

Net ecosystem carbon exchange in three contrasting Mediterranean ecosystems – the effect of drought

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Abstract. Droughts reduce gross primary production (GPP) and ecosystem respiration (Reco), contributing to most of the inter-annual variability in terrestrial carbon sequestration. In seasonally dry climates (Mediterranean), droughts result from reductions in annual rainfall and changes in rain seasonality. We compared carbon fluxes measured by the eddy covariance technique in three contrasting ecosystems in southern Portugal: an evergreen oak woodland (savannah-like) with ca. 21% tree crown cover, a grassland dominated by herbaceous annuals and a coppiced short-rotation eucalyptus plantation. During the experimental period (2003–2006) the eucalyptus plantation was always the strongest sink for carbon: net ecosystem exchange rate (NEE) between -861 and $-399 \text{ g C m}^{-2} \text{ year}^{-1}$. The oak woodland and the grassland were much weaker sinks for carbon: NEE varied in the oak woodland between -140 and $-28 \text{ g C m}^{-2} \text{ year}^{-1}$ and in the grassland between -190 and $+49 \text{ g C m}^{-2} \text{ year}^{-1}$. The eucalyptus stand had higher GPP and a lower proportion of GPP spent in respiration than the other systems. The higher GPP resulted from high leaf area duration (LAD), as a surrogate for the photosynthetic photon flux density absorbed by the canopy. The eucalyptus had also higher rain use efficiency (GPP per unit of rain volume) and light use efficiency (the daily GPP per unit incident photosynthetic photon flux density) than the other two ecosystems. The effects of a severe drought could be evaluated during the hydrological-year (i.e., from October to September) of 2004–2005. Between October 2004 and June 2005 the precipitation was only 40% of the long-term average. In 2004–2005 all ecosystems had GPP lower than in wetter years and carbon sequestration was strongly restricted (less negative NEE). The grassland was a net source of carbon dioxide ($+49 \text{ g C m}^{-2} \text{ year}^{-1}$). In the

oak woodland a large proportion of GPP resulted from carbon assimilated by its annual vegetation component, which was strongly affected by the shortage of rain in winter. Overall, severe drought affected more GPP than Reco leading to the deterioration of NEE. Although the rain-use efficiency of the eucalyptus plantation increased in the dry year, this was not the case of evergreen oak woodland, which rain-use efficiency was not influenced by drought. Recovery after drought alleviation, i.e., beginning with heavy rain in October 2005, was fully accomplished in 2006 in the oak woodland and grassland, but slow in the eucalyptus plantation.

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