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**Biogeosciences Discussions**

# *Interactive comment on* "Response of temperate grasslands at different altitudes to simulated summer drought differed but scaled with annual precipitation" *by* A. K. Gilgen and N. Buchmann

**Anonymous Referee #1**

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General Comments: In this manuscript the authors tested predictions that future reductions in summer precipitation will impact grassland ecosystems along an altitudinal gradient in Switzerland. Response to drought varied by site, with the highest altitude site showing the strongest drought responses while responses at the other two sites were somewhat unpredictable. These data suggest that Swiss grasslands with low annual precipitation are the most susceptible to future rainfall reductions.

At the high altitude (low ppt) site, the data may suggest that the structure and function of this grassland may be shifting to a more semi-arid ecosystem. This may be evidence for an ecosystem in transition.



The varying sampling strategies, implementation of treatments, and site management policies across each of the 3 sites made it very confusing and difficult to keep track of appropriate comparisons and responses. As a field ecologist myself, I sympathize with the perils and pitfalls of site-dependent fieldwork, but the inconsistent (or site-specific) methods and inconsistent results (or lack of treatment results) across sites made it difficult to recognize general conclusions from this research.

In general, the Results section needs to be condensed and presented more succinctly.

What mechanism do you propose for the positive biomass response of grasses at Fruebuel during drought? The statement on line 21, page 5231 seems odd. Are you suggesting that water-logged soils and anaerobic conditions (or some other mechanism) are somehow reducing productivity?

In the second paragraph of the Discussion, root depths for the grasses and forbs are used as potential mechanisms to interpret varying community responses to drought. Grasses and forbs can have similar maximum rooting depths, but the proportion of roots at depth and the utilization of water at depths can differ markedly. It has been shown that the presence of roots at depth in grasslands is not a good predictor of water use at depth, even during dry periods (Nippert and Knapp, 2007 Oikos V116 1017-1029; Oecologia V153:261-272). Thus, it is a possibility that the forb and grass communities were utilizing water from different portions of the soil profile during the drought treatments, regardless of maximum rooting depth. Without water isotope data, it is difficult to tell.

Specific Comments: 1. Page 5219, line 26, you missed some key citations from Alan Knapp (Colorado State), John Blair (Kansas State) and Philip Fay (USDA-ARS) who are the pioneers in large-scale precipitation manipulation experiments in mesic grasslands. Their work has shown large ecosystem level responses to manipulations in precipitation timing, independent of changes in precip amount. Check their webpages and cite accordingly. 2. Page 5220, line 4: What is altitude a surrogate for environmen-

tally (of interest)? I would assume 'dryness', and as such, yes this question has been done before (Heisler-White et al. 2008). As you've currently phrased this question, the uniqueness doesn't really appear to be that unique. I would suggest you rephrase this sentence to highlight more of the ecology and predicted response. Additionally, responses are not replicated by altitude and thus it is hard to draw general 'altitude' conclusions from this research since there is only 1 site at each altitude. Presently, it is hard to tell if the responses measured are simply a low precip. response, an altitude response, or some interaction of the two. 3. Why did you choose to exclude all rain from the sites for the treatment periods? Extended droughts are generally produced by reducing the amount of rainfall per event, or lengthening the periods of time between events (or both). In your simulations, the target reduction was simply a long absence of rainfall, but not a 'season-long' drought. The lack of an effect at the two lower-elevation sites may reflect the fact that the treatments and target reductions were not season-long, but in fact were only for a portion of the growing season after which rainfall amounts and timing were back at ambient. At the higher elevation site, it presumably has a shorter growing season, and the exclusion of rainfall for 6-8 weeks was sufficient to impact ecosystem responses. 4. How many control plots were present at each site? Five? (the same as the number of shelters per site)? 5. How did you keep water from moving laterally through the soil into the drought treatments? Was flashing buried around the plot boundaries to restrict water movement overland and through the soil? 6. ECH2O soil probes are notoriously finicky and problematic. How did you calibrate your probes? The data produced by these probes varies greatly by soil texture, and is sensitive for a fairly limited range of volumetric contents (not too wet. . . not too dry). The comparison of the vol. and grav. soil moisture data in Fig. 1 doesn't show much agreement between the two measurements. Perhaps this is just because the figure is small and one variable is continuous, but I don't see much consistency (and validation for interpreting the data from the EcH2O probes). Also, why did the dashed lines in panel E (drought treatment) drop to <10 before the treatments were initiated (shaded section)? 7. In section 2.3 (Aboveground productivity), did you record



the number of species per plot / per site? Did richness vary over time as a function of the treatments? 8. I don't understand the first sentence on page 5225. Do you mean that you used all data within a plot as an independent replicate rather than placing the statistical inference at the plot scale? If so, this is pseudo-replication and your inference is now only these plots at these few grassland sites and not the larger altitudinal gradient in Switzerland. Please elaborate on how the data was used in the analysis. 9. A common consequence of rain-out shelters in close proximity to the ground is they can alter the boundary layer dynamics above grasslands. How did RH and/or VPD vary as a consequence of a "shelter-effect"? If RH was higher in sheltered plots, this may have mitigated some of the soil water losses during the treatment period. 10. On page 5227 line 9/10, is the reduction in productivity really from the drought treatment, or from the increased productivity of Rumex? This is a difficult effect to tease out and I'm not convinced that simply excluding Rumex biomass from the total sample allows you to infer a treatment response for the remainder of the productivity sample. 11. What do the values in the column 'duration' mean in table 2? 12. What year do the data in Fig. 4 come from? 13. In the discussion, heavier $\delta$13C in the drought treatment are used to infer water-savings from greater stomatal regulation. It is somewhat difficult to interpret data from Alp Weissenstein since there was only 1 sampling each year. However, since this was the only site to illustrate a reduction in biomass from the treatment effects, it may be interesting to discuss the somewhat marginal differences in $\delta$13C between treatments at this site. Perhaps stomatal regulation is lower at this site? 14. In Fig. 6, what is the difference in the solid versus dashed lines? Are you proposing a causal response between reductions in precip and changes in biomass? The data in Fig. 4 doesn't suggest such mechanism exists. As such, is Fig. 6 simply showing that a precipitation*biomass gradient exists along the altitudinal gradient? If so, is that response worth a figure in this manuscript?

Technical corrections:

15. First sentence page 5218, replace 'live' with 'life'. 16. Line 24 page 5218 and

line 27, page 5234: what is an ‘adaptation measures’? A management strategy? 17. Page 5219 line 1, use of the word ‘probably’ is weak and needs to be rephrased. 18. page 5220, line 7. Focused is misspelled. 19. page 5220 line 9: replace “react in accordance” with the word ‘scale’. 20. page 5223, line 3: replace “an own. . .” with “its own”. 21. Page 5227, line 21, 26, focused is misspelled. 22. Focusing is misspelled on page 5228, line 10 23. Line 26, page 5232. Starting a paragraph with “But. . .” is very awkward. 24. Line 15, page 5233 add the word “integrated” before WUE. 25. Line 24, page 5233, delete ‘also’.

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Interactive comment on Biogeosciences Discuss., 6, 5217, 2009.