USING SOIL WATER CONTENT FOR CALCULATION OF ECOSYSTEM ROOT WATER UPTAKE PATTERNS

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Motivation

Soil water is an essential resource for plants, acts as a transport medium for dissolved organic matter, and mediates microbial activity. Thus, soil water fluxes and resulting redistribution of soil water provide important information to understand, besides biotic and abiotic processes, resource use strategies of ecosystems. Our knowledge about changes of ecosystem root water uptake profiles with plant diversity is rudimentary and soil water fluxes can only be estimated either

(i) through inverse modelling or

(ii) as water budgets derived from large soil monoliths in lysimeters, where with the drainage flux a closed water balance can be recorded.

Here, we investigate

(1) whether root water uptake profiles differ significantly between ecosystems of different diversity and

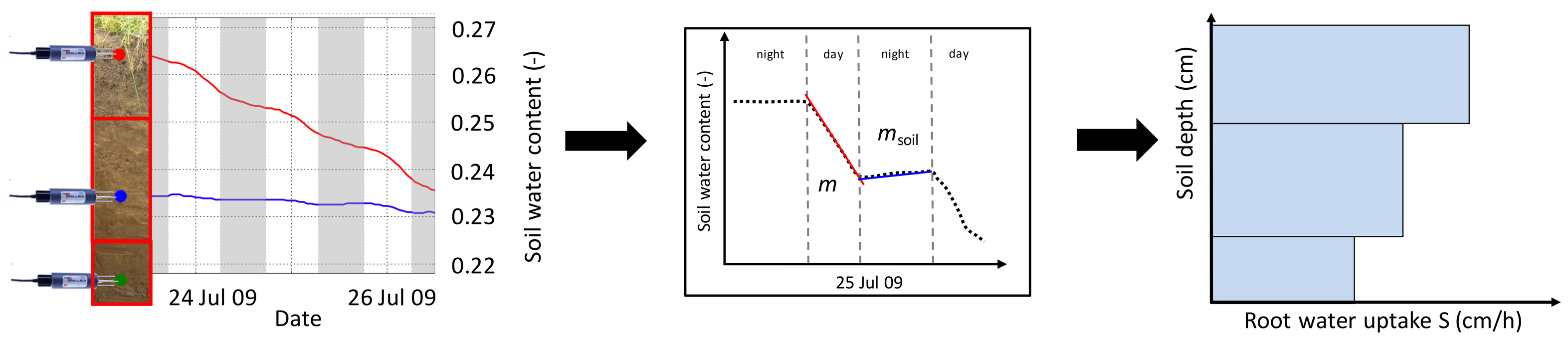
(2) whether plant diversity influence vertical soil water fluxes and redistribution of soil water.

For this, a measurement campaign has been carried out on twelve large scale lysimeters from the Jena Biodiversity Experiment with two diversity levels (4 and 16 species) in the CNRS ECOTRON, Montpellier, from April to August 2012. We analyse time series of soil matric potential, soil moisture, groundwater table, drainage, irrigation as well as evapotranspiration to close the water balance. Additionally, we apply data-driven methods on these lysimeters with different diversities to estimate root water uptake profiles and soil water fluxes based on the short term fluctuations of soil moisture.

Methods

- Estimation of evapotranspiration from weight changes of 12 lysimeters
- Estimation of root water uptake patterns from soil water content measurements with the Slope Approach

<u>Slope Approach</u>



Day: $\frac{\Delta\theta}{\Delta t} = \frac{\Delta\theta}{\Delta t}\Big|_{soil} + \frac{\Delta\theta}{\Delta t}\Big|_{roots}$ $\quad m = m_{soil} + m_{roots}$

Night: $\frac{\Delta\theta}{\Delta t} = \frac{\Delta\theta}{\Delta t}\Big|_{soil}$ $\quad m = m_{soil}$

$\longrightarrow$ $S_i = (m_i - m_{soil,i}) \cdot d \cdot z_i \qquad ET = \sum_{i=1}^{n} S_i$

ET - evapotranspiration (cm/h)
z_r - active rooting depth (cm)
Θ - soil water content (-)
t - time (h)
m - average slope on the soil water content time series
S - root water extraktion (cm/h)
z_i - soil layer thickness representative for the measurement (cm)
i - number of soil layer

Requirements:

- Time series of soil water content measurements at several depths
- Rainfall measurements to determine dry periods
- Global radiation to determine time of active transpiration *d*

Experimental Setup

<u>CNRS Ecotron Montpellier</u>

- Closed controlled environment facility for 12 weighable lysimeter with flexible platforms for ecosystem research.
- Control CO_2, relative humidity and temperature conditions
- Online measurements of soil water content, temperature and evapotranspiration etc.
- Set up of a vertical soil temperature gradient
- Natural light and undisturbed soil monoliths

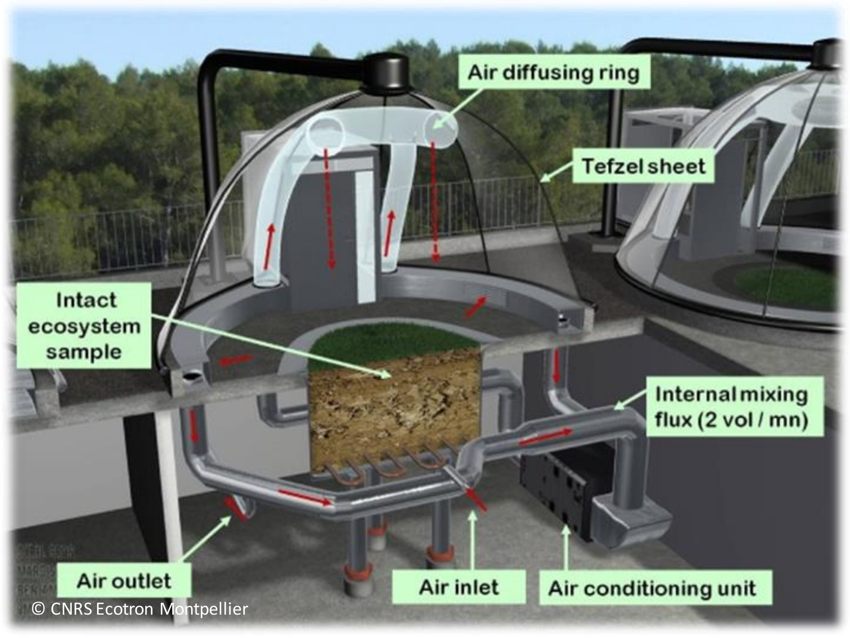


Fig. 1: Detailed scheme of the macrocosm chambers in the CNRS Ecotron Montpellier to control CO_2, relative humidity and temperature conditions

<u>Ecosystem samples from the Jena Experiment</u>

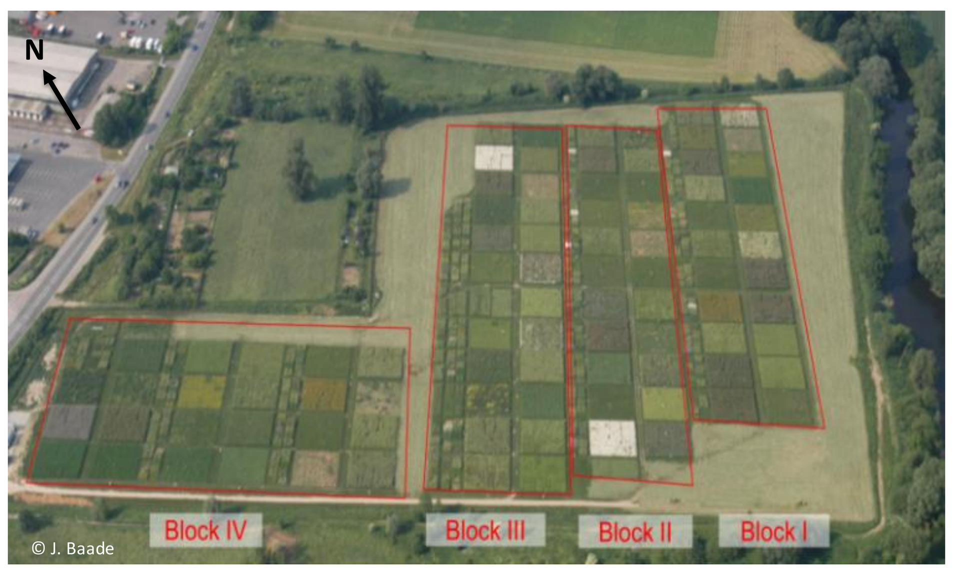


Fig. 2: Experimental field site of the Jena Biodiversity Experiment next to the river Saale. The experimental design insists of 78 plots, each 20x20 m. On each plot grow plant communities of different diversity. The plants are grasses, legumes, tall and small herbs with differing compositions (1 to 60 species).

- 2 diversity levels with small herbs, tall herbs, grasses and legumes:
  - 6 lysimeters with 4 species diversity level
  - 6 lysimeters with 16 species diversity level
- Lysimeter area: 2 m²
- Hight: 2 m
- Lysimeters with different soil textures from sandy loam (excavated near the river) to silty clay (with increasing distance from the river)

<u>Lysimeter setup</u>

- Set up of the climate recorded in Jena 2007 (relative humidity, temperaure, precipitation, soil temperature and global radiation)

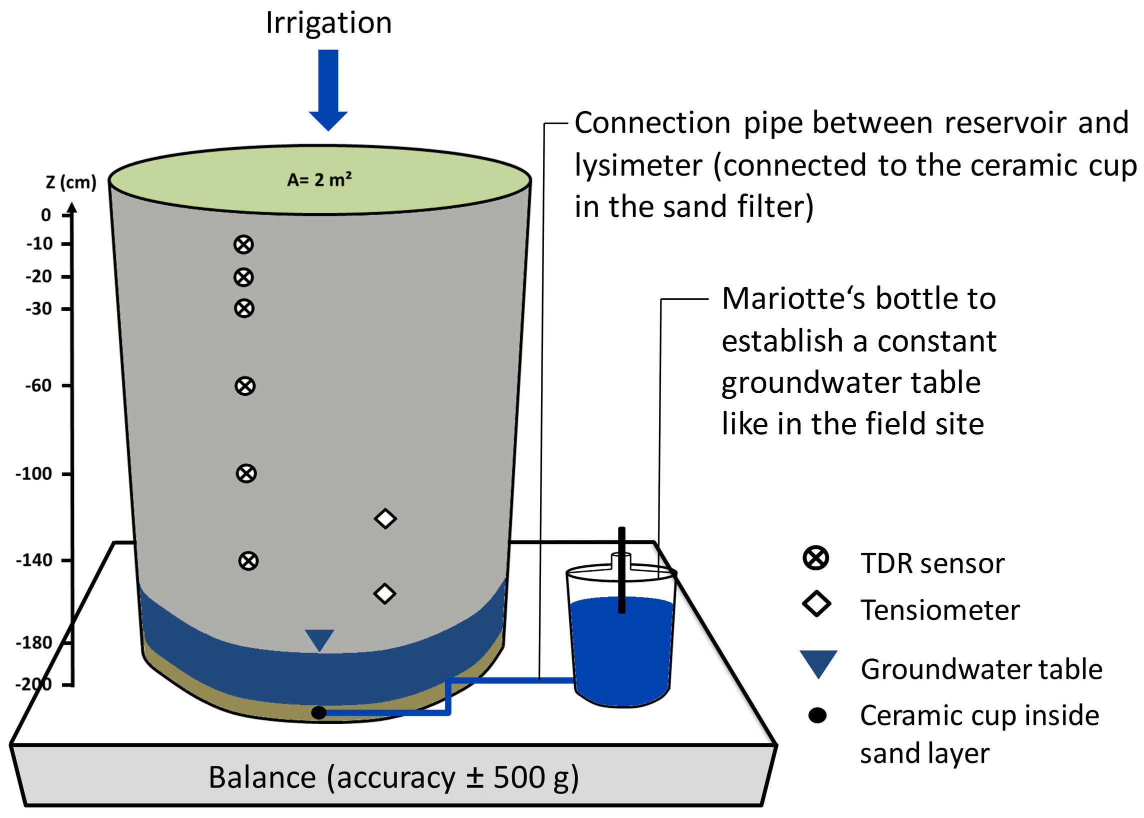


Fig. 3: Scheme of equipped lysimeter displaying the location of time domain reflectrometry (TDR) sensors, tensiometers, the groundwater table and the ceramic cup (left) as well as the Mariotte's bottle for establishing the groundwater table (right) (not to scale).

Preliminary Results

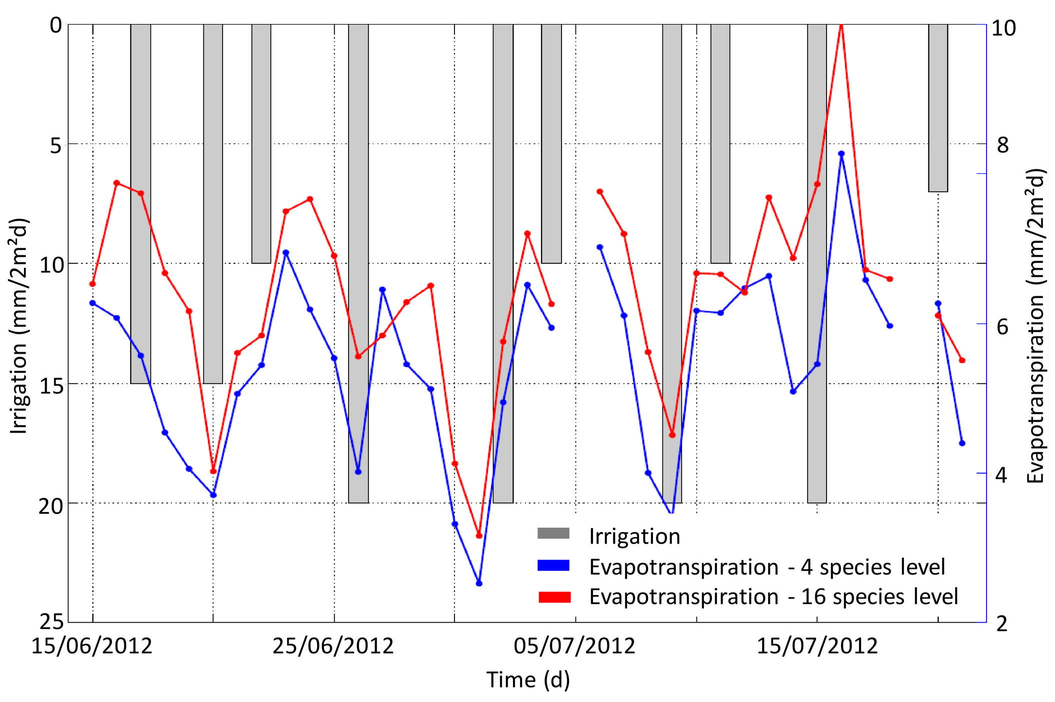


Fig. 4: Time series of absolute evapotranspiration from lysimeters with 4 species diversity level (blue line) and 16 species deiversity level (red line) estimated from weight changes (15 June to 22 July). The grey bars shows the absolute irrigation for every lysimeter.

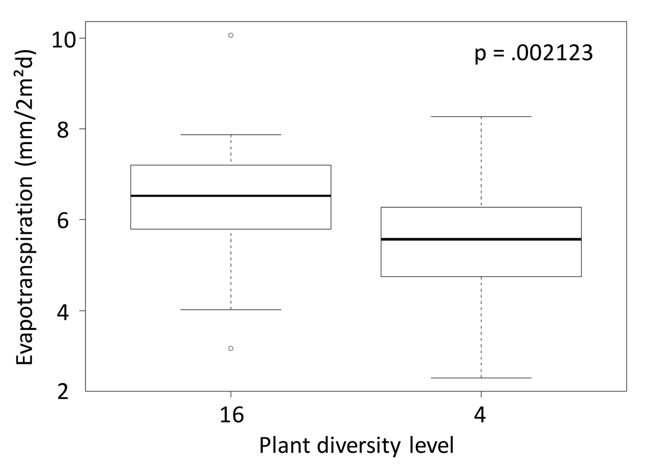


Fig. 5: Comparison of evapotranspiration for 16 species diversity level (left) and 4 species diversity level (right).

Evapotranspiration is significantly higher for a 16 species diversity level than for a 4 species diversity level.

Further Work

Answer the questions:

- Where does the water come from?
- Is the water uptake in diverse plots spread out over a greater depth compared to water uptake in less diverse plots?
- Are the root water uptake profiles comparable with measurements of root length density and root water uptake depths estimated with tracer experiments?
- Does the root water uptake differ significantly between plant functional groups and their specific traits?

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