

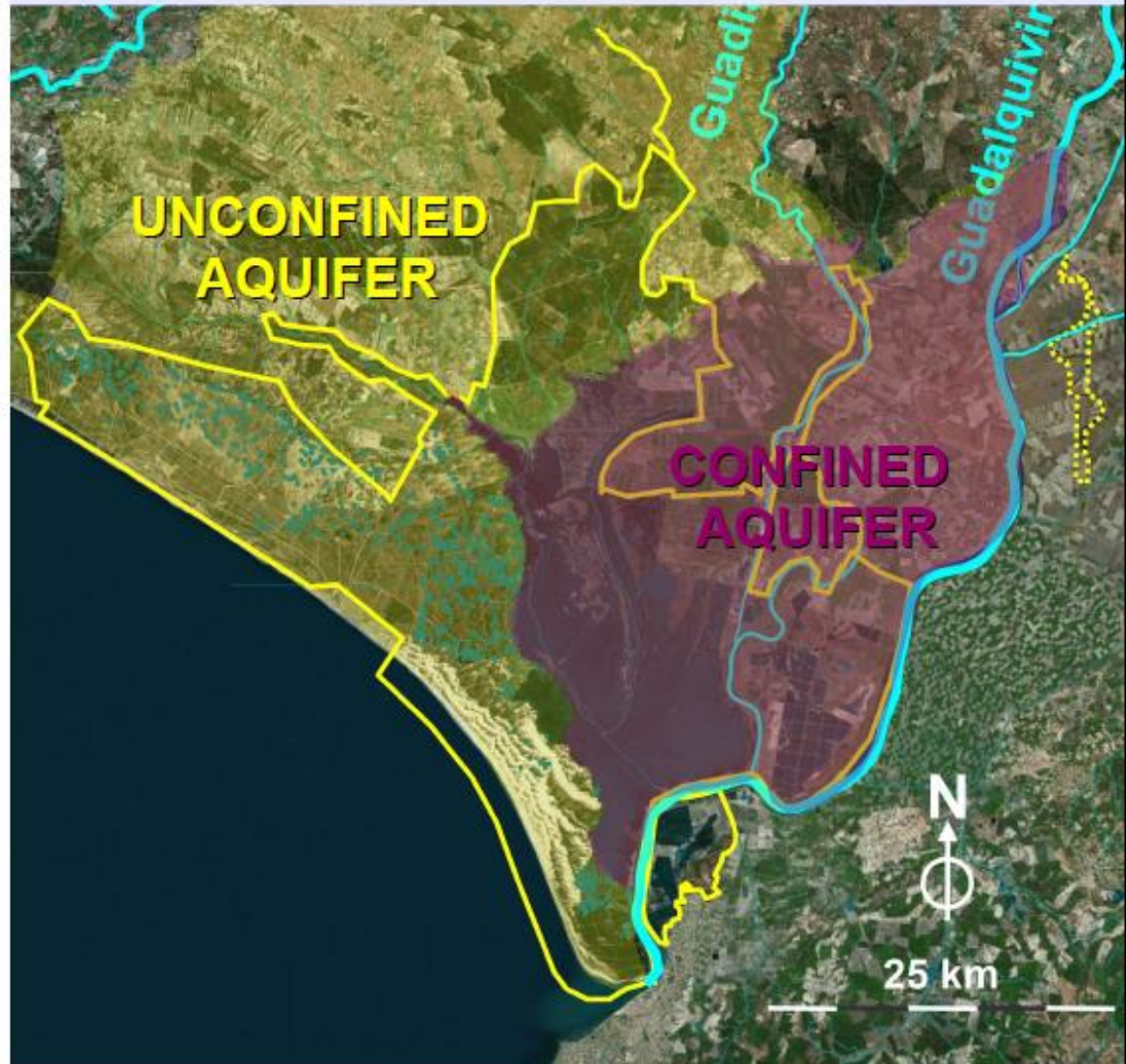
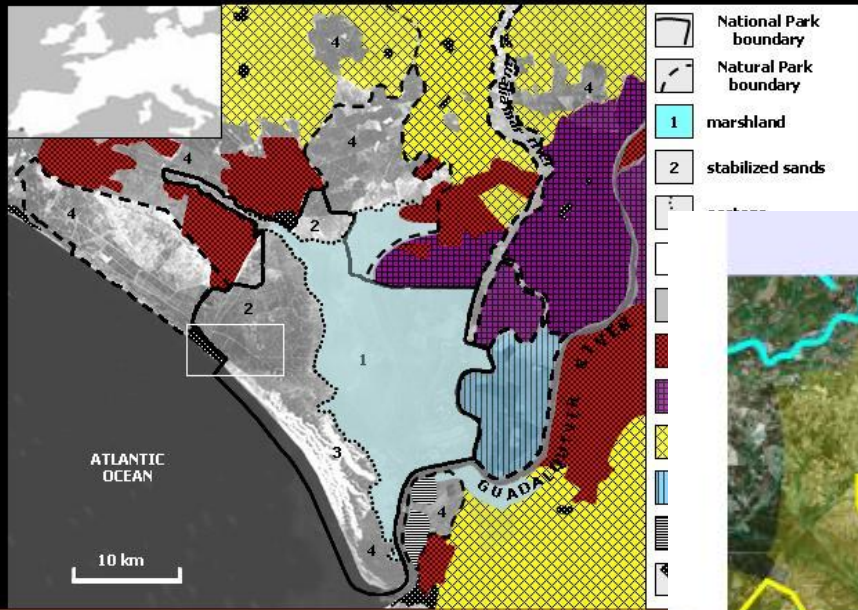
A landscape of Doñana dunes. The background is dominated by a dense forest of tall, green pine trees. In the middle ground, there are several clumps of tall, dry, brown grasses. In the foreground, three horses are grazing in a field of green grass. The sky is a pale, clear blue.

***Avoider and tolerant strategies  
coexisting in Mediterranean  
species of Doñana dunes***

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Doñana National Park is located in the SW of Spain facing the Atlantic ocean. It has three main ecological domains: the marsh, the stabilized sands and the mobile dunes

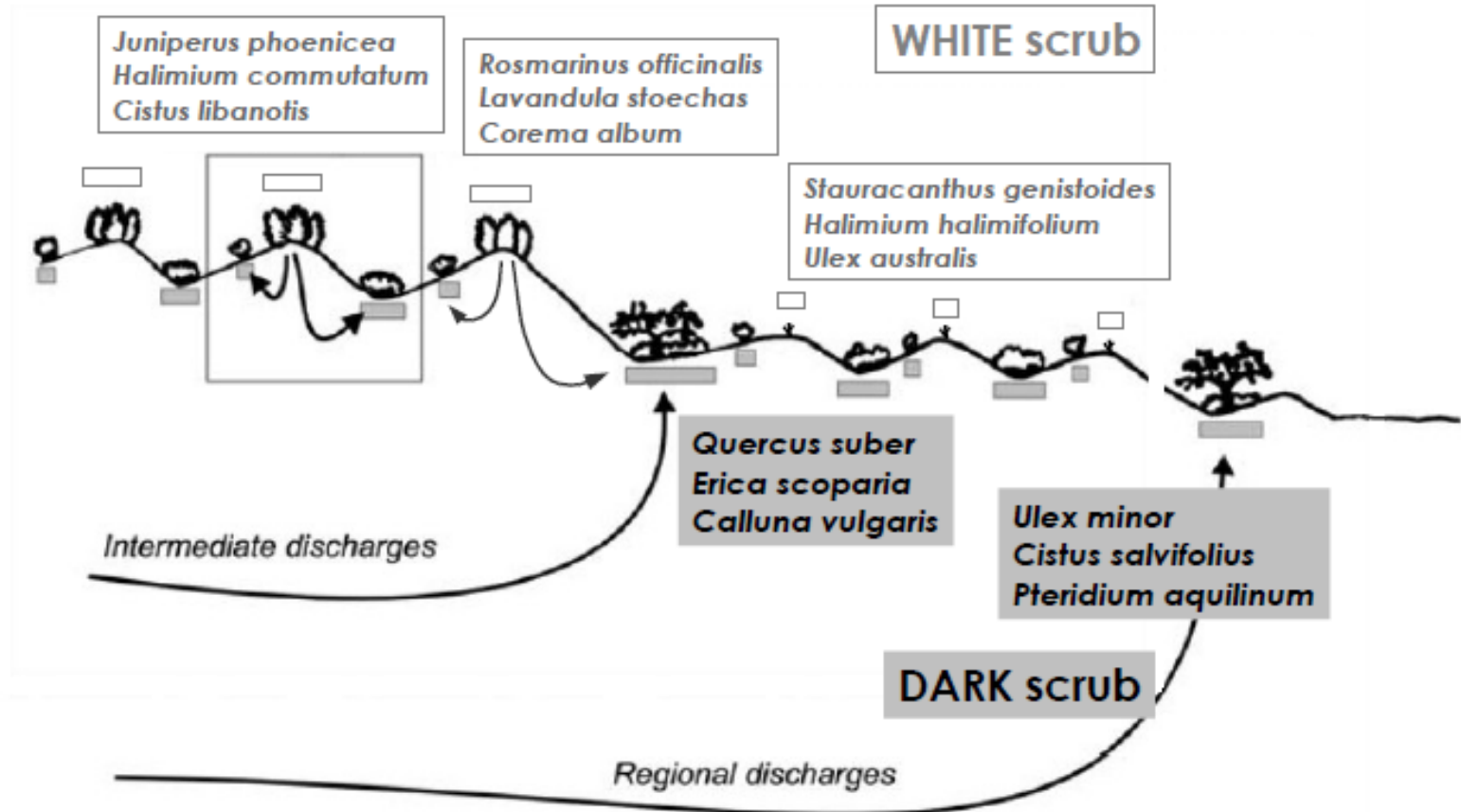


The underground water is divided in an unconfined (under the sands) and confined aquifer (below the silty-clay deposits of the marshland.)

# Nested pattern of vegetation communities

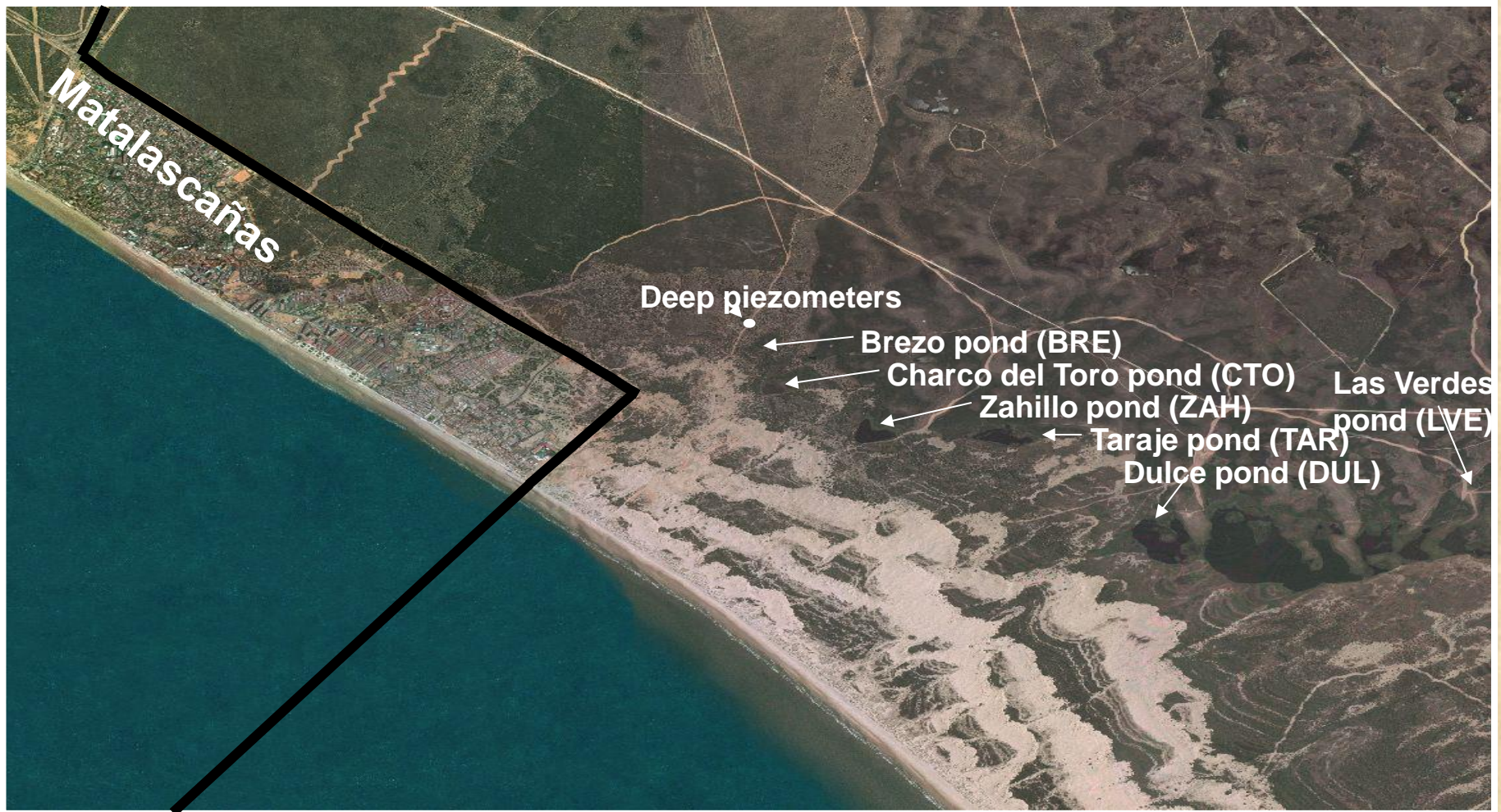
Stable dunes

Marshland



(Muñoz-Reinoso & García-Novo, 2005)





In the transition between the mobile dunes and stabilized sands there are a set of ponds





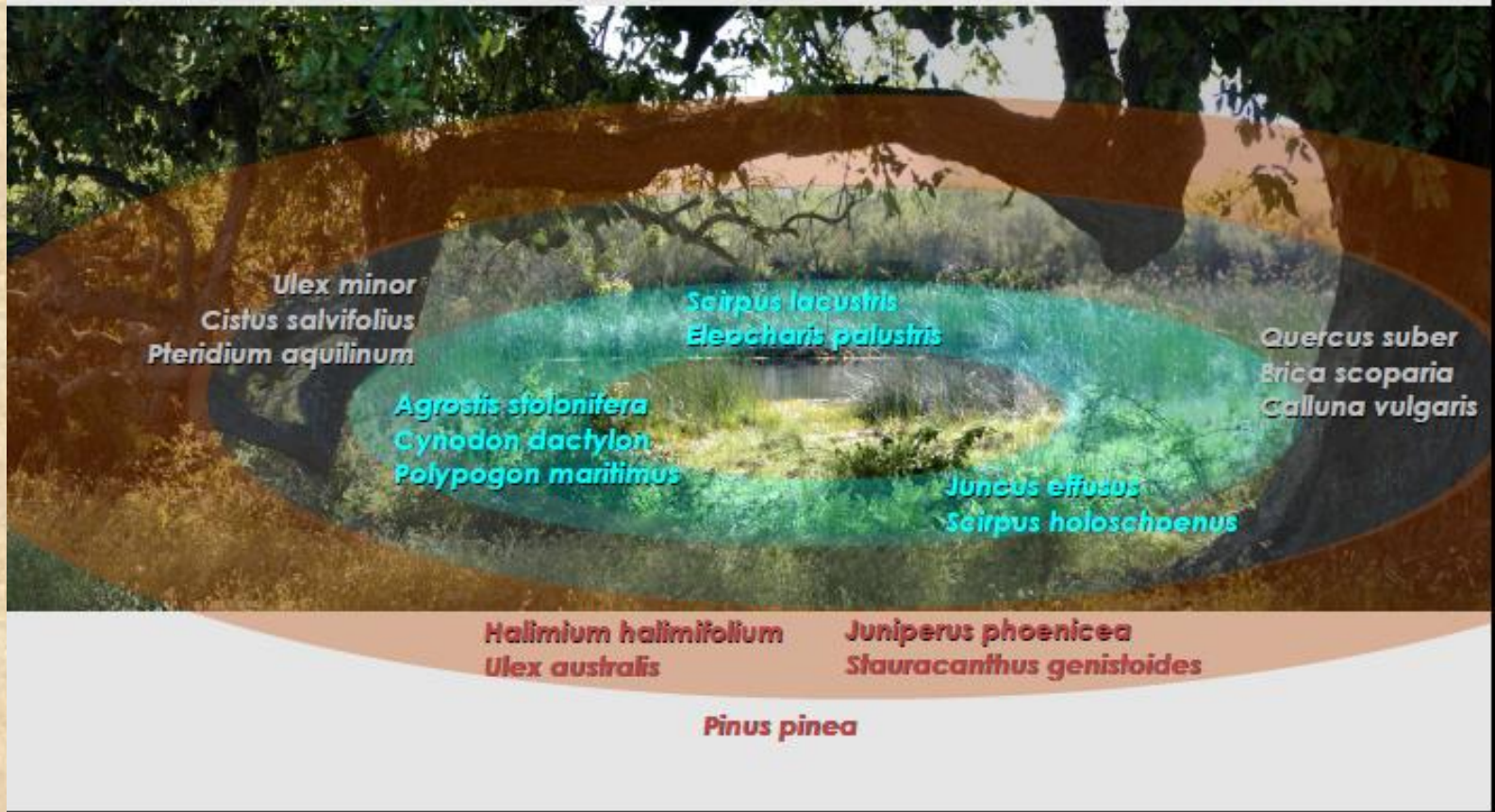


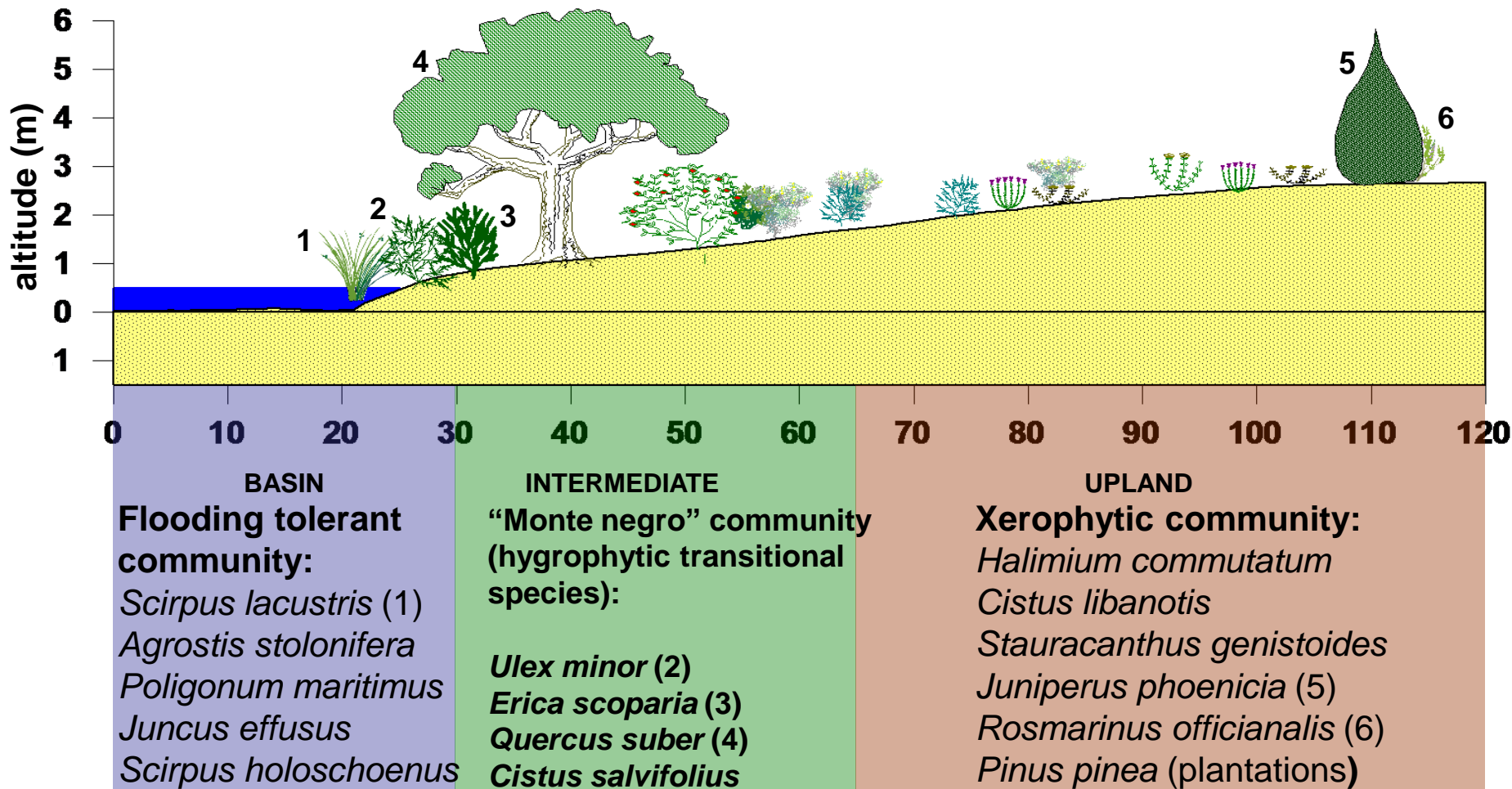
## Pond vegetation pattern

**Inner ring**  
seasonal flooding  
(wetland plants)

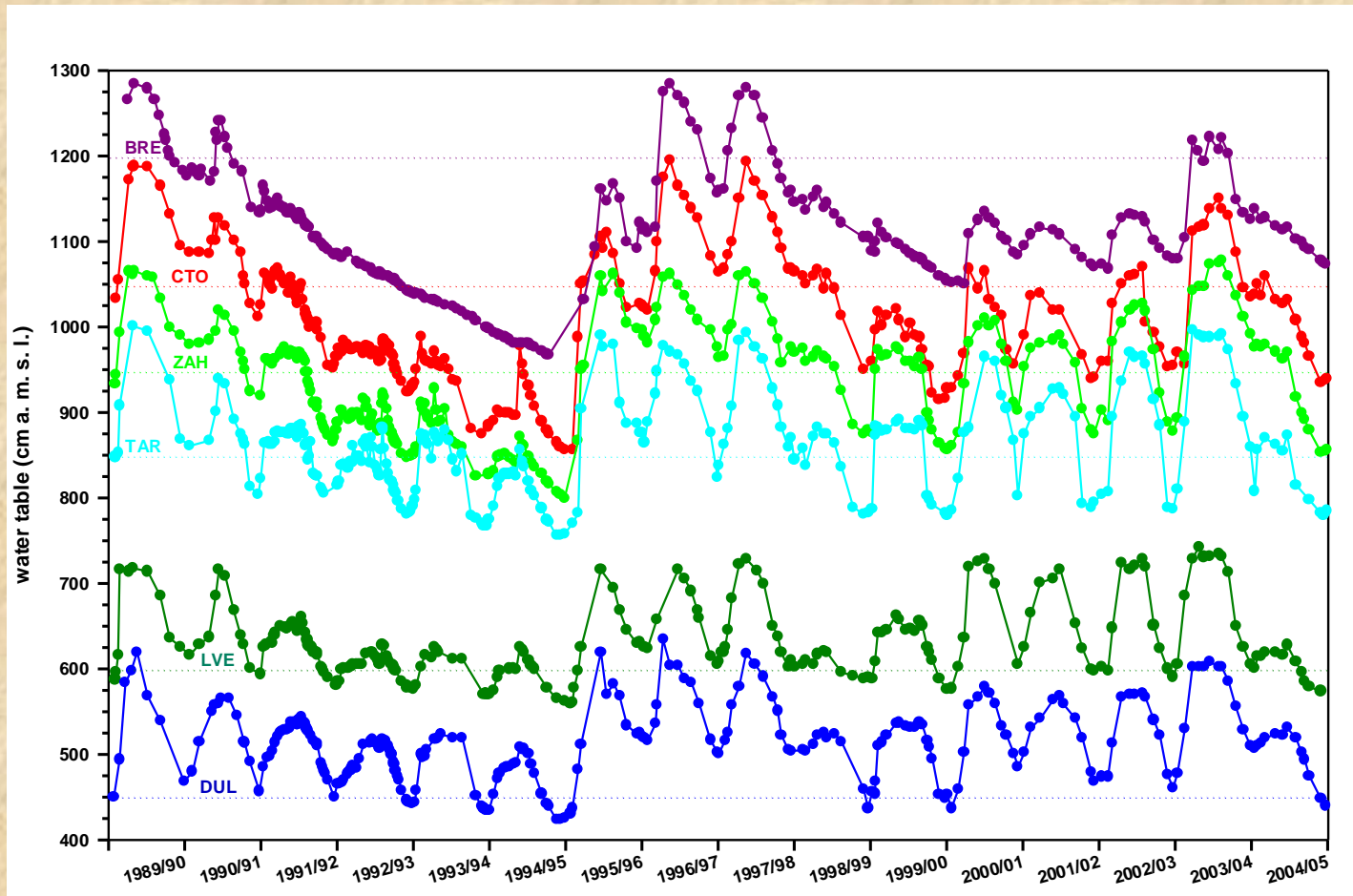
**Middle ring**  
flood-tolerant  
(heath)

**Outer ring**  
flood-intolerant  
(dry scrub)

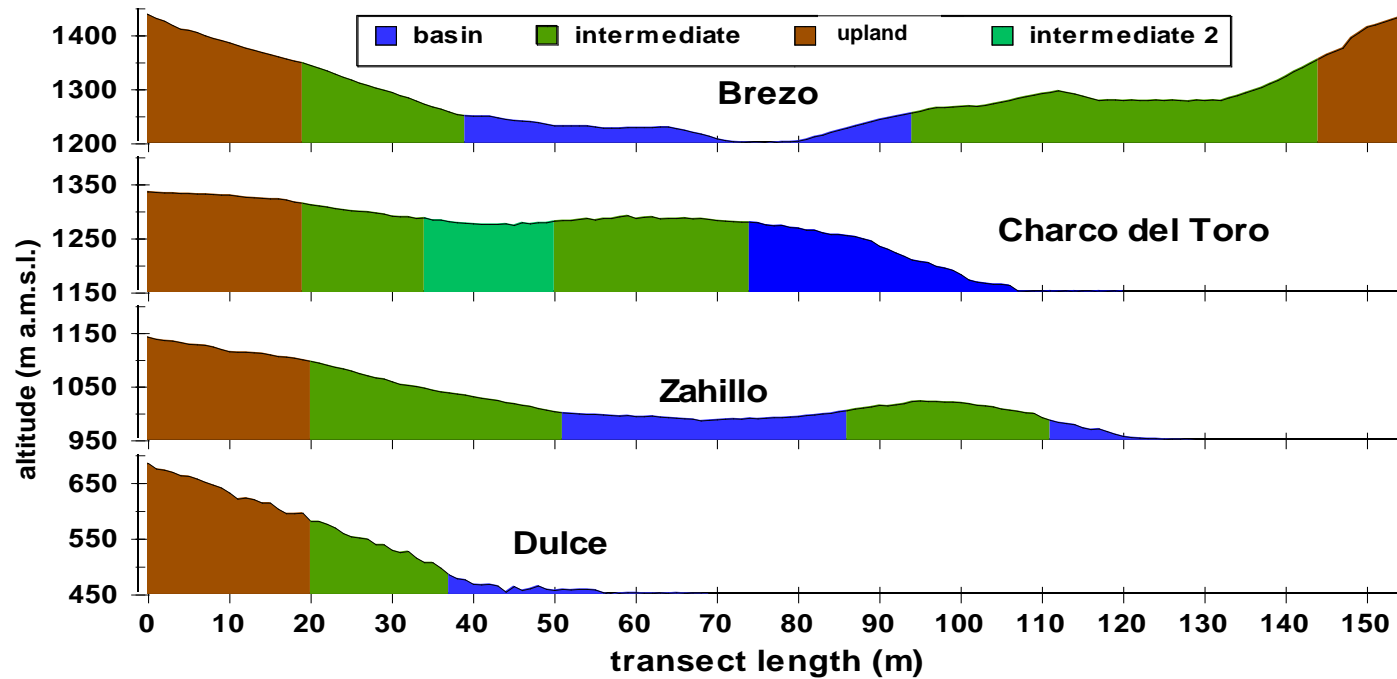




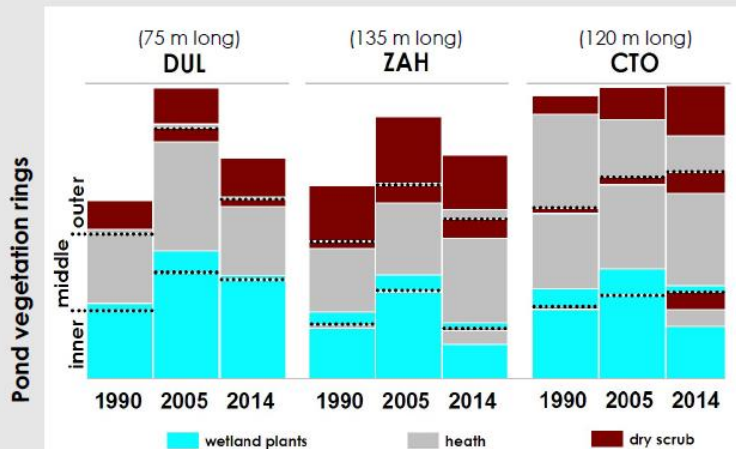
We have monitored water table depth in the dune ponds for 25 years.







Changes in plant cover of each ring in 3 ponds



Plant cover (%) did not change significantly from the expected ring pattern in DUL pond compared to the other ponds

Plant cover across the vegetation rings oscillate depending on annual rainfall

# Species physiological responses

- Following this gradient of xerophytic to hygrophytic sites depending on water availability we have monitored different physiological variables (LWP, chlorophyll fluorescence, leaf chlorophyll and proline content) in some woody species.
- We selected typical species of the xerophytic areas: *Juniperus phoenicea*, *Cistus libanotis*, *Rosmarinus officinalis*, *Lavandula stoechas*, *Halimium calyciniun*; species from the hygrophytic areas: *Erica scoparia*, *Cistus salvifolius*, *Myrtus communis*, *Pistacia lentiscus*. *Halimium halimifolium* is present across all the gradient of water availability.





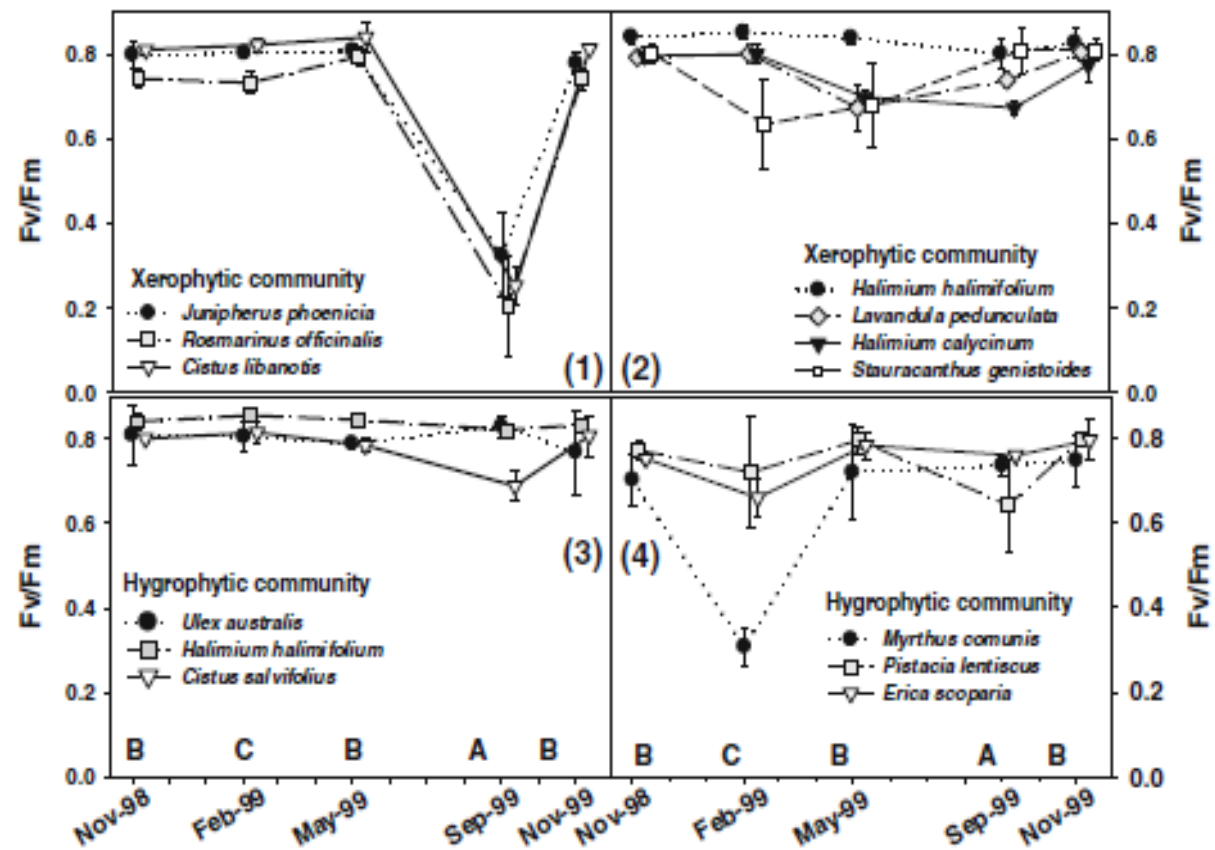






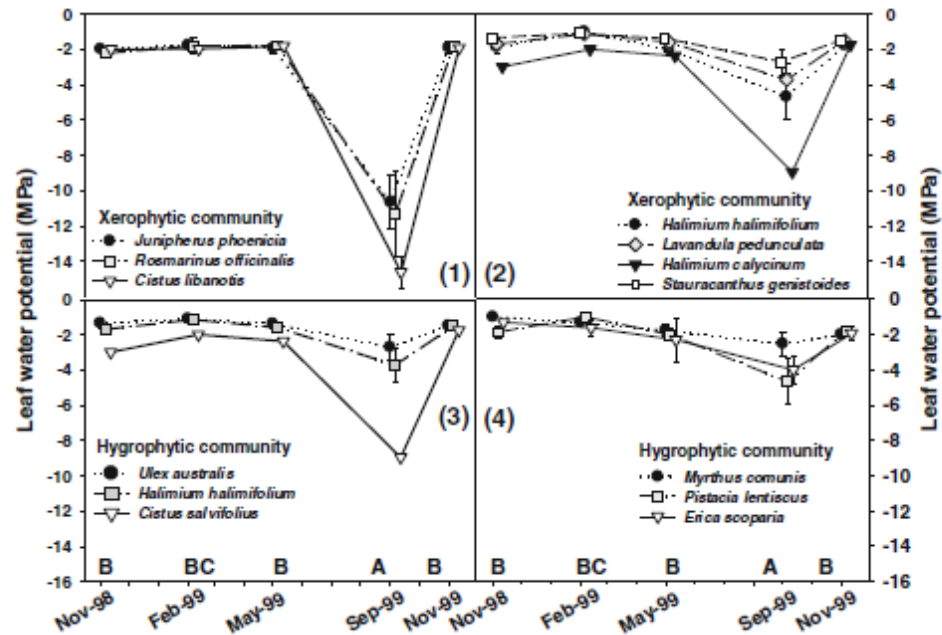
## Maximal photochemical efficiency Fv/Fm

**Fig. 2** Seasonal variations of mean maximal photochemical efficiency ( $F_v/F_m$ ) in all the study species in the xerophytic and the hygrophytic communities. Vertical bars indicate standard deviation and capital letters indicate significant differences between seasons



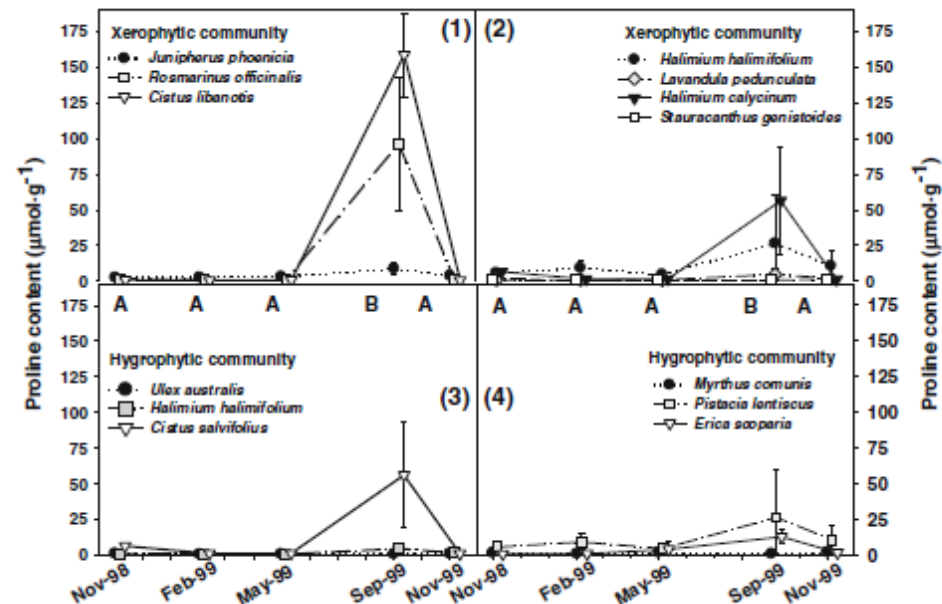
Zunzunegui et al. 2010. Seasonal physiological plasticity and recovery capacity after summer stress in Mediterranean scrub communities. *Plant Ecology*

**Fig. 4** Seasonal variations of mean leaf water potential (MPa) in all the study species in the xerophytic and the hygrophytic communities. Vertical bars indicate standard deviation and capital letters indicate significant differences between seasons



## Leaf Water Potential

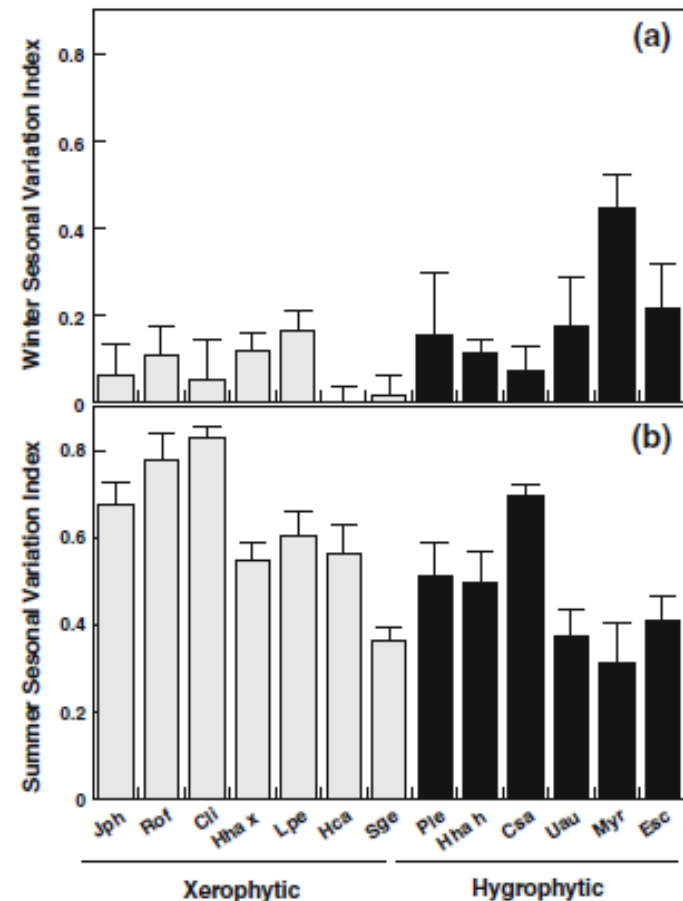
**Fig. 5** Seasonal variations of mean proline content ( $\mu\text{mol g}^{-1}$  dw) in all the study species in the xerophytic and in the hygrophytic communities. Vertical bars indicate standard deviation and capital letters indicate significant differences between seasons



## Leaf proline content



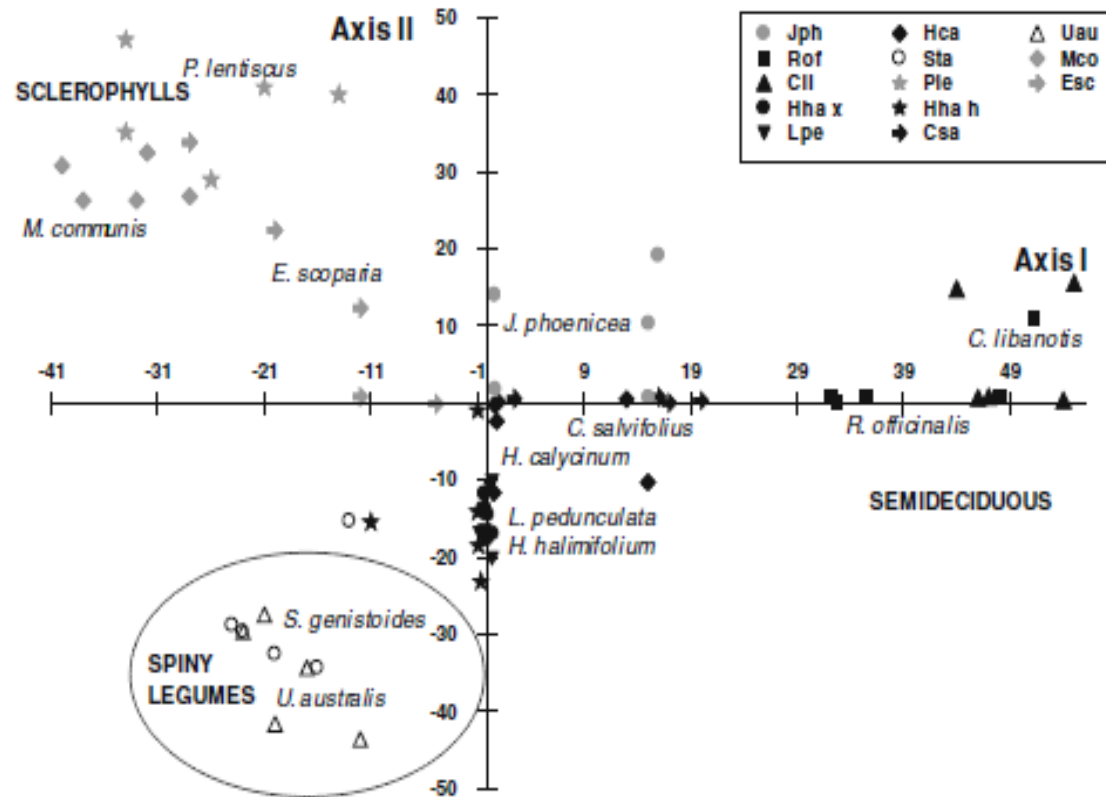
Mean Phenotypic  
Plasticity Index  
(Valladares et al. 2000)  
(M-m)/M



**Fig. 6** Mean phenotypic plasticity index values (+SD) per species to evaluate seasonal (summer and winter) physiological variability as the difference between autumn and summer or winter traits divided by the maximum value and average of up to 7 traits (PSII maximal photochemical efficiency, effective quantum yield, leaf water potential, leaf proline content, total carotenoids/chlorophyll ratio, chlorophyll *a/b* ratio and leaf total chlorophyll content). *Jph* *J. phoenicea*, *Rof* *R. officinalis*, *Cli* *C. libanotis*, *Hha x* *H. halimifolium* from xerophytic area; *Lpe* *L. pedunculata*, *Hca* *H. calycinum*, *Sge* *S. genistoides*, *Ple* *P. lentiscus*, *Hha h* *H. halimifolium* from hygrophytic area; *Csa* *C. salvifolius*, *Uau* *U. australis*, *Myr* *M. communis*, *Esc* *E. scoparia*

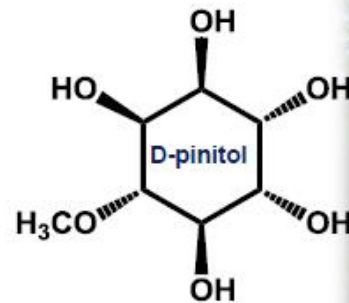
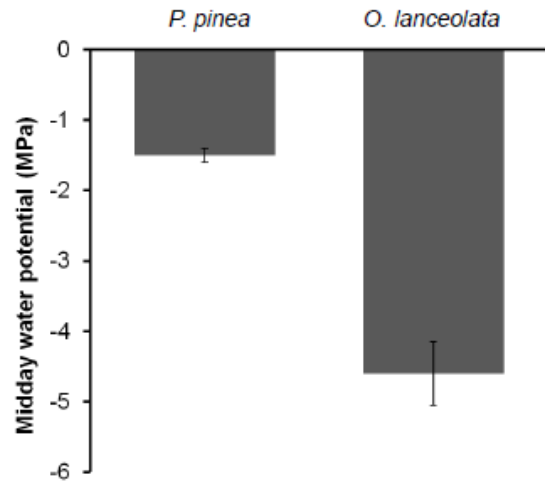
# Principal Component Analysis of plant traits

**Fig. 7** Principal Component Analysis (axes I and II) of the 65 individuals belonging to the different study species defined by their ecophysiological traits in the four seasons of the year. *Jph* *J. phoenicea*, *Rof* *R. officinalis*, *Cli* *C. libanotis*, *Hha x* *H. halimifolium* from xerophytic area; *Lpe* *L. pedunculata*, *Hca* *H. calycinum*, *Sge* *S. genistoides*, *Ple* *P. lentiscus*, *Hha h* *H. halimifolium* from hygrophytic area; *Csa* *C. salvifolius*, *Uau* *U. australis*, *Mco* *M. communis*, *Esc* *E. scoparia*





# The role of hemiparasitic plants, *Osyris lanceolata*



# Conclusions

- The sands of Doñana National Park exhibit a typical dune topography. This type of landscape originates charge and discharge areas of the aquifer at different spatial scales.
- The vegetation of the dunes follows this topography and around the temporal ponds is organized in concentric belts.
- The scrub species of each belt present different physiological strategies to face the environmental stresses of mediterranean climate, but avoiders and tolerants can coexist in the same area.
- Some species exhibit other strategies, as the scrub *Osyris lanceolata*. It is an hemiparasitic species and is able to obtain water and minerals from other species as *Pinus* and *Juniperus*.
- The existence of different geomorphological units and the variety of strategies within the species allow the diversity of plant communities present in Doñana sands.





Thank you very much for your  
attention