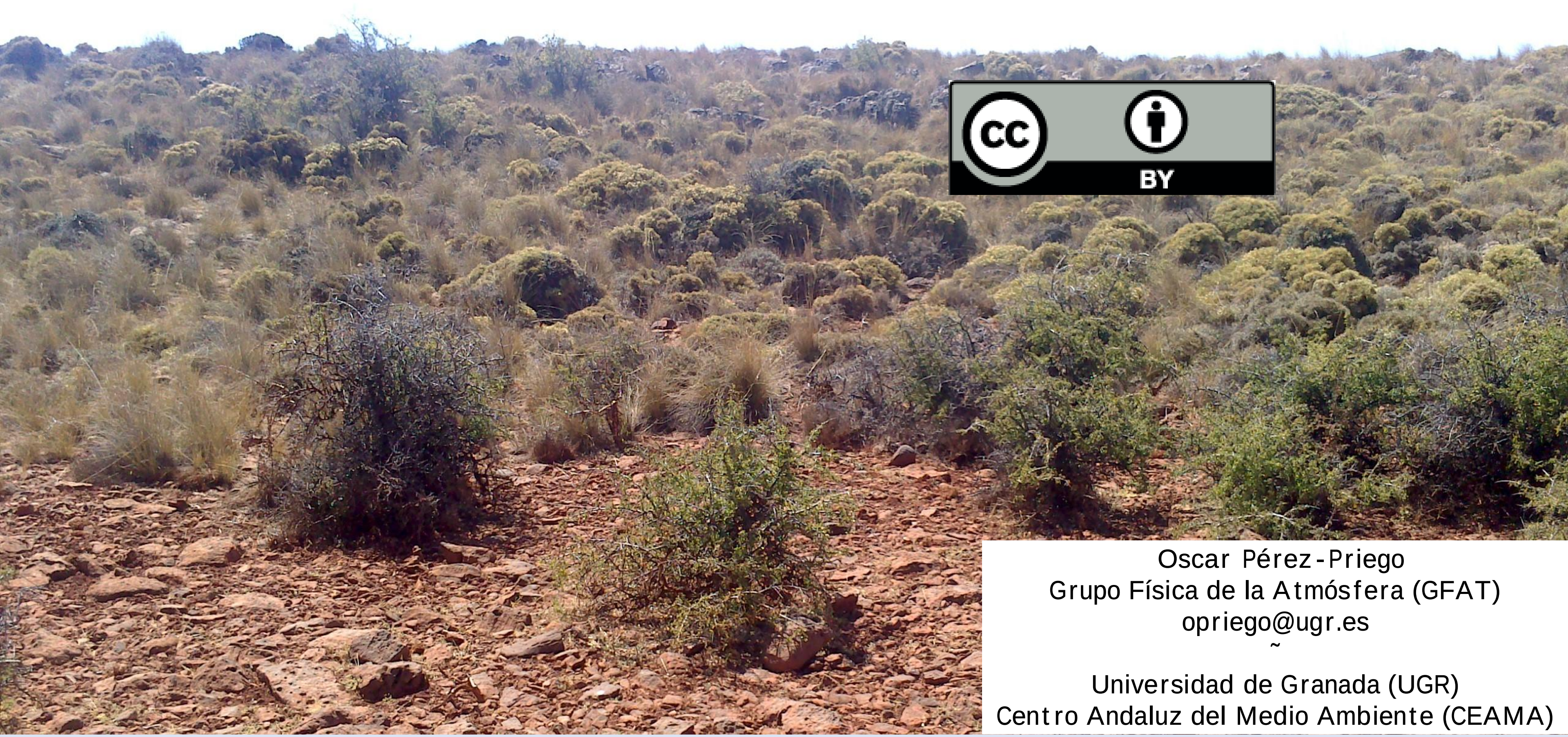
Water use efficiency and functional traits of a semiarid shrubland



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Introduction

Max. CO_2 assimilation

Min. Water lost

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•In semiarid climates, water is the fundamental factor determining ecosystem productivity and thereby the capacity for carbon sequestration.

•Increased water use efficiency (WUE), the ratio of carbon assimilation (photosynthesis) to water transpired (transpiration), is assumed to be an adaptive strategy for sclerophyll shrublands to improve stress resistance in drylands.

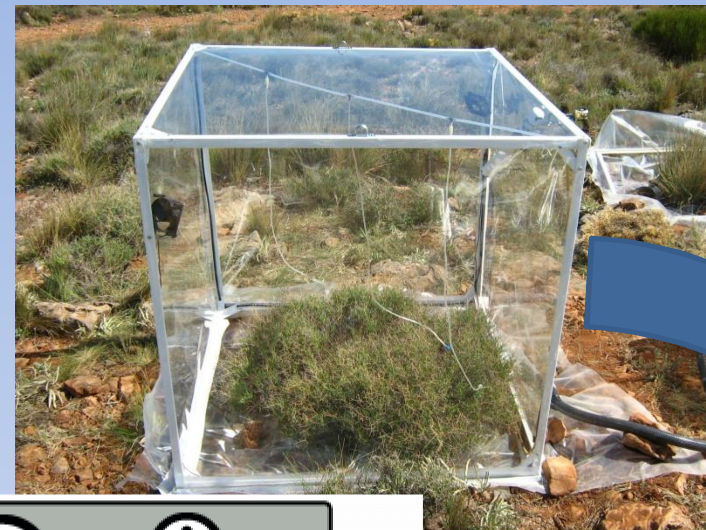
•Although, high WUE is often related to low such a relationship may vary among species and/or environmental conditions.

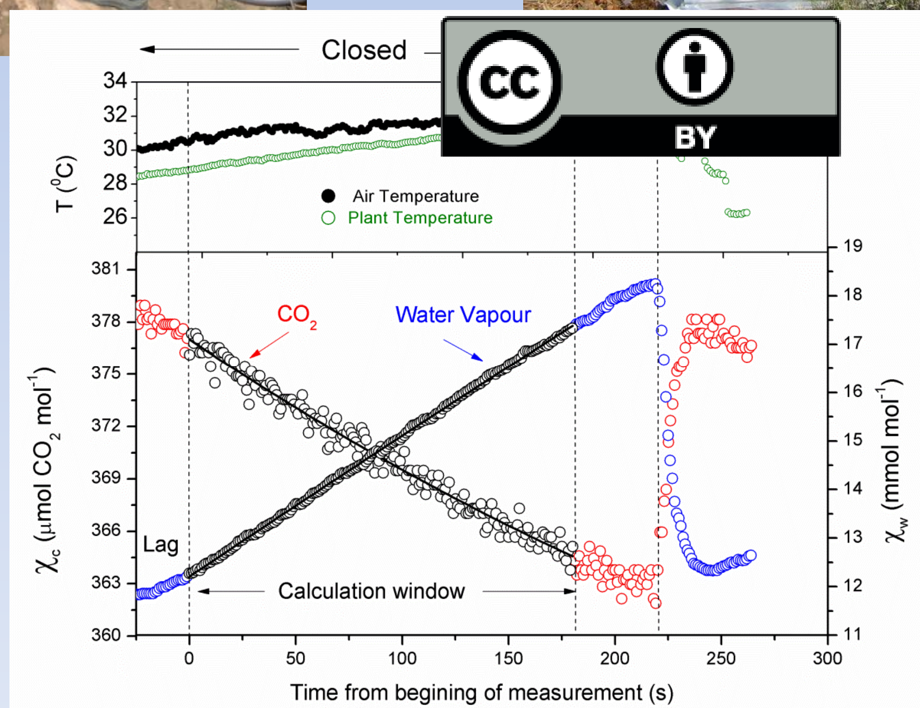
•WUE is usually determined using instantaneous measurements of leaf gas exchange in sunny and non-senescent leaves.

•However, leaf level measurements of photosynthesis and transpiration do not always represent the whole plant carbon and water balance (Medrano *et al*., 2012), and large discrepancies between leaf WUE and plant WUE are found (Poni *et al*., 2009).

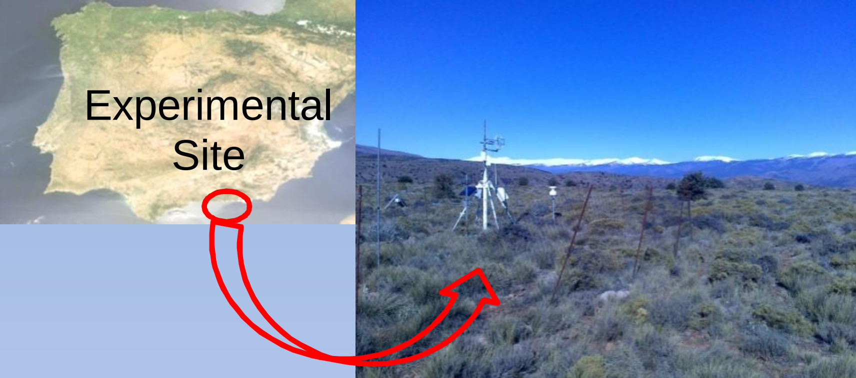
Whole-plant scale measurements are needed ¡¡

Measurement of canopy CO_2 and water vapour fluxes using a transient-state closed chambers

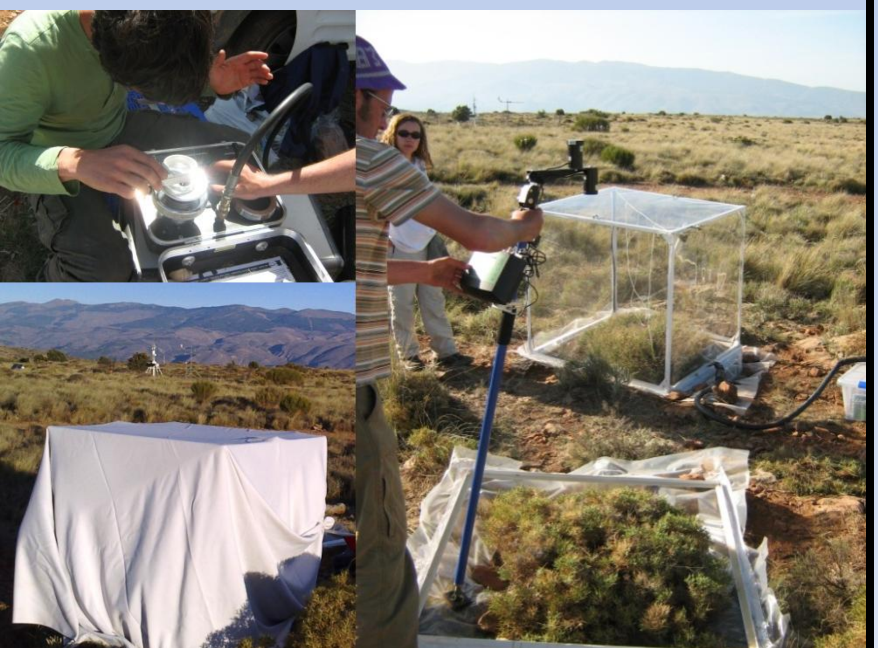




Pérez-Priego et al., 2010, Env. Exp. Botany, 68, 131-138



Sites:	El llano de los Juanes, Almería
Elevation (m)	1600
Vegetation covered (%)	50



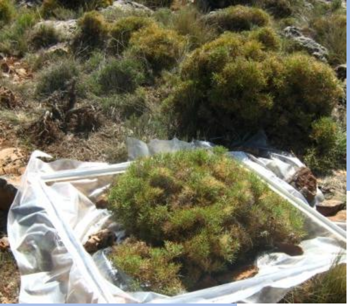
(475 mm)

mostly occur in spring and in autumn.

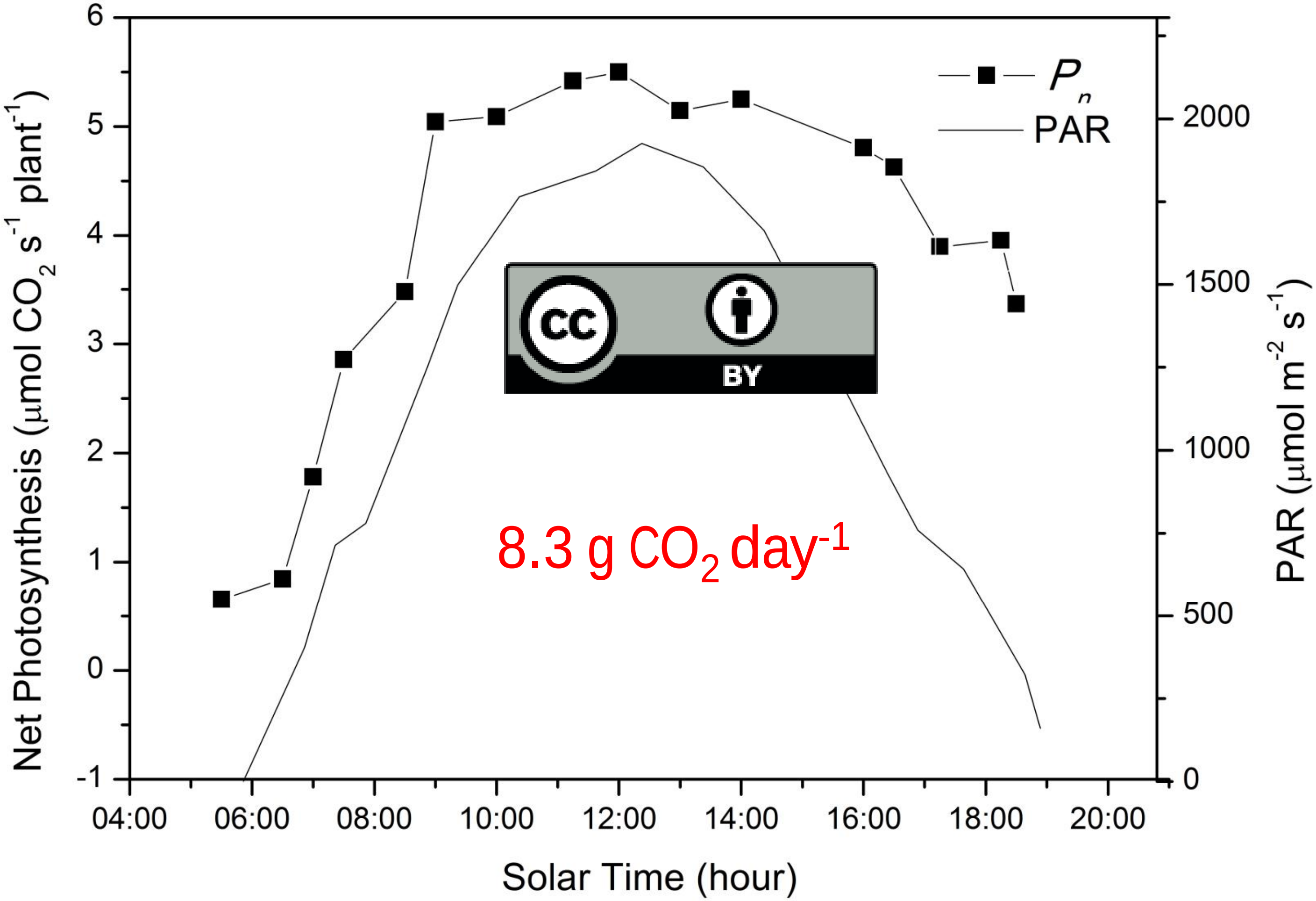
Objective:

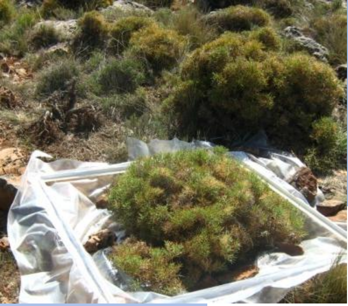
Evaluate physiological and environmental regulation of whole plant water-use efficiency (WUE) in the field.

Growing period (May 2012)

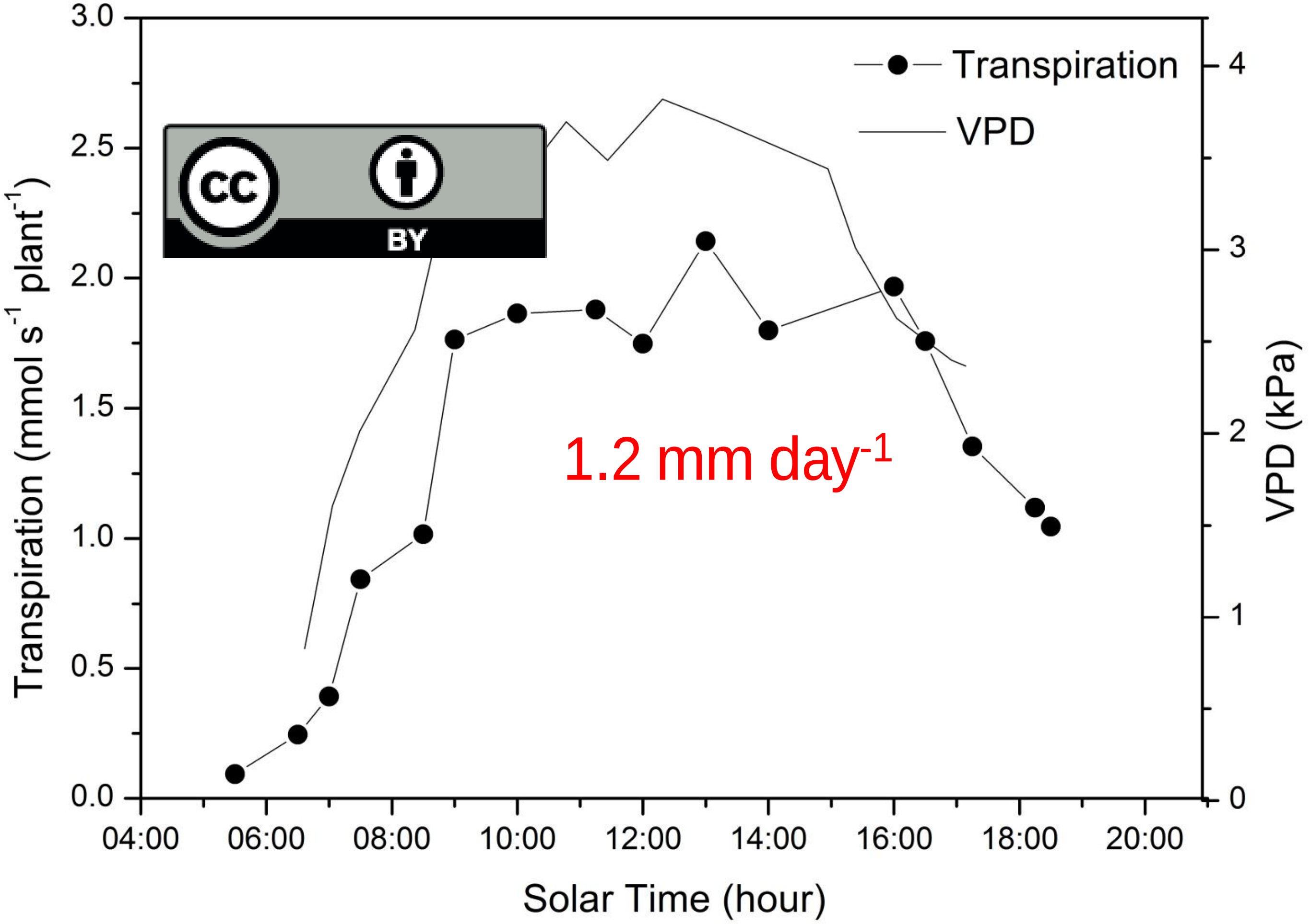


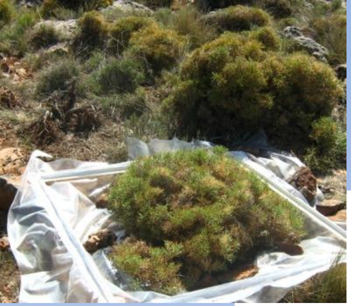
Typical diurnal time course of photosynthesis during growing period *Hormatophylla* sp.



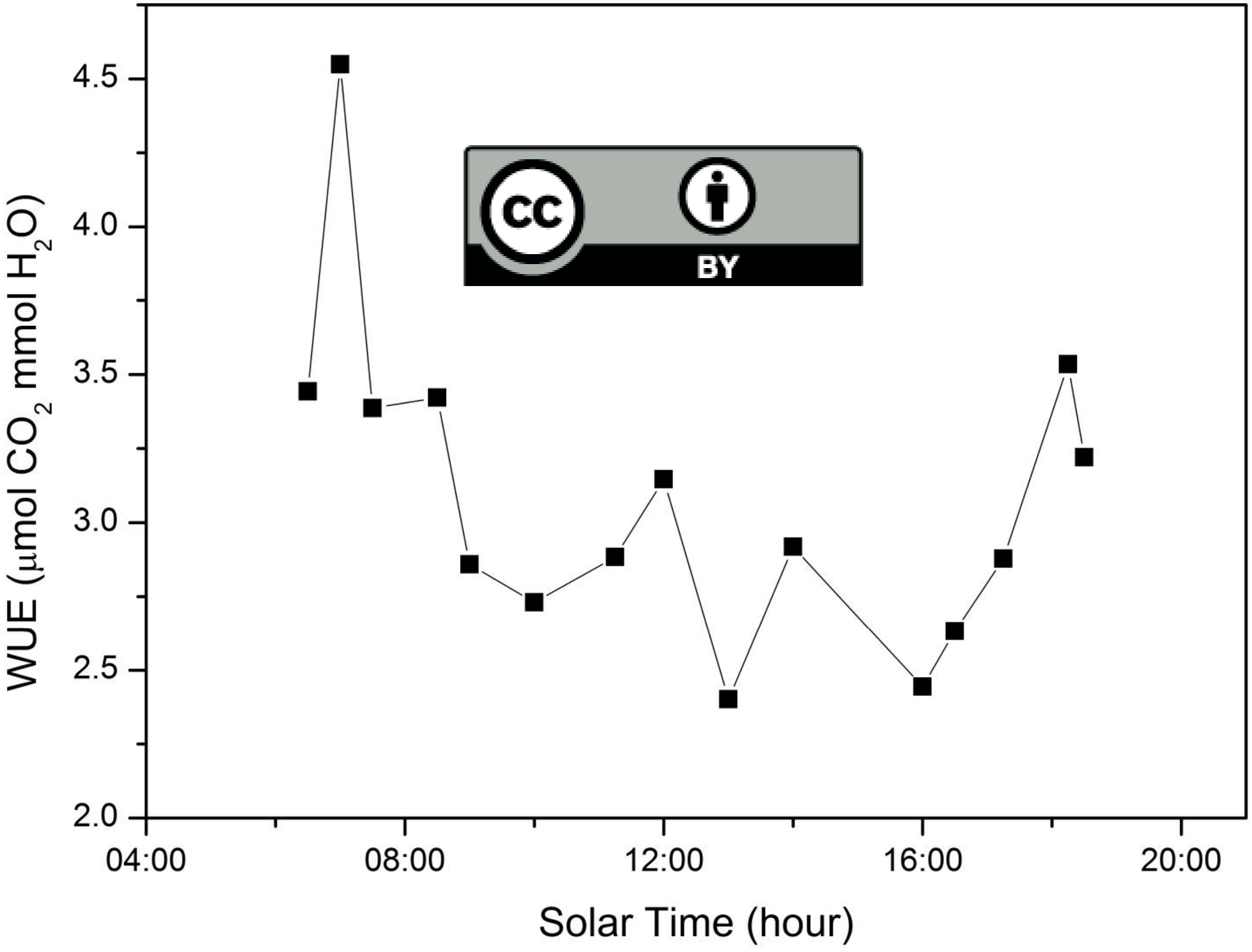


Typical diurnal time course of Transpiration during growing period *Hormatophylla* sp.



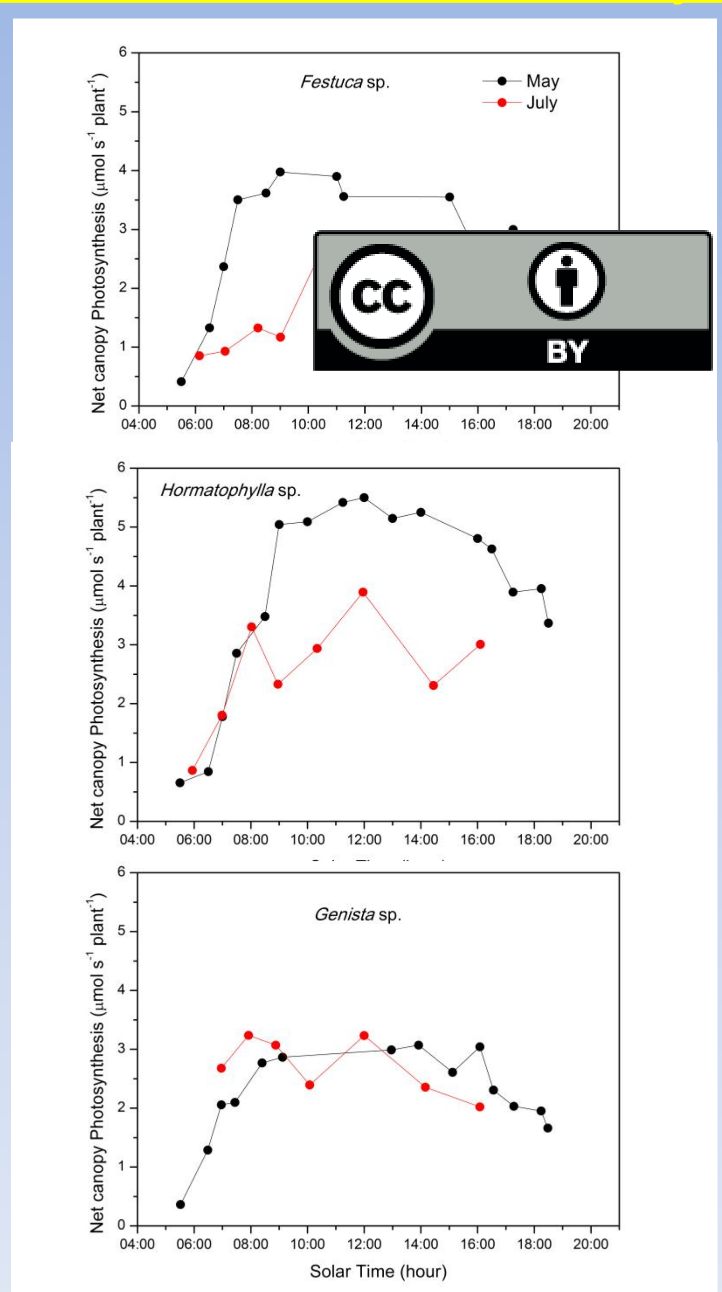


Typical diurnal time course of Water-Use Efficiency during growing period *Hormatophylla* sp.



Drought conditions (July 2012)

Effect of water stress on Photosynthesis



Water Potential & Leaf area

Ψ= -2.8 MPa, LA=1.2 m^2

Ψ= -7.9 MPa, , LA=0.8 m^2

Water Potential & Leaf area

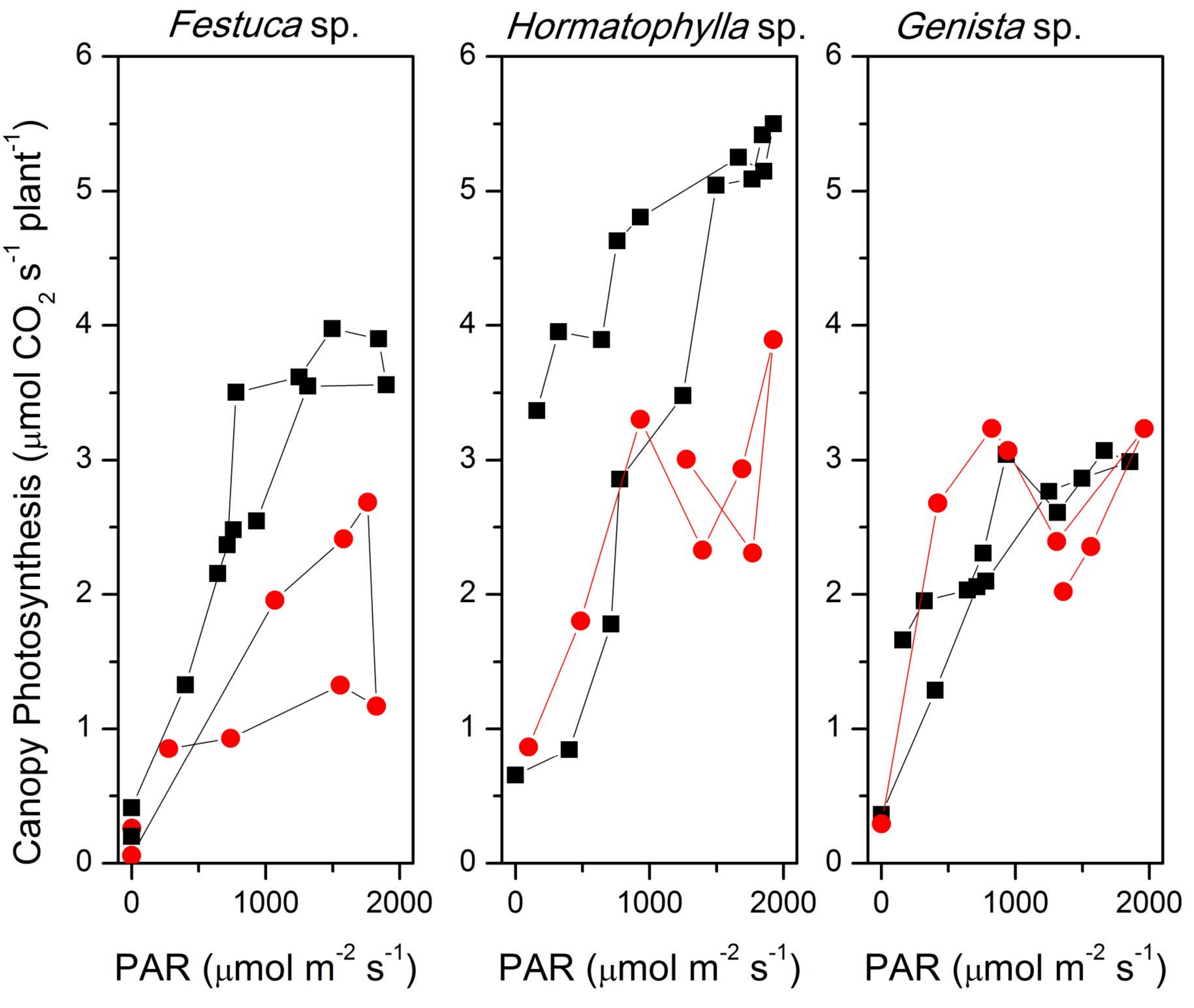
Ψ= -3.3 MPa, LA=2.1 m^2

Ψ= -4.6 MPa, , LA=2.1 m^2

Water Potential & Leaf area

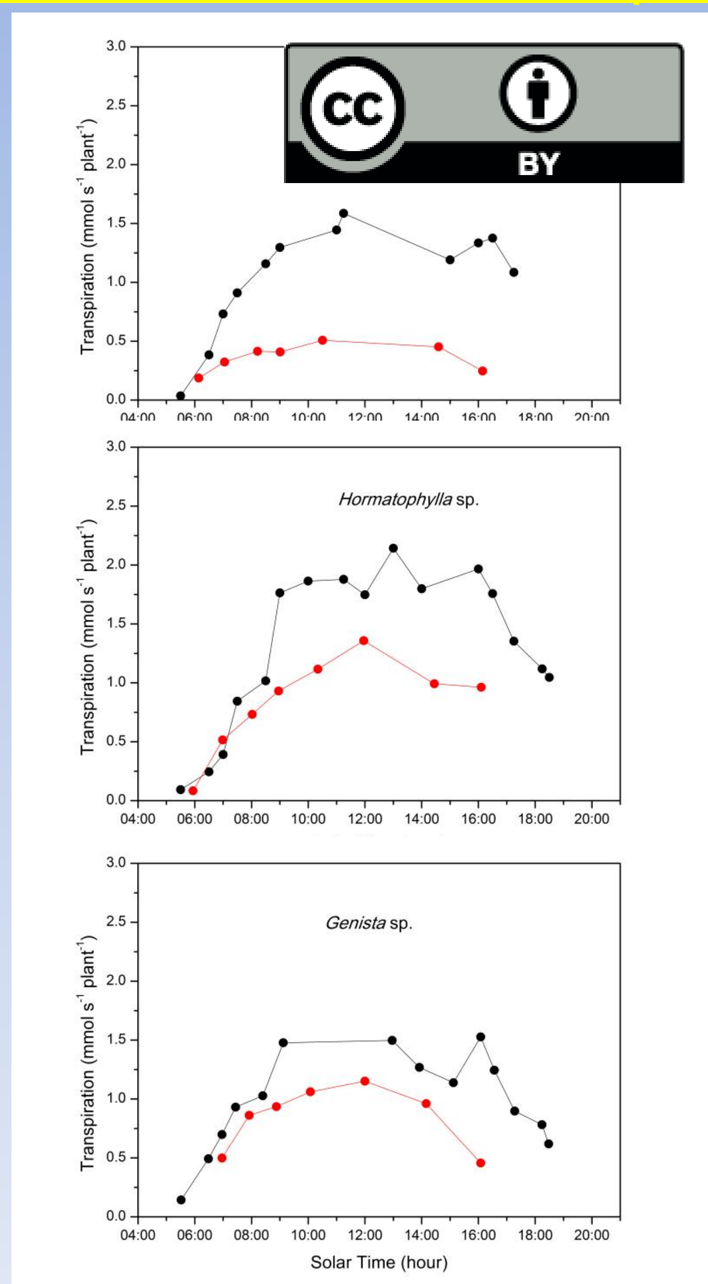
Ψ= -2.1 MPa, LA=1.7 m^2

Ψ= -3.5 MPa, , LA=1.6 m^2



Festuca sp.
Hormatophylla sp.
Genista sp.
Canopy Photosynthesis (μmol CO2 s-1 plant-1)
0
1
2
3
4
5
6
0
1000
2000
PAR (μmol m-2 s-1)

Effect of water stress on Transpiration



Water Potential & Leaf area

Ψ= -2.8 MPa, LA=1.2 m^2

Ψ= -7.9 MPa, , LA=0.8 m^2

Water Potential & Leaf area

Ψ= -3.3 MPa, LA=2.1 m^2

Ψ= -4.6 MPa, , LA=2.1 m^2

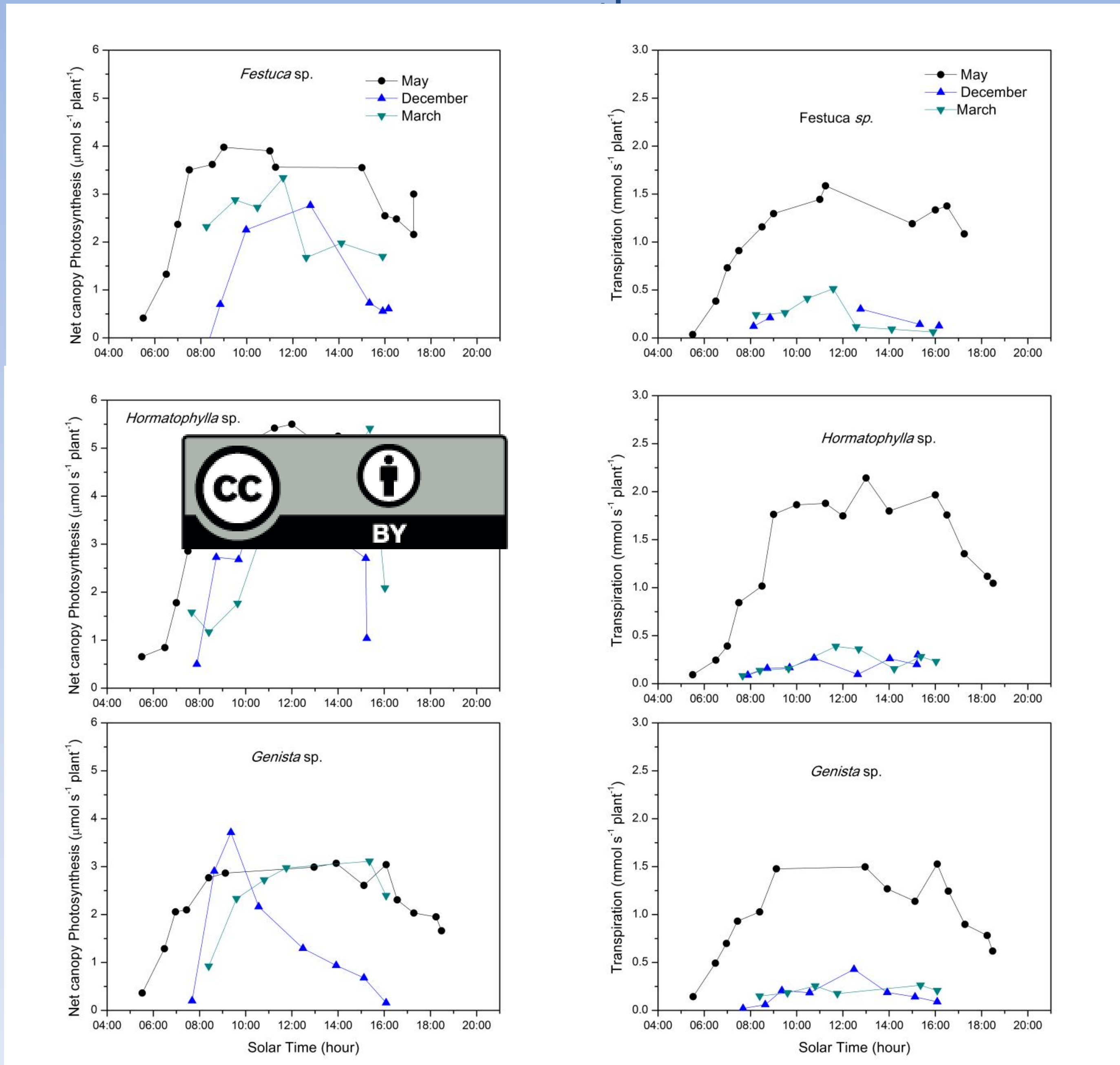
Water Potential & Leaf area

Ψ= -2.1 MPa, LA=1.7 m^2

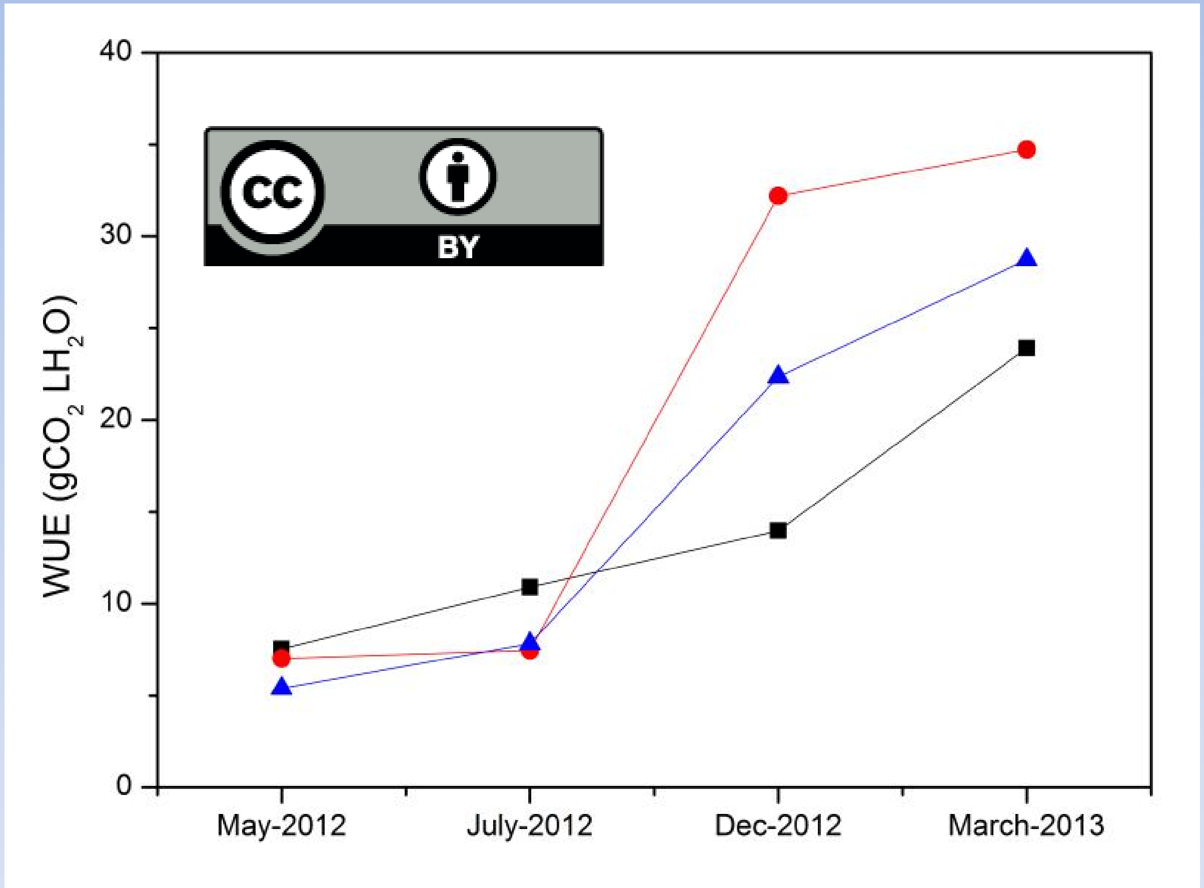
Ψ= -3.5 MPa, , LA=1.6 m^2

Autumn and Winter time
(December 2012 and March 2013)

Temperature and light limitation during winter



Seasonal time courses of Water-Use efficiency



Conclusions

1. Differing water use strategies and ecological functions
   1. Summer:
      1. Grasses (*Festuca* sp.) water potential values as low as -7.9 MPa reduce both photosynthesis and transpiration rates.
      2. Shrubs (*Hormatophylla* sp. and *Genista* sp.) showed moderate drought effects.
   2. After autumn rains, ecosystem functioning is recovered (but light and temperature limitations).

2. WUE is strongly dependent on bot[illegible]ant Vs. leaf level) and time-scale considered (daily *Vs.* hourly). This chamber design is as a valuable tool to study whole plant carbon and water budgets.

3. Overall, drought had a small impact on plant WUE among species (May and July similar). However, the recovering of carbon assimilation after autumn rainfall and the strong reduction of transpiration by low VPD caused a drastic increase in WUE in Winter.

4. The positive response of WUE to long drought periods and cool winter explains the sustainability of this ecosystem under such limiting environmental conditions. Measurements of carbon assimilation in individual plants with the chamber revealed the high capacity of shrub canopies for carbon sequestration.

Measurement of carbon and water balances of semiarid scrubs using transient-state closed chambers

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Introduction

· Physiological knowledge of species is crucial to allow proper management of natural resources and to **quantify the different processes determining the carbon and water balances of an ecosystem**.

· Most techniques do not accomplish this task at adequate spatial sc

· Whole-plant scale measurements are needed.

· In this work, we present a methodological description of a **tran** **chamber** which is used to measure the carbon and water vapour level.

Conclusions

· **System viability** is demonstrated by linear changes in gas molar fractions and minimal variations of environmental conditions inside the closed system.

· Transient-state closed chamber technique allow the **characterization of** **strategies** of species, which are significant in **water-limited** ch as semiarid scrublands.

chamber systems with methods such, as eddy covariance or leaf- is **possible to quantify ecosystem carbon and water balances**,

Chamber description

The chamber consists of a 1 m3 cubic aluminum frame structure overlaid with a Llumar® "NRS90 clear" polyester film (90% radiation transmissivity) **(Fig. 1)**. An angled 1m² - metal collar-frame is installed around each plant to which the bottom of the chamber is tightly sealed. **Fluxes from the soil are excluded** by putting a thick plastic around the plant.

Supplementary chamber instrumentation: ventilation system, PAR sensor (Li-190, Li-Cor, Lincoln, NE, USA), thermocouple and infrared thermometer (IRTS-P, Apogee, UT, USA) to measure air and plant temperatures, respectively.

Fig. 1. Picture of the chamber measuring in "Llano de los Juanes "(Sierra de Gádor, Almería, Spain). **(a)** Net canopy photosynthesis measurement and **(b)** Above-ground respiration measurement. In the latter, an **opaque material** covers all the chamber surface, **leading to darkness conditions.**

Chamber Operation

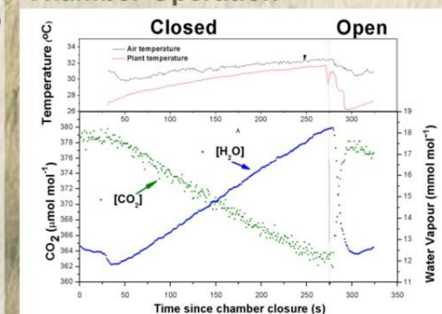

Fig. 2. Changes recorded in CO_2 and water vapour molar fractions (ref. dry air) **and chamber environmental variables** (air and plant temperature) **during the closure**.

The chamber operates as a closed system: a small pump circulates an air flow of 1 $Lmin^{-1}$ through the sampling circuit, to an IRGA (LI-840, Lincoln, NE, USA) which measures CO_2 and water vapour molar fractions (ref. dry air) at 1 Hz, and is then returned to the chamber. The ventilation system homogenize the air inside the system.

Rates of A_c, T_c and R_c are calculated from the initial (1 min.) slopes of molar fractions of the confined air (versus time) generated by gas exchanges **(Fig. 3)**. Flux corrections were performed following the procedure proposed by Pérez-Priego *et al.*, 2010, Env. Exp. Botany, 68, 131-138.

Chamber tests: leakage had a minimal impact on flux calculations (**0.9 % min^{-1}**), and chamber´s walls adsorption of water was not detected. **Maximum increases** in **air and plant temperature** were **0.6 ºC min^{-1}** and **0.9 ºC min^{-1}**, respectively. Dilution effect was corrected.

Results

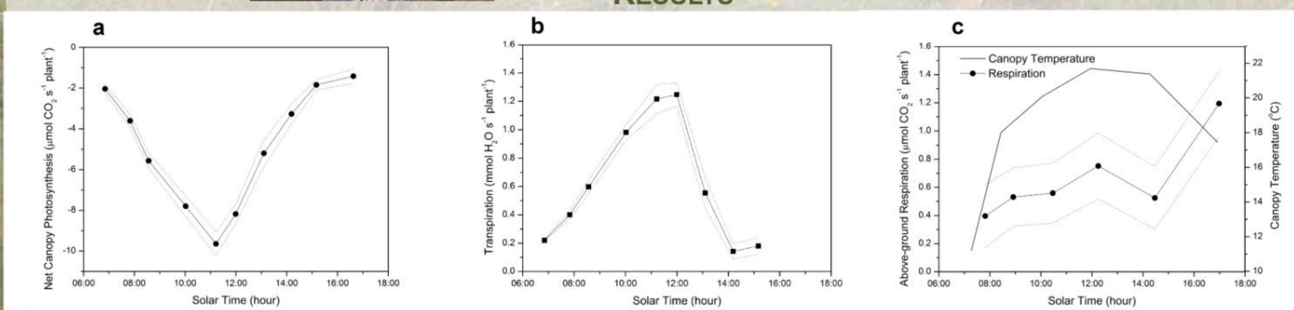

Fig. 3. Diurnal patterns of **(a)** net canopy photosynthesis, P_c; **(b)** transpiration, T_c, and **(c)** above-ground respiration, R_c (continuous line) and canopy temperature, T_c (dotted line) for *Stipa tenacissima* on 15th March 2013 in "Balsablanca" (Almería, Spain).

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Thanks

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