Geophysical Research Abstracts
Vol. 18, EGU2016-13346, 2016
EGU General Assembly 2016

Plant diversity effects on ecosystem evapotranspiration and carbon uptake: a controlled environment (Ecotron) and modeling approach

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Effects of species and functional diversity of plants on ecosystem evapotranspiration and carbon fluxes have been rarely assessed simultaneously. Here we present the results from an experiment that combined a lysimeter setup in a controlled environment facility (Ecotron) with large ecosystem samples/ monoliths originating from a long-term biodiversity experiment ("The Jena Experiment") and a modelling approach. We aimed at (1) quantifying the impact of plant species richness (4 vs. 16 species) on day- and night-time ecosystem water vapor fluxes and carbon uptake, (2) partitioning ecosystem evapotranspiration into evaporation and plant transpiration using the Shuttleworth and Wallace (SW) energy partitioning model, and (3) identifying the most parsimonious predictors of water vapor vapor and CO_2 fluxes using plant functional trait-based metrics such as functional diversity and community weighted means. The SW model indicated that at low plant species richness, a higher proportion of the available energy was diverted to evaporation (a non-productive flux), while at higher species richness the proportion of ecosystem transpiration (a production-related water flux) increased. This led to an increased carbon gain per amount of water vapor loss (i.e. increased water use efficiency). While the LAI controlled the carbon and water fluxes, we also found that the diversity of plant functional traits, and in particular of leaf nitrogen concentration are potential important predictors of ecosystem transpiration and carbon uptake and consequently significantly contributed to increase in water use efficiency in communities with higher plant diversity.