Hydrol. Earth Syst. Sci. Discuss., 9, C6272–C6278, 2013
www.hydrol-earth-syst-sci-discuss.net/9/C6272/2013/

Hydrology and Earth System Sciences Discussions

Interactive comment on "The importance of plant water use on evapotranspiration covers in semi-arid Australia" *by* A. Schneider et al.

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Received and published: 12 January 2013

General Commentary:

We (the Authors) thank the anonymous referee for significant commentary and suggestions. Some of the comments were found to be crucial in improving our work for potential publication (e.g., regarding the description and novelty of our experimental design, and subsequent implications for the design of evapotranspiration cover systems). In contrast, other comments were deemed to be less relevant with regard to the scope of the study.

Further responses to the referees' queries:

Comment: The Authors present a very limited amount of data. Evapotranspiration depends on many variables and it varies in time and space. The data presented refer to few days before and after a single artificial rainfall event and thus are not sufficient to lead to conclusions about the water use of the two vegetation species analysed; transpiration results from meteorological conditions, soil water content and the duration of periods between rainfall events. These variables are not accounted in the experiment presented. Likewise, the single bare soil measurement is not enough to draw general conclusions on bare soil evaporation. Response: The limited availability of replicates for the bare soil treatment represented an unavoidable component of the field trial. In spite of this, the size of the sample plot was considered to be adequately representative of the broader cover treatment and the pooled sub-samples (within the plot) accounted for potential heterogeneity therein. Also, we minimised any uncertainty involved in the ET measurements using an open-top chamber through a laboratory calibration (page 11917, lines 5-7) and applied these findings to actively correct any measurements on-site. While the open top chamber underestimated gravimetrically determined evaporation from a water tray, a sound correlation between OTC and tray were found. All field measurements were corrected based on the laboratory findings. Furthermore, during the 10 min of field measurements readings were taken every minute inside and outside of the chamber alternatively, which occurred on all location throughout the day. The shorter timeframe readings over the field campaign showed the same patterns as presented in the manuscript. While we cannot exclude systematic errors we conclude that the presented patterns are representative and substantial to conclude on the water use of selected plant species. The measurements were not related to periods between rain events because these events are quite unpredictable in this environment. The addition of water to the soil surface resulted in limited wetting at depth, so it was considered reasonable to assume that the site was in hydraulic equilibrium at the beginning of the study.

Comment: The calculation of transpiration for individual plants is based on the area of bare soil within a chamber. I can see two problems with this estimation. 1) As shown in Fig. 1, the vegetation partially covers the ground so that it is difficult to distinguish between vegetated and bare soil. How is the contribution of the bare soil under the vegetation canopy accounted for? What is the effect of the shadow? 2) The evaporation from bare soil is calculated using a single measure from the chamber installed on bare soil. What is the error associated with this estimate? The bare soil near plants might be wetter than the bare soil where the bare-soil chamber is installed because of shade and maybe hydraulic redistribution. How are these differences accounted for? Response: Measured ETi (Eq. 6) integrates both the transpiration from the individual plant i and the evaporation "[. . .] from the area covered by an individual plant [. . .]" (page 11918, line 1). Hence, ETi integrates both the contribution of bare soil under and near vegetation canopy as depicted by Av (projected area of vegetation coverage) in Fig. 2, and photosynthetic transpiration. In addition, the bare soil measurement, as every measurement location, is not a single measurement but a composite of measurements taken every minute across the total 10 min measurement period.

Comment: The limited amount of data makes the extension to the plot rather arbitrary. Likewise, the discussion section appears very speculative and quite vague. Many of the statements in the discussions are reported as results of general validity, while they might be simply due to local characteristics of the plots studied in the experiment. Response: We agree with the referee's comment and will address the rationale of these scenarios in the revised manuscript. The strategy of linearising relationships between vegetation coverage and plot evapotranspiration was used to depict the most conservative relationship regarding maximum possible evapotranspiration. For ecosystems with vegetation cover smaller than 50%, our data set provided a valuable projection of vegetation/species composition coverage. Indeed, at certain scales of resolution, the incorporation of further parameters (i.e., accounting for increased shading, albedo, plant competition for water) would likely result in the mentioned non-linear relationships. However, the inclusion of the various parameters impacting on the transpiration rate of plants leading to such non-linear relationship would project lower ET rates and hence provide further support to our critical conclusion that "relatively large vegetation

coverage [. . .] is required to make plant community composition a critical determinant of water loss through evapotranspiration" (page 11926, lines 12-14) – a conclusion based on projections rather than predictive models. These aspects will be revised and clarified in the discussion.

Comment: Title: too general and vague. I would change it. Response: We have revised the title to better reflect the content of our study: "The limited role of vegetation in the water balance of mine waste cover systems in semi-arid Australia".

Comment: Page 11914, lines 10-15: I would specify the years used to calculate the long-term averages of rainfall and temperatures. Response: Calculations of long-term average rainfall and temperature are based on the years 1963-2011. We will revise the paragraph accordingly.

Comment: Page 11914, line 20: the residual moisture should be larger than zero. Response: While the residual moisture will be larger than zero, this value was an outcome of water retention curve modelling with RETC (van Genuchten et al., 1991) and is a fitting value. The according plant-physiological residual soil moisture content will range in the order of magnitude equivalent to approx. 1.5 – 5 MPa (based on values cited in literature for semi-arid environments). This information will be added to the manuscript

Comment: Page 11915, lines 15-16: the two species are defined here using the short notation Sen and Scl. However, these are not used throughout the manuscript, but the full name is always reported. Please, choose one notation and be consistent. Response: We will revise notations throughout the manuscript.

Comment: Page 11915, lines 20-23: how was 17 mm chosen? What area has been watered? From Fig. 3, soil moisture goes from about 0.02 to about 0.13-0.16 in the first 50 mm of soil. A lot of the water thus infiltrated below 50 mm. What is the meaning of reporting the measurements in Fig. 3? How do they relate to the results in Fig. 4? Response: During the review progress we realised that we provided a faulty number for the simulated rainfall event. A total of 54L was applied per location, using a 9L watering-can over a ground area slightly larger than the open top chamber (0.79m2). This equates to a simulated rainfall event of 42 mm, representing a major storm event in the area. The purpose of Fig. 3 is to depict that watering was effective, i.e. infiltration occurred rather than runoff or any other loss of water. Fig. 4 relates the water use (ET) of plants in relation to evaporation from bare soil to the time elapsed since watering. This information is critical to evaluate the functionality of plants on waste cover systems, i.e. their potential to maximise water loss from evapotranspiration.

Comment: Page 11915, line 25-26: how was 10 minutes chosen? How are different evapotranspiration rates affecting the quality of the measurements? I would provide more details on the testing of the chambers. Response: The purpose of this study was to apply the OTC method rather than testing it. Furthermore, the OTC chamber has been previously described in the literature (Hutley et al., 2000, Zeppel et al., 2006), which is cited in the manuscript (pg 11917 Line 8). Therefore, we would prefer to maintain the current brief description of the OTC method in the main body of the manuscript. At the discretion of the Editor, a more detailed description can be presented as Supplementary Information.

Comment: Page 11917, line 2: in the environment described, G is unlikely to be zero. Response: Based on the FAO 56 Penman Monteith equation (adopted in the manuscript) soil heat flux between one and 10 days will be low and can be assumed zero (Allen et al., 1998).

Comment: Eq. 6: the rationale behind this equation should be better explained. What is the effect of shades, different soil moisture and temperature, and different wind conditions on bare soil evaporation? Response: The rationale of Eq. 6 is to estimate ET of the projected area covered by vegetation, which is usually smaller than the ground area of the chamber. Hence, the chamber measures an integrated value of ET (evaporation from bare soil + evapotranspiration of the plant), which needs to be corrected by the portion of bare soil area. Evaporation from bare soil was determined separately at a

different location of the same plot. Given the extreme but constant weather conditions of the semi-arid field site during the trial, we believe that the effect of shade, differences in soil moisture and temperature, and wind conditions on the bare soil evaporation is rather irrelevant for the ET estimates as shown in a more detailed description of the uncertainty analysis in the revised manuscript. The effect of shade varied between the two species because of the different canopy densities and mean distances from the ground. Because vegetation cover is conventionally recorded as the total project area beneath a plant canopy, without adjustment for canopy density, we followed this procedure.

Comment: Page 11920, line 1: it is not clear how morning and afternoon are defined. Which hours of the day are used? Response: "ETi measurements were conducted [. . .] over the course of a day from dawn (06:00 h) to dusk (18:30 h) [. . .]." (page 11915, line 24). The separation between morning and afternoon was made based on maximum PAR, which occurred between 12:00 and 14:00 hrs.

Comment: Page 11921, line 2: I don't think Rodriguez-Iturbe et al. (2001) define evapotranspiration as the most critical ecohydrological variables, since the focus of their study was soil moisture, which was considered as the key variable. Response: We agree that the work of Rodriguez-Iturbe et al. (2001) focuses on soil moisture rather than evapotranspiration. However, "[. . .] plants have an active role in water use that heavily conditions the water balance of the system." (Rodriguez-Iturbe et al. (2001)), which is critical in the context of waste cover systems that aim to minimise drainage into deeper soil layers through maximising ET. We will clarify this in the revised manuscript.

Comment: Page 11921, lines 19-29: these are general speculations not based on the results of the manuscript. Response: The purpose of the discussion is to broaden the context of water use strategies of plants to make it accessible to an ample community. Likewise, the discussion is based on peer-reviewed literature that provides alternatives of water use strategies and ecohydrological functioning of ecosystems observed elsewhere rather than being speculative.

Comments: Figures 1 and 2 are not useful. Response: We find figure 2 useful to explain how areas shaded by the individual plant are accounted for ET estimates of individual plants. Therefore we believe the manuscript will certainly benefit from this figure as well as a more detailed description of the rationale of Eq. 6 to which figure 2 refers to. Fig.1 will be deleted.

Comment: Figure 4: I would move the legend in the frame and make the whole graph larger. Response: Figure 4 has been amended as suggested.

Comment: Figure 5: I would report ET in mm/hour. Response: The values will be changed to mm/hr

Literature Allen, R. G., Pereira, L. S., Raes, D., and Smith, M.: Crop evapotranspiration: guidelines for computing crop water requirements, FAO Irrigation and Drainage Paper, 56, 1–328, 1998. Hutley, L. B., O'Grady, A. P., and Eamus, D.: Evapotranspiration from eucalypt open-forest savanna of northern Australia, Funct. Ecol., 14, 183–194, 2000. Rodriguez-Iturbe, I., Porporato, A., Laio, F., and Ridolfi, L.: Plants in water-controlled ecosystems: active role in hydrologic processes and response to water stress – I. Scope and general outline, Adv. Water Res., 24, 695–705, doi:10.1016/s0309-1708(01)00004-5, 2001. van Genuchten, M. Th., F. J. Leij, and S. R. Yates:The RETC Code for Quantifying the Hydraulic Functions of Unsaturated Soils, Version 1.0. EPA Report 600/2-91/065, U.S. Salinity Laboratory, USDA, ARS, Riverside, California, 1991. Zeppel, M.J.B., Yunusa, I.A.M. and Eamus, D.: Daily, seasonal and annual patterns of transpiration from a stand of remnant vegetation dominated by a coniferous Callitris species and a broad-leaved Eucalyptus species, Physiologia Plantarum,127:3, 413-422, 2006.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 11911, 2012.