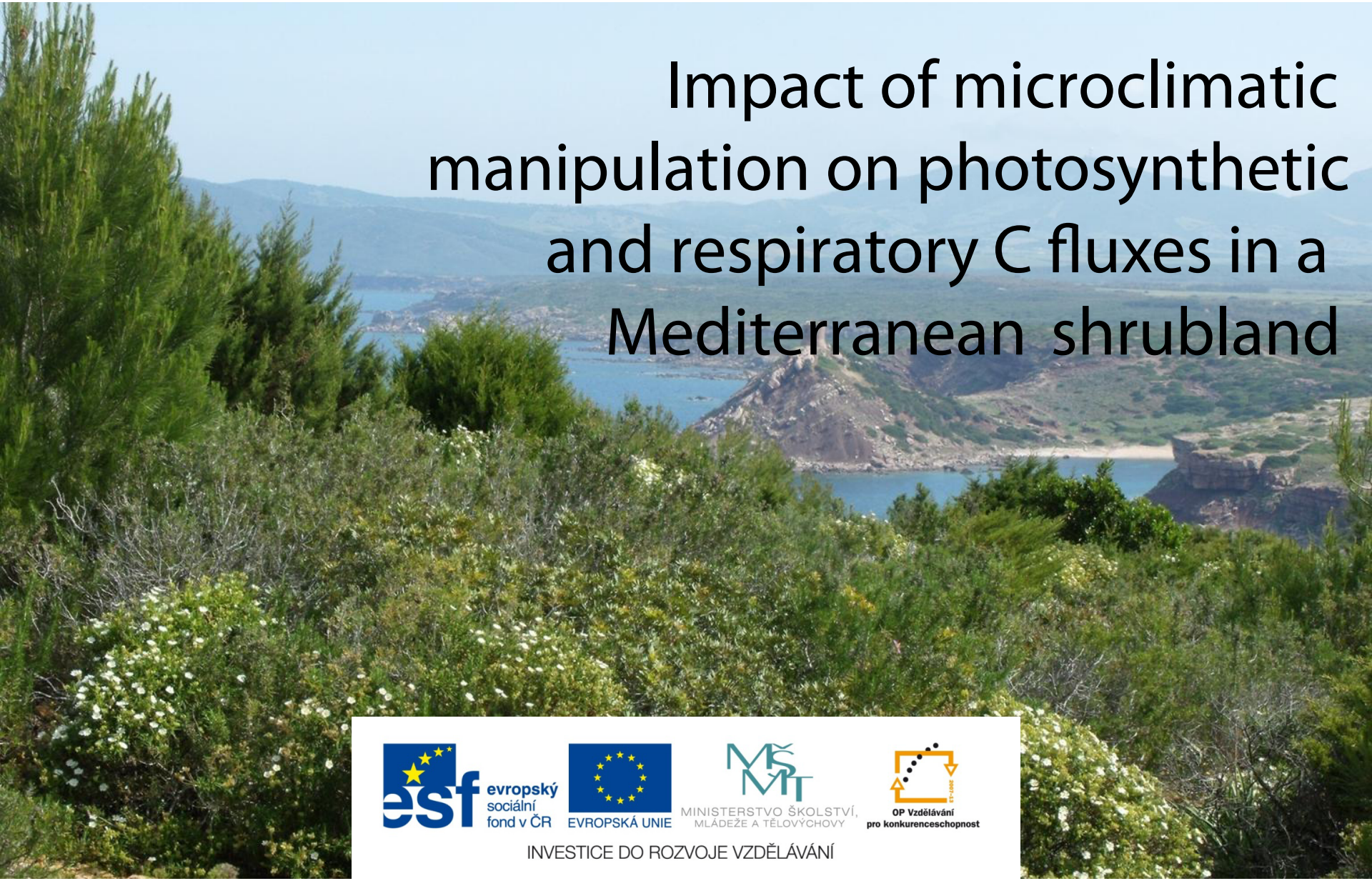
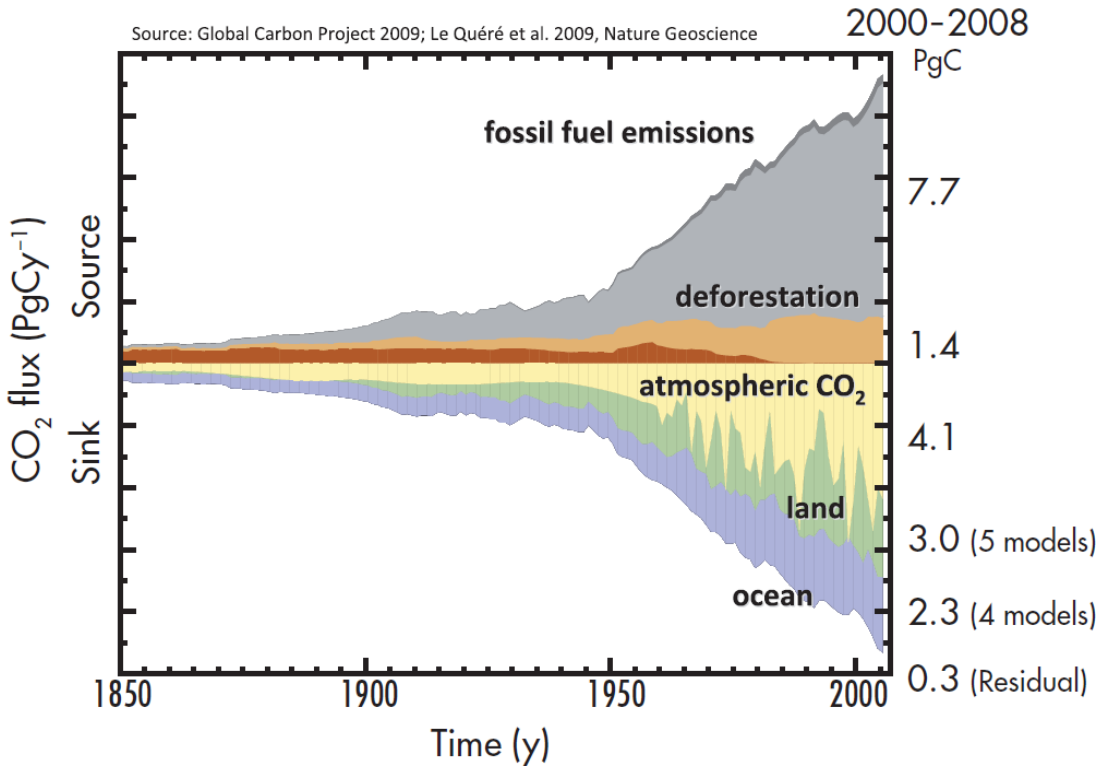


Impact of microclimatic manipulation on photosynthetic and respiratory C fluxes in a Mediterranean shrubland

Gabriele Guidolotti

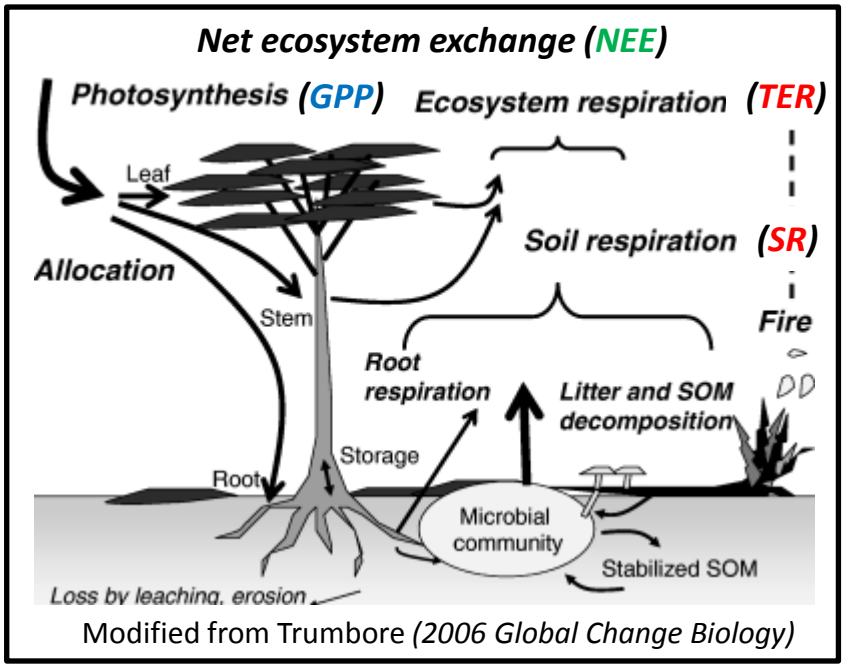
Climate Change and Carbon Cycle



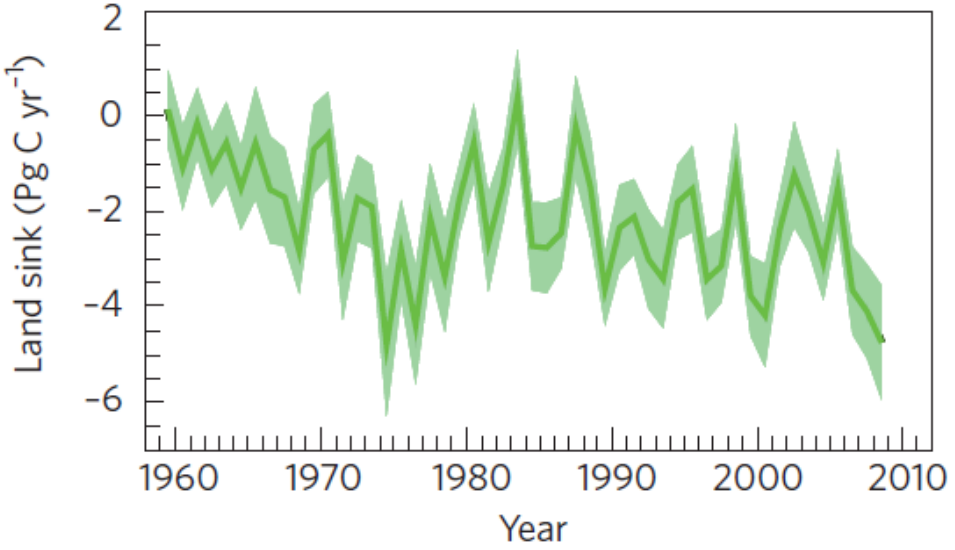
- Human activities ≈ 9,9 Pg C yr^{-1} (2008)
- On average (1959-2008) il 43% emitted CO_2 stay in the atmosphere
- During 2000-2008 terrestrial ecosystem absorbed 29% (4.1 Pg c yr^{-1}) of anthropic emission

Source: *Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience*

Climate Change and Carbon Cycle

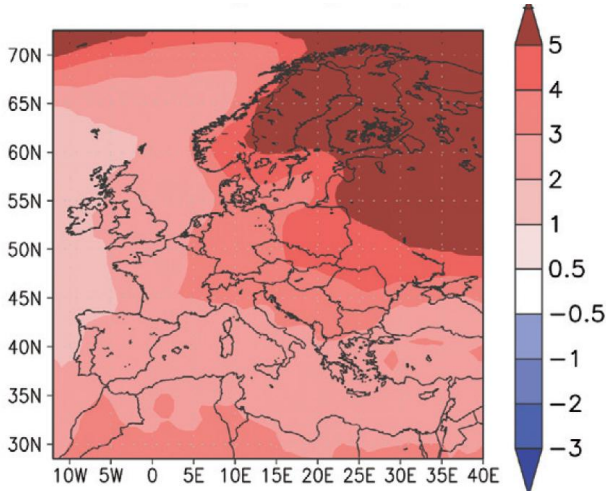


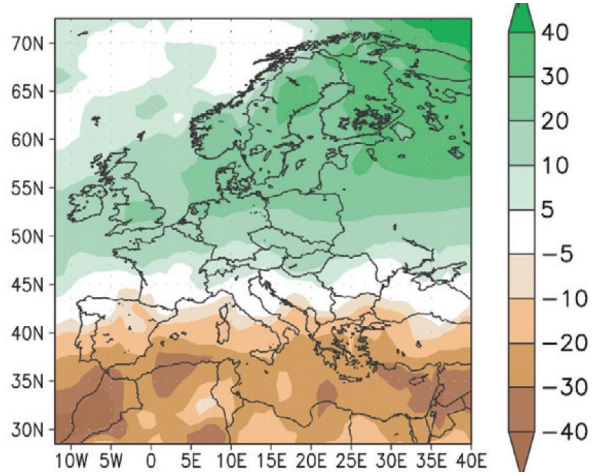
Modified from Trumbore *(2006 Global Change Biology)*



The sink capacity of terrestrial ecosystem oscillate probably as a function of climate change and variability *(Le Quéré et al. 2009 Nature Geoscience).*

Climate Change and Carbon Cycle





- 0.74 °C 20th century temperature increase
- Future forecasted 1.1 - 6.4 °C

- About 20% Reduction precipitation in Mediterranean area

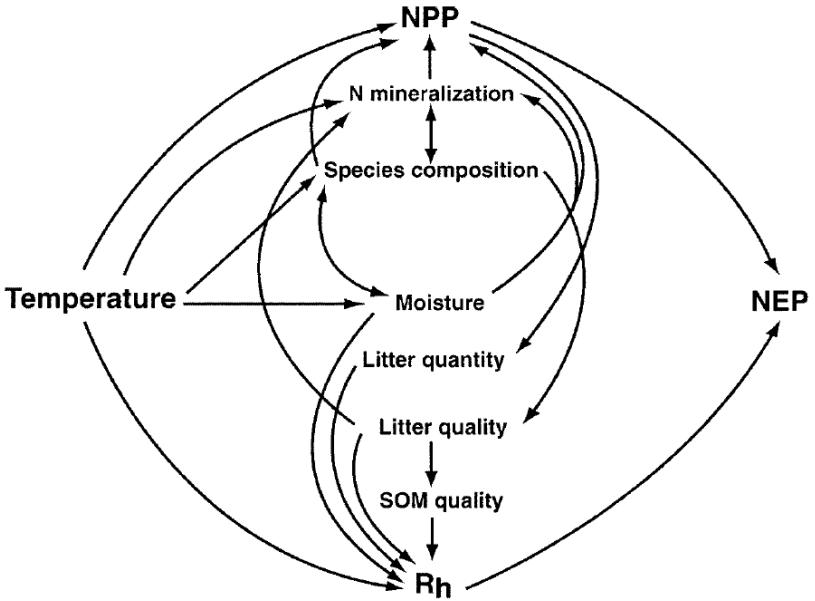
Source: Giorgi *et al.* (2009 *Geophysical Research Letter*)

Climate Change effects on terrestrial ecosystems

TEMPERATURE INCREASE *(WARMING)*

Warming is a continuous disturbance regulating both photosynthetic and respiratory processes directly and indirectly with:

- **Growing season length** (Churkina *et al*. 2005)
- **Increasing N mineralization and availability** (Rustad *et al.* 2001; Sardans *et al.* 2006)
- **Changing the plant specific composition** (Weltzin *et al.* 2003).



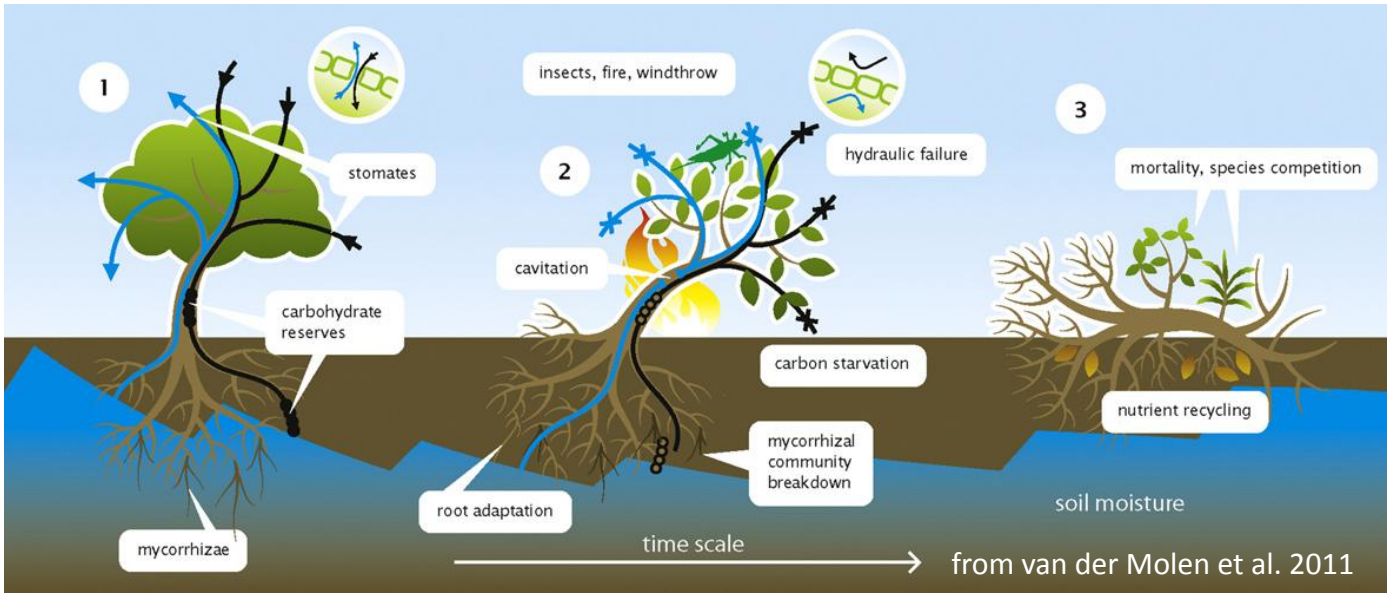
from Sharved et al. 2000

Climate Change effects on terrestrial ecosystems

PRECIPITATION REDUCTION (DROUGHT)

Drought can be considered as an intermittent disturbance reducing both Photosynthesis and Total Ecosystem Respiration (Cias et al. 2005; Granier et al. 2007; Reichstein et al. 2007)

-GPP reduction depends from both physiological (stomata) and morphological (leaf area, mortality) traits (van der Molen et al. 2011)
- TER reduction depends from both soil microorganism inhibition and substrate availability limitation (Hogberg & Read 2006).



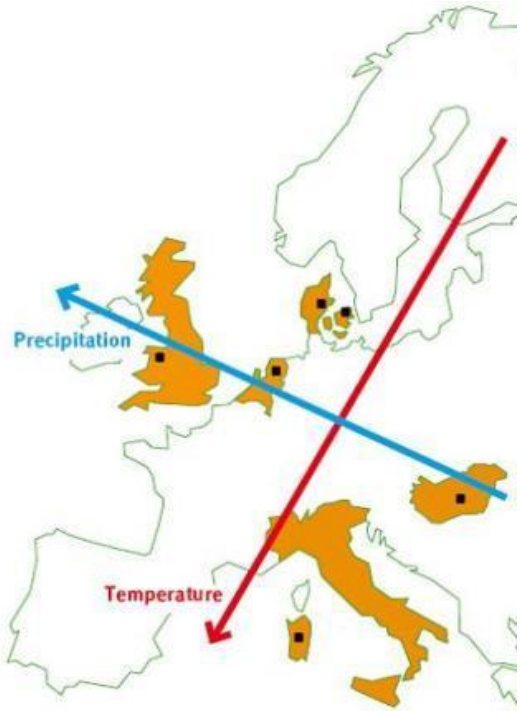
from van der Molen et al. 2011

Arid and semi-arid woody shrublands

- 35% of the global terrestrial surface area (Asner et al.2003)
- 24% of the global organic carbon (Atjay et al.1979)
- 16% of the global aboveground biomass (Shmida et al.1985)

Despite their potential impact on the global carbon balance, these ecosystems and their responses to climate change are still poorly studied.

Climatic Manipulation and the increase network

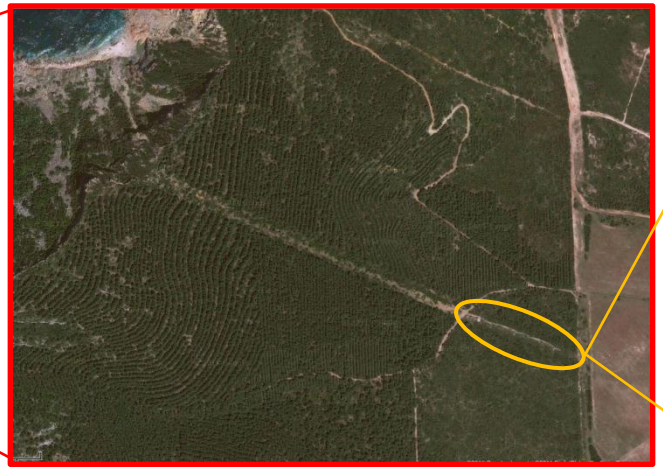


increase

6 SHRUBLAND ECOSYSTEM UNDER MICROCLIMATIC MANIPULATION:

- INCREASE ≈ **1 °C** OF MINIMUM TEMPERATURE
- ≈ **20%** REDUCTION OF PRECIPITATION

PORTO CONTE EXPERIMENTAL SITE



Located in northeast Sardinia, Italy (40° 37’ N, 8° 10’ E).
Semi-arid climate: mean annual rainfall 640 mm; mean annual temperature of 16.8 °C

REMOVEABLE ROOF COVER VEGETATION DURING RAIN EVENTS.

ALUMINIUM REMOVABLE ROOF COVER VEGETATION DURING NIGHT, PREVENTING HEAT LOSS.

NO MANIPULATIONS

PORTO CONTE GARRIGUE

The species of the genus *Cistus* are common in Porto Conte garrigue ecosystems, showing:

- semideciduous habitus (shedding most of leaves in summer)
- seasonal dimorphism, with long shoots bearing big leaves in winter (dolichoblasts)and short shoots (brachyblasts) bearing small leaves in summer

C. monspeliensis is considered one of the primary fire opportunists. In fact adult specimens are killed by fire but the seeds stored in the soil are able to form a dense post-fire stands.

Our Question:

Could increased soil - air minimum temperatures (warming) and reduced water input from precipitation (drought) affect the **functionality** of this ecosystem altering the principal processes such Gross Photosynthesis and Total Ecosystem Respiration ?

MEASUREMENTS

LEAF LEVEL

- Leaf Photosynthesis
- Leaf water potential
- Photosynthetic capacity: (V_{cmax}, J_{max}) *(A-Ci curves)*
- Leaf and shoot morphology

SOIL LEVEL

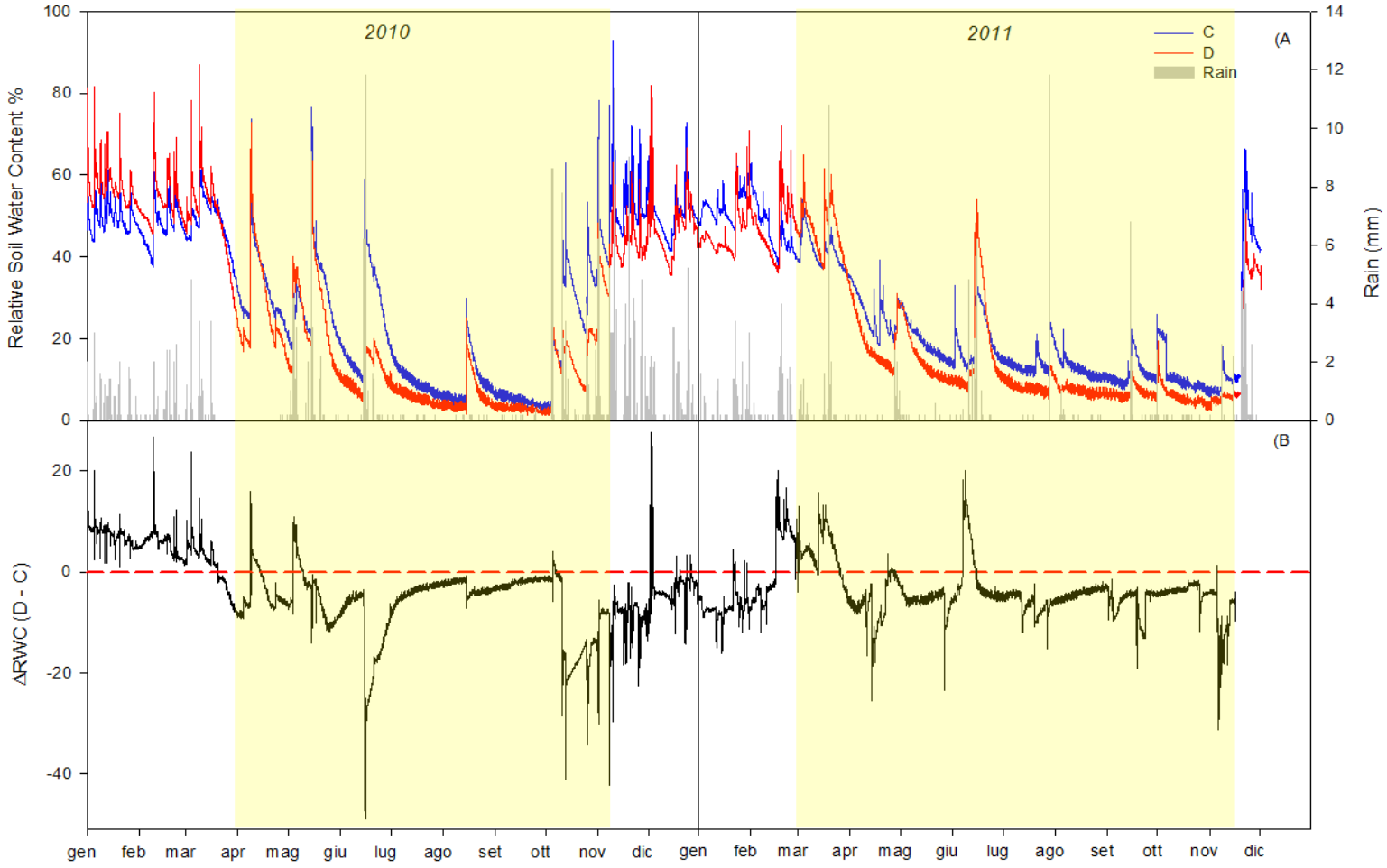
- Soil Moisture and Soil temperature
- Soil CO_2 efflux

ECOSYSTEM LEVEL

- Ecosystem CO2 gas exchange (GPP, TER, NEE)
- PAR
- RH
- T air
- LAI

DROUGHT TREAMENT

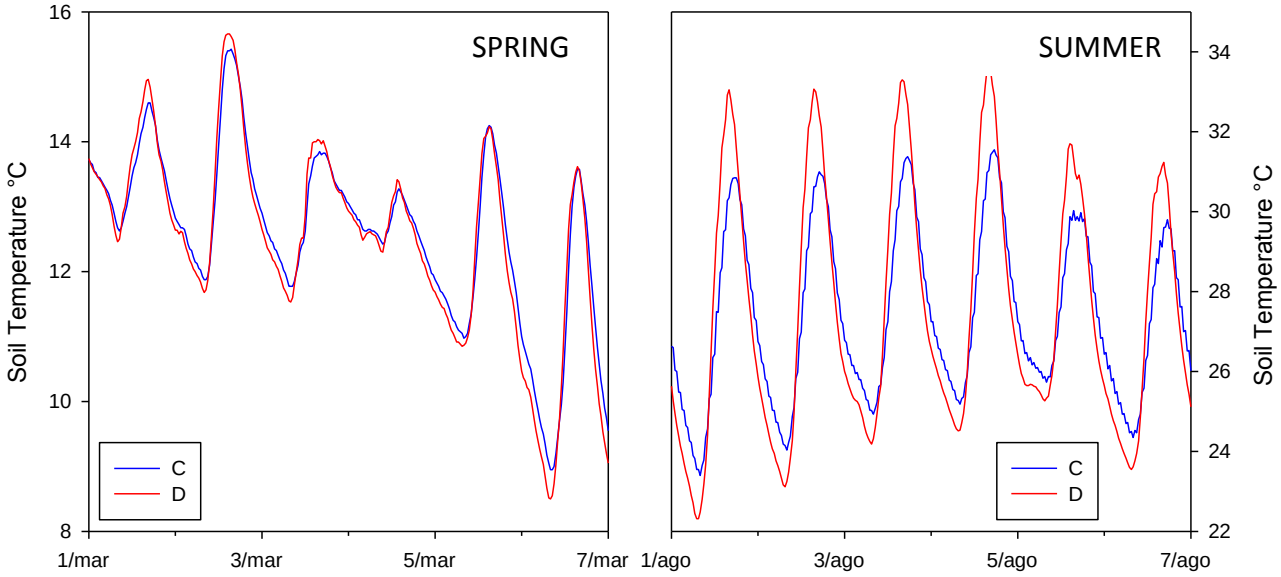
DROUGHT TREATMENT



1 April – 10 November 2010	1 March - 20 November 2011
-190 mm (23% Tot Precip.)	- 91 mm (16% Tot Precip.)

DROUGHT SECONDARY EFFECTS:

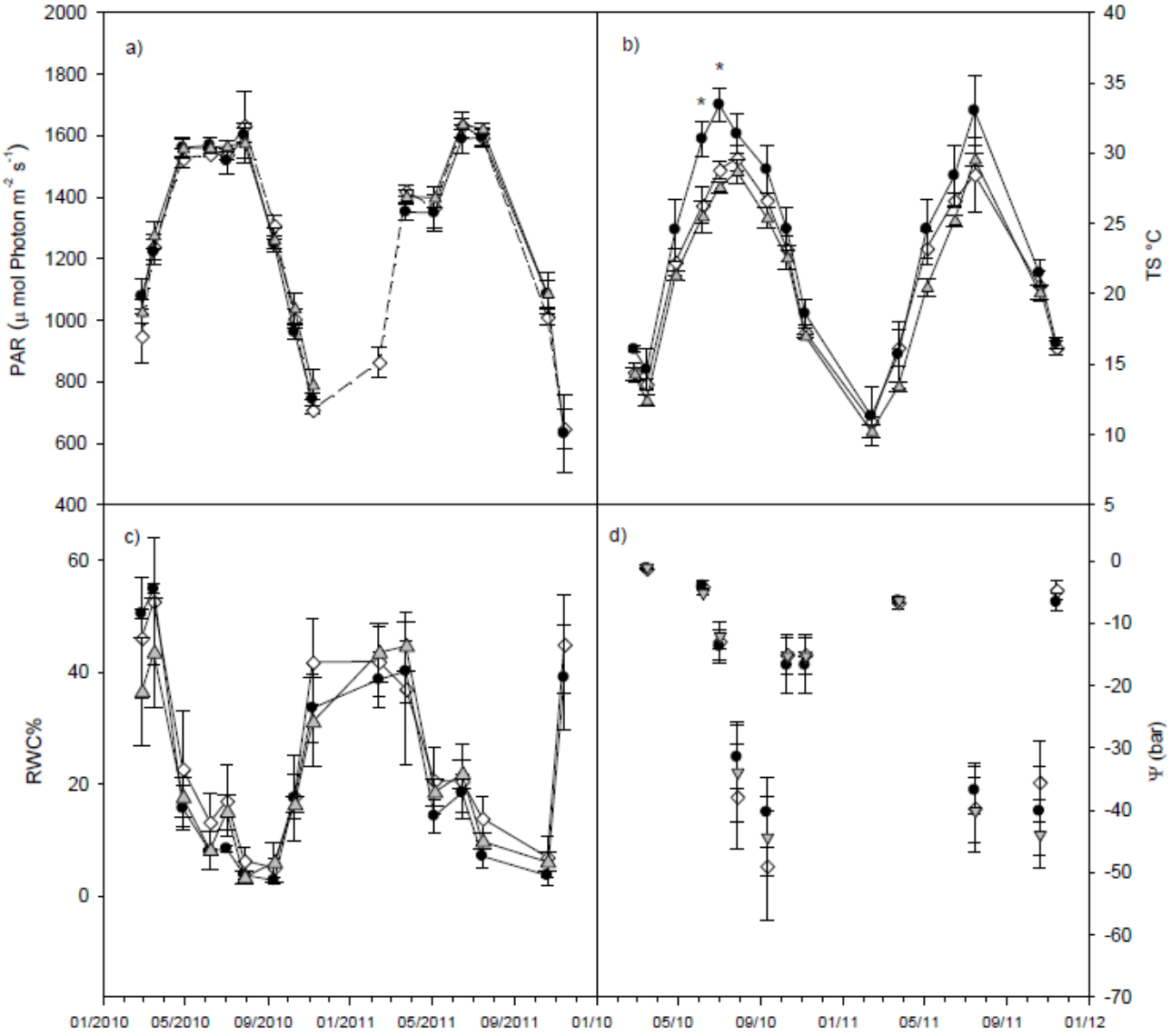
AVERAGE SOIL TEMPERATURE INCREMENT 0.3 °C



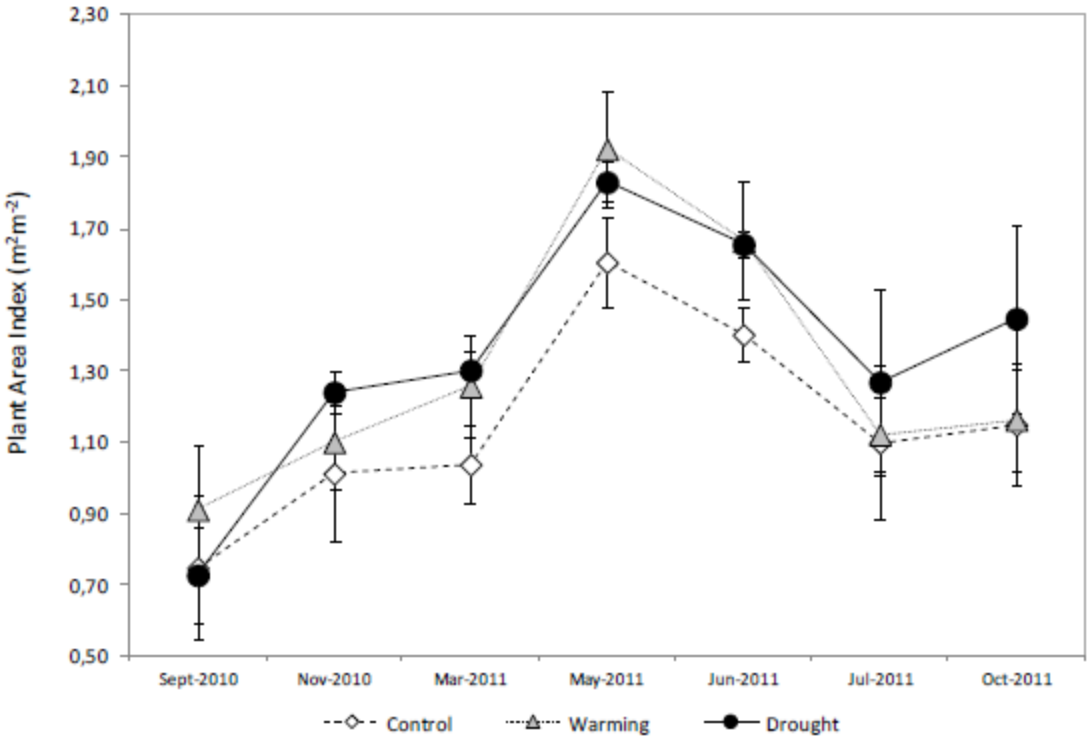
NEGLIGIBLE IN SPRING AND WINTER

SIGNIFICATIVE IN SUMMER

Environmental Conditions

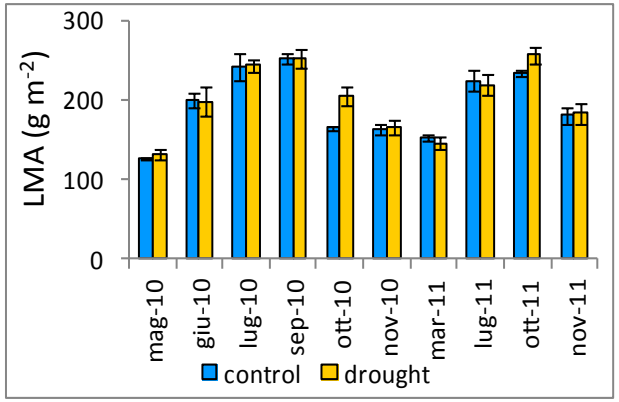


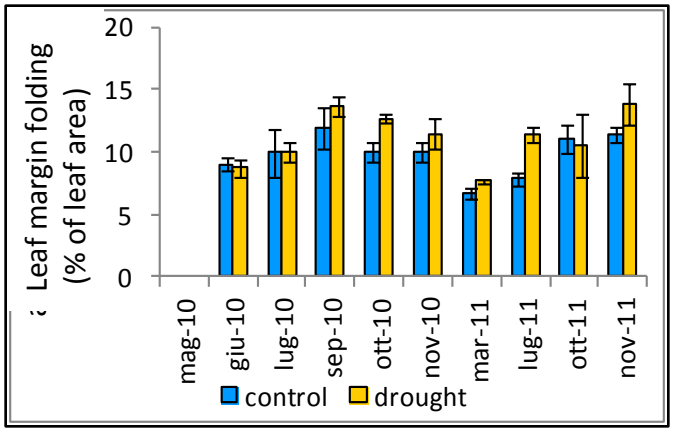
Plant Area Index



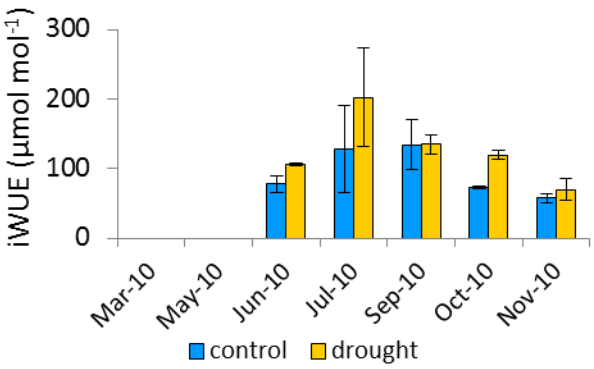
Leaf Level

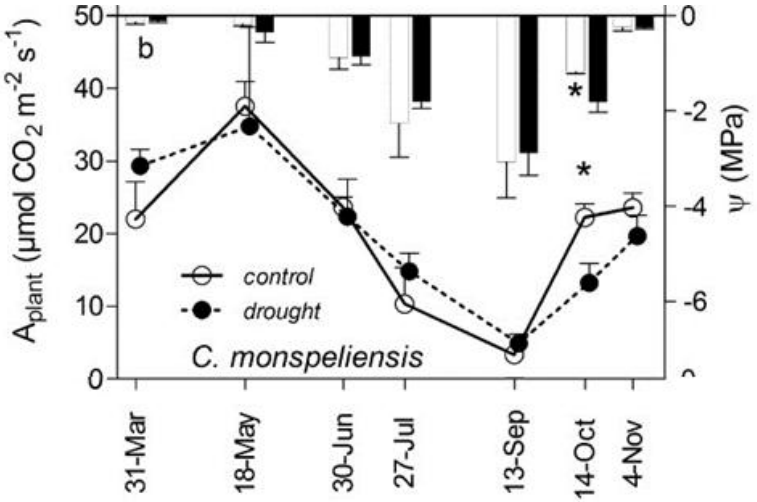
- no significant change in number of shed leaves from spring to summer drought
- Tendencies of higher leaf mass per area and leaf margin folding



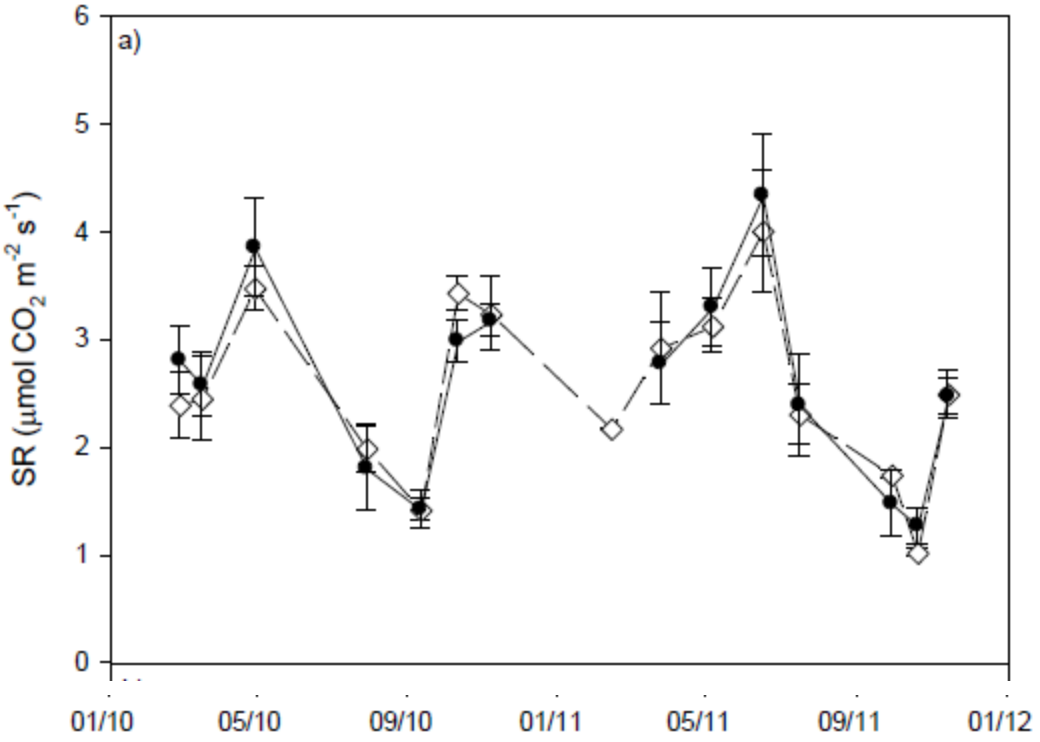


- increase in iWUE (summer leaves), generally not decrease in photosynthesis





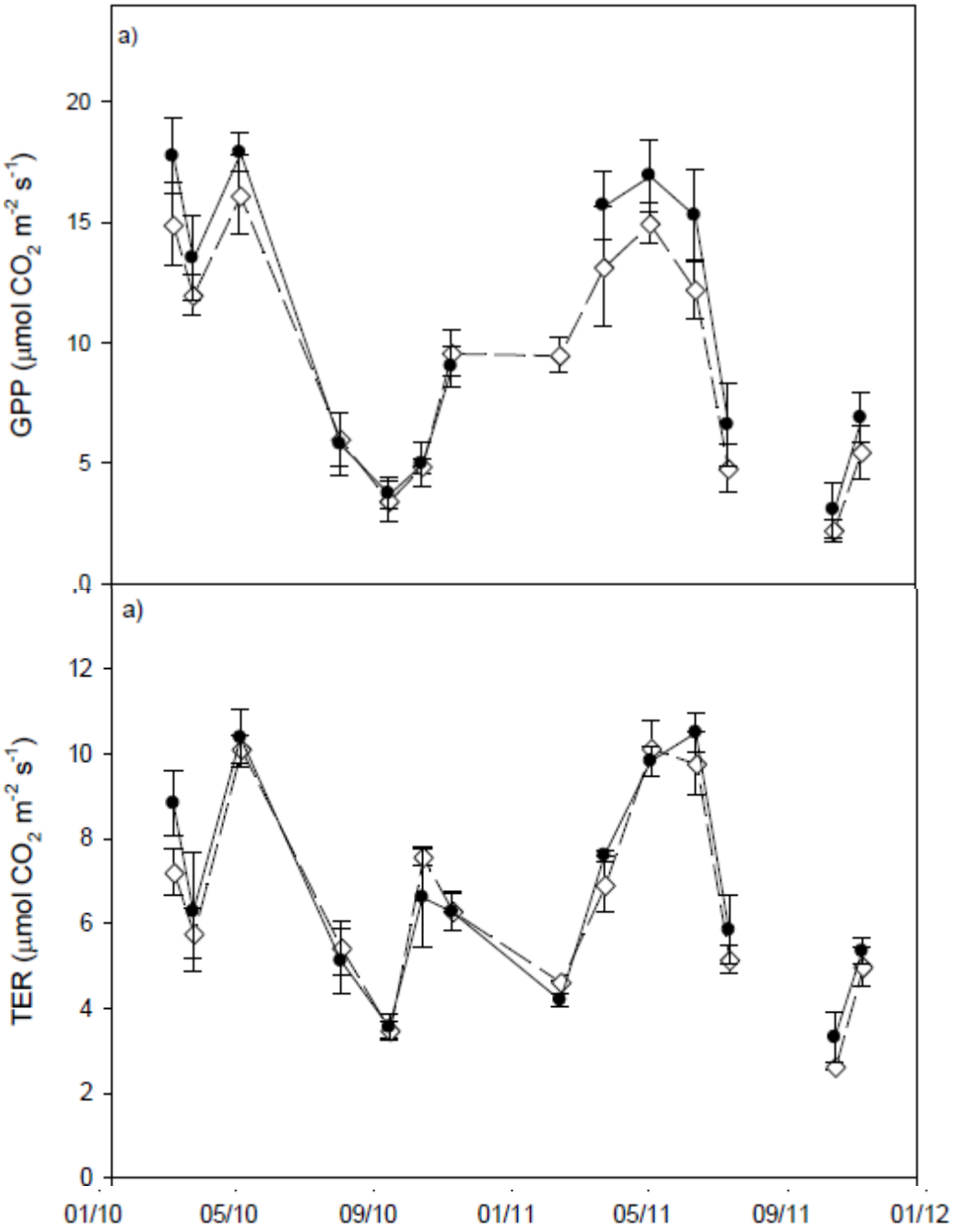
Soil Level



- no significant effect of drought treatment on soil respiration

Ecosystem Level

- no significant effect of drought treatment on Gross Photosynthesis and Total Ecosystem Respiration



DROUGHT EFFECT

THE GENERAL LACK OF EFFECTS OF THE RAINFALL EXCLUSION ON:

- LEAF PHENOLOGY
- LEAF MORFOLOGY
- SOIL RESPIRATION
- GROSS PHOTOSYNTHESIS
- TOTAL ECOSYSTEM RESPIRATION

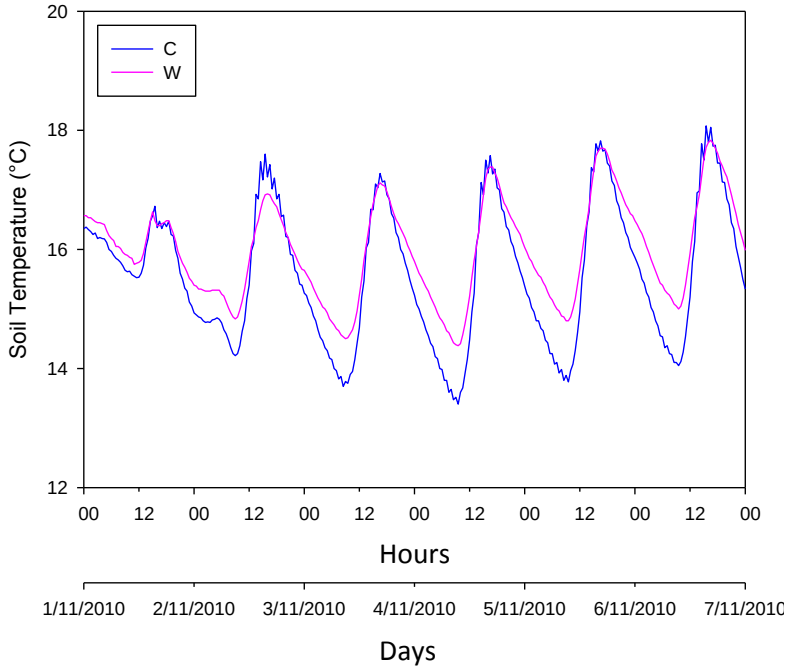
INDICATE THE GOOD ADAPTATION TO DROUGHT OF THE CYSTUS GARRIGUE.

MOREOVER CONSIDERING THE DISCONTINUOUS MEASUREMENT TECHNIQUE AND THE CLIMATIC MANIPULATION BASED ON A SHOR-TERM REALISTIC PROJECTION THE ABSENCE OF DIRECT EFFECT IS NOT SURPRISING.
THIS RESULT CORROBORATE THE HYPOSTESIS OF AN EXTREME RESILIENT ECOSYSTEM EVEN AFTER 10 YEARS of MANIPULATION.

WARMING TREATMENT

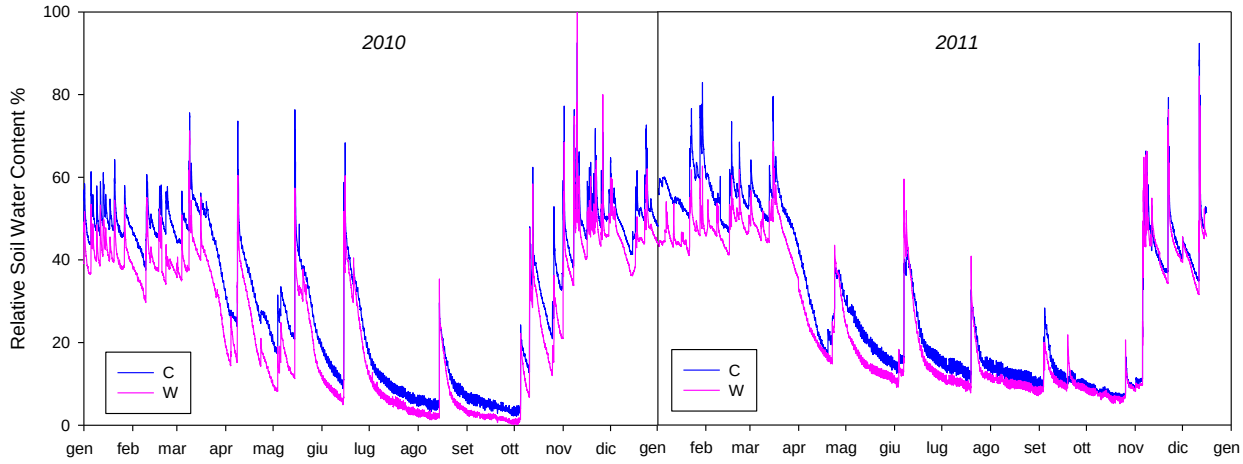
WARMING TREATMENT

Δ (W-C)	2010	2011
Air minimum temperature	+ 1.01 °C ***	+ 0.66***
Soil minimum temperature	+ 1.18 °C ***	+ 0.69***
≈ 60% reduction of frost days		

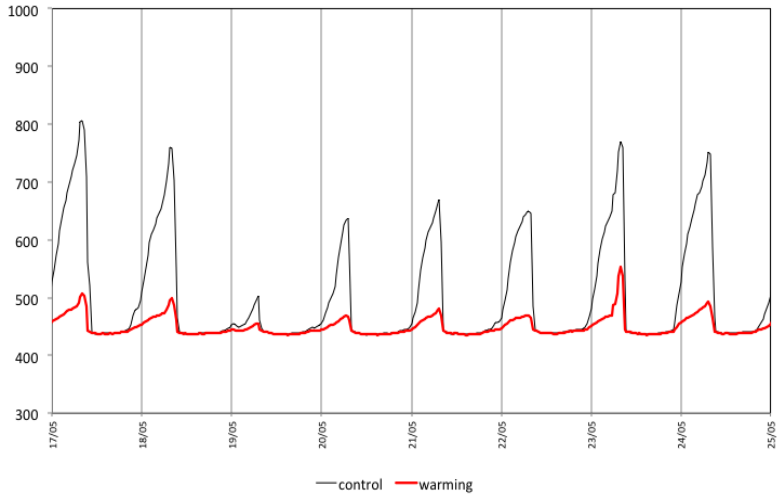


- **Similar warming up phase**
- **Cooling phase slower in the warming plots**
- **Delta Temperature highest in the minimum**

WARMING SECONDARY EFFECTS



Increase of evaporation: Soil Water content of Warming plots lower than control



Reduced nocturnal dew formation

MEASUREMENTS

LEAF LEVEL

- Leaf Photosynthesis
- Leaf water potential
- Photosynthetic capacity: (V_{cmax}, J_{max}) *(A-Ci curves)*
- Leaf and shoot morphology

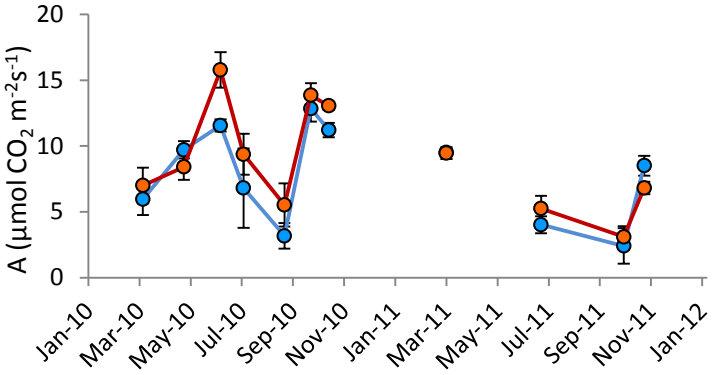
SOIL LEVEL

- Soil Moisture and Soil temperature
- Soil CO_2 efflux

ECOSYSTEM LEVEL

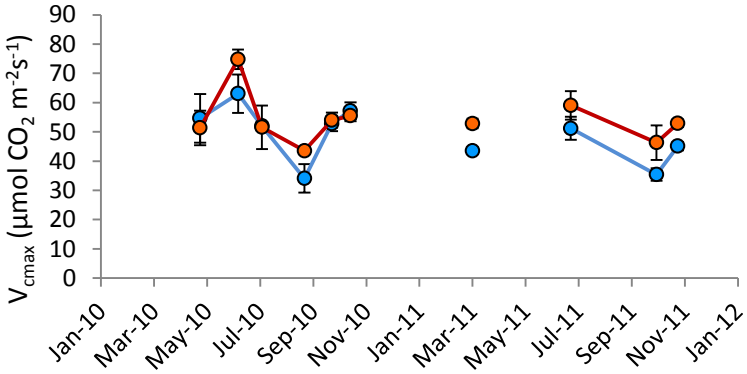
- Ecosystem CO2 gas exchange (GPP, TER, NEE)
- PAR
- RH
- T air
- LAI

Leaf Level



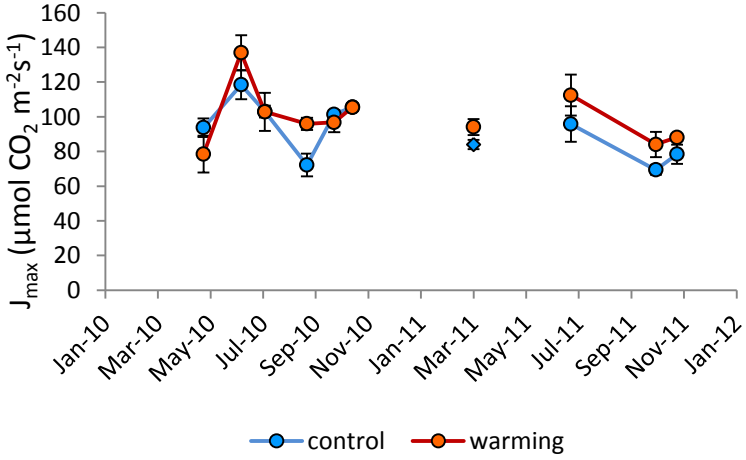
A (photosynthesis)

- **+ 14 %** (p = 0.033)



V_{cmax} (maximum carboxylation rate)

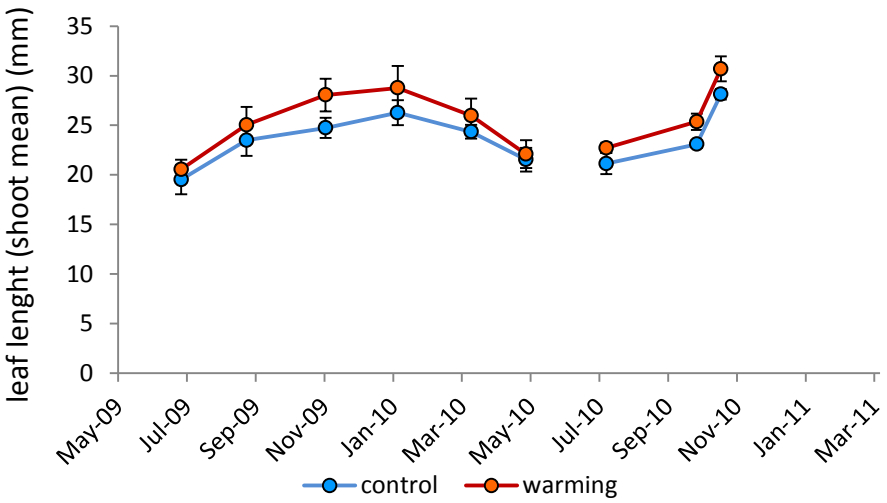
- **+ 7 %** (p = 0.005)



J_{max} (maximum photosynthetic electron transport)

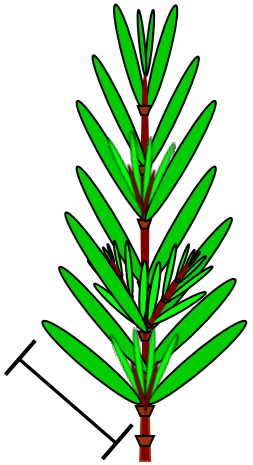
- **+ 8 %** (p = 0.016)

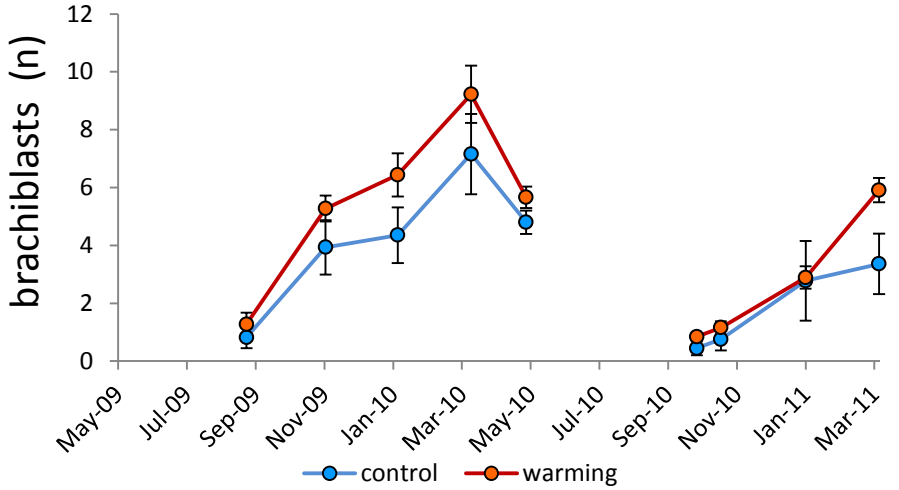
Leaf Morphology



Leaf length

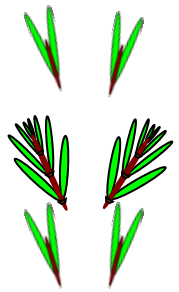
- **+ 8 %** (p =0.04)



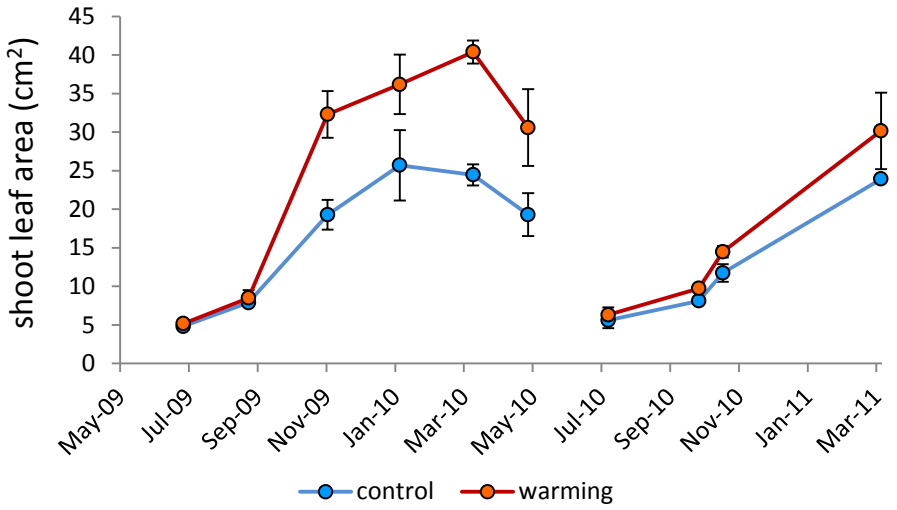


Number of brachiblasts

- **+ 36%** (p =0.03)

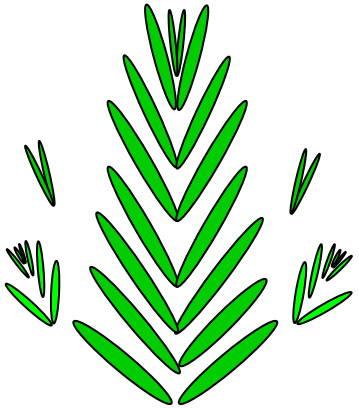


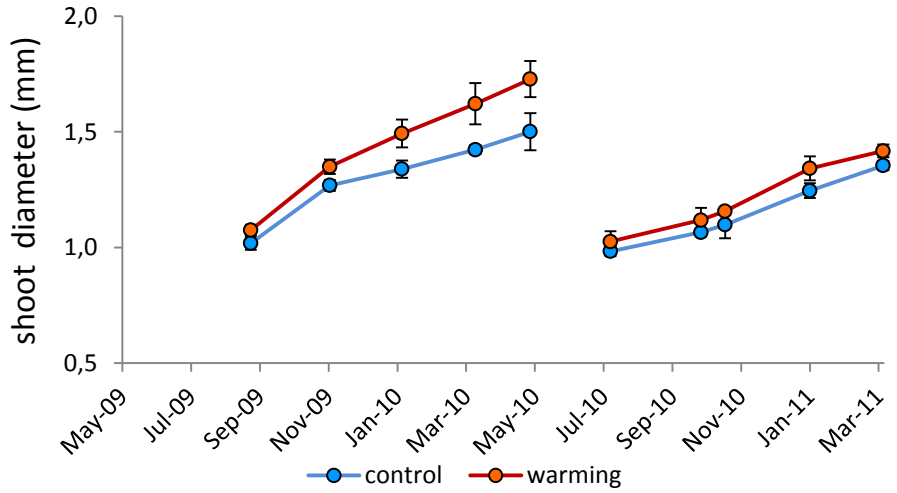
Shoot Level



Total shoot leaf area

- **+ 42 %** (p<0.001)

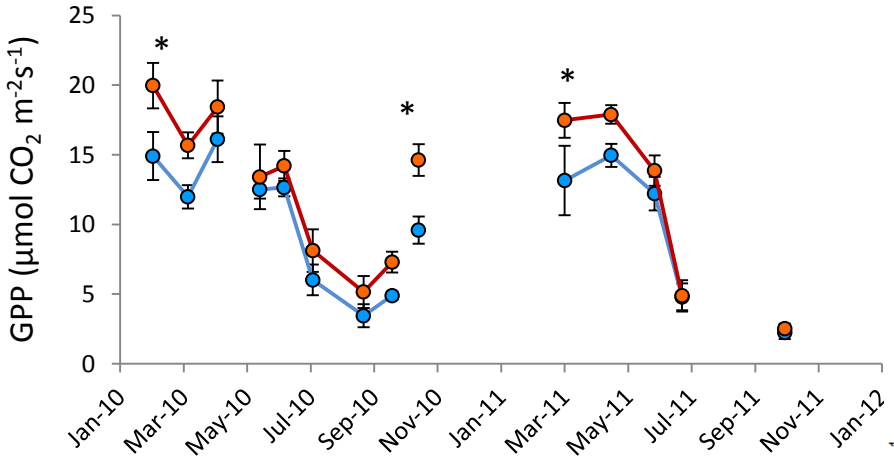




Shoot basal diameter

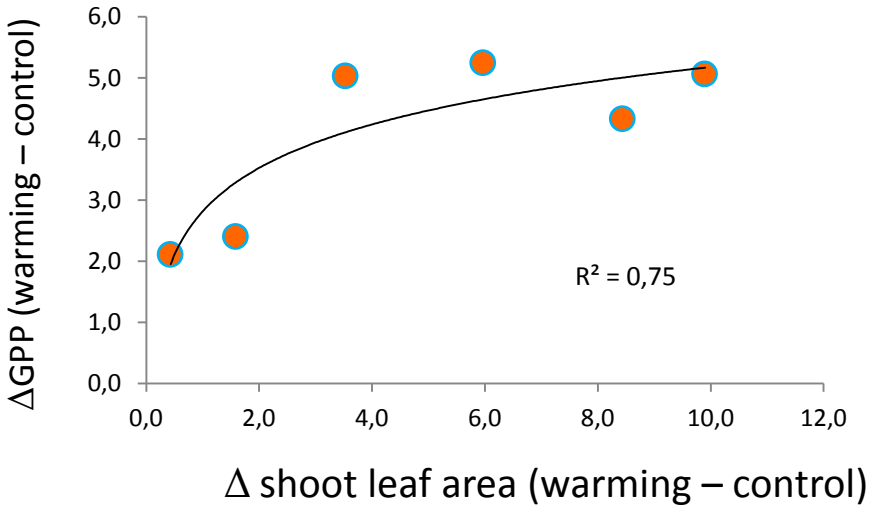
- **+ 8 %** (p < 0.001)

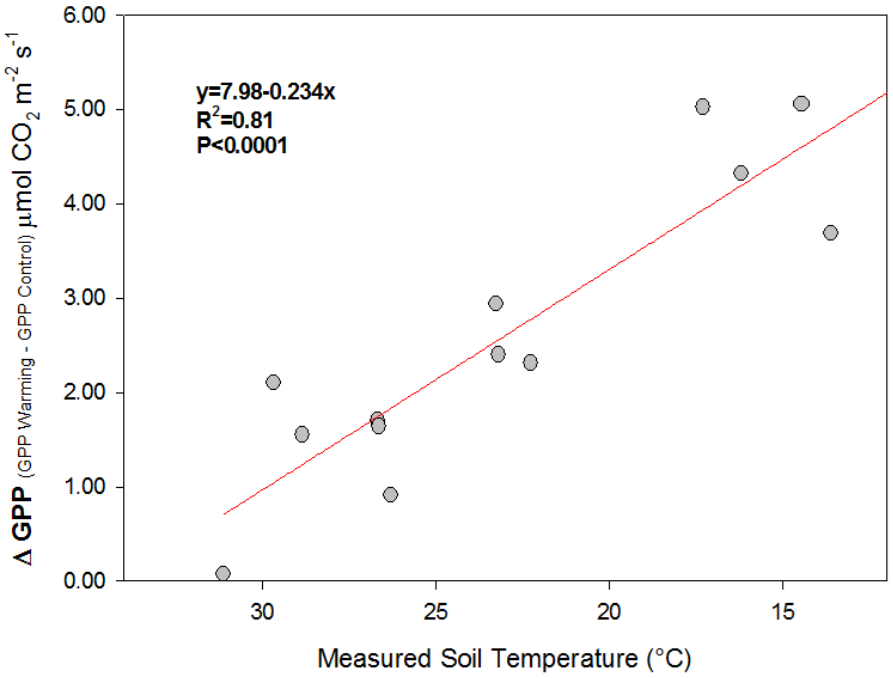
Ecosystem Level



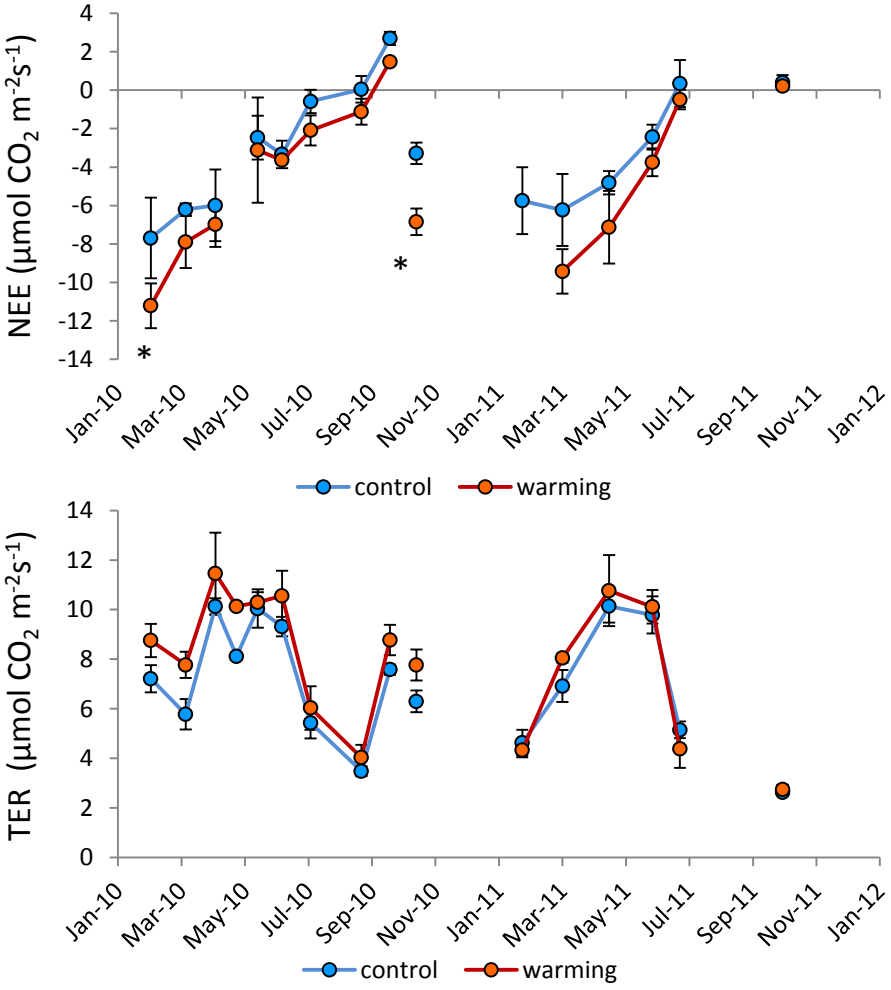
Gross primary production

- **+ 25 %** (p<0.001)





Ecosystem Level



Net ecosystem exchange

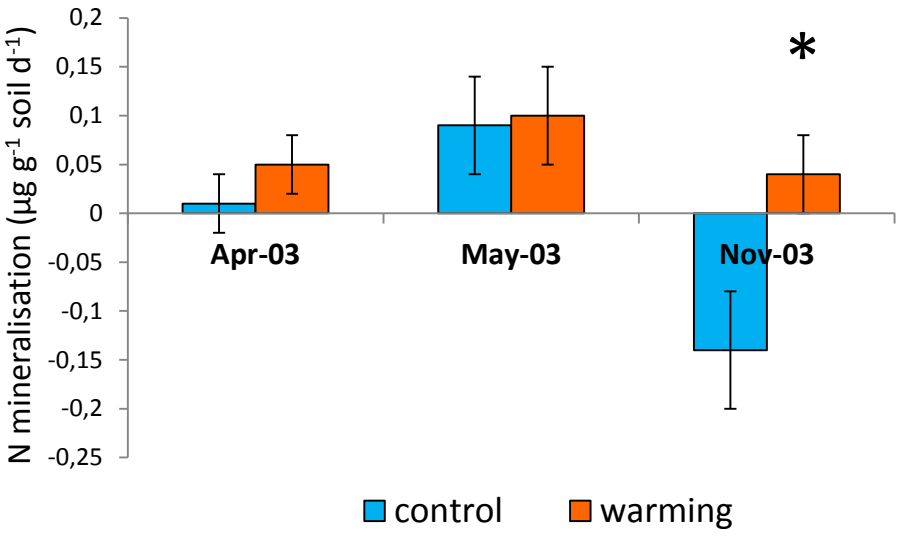
- **+ 47 %** ($p < 0.001$)

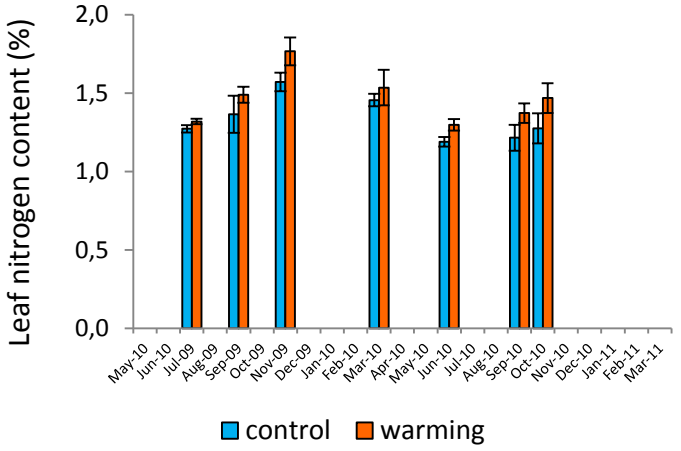
Total ecosystem respiration

- **+ 12 %** ($p = 0.052$)

Hypothesis to explain the warming effect on productivity

- protection against frost events (<60% frost days)
- increase in nitrogen availability due to increase in nitrogen mineralization (previous experiment at the site)





Leaf N content (% of dry mass)

- **+ 10 %** (p<0.001)

Main conclusions:

- Never take something for granted
- The biogeochemical feedbacks between ecosystems and the climate can either increase or decrease the atmospheric load of greenhouse gases.
- The lack of effect of drought on the Mediterranean garrigue showed the extreme resilient capacity of this ecosystem even after 10 years of manipulation
- The increase in productivity observed at the mediterranean garrigue in response to the temperature could be explained by higher mineralization rates, that overshadows the water limitations connected to the warming treatment. This process seems to enhance the carbon uptake, at least in this early successional stage ecosystems.

THANKS TO:

Dario Liberati

Giovanbattista de Dato

Paolo De Angelis

…and thank you!!

guidolotti.job@gmail.com