Response to Reviewer Comment 1 (RC1) to

preprint bg-2021-343: "Pioneer biocrust communities prevent soil erosion in temperate forests after disturbances"

We thank the reviewer very much for this in depth and positive evaluation of our work. The comments provide a strong basis for substantial improvements, which are included in the revised manuscript.

Comments	**Authors responses**
"First, I doubt that many of the bryophytes reported in this study fully meet the characteristics of biological soil crusts (biocrusts). The biocrust definition, as it was first brought forward by Belnap, Büdel and Lange (2003) in the first Ecological Studies volume on biocrusts, referred to communities of organisms that live within or only few centimeters on top of soil. A key characteristic is that the major part of the biomass is located within the soil and that it creates a hardened soil surface (an encrustation). I think both of these factors are not fully met by the communities reported here. In genera like Atrichum, Rhytidiadelphus and Plagiomnium the major part of the biomass grows above the soil surface and I also have not experienced a soil hardening effect in the vicinity of them. Thus, I think the term "biological soil crust" is irritating in this context, as the reader expects somewhat different properties. I think that biocrusts indeed could occur at the slopes next to a forest path with species like Polytrichum piliferum and it might be that in some parts of the investigated sites biocrust fragments could occur. But for the complete community I doubt the correctness of this term. *However, I do not see that as a deficit of this study at all. The authors could describe the studied communities as bryophyte or cryptogam communities and they could discuss the similarities and differences between biocrusts and their study objects. I think it also is relevant that not only biocrusts, but cryptogam communities in general are highly relevant for a variety of functional ecosystem processes and the present study shows this clearly once more."*	We would like to thank you for this significant comment, which hits a most interesting point that has been discussed intensively. It is agreed that the moss genera mentioned grow with the bulk of their biomass above the ground and do not meet the basic definition of a biocrust. At the same time, however, they make up a smaller part of the biomass at the beginning of succession. Along with many other moss species, single lichens, algae, and cyanobacteria, larger amounts of moss protonema can be observed on the soil surface immediately after disturbance. Together, they can show crustal characteristics at the beginning, which fulfill the definition of Belnap et al. (2003). In this mesic forest ecosystem, however, biocrusts occurred as visually recognizable green cover, which was also reported in recent biocrust studies of comparable forest sites (Kurth et al., 2021; Glaser et al., 2022). In contrast to these studies, the green cover of our sites is primarily due to moss protonema, which is found, as you are correctly assuming, only selectively and continues to develop quickly, with the crustal characteristic disappearing more and more. Furthermore, we accounted thallose liverworts among the biocrust species. Nevertheless, this observation has been made more often in mesic ecosystems, and very clearly e.g. in highly disturbed subtropical forest plantations, where larger crustal patches were still detectable after 2-3 years (Seitz et al., 2017). In this context, this early soil cover after timber harvest fulfills an essential (biocrust) function, namely, the protection against erosion at a moment when the soil is highly susceptible. This protective function then passes smoothly into further vegetation development and, according to our observations, is even more enhanced by fully developed mosses. However, the distinction between biocrust and cryptogamic or just non-vascular vegetation is not always easy to make. In summary, we agree that the prominent use of the term biocrusts may lead the reader down the wrong track. This will be adjusted accordingly, and more reference to cryptogamic and/or non-vascular vegetation will be made. Nevertheless,

	we think that plant communities under the biocrust definition are not yet adequately described in these mesic (and thus rather atypical) ecosystems. We therefore strongly welcome your suggestion to compare and discuss similarities and differences between the communities.
"Second, I think the illustrations in this manuscript could be improved. In section 3.1.1 the composition of bryophytes is explained, but the taxa are only listed in a table and the taxonomic composition is not graphically displayed. I think this is urgently needed and would clearly improve the comprehensibility of the results. In figures 2 and 3 the line diagram is not the correct way to illustrate the results, as there are no data available for the times between the measurements. For this type of data, box-whisker plots are correct, as they have also been used in the subsequent figures. In figure 3, the signatures are difficult to be separated from each other; I think this could be improved regarding form and color. In all plots where sampling was conducted at different times, the statistics should be added in order to illustrate which changes were statistically significant."	Thank you for your recommendation to display the taxonomic composition graphically which has considerably increased the comprehensibility of the results. We added a pie diagram that illustrates the occurrence of bryophyte species in the ROPs for each vegetation survey time step in every skid trail site (see Figure 1). The connected scatterplot diagrams in Figures 2 and 3 were replaced with boxplot diagrams. (see Figure 3 and Figure 4). Furthermore, the visualization of the results in Figure 3 was adjusted so that the signatures can be better distinguished (see Figure 4). On the level of individual skid trails, which is displayed in the figures, there are four replicates per track position, which is insufficient for performing post-hoc statistics. Furthermore, the figures are already quite detailed, which is why we did not consider it helpful to include additional information.
"Third, the naming of the plots could be improved. The names of the different forests do not mean anything to the reader. I think it would be better to name the plots e.g. according to the parent material, soil type and/or texture or to just give them numbers. This would be particularly helpful, as you explain later that the substrate indeed had an effect on the observed vegetation."	Thank you for this suggestion. The sites are named according to the geologic formation of the parent material, and the associated soil types and textures are outlined in Table A1 in the Appendix. Since these designations are already used in another publication related to this manuscript, we suggest to retain them (Thielen et al., 2021). However, with regard to your comment and as we agree that readability can generally be improved, we decided to reduce the use of abbreviations in the text. Therefore, we have spelled out CT (center track), WT (wheel track), and UF (undisturbed forest soil) in the revised manuscript.
"Fourth, I think it might be irritating to name only the month of sampling. It would be clearer if you name them e.g. as Mar19, Jul19, Oct19, Feb20"	For clarification, we have added the years to the months in all figures (see Figure 2, Figure 3, Figure 4, Figure 5) and in the text, as suggested.
"Fifth and finally, the language needs to be carefully and thoroughly checked throughout the manuscript. Beyond minor mistakes, which are not a big issue, there are also sentences where the meaning remains unclear. Thus, careful and thorough language editing is urgently needed before final publication could be considered."	We regret that there were problems with our uses of English. According to your recommendation the revised manuscript has been carefully proofread by a native English speaker to improve the grammar and readability.
"In line 143-145 it is written that "Four ROPs were placed in the WT and the CT in every skid	We followed your suggestion and clarified the sampling design.

trail (n = 32), and two ROPs in the undisturbed forest soil (UF) next to every skid trial site (n = 8).” This is not clear. Does it mean that on every skid trail four ROPs were installed? This would mean that there were 4 skid trails in total? Does it mean 4 skid trails each at WT and CT? This needs to be clarified. Also the rainfall simulation numbers given in the following sentence are not clear. I think a thorough language check will help to also clarify these issues.”	In total, we had four skid trails and installed four ROPs in each wheel track and center track (n = 32), and two ROPs in the undisturbed forest soil adjacent to every skid trail (n = 8). The rainfall simulations in the skid trails were repeated four times a year (March 2019, July 2019, October 2019, February 2020), while the rainfall simulations in the undisturbed forest soil were repeated twice in October 2019 and February 2020. In summary, this brings us to 144 measurements.
“Line 35-37: In this sentence there are several language style problems. I would suggest to reformulate it in the following way: The most prominent soil loss occurs in agricultural environments, and thus a considerable part of relevant research is conducted in these habitats.”	Thank you for the wording suggestion. We changed the sentence accordingly.
“Line 46-47: here I think you want to say “The most important reason for this is soil compaction and reduced infiltration rates caused by heavy machines used for timber harvesting””	Thank you for bringing this to our attention. We inserted the word “caused”, which clearly improves the sentence.
“Line 48: significantly”	We inserted “significantly”.
“Line 55: exchange “which” by “that””	We replaced “which” by “that”.
“Line 60: “These” instead of “those””	We exchanged “Those” by “These”.
“Line 75: As most studies investigating the impact…”	We adjusted the sentence accordingly.
“Line 80-81: This sentence is upside down. ‘Pioneer biocrust communities could provide benefits’ or ‘the soil benefits from biocrusts’”	We changed the order of the sentence as suggested.
“Line 114: The skid trails show no geological formation, but the underlying rocks and soil do. Please adapt wording”	We have made clarifying rephrasings for this purpose
“Line 119: formed by extensive periglacial processes…”	We have reformulated the sentence accordingly.
“Line 125-127: There are several abbreviations that need to be explained: Ad-hoc-Ag Boden, Iuss Working Group Wrb, WRB Tool”	The explanations for the abbreviations were inserted in the revised manuscript.
“Line 148: A rainfall intensity of 45 mm does not make sense. I think you speak of a rainfall intensity of 90 mm h-1, applied over a duration of 30 minutes”	Thank you for clarifying this. We have corrected the sentence accordingly.
“Line 200-201: meaning of sentence unclear”	We removed this sentence.

References

Belnap, J., Büdel, B., and Lange, O. L.: Biological Soil Crusts: Characteristics and Distribution, in: Biological Soil Crusts: Structure, Function, and Management, edited by: Belnap, J., and Lange, O. L., Springer Berlin Heidelberg, Berlin, Heidelberg, 3-30, 10.1007/978-3-642-56475-8_1, 2003.

Glaser, K., Albrecht, M., Baumann, K., Overmann, J., and Sikorski, J.: Biological Soil Crust From Mesic Forests Promote a Specific Bacteria Community, Frontiers in Microbiology, 13, https://doi.org/10.3389/fmicb.2022.769767, 2022.

Kurth, J. K., Albrecht, M., Karsten, U., Glaser, K., Schloter, M., and Schulz, S.: Correlation of the abundance of bacteria catalyzing phosphorus and nitrogen turnover in biological soil crusts of temperate forests of Germany, Biology and Fertility of Soils, 57, 179-192, https://doi.org/10.1007/s00374-020-01515-3, 2021.

Seitz, S., Nebel, M., Goebes, P., Käppeler, K., Schmidt, K., Shi, X., Song, Z., Webber, C. L., Weber, B., and Scholten, T.: Bryophyte-dominated biological soil crusts mitigate soil erosion in an early successional Chinese subtropical forest, Biogeosciences, 14, 5775-5788, https://doi.org/10.5194/bg-14-5775-2017, 2017.

Thielen, S. M., Gall, C., Ebner, M., Nebel, M., Scholten, T., and Seitz, S.: Water's path from moss to soil: A multi-methodological study on water absorption and evaporation of soil-moss combinations, Journal of Hydrology and Hydromechanics, 69, https://doi.org/10.2478/johh-2021-0021, 2021.

Figures

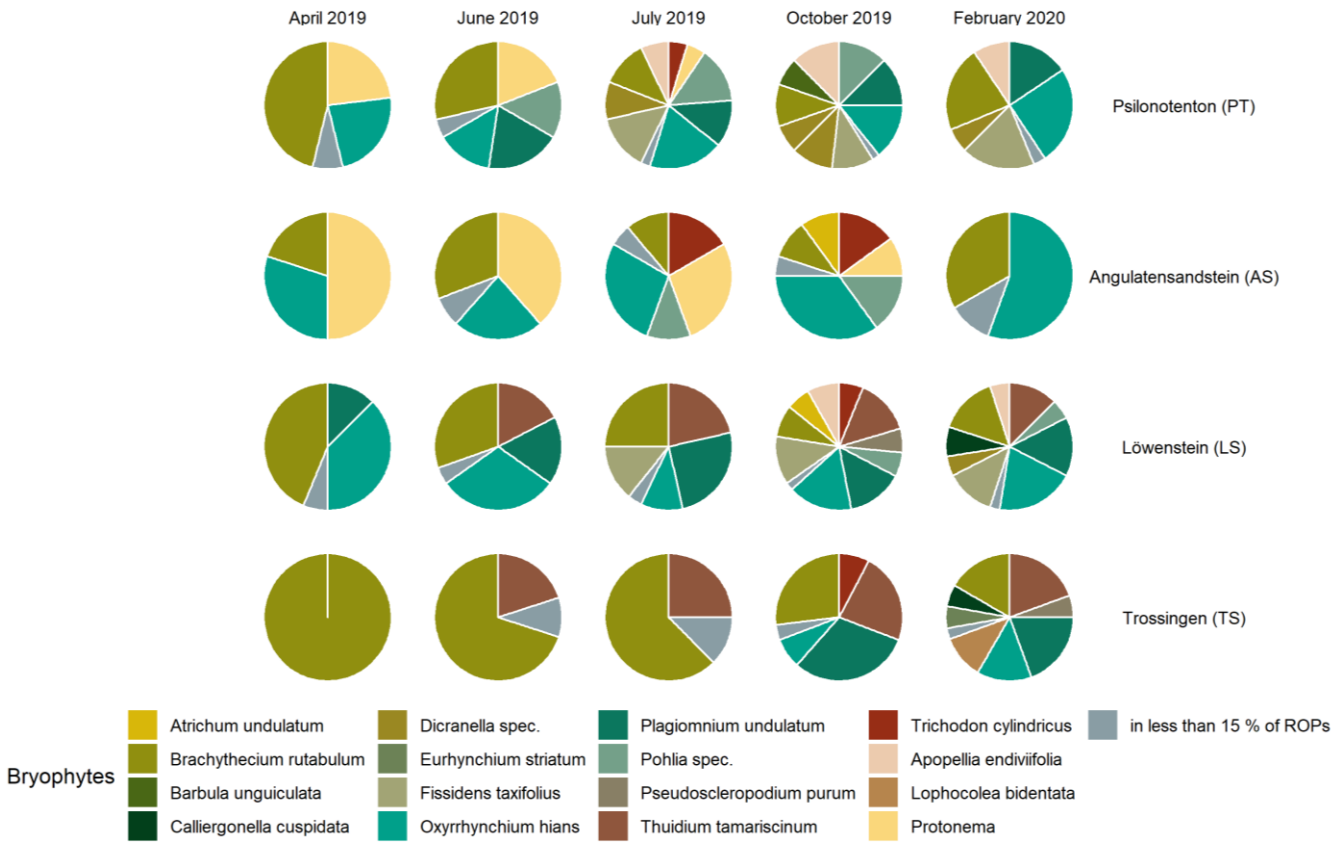

Figure 1: Bryophyte species composition in the different skid trails for each vegetation survey time step. Species from same genera are grouped together and species which occur in less than 15 % of the runoff plots are listed in one group.

Figure 2: Vegetation succession of four examplary runoff plots in wheel tracks of the skid trails in Schönbuch Nature Park

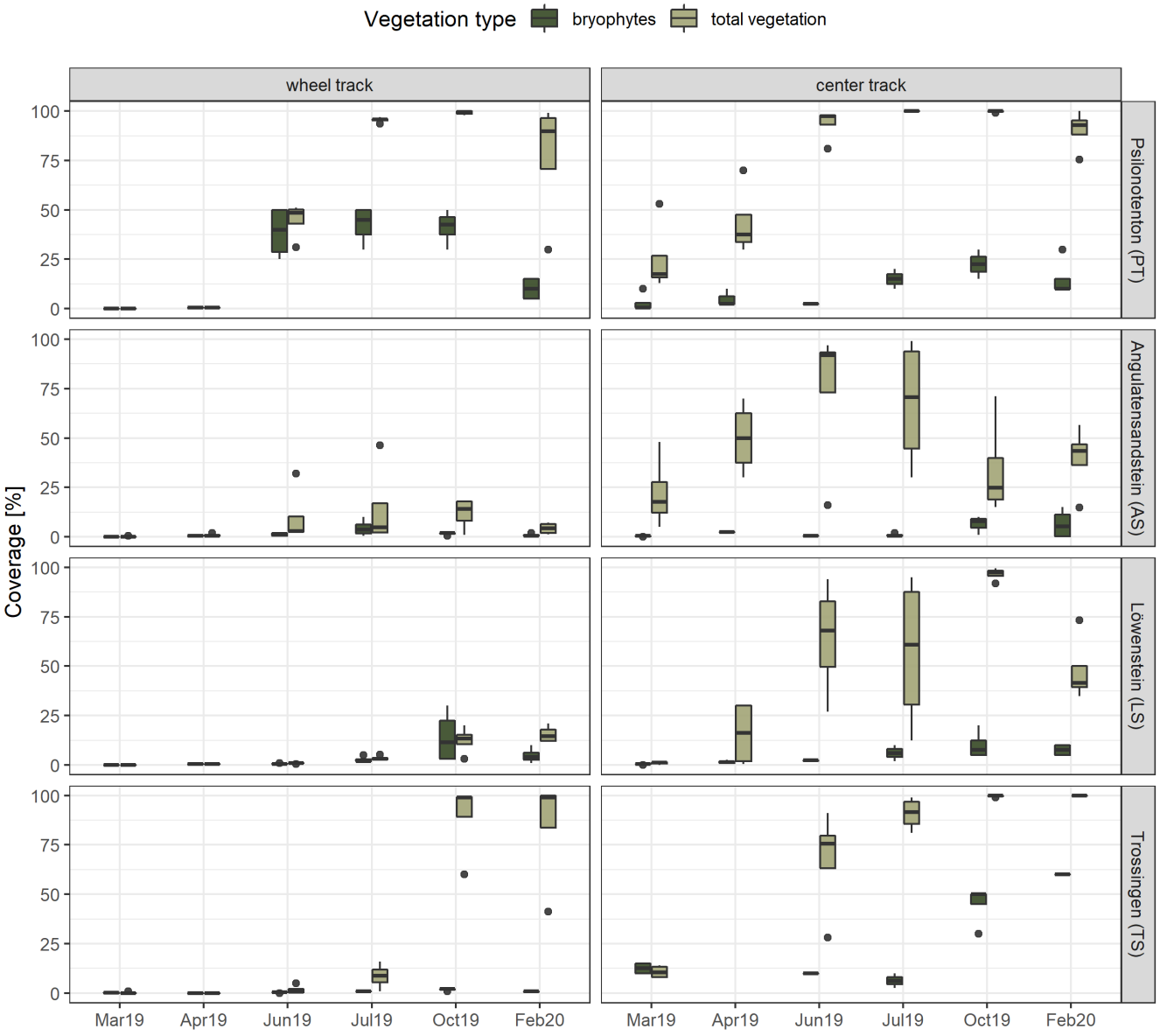

Figure 3: Development of bryophyte (n = 4) and total vegetation coverage (n = 4) per runoff plot at the individual skid trails. The bottom and top of the box represent the first and third quartiles, and whiskers extend up to 1.5 times the interquartile range (IQR) of the data. Outliers are defined as more than 1.5 times the IQR and are displayed as dots.

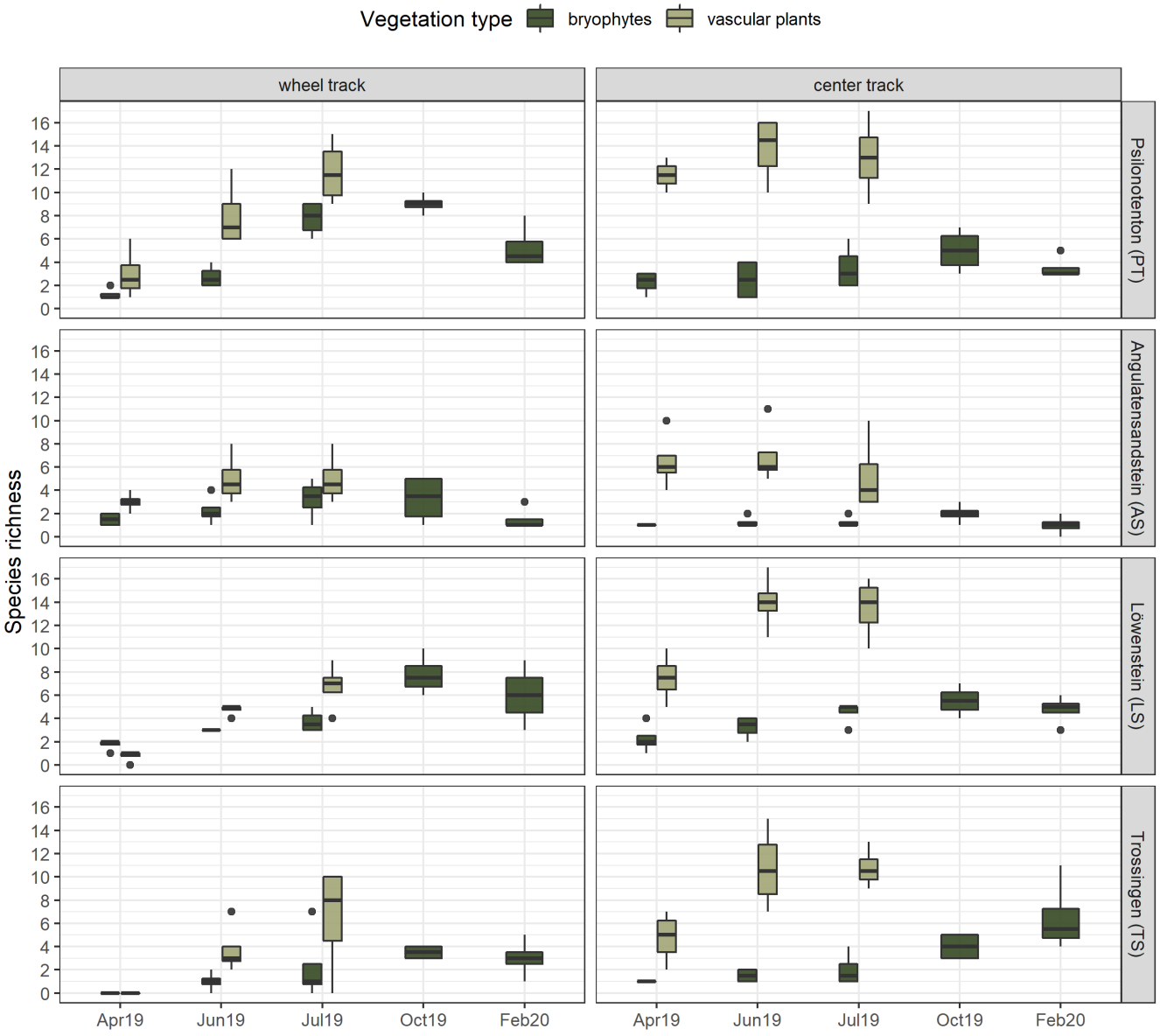

Figure 4: Species richness of bryophytes (n = 4) and vascular plants (n = 4) per runoff plot at the individual skid trails. The bottom and top of the box represent the first and third quartiles, and whiskers extend up to 1.5 times the interquartile range (IQR) of the data. Outliers are defined as more than 1.5 times the IQR and are displayed as dots.

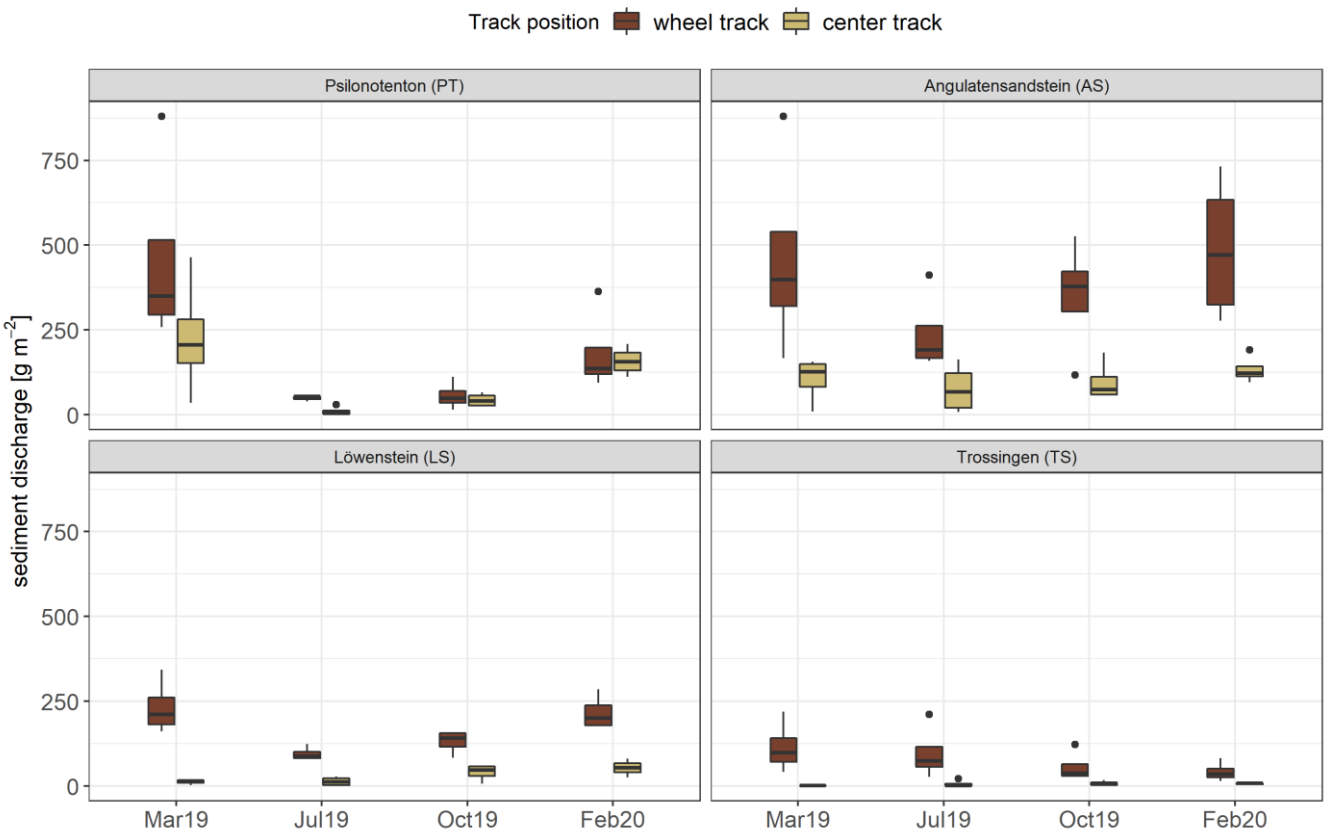

Figure 5: Sediment discharge in the wheel track (n = 4) and center track (n = 4) of the four skid trails for every rainfall simulation time step. The bottom and top of the box represent the first and third quartiles, and whiskers extend up to 1.5 times the interquartile range (IQR) of the data. Outliers are defined as more than 1.5 times the IQR and are displayed as dots.