Effects of night-time warming in a Mediterranean "*garrigue*"

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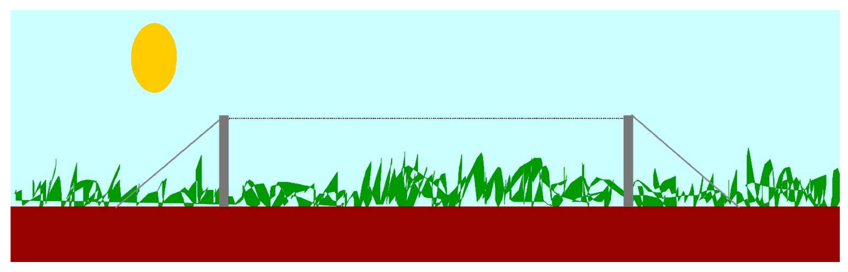
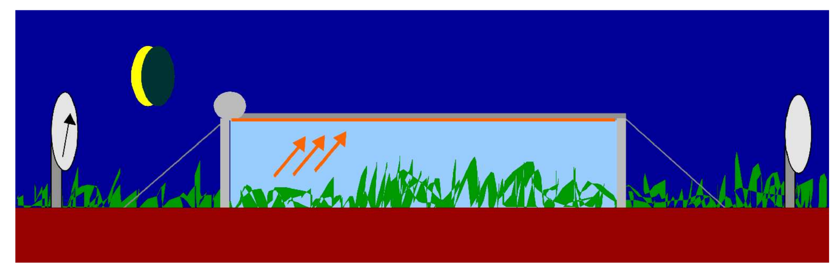
Global warming is basically caused by a reduction in the loss of long wave infrared radiation from the earth back into the atmosphere because of the greenhouse gas accumulation in the atmosphere. The increase in mean temperature observed since the late of 19th century (0.6±0.2 °C) has been due to increased minimum temperatures (that is to say nocturnal temperature) at a rate twice than that of maximum temperature (i.e. diurnal), respectively 0.2°C decade^{-1} and 0.1°C decade^{-1}. Change in precipitation has also been detected in some regions, even if the signal is less evident. Projections for future climate depict scenarios with increasing temperature, mainly in southern Europe, with more frequent hot summers and milder winters; decreasing precipitation, especially during summer in southern Europe; and extreme events, i.e. dry spells and high intensity precipitation, more frequent.
The alteration of climatic factors that create drier conditions (reduced precipitation and higher temperature and consequently more evapotranspiration) could have great impacts on Mediterranean shrubland communities, one of the most important vegetation aspects in the Mediterranean Region. Change in physiology, phenology and species composition and distribution are expected, with effects on their functioning and structure.

To study the effect of climate change on Mediterranean shrubland community, a new method is applied for a relatively long time period to assess climate change effects on ecosystem driving processes on a Mediterranean *garrigue*, that represents the first step of revegetation of soil after soil disturbances (fires, cutting, grazing).
Covering ecosystem at night by IR-reflective material, natural night-time warming is obtained. Similarly, covering ecosystem during rain events reproduces a drought effect (see the drawing).



During the day and without precipitation the cover is withdrawn........

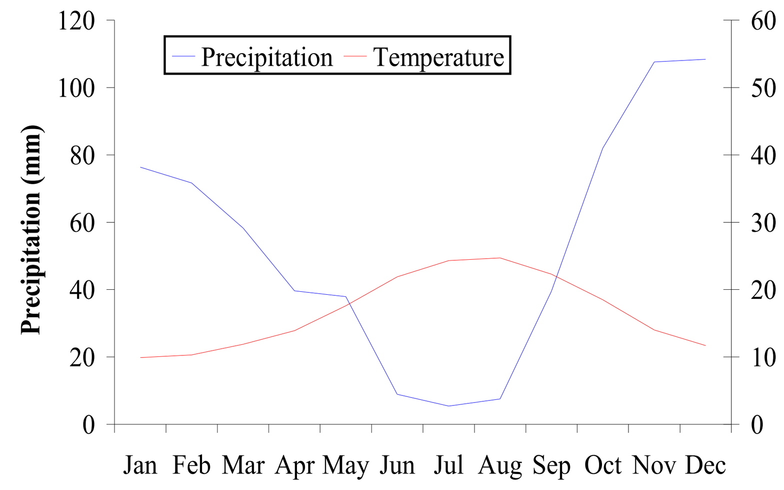


.......during the night or rain events it covers the vegetation.

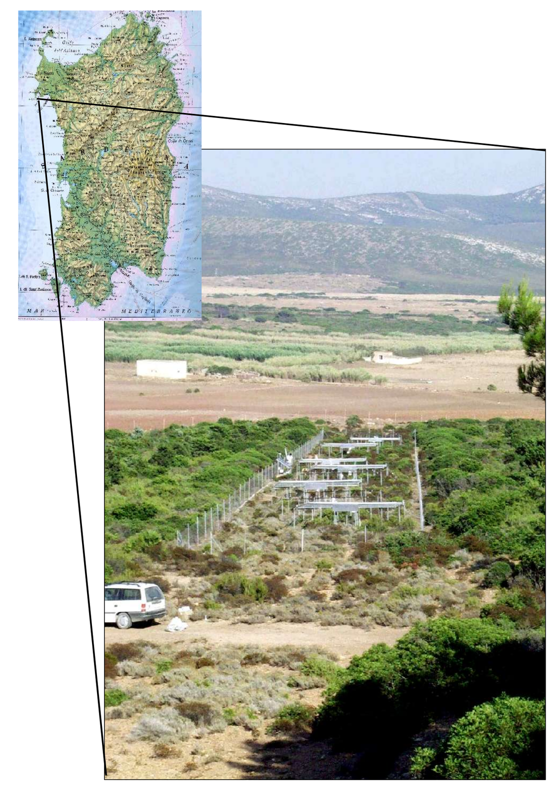
The site is located in the Peninsula of Capo Caccia, NW Sardinia within the Nature Reserve "Porto Conte Le Prigionette" (40° 36' N, 8° 9' E – Picture 1). The most frequent geologic substrate of the area is represented by Mesozoic rocks with calcareous outcrops with dolomites. The most common soils are Luvi and Litosoils, neutral, with depth hardly exceeding 20-30 cm.
The climate (Figure 1) is semi-arid with a remarkable water deficit from May through September.
The experimental plots were installed in June 2001. They are placed in a firebreak (Picture 1) strip realised during the year 1973 and cleared regularly by controlled fire until 1990. In both years 1991 and 1992, the firebreak strip was cleared mechanically and since 1993 a natural recolonization process started without any other disturbance. An enclosure was installed to protect the experimental area from the impact of the large mammals (horse, wild boar, fallow deer). Taking into account the moderate slope of the site, a randomised blocks design was applied and the 3 treatments (Heat, Drought, Control) were randomly assigned in 3 blocks.
The soil is mainly covered by shrubs (*C. monspeliensis* L., *H. microphyllum* and *D. pentaphyllum* Scop.) with an important percentage of bare soil, about, 21%, and residual herbaceous components (*Carlina* spp., *Asphodelus* spp., *Brachipodium ramosus*, *Ammoides pusilla*, and others).

Different biological processes are investigated at plant and soil level. Phenology, plant growth, soil CO_2 efflux, nitrogen mineralization are key issues to understand changes in structure and functioning of the community. For brevity, here I present only some first result about some aspect of the research.

***Figure 1** - Monthly mean values of air temperature and precipitation, calculated over the period 1960-1990 in the meteo station of Alghero (N 40° 38' 00"; E 8° 17' 00"; 40 m sl; sea distance 4273 m).*

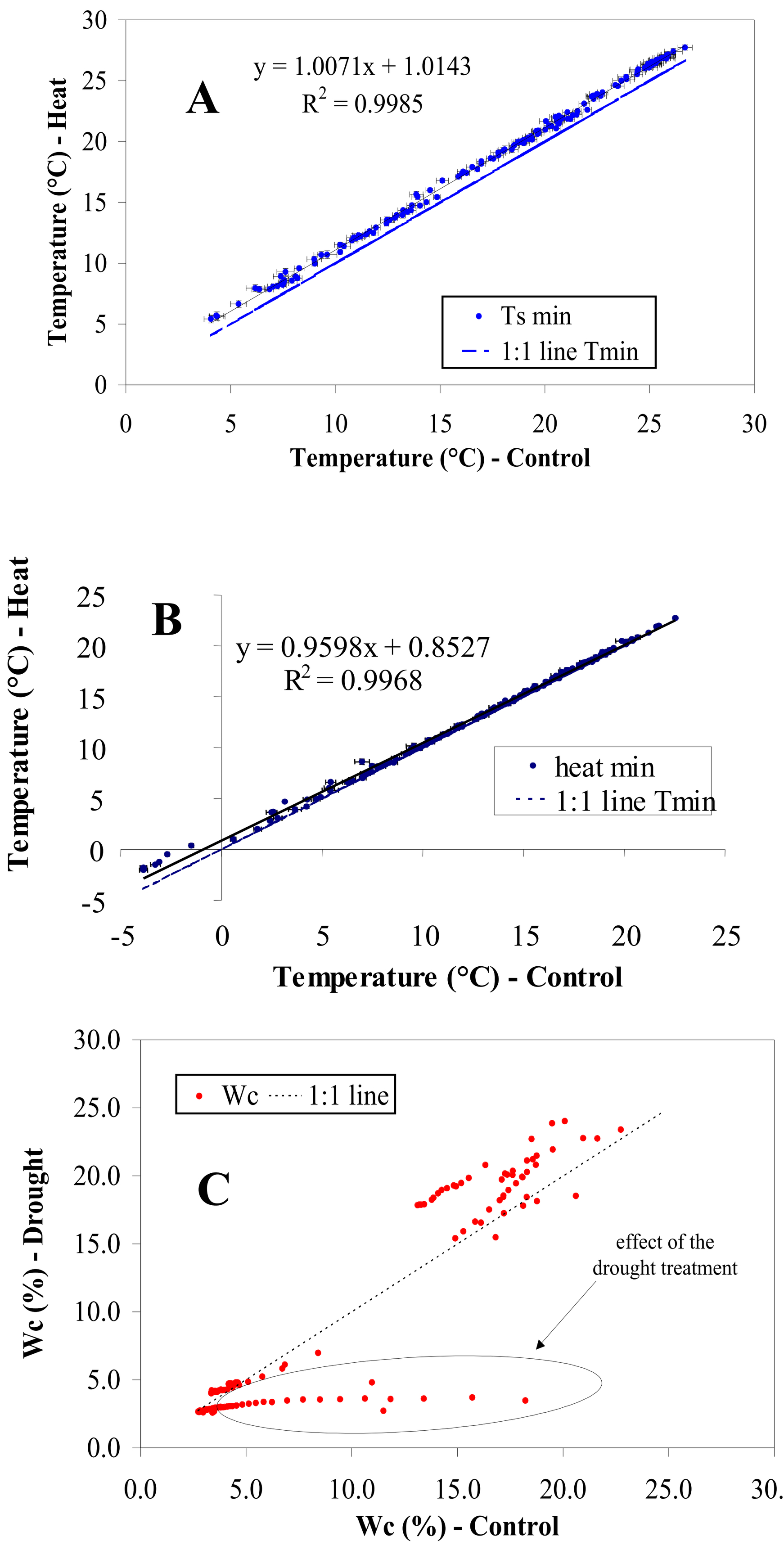


Annual precipitation = 640 mm
Mean annual temperature = 16.8 °C
Mean maximum for the hottest month = 6.7 °C
Mean minimum for the coldest month = 29.9 °C



***Picture 1** – The experimental area*

***Figure 2** - Daily minimum soil (A) and air (B) temperature at, respectively, -10 cm and +20 cm and the daily mean soil water content (m³m⁻³) (C)*



Treatment effects on microclimate

In each plot the microclimate was continuously monitored by means of: 1 sensor for air temperature (+20 cm); 1 sensor for air relative humidity (+20 cm); 4 sensor for soil temperature (3 at -10 cm and 1 at -20 cm); 1 sensor for soil water content (-10 cm). Moreover, outside the plots, additional sensors were installed for monitoring the climate of the site: 1 air temperature sensor (+200 cm); 1 air relative humidity sensor (+200 cm); 1 wind speed and direction sensor (+200 cm); 1 global radiation sensor (+200 cm); 1 rain gauge (+200 cm). All the data are temporarily stored in a datalogger and downloaded every 15 days.

The largest effect of the heating treatment was observed on the daily minimum surface soil temperatures (-10 cm depth), as a consequence of the cumulative action of the IR reflective roofs during the night, as expected (Figure 2). A warming effect was also evident more in deep in the soil (-20 cm) even if less pronounced. The heating treatment was less effective on daily minimum air temperature, measured up to soil surface at 20 cm (Figure 2). The treatment effect on daily minimum soil temperatures was not affected by the season, as demonstrated by the linear relationships (figure 3) with a slope close to 1, during the first year of experiment (July-December 2001). Differently, a preliminary slight evidence of a seasonal interaction appeared on daily minimum air temperature, with an increasing warming effect with decreasing temperatures (slope < 1), possibly related to more stable atmospheric conditions during colder night.

A first drought treatment was applied from August to October 2001. In this period, the soil water content (Ws) in the drought plots remain below 5%, whereas in the control plots values over 25% were recorded (Figure 2).

Effects on plants: plant biomass, plant cover, litterfall production

The relative frequency of species and the percentages of cover inside the plots were estimated by pinpoint method in year 2001 and successive years. Along four transects per plot (4 m long, 1 m distant from each other), by a plumb line, the number of contacts with vegetation and bare soil were registered. The degree of soil cover was expressed as the percentage of the number of contacts of the species to the total of contacts.

After the 3th assessment of vegetation cover, a reduction of bare soil, i.e. an increase in degree of soil cover, seems to be more pronounced in the control plots than in both heat and drought treated plots (Figure 3). Minor species, such as *D. pentaphyllum* and *H. italicum*, could take advantages from warmer conditions: this could bring to a new specific composition and structure.

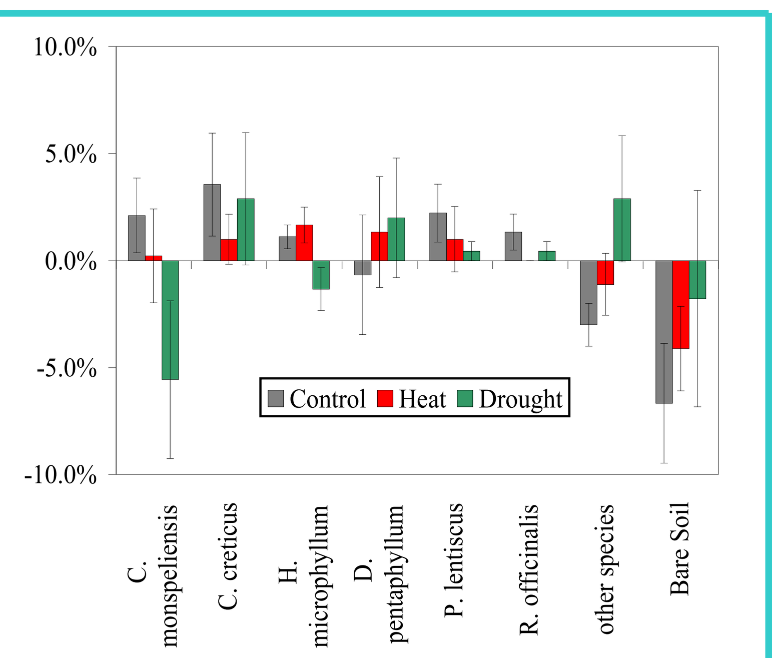


***Figure 3** - Absolute changes (2001-2002) of specific degree of soil cover*

Pre-treatment biomass was estimated by a complete harvest in an external plot 5x5 cm wide.
For each plant, the dry weight was determined in the laboratory after 48 hours at 70 °C. Preliminary, the diameter of the crown and the height of all the plants of *Cistus monspeliensis*, *C. incanus*, *Pistacia lentiscus*, *Helichrysum microphyllum* and *Dorycnium pentaphyllum* were recorded, and additionally the basal area of the shoots were determined for *C. monspeliensis*, *C. incanus* and *P. lentiscus*. With these data, allometric regressions were estimated for the 5 species, and applied in the 9 plots to calculate the pre-treatment value of biomass among the species and to calibrate the relationship between biomass and number of pin contacts.

The total aboveground woody biomass, estimated by regressions, was 380 g m^{-2}, as mean value calculated in all plots. About 86% of this biomass was referred to the three main species: *H. microphyllum*, *C. monspeliensis* and *D. pentaphyllum,* while the contribution of other species was marginal (Figure 4).

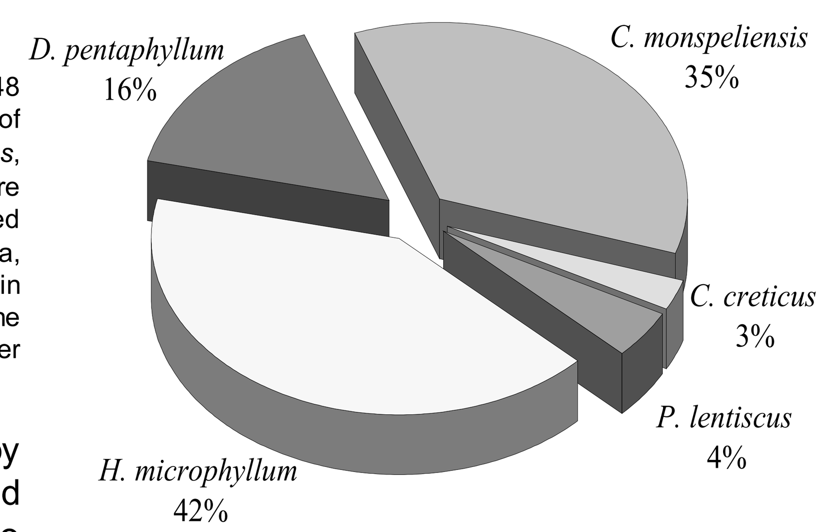


***Figure 4** - Distribution of biomass among the species*

In the different plots, inverse relationships were founded between the relative contribution to the total biomass of *C. monspeliensis* versus *H. microphyllum* and *H. microphyllum* versus *D. pentaphyllum*. To an increase of biomass of *H. microphyllum* a reduction of both *C. monspeliensis* and *D. pentaphyllum* was observed. These relationships could be interpreted as a result of the different capacity to respond to a disturbance or, as a result of the competition, where one species can exclude the other. In the Mediterranean shrubland the complexity of relationships between the different species in response to climate change need to be clarified, to preserve the biodiversity and to predict the role of this type of vegetation also in the future.

Soil CO_2 efflux

Preliminary results on soil respiration are presented in figure 6. Measurements of soil respiration were performed by EGM-1 PP System, over five fixed collars for each plot, in three different moments of day (morning, midday, afternoon).

The soil respiration rates showed the maximum values during the spring and autumn season, when the temperature and soil water content were around optimal values. On the other hand, the minimum values were recorded during the colder and dry months, December and August, respectively. As expected for this site, the water limitation plays an important role on the control of the biological processes at the soil level (figure 6). After one year from the start of the experiment, a reduction of soil respiration seems to be started from summer 2002, in heat and drought treated plots, after the period of water stress, started in May 2001.

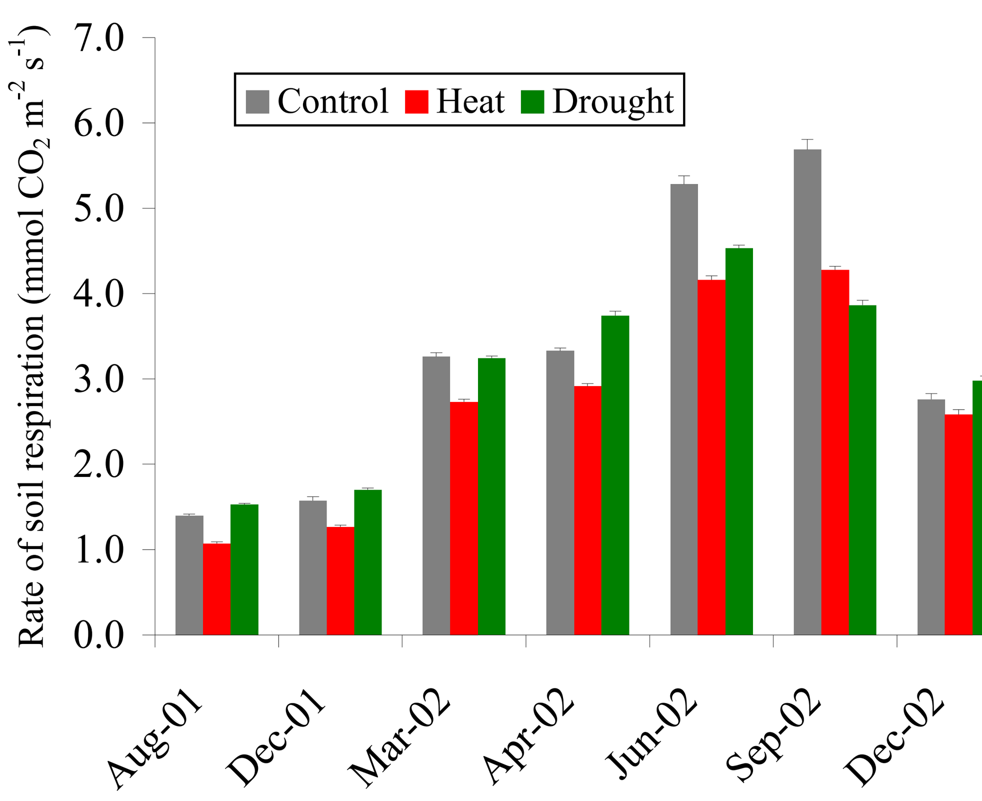


***Figure 6** – Rate of soil respiration at midday*

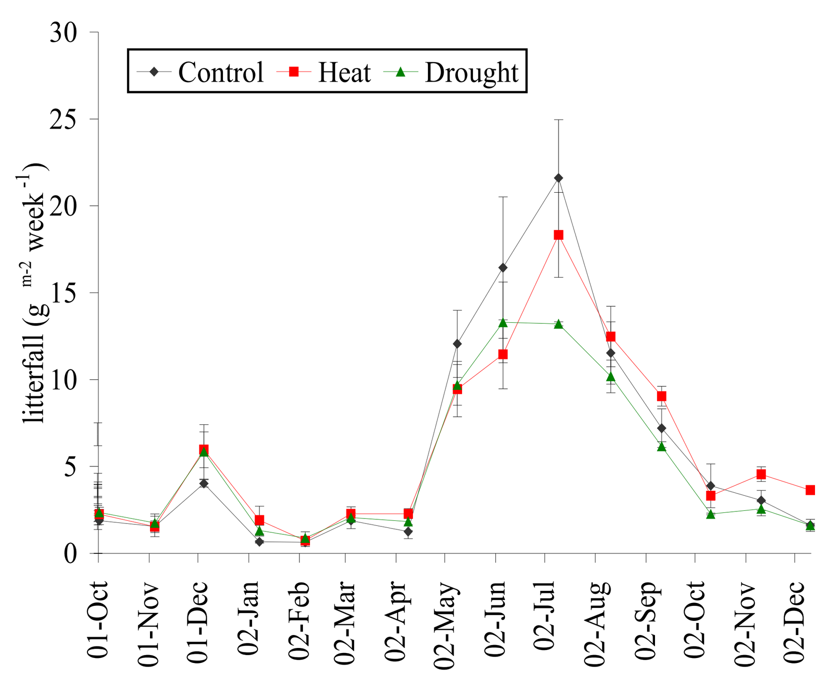


***Figure 5** - Weekly rate of litterfall (leaves, fruits, flowers)*

To monitor the aboveground litterfall of the community, 10 litter traps were installed in each plot according to a spatial arrangement balanced for the degree of cover of the different species. The litter is collected monthly and the dry weight determined after 24 hours at 70 °C. The litter is separated in three main categories: leaves, fruits, flowers; no differentiation for the species is currently made.

As typical for the Mediterranean ecosystems, the seasonal variation of the litterfall rate was dominated by a major summer peak (Figure 5). During winter 2001 (the growing season!) a slight increase of litterfall was observed for both heat and drought treated plots, that, even if not statistically significant, could be interpreted as a signal of a positive effect of warming on plant production when the temperature is the limiting factor. A more strong effect of treatments was evident during summer 2002, with reductions of litterfall in heat and drought treated plots. In July 2002, a drastic change of the seasonal trend of litterfall was observed in the drought plots possibly as a consequence of the previous period of water stress. These reductions could be interpreted as a negative interaction of the treatments on plant growth, during the hot and dry summer months.