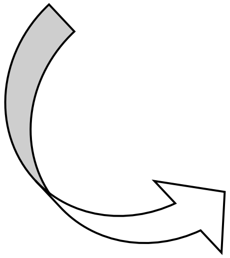

Clay
pot

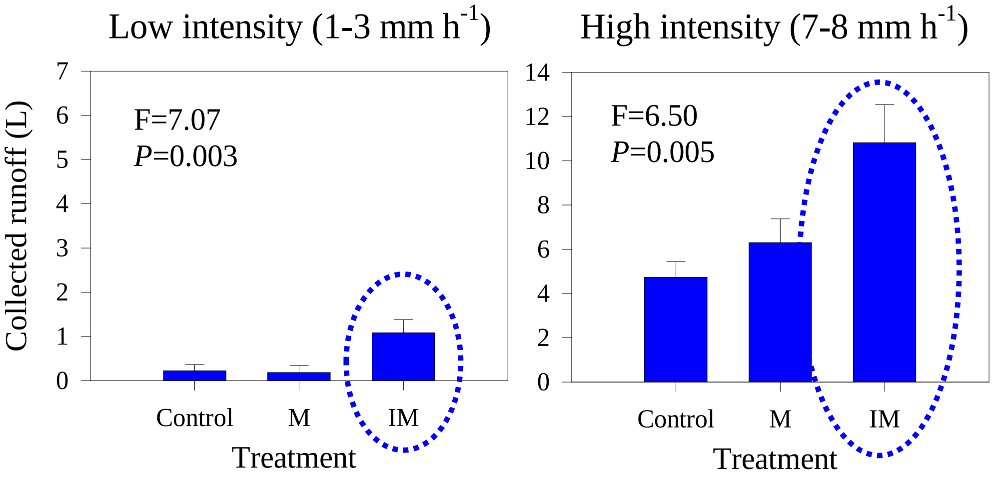

Dry
well

IMPROVED MICROCATCHMENT RAIN WATER CAPTURE EFFICIENCY

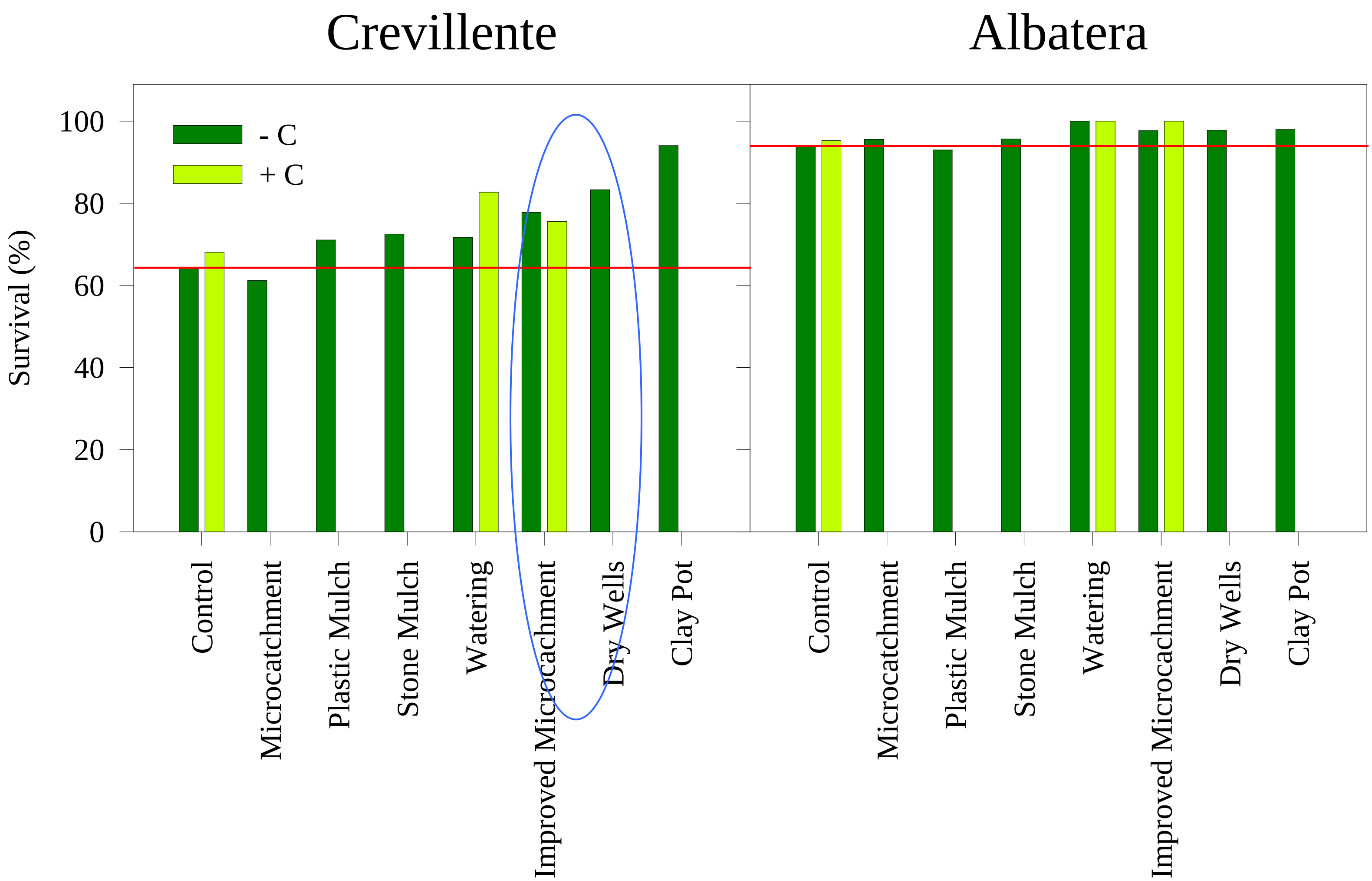


Rain events < 10 mm





EFFECT ON PLANTED SEEDLINGS

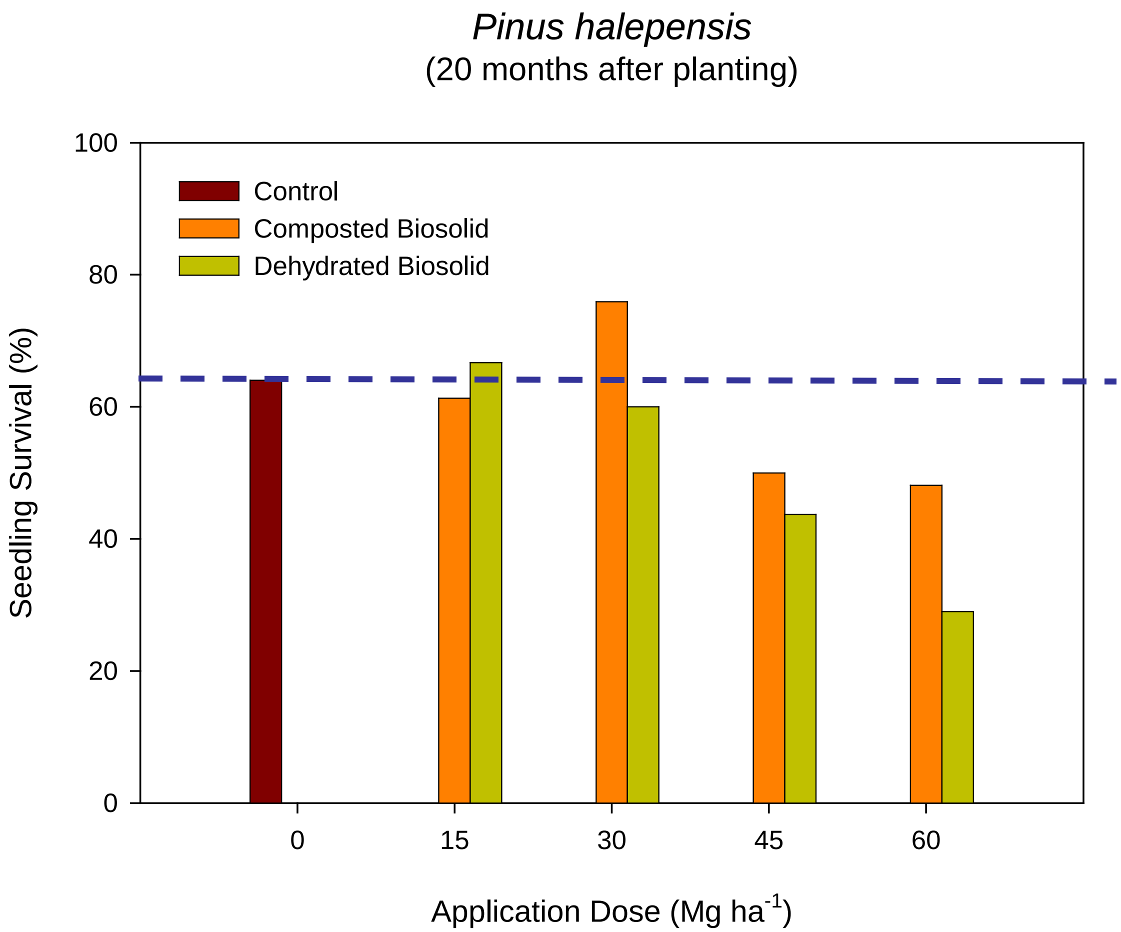


Survival of *Olea europaea* seedlings 2 years after planting in two experimental semiarid stations

Dry wells

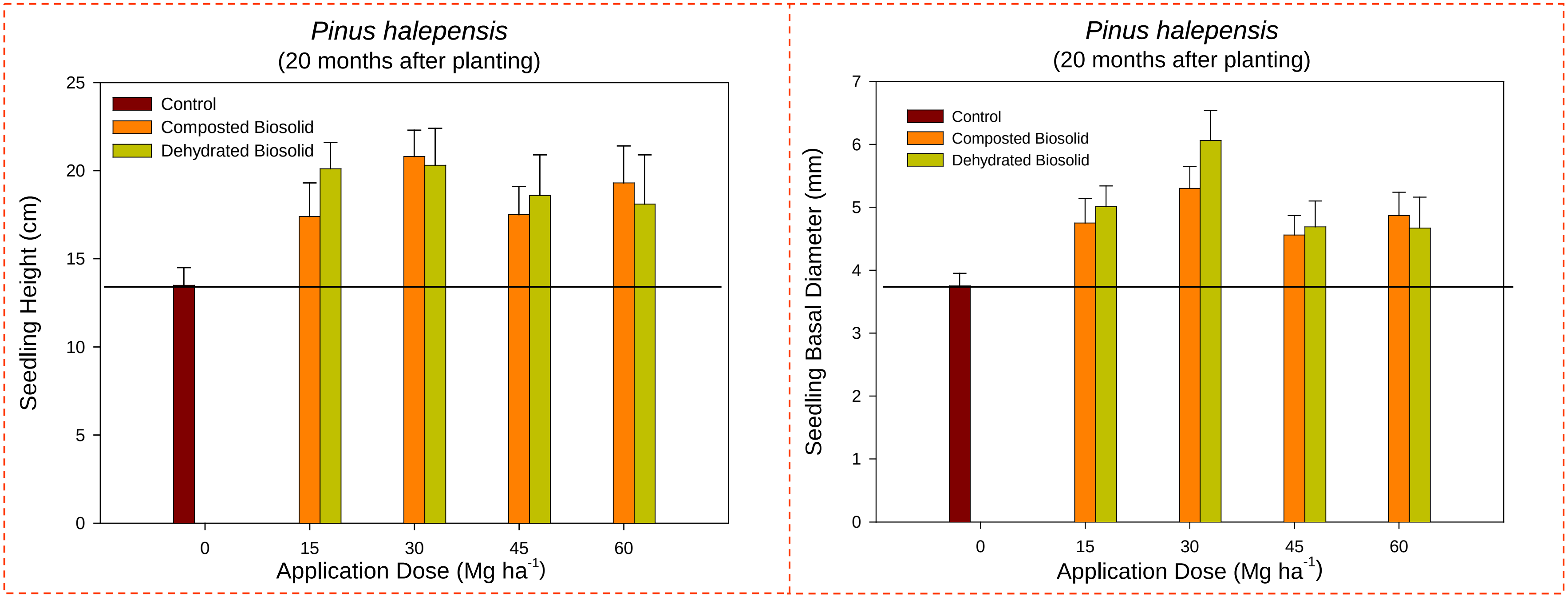
Enhanced
accumulation of
roots, organic matter
faunal activity
Preferential water flow

Soil amendments: Biosolids



Fuentes et al 2010

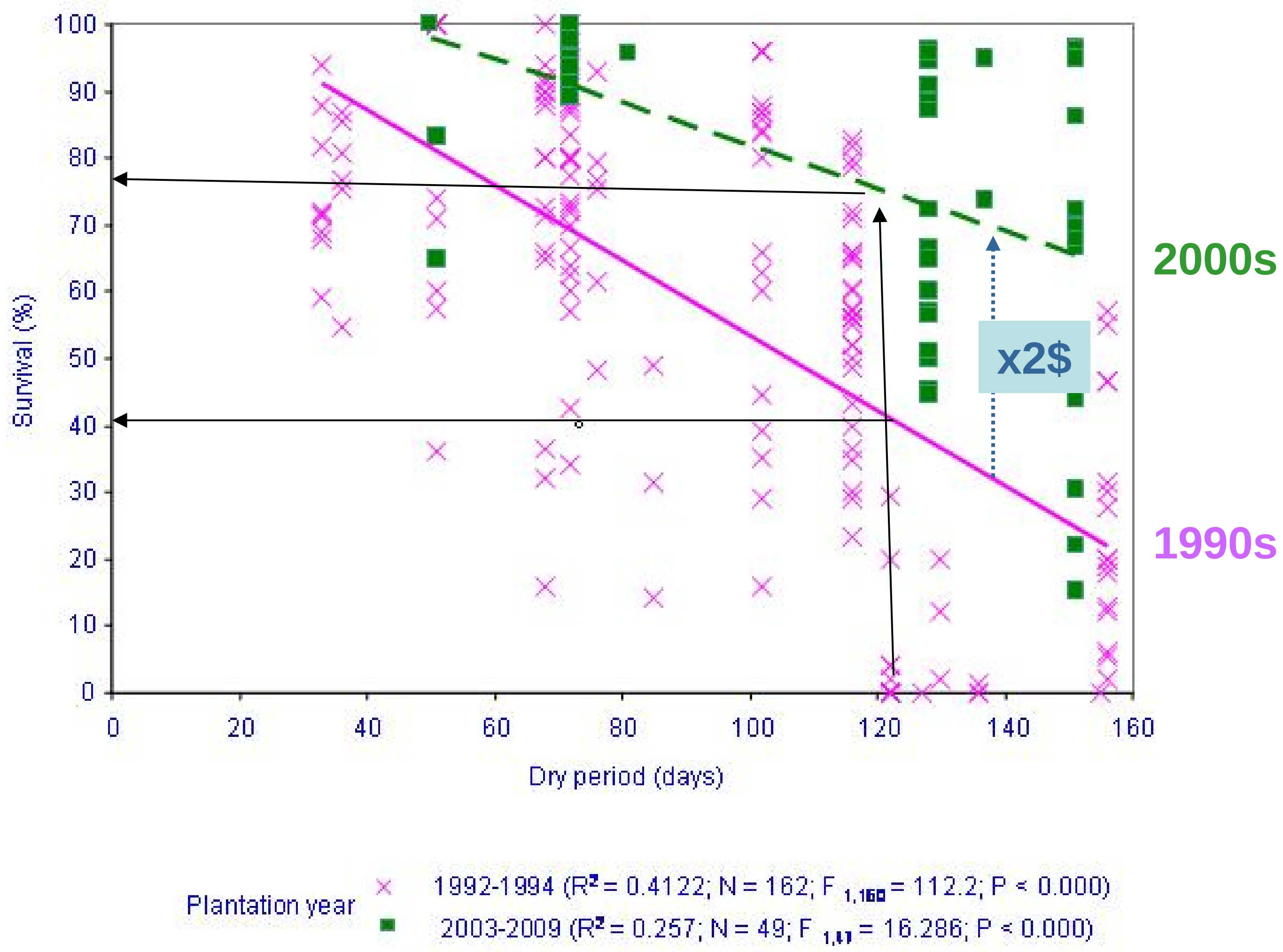
Soil amendments: Biosolids



Fuentes et al. 2010

THE COST OF PLANTATION QUALITY IMPROVEMENT

SEEDLING SURVIVAL *VS* DROUGHT DURATION
1st PLANTATION YEAR

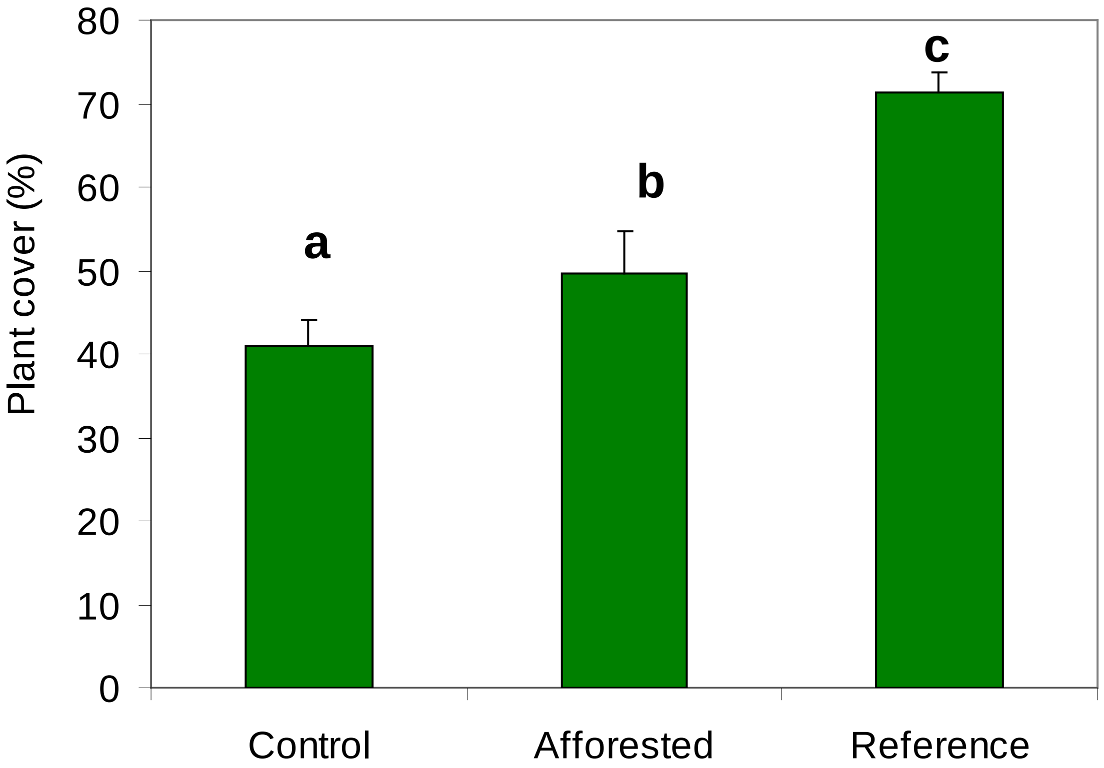


Vallejo et al., 2012

MEDIUM-TERM EFFECTS OF PLANTATIONS

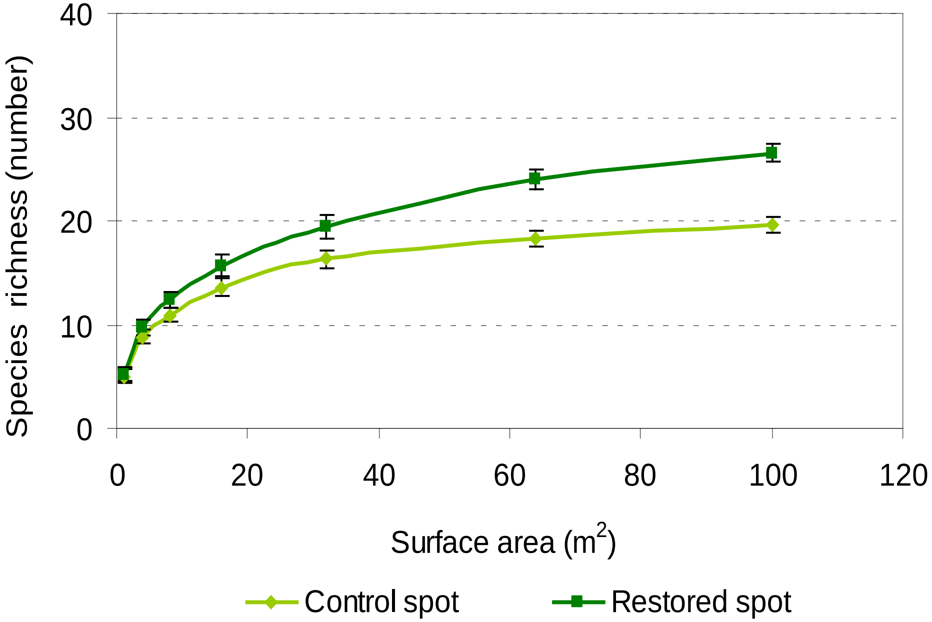
ALBATERA: Functional analysis

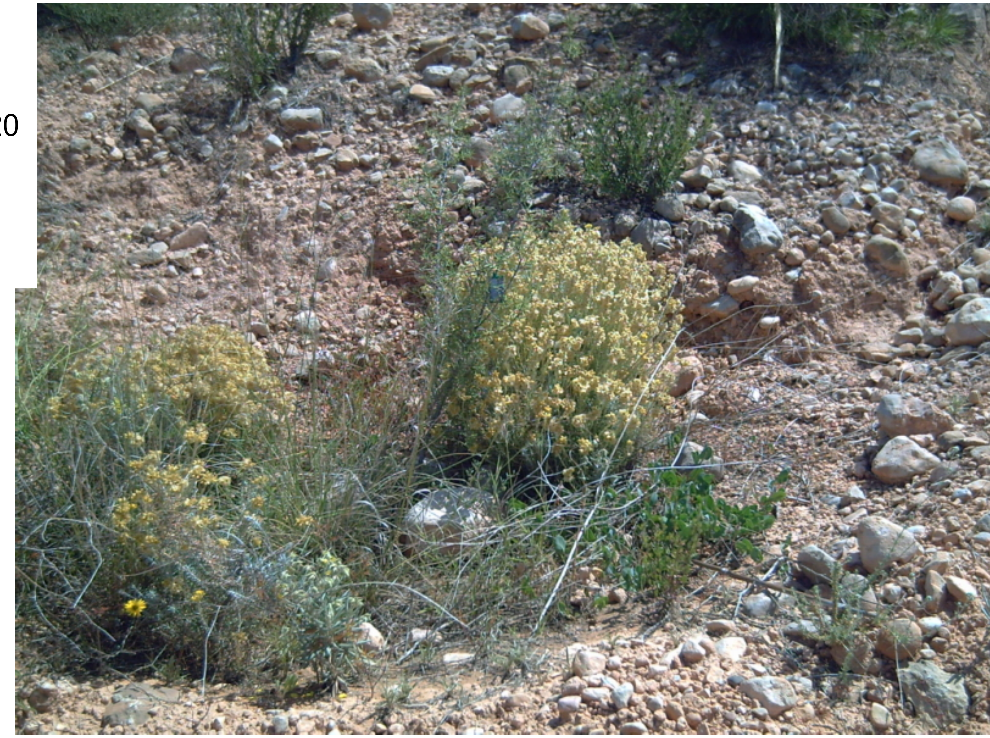
Six years after afforestation



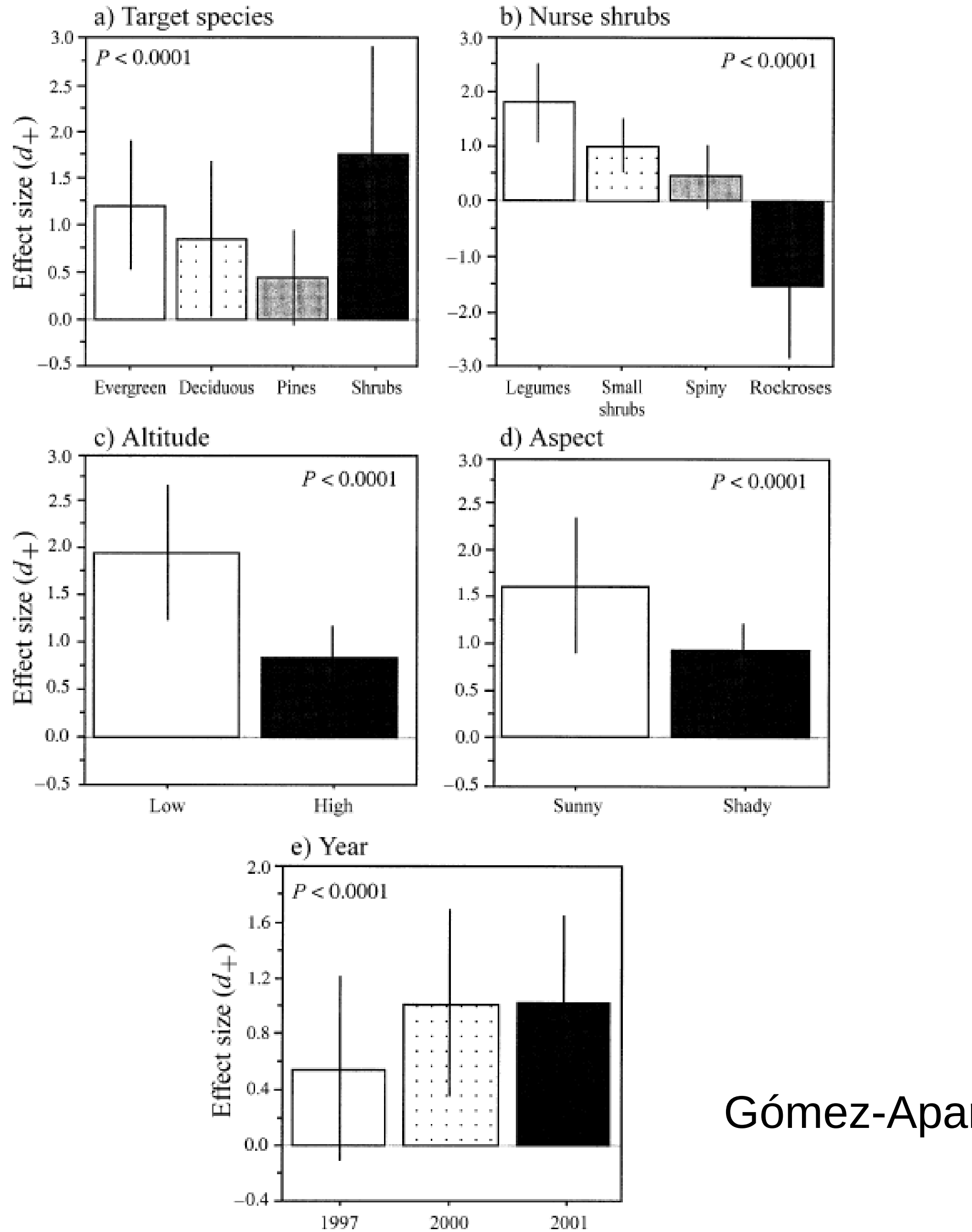
ALBATERA: Functional analysis

Six years after afforestation





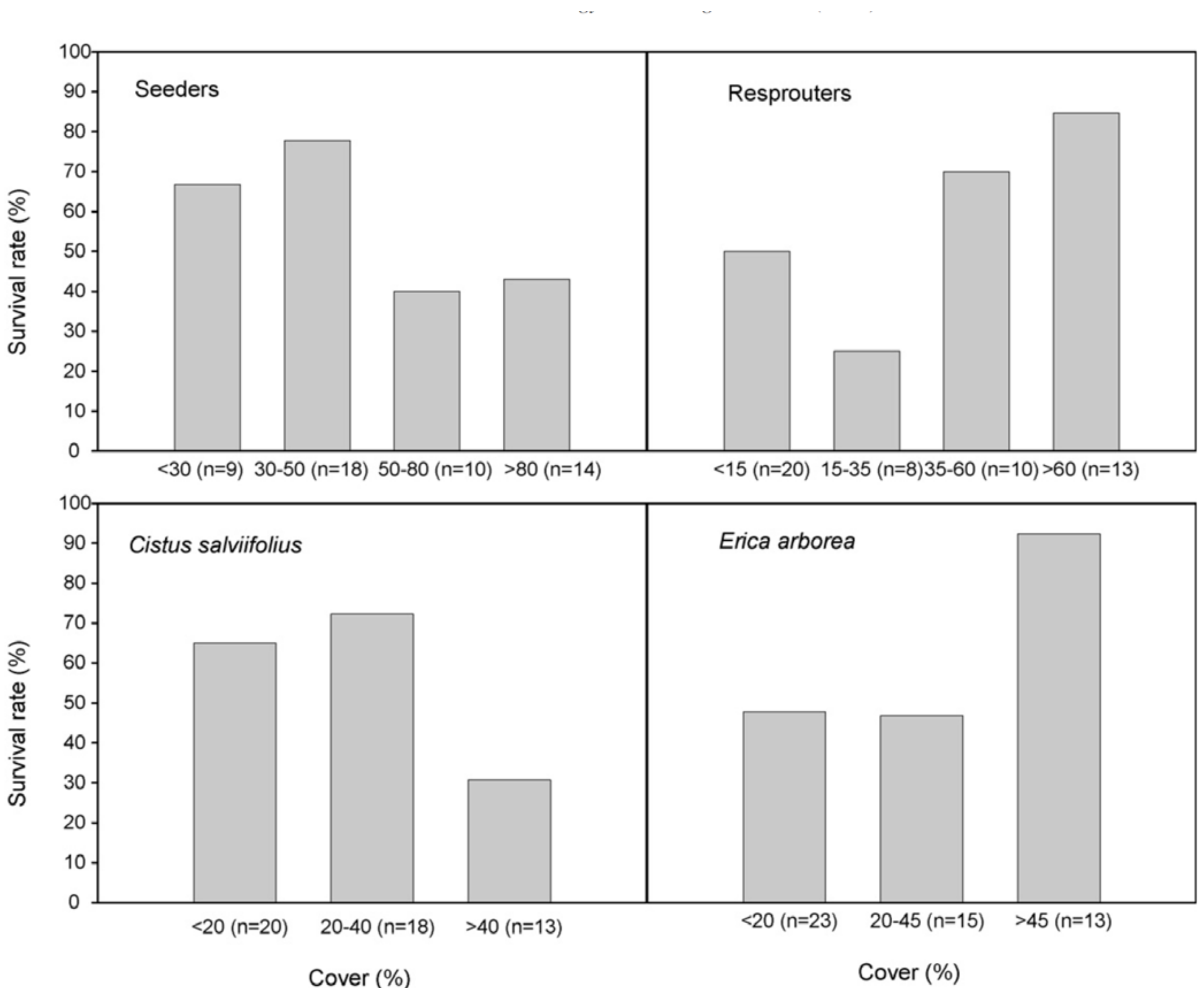
The role of extant vegetation: facilitation or competition?



Gómez-Aparicio et al 2004

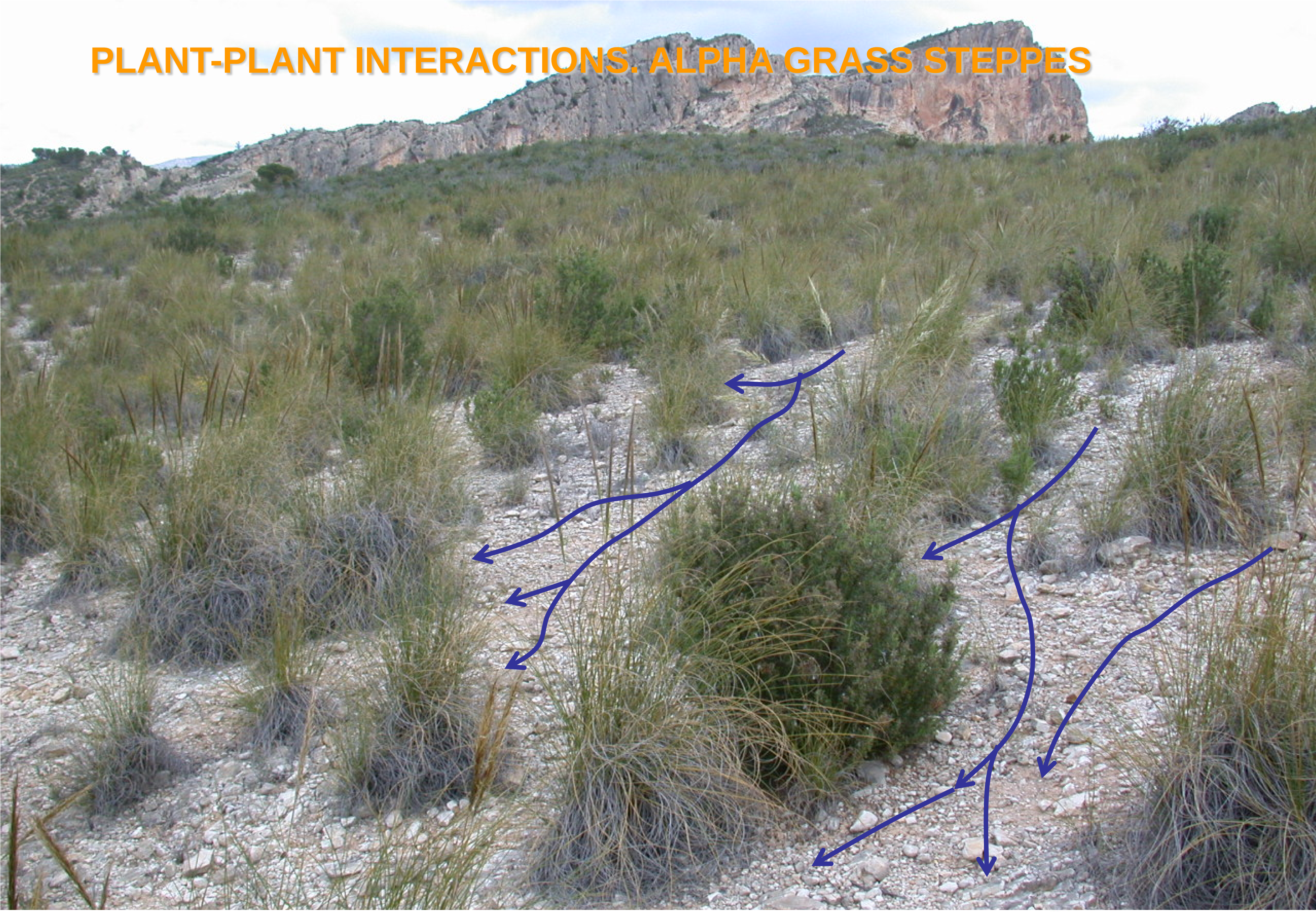
FIG. 2. Results of the mixed model for survival. Values reported are the mean effect size (d_+) and the 95% CI. The significance (P) of the Q statistic for the difference between groups in the effect of nurse shrubs on survival is given. See *Methods* for a description of the grouping variables.

Quercus suber, post-summer survival. S. Espadà (Castelló, Spain)

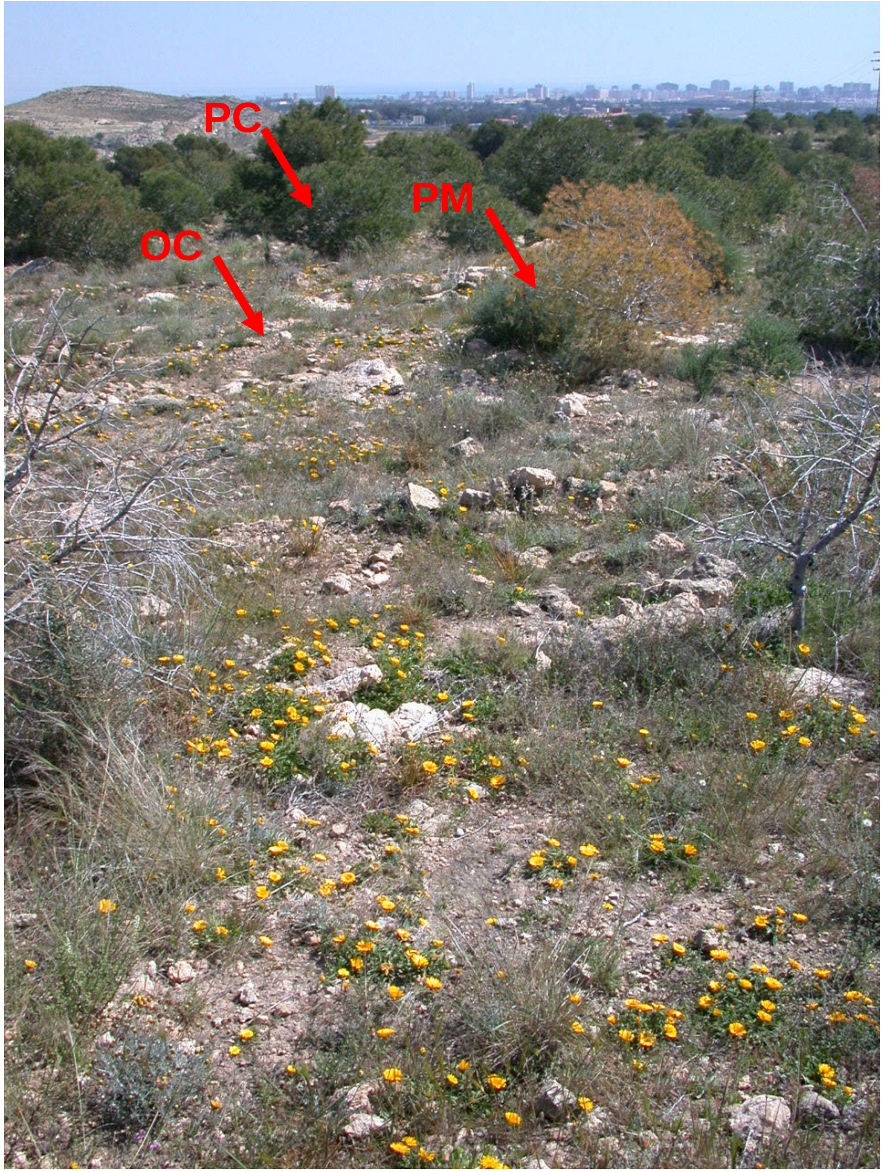


Pérez-Devesa et al. (2008). For. Ecol. Manage. 255: 374-386.

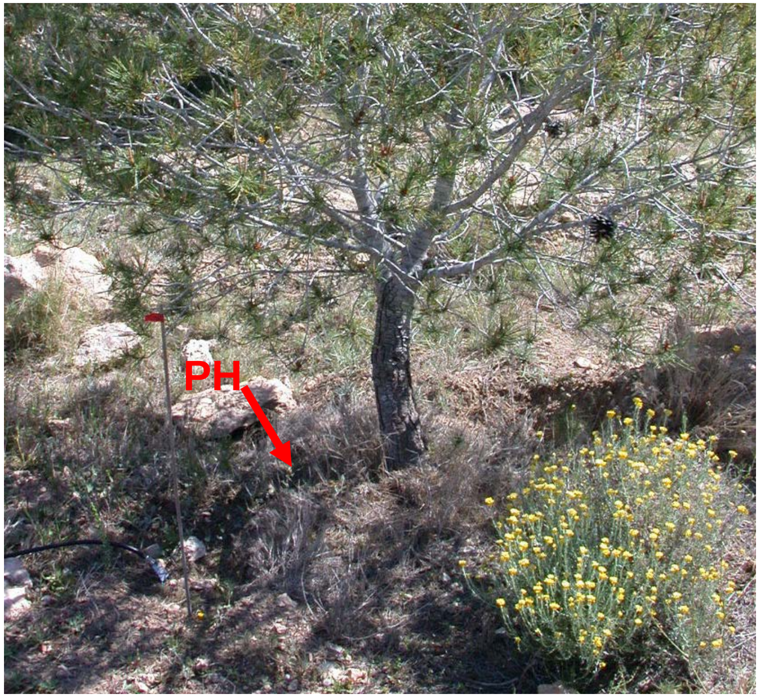
PLANT-PLANT INTERACTIONS. ALPHA GRASS STEPPES



Alpha grass steppe restoration

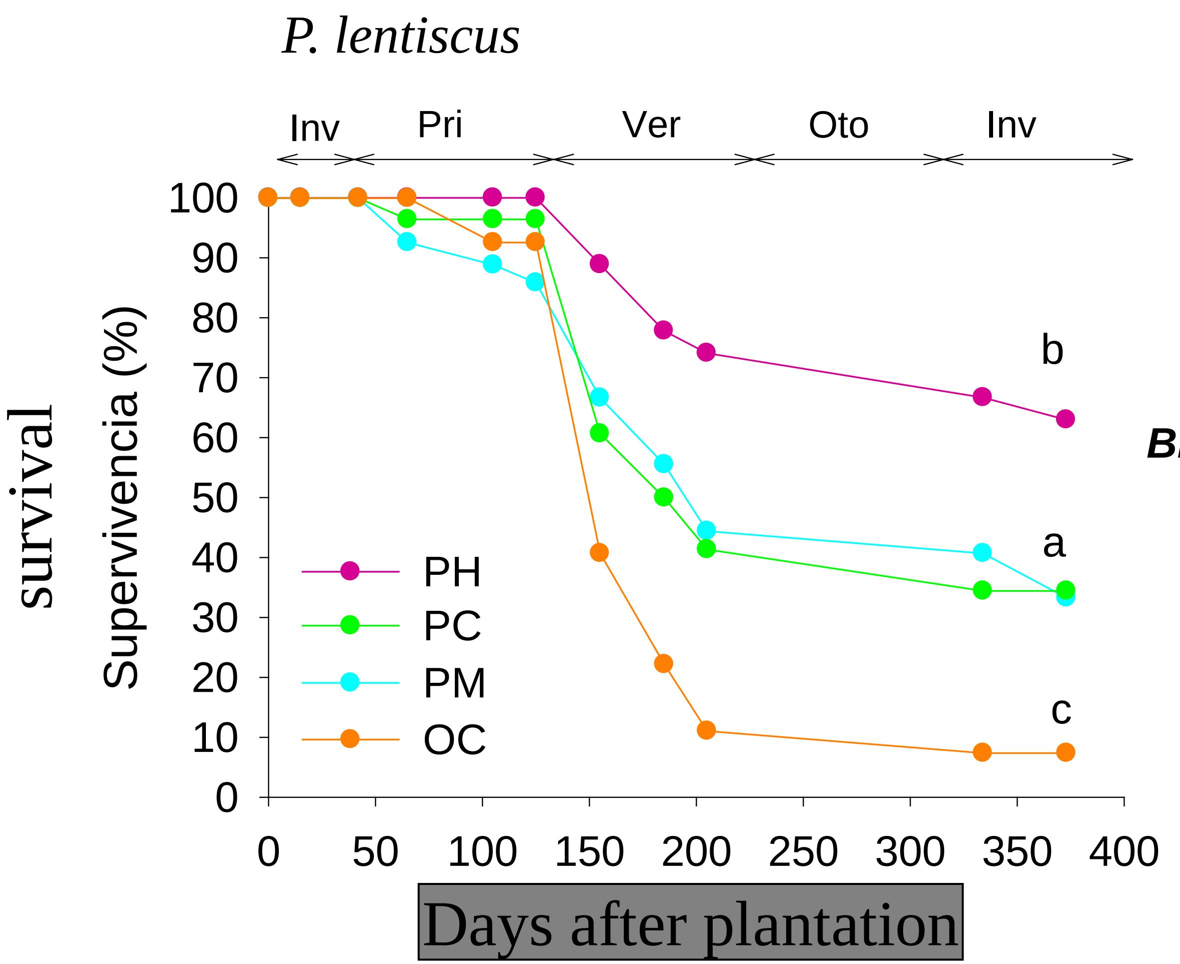


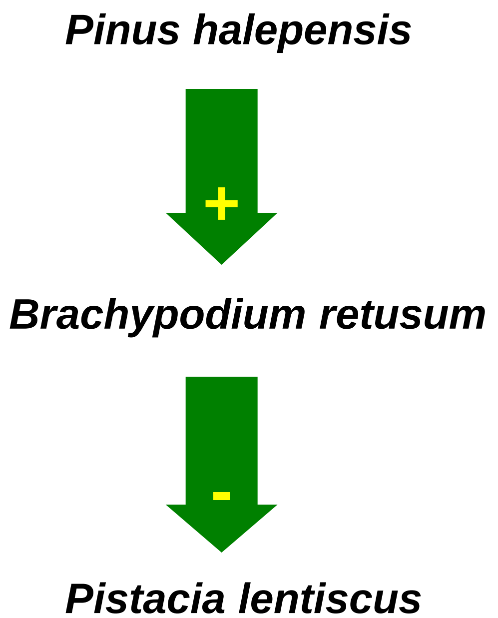
We carried out a manipulative experiment to evaluate the importance of competition by pines, competition by the herbaceous understorey, and all other factors pooled



PC: pine control; OC: open control; PM: dead pine; PH: herbicide for grasses

Alpha grass steppe restoration





Competition by grasses seems to be the most limiting factor for the establishment of woody resprouters

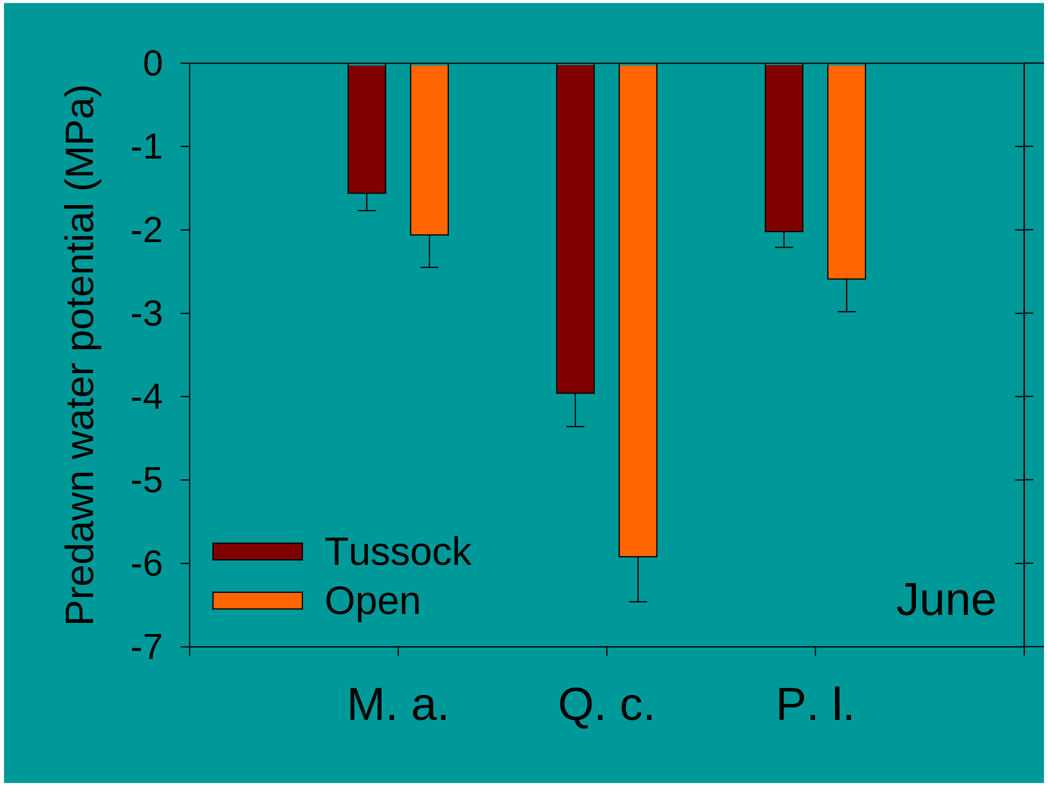
Maestre et al., 2004

PLANT-PLANT INTERACTIONS. ALPHA GRASS STEPPES

Which are the main drivers of alpha grass facilitation?

Alpha grass steppe restoration

Alpha grass has a consistent positive effect on the establishment of woody seedlings



Maestre et al., 2001

Alpha grass steppe restoration

Tussock control (ECO)

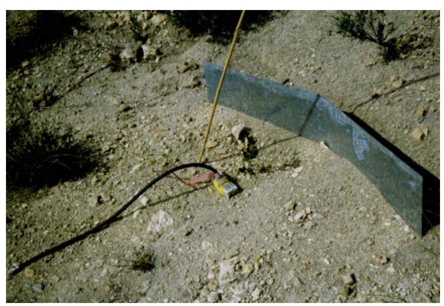
Tussock no shadow (ESO)

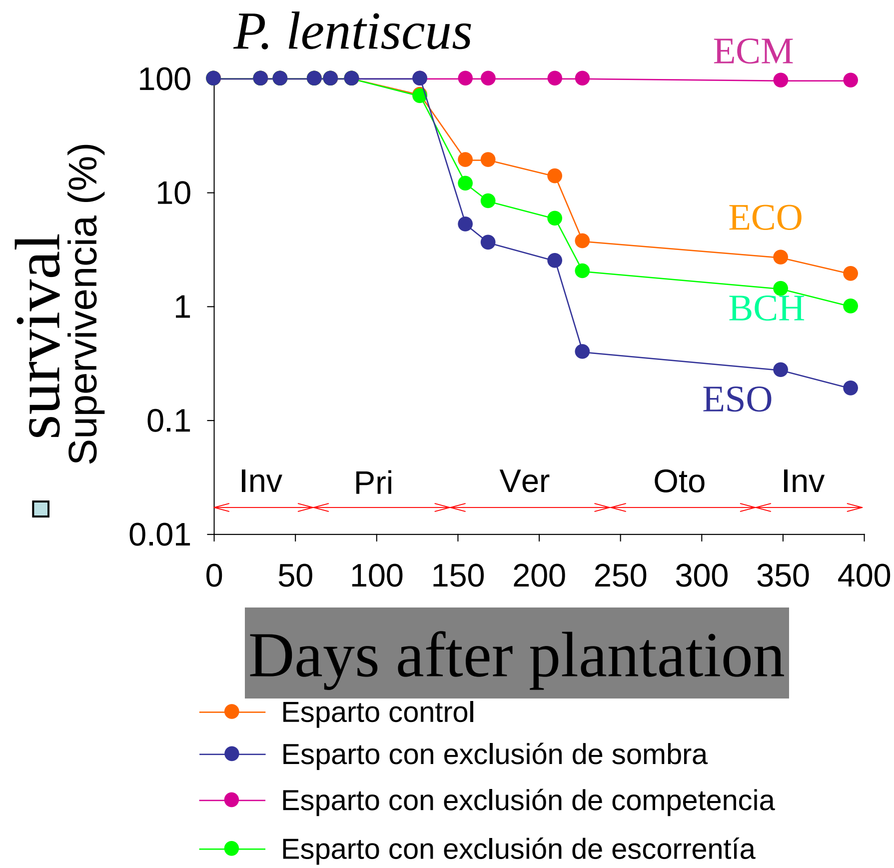
Tussock no runoff (ECH)

Open control (BCO)

Tussock nocompetition (ECM)

Open no runoff (BCH)





Shadow is the main control of facilitation

Maestre et al., 2003

Field plantations 2011

La Hunde site (Ayora, Valencia, Spain)

Secondary pine woodlands.
Stand densities: low, medium and high.
Three replicates (zones): 9 plots and 60 seedlings/plot

TREATMENTS		
HIGH DENSITY (HD)	**MEDIUM DENSITY (MD)**	**LOW DENSTITY (LD)**
Stand density: 600-900 trees/ha **GSF = 0.38**	**Stand density: 500-700 trees/ha** **GSF = 0.44**	**Stand density:100-300 trees/ha** **GSF = 0.75**
		

REINTRODUCING RESPROUTERS UNDER PINE CANOPY

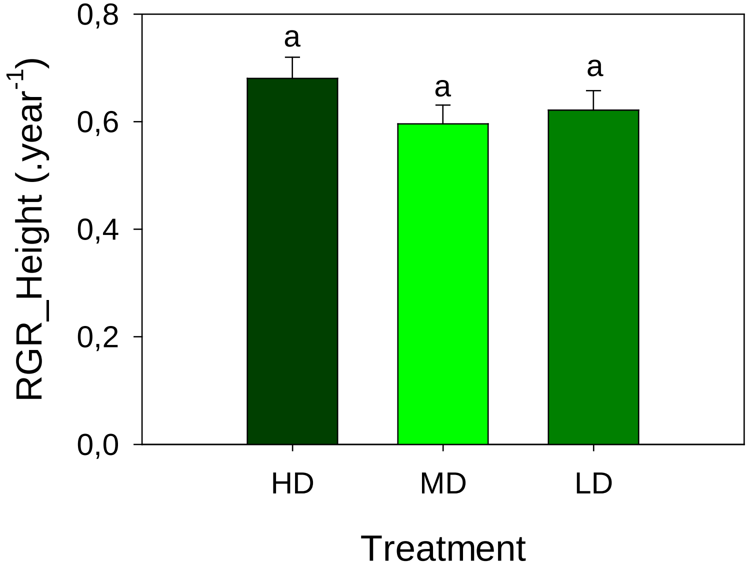
Species	Life form	Leaf habit
Arbutus unedo	Shrub	Evergreen
Rhamnus alaternus	Shrub	Evergreen
Quercus ilex	Tree	Evergreen
Quercus faginea	Tree	Deciduous
Fraxinus ornus	Tree	Deciduous
Acer granatense	Tree	Deciduous

A. unedo *F. ornus* *A. granatense*

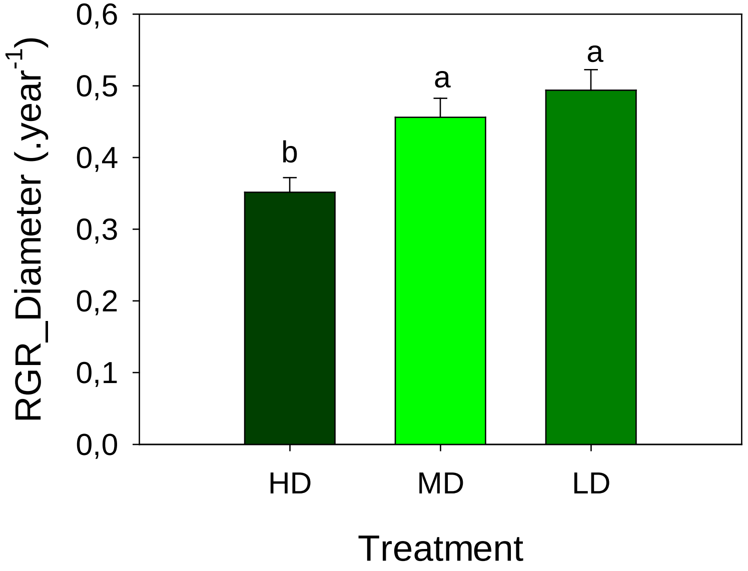
Q. ilex *R. alaternus* *Q. faginea*

Results. Survival and RGR per treatment

SURVIVAL (%) post-transplanting shock		
HD	MD	LD
97.7	96.4	99.0



p = 0.805 ns



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CONCLUSIONS

- Available ecological restoration technology allows for reintroducing native plants and recovery critical ecosystem functions for many Mediterranean lands
- Higher inputs are required for highly degraded ecosystems, higher stress conditions

…but

- We need understanding the thresholds for cost-effective restoration, both in biophysical and socieconomic terms