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Biogeosciences Discussions

# *Interactive comment on* "Reviews and syntheses: On the roles trees play in building and plumbing the Critical Zone" *by* Susan L. Brantley et al.

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General comments:

This manuscript presents a set of cross-disciplinary hypotheses addressing the impact of trees on the Critical Zone over a wide range of time and spatial scales. As the different disciplines (eg geology, ecology, soil science) have taken very different approaches to these questions, there is a need for all of us both to revisit "established" viewpoints and to consider new ones in order to gain a holistic understanding of the function and development of the Critical Zone. Amongst the hypotheses are several which I have been thinking about for some years, and I am pleased to see them presented here along with several other things I had not thought about in as much detail before. This paper provides a useful framework for cross-disciplinary cooperation.



Specific comments (explicit list of things to do at the end above "Technical corrections"):

Hypothesis 1. I have long been rather skeptical of claims that roots (or hyphae) exert forces that fracture bedrock, especially in directions perpendicular to the bedrock surface where there is nowhere for the rock to go (eg a free surface as on a hillslope, or into compressible soil). What is the role of the chemical environment of a root or hypha (ie the rhizosphere or hyphosphere) in crack propagation?

Hypothesis 2. I think that dissolution rates for surfaces covered with cryptogams (lichens and bryophytes) could do with more investigation, as the critical zone for these ecosystems is very different from those with vascular plants.

Hypothesis 3. Is tree throw a function of tree density? Do trees fall less frequently when surrounded by other mature trees? What is the slope angle of of the Oregon hillslopes discussed in lines 16-29, for comparison with that of West et al 2013? What was the state of the canopy in the forest on shale studied by West et al? Does this forest have pit-mound features? What is the disturbance timescale for these sites, and do either of them have smectites that might lead to more frequent landslides? Where do steady-state values of "h" occur?

Hypothesis 4. This section needs a brief discussion of how dust particles differ from soil particles. Does dust have a smaller anion exchange capacity? Is dust primarily mineral (and if so what sort of minerals) or is there an organic component? Why would dust be a better source of P than soil? Are the particles so small that they disappear and leave a legacy of ions behind?

Hypotheses 5,7,8. It sounds like we need a thorough overview of wilting points for a variety of plant and mycorrhizal functional types; this has important implications for global vegetation models especially if they use hardcoded or database values for wilting points. Is the greater amount of nutrients in surface soils due to organic matter; is this because the plants are in general recycling nutrients? Are the deeper, saturated soils referred to on line 15 page 16 above field capacity, and are the roots aerenchymatous?

It may be worth citing Bornyasz et al 2005b under hypothesis 8, as they showed that ectomycorrhizal hyphae penetrated bedrock matrix. They cited Hubbert et al 2001b and Egerton-Warburton et al 2003 as earlier sources suggesting that hyphae were important for tree water relations; these should probably be cited along with Bornyasz et al 2005b.

Hypothesis 6. Hydraulic redistribution of nutrients must depend on the amount of nutrients that enter the roots in the transpiration stream and are then not taken up internally. How well understood are those processes? Also, is there an effective redistribution of nutrients due to throughfall, ie leaching of ions from leaves by rainwater, and if so, it this a function of leaf attributes such as shape, specific leaf area, etc?

Hypothesis 9. The effect of different soil layers on streamwater chemistry is surely strongly dependent on the timescale of interest. It begs the question of how well we understand the residence time of water in the different soil compartments. Is there a reference available for the statement that most streamwater solutes originate from soil weathering?

General. As stated in the conclusions, the characteristic timescales of water movement are critical for understanding the Critical Zone. I am a bit surprised that there was no explicit discussion of macroporosity however, as old roots are important components of macroporosity and conduits for water to deeper layers. Also, not all sections provide any suggestions for how to test the hypotheses, or what needs to be done, ie do we need to collect a lot of data, do we need new techniques, is there conflicting evidence etc. However, given the wide range of material covered, I think this is a good paper.

Things that the authors should do: Most of my comments above were questions that came to mind because I was interested rather than because I think the authors need to make major changes (although they can certainly do so if they wish). There are however a few things that need to be done: 1. Address the questions about the field sites discussed in Hypothesis 3, ie so that comparable information eg slope angle is



given for both. 2. Answer the questions about why dust is a better source of P that soil particles under hypothesis 4. 3. Add some citations for hypothesis 8 as described. 4. If there is a citation for the the statement that most streamwater solutes originate from weathering in soil, please add it.

Technical corrections. This paper is generally well-written, but I do have a few corrections to list.

Terminology. The manuscript divides the regolith into three units: mobile soil, weathered but immobile material, and fresh bedrock. This is fine, but there are a few places in the manuscript where it is not immediately clear which of these three units is being referred to. For example, under Hypothesis 3, page 12, line 3, and also page 13, line 21, one needs to refer to Figure 3 to know that "soil thickness" refers to "h" (mobile soil depth). As Figure 3 is discussed here that is perhaps OK, but on page 20, Hypothesis 9, line 7, it is less clear. Weathering reactions occur in both the mobile and immobile soil but which of these layers is the primary donor of weathering products to streamwaters? Please clarify.

Other corrections and suggestions: 1. When at first reading the abstract (line 24), it was not immediately clear to me whether "the depth of weathered material, H" referred to the top or the bottom of the weathered layer. On line 25 it is perhaps implicit that "h" is measured from the soil surface. However, one's familiarity with these terms depends on one's disciplinary background. 2. Define "denudation" which occurs in section 1.3, page 8, line 12. I have seen this term used in different ways, to express physical, chemical or all removal of material. 3. Define "soil dilation" which occurs in section 2.3 page 11 line 28. 4. Page 14 Section 2.4 line 27: The sentence "These long time periods can magnify slow losses of P." sounds slightly odd; I had to read it a few times. It means that P losses slow down as rates of uplift and erosion are slow, but perhaps it could be rephrased... 5. Figure 1. There are four panels including three photographs that are not described. These photos need some sort of reference or description: where are they, what are they meant to illustrate here? Also, the labels on the conceptual

diagram have lost their final letters: EVAPOTRANSPIRATIO (with N having wrapped around) and DRAINAG (with E having wrapped around). 6. Figure 2. Panels C and D are never referred to. They clearly belong with Panels A and B respectively and are implicitly discussed as such, but they need references of their own if they are to be labeled separately. also, they contain some awkwardly-phrased labels. "nutrient aquire" should be "nutrients aquired" or "nutrient aquisition", while "nutrient recycle" should be "nutrients recycled" or "nutrient recycling". The panels could be larger; they could easily fill the width subtended by the caption. 7. Figure 3. I had to look at this figure for a while, as I was thrown by the labels h$\sim$H and h«H. H is not defined anywhere in the figure or its caption. Perhaps label the X axis "mobile soil thickness" and somehow relate H to the thickness of bedrock disrupted by tree throw. I am still not sure how these are related, and maybe it is just not clear anyway; I realise this is someone else's figure. Once I had read the text I understood what was meant (mostly), but I looked at the figures before reading the text and so will many of your readers. 8. Table 1. "is comprised of" is not correct... replace with "is composed of" or rephrase.

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