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Comparing the functioning of two karst ecosystems different in successional stage as revealed by eddy covariance measurements

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Abandonment and spontaneous afforestation is one of the most prominent land-use changes in many marginal areas in Europe, Mediterranean and beyond. Ecosystem functioning of these lands in terms of carbon and water exchange has rarely been studied. However, existent publications show that the change from dominant herbaceous to woody vegetation substantially influences the magnitudes, phenology and environmental regulation of energy and matter fluxes. In this study, almost ten years of carbon and water vapour exchange measurements were evaluated for two ecosystems, located in close proximity in the sub-Mediterranean region of Slovenia (45°32'36" N 13°55'05" E) but differing in successional stage. Sparse secondary forest developed on a former semi-dry calcareous grassland was compared with the nearby karst pasture still in use for low-intensity horse and cattle grazing. On both sites eddy covariance system was used along with other meteorological and soil measurements needed for the interpretation of instantaneous, seasonal and yearly CO_2 and H_2O fluxes. Despite several gaps in flux data significant differences in yearly cumulatives, seasonal phenology of C assimilation, resource use efficiency and drought resistance between the investigated ecosystems were shown. The occurrence of drought seemed to largely govern ecosystem functioning and productivity; more than the drought severity the length of the period below threshold soil water content determined yearly gross primary productivity. For years with mild drought, the secondary forest was shown to sequester more than three-fold larger amount of carbon than the grassland. In terms of phenology, the grassland shifted from C source to C sink earlier in the season but sink capacity was soon diminished, particularly in dry years. The functioning of ecosystems was also compared with respect to ecosystem-level water use efficiency, rain use efficiency and light use efficiency in different environmental conditions and phenological phases. In August 2016 both ecosystems suffered from surface wildfire event which destroyed much of herbaceous vegetation and shrubs, but the trees were only partially affected. Post-fire ecosystem functioning of both ecosystems was addressed showing faster regeneration of fluxes on the grassland site.