

Interactive comment on “Drought in forest understory ecosystems – a novel rainfall reduction experiment” by K. F. Gimbel et al.

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General comments

1.Referee: "...although this is important, the paper is now written to understand ecosystem consequences, while the experimental design was only one year without having any statistically differences. They finally conclude that the roof structure itself also has the problem that adult trees can extract water from the surrounding, which is already the problem for decades by these manipulation experiments. So I do not see why the system is that innovative. In the whole paper I can not find any interesting point that increases our understanding of the system."

Answer: We do not agree with the referee – a misapprehension might have occurred

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here: in this paper, we present the construction of an innovative flexible roof for rainfall exclusion/reduction experiments. The focus lies on the construction and operation of this roof which allows flexible reduction of the precipitation and not only a fixed amount of reduction. It is well suited to reach predefined target values and can be operated at many sites and also in remote areas since for operation neither electricity nor intensive technical supervision is necessary; moreover as stated repeatedly in the manuscript the roofs are meant to manipulate the water relations of the understory. The results of the plant experiments are an illustrative "add-on" to show how initial understory reactions look like. The general focus is NOT on the adult trees and thus their extraction of water from the surrounding soil is not a problem. This is, because the trees consume the additional water and don't change the water budget for understory plants under the roofs. Only hydraulic redistribution could change the budget, which we didn't observe. Hydraulic redistribution to drier soil areas should occur during night and thus a night-time increase in soil moisture should be observed when we assume that such mechanism should play a role. Since we did not observe such night-time response we can be confident that hydraulic redistribution is negligible and thus does not compromise our design at all. If our roofs were to be applied for assessing the effects of drought for adult trees the problem of their roots taking up water from outside the roofed area can be easily avoided by enlarging the roof over the perimeter of the roots (Please see also the answers to comment no. 1, 10, and 11 of referee#1, and comment no. 3 of referee#3). To conclude, our system is indeed innovative: we've overcome the problem of complete reduction of precipitation; our roof offers the possibility to use an adaptive reduction level between 11 - 100 %; it does not need any electrical components; it can be adjusted in size to the experimental and local requirements; it is easy to build, to handle, and to maintain; it is not promoting any greenhouse effect; and, with extra handling, litter build up is least disturbed (not described in this paper).

Specific comments:

2.Referee: Pg 14322, L19-20: How will ecosystem response depend on ecosystem

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stability? This is a very important question from ecology. But what is ecosystem stability, can you measure this? It is unclear why the authors have stated this. Do they refer to the stability-diversity debate, as they have included in their introduction microbial community structure?

Answer: Since the paper is mainly meant to demonstrate the design of the rainfall reduction system and referee # 1 also suggested to focus on this part we have now omitted this sentence. We agree with the referee that this is an important question but discussing this point here would be beyond the scope of our manuscript.

3.Referee: Pg 14330 L3-5: The specific LAI was measured, but unclear what this is. It seemed to be the total LAI assuming that the leaves are horizontal. Interesting from an ecohydrological point of view is the real LAI, so including the angle of the leaf. Why didn't you measure this?

Answer: We agree that the LAI as determined here is a proxy for the real LAI. However, especially when assessing a not very intensively structured canopy with most of the species having their leaves very close to the ground classical LAI measurements (e.g. with ceptometers) are difficult and error prone. We think that our approach is a good compromise and it also allows an estimate of the effect of drought on leaf area.

4.Referee: Pg 14330 L19: Interesting are the experiments with phytometers, but it is unclear to me how this will work.

Answer: For clarification, we changed the sentence 14331 L1 to: "Growth of all planted beeches was recorded by measuring different growth response variables such as leaf number, plant height, leaf length and crown expansion and compared with the phytometer data of the control plots." (Please see also answer to comment no. 8 of referee#2 below)

5.Referee: Pg 14331 L9: You measure evapotranspiration in the gas chambers. I do not understand this, I assume that you measure the transpiration and not the evapora-

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tive fluxes, right?

Answer: We indeed measured evapotranspiration. To make that point more clear we have now added the following explanation to the Materials and Methods section: "The chambers were open to the soil, sealed with rubber foam gaskets to the ground and were used as closed systems to assess the build up of water vapour from soil evaporation and plant transpiration."

6.Referee: Pg 14333 L20: Interesting would be how CO₂ will change under the canopies as I would expect higher values. This would be a nice research, however, the authors didn't look to that.

Answer: We agree that CO₂ concentration measurements would have been a nice complementary assessment. We think, however, that we have very good arguments not to assume a CO₂ build up under the roofs. We normally need to assume that total evaporation fluxes from the whole understorey system should be up to three orders of magnitude higher than net CO₂ emission (mmol/m²/s for water vs μ mol/m/s for CO₂). If the roofs would prevent air mass mixing this should be then also visible in the RH under the roofs. Our measurements show no difference in RH and air temperature between roofed and control plots, which clearly points to a comparable coupling of airspace on both subplots. In addition, the design of the roofs with an incomplete coverage (2 m high, four sides open, maximum roof coverage 55 %, complete roof area only 10 m²) definitely not represent a closed roof. Given that, it is very unlikely, that RH and temperature stay totally unaffected and CO₂ would be affected. We have stated this point as follows in our manuscript (section 4.2): "Our measurements show no difference in humidity and air temperature between roofed and control plots, which clearly indicates a comparable coupling of airspace on both subplots. In addition, the design of the roofs with an incomplete coverage (2 m high, four sides open, maximum roof coverage 55 %, complete roof area only 100 m²) definitely not represent a closed roof. Given that and the findings that air humidity and temperature stay totally unaffected, it is very unlikely, that CO₂ concentrations increased under the roofs and thus also no

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CO₂ fertilization effects are to be expected.”

7.Referee: Pg 14333 L25: Now I am lost. What kind of significant effects? We are now discussing your results while you came up with references

Answer: We agree, the sentence might be capable of being misunderstood. We changed the sentence to: “Because elevation of air temperature and humidity has significant effects on growth, germination, transpiration and water uptake of plants, on microbial activity and on soil evaporation, we aimed at avoiding any alteration of air temperature and humidity as well as radiation.”

8.Referee: Pg 14335 paragraph 3.4: Plant community and phytometer: More information is needed for the phytometer, what are the rooting depths, are they different. How well are they performing.

Answer: We agree with the referee and inserted following explanation and a reference in section 2.4: “The saplings had an initial height of 30–50 cm (with a mean and sd of 34.74 cm \pm 8.15 cm, respectively) and a tap root length approximately of 10 cm. At the time of planting, roots of all saplings were pruned to 10 cm to avoid crooked roots in shallow soils, as they occur at the Hainich and Schwäbische Alb site.” “...For further information on the experimental design of the phytometer experiment see Baudis et al. 2014.”

9.Referee: Pg 14335, L 14: If there is no significant difference then a tendency is not interesting. It is not significant so.

Answer: The description of the non-significant tendencies has been omitted.

10.Referee: Pg 14335, L23: “Interesting that there is an interaction effect between drought and site, however, why? Do you have a hypotheses on this, e.g. due to higher storage capacities? The authors doesn’t give any information about this.”

Answer: The interaction effect between drought and site corresponds to the soil moisture results (Figure 6) and caused by soil texture and total precipitation input: the

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amount of plant available water is (in general) highest in the Schwäbische Alb region, caused by the interaction of water storage capacity and absolute water input.

11.Referee: Pg 1433, L4-6: This is the only interesting result I would say, and it would be great to understand this. Apparently the ecosystem can adapt in such a way that the functioning remains the same. Interesting would be to find the shift, but for that the system needs to be run for more years with probably more extreme drought and fixing the problem that the roofs are too small.

Answer: We agree that for the understanding the general reaction of an ecosystem with threshold values and tipping points towards extreme drought long-term experiments would be necessary. We are however, also of the strong opinion that we additionally need to assess responses of ecosystems to realistic drought conditions most probably occurring in future. The roofing system presented here allows both, realistic rather short drought periods and more intensive long-term treatments and is also flexible enough to adapt the precipitation regime.

12.Referee: Pg14337, L20: The work of Dermody et al (2007) is work on CO₂?

Answer: The citation has been omitted. The sentence reads now as follows: “This is in line with the findings of English et al. (2005), who found a decrease of soil moisture deficit with depth.”

13.Referee: Pg14338, L1: The problem that the soil under the roof is influenced by trees rooting outside the roof is always the problem. This is why the roofs should be made bigger and I hoped that this was the case with this study. It means that still all interpretations should be made with care.

Answer: We agree with the referee, and therefore used and propose the use of roofs with the size of 100 m². The referee is also referring to the problem of adult trees rooting inside and outside of the roofed area, and therefore possible extract water outside the roofed area and release it via hydraulic redistribution inside. We did not detect any

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nocturnal rise in our soil moisture data, which can be associated with hydraulic redistribution. We focused in our study on understory vegetation and not on adult trees. Any water that is extracted from adult trees outside the roofed area (and is not redistributed) is consumed by the tree itself and therefore not changing the soil moisture budget. (Please see also the answers to comment no. 1, 10, and 11 of referee#1, comment no. 1 of referee#2, and comment no. 3 of referee#3).

14.Referee: Pg 14338, L12: Of course stress induced by drought may alleviate competitive exclusion, but indeed I would expect that shifts in species will take more time. So this paragraph is a bit confusing, as later on you only talk about effects in fluxes by (e.g. Leuzinger et al. 2011) and not in species shifts. As your experiment is not long enough and not strong enough (L26, p 14338), your experimental design can not say anything on these processes

Answer: We have now omitted this speculative part of the discussion also in agreement with comment of referee # 1.

15.Referee: Pg 14339 L22: We conclude that our innovative roofing ... etc: But you have not tested anything. Why innovative, as you still have the problem of adult tree extracting water outside the roof.

Answer: We do not fully understand this point raised by the referee: As stated above (comment #1). Our roof allows for a flexible rainfall reduction and therefore overcomes the problem of fixed amounts of former roofing designs. Furthermore, our roof offers the possibility to use an adaptive reduction level between 11 - 100 %; it does not need any electrical components; it can be adjusted in size to the experimental and local requirements; it is easy to build, to handle, and to maintain; and it is not promoting any greenhouse effect. As also stated above and repeatedly in the manuscript, the roof was designed to manipulate the water relations of the understory. Nevertheless, if the roof sized is enlarged over the perimeter of the adult tree roots, the addressed problem of external extraction of water can be easily avoided (Please see also the answers to

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comment no. 1, 10, and 11 of referee#1, and comment no. 3 of referee#3)

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