INNOVATIONS IN DRYLAND RESTORATION

Jordi Cortina

Departament d'Ecologia - Universitat d'Alacant

Alacant (Spain)

Alfa grass (*Stipa tenacissima*) steppes as model ecosystems for dryland restoration

1.1 Introduction to alpha grass and alfa grass steppes in SE Spain.

1.2 Ecological interactions in alfa grass steppes, from microscopic to landscape scales.

1.3 A framework for alfa grass steppes restoration.

Ecological interactions provide clues for restoration

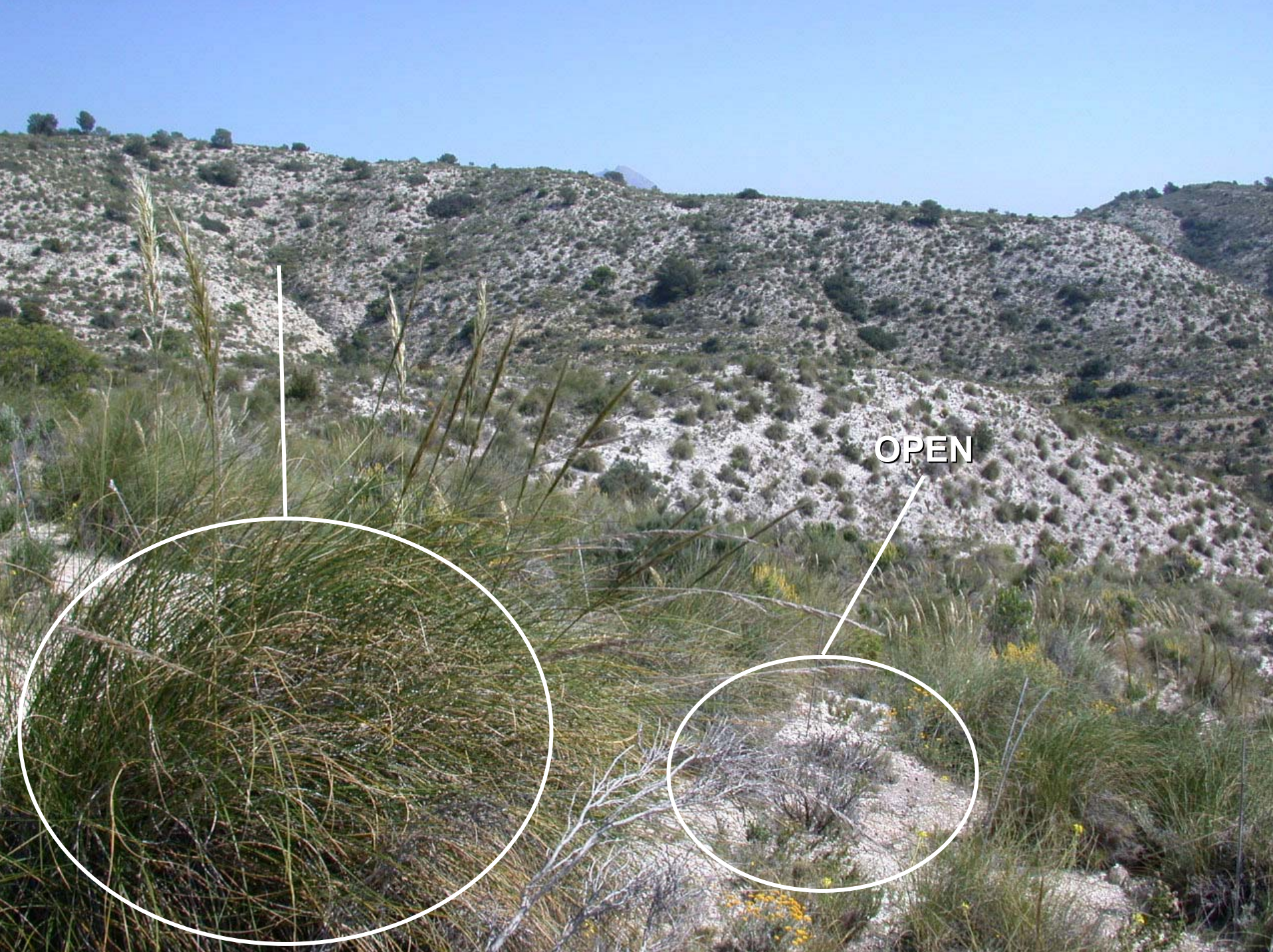
2.1 Landscape structure, functional state and ecosystem restorability.

2.2 The use of biological soil crusts.

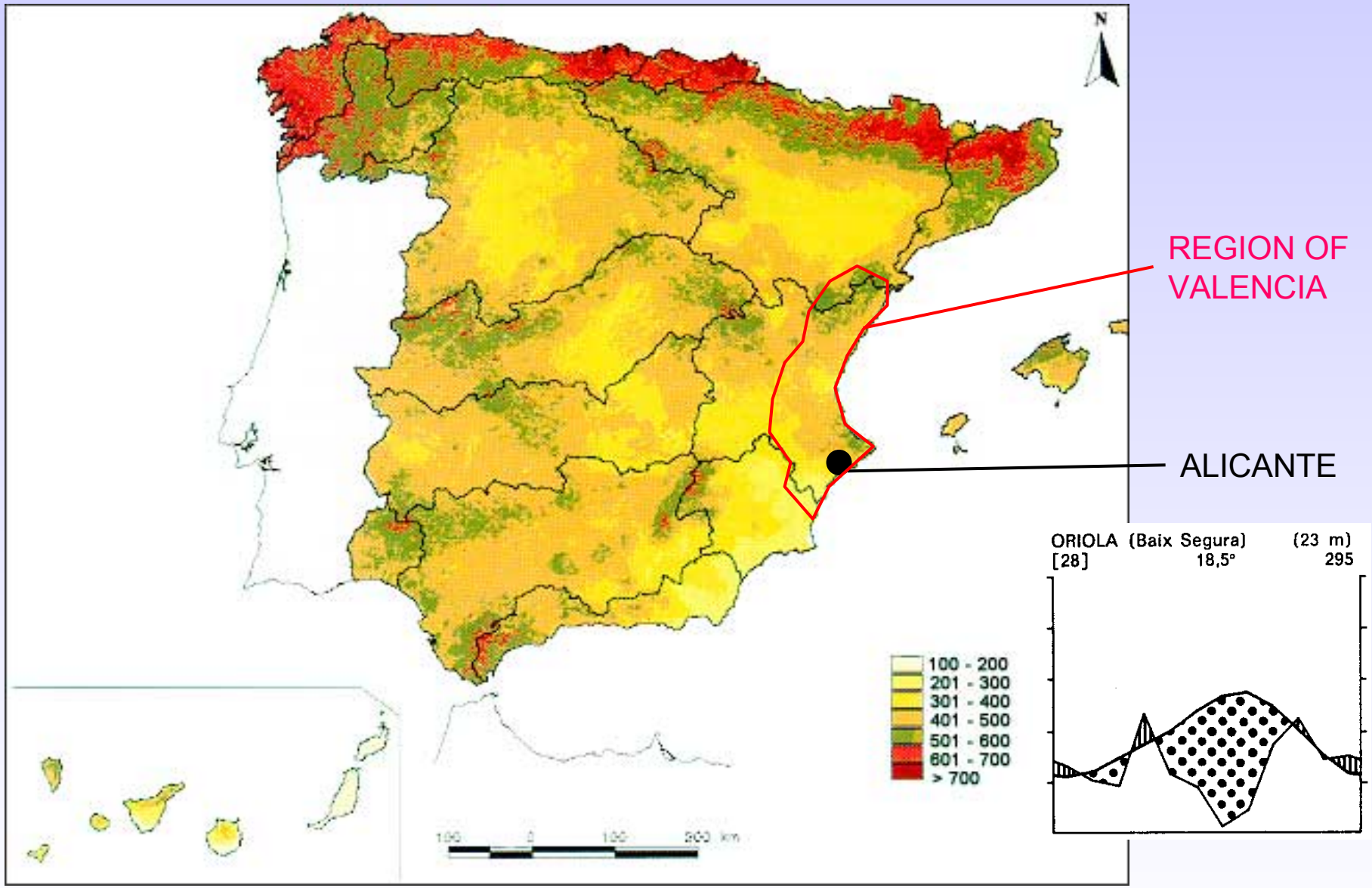
2.2 Facilitation by alfa grass.

2.3 The role of Aleppo pine (*Pinus halepensis*) in alfa grass restoration.

2.3 Ecotechnology as a replacement for ecological interactions.


OPEN

Alpha grass steppes in Spain - Distribution



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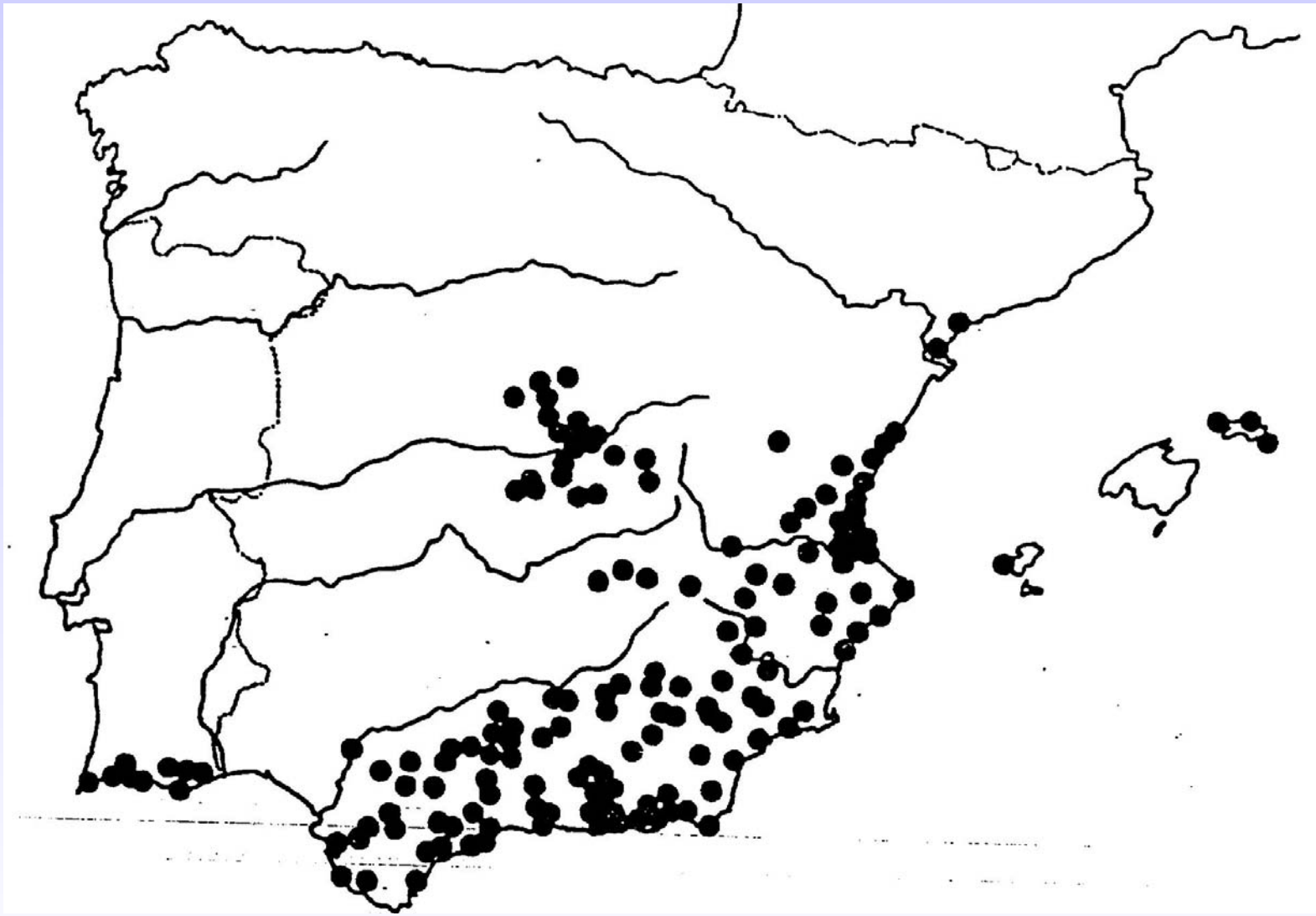
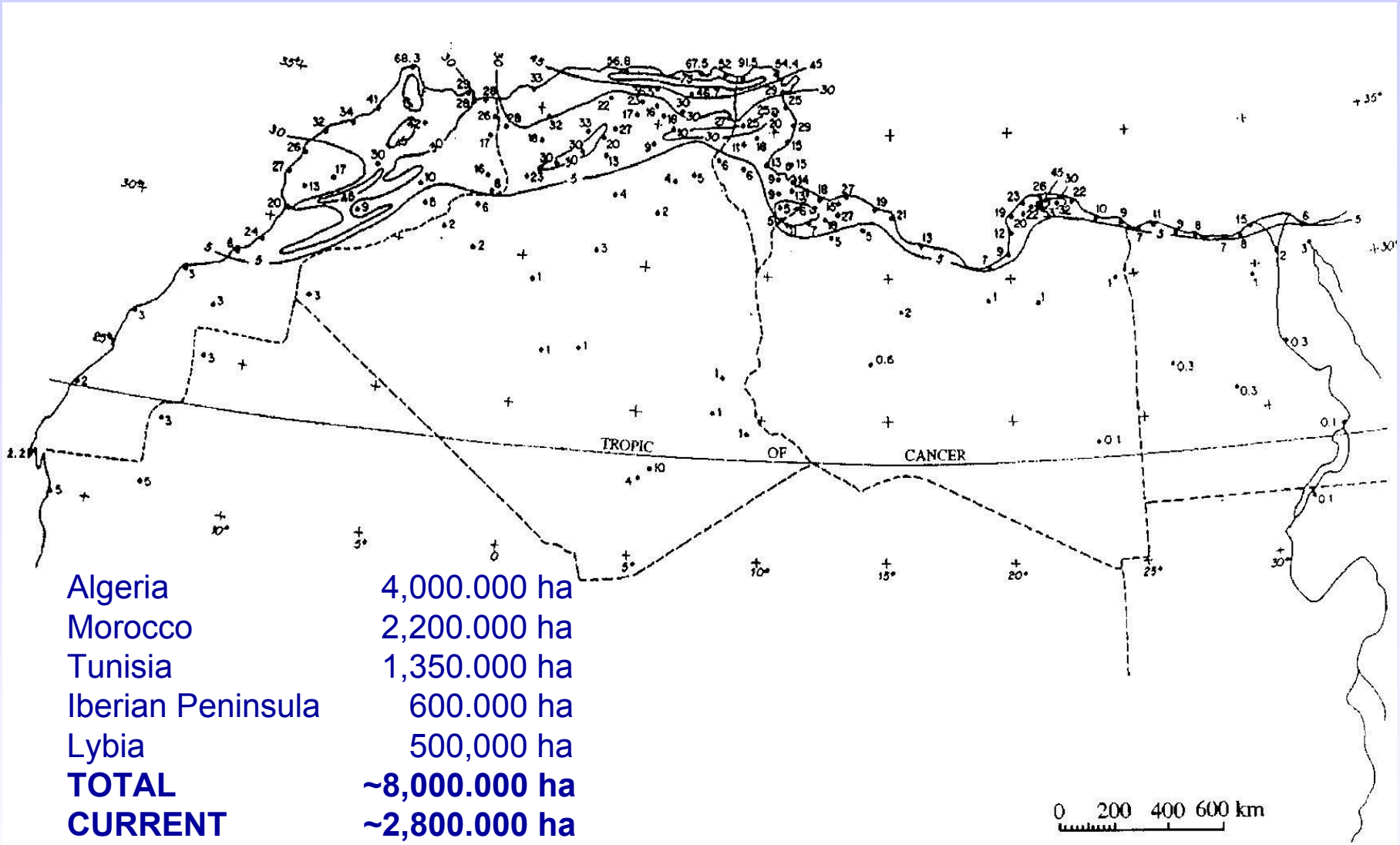


In Europe: 600.000 ha (Spain and Portugal): ca. 6% of stepic areas

Alpha grass steppes in the world



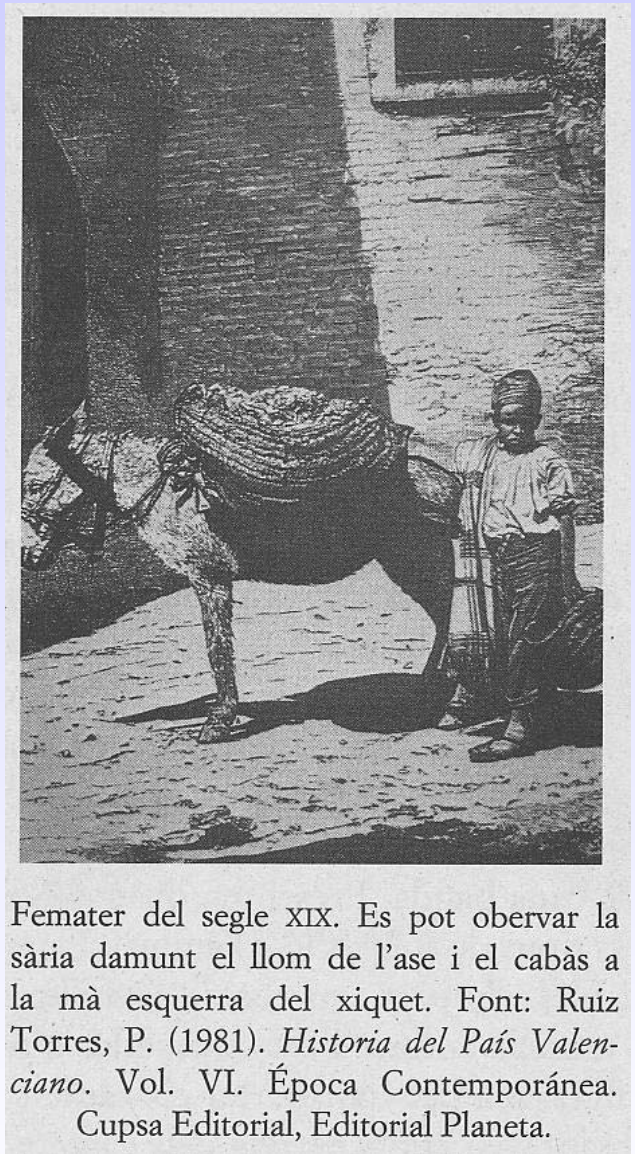
Algeria	4,000.000 ha
Morocco	2,200.000 ha
Tunisia	1,350.000 ha
Iberian Peninsula	600.000 ha
Lybia	500,000 ha
TOTAL	**~8,000.000 ha**
CURRENT	**~2,800.000 ha**

Djebaili, 1988 et Le Houérou, 2001

Prehistoric evidences of alpha grass use

- Remainings from Copper Age - Deforestation in certain parts of the Iberian Peninsula (ca. 4000 BP)
- More frequent Bronze Age - Strings, baskets and shoes. Alpha grass steppes suggest shrubland clearing (ca. 3000 BP)

Flora Atlantica, sive Historia plantarum quae in Atlante, Agro Tunetano et Algeriensi Crescunt. Tomus Primus.. Desfontaines, Renato L. Parisiis: L.G. Desgranges, [1798-1799?]



Femater del segle XIX. Es pot obervar la sària damunt el llom de l'ase i el cabàs a la mà esquerra del xiquet. Font: Ruiz Torres, P. (1981). *Historia del País Valenciano*. Vol. VI. Época Contemporánea. Cupsa Editorial, Editorial Planeta.

Buxó, 1999; Barber, 1997

20th Century rise and fall

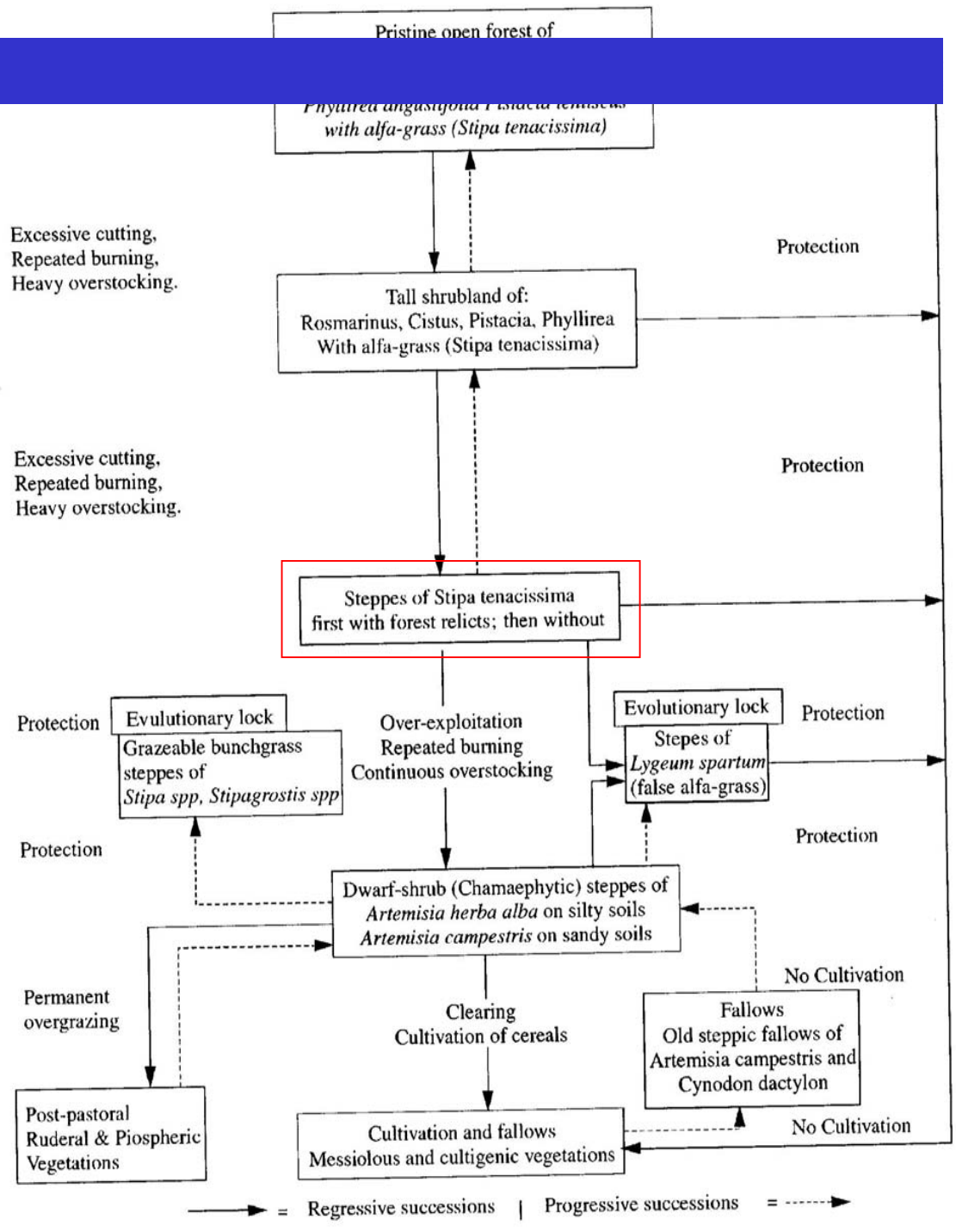
- 1920 *Comité Especial* (regulations on local commerce and export)
- 1940 *Instituto de Fomento de la Producción de Fibras Textiles*
- 1947 Reglamento Nacional de Trabajo para el Sector Manual del Esparto de la Industria Textil
- 1948 *Servicio Nacional del Esparto* (M. Industria y Comercio and M. Agricultura)
- Harvesting gradually abandoned since 1950-60
- Grazing gradually reduced (500.000 sheeps 100.000 goats en 1999)

Barber, 1997

Community dynamics

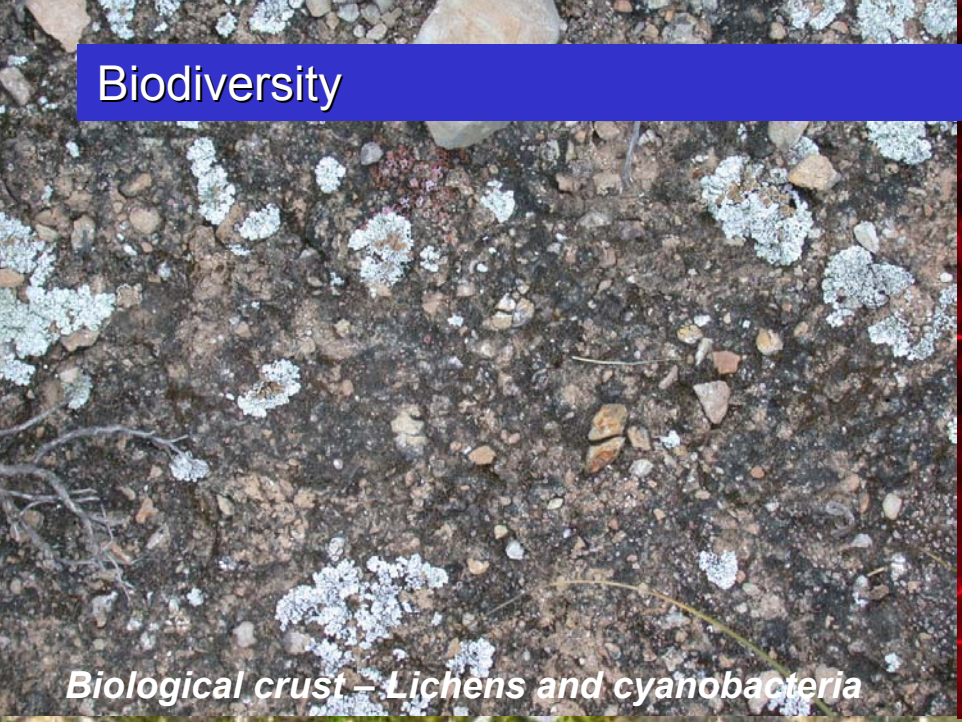
Al. *Stipion tenacissimae*

- *Helictrotichon filifolii-Stipetum tenacissimae*
- *Lapiedro martinezii-Stipetum tenacissimae*
- *Lapiedro martinezii-Stipetum tenacissimae* subas. *sedetosum dianii*
- *Heteropogo contortii-Stipetum tenacissimae*

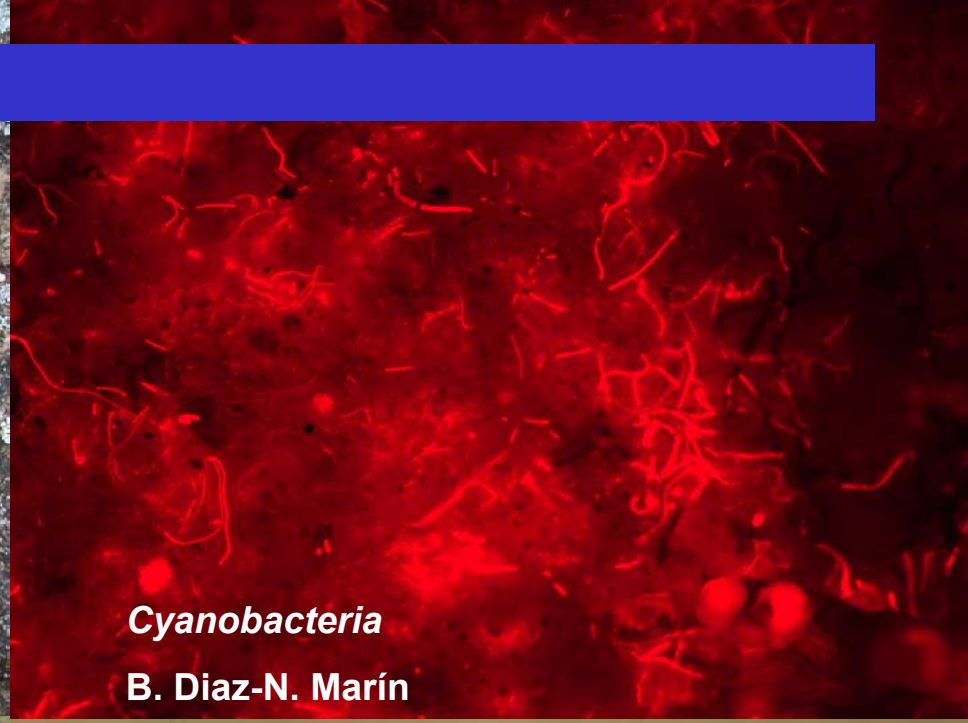


Le Houérou, 2001

Biodiversity

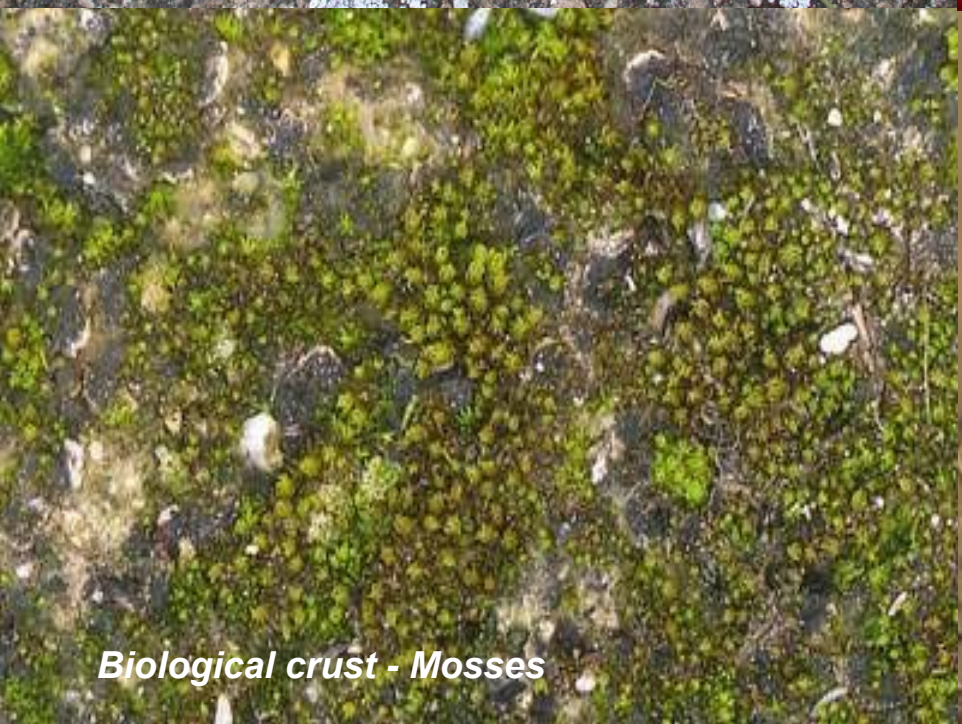


Biological crust – Lichens and cyanobacteria



Cyanobacteria

B. Diaz-N. Marín

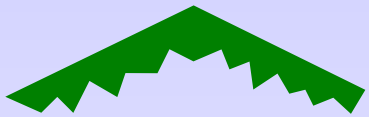


Biological crust - Mosses

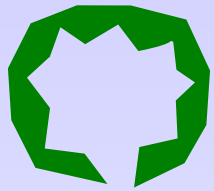
Galerida theklae

José J. Matamala (www.almeriware.net)

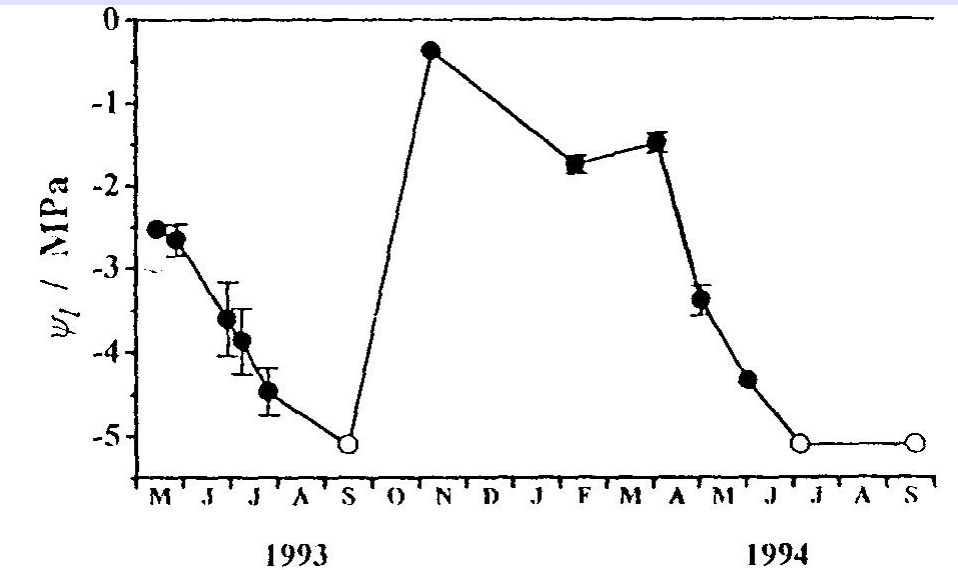
Morpho-functional traits

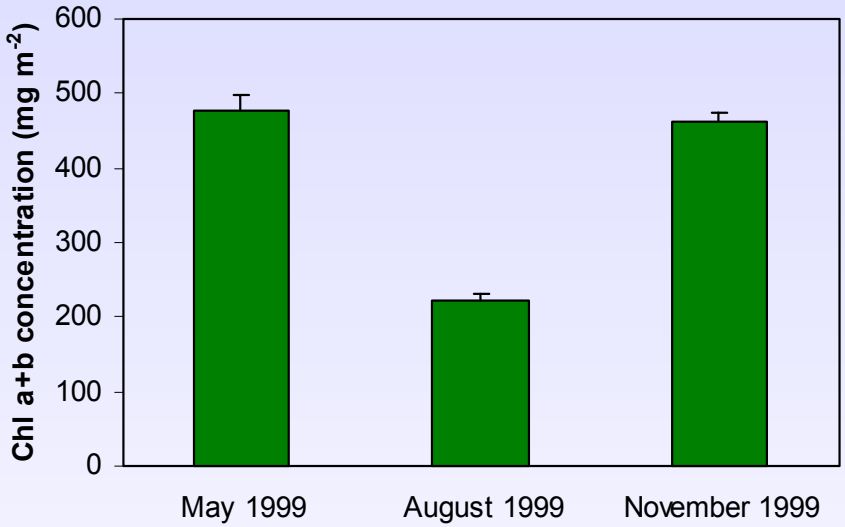


100º - 100% RWC



0º - 70% RWC



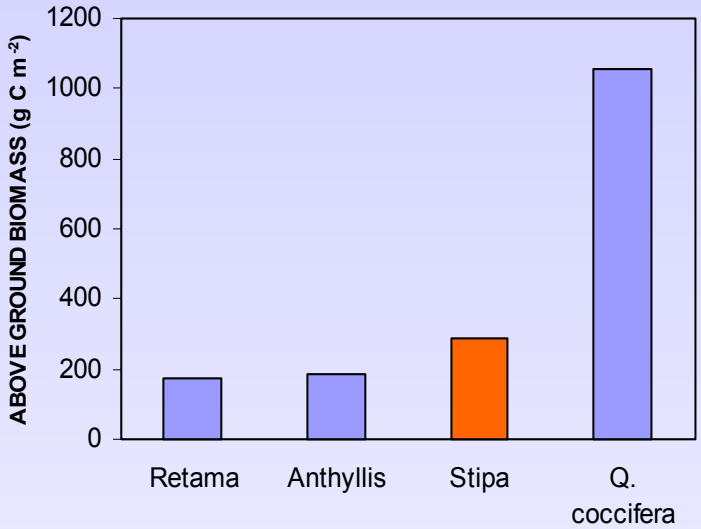


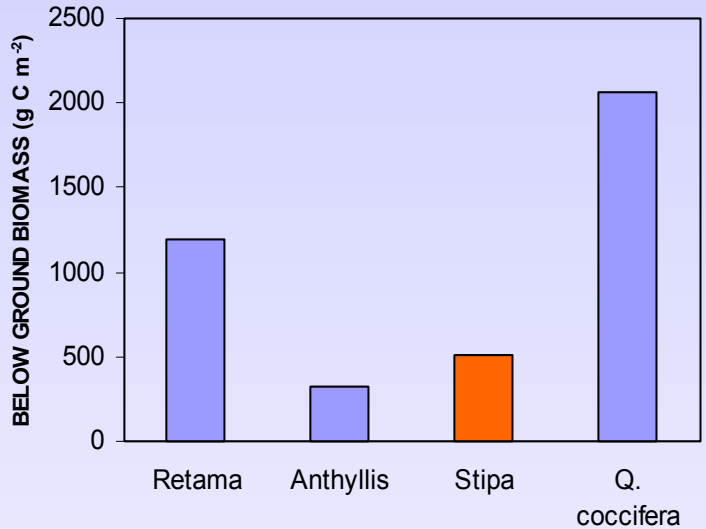
Haase et al., 1999

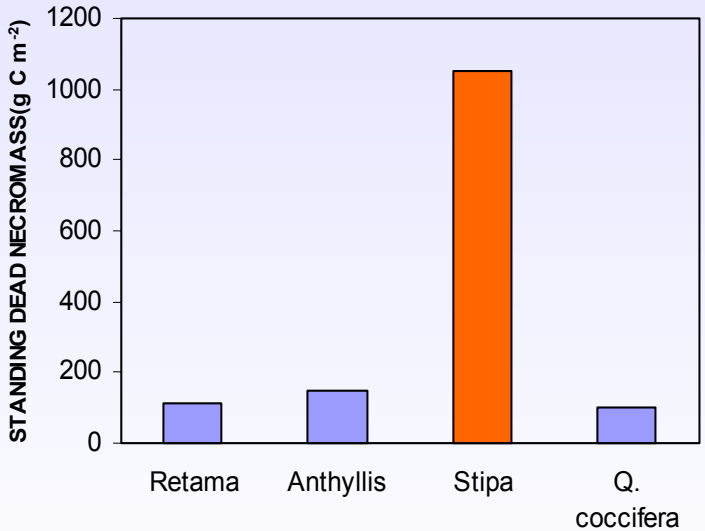
Balaguer et al., 2002

Morpho-functional traits

Biomass accumulation and productivity







Puigdefábregas, 1998

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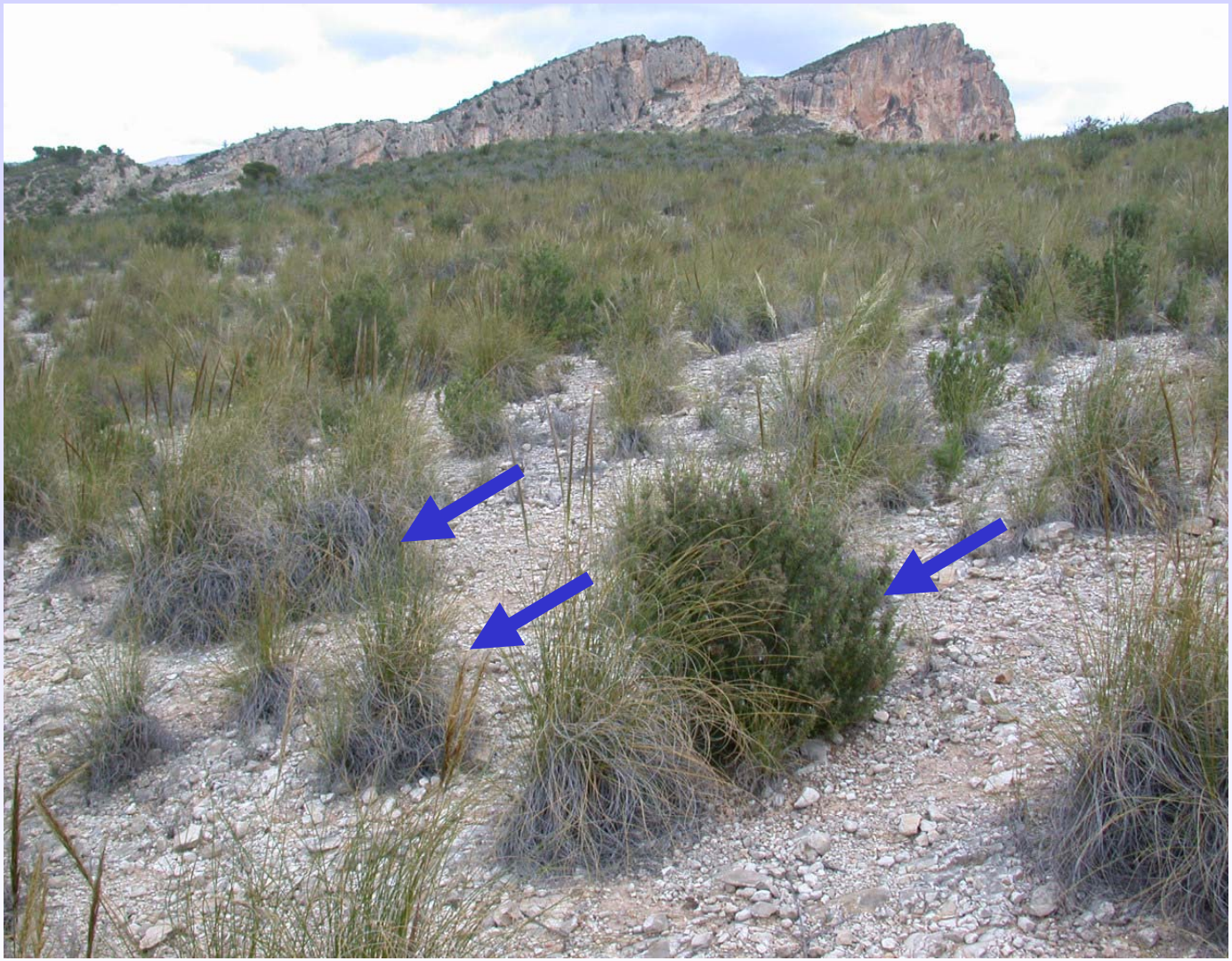
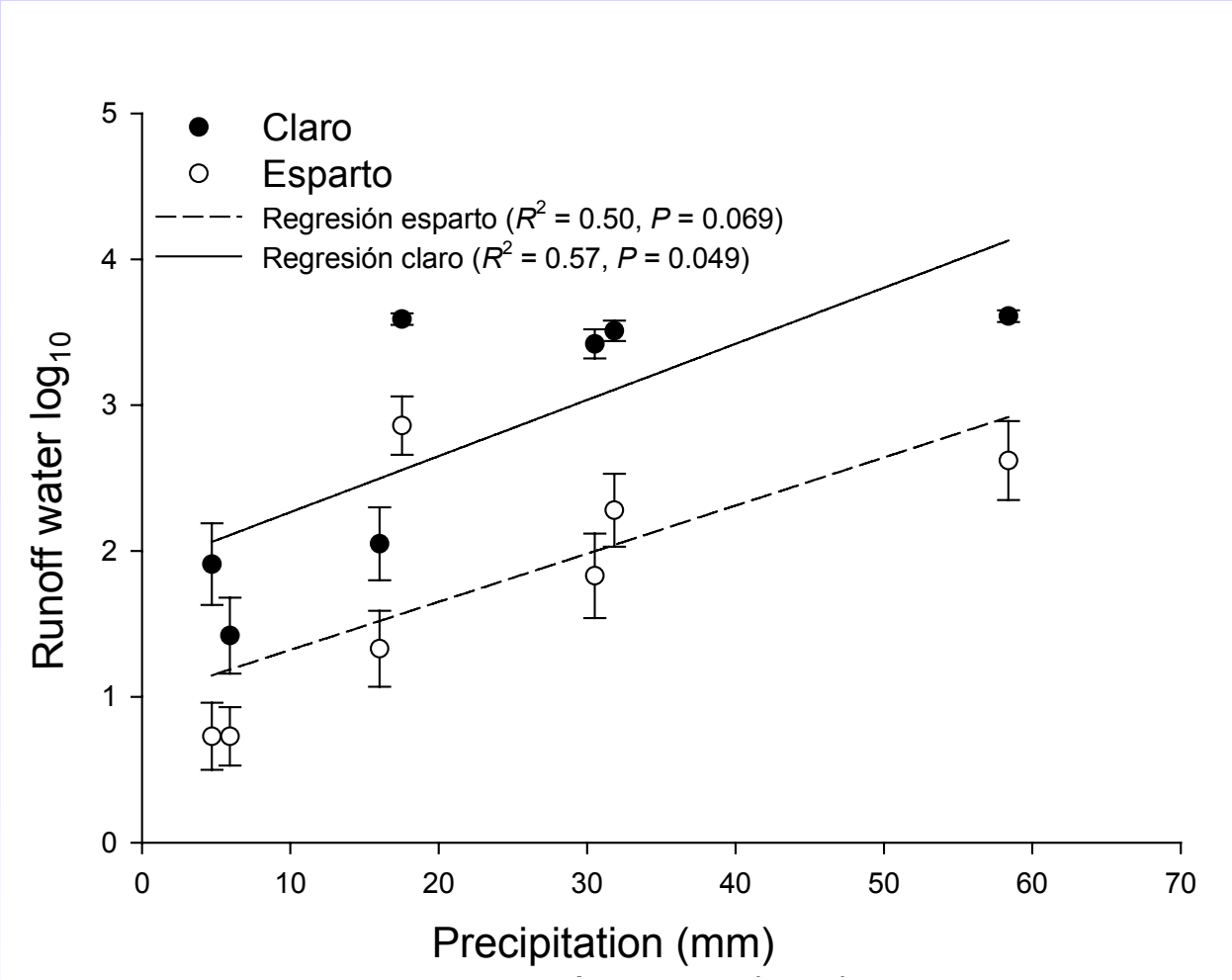
Spatial heterogeneity of resources and organisms

Alpha grass tussocks capture resources (water, sediments, nutrients, seeds)



Spatial heterogeneity of resources and organisms

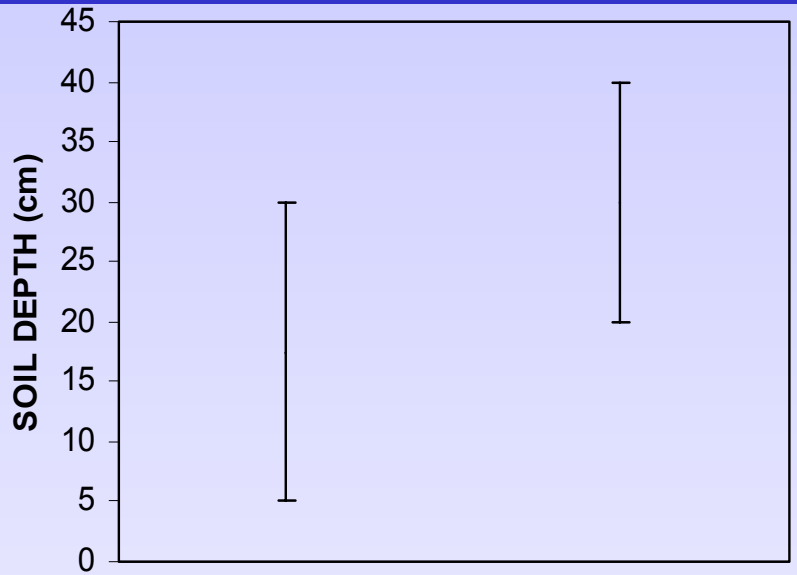
As a result alpha grass tussocks act as sinks for resources generated upslope

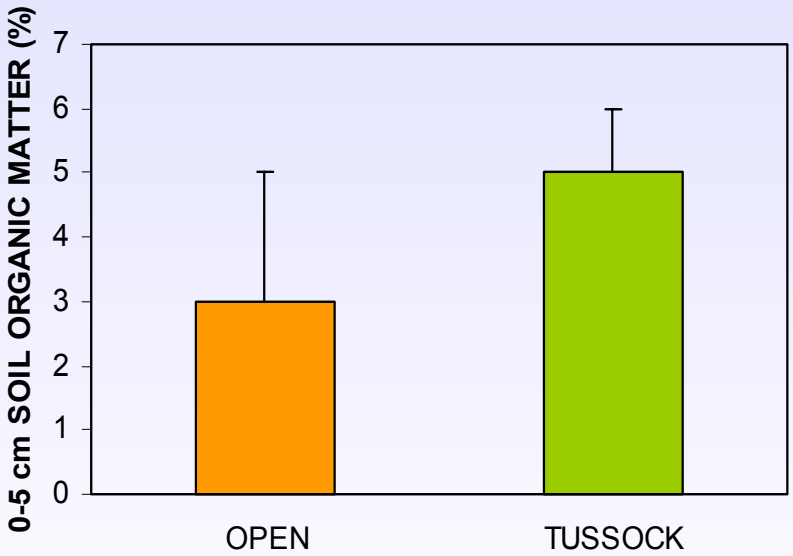


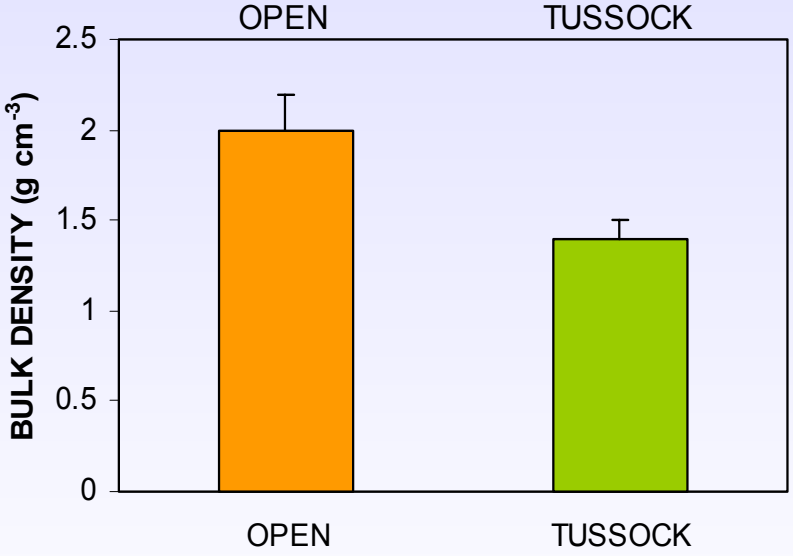
Martín et al., unpubl.

Spatial heterogeneity of resources and organisms

Soil properties underneath the tussocks gradually differ, in a positive feedback creating islands of fertility







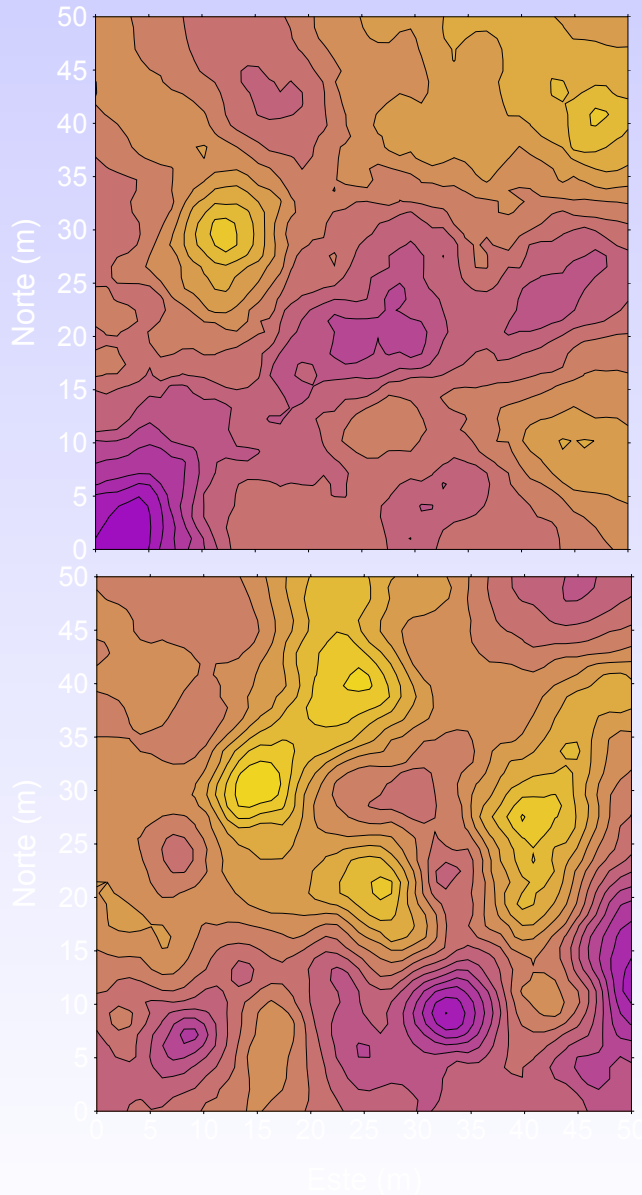
Puigdefábregas & Sánchez, 1996

Spatial heterogeneity of resources and organisms

Stipa tenacissima

+ Biological crust
+ Roots
+ Rock fragments surface
- Physical crust

	S. tenacissima
Roots	**0.366**
Mosses	0.101
Earthworm casts	-0.151
Bio crust	0.196
Surface stone	-0.102
Rock outcrops	0.201
Physical crust	-0.175

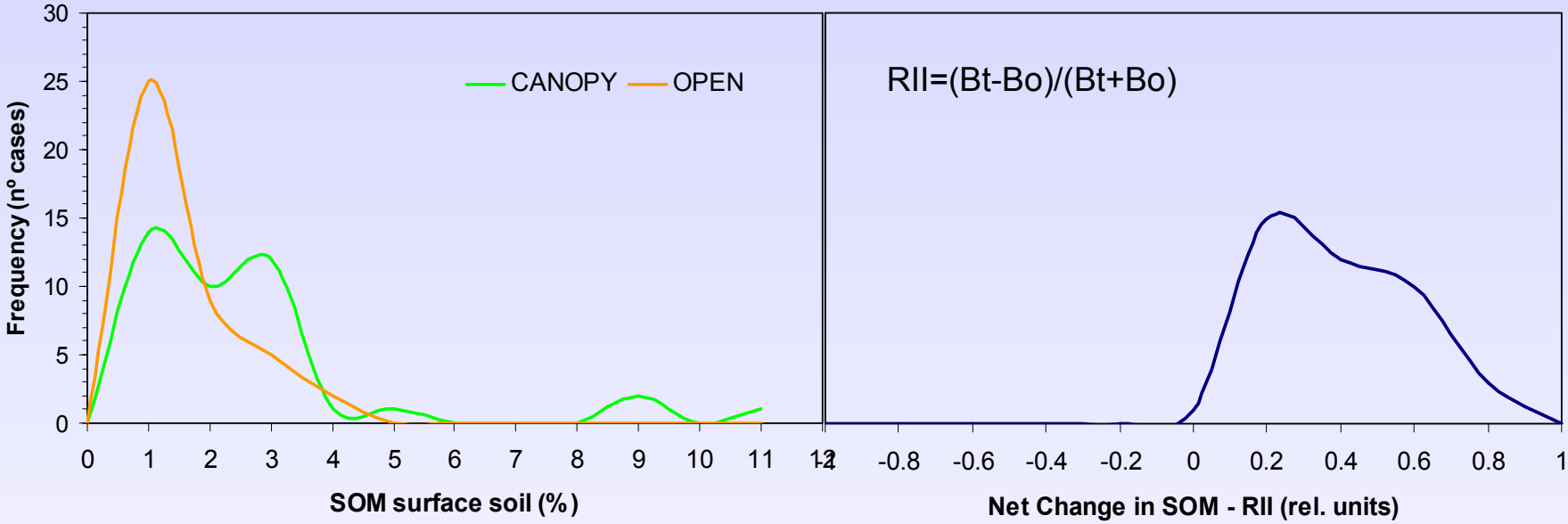


Maestre & Cortina, 2002




Spatial heterogeneity of resources and organisms

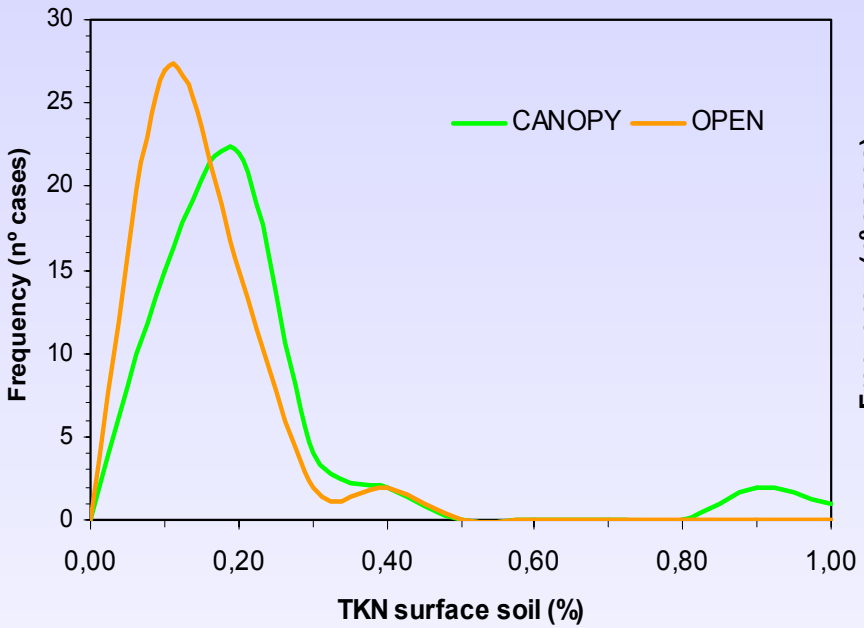
Organic matter in islands of fertility

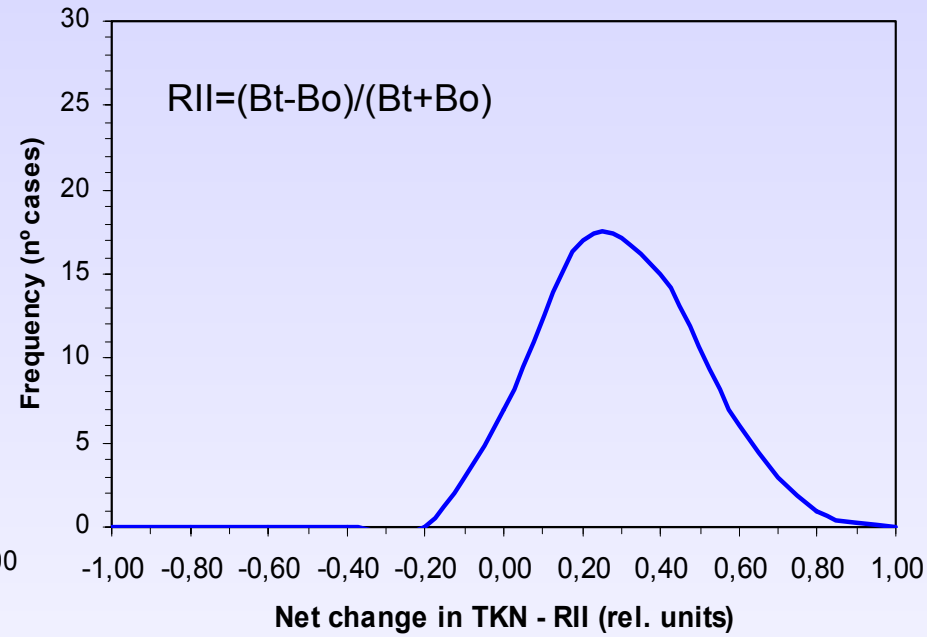


Cortina & Maestre, 2005

Spatial heterogeneity of resources and organisms

Nitrogen in islands of fertility

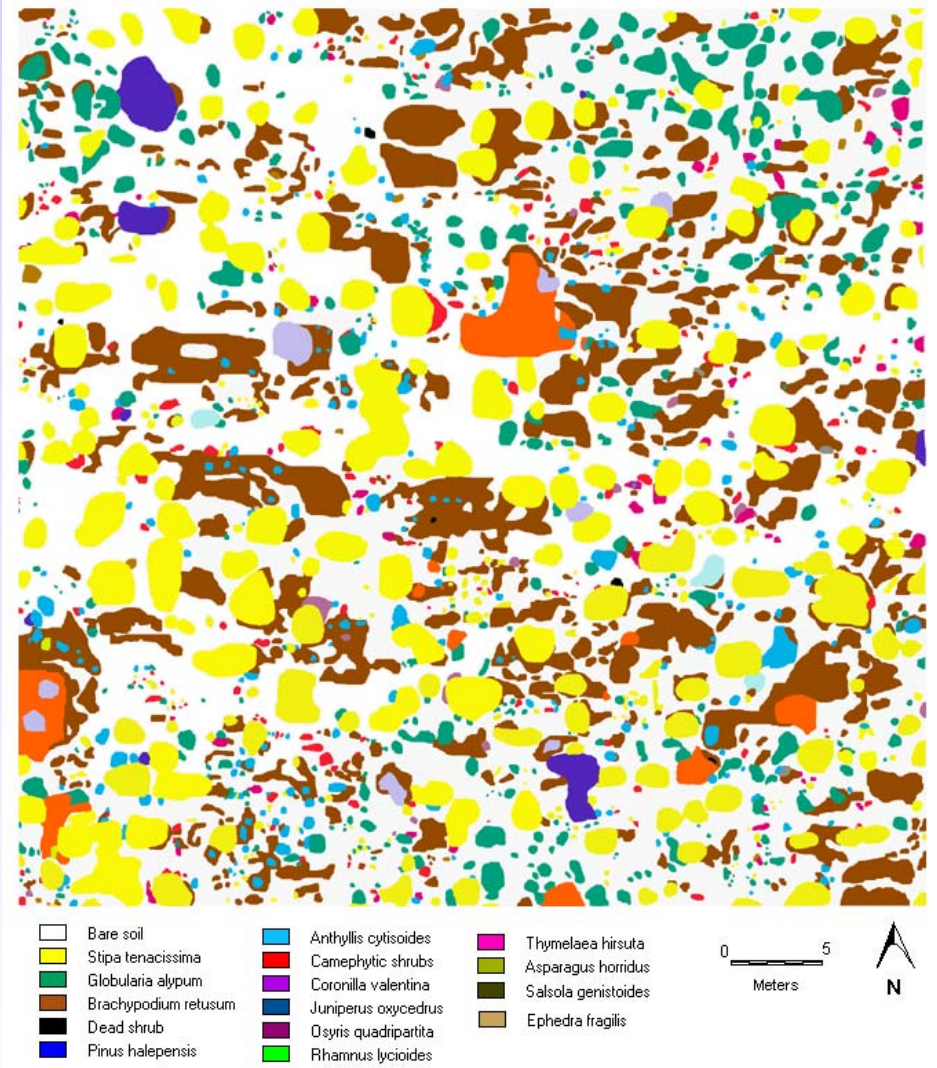




Cortina & Maestre, 2005

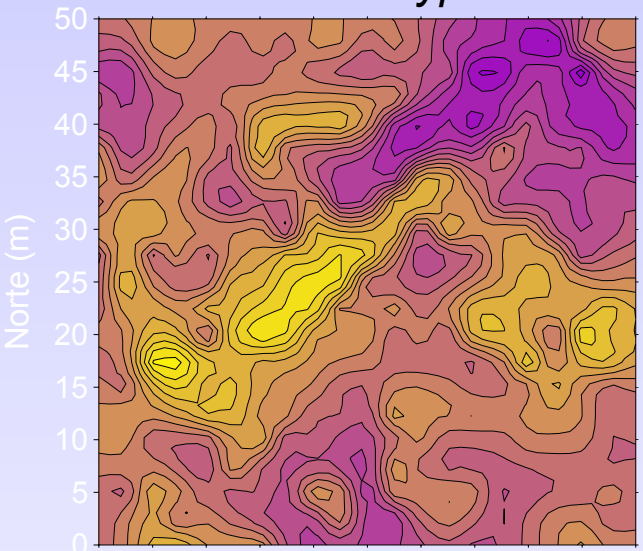
Interspecific interactions and community structure

Plant community structure reflect these and other interactions

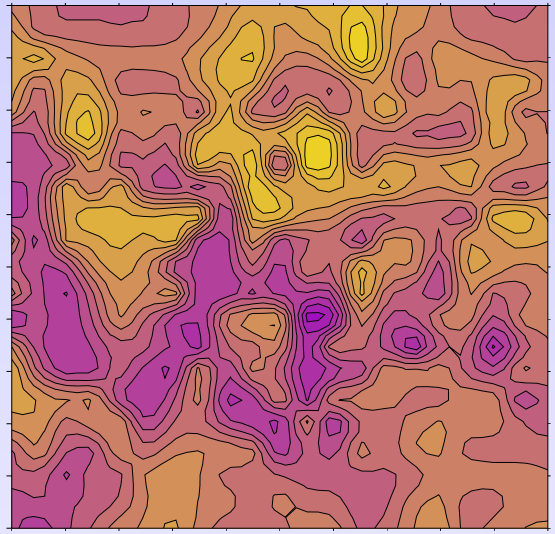


Interspecific interactions and community structure

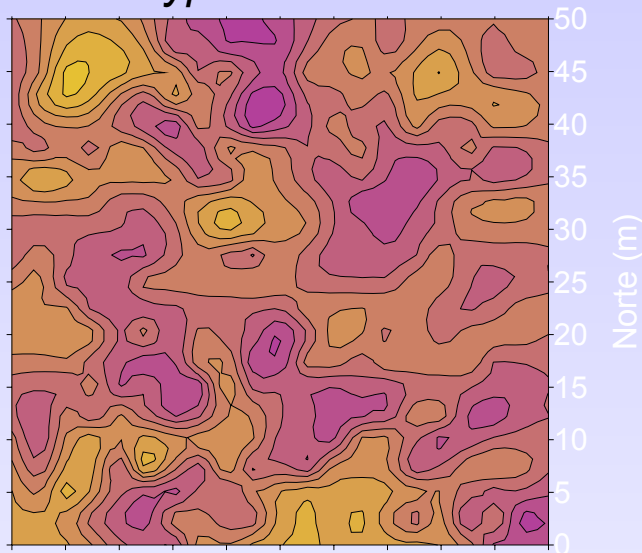
Globularia alypum



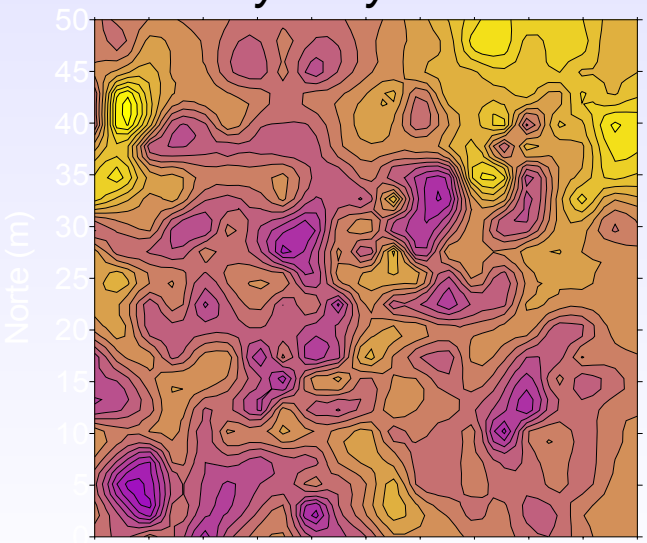
Stipa tenacissima



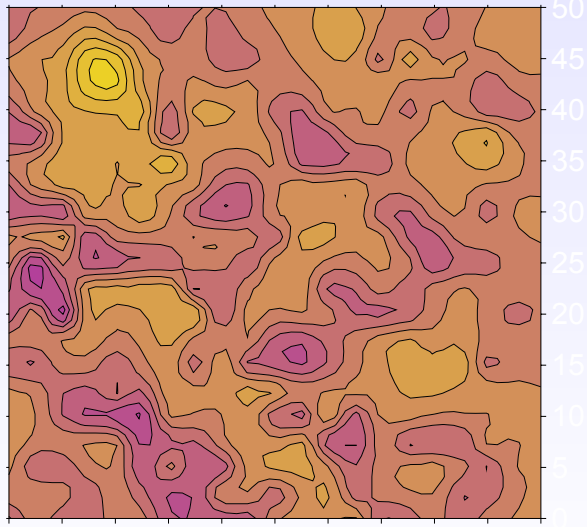
Brachypodium retusum



Anthyllis cytisoides



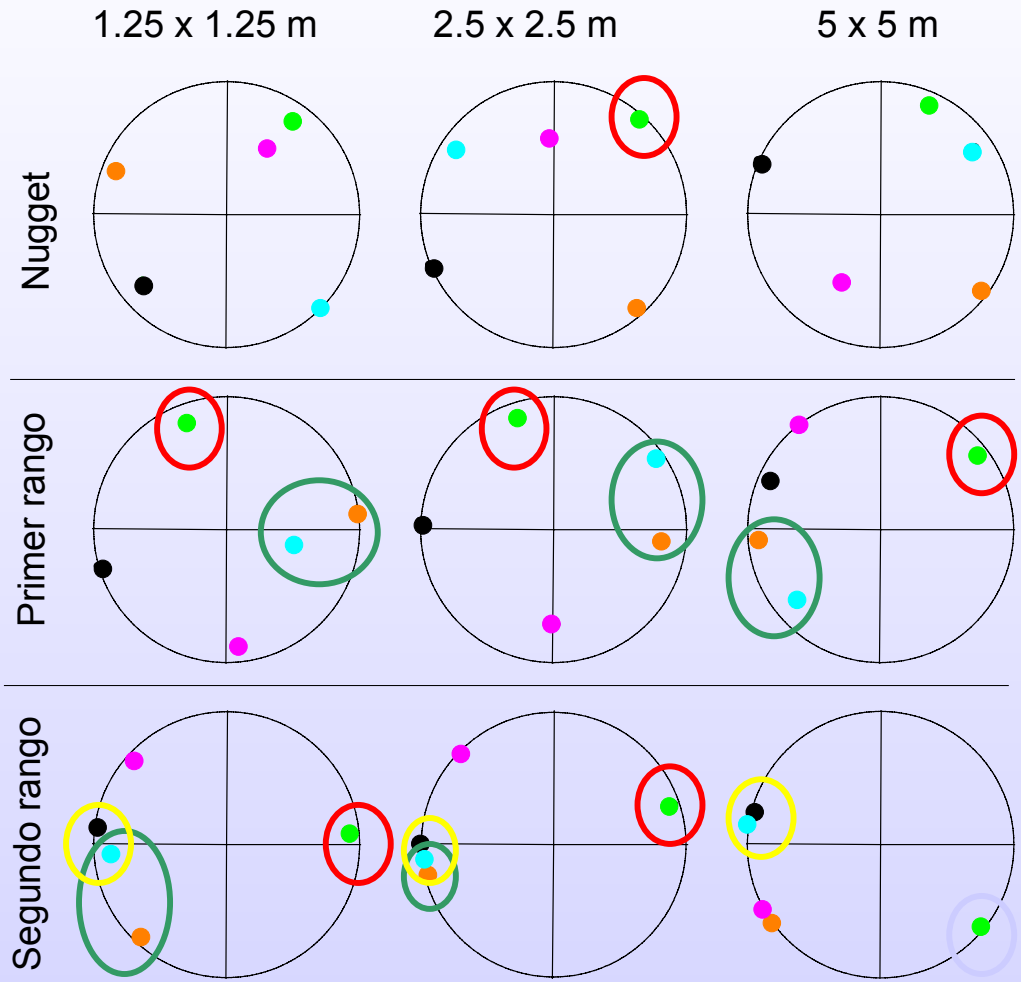
Caméfitos



Maps of SADIE index of clustering at a 2.5 x 2.5 m scale

Maestre & Cortina, 2002

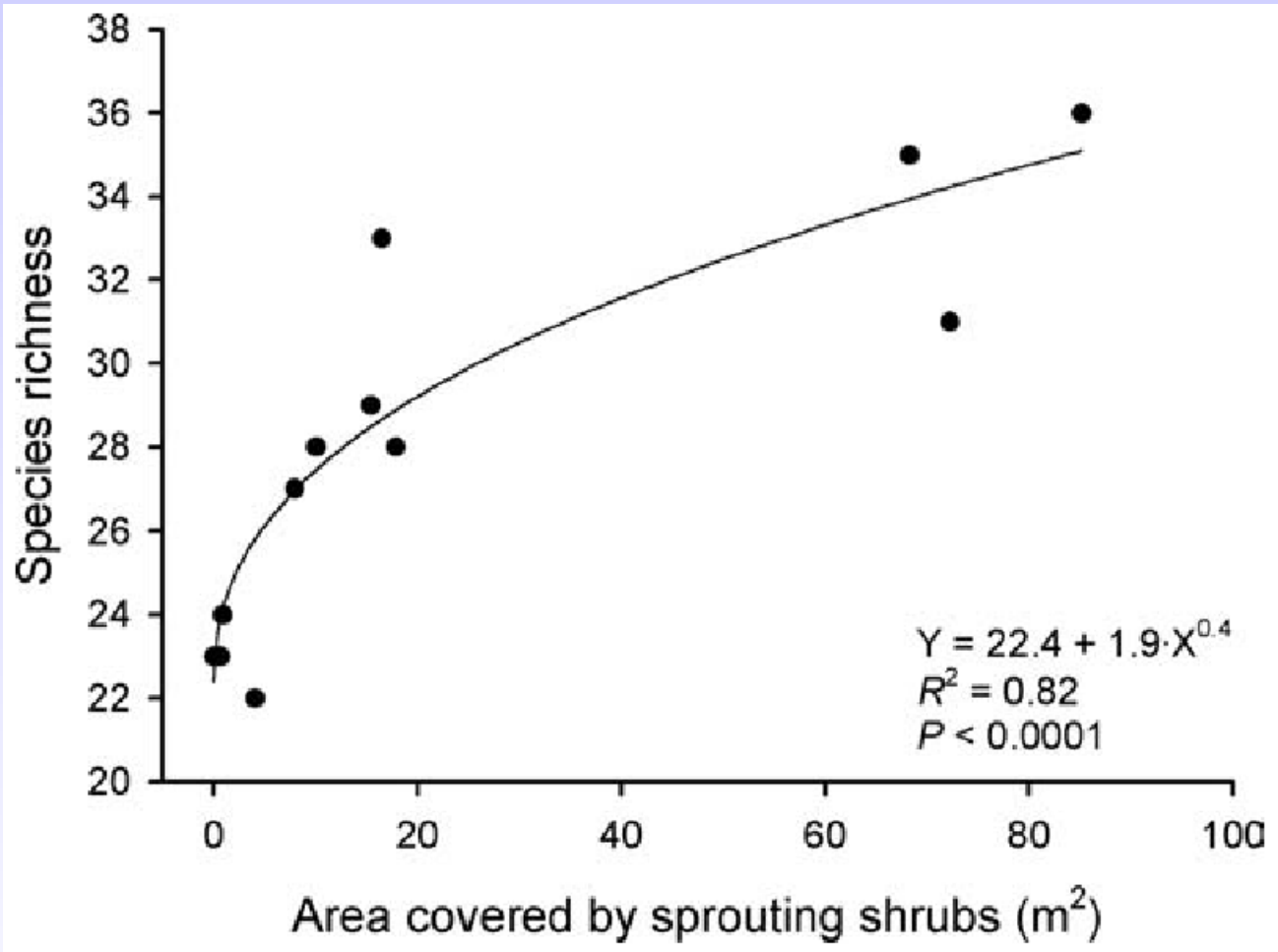
Interspecific interactions and community structure



islands of fertility aggregate some plants but not others

Maestre, 2002

Interspecific interactions and community structure



Ephedra fragilis

Juniperus oxycedrus

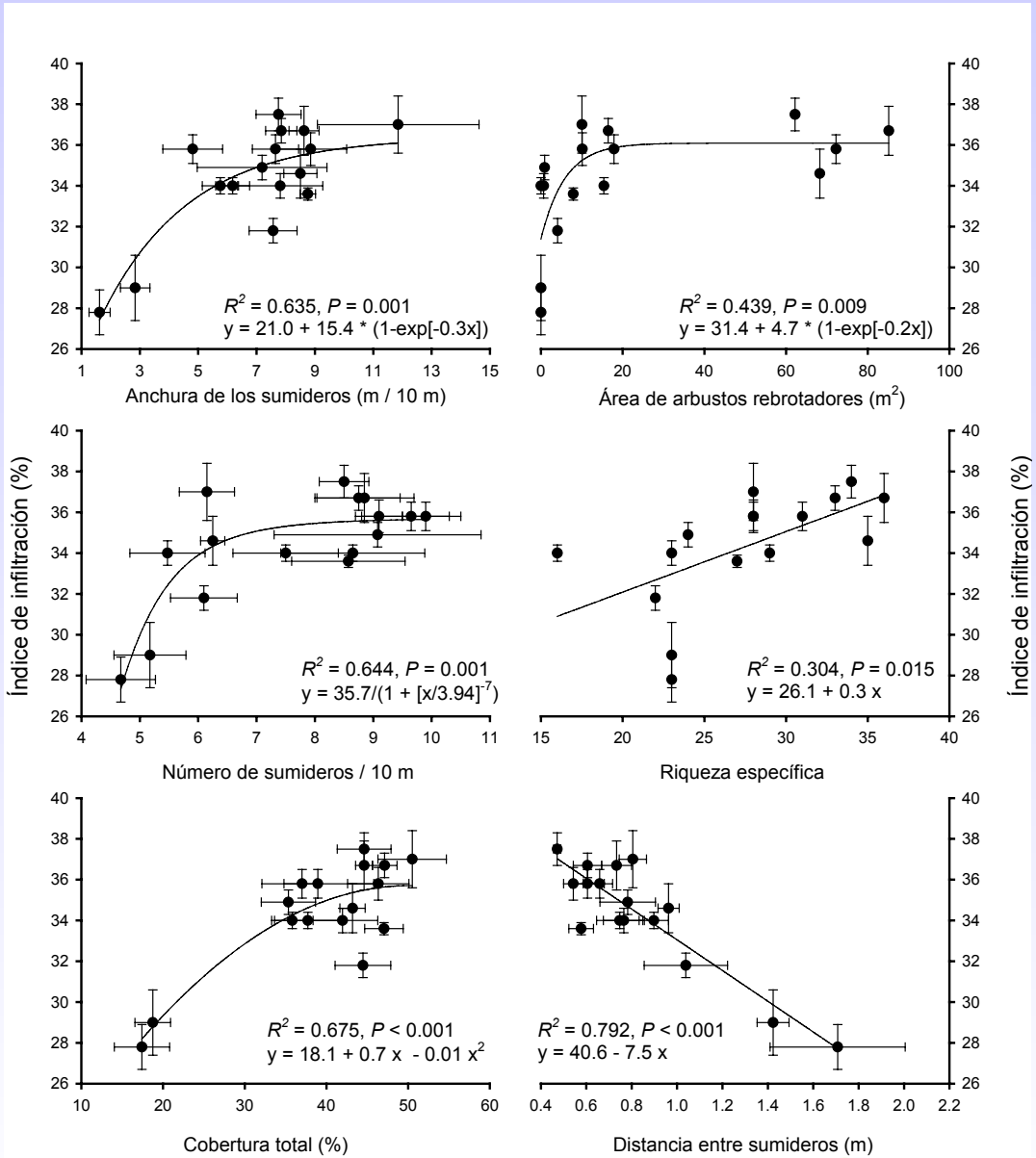
Quercus coccifera

Erica multiflora

Rhamnus lycioides

Maestre & Cortina (2005) *Acta Oecol.* 17: 161-9.

Interspecific interactions and community structure



Maestre & Cortina (2004). *Restoration Ecology* 12(4): 493-501.

Interspecific interactions and community structure

How important are biological crusts for alpha grass performance?

Experimental plots:

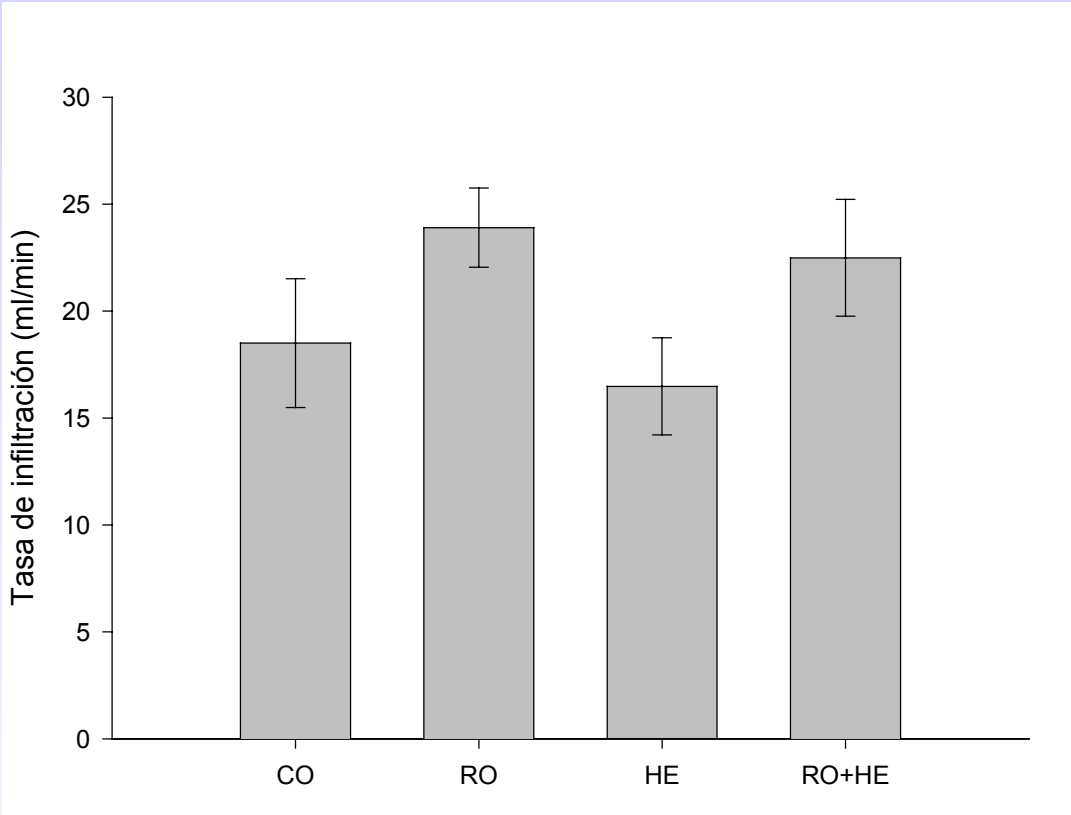
- ALPHA +/-
- BIOCRUST FRAGMENTED +/-
- BIOCRUST HERBICIDED +/-

5 replicates: 40 plots

PROJECT **FANCB -** *Water and nitrogen fluxes in biological crusts in semiarid environments* (REN2001-0424-C02-02 / GLO)

Interspecific interactions and community structure

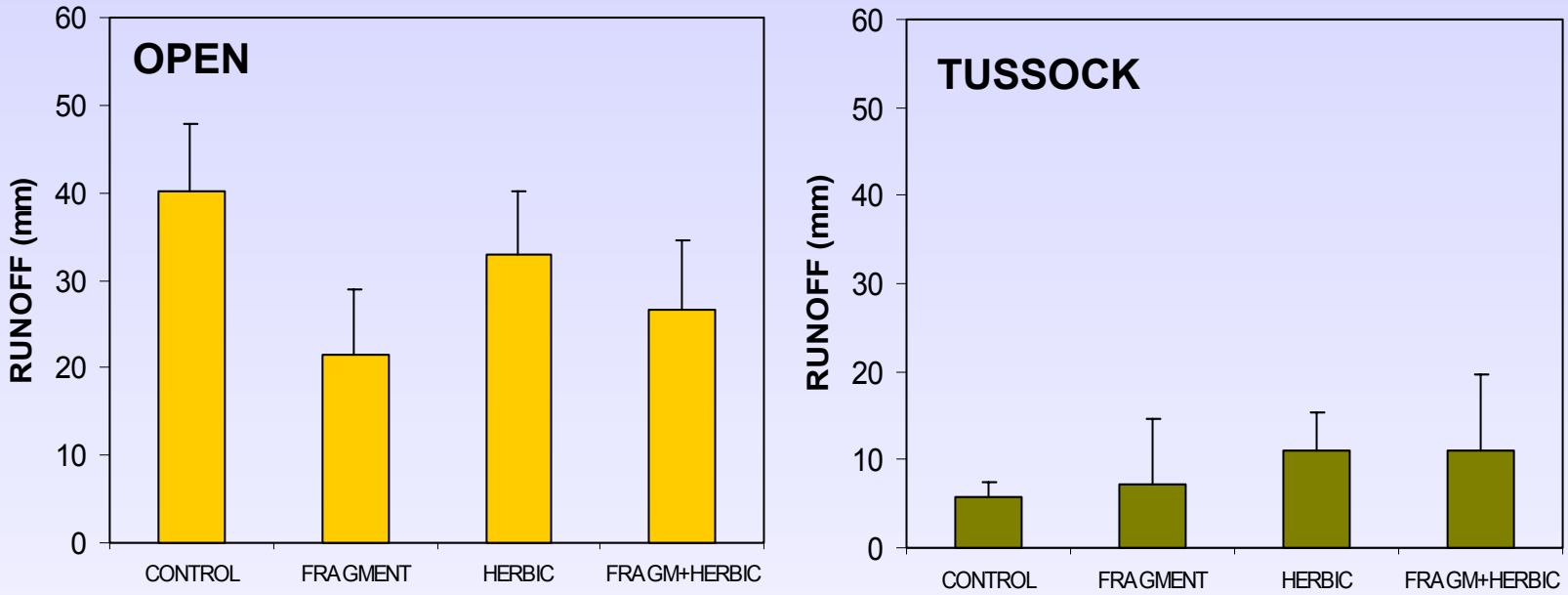
The effect of biological crusts on water infiltration is reduced when the physical structure is altered, but not when crusts are killed



Martín et al., unpubl.

Interspecific interactions and community structure

The effect of biological crusts on runoff is buffered by alpha grass tussocks



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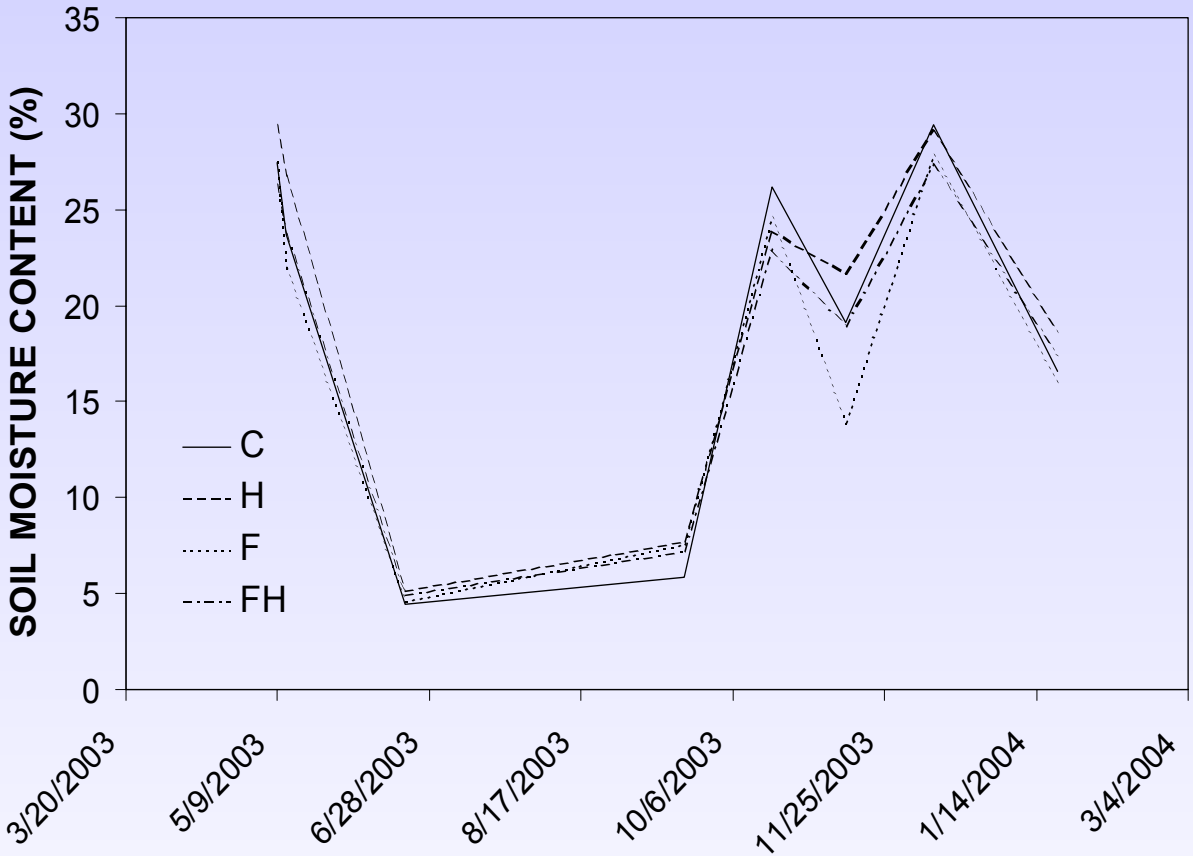

Martín et al., unpubl.

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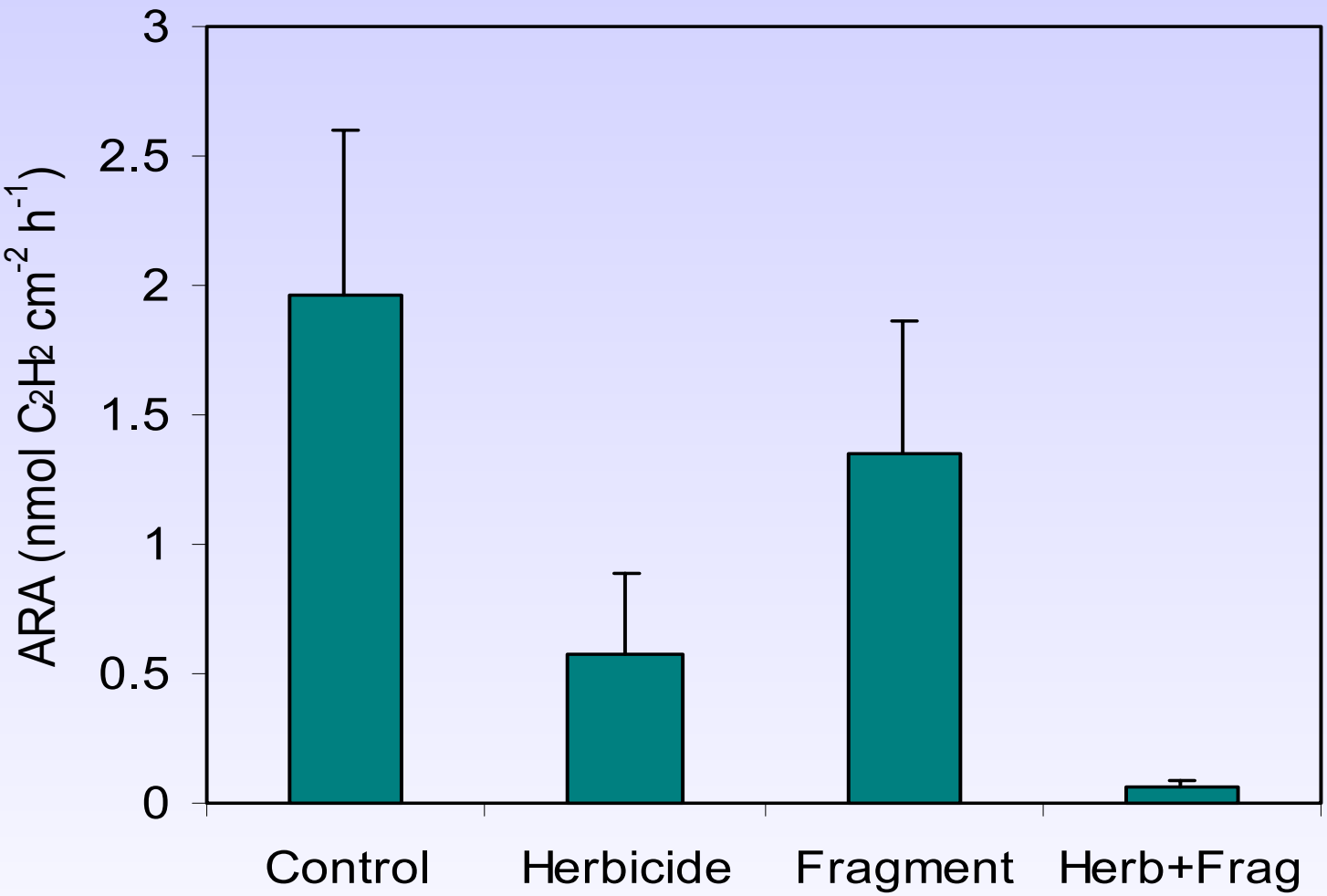
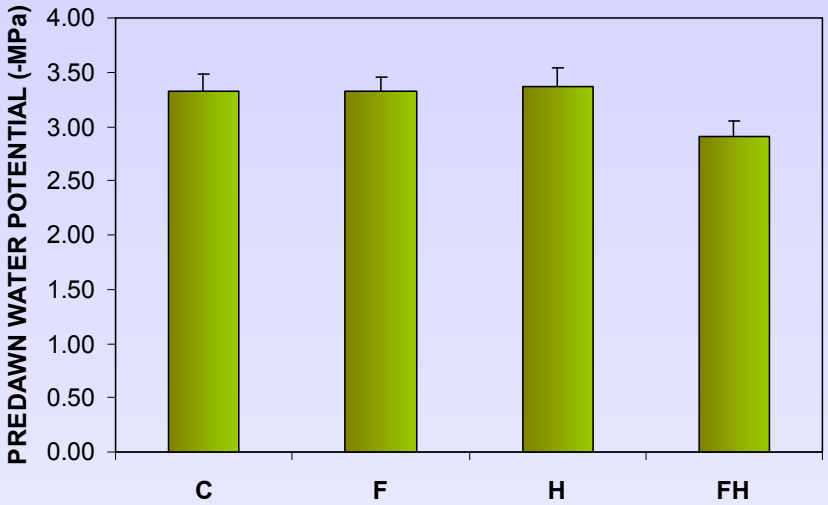
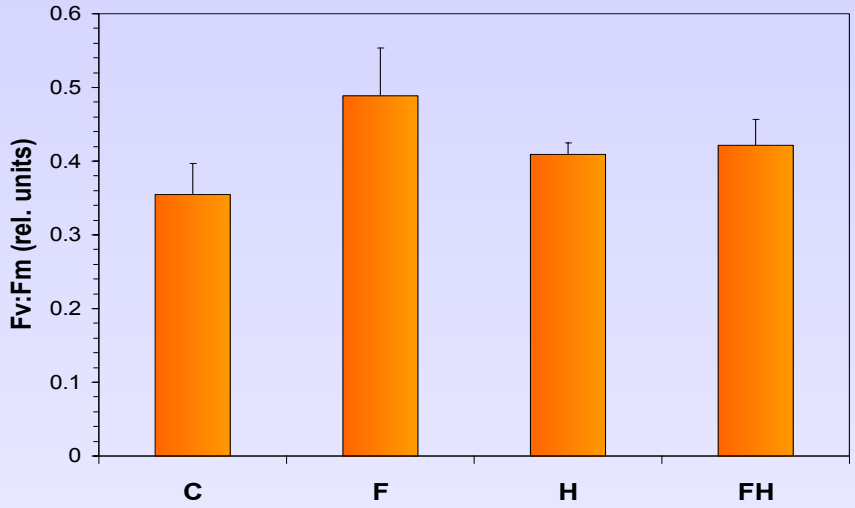


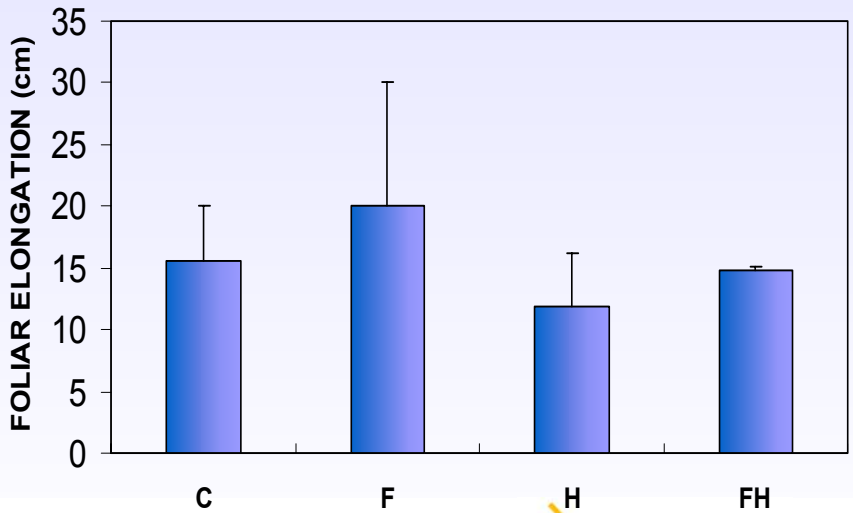
Martín et al., unpubl.

Interspecific interactions and community structure

Crust manipulation did not affect alpha grass performance







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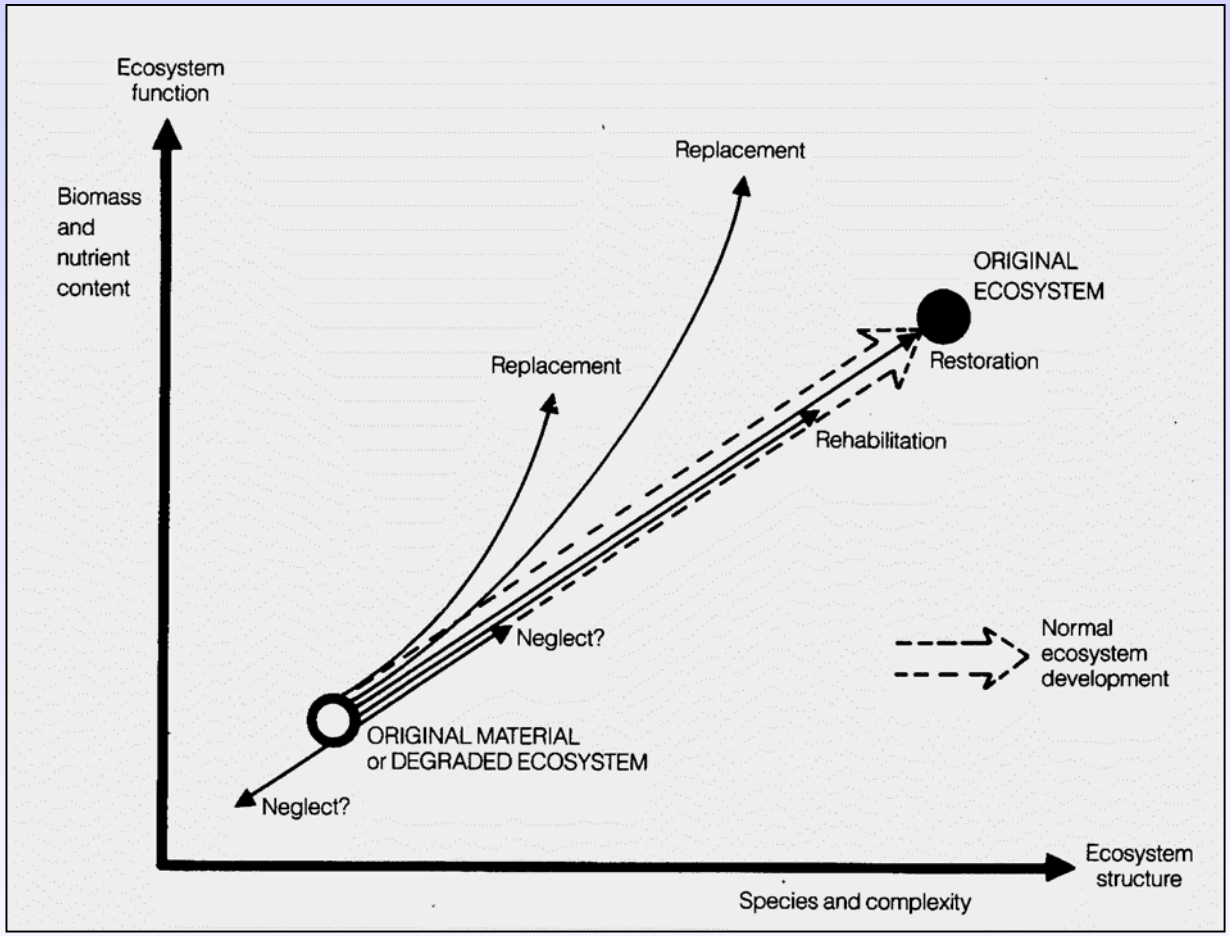
ECOLOGICAL RESTORATION *is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed*

Society for Ecological Restoration International, 2002

A framework for alpha grass steppe restoration



Bradshaw & Chadwick, 1988

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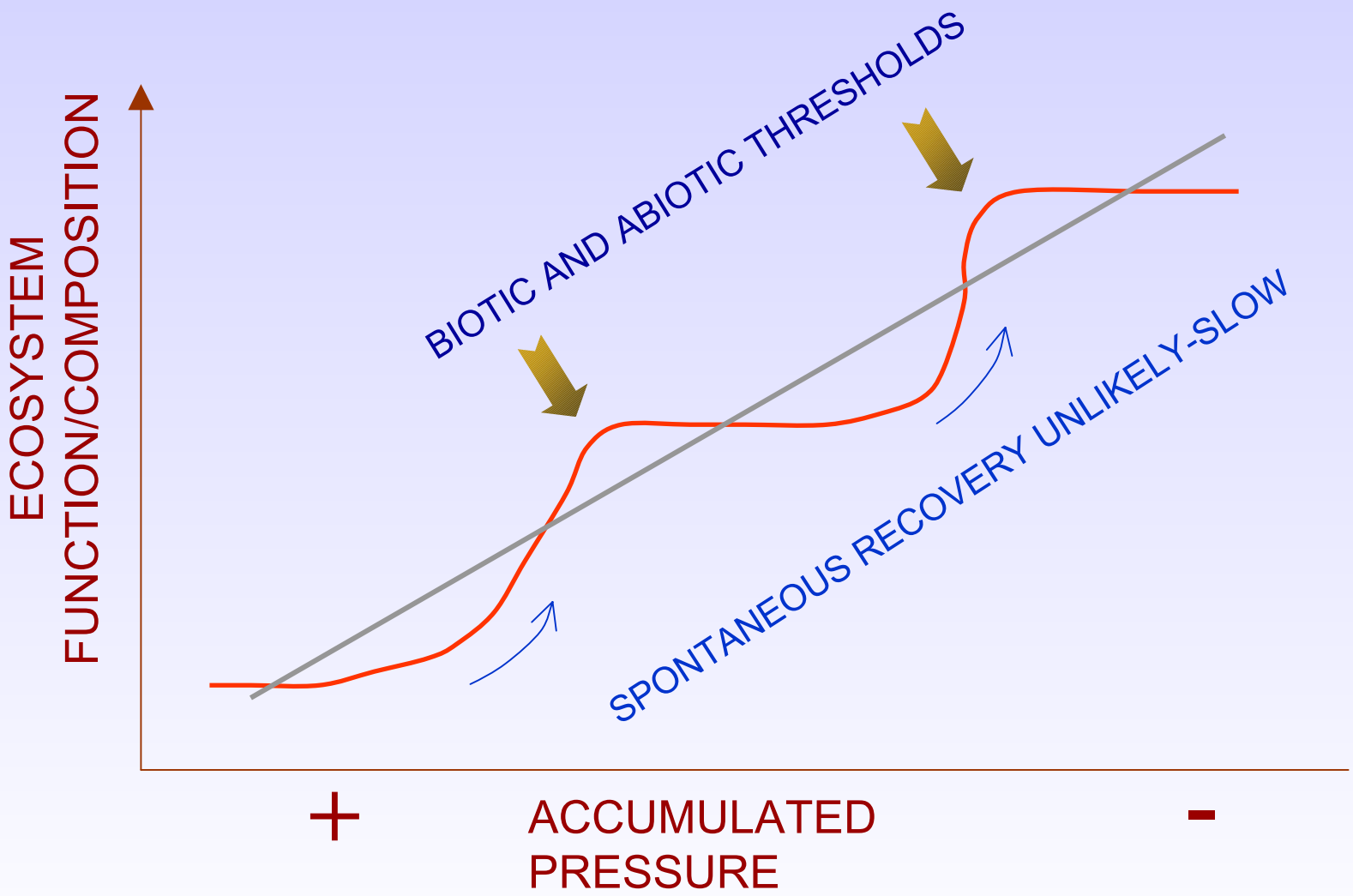

A framework for alpha grass steppe restoration

FACTOR	ACTION	TECHNIQUE
o PERSISTENT STRESS	o RELEASE STRESS	o SPECIES CONTROL...
o PROPAGULES NOT AVAILABLE	o ARTIFICIAL INTRODUCTION	o SEEDING & PLANTING
	o PROMOTE DISPERSION	o DISPERSERS ABUNDANCE & ACTIVITY
o ENVIRONMENTAL CONDITIONS ADVERSE	o SPECIES SELECTION & SEEDLING PRODUCTION	o SPECIES TEST & SEEDLING 'QUALITY'
	o SELECT SUITABLE MICROSITES	
	o AMELIORATE SOIL PROPERTIES	o AMENDMENTS
	o IMPROVE MICROCLIMATE	o SHELTERS

Cortina & Vallejo, 2004. EOLSS. UNESCO

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Landscape structure, functional state and restorability

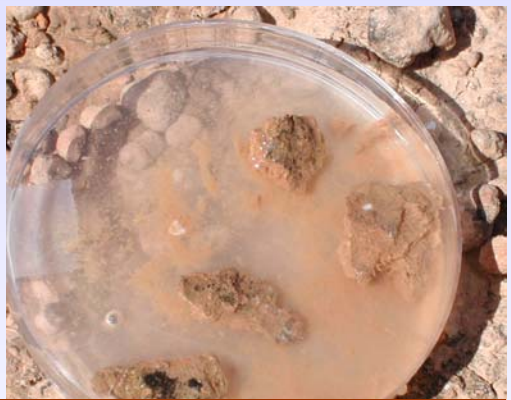
LANDSCAPE **F**UNCTION **A**NALYSIS (CSIRO, D.Tongway y colaboradores)

http://www.cse.csiro.au/research/Program3/efa/

Landscape structure, functional state and restorability

Croûte biologique

Détachement de la croûte



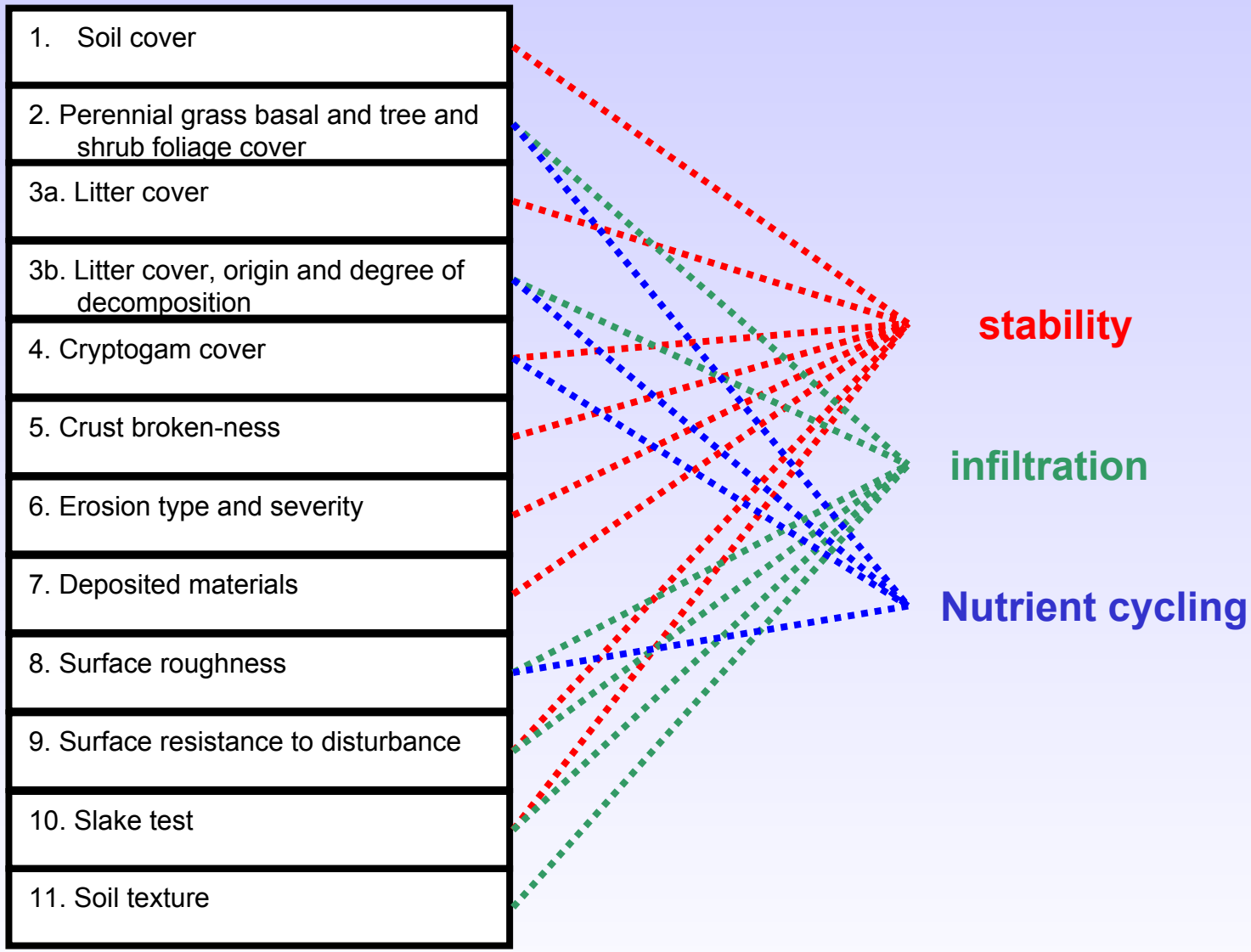
Test resistance agregats

Formes d'érosion: terracette

Formes d'érosion: scalding

SOIL SURFACE ASSESSMENT

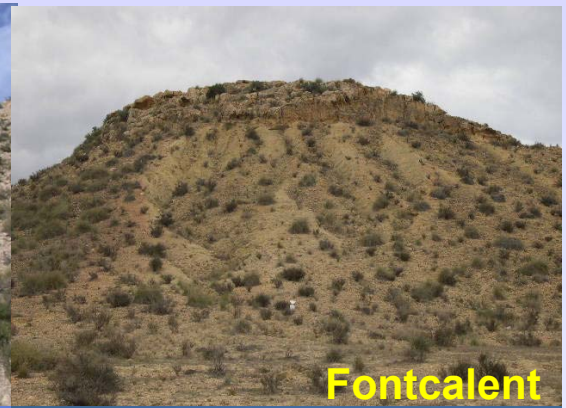
Landscape structure, functional state and restorability



Landscape structure, functional state and restorability

APPLICATION LFA STEPPES D'ALFA

Stability 50.7%
Infiltration 27.5%
Nutrient cycling 15.5%



Stability 50.7%
Infiltration 26.7%
Nutrient cycling 13.2%

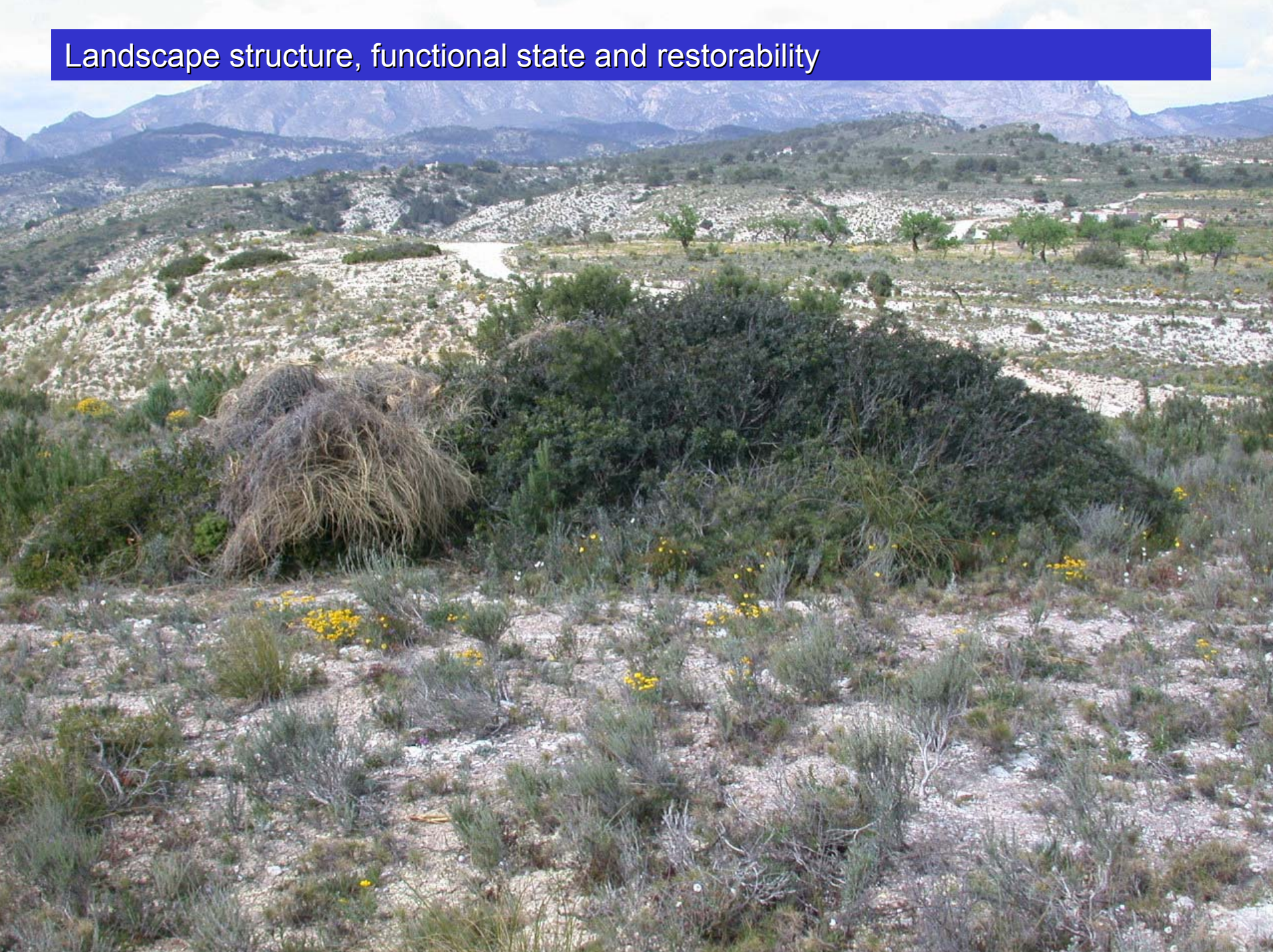
Stability 60.4%
Infiltration 32.2%
Nutrient cycling 24.3%

Stability 63.7%
Infiltration 33.5%
Nutrient cycling 25.4%

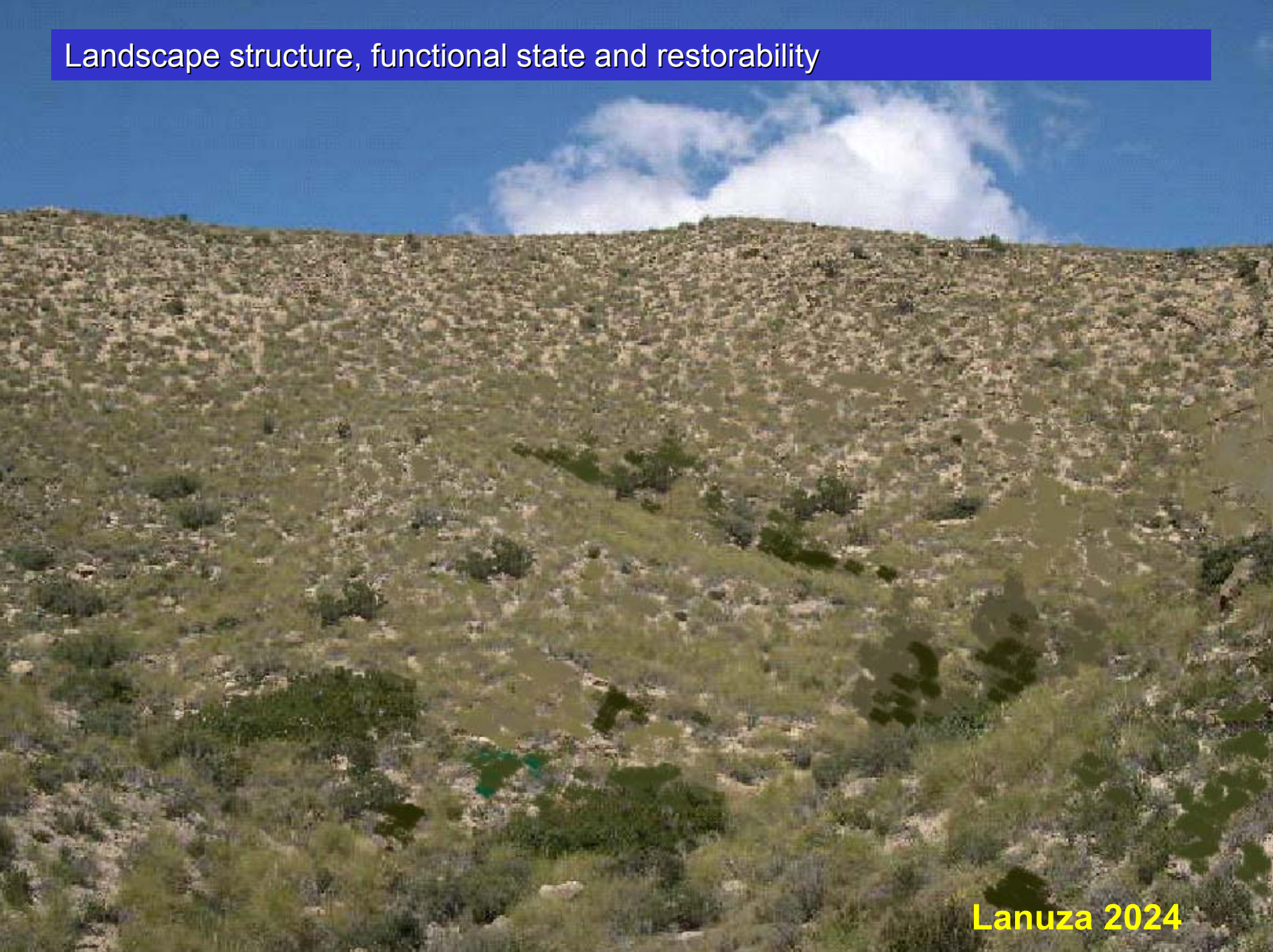
Landscape structure, functional state and restorability

Pistacia lentiscus

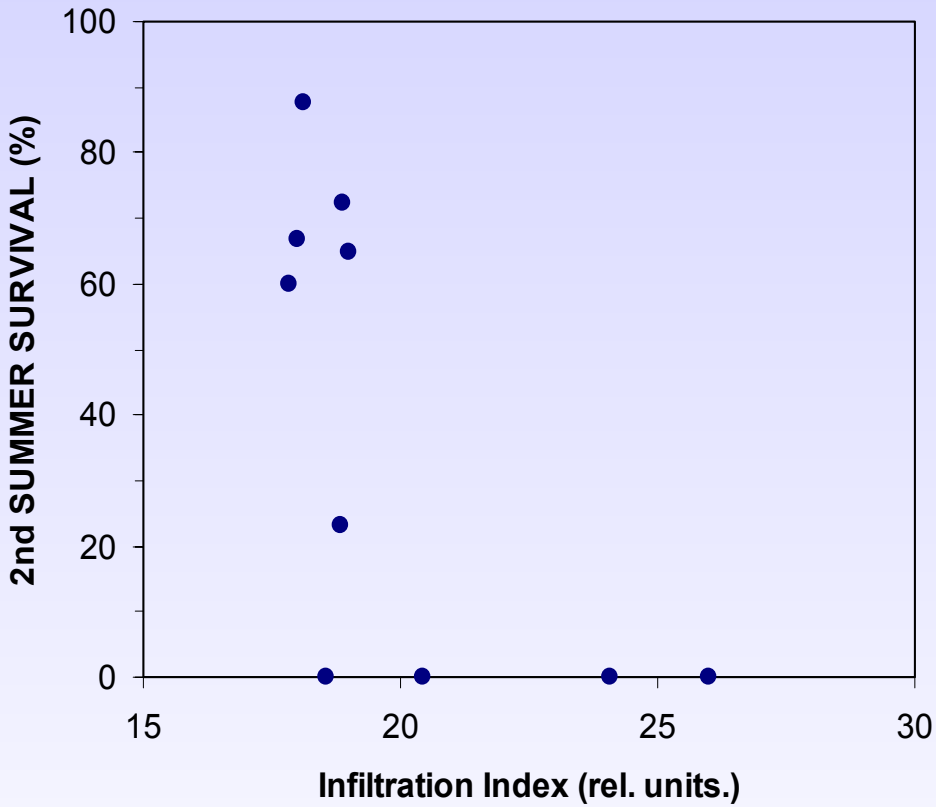
Landscape structure, functional state and restorability



Landscape structure, functional state and restorability



Landscape structure, functional state and restorability



Alfa grass (*Stipa tenacissima*) steppes as model ecosystems for dryland restoration

1.1 Introduction to alpha grass and alfa grass steppes in SE Spain.

1.2 Ecological interactions in alfa grass steppes, from microscopic to landscape scales.

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Ecological interactions provide clues for restoration

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2.2 The use of biological soil crusts.

2.2 Facilitation by alfa grass.

2.3 The role of Aleppo pine (*Pinus halepensis*) in alfa grass restoration.

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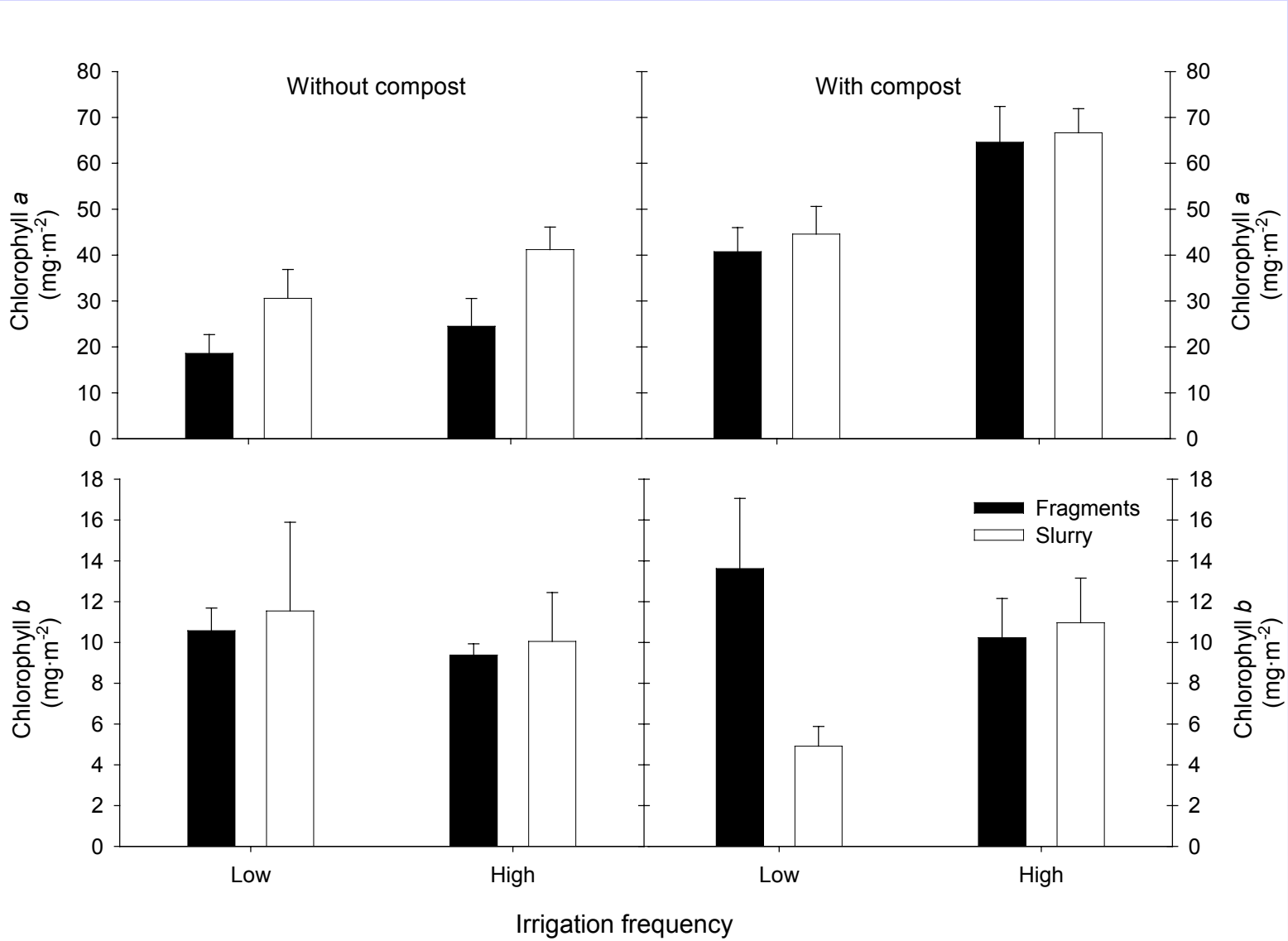
THE USE OF CYANOBACTERIAL CRUSTS IN RESTORATION

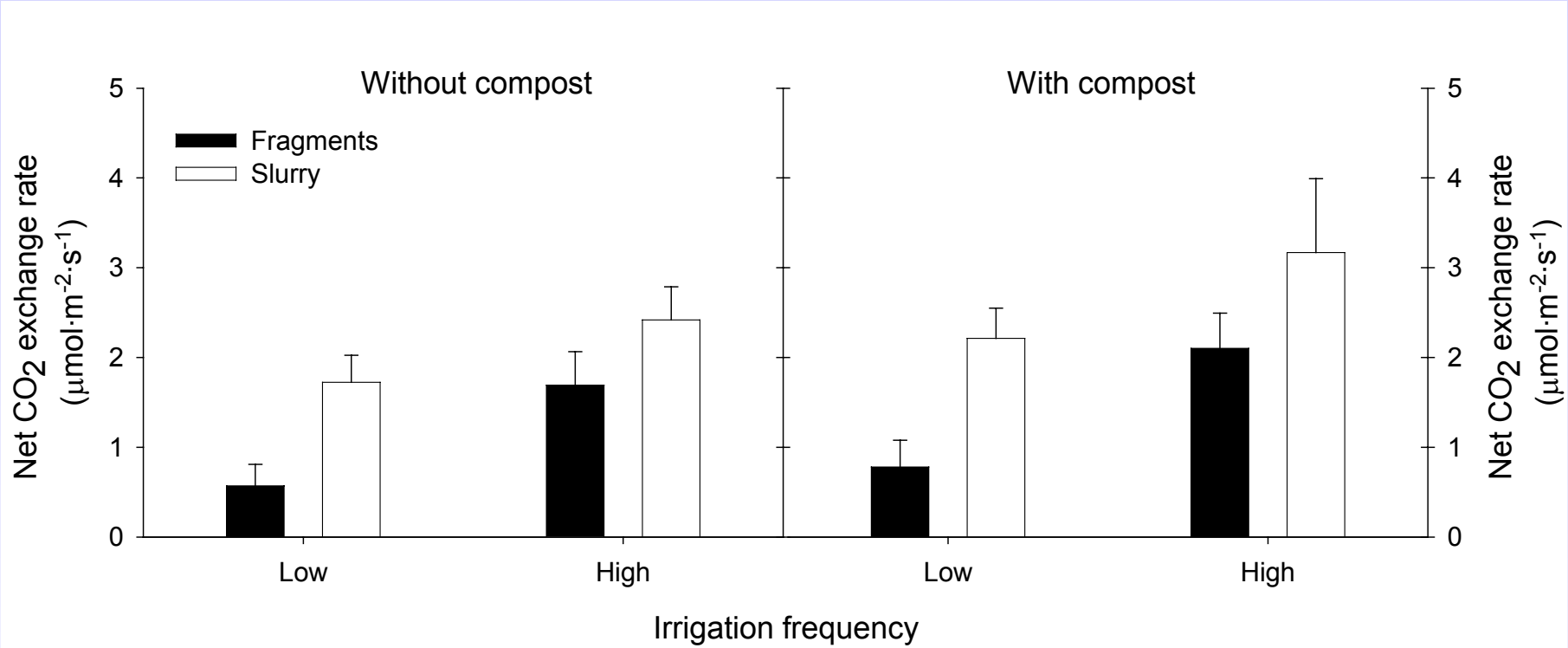
Experimental design:

- Laboratory incubation
- Crust transplanted or applied as slurry
- 2 watering regimes (1-3 watering per week)
- +/- compost added

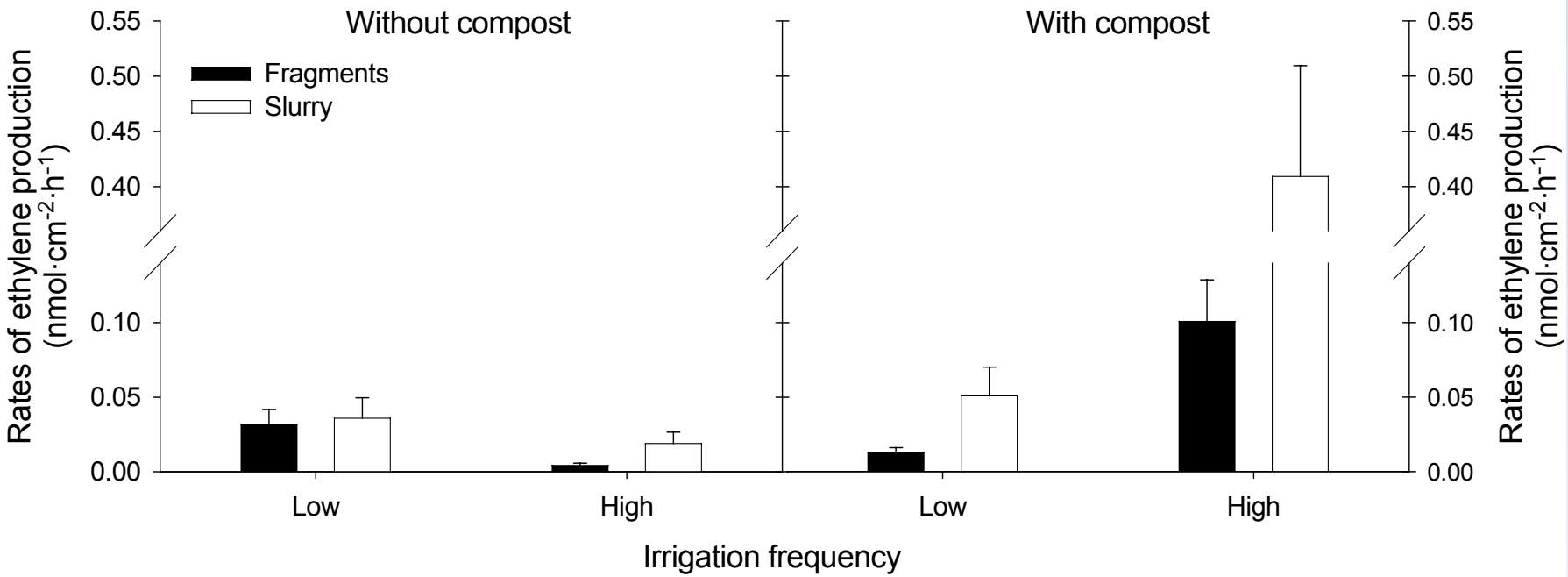
The use of biological crusts



The use of biological crusts



The use of biological crusts



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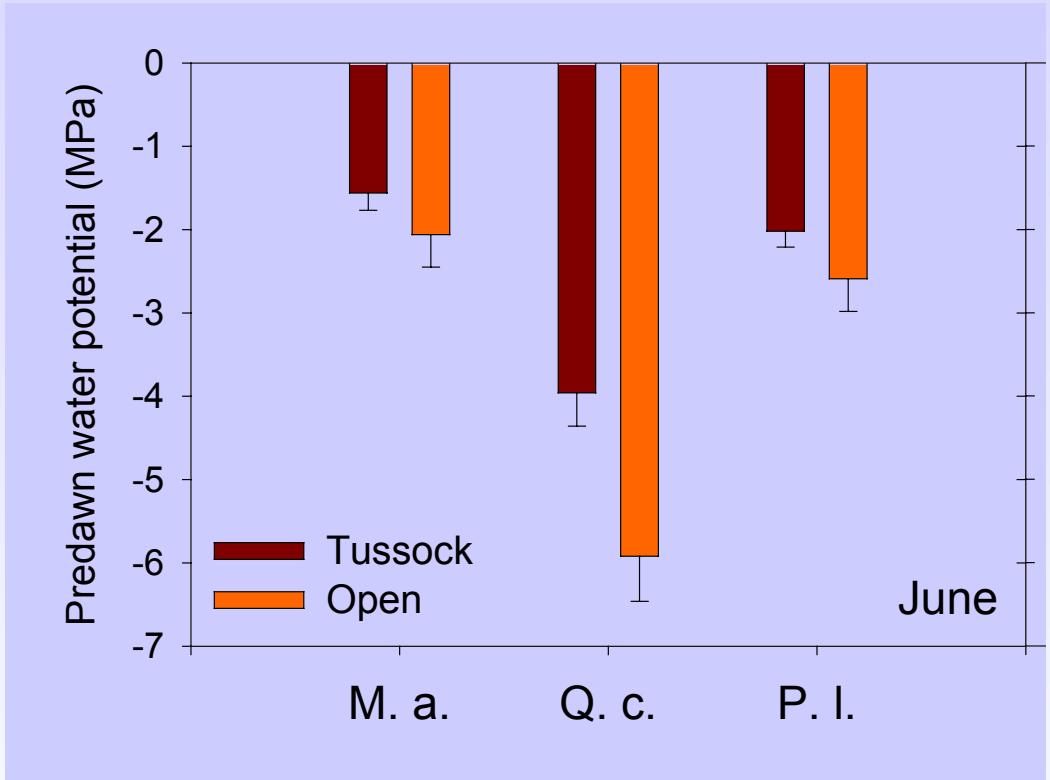
Facilitation by alpha grass

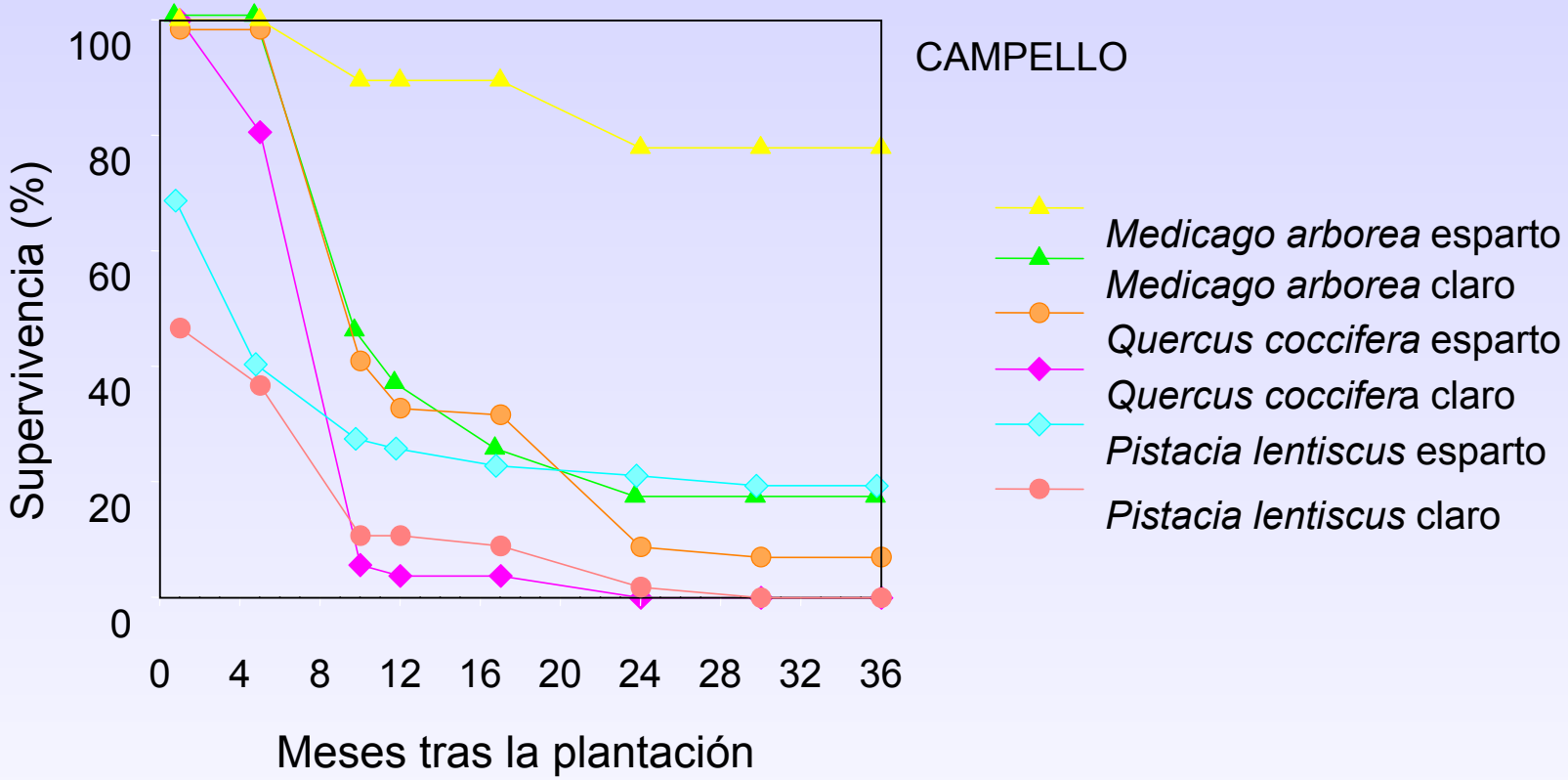
Facilitation by alpha grass

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



Maestre et al., 2001

Facilitation by alpha grass



Maestre et al., 2001

Facilitation by alpha grass

Tussock control (ECO)

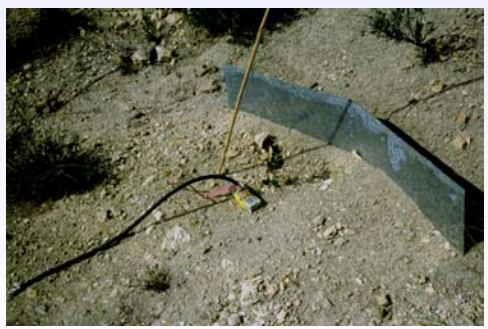
Tussock bended (ESO)

Tussock no runoff (ECH)

Open control (BCO)

Tussock herbicided (ECM)

Open no runoff (BCH)

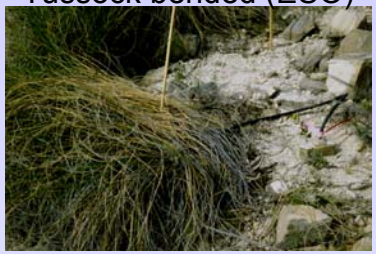


Maestre et al., 2003

Facilitation by alpha grass

Tussock control (ECO)

Tussock bended (ESO)

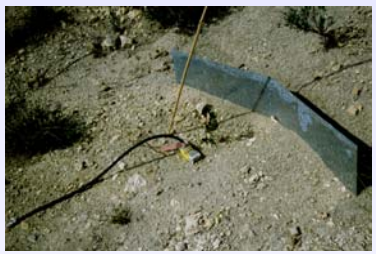


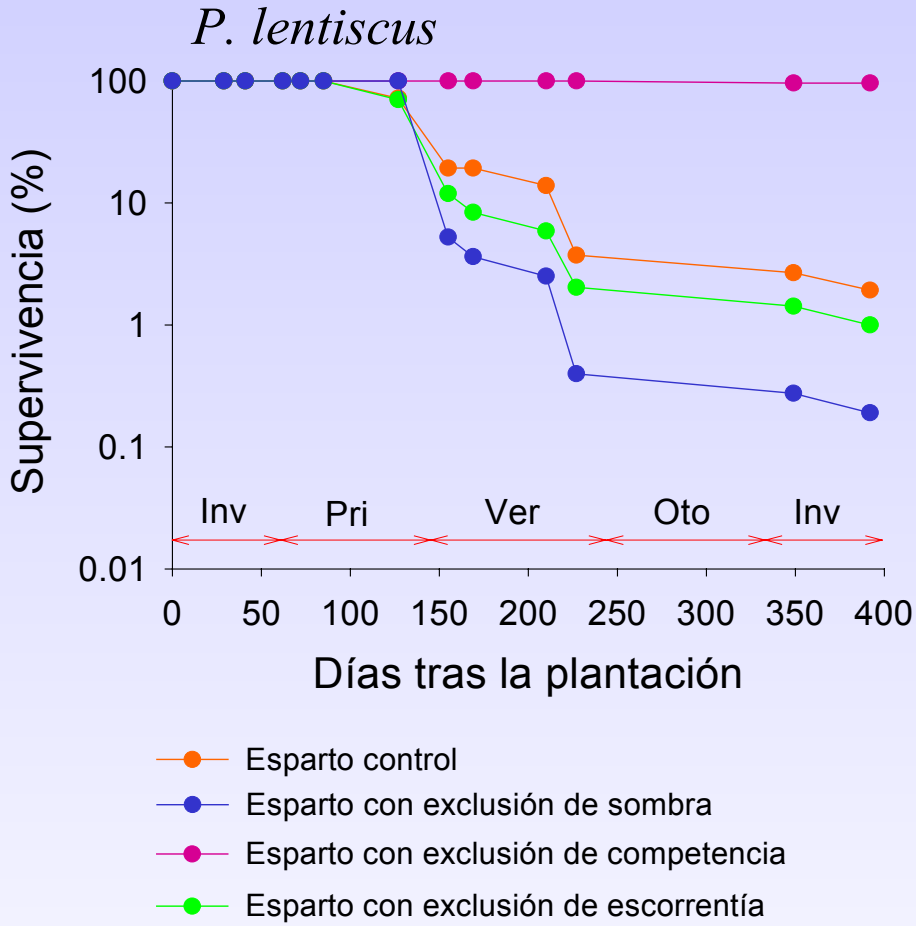
Tussock no runoff (ECH)

Open control (BCO)

Tussock herbicided (ECM)

Open no runoff (BCH)

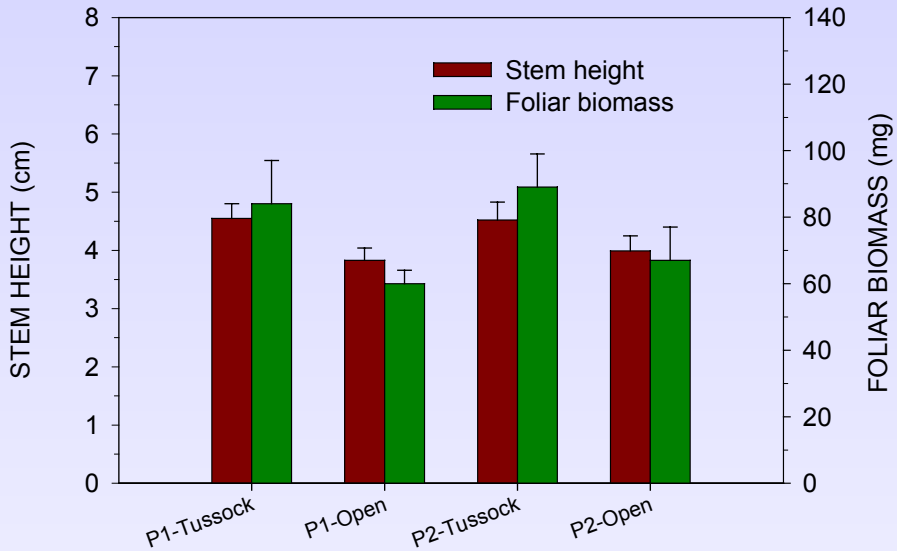


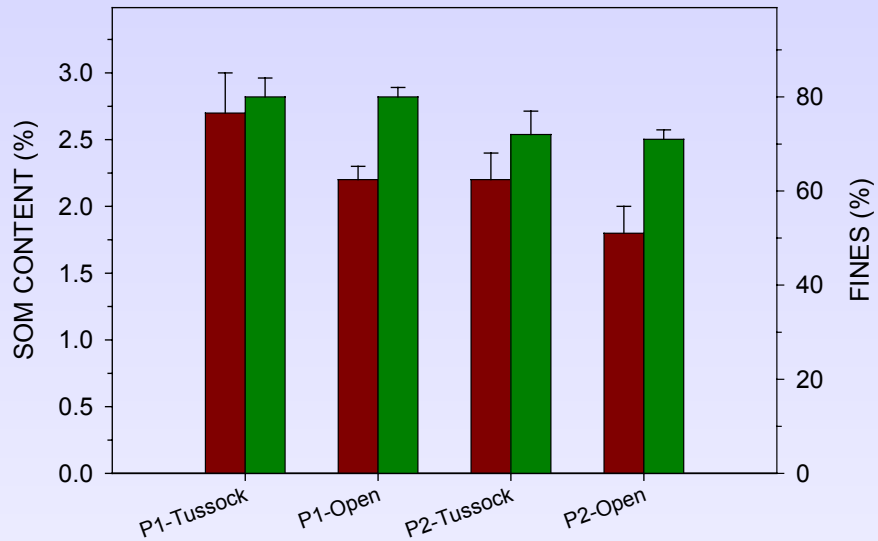


Maestre et al., 2003

Shadow is the main driver of facilitation between alpha grass and woody seedlings

Facilitation by alpha grass



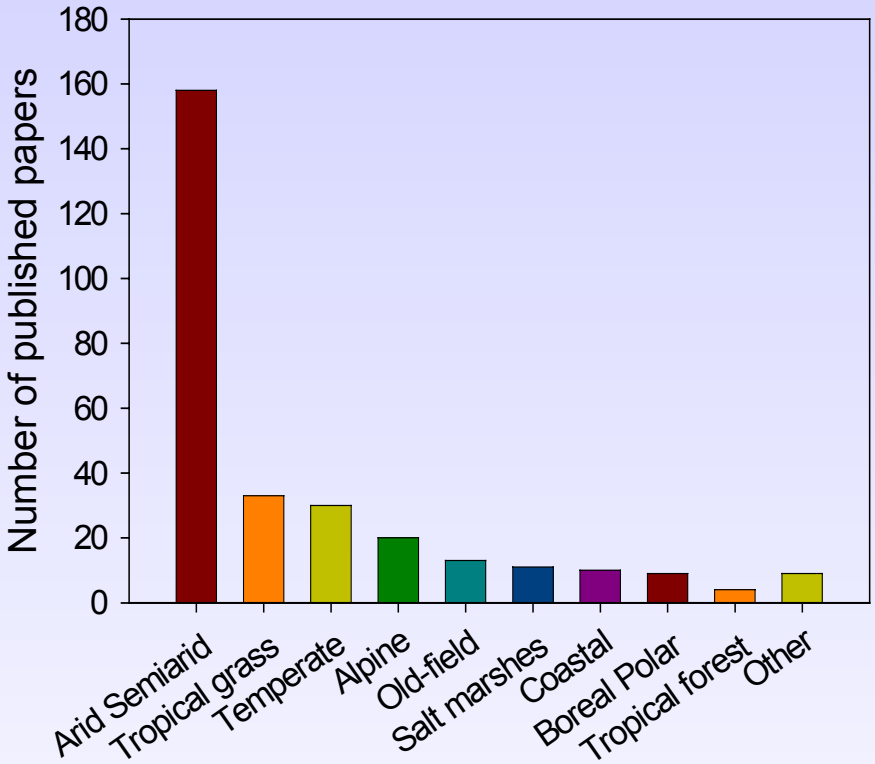


Maestre et al., 2003

Improved soil fertility may also be relevant, but we failed to find a significant effect

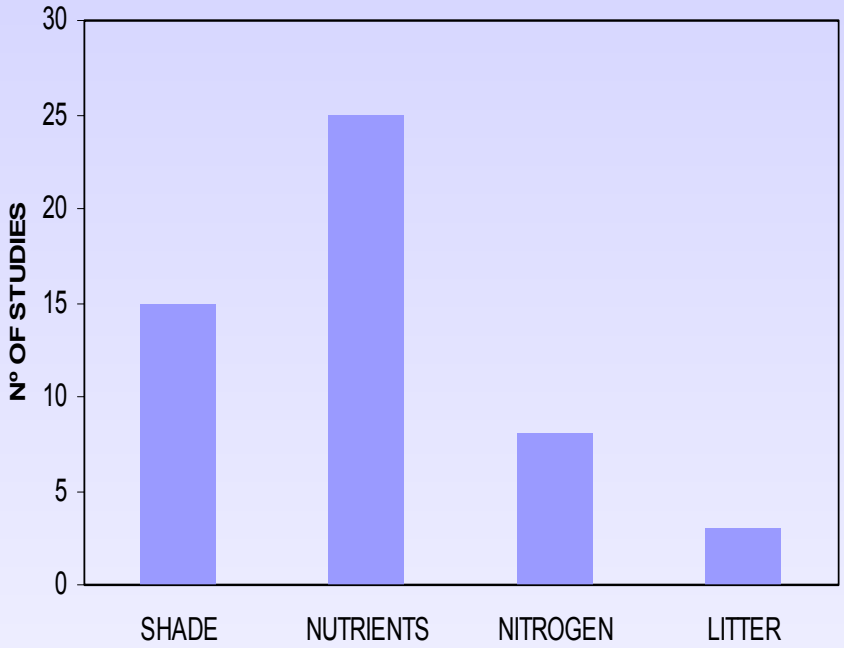
Facilitation by alpha grass

FACILITATION IN ARID AND SEMIARID COMMUNITIES



Flores & Jurado, 2003

DRIVERS OF POSITIVE INTERACTIONS

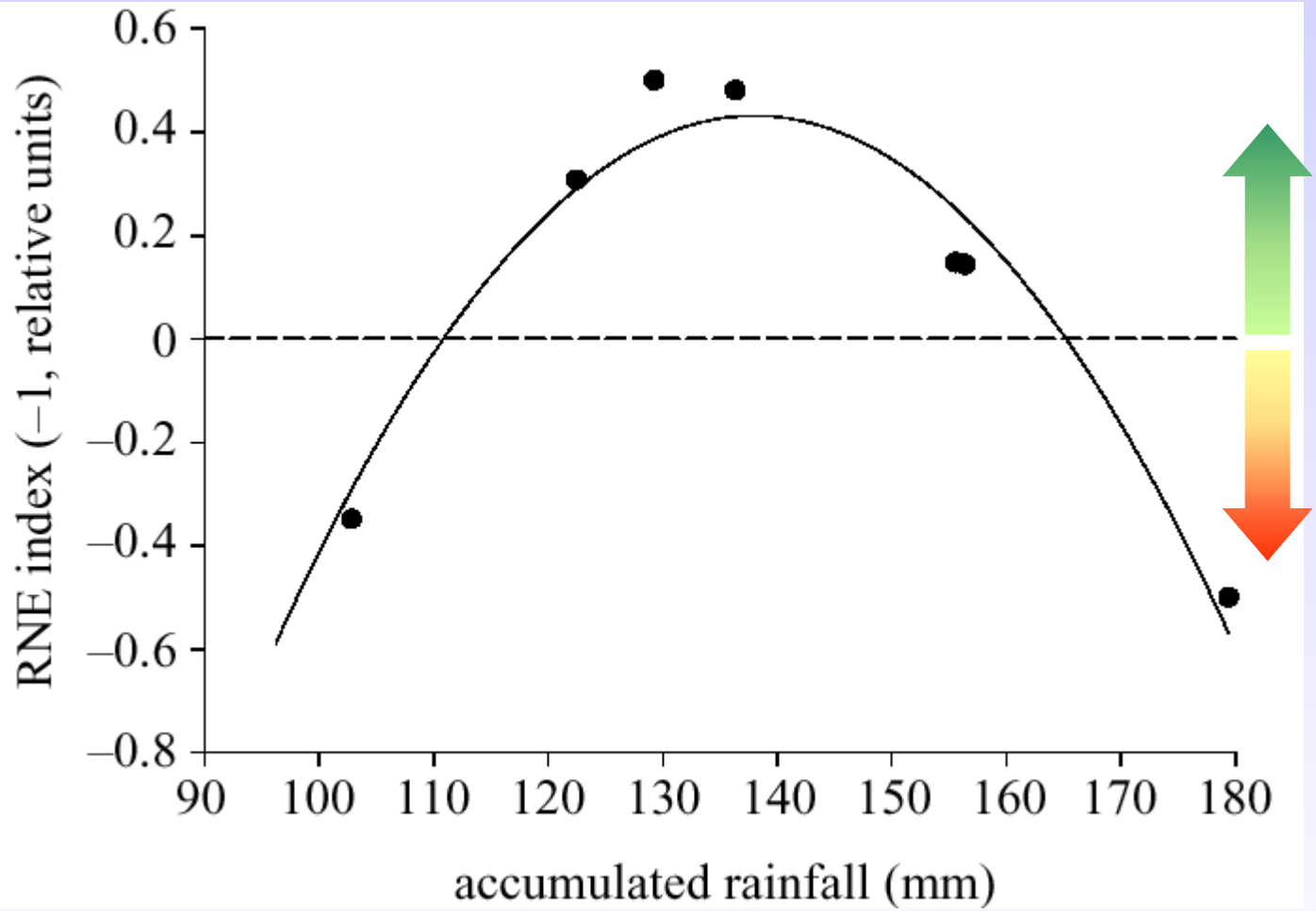


VV.AA.

Facilitation may be more common in arid and semiarid communities

Studies on facilitation refer to soil fertility, but manipulative experiments are scarce

Facilitation by alpha grass



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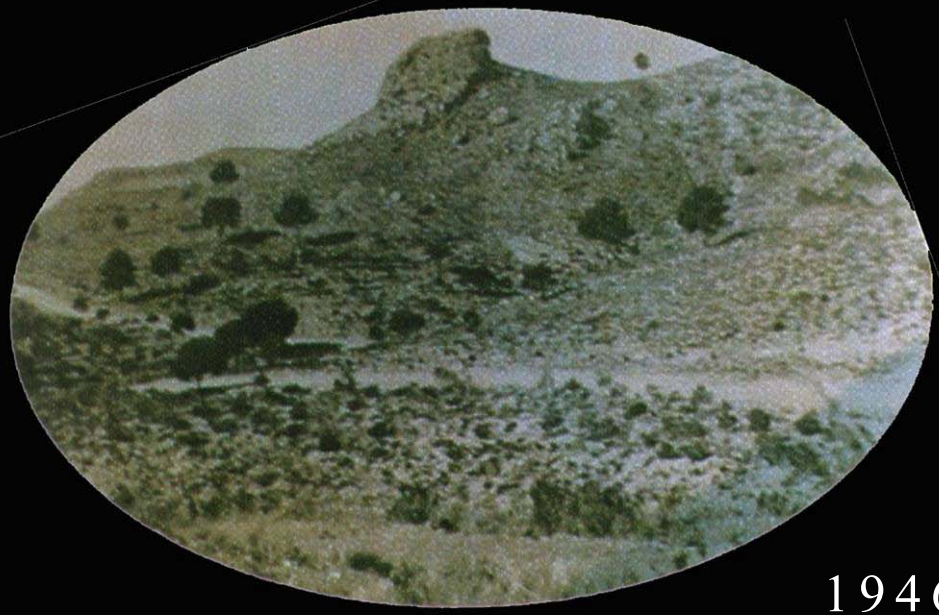
Biar

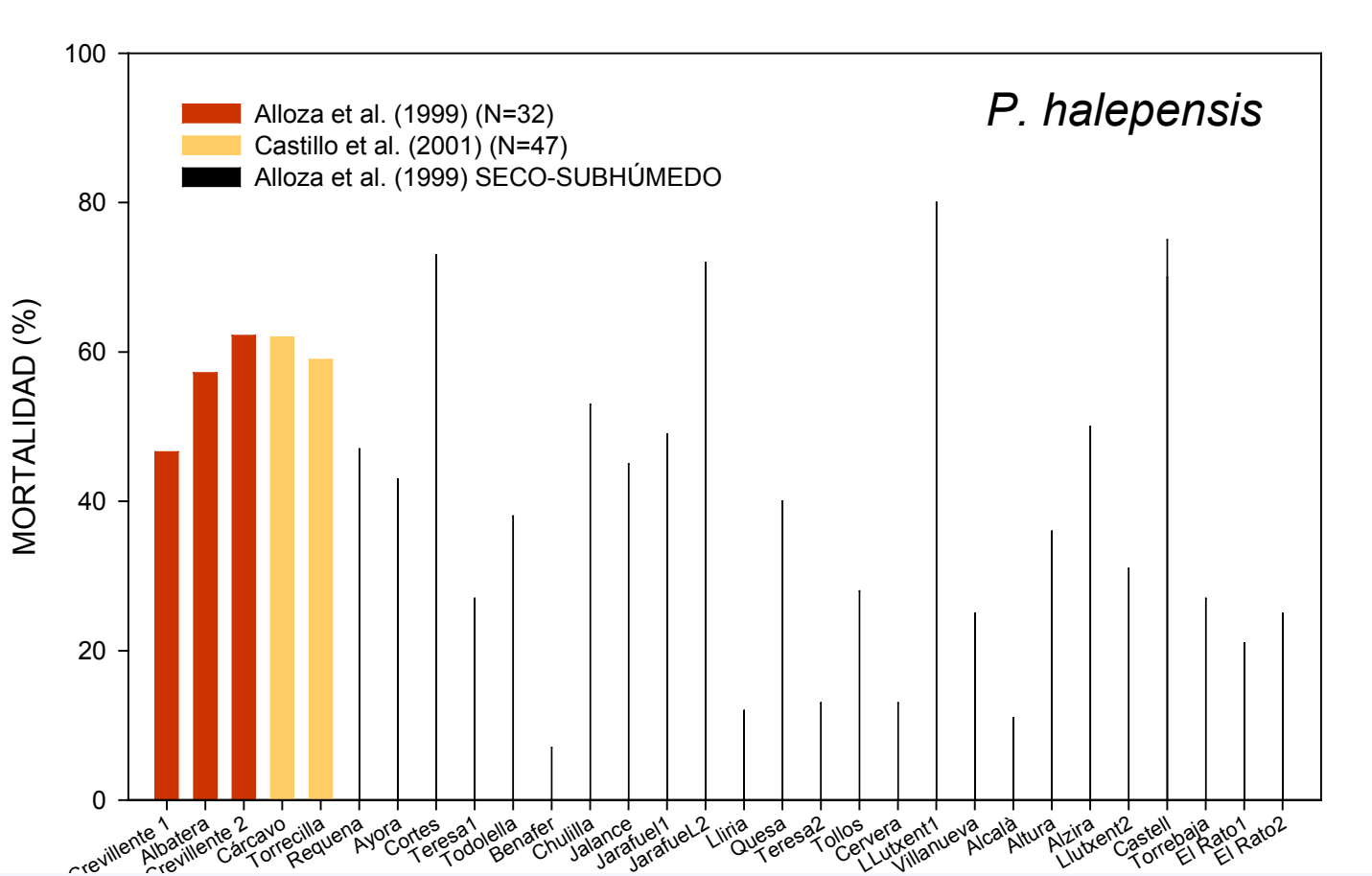


1946

1993

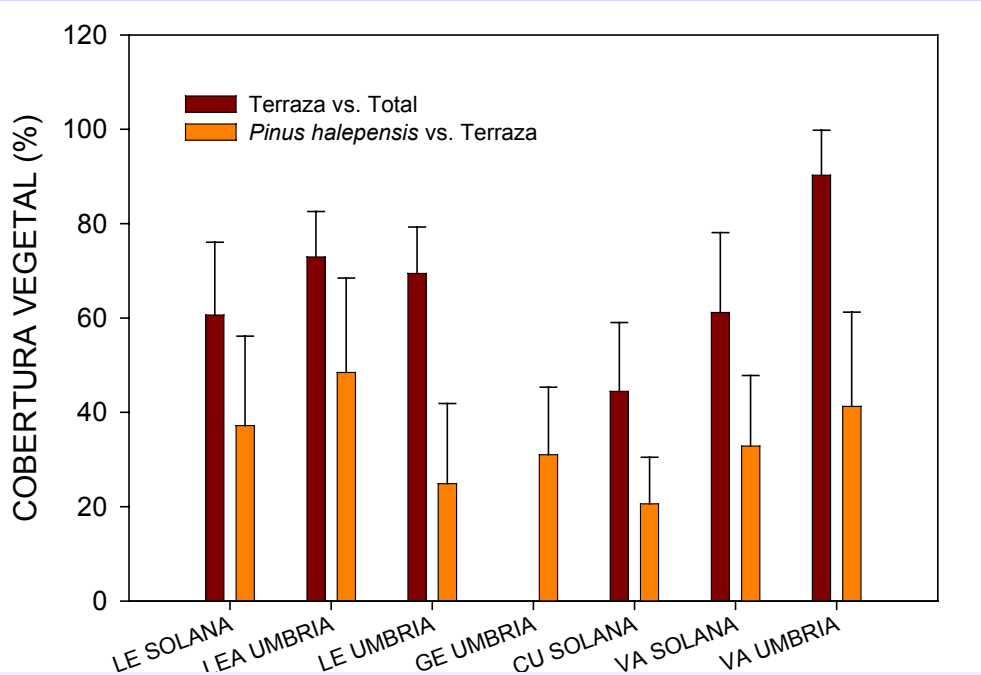
The role of Aleppo pine plantations

Mortality of introduced *Pinus halepensis* seedlings under semiarid conditions is high



The role of Aleppo pine plantations

And pine cover in *Pinus halepensis* afforestations is frequently low

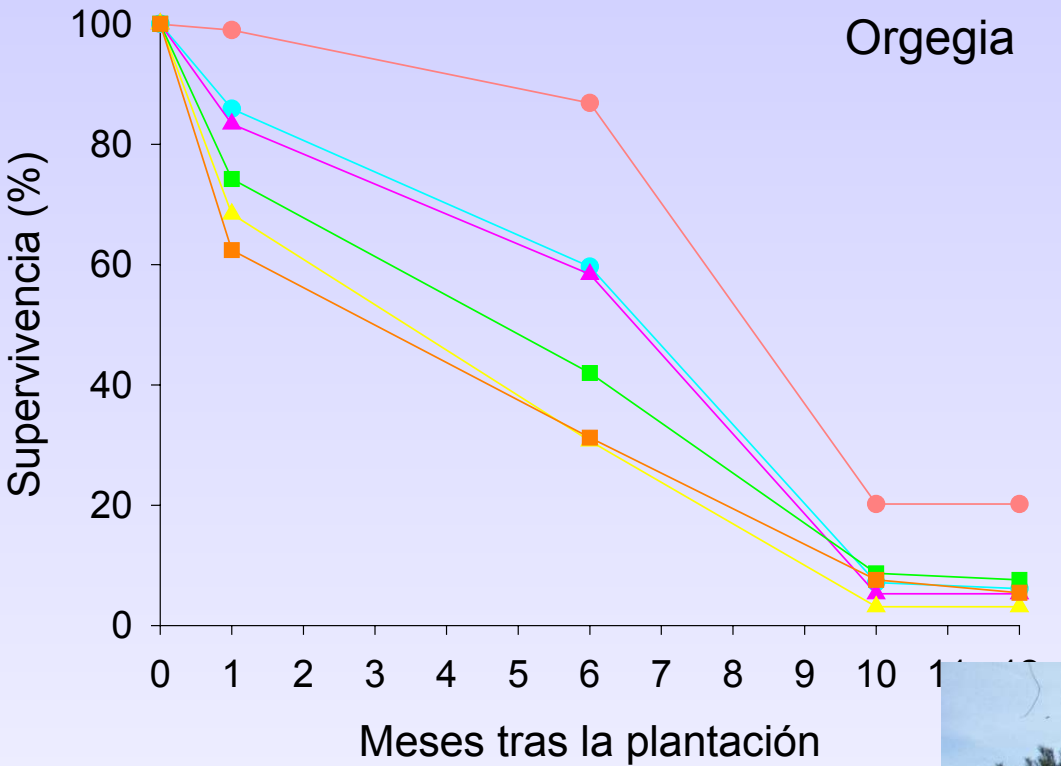


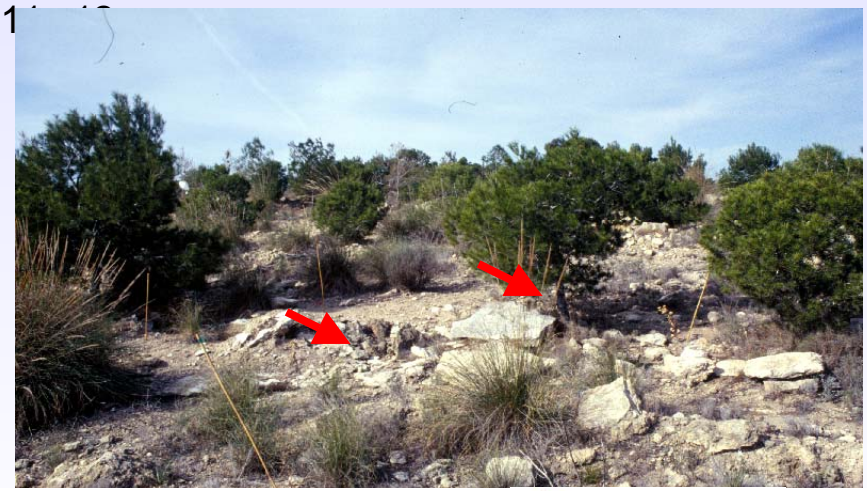
Chaparro, 1994

ca. 50% terraces vs. slope

17% cover *P. halepensis* 23 years

The role of Aleppo pine plantations

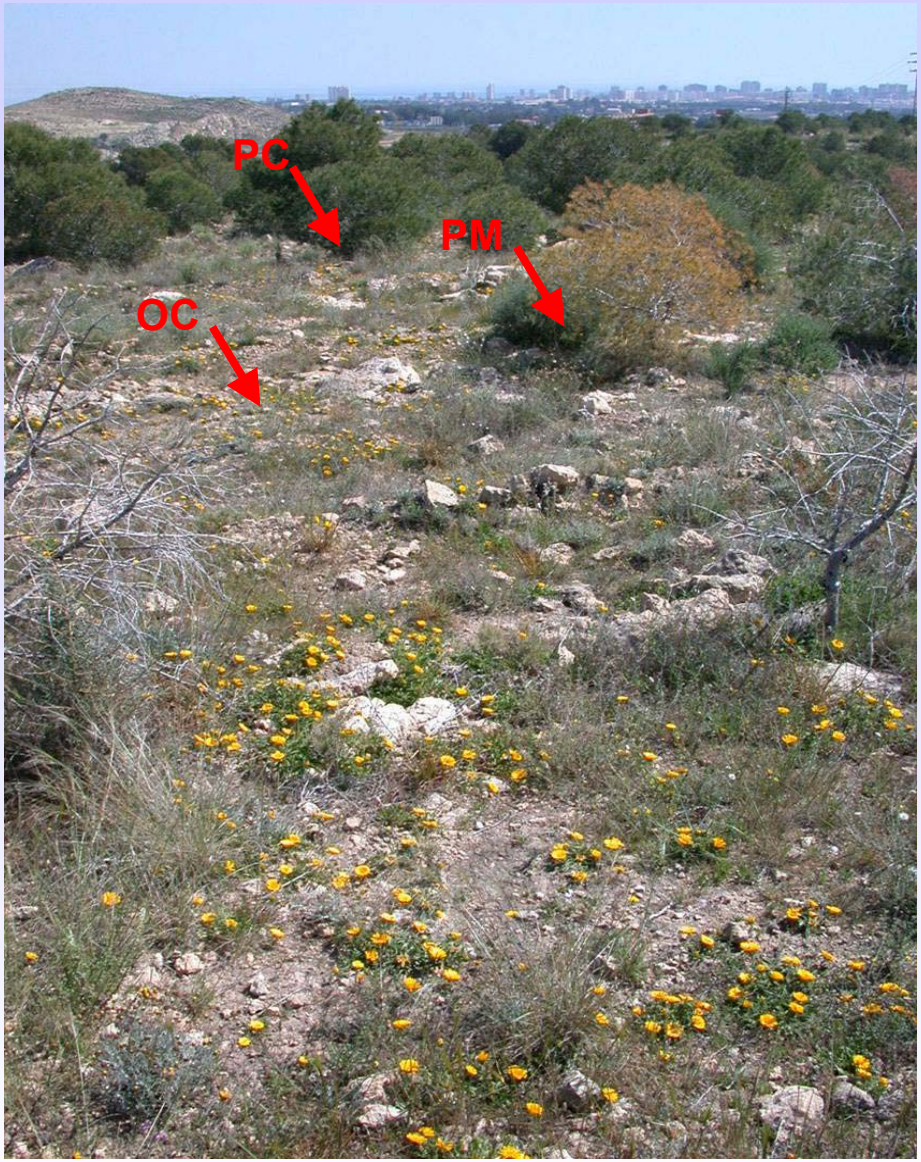


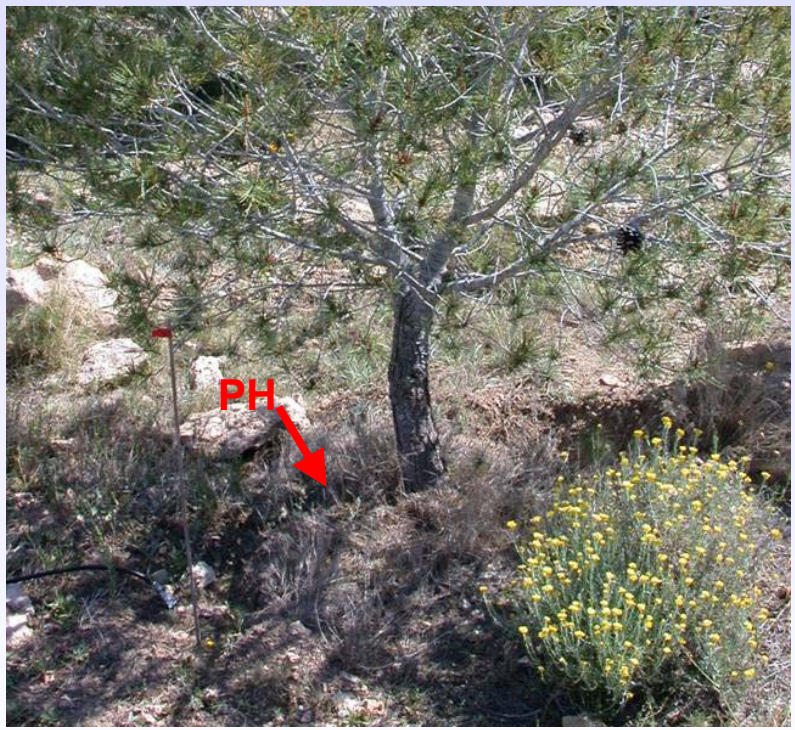


Pinus halepensis often show a negative effect on the establishment of other woody species

Maestre et al., 2002

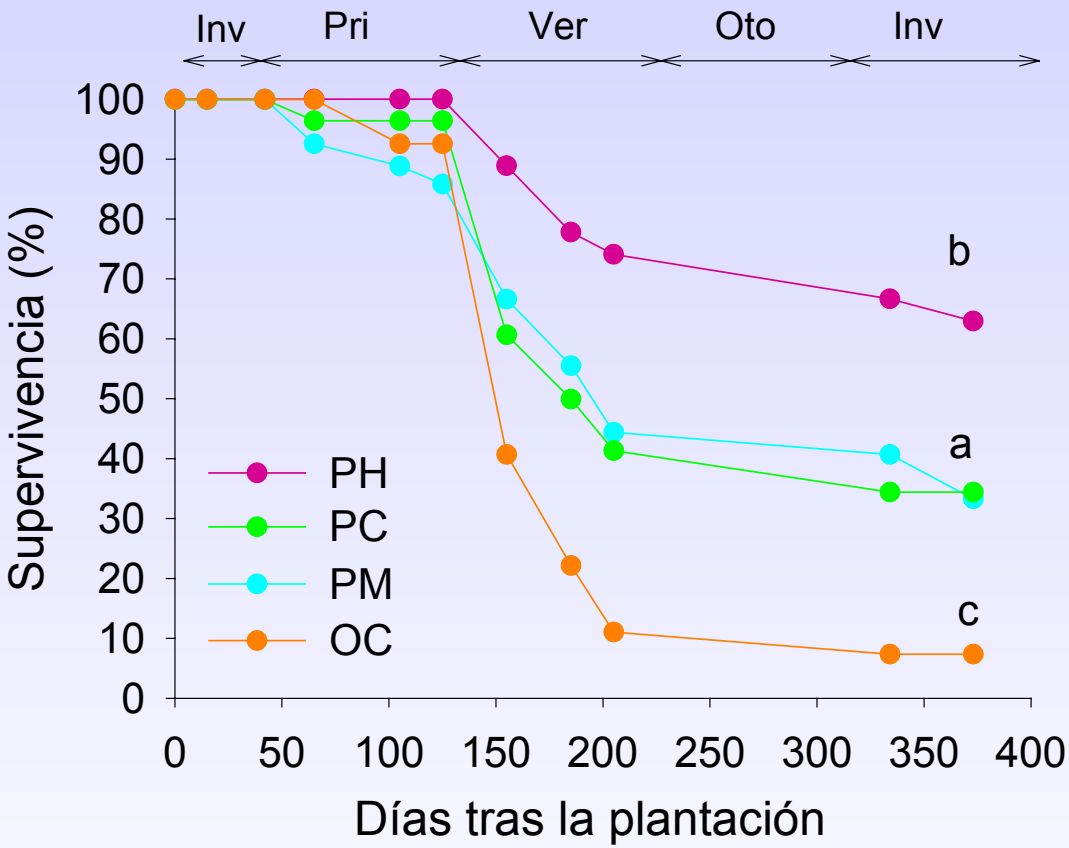
The role of Aleppo pine plantations





The role of Aleppo pine plantations

P. lentiscus



Pinus halepensis

+

Brachypodium retusum

-

Pistacia lentiscus

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Ecotechnology

Technique	Ecosystem component	Process
Branches, mulch, etc.	Sinks	Sediment, runoff and seed capture
Perches	Birds rest	Propagule concentration, eventually water and nutrients
Organic amendments and fertilisation	Islands of fertility	Local soil improvement
Stones around introduced plants	Sinks	Resource retention including soil moisture
Stone pavements	Patches with low infiltration	Runoff
Treeshelters	Nurse plants	Protection against incomming radiation and herbivory
Field and nursery mycrorrhizae and rhizoflora inoculation	Exo and endosimbiontic microflora	Increase in resource availability, protection againsta pathogens and stress
Site preparation (microcatchments, terracing, etc.)	Sinks	Resource capture, mainly water. Increase in available soil
Cyanobacteria inoculation	Biological crusts	Soil protection, runoff generation
Nurse species plantation	Nurse plants	Processes associated with facilitation

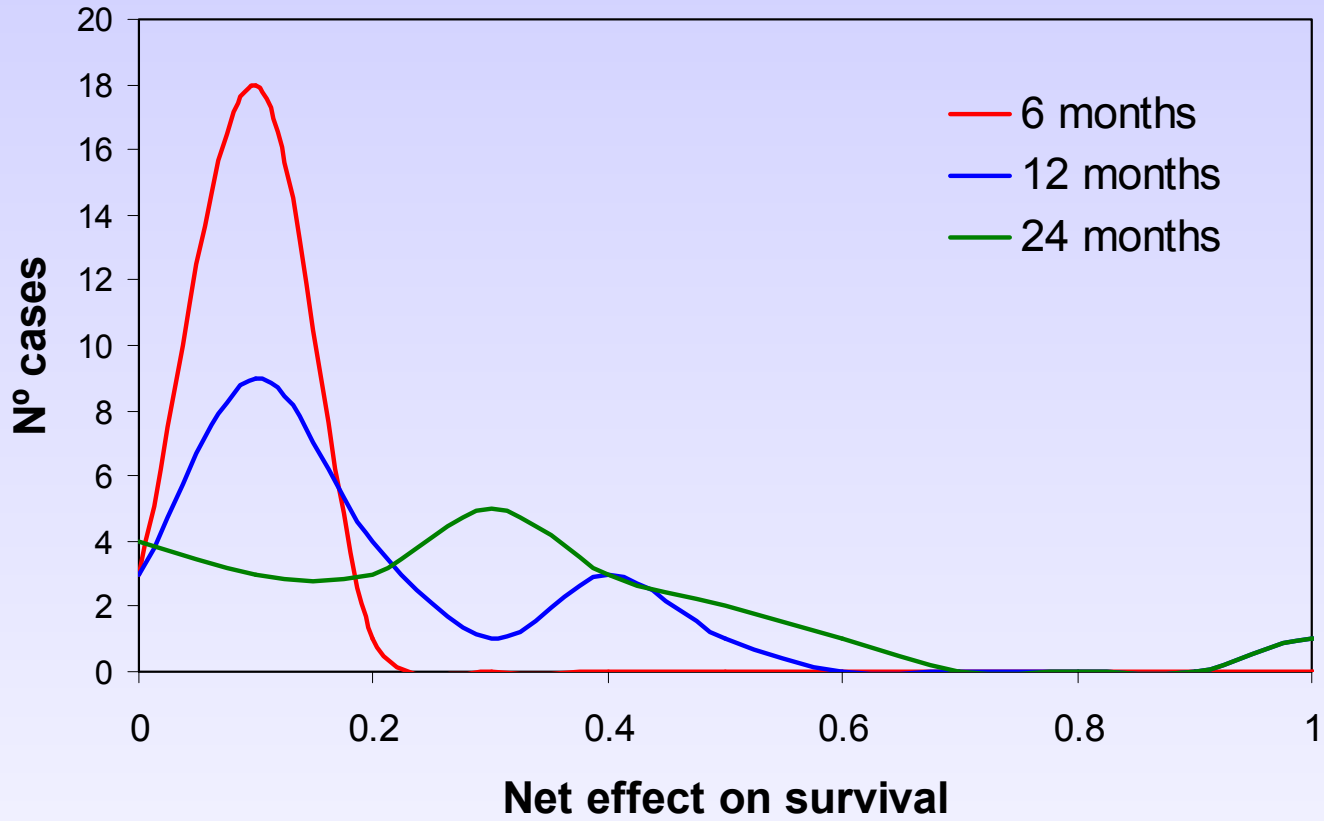
Tongway et al., 2004

Ecotechnology - Seedling quality

Seedling quality as a function of restoration objectives

- Increase genetic diversity, phenotypic plasticity
- Resistance against adverse conditions (current or future)
- Soil protection
- Carbon storage
- Food for herbivores– Palatability and tolerance
- Flower or fruit production
- Resistance and resilience against disturbances
- Improvement of soil fertility
- Ecological engineering
- Production of market products (wood, resin,...)
- Water use efficiency
- …

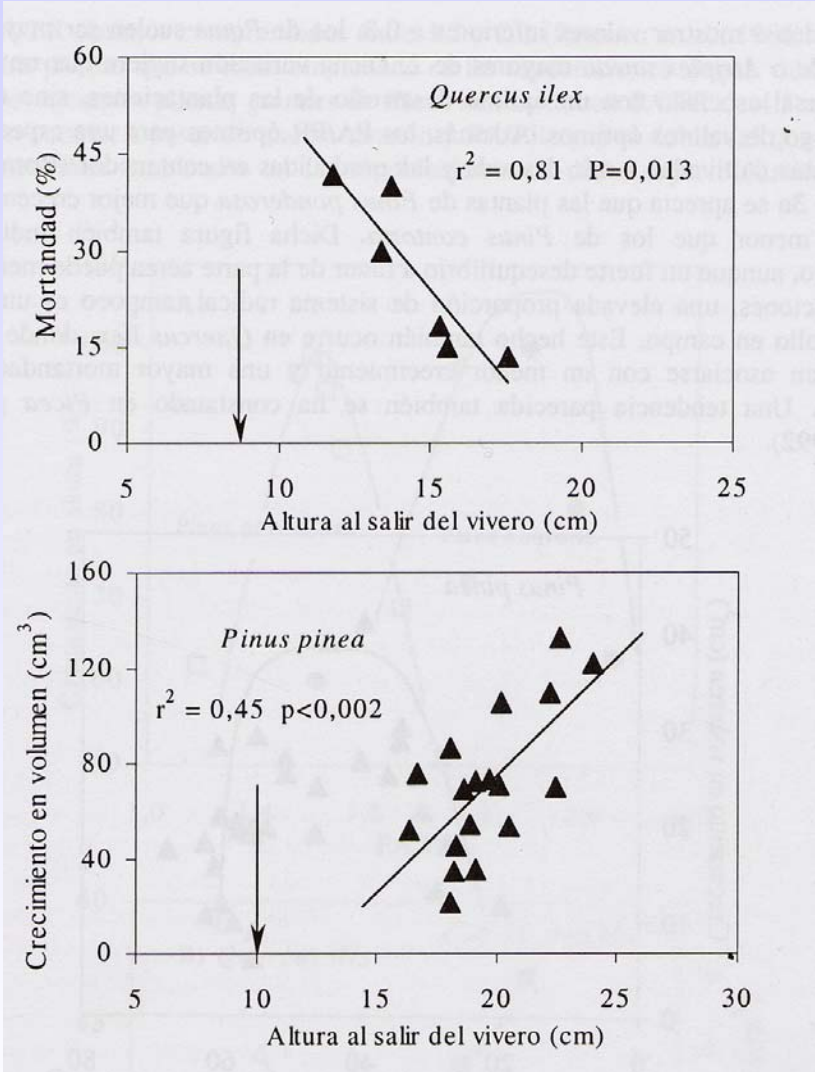
Ecotechnology - Seedling quality



$$NET\_EFFECT = \frac{SURVIVAL\max - SURVIVAL\min}{SURVIVAL\max + SURVIVAL\min}$$

Ecotechnology - Seedling quality

A positive relationship between seedling size and field performance is frequently found

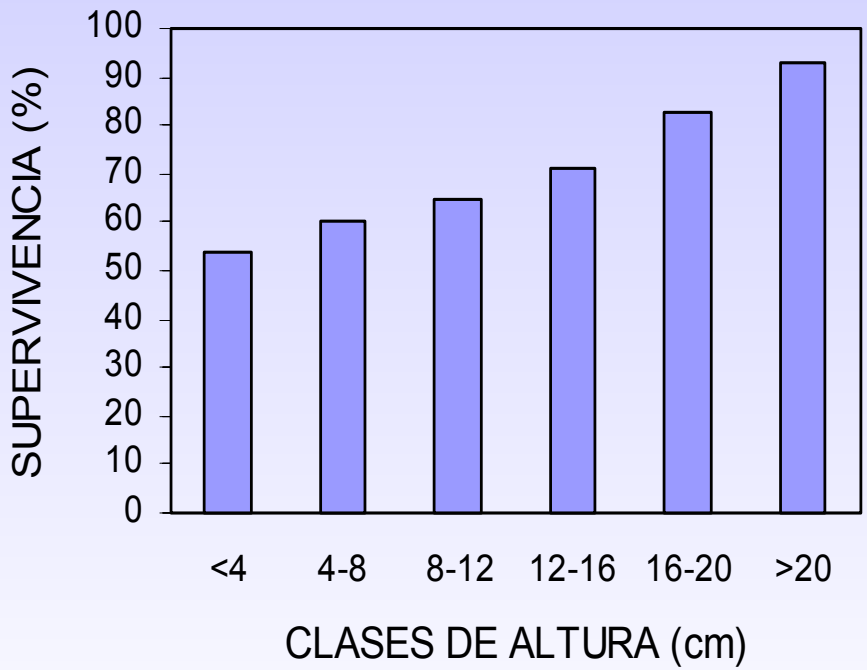


Villar (2003)

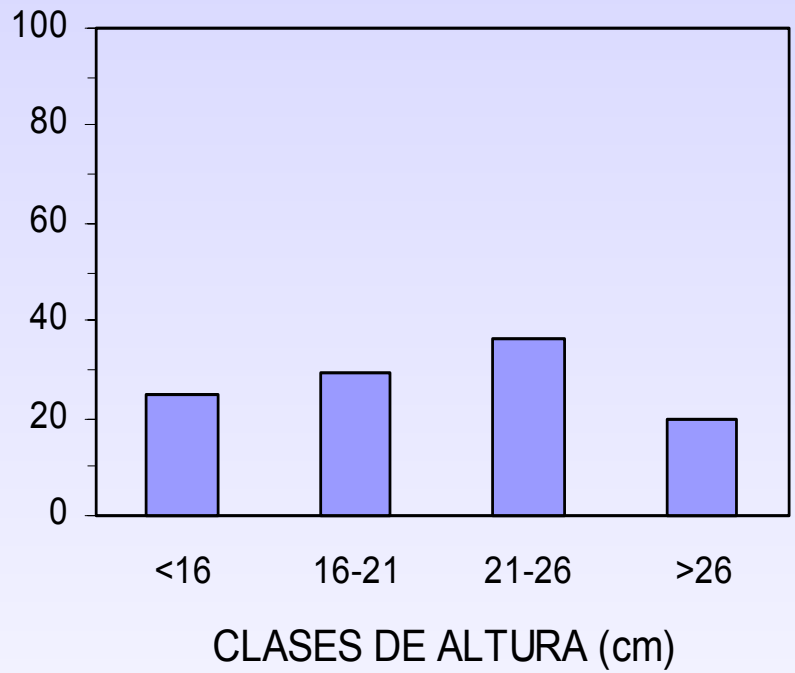
Ecotechnology - Seedling quality

But not always...

Quercus ilex ballota



Quercus coccifera



Seva et al., 1997

Ecotechnology - Seedling quality

Seedling size and field performance under semiarid conditions - Garden of deficiencies

Seedling manipulation by altering the nutritional regime. Experimental design:

- Nutritional optimum (160 ppm N; 16:8:12 N:P:K) **OPT**
- Nutritional suboptimum (80 ppm N) **SOP**
- Slow release fertiliser (Plantacote 0'8 g L^{-1}) **FLL**
- Phosphorus deficiency **PDP**
- Nitrogen deficiency **NDP**
- Micronutrient deficiency **MDP**
- Nutritional hardening (40 ppm N last month) **END**

Ecotechnology - Seedling quality

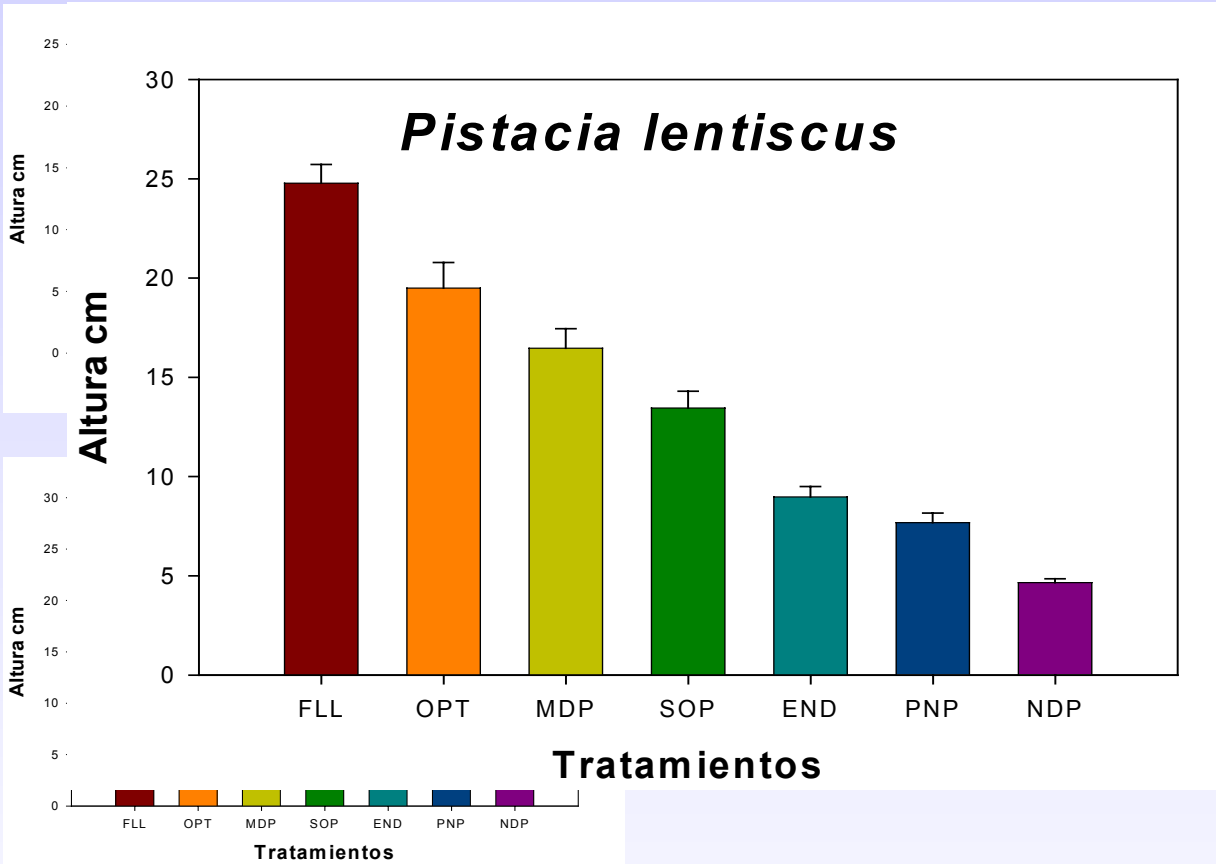
P. lentiscus

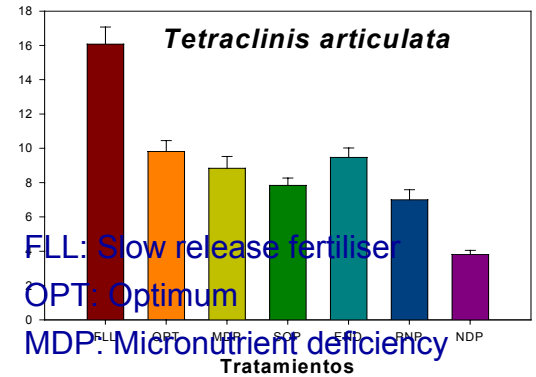
N deficiency

P. lentiscus

P deficiency

Ecotechnology - Seedling quality





FLL: Slow release fertiliser

OPT: Optimum

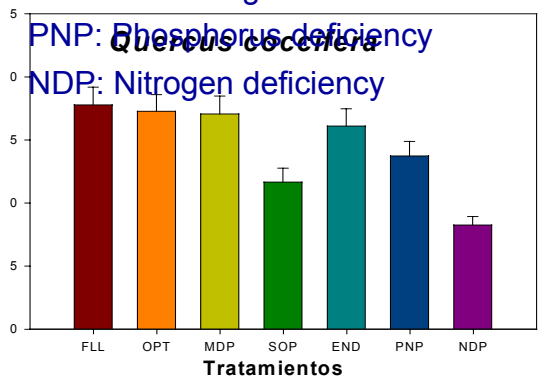
MDP: Micronutrient deficiency

SOP: Suboptimum

END: Hardening

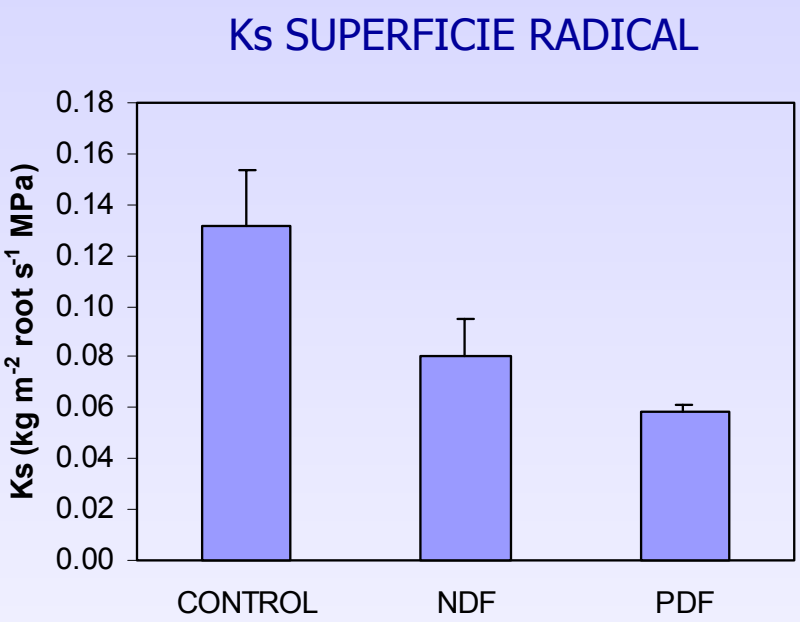
PNP: Phosphorus deficiency

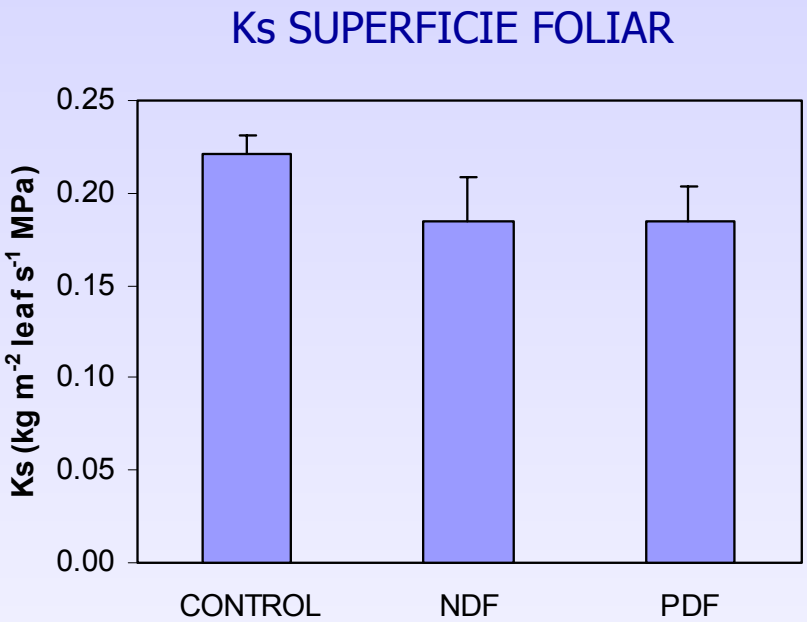
NDP: Nitrogen deficiency



Trubat et al., 2004

Hydraulic conductivity *Pistacia lentiscus* - 3 months





Trubat et al., sumitted

Ecotechnology - Seedling quality

Albatera (Alicante). Semiarid

Plantation density: 1000 trees ha^{-1}

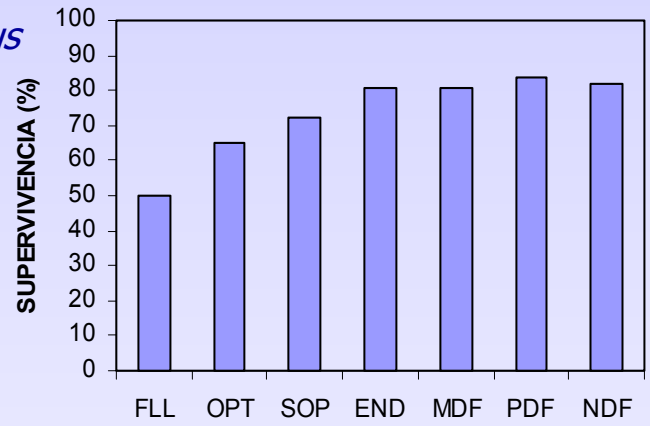
Nº seedlings per treatment: 25 to 35

40x40x40 cm planting holes with back-hoe spider

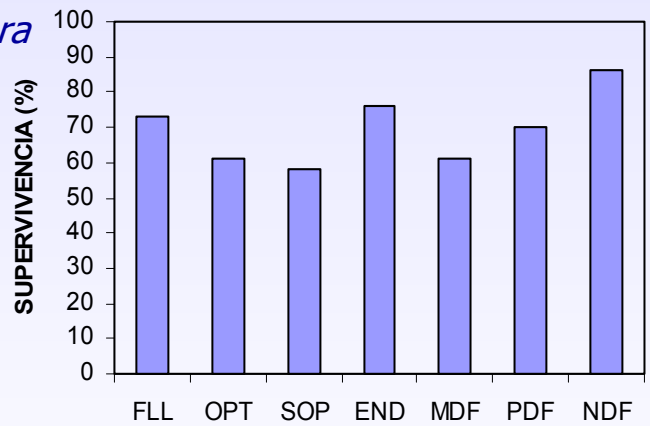
Ecotechnology - Seedling quality

Post-plantation survival (3 months)

P. lentiscus



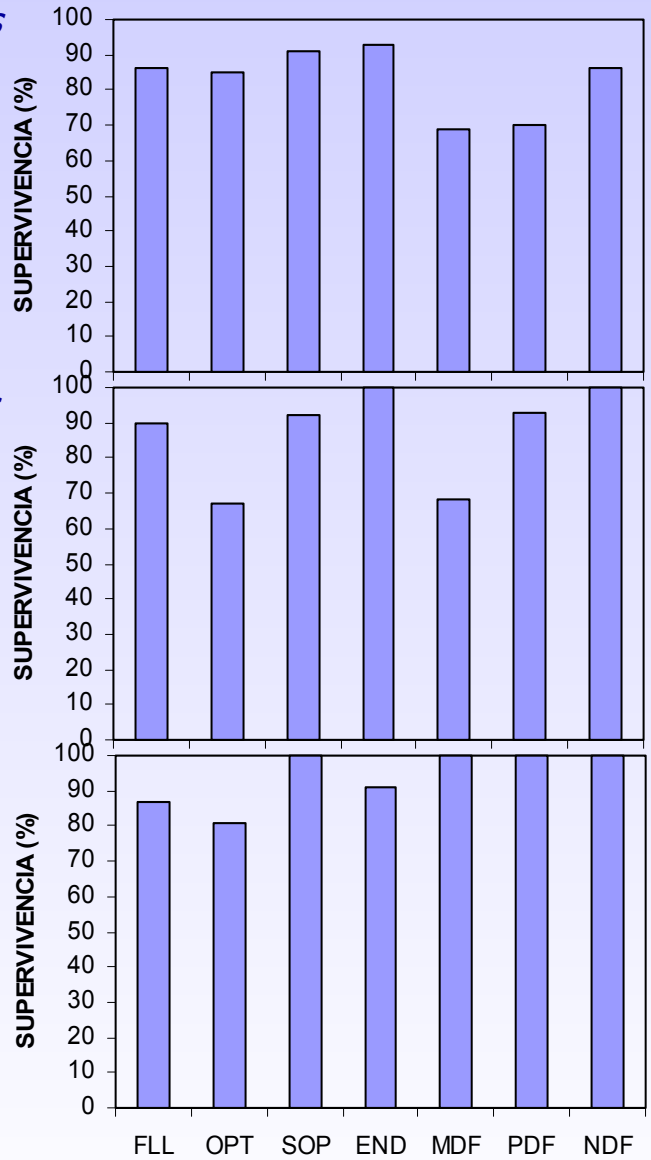
Q: coccifera



R. lycioides

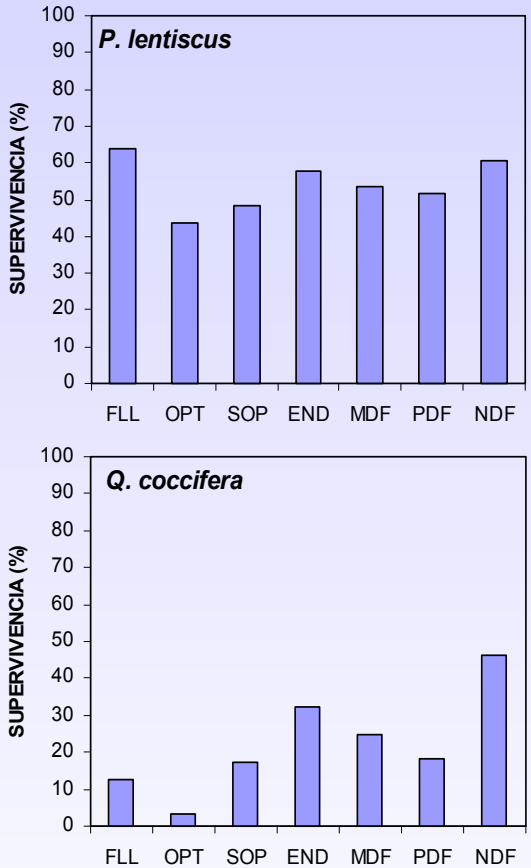
R. alaternus

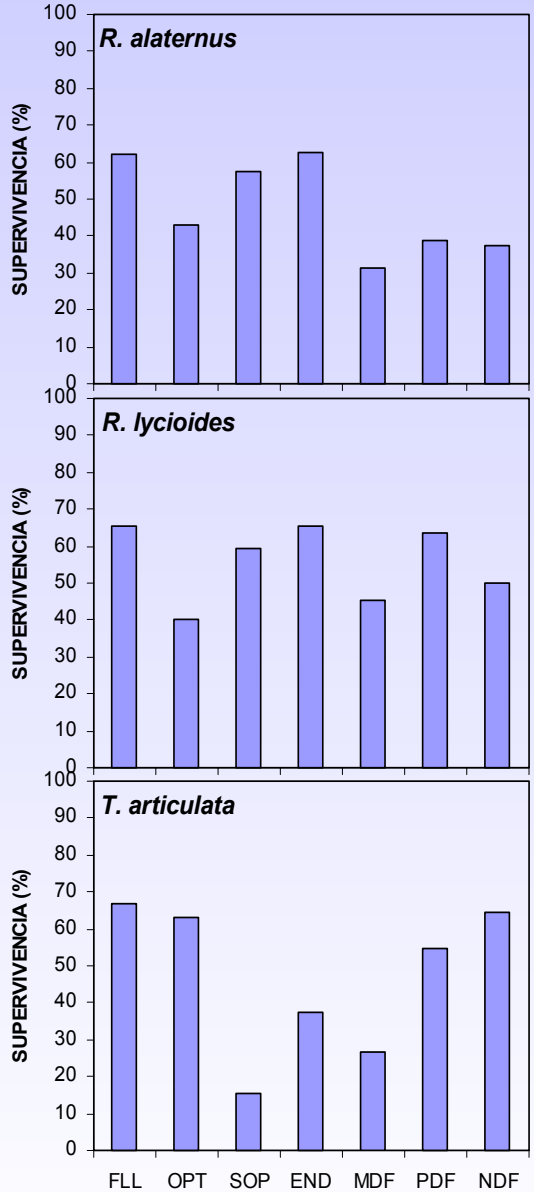
T. articulata



Ecotechnology - Seedling quality

Post-summer survival (11 months)

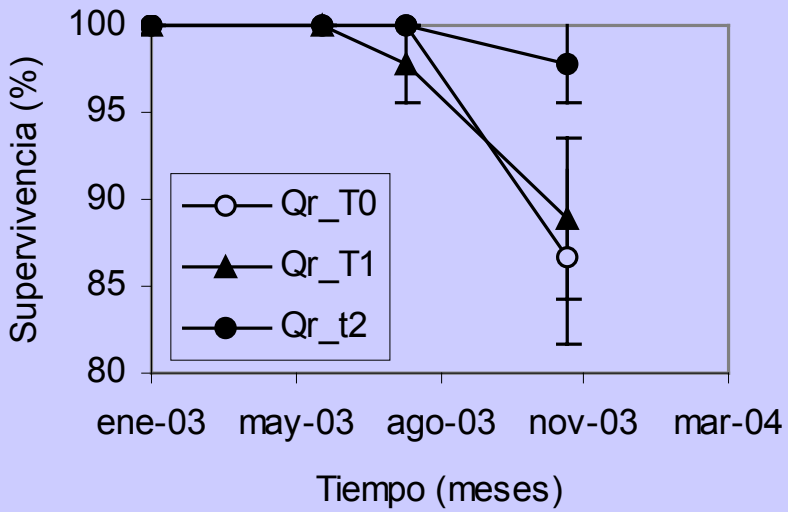




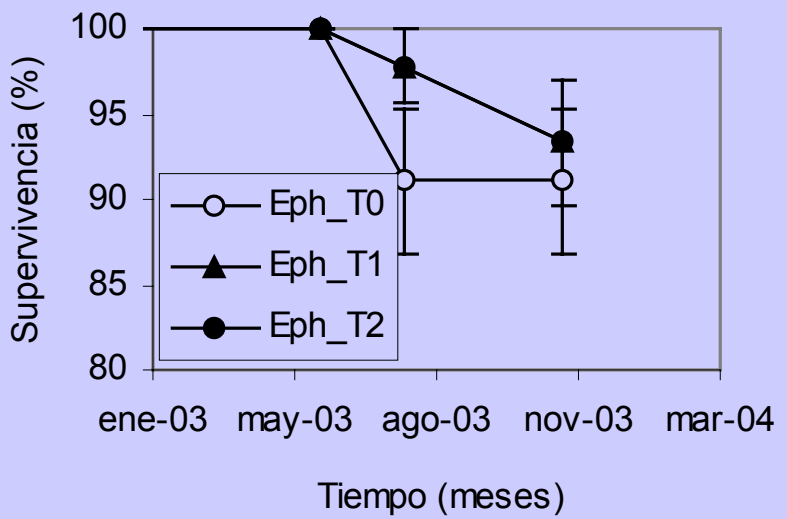
Ecotechnology - Seedling quality

An easy way to get smaller seedlings: top pruning

Quercus ilex ballota – S. Crevillente

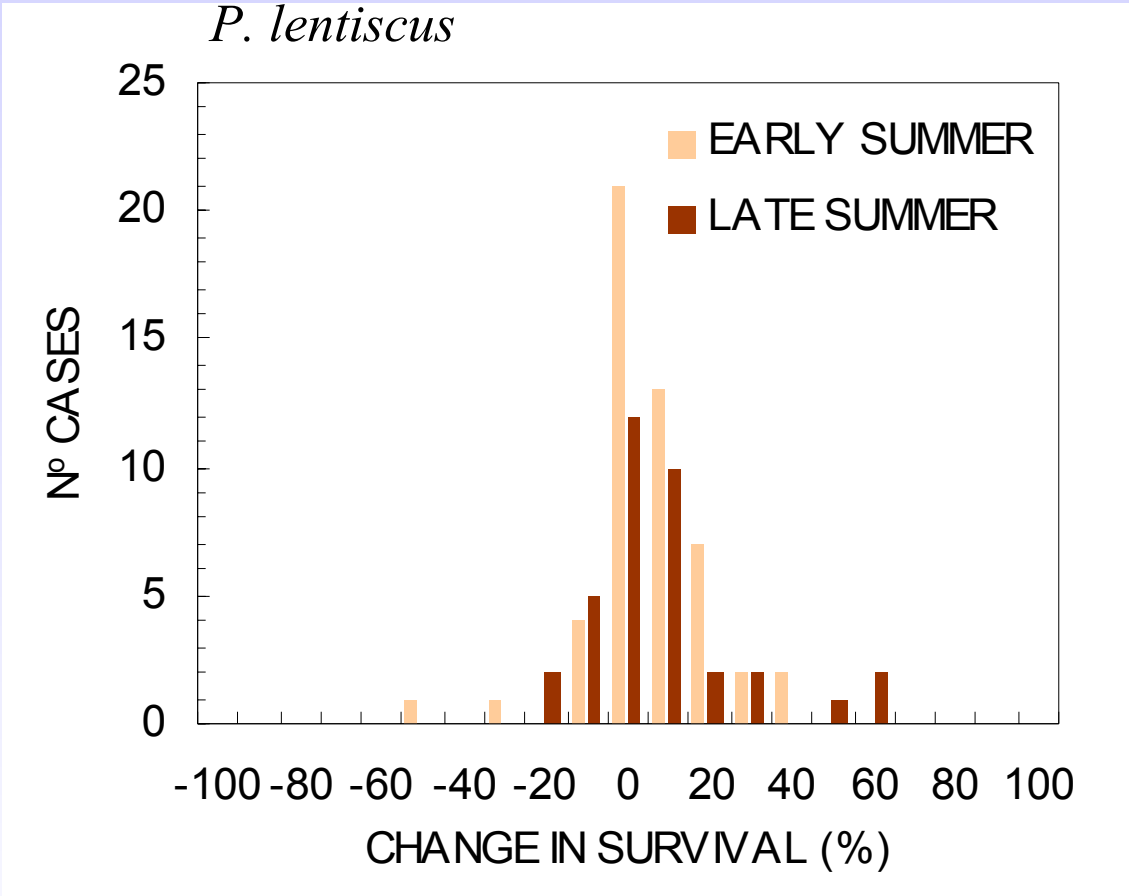


Ephedra fragilis - Albatera



Chirino et al. (no publ.)

Drought preconditioning



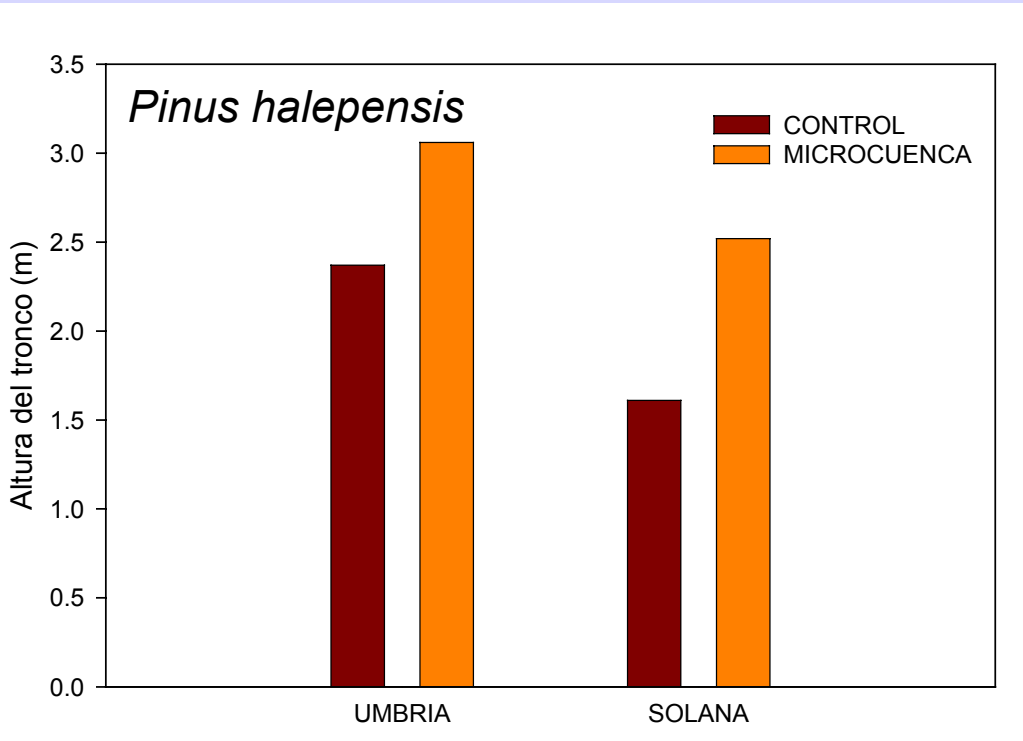
REDMED project (unpubl.)

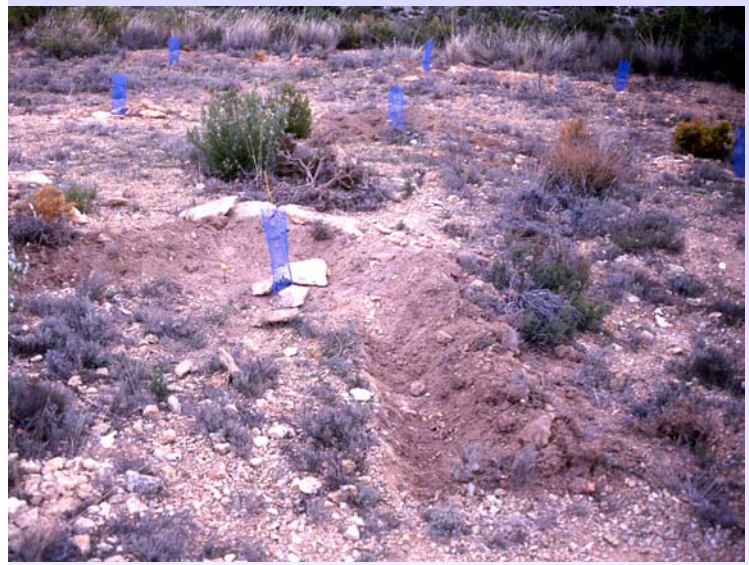
Ecotechnology – Site preparation

Soil preparation

Ecotechnology – Site preparation

Microcatchments to concentrate runoff water

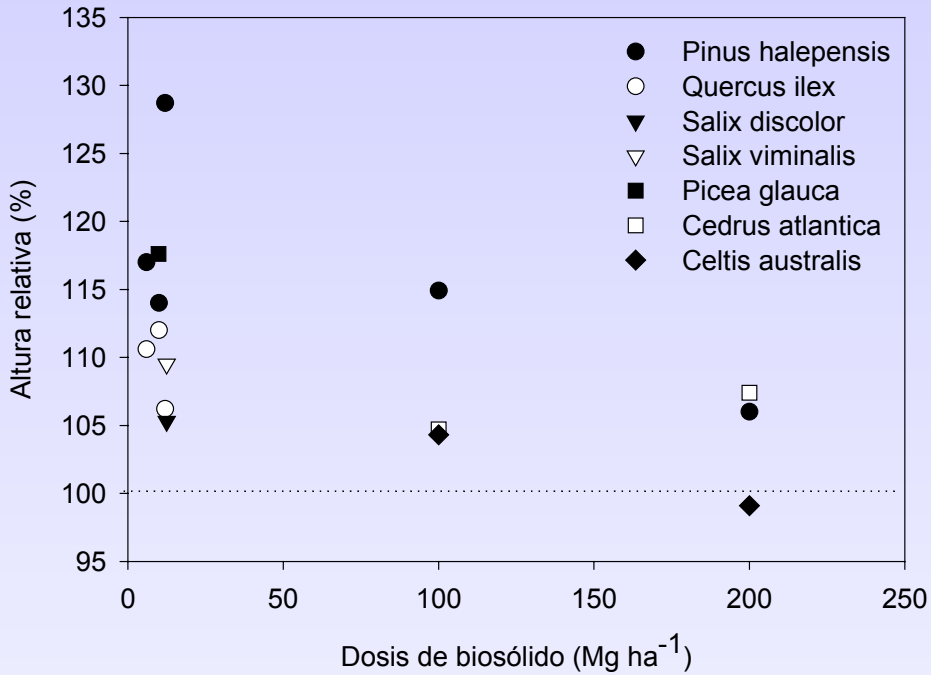




A. Saquete (unpubl.)

Ecotechnology – Site preparation

Reuse of sewage sludge to ameliorate soil fertility

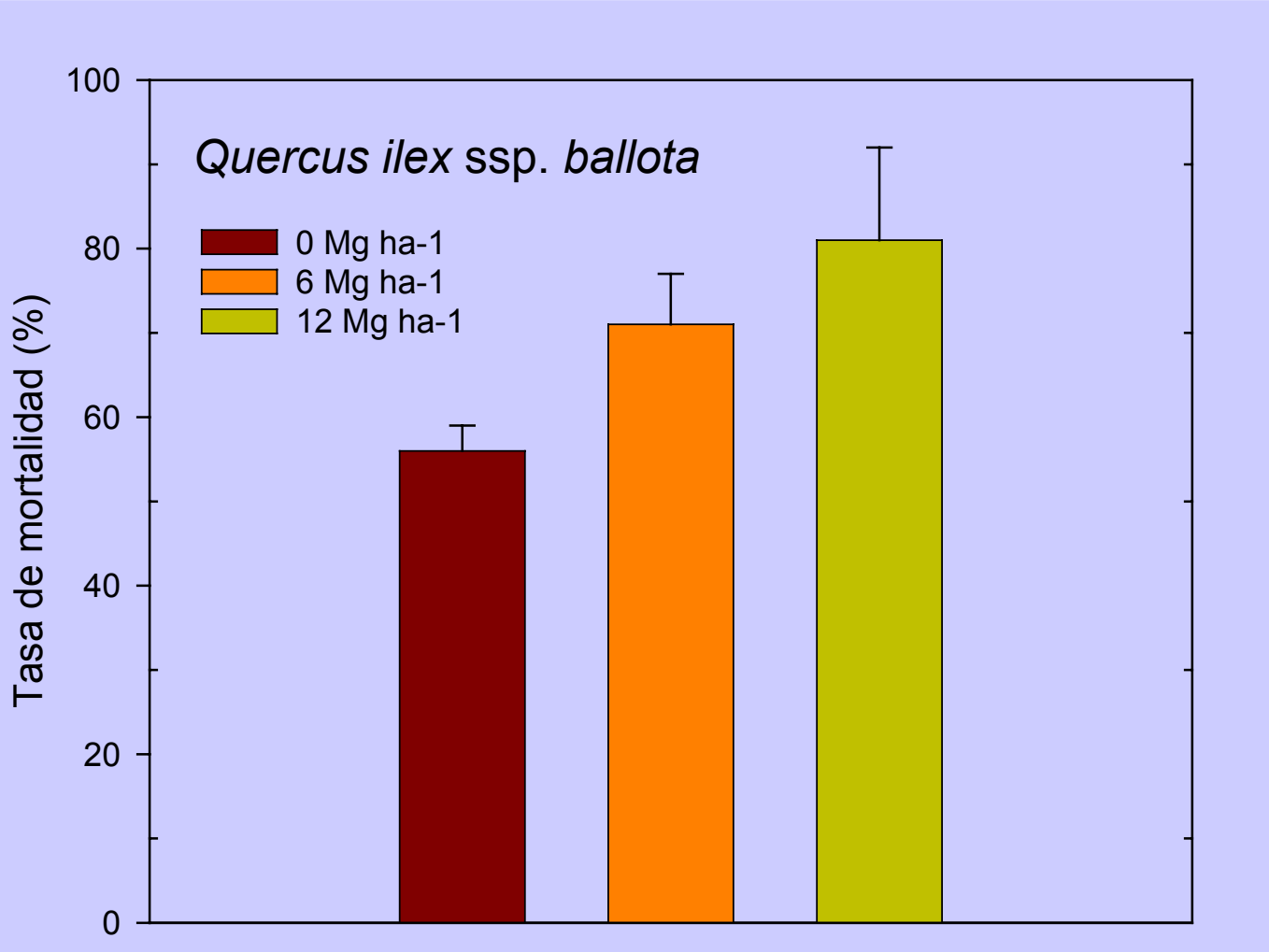


Valdecantos et al., in press

PROJECT **BIOMON** - *Scientific basis for biosolid application in Mediterranean woodlands* (REN2000-0181P4-03)

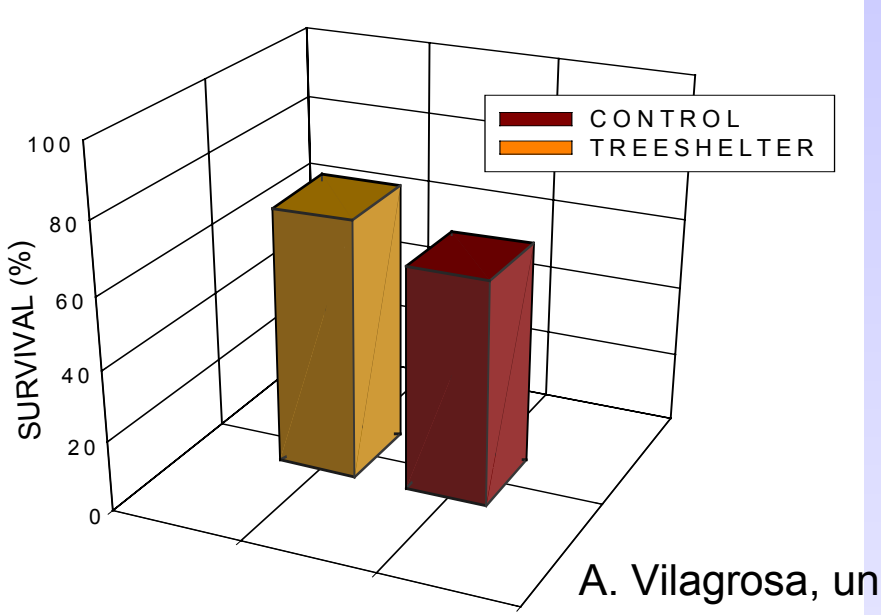
Ecotechnology – Site preparation

Reuse of sewage sludge to ameliorate soil fertility

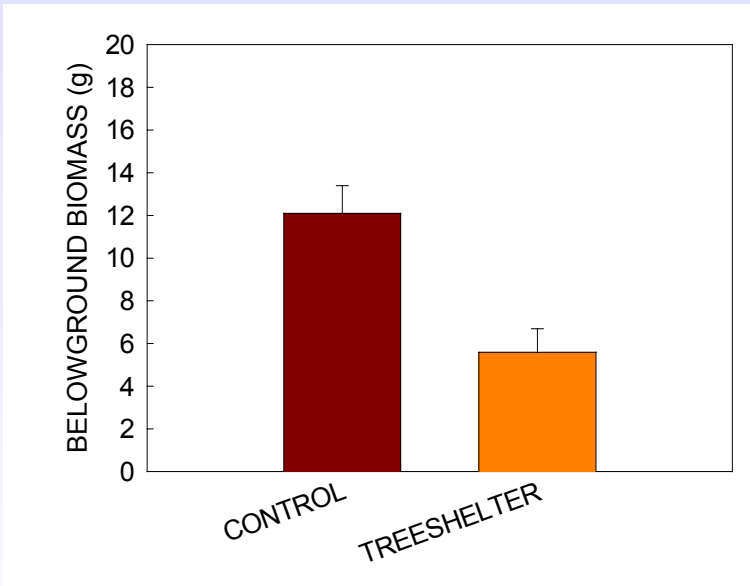


Ecotechnology – Treeshelters

40 MONTHS
***QUERCUS COCCIFERA*-**
XIXONA, E SPAIN



A. Vilagrosa, unpubl.



Treeshelters provide shadow, and protection against herbivores

THANKS FOR YOUR ATTENTION !!

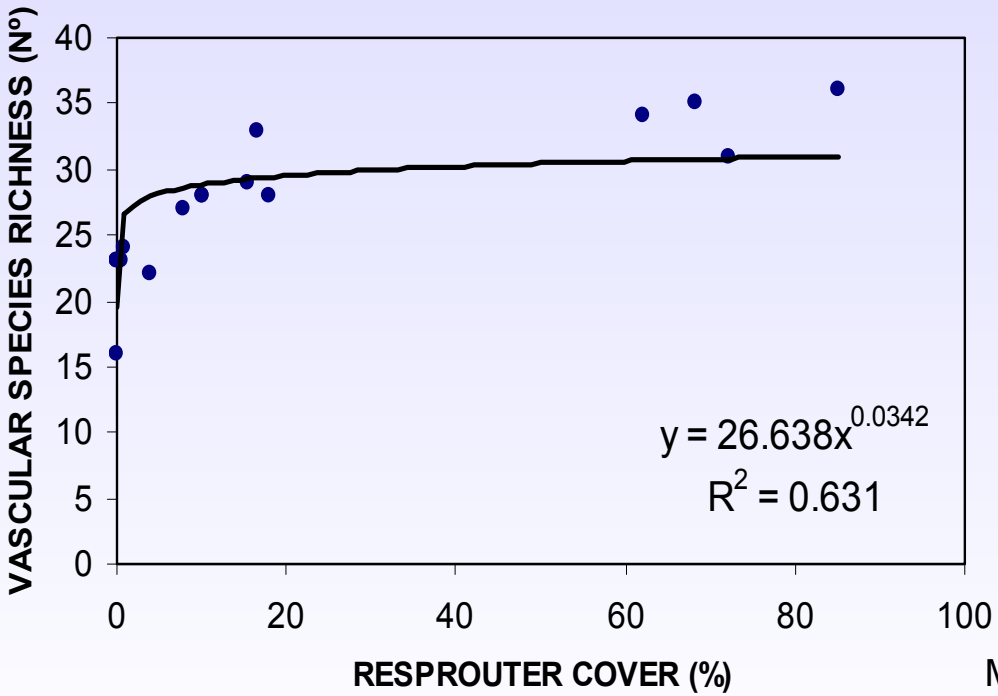
COMMERCIALS

Don't forget to visit ECOSISTEMAS at WWW.REVISTAECOSISTEMAS.NET

Free electronic journal of the Spanish Association for Terrestrial Ecology

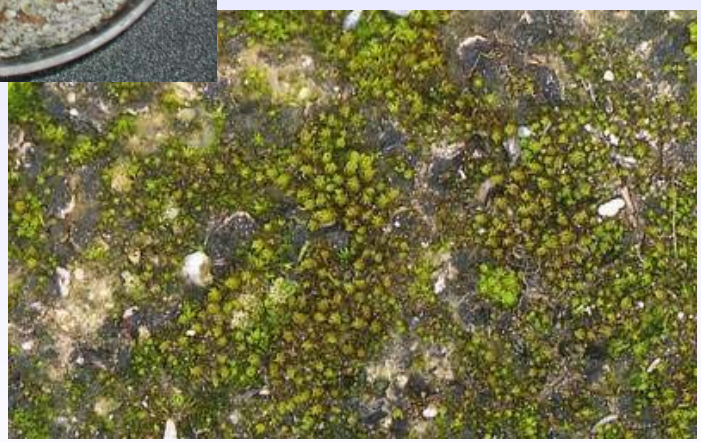
Biodiversity - Vascular plants

- 1821 vascular plant species in Iberian steppes, 76% of them found in N Africa (Maghrib) steppes
- Alpha grass steppes are not very diverse:
  - 10 endemics in the Ibero-Maghrib region (0.3% of the flore; 0.6% of the stepic flora in N Africa)
  - Perennial vascular plants 16 plots Alicante (E Spain)→ H'=1.2 S=28
- Annual species



Maestre & Cortina, unpubl.

Biodiversity - Cryptogams



ALGAE

Scytonema sp.
Trentepohlia sp.
Nostoc sp.

LICHENS

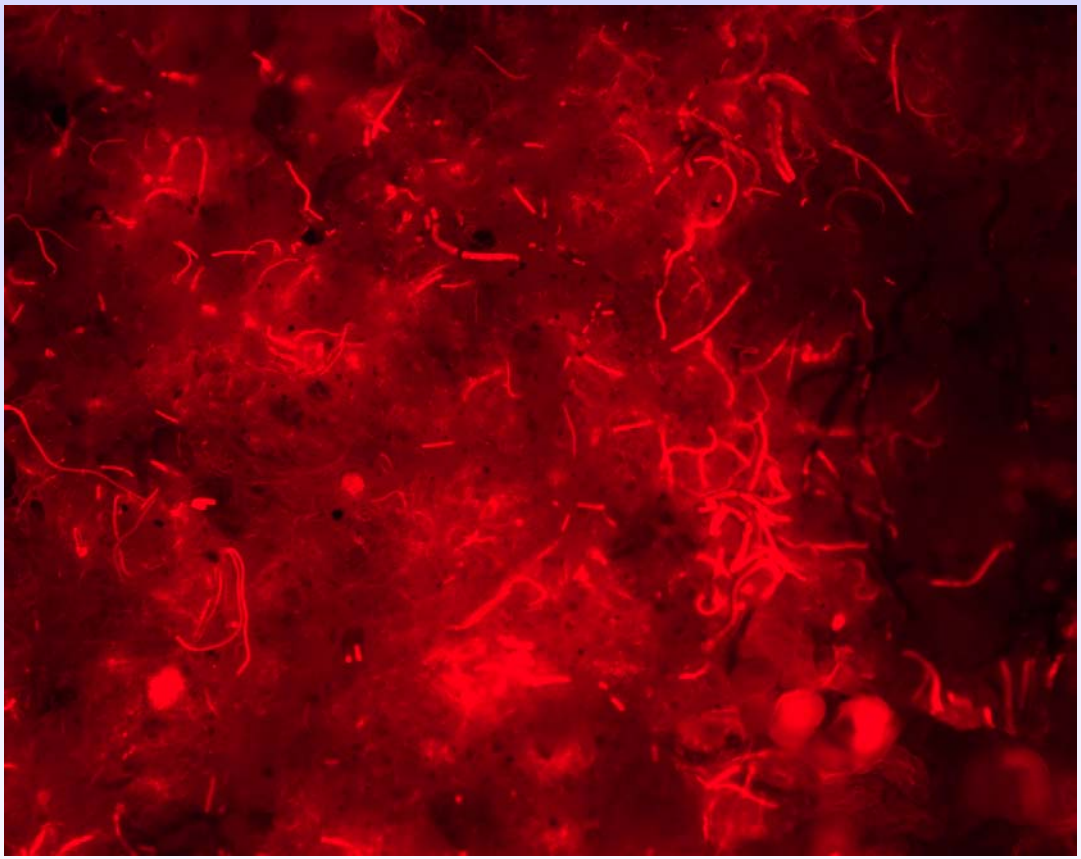
Squamarina concrescens
S. lentigera et *S. cartilaginea*
Toninia sedifolia et *T. tristis*
Psora decipiens et *P. crenata*
Fulgensia fulgida
Catapyrenium sp.
Synalissa symphorea
Collema

MOSSES

Didymodon acutus
Weissia sp.
Gymnostomum lusieri
Aloina rigida
Crossidium sp.
Fossombronia sp.
Southbya sp.

V. Calatayud (unpubl.)

Biodiversity - Cryptogams



Phylogenetic affiliation

(GenBank accession Nº)

Aphanizomenon issatschenkoi (AY493984)
Chlorella mirabilis plastid (X65100)
Oscillatoria spongeliae 513bg (AF534693)
Anabaena cylindrica (AF091150)
Chlorella sorokiniana plastid (X65689)
Microcoleus steenstrupii (AJ871987)
Oscillatoria spongeliae 504bg (AF534688)
Lyngbya majuscula (AF368300)
Lyngbya majuscula (AF368300)
Plectonema cf. battersii (AJ621837)
Oscillatoria sp. J-24-Osc (AF263344)
Phormidium sp. ETS-05 (AJ548503)
Lyngbya hieronymusii (AF337650)
Symploca sp. PCC8002 (AB039021)
Phormidium autumnale (AF218371)
Nostoc sp. 8916 (AY742447)
Oscillatoria sp. MPI 990BR03 (AF284810)
Symploca sp. PCC8002 (AB039021)
Oscillatoria spongeliae 513bg (AF534693)

Biodiversity - Fauna

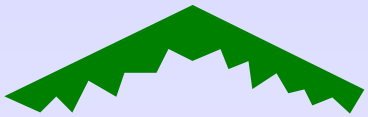
- Low bird richness, probably as a result of low plant diversity and poor community structure
- Common species: Cogujada montesina (*Galerida theklae*) and Camachuelo trompetero (*Rhodopechys githaginea*)

Galerida theklae

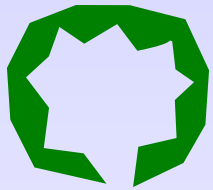
José J. Matamala
(www.almeriware.net)

Morpho-functional traits

- 200 - 400 mm (semiarid to dry sub-humid)
- -19ºC to 40ºC
- Limited by flooding, salinity and clay



100º - 100% RWC



0º - 70% RWC

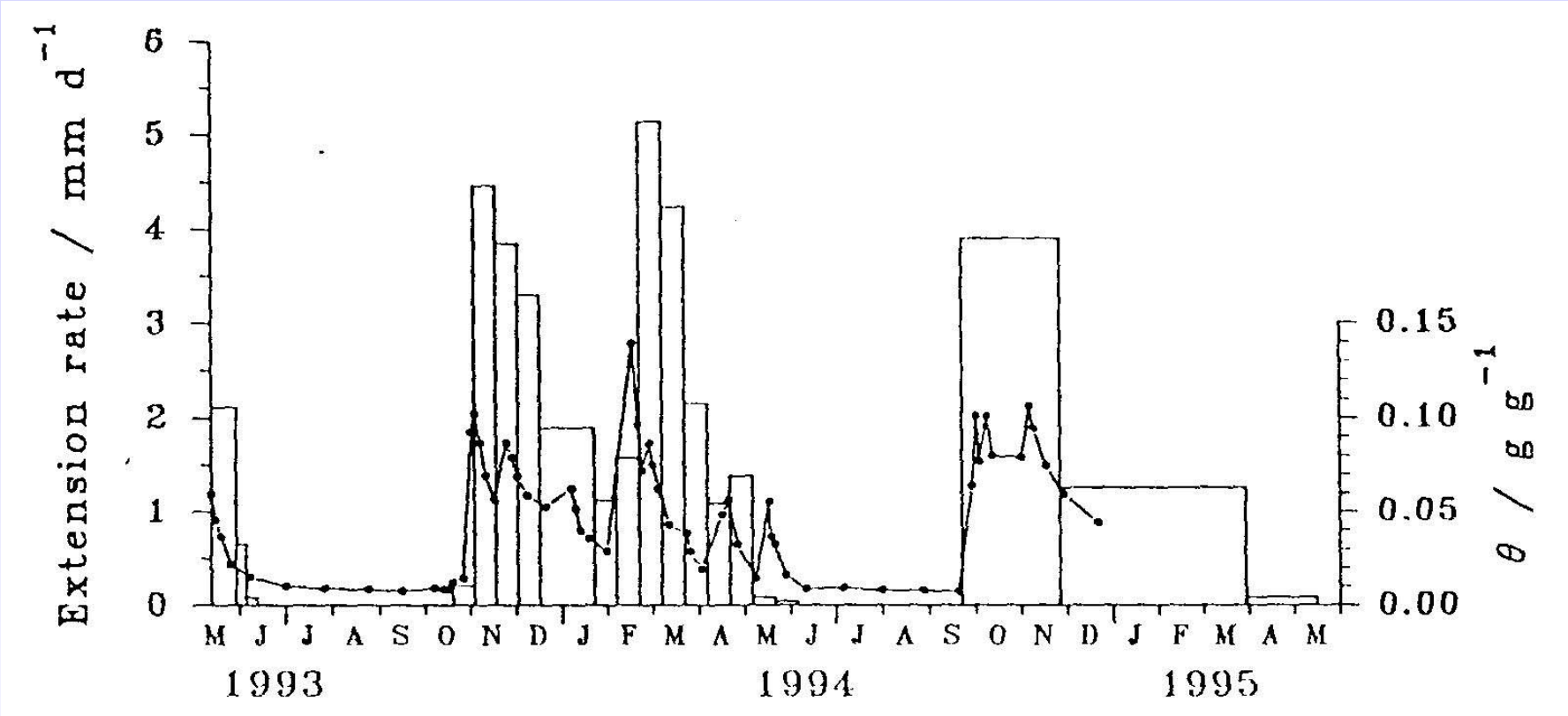
Pression-volume curves in alpha grass and other Mediterranean species

		Stipa tenacissima	*Lygeum spartum*	*Pistacia lentiscus*	*Quercus coccifera*
$\Psi\pi$	(MPa)	-1.85	-4.18	-2.63	-2.66
Ψtlp	(MPa)	-2.67	-7.2	-3.3	-3.46
RWCtlp	(%)	85	83	86	87
ε	(MPa)	16.2	17.8	29.2	25.4

Pugnaire et Haase, 1996 et Vilagrosa, 2002

Morpho-functional traits

Poikilohydric. Seasonal variation in leaf extension



Haase et al., 1999

Poikilohydric. Predawn water potential

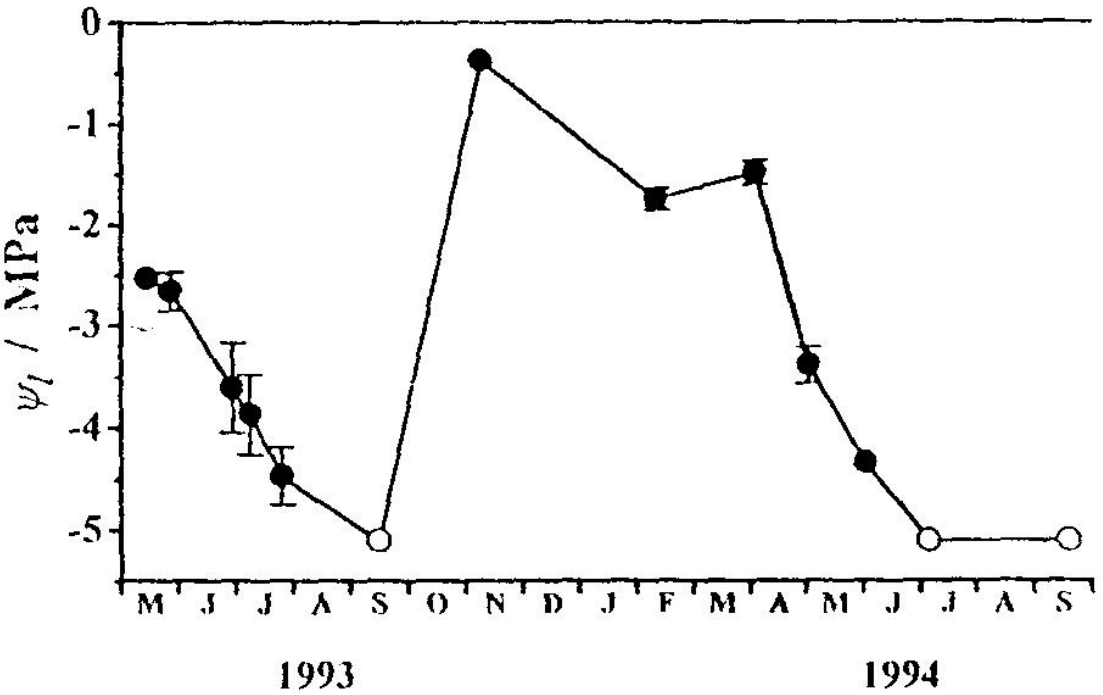
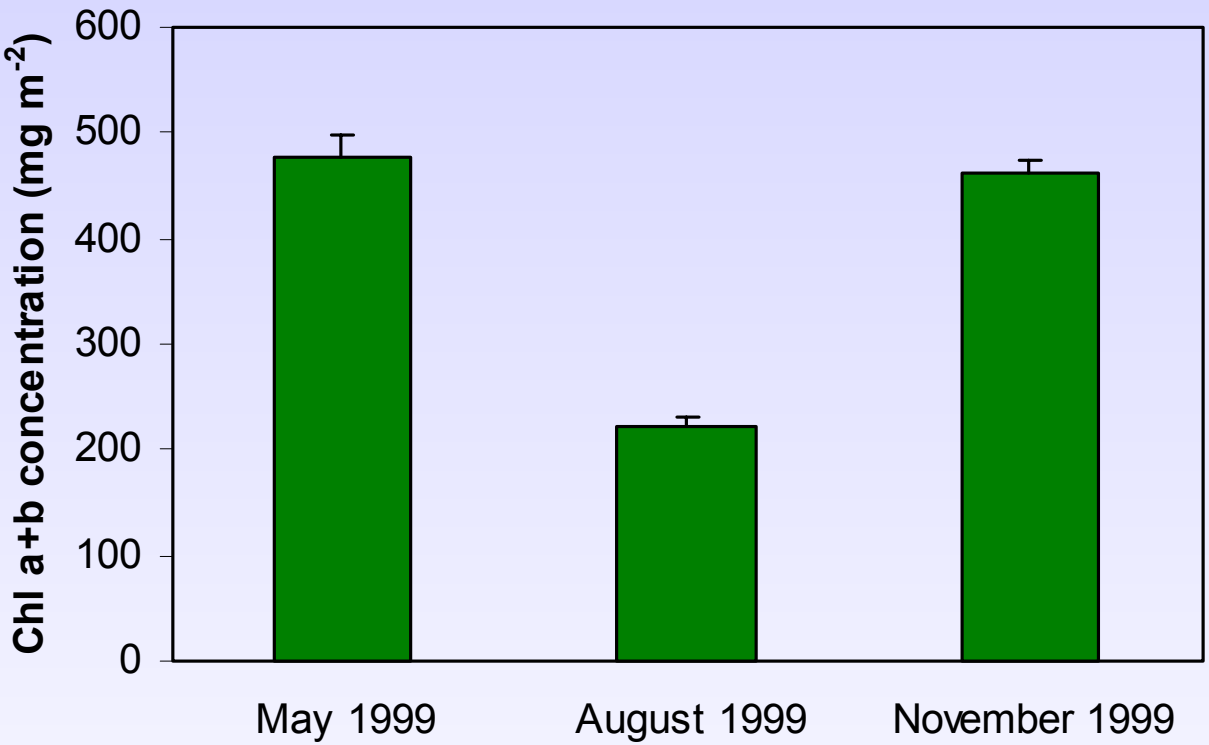


Figure 5. Pre-dawn water potential (ψ_l) of leaves of *Stipa tenacissima* from May 1993 to September 1994 (mean ± SE, n = 3–6; open symbols indicate values < −5.0 MPa).

Haase et al., 1999

Morpho-functional traits

Poikilohydric. Chlorophyll concentration



Balaguer et al., 2002

Morpho-functional traits

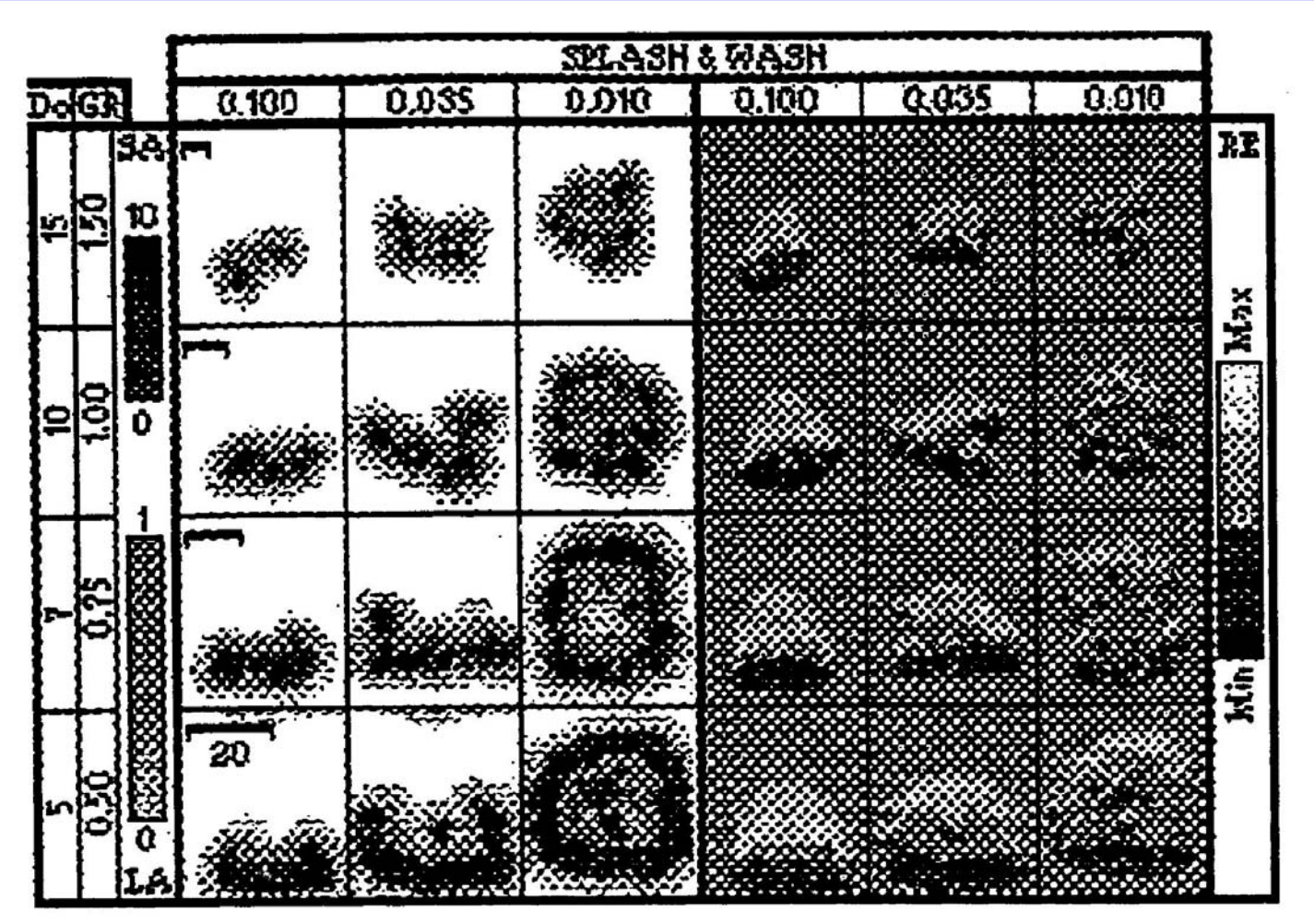
Branched rooting system under the tussocks

Figure 47.8 Root dry weight content at different soil depths (a) in bare-ground patches and (b) under tussocks, in the Rambla Honda field site. Error bars indicate 1 SE

Puigdefábregas & Sánchez, 1996

Spatial heterogeneity of resources and organisms

Interaction between alpha grass growth and slope



Puigdefábregas & Sánchez, 1996

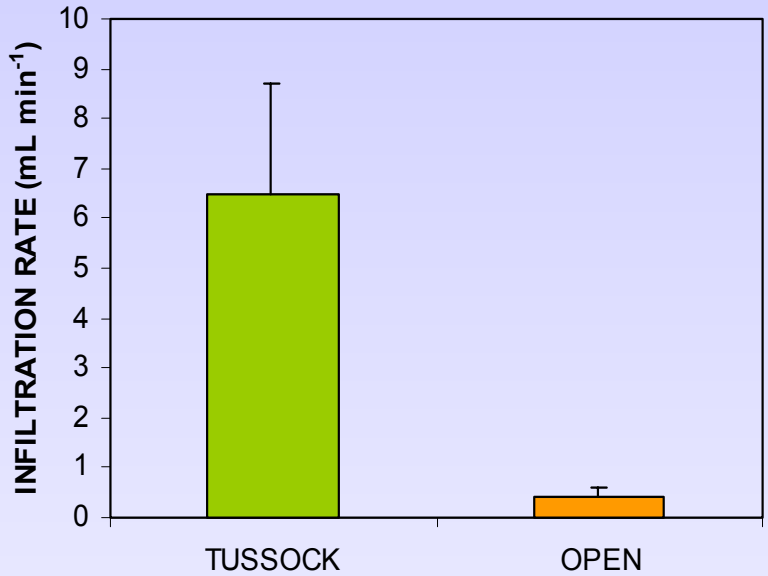
Spatial heterogeneity of resources and organisms

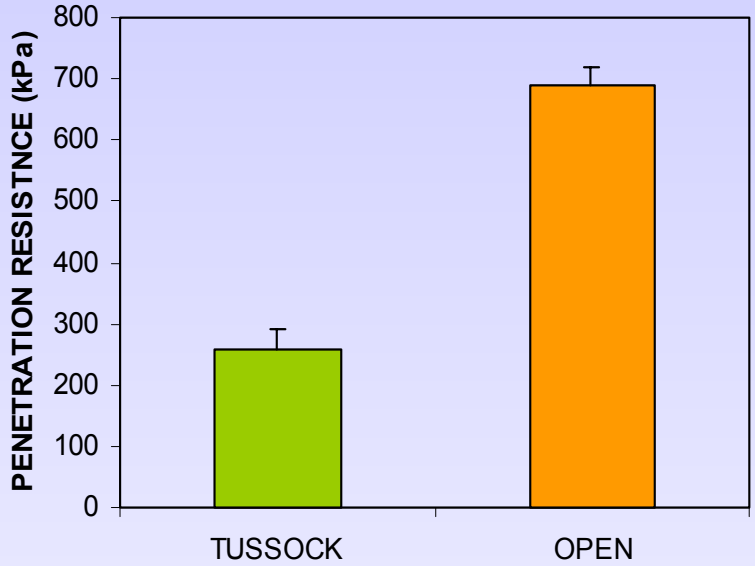
Tussocks affect surface soil properties

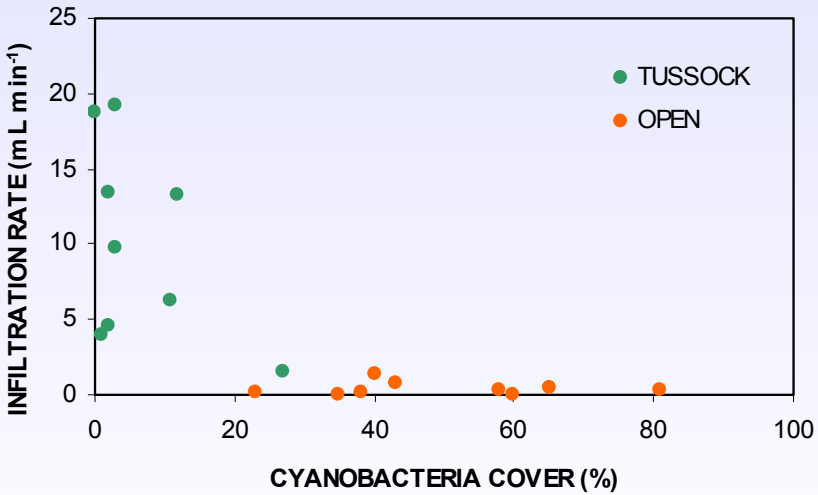
	Cover (%)	
	Tussock	Open
Cyanobacteria	6.8 ± 2.9	49.2 ± 6.0
Mosses	71.4 ± 5.5	12.0 ± 4.8
Lichens	0	15.56 ± 5.8
Bare soil	5.6 ± 1.1	16.8 ± 1.8

Maestre et al., 2002

Spatial heterogeneity of resources and organisms







Changes in surface soil conditions favoured by alpha grass tussocks affect hydrological properties

partial correlation

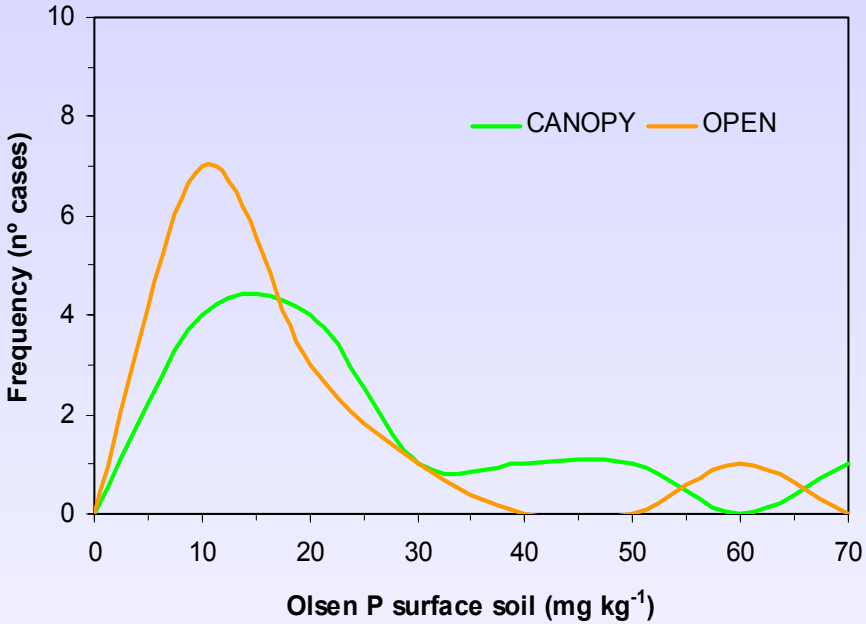
r^2=-0.537 p=0.039

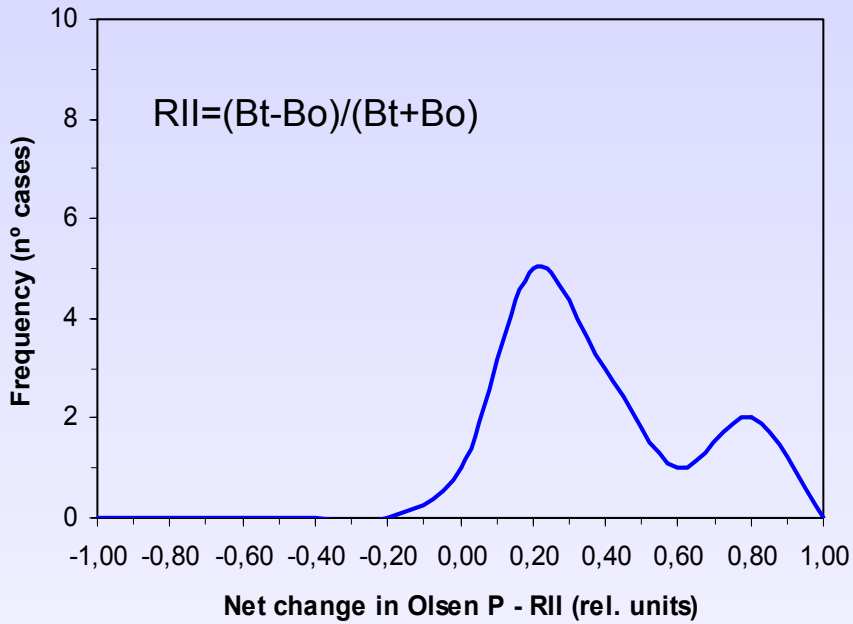
Maestre et al., 2002

Spatial heterogeneity of resources and organisms

Spatial heterogeneity of resources and organisms

Phosphorus in islands of fertility

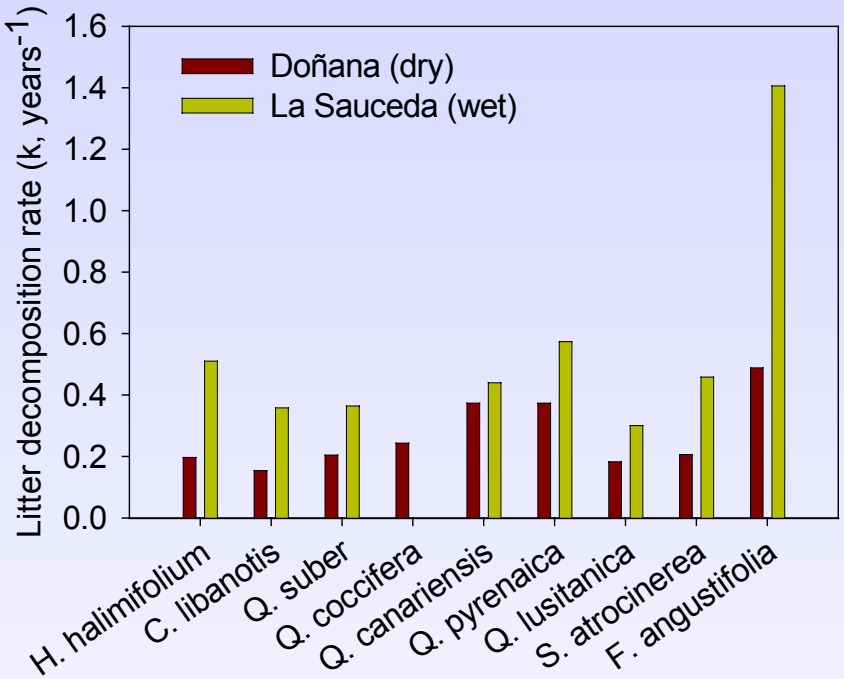




Cortina & Maestre, 2005

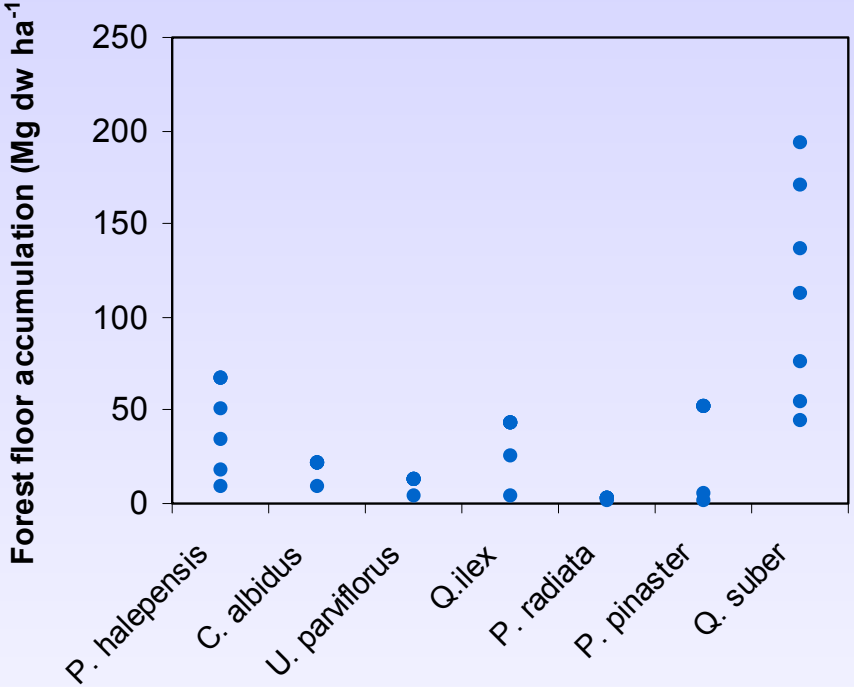
Spatial heterogeneity of resources and organisms

Litter decay rate



Gallardo & Merino, 1993

Forest floor accumulation

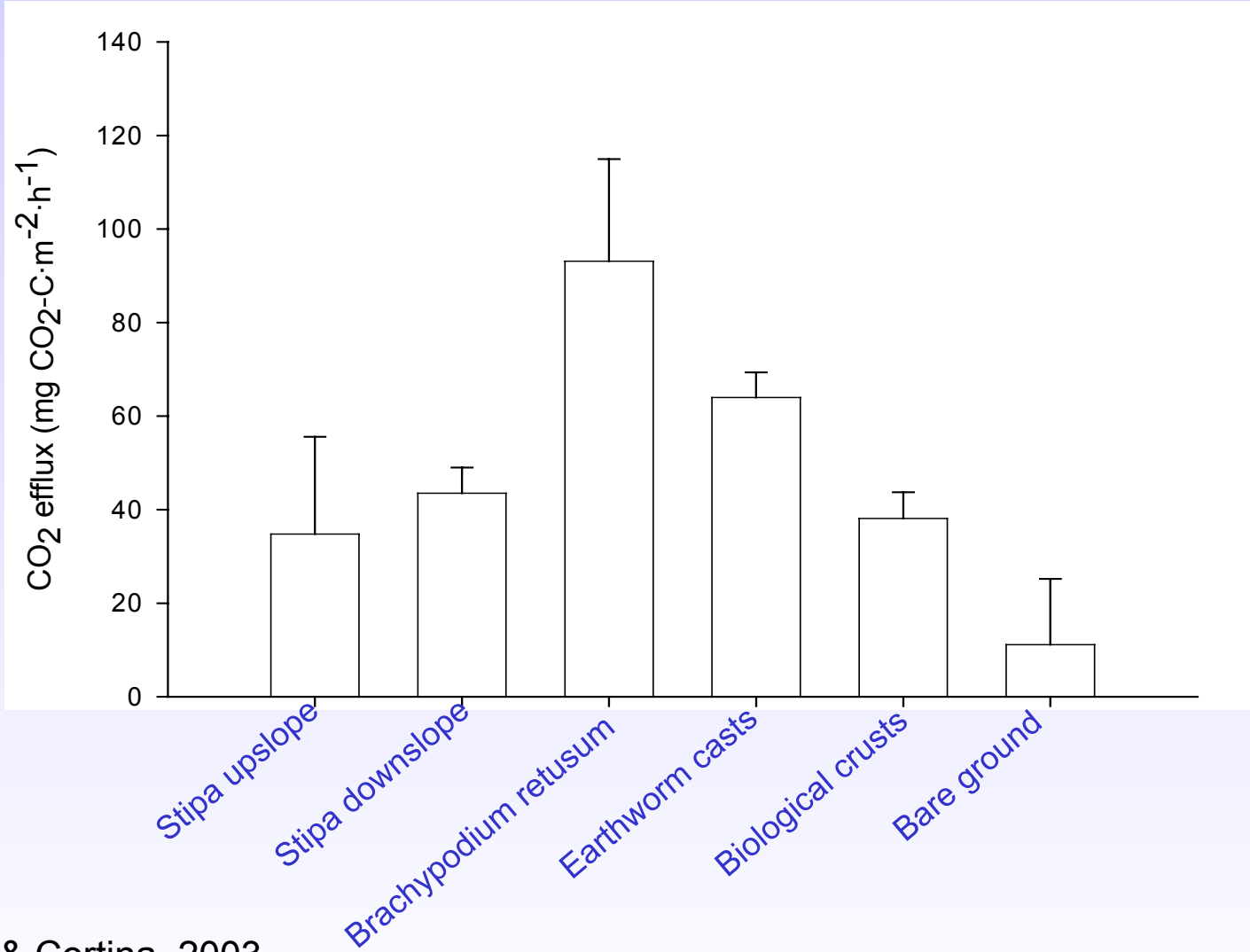


VV.AA.

Species and site effects on decay rates and forest floor accumulation are strong

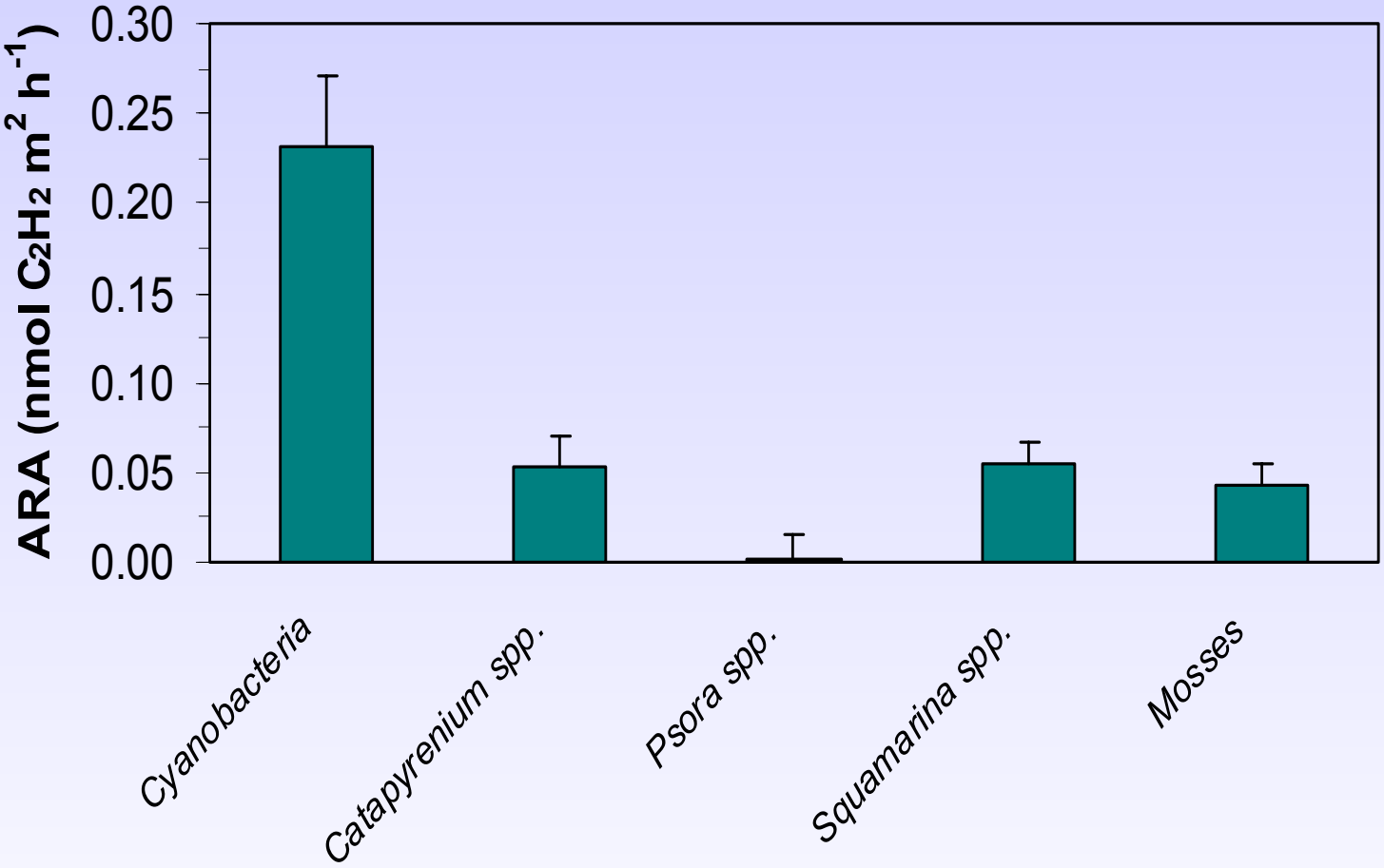
Spatial heterogeneity of resources and organisms

Biological properties also differ



Maestre & Cortina, 2003

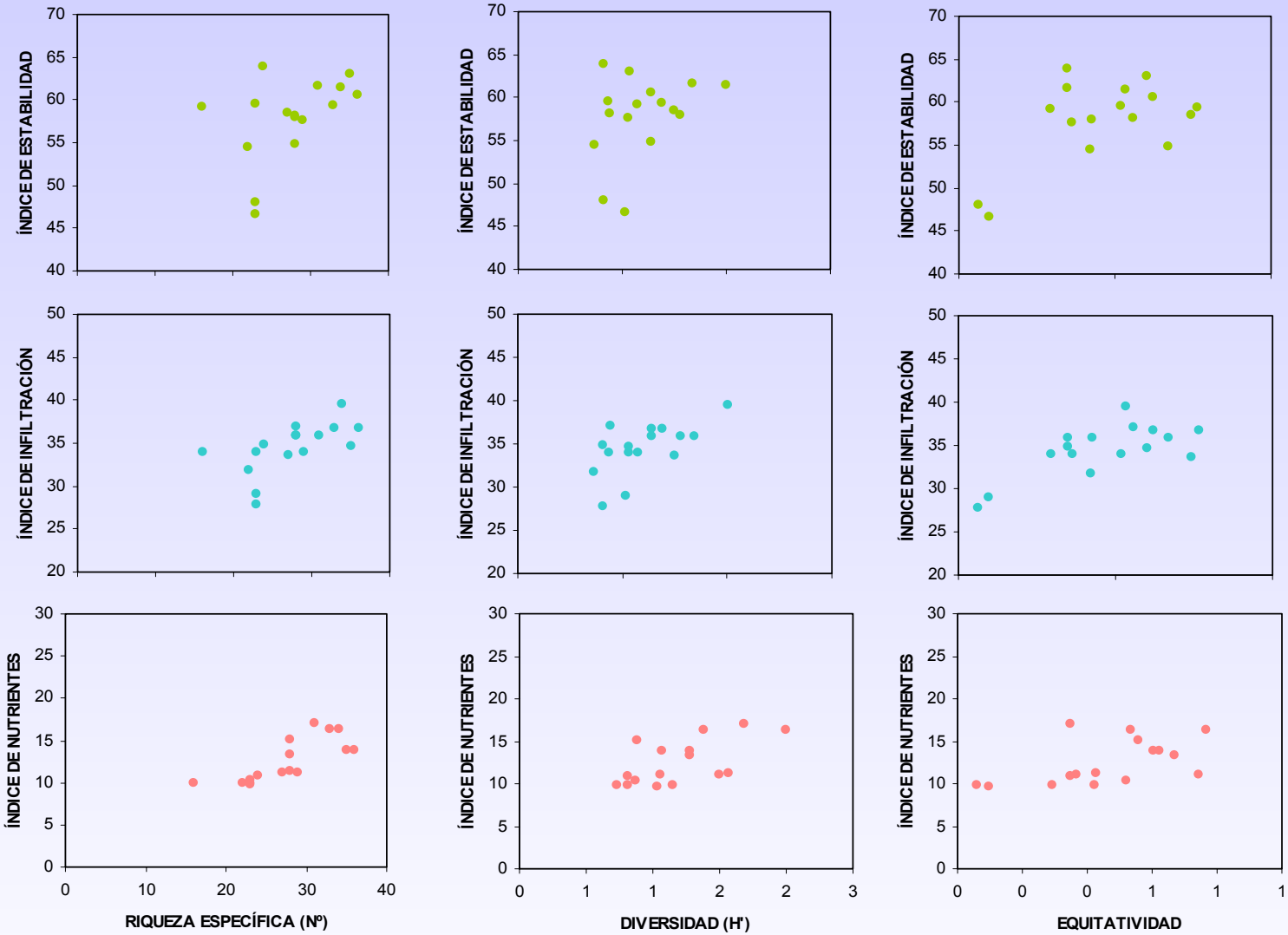
Interspecific interactions and community structure



Biological crusts can be a significant source of Nitrogen in drylands

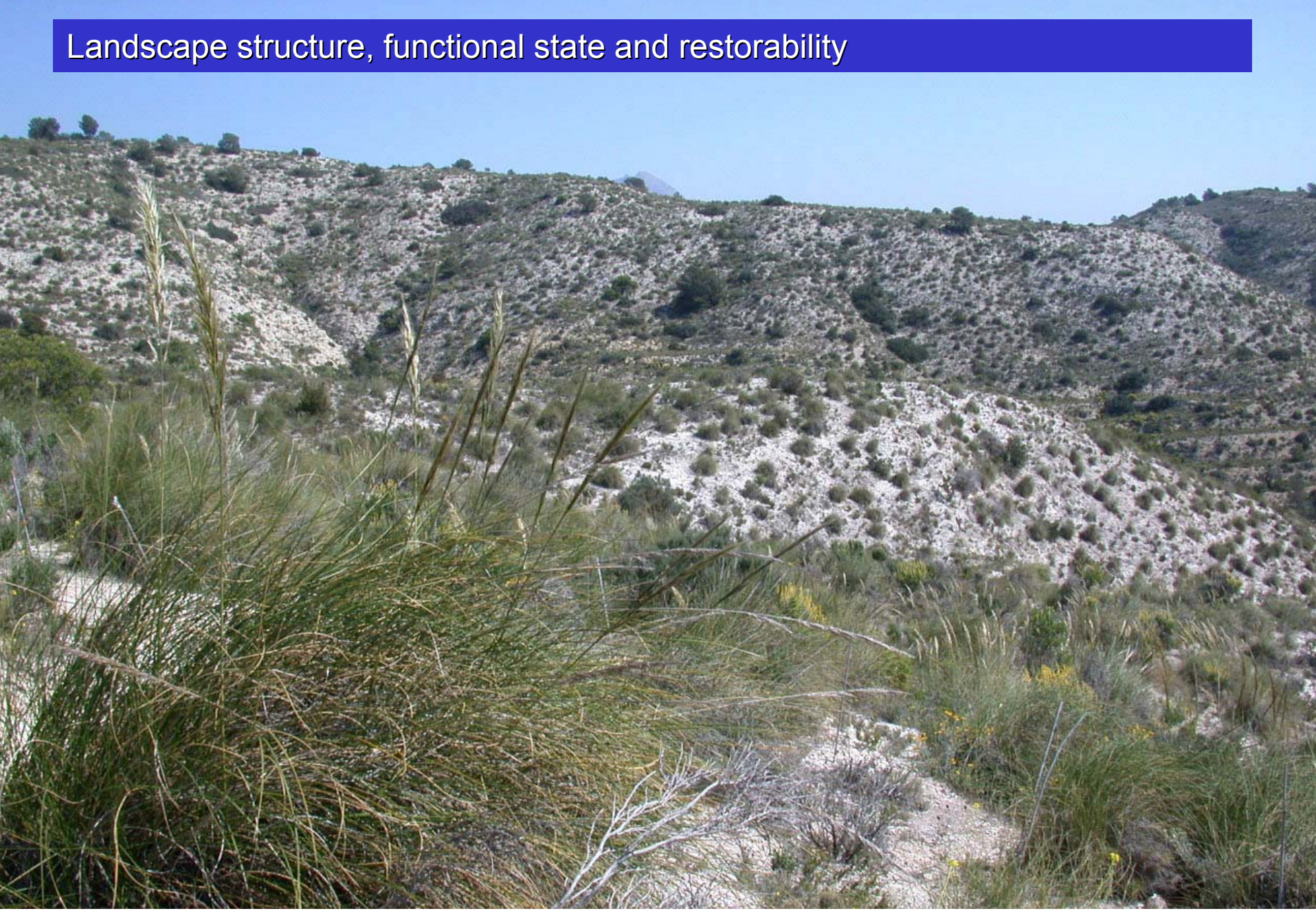
Martín et al., unpubl.

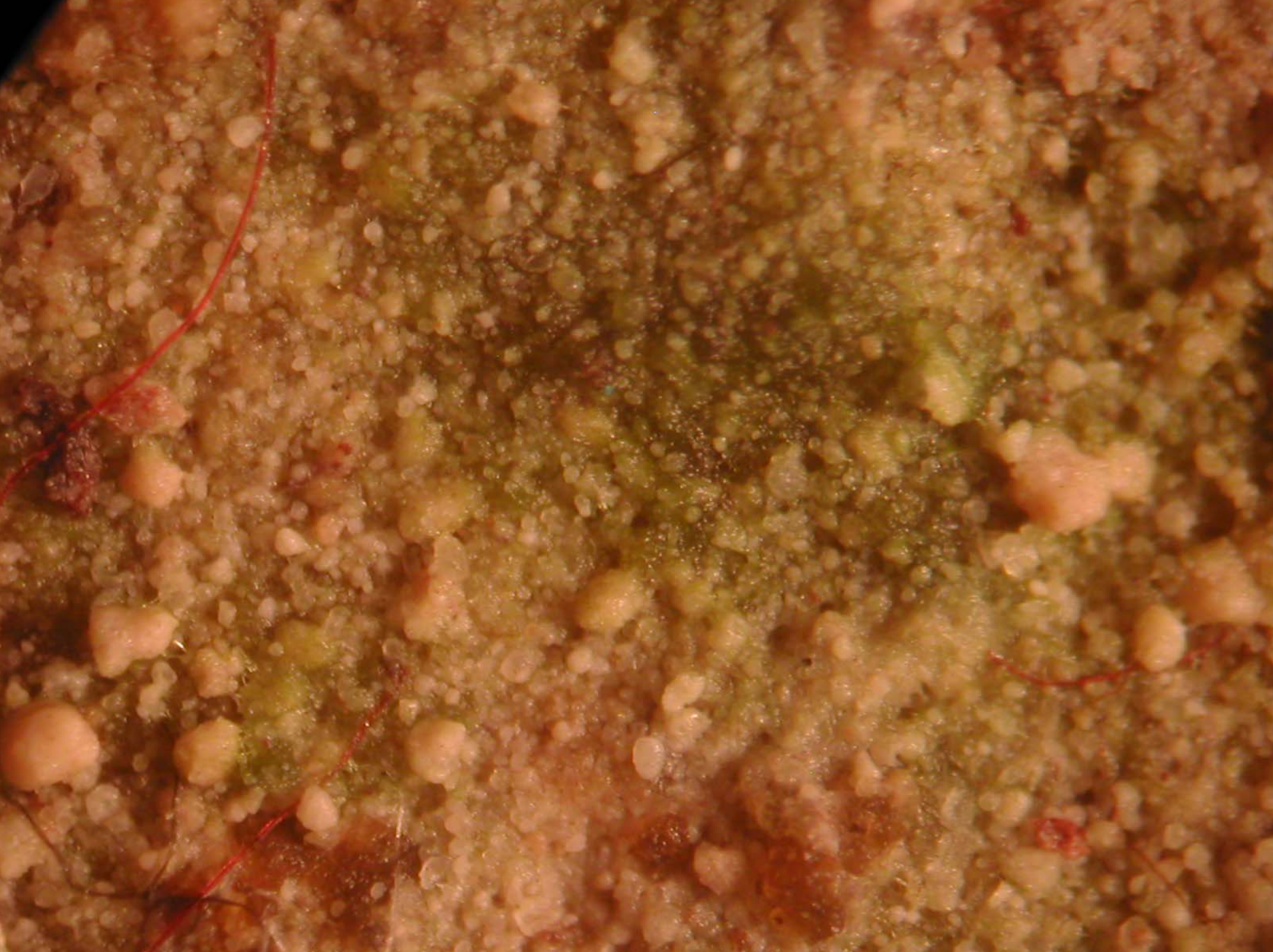
A framework for alpha grass steppe restoration



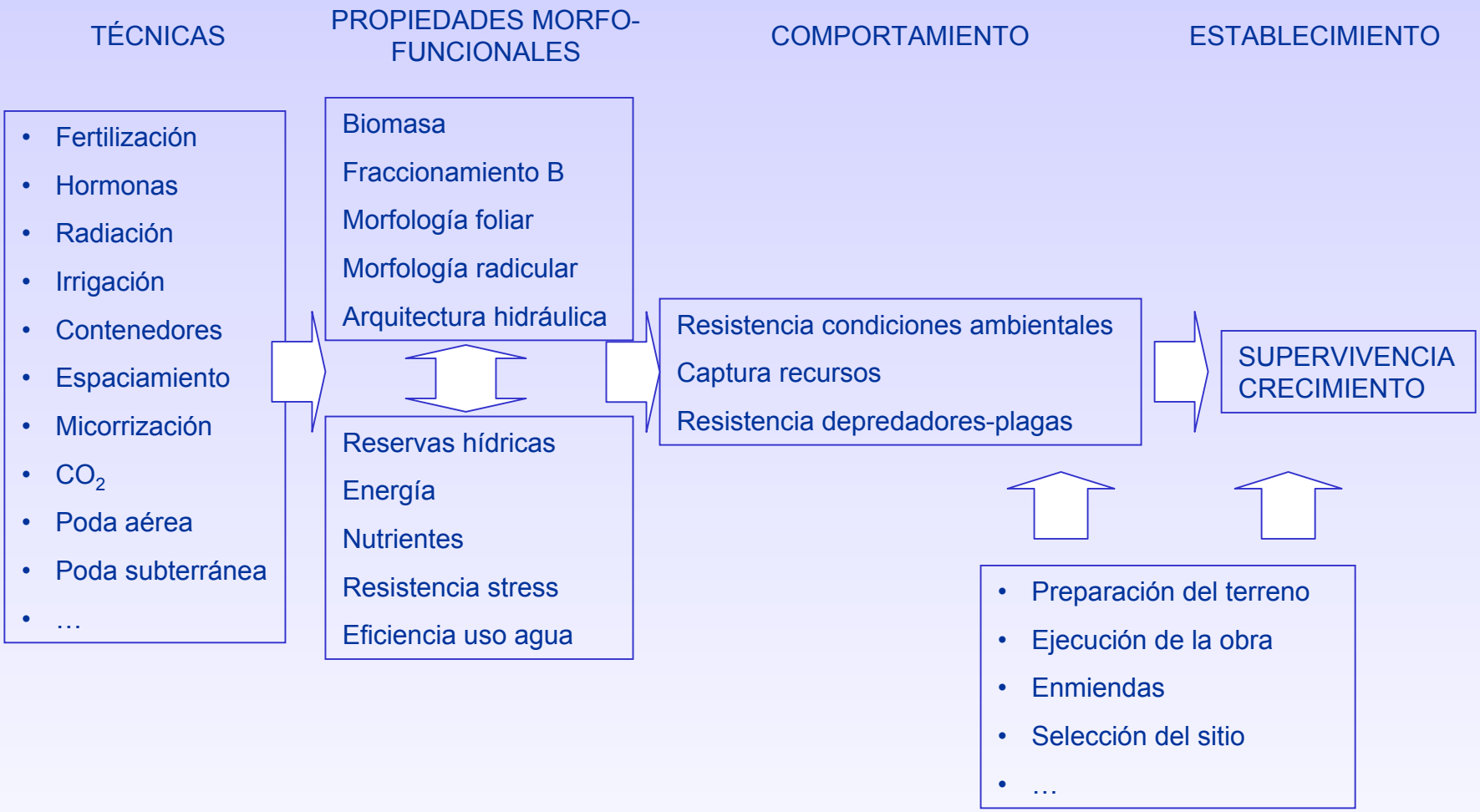
Maestre & Cortina, unpubl.

Landscape structure, functional state and restorability

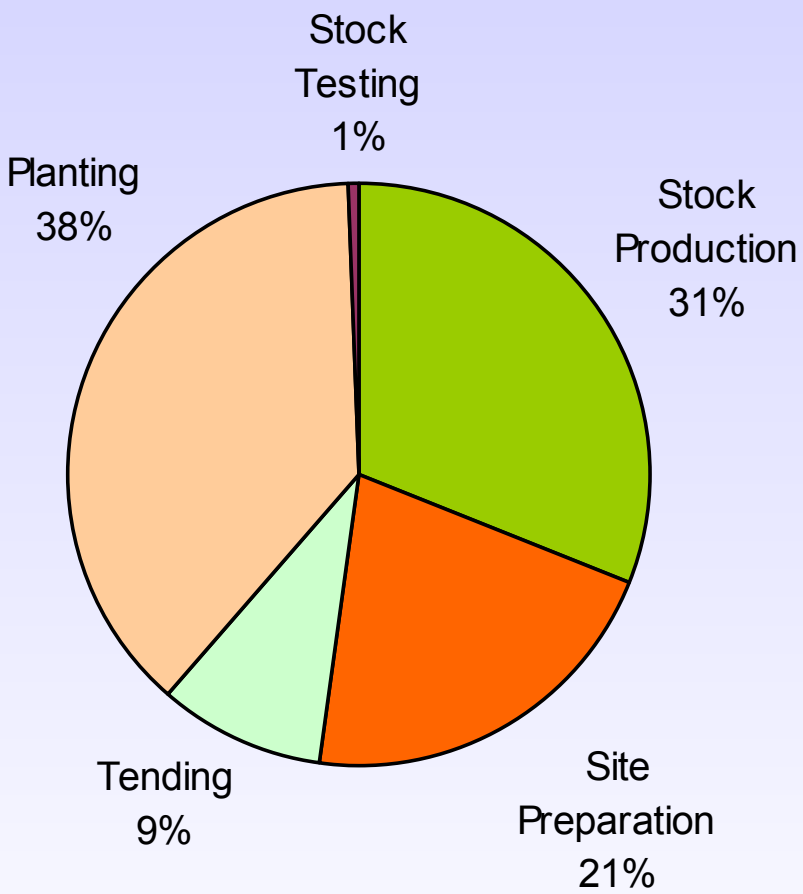




Ecotechnology - Seedling quality



Costes medios de una plantación comercial (Ontario)

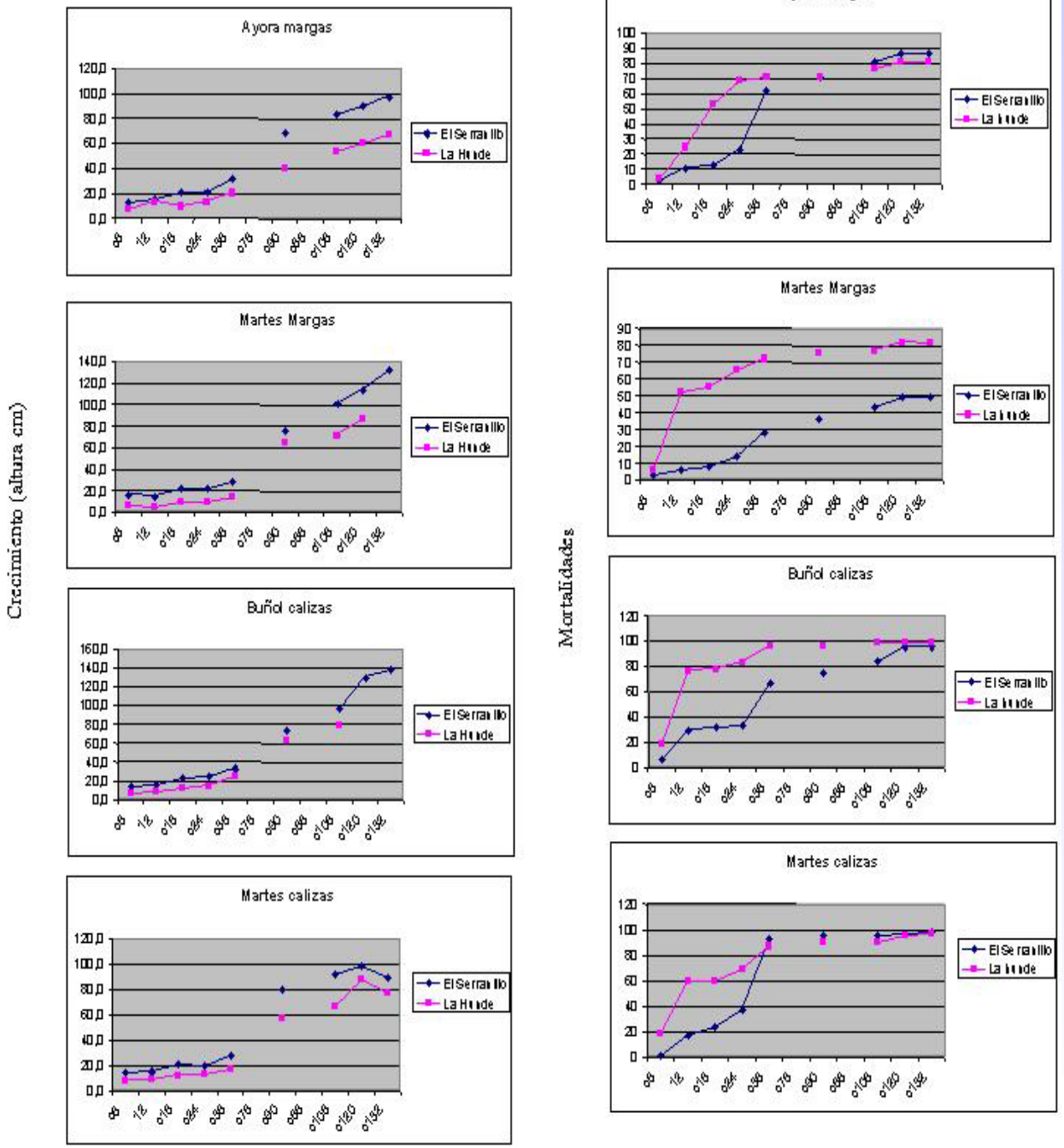


Sampson et al., 1997

Ecotechnology - Seedling

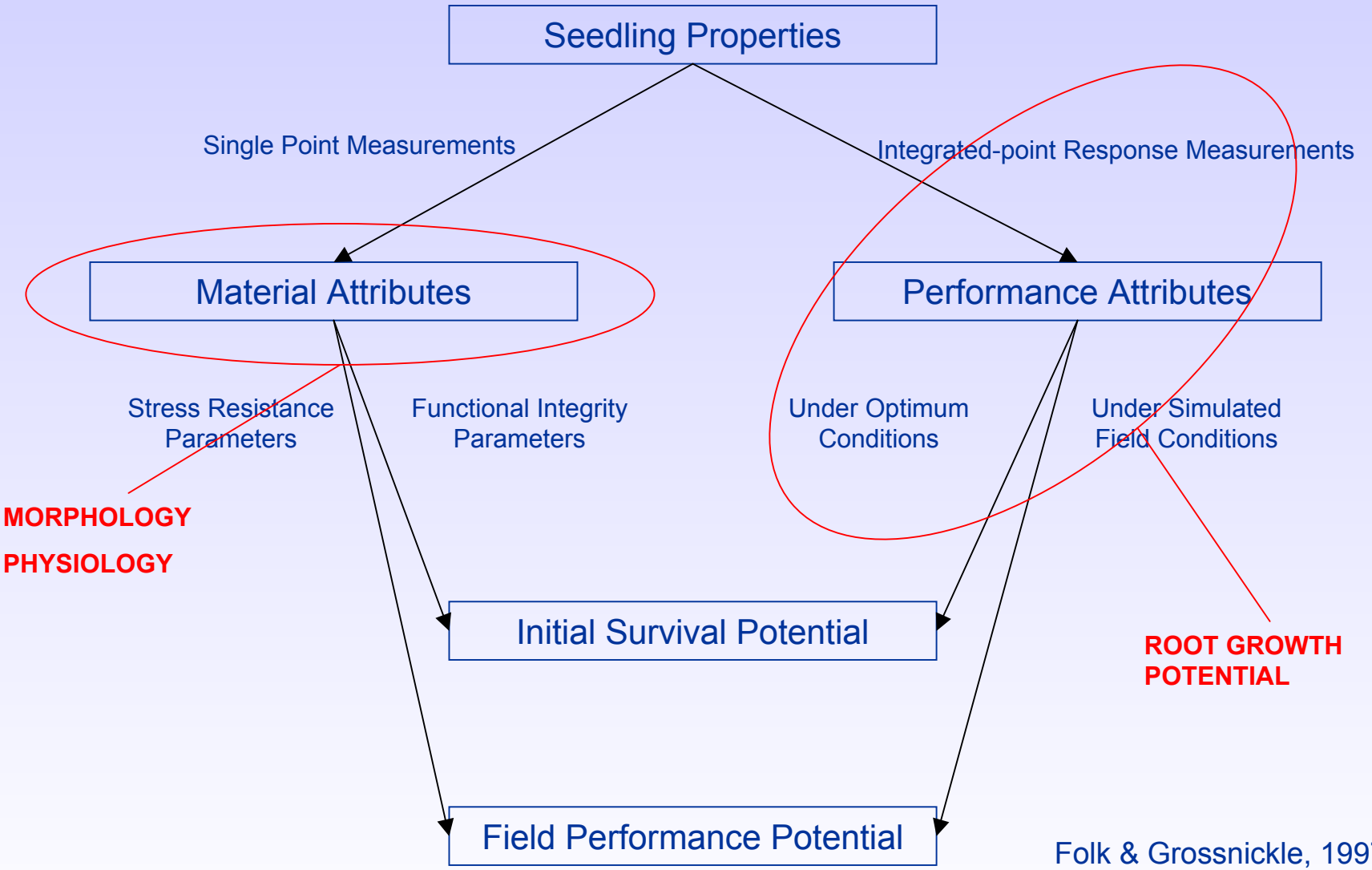
Seedling mortality experimental plantations

CEAM 1992-1994



J.A. Alloza (unpubl.)

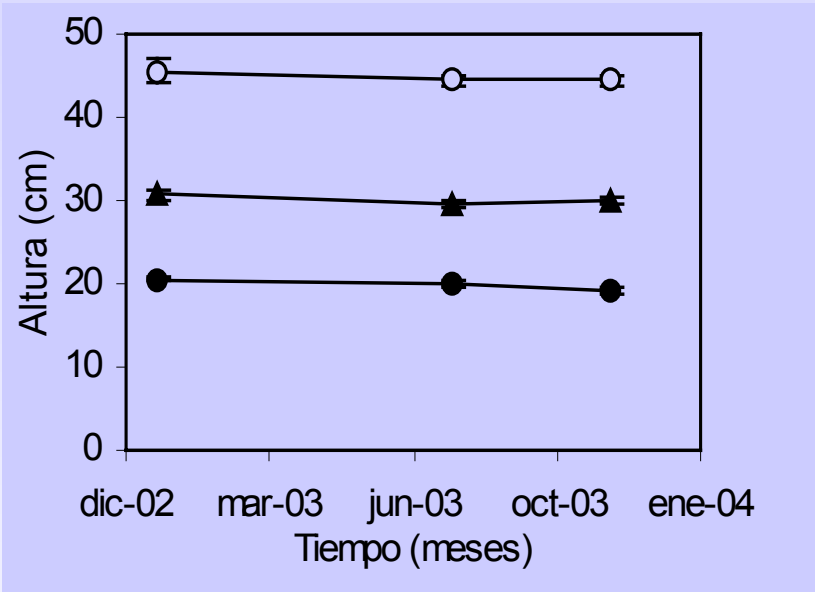
Ecotechnology - Seedling quality



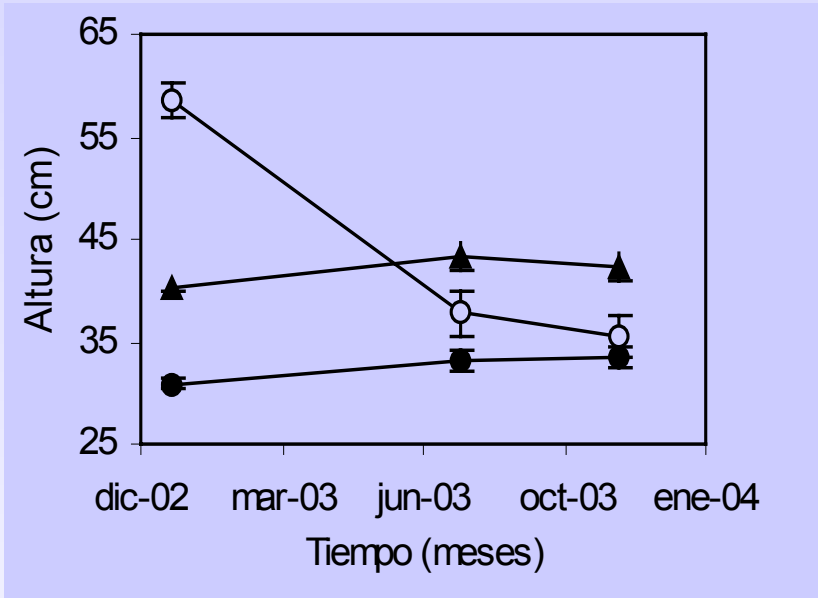
Folk & Grossnickle, 1997

Este ajuste se puede anticipar mediante poda

Quercus ilex ballota – S. Crevillente

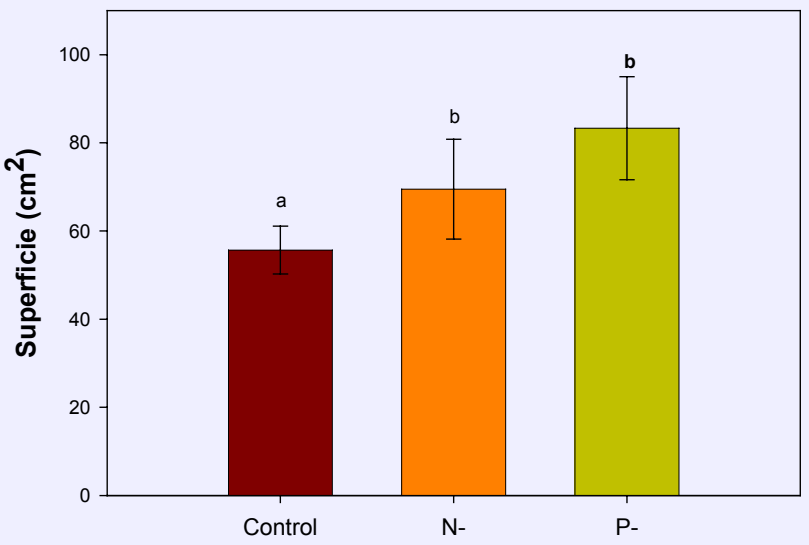


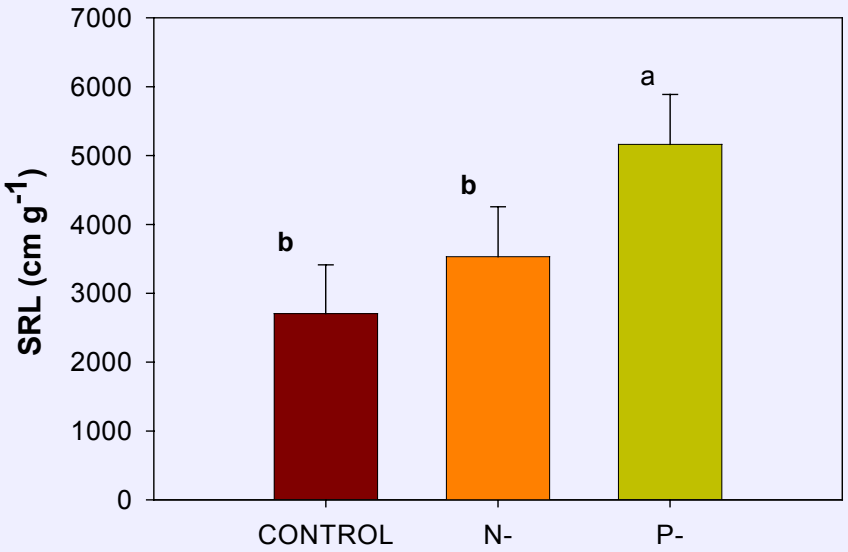
Ephedra fragilis - Albatera



Chirino et al. (no publ.)

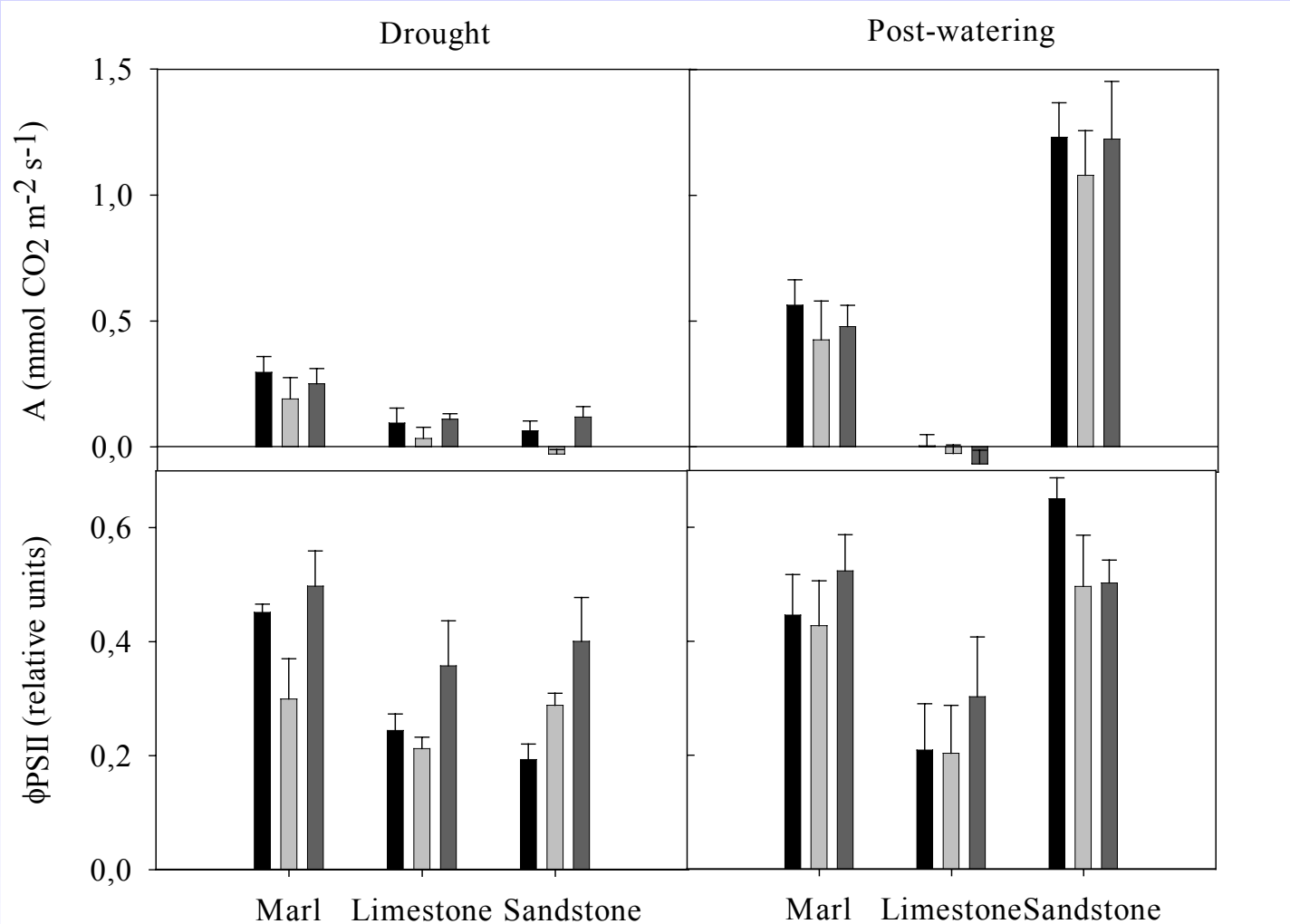
Morfología radicular *Pistacia lentiscus* – 3 meses



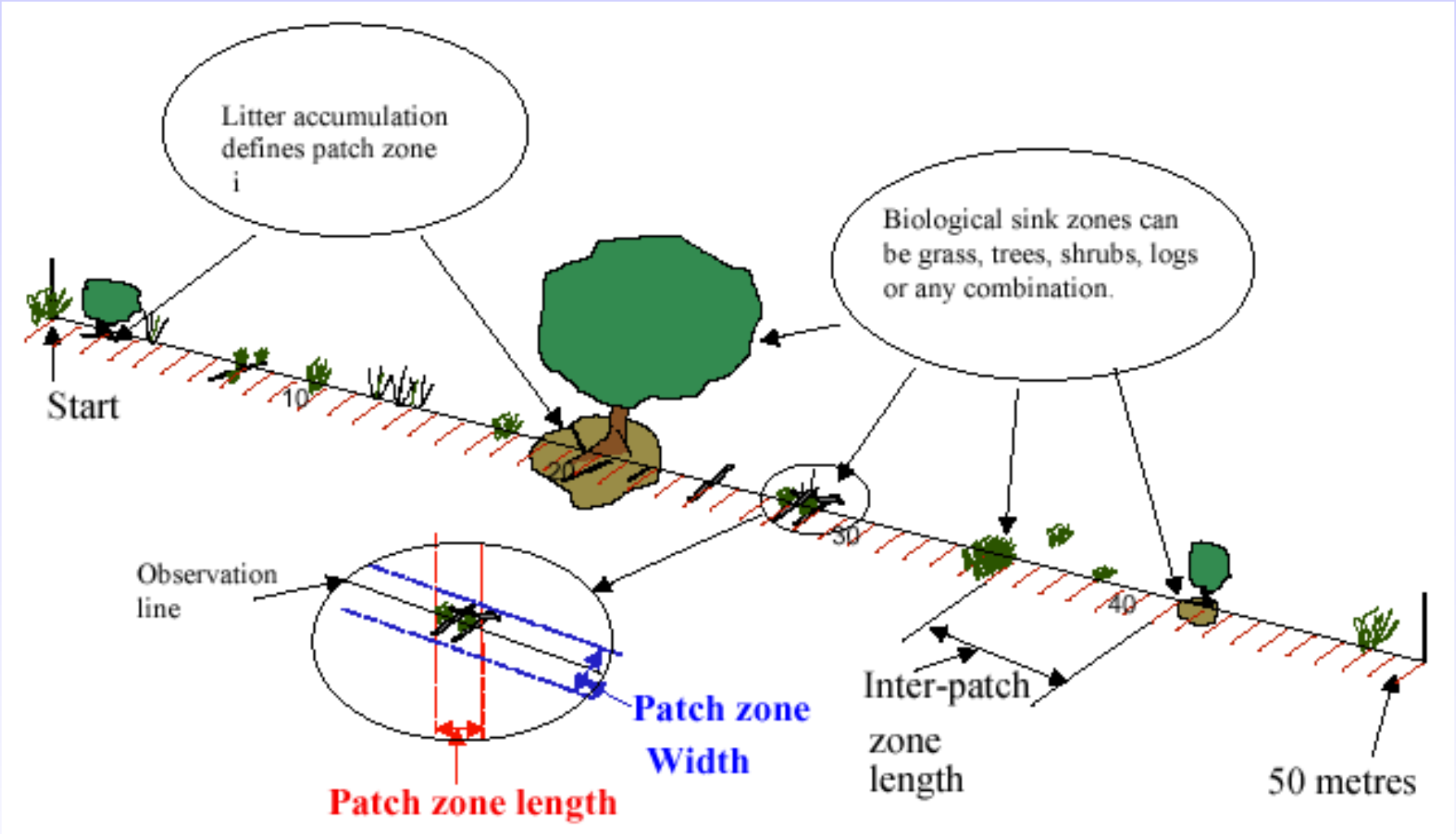


Trubat et al., en prensa

Ecotechnology – Site preparation

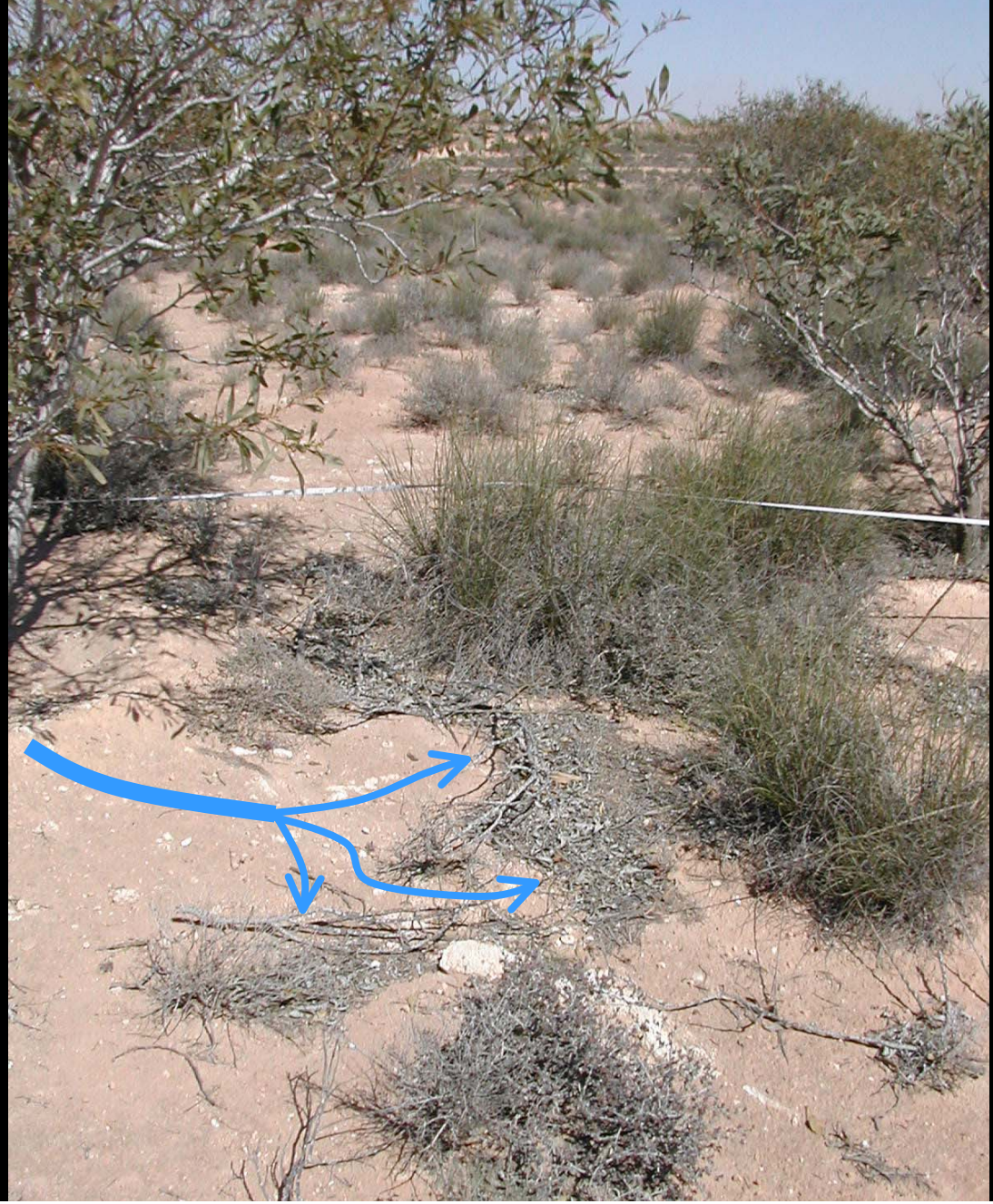


Landscape structure, functional state and restorability

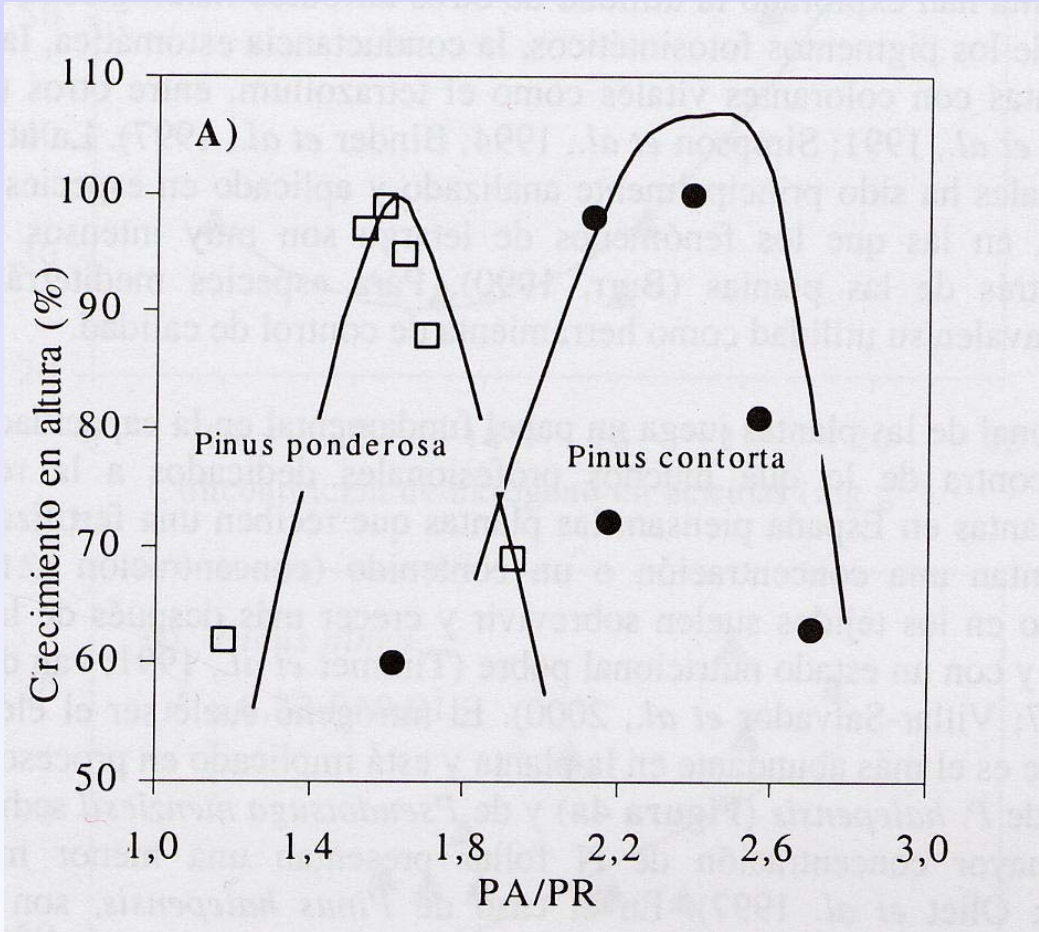


1. LANDSCAPE ORGANISATION

Tongway & Hindley, 2004



Las relaciones entre las variables morfológicas y el comportamiento en campo pueden ser de tipo unimodal



MacDonald et al. (1984) en Villar (2003)