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Hydrology and Earth System Sciences Discussions

Interactive comment on "Significance of tree roots for preferential infiltration in stagnic soils" *by* B. Lange et al.

B. Lange et al.

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Response to Referee #1

We like to thank Referee #1 for his helpful and constructive comments on the submitted manuscript. We acknowledge the suggestions for improving the paper, which will be integrated in the upcoming revised manuscript. The first main concern of Referee #1 was that we conceivably investigated not only the effect of roots but the soil-root system as a whole.

Hegg et al. (2004) showed that water storage capacities varied among types of forest sites. We conducted our experiments in the forest site type Bazzanio-Abietetum (Ellenberg and Klötzli, 1972). It comprises a wide range of infiltration capacities, which are also determined by the condition of the forest: the closer the forest is to its natural stage, the higher is the corresponding infiltration capacity. Hegg et al. (2004) stated that tree roots are able to penetrate into stagnic horizons and may enlarge the pore system and infiltrability. Hence, our hypothesis that tree roots govern infiltrability. However, the hypothesis' generalization requires comparable site conditions, including water balance, tree species and soils with some stagnic conditions with respect to the water balance.

Soil structure was only rudimentarily recorded. With two exceptions, the horizons showed aggregate structure, but the structure type of the aggregates was not further determined, and we cannot exclude the influence of soil structure on infiltrability. Angers and Caron (1998) summarized that soil structure influences root grow, and roots and other soil organisms affect soil structure. Roots create pores, but could also fragment aggregates by penetration (Materechera et al. 1994) and therefore modify soil structure. In conclusion: Root distribution and soil structure depend on one another in many intricate ways. Forest managers may eventually influence roots and root distributions through species selection, tree density and a forest's age structure, among other possible tricks of the trade. However, it might be much more difficult to manage soil structure directly.

Soil texture did affect neither contact length L nor film thickness F. Coefficients of determination between the percentage of sand, silt and clay on one side, and film thickness F and contact length L on the other side varied from 0.03 to 0.16.

Numerous parameters describe infiltrability as the many pedotransfer functions illustrate. We tested the hypothesis that tree root length distributions in stagnic soils are linked to the basic properties of preferential infiltration i.e., film thickness F and contact length L. The high degrees of determination allow us to use tree root density as predictor for preferential infiltration in that tree roots seem to represent pores that carry preferential infiltration.

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The upcoming revised manuscript will be mended according to the following: 1. We will add a paragraph regarding the relation between roots and soil structure in the introduction. Furthermore, the findings of Hegg et al. (2004) will be mentioned. 2. Materials and Methods: Soil structure will be included. 3. Results: Correlations between texture and contact length L and film thickness F will be added. 4. Statements like "tree roots improve infiltrability" will be replaced by statements like "tree root length distributions in stagnic soils are linked to the basic properties of preferential infiltration, film thickness F and contact length L, and can therefore be used to describe preferential infiltration. Hence, tree roots represent the pore system that carries preferential infiltration." 5. Limitations of the results will be clarified: The results are applicable to sites that are comparable to those investigated.

The second main concern was our omission of coarse roots. We agree with Referee #1 and will include coarse roots in the revised manuscript. Consequently, the result section will be modified. In due consideration of the whole root length, the cluster analyses of the root length (Fig. 5) yields to slightly modified group limits and, as a consequence, to minor changes in Fig. 6 that compares soil properties and hydrological parameters of the root length groups. Including all roots, the relationships between root length on one side, and film thickness F and contact length L on the other side alter to minor degrees (Eq. 11 and 12, Fig. 7), and will impact the modelled water content waves. Due to larger root length, the peak values of maximum mobile water content and drainage are reached at a root density of 1.5 cm cmˆ-3 instead of 1 cm cmˆ-3. The relative progression of the modelled water content waves did not change (Fig 8 and 9).

The following paragraphs respond to the specific comments of Referee #1:

Referee #1: "...but the theoretical part is a bit difficult to follow without reading first Germann et al. (2007)." And "Several variables in the equations 1 to 11 are not defined." AC: Variables will be defined and theory will be simplified.

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Referee #1: "Gerke (2006) did not explicitly states that Richards' equation is inadequate but rather that its application is rather limited." AC: "...since Richards' equation (1931) and Darcy's law (1856) are inadequate" will be replaced by "... since the application of Richards' equation (1931) is rather limited".

Referee #1: "I understand that you actually partition the time period into N sections of equal duration and then estimate the corresponding w_j with the increasing limb of w (Z,t). Please clarify that explicitly in the manuscript. AC: Will be clarified in the "theory".

Referee #1: Bulk density is likely not enough to state that "root growth is not limited by soil compaction". This is probably true that there is no compaction in the studied soil but root growth could be limited even in a not compacted soil due to soil dryness (which increases the soil mechanical resistance). Please rephrase or give a reference. AC: Reference: Polomski and Kuhn (1998) claimed that up to a fine soil density of 1.4 g cm-3, root grow is not limited. Furthermore, the soils of our study site are hydromorphic, therefore increasing soil mechanical resistance due to dryness should not limited root grow.

Referee #1: What you characterize is not the root morphology (which characterizes the complete root architectures through indices) but rather the root diameter distribution profile. AC: The term "root morphology" will be changed in "root diameter distribution profile".

Referee #1: p. 2389, line 10: another reason could be the difference between root length density profiles and root architecture, which would then describe how large soil pores are connected. AC: We agree with Referee #1 at this point.

Referee #1: p.2389, line 27: "kind of funnel effect": please clarify. AC: Preferential flow in upper horizons with high root densities is characterized by large contact lengths L but thin films of the mobile water. An increase in soil depth, which corresponds to a decrease in root density, yields to a reduction of pores accessible to mobile water and therefore to a decrease in contact length L. The diminution of L leads to an increase

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of the film thickness F, resulting in an acceleration of the water (Eq. 2), as it can be observed in a funnel.

Referee #1: p. 2392, line 1: did you show that "the water storage space" is enlarged? I would rather say "enlarge the potential soil volume accessible to surface water". AC: We showed that preferential infiltration is related to root densities (Fig. 7). In addition, our modeled water content waves showed that up to a root density of 1.5 cm cm-3 soil, infiltrability and therefore water storage space was enlarged with increasing root densities. Due to the fact that we did not found root densities exceeding 1.5 cm cm-3 in subsoils, we assume that deep rooting tree species would be able to enlarge the water storage space on condition that preferential flow is the dominating flow in the soil.

Literature:

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Hegg, C., Thormann, J.-J., Böll, A., Germann, P., Kienholz, H., Lüscher, P. and Weingartner, R.: Lothar und Wildbäche. Schlussbericht eines Projektes im Rahmen des Programms "LOTHAR Evaluations- und Grundlagenprojekte". Eidg. Forschungsanstalt WSL, Birmensdorf, 2004.

Materechera, S.A., Kirby, J.M., Alston, A.M. and Dexter, A.R.: Modification of soil aggregation by watering regime and roots growing through beds of large aggregates, Plant Soil, 160, 57-66, 1994.

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