

Response to Community Comment 1 (CC1) on preprint bg-2021-343: “Pioneer biocrust communities prevent soil erosion in temperate forests after disturbances”

Thank you again for selecting our study for discussion in your undergraduate course. We were very pleased that you have dealt with our manuscript in such detail and your feedback has contributed significantly to the improvement of our manuscript.

Comments	Authors responses
<p>Abstract <i>“In overall it is well written. We suggest the authors make clearer why is it important to study what they have studied e.g. why is the succession so important?”</i></p>	<p>To date, very little is known about when soil-protective vegetation begins to develop in a forest disturbance area, so that it is important to monitor the process of succession. Furthermore, we wanted to determine the timing of biocrust occurrence and its impact on soil erosion, which is generally poorly studied in temperate climates. We included a sentence in the abstract that highlights the importance of vegetation succession to our study.</p>
<p><i>“In addition, the final 2-3 sentences of the ‘Abstract’ need some modifications – making them simpler and easier to understand will increase their impact. It might be preferable to avoid use of “we” in the abstract and perhaps the detail of results could be reduced; authors might also be more clear in highlighting one main conclusion to express.”</i></p>	<p>Thank you very much for this comment, as it helped to improve the presentation of results in the abstract. We reduced the results in the abstract to the most important points of the study, which increases comprehensibility for the reader. Additionally, we now use the passive form exclusively in the abstract.</p>
<p>Introduction <i>“Line 35: Please provide some examples why soil erosion will increase through climate change. Also are there any (numerical) projections about how much erosion will increase in years and decades to come?”</i></p>	<p>In the context of climate change, increasing rainfall intensities are the key driver of soil erosion, as this enhances the erosive power of precipitation and thus the probability of soil losses. We added this example in the introduction. In our opinion, further examples and explanations would lead too far at this point. Projections of soil erosion rates are clearly influenced by local conditions and the percentage increase varies widely. For example, Li & Fang 2016 concluded that 136 studies predict an increase in soil erosion rates in the future, with relative increases ranging from 1.2% to 1614%. (Li, Z. & Fang, H. (2016): <i>Impacts of climate change on water erosion: A review, Earth-Science Reviews, 163, 94-117, https://doi.org/10.1016/j.earscirev.2016.10.004</i>)</p>
<p><i>“Line 41-42: Is there a reason behind these relatively large shifts in erosion of forestlands?”</i></p>	<p>There are a variety of factors influencing soil erosion in forests, and it would be too much of a stretch to discuss them all at this point. In the references we highlighted here, the shifts in erosion rate referred mainly due to forest management intensity and tree species composition. We added these factors in in the mentioned lines of the introduction.</p>
<p><i>“Line 44: Please use more plain language in “showed that unsealed forest roads at the catchment scale” so that the reader can get a clearer understanding.”</i></p>	<p>We simplified the sentence in the mentioned line.</p>

<p><i>“Lines 46-53: This numerical information provided is useful, but we feel it would be better to be used in the “Discussion”. Here in the “Introduction” make sure you present the bigger picture and why it is important for this research to be carried out. Lots of numerical information can distract the readers from the major messages.”</i></p>	<p>According to your recommendation, we reduced the number of numerical information in the introduction to avoid distractions from the overall context.</p>
<p><i>“The sentence on line 55 could be modified to summarise the point of referencing all of these studies and then group them together in the citation for reference”</i></p>	<p>We followed your comment and changed the structure of this sentence.</p>
<p><i>“Line 61: Please explain where the term “cryptogamic” refers to. Also, what do you mean by “understory”?”</i></p>	<p>We explained what we meant by “cryptogamic” in the abstract and in the introduction. This term includes all non-flowering plants and plant-like organisms that reproduce by spores, such as bryophytes, lichens, ferns, algae and fungi. The term “understory” was also specified in the introduction. By this we refer to the vegetation growing on the forest soil.</p>
<p><i>“Line 63: Perhaps replace “edaphic” by “floor”?”</i></p>	<p>We replaced “edaphic” by “soil” in this line.</p>
<p><i>“Line 68: We feel this should be “bryophyte-dominated”?”</i></p>	<p>Thank you for bringing this to our attention. We corrected this according to your comment.</p>
<p><i>„Lines 68-70: Please provide briefly some information on the direction of these effects by bryophytes e.g. increase/decrease in runoff etc.”</i></p>	<p>We provided the direction of these effects in the mentioned lines.</p>
<p><i>“Line 81: Please improve wording.”</i></p>	<p>We changed the order of the sentence to improve wording.</p>
<p><i>“Line 86: The authors need to make clearer which is the research gap and especially to link it better with previous lines/sections.”</i></p>	<p>We followed your suggestion and clarified the research gaps in the introduction.</p>
<p><i>“Lines 92-94. It is welcome that authors make clear the objectives of their study. We feel though that it would be even better if they make some null hypotheses related to their points e.g., how do they expect that the underlying substrate, vegetation cover and track position will affect soil erosion?”</i></p>	<p>Thank you for noting this. We agree that null hypotheses improve the comprehensibility of the manuscript and implemented this wherever possible.</p>
<p><i>“Line 96: Please explain what you mean by “interrill”.”</i></p>	<p>Soil erosion processes by water can be divided into three different stages: splash erosion, interrill and rill erosion. Interrill erosion is known as the discharge of sediment in thin sheets between rills by shallow surface runoff after raindrop impact. We added an explanation on that term in the introduction.</p>
<p><i>“In the “Introduction” and especially towards the end of it the authors should make some clearer references on how their findings can be used in good practices for management. They can elaborate on that aspect in the discussion.”</i></p>	<p>According to your suggestion, we added a short outlook of good practices for forestry at the end of the introduction.</p>
<p>Materials and Methods <i>“Line 121 and further: Could abbreviate genus name in species scientific names for conciseness purposes (e.g. P. sylvestris)”</i></p>	<p>For the second use of the scientific name of each species, we used an abbreviated genus name.</p>

<p><i>“Lines 140-146: Please provide references about the use of similar experimental set up in previous studies.”</i></p>	<p>We provided more references about the use of rainfall simulators in combination with small-scale runoff plots.</p>
<p><i>“Lines 148-149: The authors need to provide more information about the particular selection of this rainfall intensity e.g., is similar intensities observed often in the studied area? Provide also relevant references.”</i></p>	<p>We inserted more background information to the selected rainfall intensity with a reference. The rainfall intensity refers to a heavy rainfall event for this region that occurs less frequently than once every 100 years.</p>
<p><i>“Line 149- 153: The authors should provide more details about technical aspects mention in there e.g., measurements on surface run off. Please also provide references.”</i></p>	<p>In our opinion, it is not necessary to add further details or references here, since the common procedure in soil erosion measurements is to collect surface runoff and the sediment discharged with it in sample bottles. References to this are already available in the previous section.</p>
<p><i>“Line 154-155: For how long were the samples left to dry?”</i></p>	<p>It usually took about three to four weeks until all samples were dry. But this depended strongly on the amount of water, which was different in each measurement.</p>
<p><i>“Line 156: Please mention what is exactly the aggregate size and which are the measurement units for this parameter.”</i></p>	<p>Soil aggregate size is a basic parameter in soil science what we assume as basic knowledge and would not explain it in detail in the manuscript. Depending on a variety of biotic and abiotic factors, soil forms aggregates consisting of agglutinated soil particles.</p>
<p><i>“Line 159-162: It is interesting that measurements on elements (C, N) were made. Please make sure that there are the relevant references made in the “Introduction” so the sections of the manuscript align better.”</i></p>	<p>According to your comment, we mentioned carbon and nitrogen levels in the introduction to point out the gap of knowledge of the factors that affect bryophyte species richness and cover.</p>
<p><i>“Line 173. Please improve the wording about nomenclature in Tables.”</i></p>	<p>We improved the wording of this sentence.</p>
<p><i>“Lines 183-187. It seems that post-hoc tests were not carried out. Also, it seems that the role of environmental parameters in the flora structure / development has not been accounted/examined for. If this is the case, then it is regarded as a major gap and needs to be addressed.”</i></p>	<p>We performed post-hoc Wilcoxon Rank-Sum tests and Wilcoxon Signed-rank tests for sediment discharge, surface runoff, coverage and species richness averaged for all skid trail sites and averaged for wheel and center tracks in each skid trail. On the level of individual skid trails, there are four replicates per track position, which is insufficient for performing post-hoc statistics.</p> <p>To assess the effect of environmental parameters on soil erosion, bryophyte coverage and species richness, we performed generalized additive models (GAM) with restricted maximum likelihood and smoothing parameters selected by an unbiased risk estimator (UBRE) criterion.</p>
<p><i>“More information on the number of replicates is needed.”</i></p>	<p>We revised the information on the replicates in the method section so that the sample design is now more comprehensible. There are four replicates for each wheel track, four replicates for each center track and two replicates for each undisturbed forest soil.</p>
<p><i>“A map showing where the research was carried out would be welcome.”</i></p>	<p>We have not provided a map to locate the research area because our study already contains a large number of figures and tables.</p>

<p><i>“Overall, we believe that the “Materials and Methods” section could have been written more succinctly to make it easier to read.”</i></p>	<p>We will try to make the methods section more concise, for example by transferring more information of the study site description into table A1.</p>
<p>Results and Discussion <i>“Line 191: ‘Section 3.1.1 – Biocrust species composition’. It seems that this title is not fully adequate as in the section 3.1.1 there are also results about temporal trends. This should be reflected in the Section 3.1.1 title.”</i></p>	<p>We changed the title of Section 3.1.1. in “Succession of bryophyte species composition” to reflect the temporal trends included.</p>
<p><i>“Line 193: Please avoid using where possible abbreviations (e.g., ‘UF’) as it is difficult for the reader to follow them.”</i></p>	<p>According to your comment, we decided to reduce the use of abbreviations in the text in order to improve readability. Therefore, we spelled out CT, WT, and UF in the revised manuscript.</p>
<p><i>“Line 196: Please clarify what is ‘protonema’.”</i></p>	<p>We introduced the term “protonema” in the abstract and later in the results and discussion section. Protonema is the earliest stage of bryophyte development consisting of green cell filaments.</p>
<p><i>“Line 205 / Table 1: Could table 1 provide more information on composition, cover and richness? Do we need Author column?”</i></p>	<p>We implemented your idea by providing additional information on the percentage occurrence of species in the runoff plots in total and for each vegetation survey time step. Furthermore, we added a diagram that illustrates the occurrence of bryophyte species in the ROPs for each vegetation survey time step in every skid trail site. This also includes more information about taxonomic composition and species richness at the different skid trail sites and considerably increased the comprehensibility of the results. In the botanical nomenclature a reference to the person who first gave a name to the botanical entity is required and we followed these rules. Instead we discarded the family names.</p>
<p><i>“Lines 222-223: This is just an assumption on the role of pH; there should be appropriate statistical analysis to explore the role of abiotic environmental parameters in shaping the communities.”</i></p>	<p>The effect of environmental parameters on species composition was not a focus of our study, so we made an assumption at this point that we did not support with statistical analysis.</p>
<p><i>“Tables 1 and 2: The information shown here is interesting; however it seems that these Tables are a bit long – how about moving them to Supplementary Material?”</i></p>	<p>With the additional information on the percentage occurrence of species in the runoff plots, we believe that table 1 and 2 should remain in the text.</p>
<p><i>“Lines 227-230: These are major findings and should be moved earlier/up in the Results and Discussion section.”</i></p>	<p>In this section, we first wanted to give a general overview of the occurrence of bryophyte species in the research area (section 1) and discuss this species composition (section 2). Afterwards, section 3 deals with the different species compositions of the four skid trail sites, which is why more detailed results are listed there for the first time.</p>
<p><i>“Lines 232: Please clarify the categories that the species belong to e.g. do they belong to ‘protonema’ or another category?”</i></p>	<p>For protonema, we did not determine the species, so either the moss occurred as protonema or the species was mentioned.</p>

<i>“Line 234: “little importance”: Please provide numbers rather than terms like “little importance”.”</i>	As recommended, we changed this wording and inserted numbers instead.
<i>“Lines 227-242: This is a big chunk of results but discussion on them is absent.”</i>	The discussion of these results can be found in the following section.
<i>“Line 243: It would be better to start the section with the key result; discussion on it should follow.”</i>	Based on your comment, we have restructured this section so that it is now more comprehensible and exciting for the reader.
<i>“Line 246: Please see comments above about stats regarding the role of environmental parameters.”</i>	To assess the effect of environmental parameters on soil erosion, bryophyte coverage and species richness, we performed generalized additive models (GAM) with restricted maximum likelihood and smoothing parameters selected by an unbiased risk estimator (UBRE) criterion.
<i>“Figure 1: Could be useful to have included a longer caption describing what photographs demonstrate to make the article more accessible for the readers that do preliminary paper skimming. A map of the area would have been highly beneficial for the readers to better visualise the studied site spatial distribution.”</i>	We added a title to Figure 1. We will not include a map of the research area in the text because our study already contains a large number of figures and tables.
<i>“Line 271: It is not clear what the authors try to say here e.g. that there are similar trends between biocrust and total coverage trends? Or something else? Please clarify.”</i>	We clarified this sentence in the revised manuscript.
<i>“Figure 2 caption: Perhaps it would read better as “mean values and standard error are given”. Please also remind to the readers the number of replicates.”</i>	The connected scatterplot diagrams in figures 2 and 3 were replaced with boxplot diagrams, so that the figure description is different now. We added the number of replicates in all figure descriptions.
<i>“Line 282: The values of pH should be mentioned.”</i>	The pH values were included in the text.
<i>“Lines 288-289: The authors should elaborate on their statements about contradictions between their findings and those from (Corbin and Thiet, 2020; Bergamini et al., 2001; Fojcik et al., 2019).”</i>	We added more information in this section to clarify the contradictory results.
<i>“Lines 289-292: The authors should elaborate on the mechanisms driving positive correlations between vascular plants and moss growth.”</i>	We inserted additional information on this in the mentioned lines.
<i>“Line 292: The statements/discussion on biocrust should be on a separate paragraph.”</i>	In order to better distinguish between biocrust cover and bryophyte cover, we have revised the entire manuscript so that we now refer to bryophyte covers in this line.
<i>“Lines 327 – 338: Please make sure that you provide p-values where needed. Also, it is not necessary to use extensively phrases such as “A was X times higher than B”. Providing the average values, standard error and the p-values would suffice.”</i>	Thank you for this comment. We included p-values, means, and standard deviations wherever appropriate.
<i>“Lines 339-341: See our comments above about examining the role of environmental parameters in shaping discharge / run off. For example, how much of the variability in discharge is explained by differences in the soil features?”</i>	To assess the effect of environmental parameters on soil erosion, bryophyte coverage and species richness, we performed generalized additive models (GAM) with restricted maximum

	likelihood and smoothing parameters selected by an unbiased risk estimator (UBRE) criterion.
<i>“Sections 3.2.1 and 3.2.2 should be merged. The independent and response variables should be subject to appropriate statistical analysis e.g. distance-based linear modelling (Clarke and Gorley 2015) Clarke KR, Gorley RN (2015) PRIMER v7: User Manual/Tutorial PRIMER-E: Plymouth”</i>	We merged the sections 3.2.1 and 3.2.2 and added the results of our GAMs.
<i>“Lines 398-401: Some of the lines mentioned here should had been included in the Materials and Methods. Also it is not clear where the term ‘reduction’ refers to – please clarify.”</i>	As suggested, we moved the mentioned lines to the methods section. Further we clarified that the term “reduction” in this section refers to sediment discharge.
<i>“Figure 5: The box plots for biocrusts and vascular plants are very close (this is not necessarily bad) and some of the outliers for biocrusts may be regarded as outliers for vascular plants (and vice versa). It would be helpful to see the outliers for each of them with different colours. We feel that a sudden change in the colour scheme on this graph could confuse the readers that got used to seeing dark green as ‘wheel track’ and light green as ‘central track’ in previous 3 figures.”</i>	Thank you for bringing this to our attention. We adjusted the colour code in all figures so that dark green is used for “bryophytes” and light green for “vascular plants”. Additionally, we reduced the size of the jitter points in figure 5, as this was the most appropriate measure to make the outliers of each displayed group more visible.
Conclusions <i>“Line 426 : it seems that null hypotheses were not made; it is suggested to adjust accordingly the text at the end of the “Introduction”.”</i>	According to your comment, we inserted null hypotheses in the introduction section wherever possible and adjusted the conclusion section as well.
<i>“The conclusions section looks too lengthy; it should appear more succinct and with higher impact. Focus on your key findings and how they fill gaps in the literature. Avoid repeating results and numerical values.”</i>	We shortened the conclusion to the most important outcomes of our study.
<i>“Could include more discussion of direction and opportunities for future studies”</i>	At the end of the conclusion section, we mentioned a variety of future research topics related to our study. We think that this outlook is sufficient.
<i>“Lines 450- 456: Would it be also of interest to study the factors that support higher growth rates for the biocrust communities?”</i>	Yes, this is very interesting to study, especially in temperate climates where the evidence of biocrust communities is scarce.
<i>“Figure A1. Please clarify in the image (using arrows) the wheel track and center track.”</i>	We inserted arrows in figure A1 to mark the location of wheel and center tracks.
<i>“It seems that there is some inconsistency in editing/coloring of symbols across the figures e.g., see color code used Figures 3 and 4.”</i>	Thank you for bringing this to our attention. We adjusted the colour code in all figures so that dark green is used for “bryophytes” and light green for “vascular plants”.