Biogeosciences

Discussions

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Interactive comment on "Bryophyte-dominated biological soil crusts mitigate soil erosion in an early successional Chinese subtropical forest" *by* Steffen Seitz et al.

Steffen Seitz et al.

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Many thanks for your critical and constructive review. We will consider your comments and rework the manuscript as suggested. Please find more detailed responses to your remarks below:

1.) There is a general question as to how the soil crust in this studied can be referred to. In the introduction (first sentence) the authors refer to the importance of biocrusts in many ecosystems. By checking the reference and also other major biocrust research and literature it becomes obvious that the biocrust in this study is very special because it occurs in a forest. Such ecosystems are dominated by trees are their sheer occurrence indicates a high water availability. So, here it comes to a contradiction to the

definition of a biocrust, which were recently defined to occur "in regions where water availability limits vascular plant cover" (Weber et al. 2016 - same reference as used by the authors). Almost every other biocrust study is taking place in drylands or at least areas where an arid element occurs. In the most recent review about biocrust distribution patterns by Bowker et al. 2016, the presence of biocrust is discussed as a function of effective precipitation within semiarid, arid and hyperarid ecosystems, certainly not in the humid forest with a mean precipitation of 1635 mm as in this case. This makes this study very special and requires that the authors explain very precisely why they discuss the topic in the biocrust background.

- We would like to thank the reviewer for his/her overall positive review and especially for the comment above. It indeed is right that the biocrust described in this manuscript is a special one, as it occurs within a forest. Biological soil crusts are defined to occur in arid environments and in places where arid (microclimatic) conditions are met. Thus, biocrusts are mostly described for dryland regions, where they form a key and enduring ecosystem component. In addition to this main habitat, however, biocrusts have also been described as a transient feature in mesic environments, where annual rainfall amounts are larger, but where biocrusts may form after major singular or repeated disturbance events. Example for such transient biocrusts are e.g. these of dry grasslands ("Mainfränkische Trockenrasen", Germany) and biocrusts occurring on Öland, Sweden (Büdel et al., 2014), but also biocrusts in former mining areas (Fischer et al., 2014). In all these habitats, biocrusts developed due to severe disturbance caused by trampling and driving, continuous grazing, soil removal and biomass removal. Once these regular disturbance events stop, a dense layer of vascular vegetation would develop and replace the biocrusts. In the current study, an existing forest has been clear-cut and trees have been replanted. After this severe disturbance, transient biocrusts developed, which could grow on the bare ground under fairly sunny conditions. However, we already observed an alteration in species inventory and expect, that eventually this biocrust will disappear again, being replaced by vascular vegetation (in light forests) or buried under persisting leaf litter (under darker conditions).

2.) It should be stated in the manuscript that biocrusts only contribute a minor ecological role in this ecosystem, certainly because of their low biomass and soil penetration depth, compared with trees and it should be taken into account that the trees are the major driver of this ecosystem. The presence of the mosses and algae may certainly have an effect as shown in this paper, but this should be seen in the bigger context and appropriately assigned.

- We fully agree with the comment, that biomass of biocrusts within this habitat is clearly negligible. Nevertheless, we observed that biocrusts play a key role within this early-successional system. By minimizing erosion and stabilizing the soil surface, they effectively preserve soil fertility within this disturbed forest habitat. Thus, despite their low biomass, we consider biocrusts to fulfil key ecosystem services within this habitat.

3.) In the ongoing introduction, the authors explicitly describe the role of biocrusts in early succession, while the study site cannot be referred to as in early succession because of the existence of trees, that indicate quite a late successional stage. Nevertheless, the study site is special, because the trees were artificially planted, so the soil itself remains at an early successional stage (straight after disturbance) while the occurring vascular vegetation is at a later stage, due to human impact (at least the trees. What other vegetation occurs?). A more detailed explanation of the hypothetical background should be taken into consideration.

- We agree that the special circumstances of the study site indeed need to be described in more detail in the paper. From a forestry perspective, the study site was referred to as an early successional tree plantation in 2013 (see Bruelheide et al. 2014). To establish the experiment and help the tree saplings ($\sim$5-15 cm) grow in their first years, shrubs and coppices have been weeded from 2010 to 2012. Thus, it is an artificial setup, but following common practice in forestry and tree plantations of this area. We will give a more detailed explanation in the revised manuscript.

4.) Additionally, it should be clearly defined which ecological process is in the focus

of this study. From the study background, the most reasonable is secondary succession after human disturbance. Within this, the biocrust may occur as one of the initial players, thus it will provide the basis for other plants but also disappear with ongoing succession. This should be stated. The hypotheses should come with explanations or at least theoretical background. In Hyp 1 is the parameter tree growth or canopy cover or light intensity? Hyp 2, what is the exact expectation here? This sound very vague. Please be precise.

- We agree and thank you again for this very helpful and to-the-point comment. We do expect that biocrusts are an initial player and they will disappear with ongoing succession (see e.g. line 267). Actually, we were surprised that their extend was still increasing after five years of tree growth as some tree species are already up to 7 m height. Nevertheless, we will clarify the process in focus and sharpen our hypotheses.

5.) In general, the introduction could benefit from more precise statements and direct explanations. In the moment, many sections ready like overall summaries rather than leading to explicit research questions for the study. Material and Methods 135: which were the determinants for the crust types

- Crust types were classified in the field based on appearance, functional groups and species composition, if possible. Further details will be added to the manuscript.

6.) Results 210: Please explain why the existence of vascular plants indicates any developmental stage of biocrust? Is this climax or are the plants taking over and the crust will disappear? If this is the case you should refer to the developmental stage of the vegetation in general and the crusts occur only for a little while.

- We believe that vascular plants like Selaginella and Poaceae will take over and biocrust covers will decline, even without a continuous leaf litter layer. We will add further information (see above).

7.) Discussion Overall the discussion could clearly benefit from more explicit argu-

ments of the given results rather than summarising literature. Sections read like reviews and summaries of recent literature. Could you please discuss your own data and indicate what information these add to the existing knowledge? Here I strongly agree with the first reviewer how also stated that the discussion needs improvement. Please explain more detailed what your own findings mean and implement.

- We agree with you and reviewer #1 and we will sharpen the discussion and strengthen the focus on our own data. More quantitative description will be added to the manuscript (see above).

8.) Additionally, you might want to consider reading more about bryophytes and their growth in forest understories. Surely the discussion could benefit from some comparisons for growth rates and microenvironments. For the implication of the story, the authors should clearly underline, that this is a case study in a single, very special subtropical forest ecosystem and therefore findings cannot easily be extrapolated to other systems.

- We agree that findings cannot be extrapolated to other ecosystems and it is not our objective to do so. Nevertheless, we believe that they could be compared to other forest plantations in subtropical China and it would be very interesting to evaluate the BSC occurrence in nearby forests right after clear-cut and replantation. Furthermore, we will add more literature about bryophyte development in forests. We fully agree that this study could benefit from comparisons of growth rates, for example. Nevertheless, there are not so much other studies on BSCs in those subtropical climates, to our knowledge.

9.) In the first section of the discussion, statements are made, that do not refer to the presented data. 243: biocrusts were highly competitive 244: biocrusts prepared the upper soil layer 246: tree growth provides shade and protection from the wind, which then leads to advancement in biocrust development (Please explain that you use crown cover as a proxy for shading. Are there data about the wind?). Other 260:

Replace competitive by coexisting. 261-265: The authors provide a very nice list of moss species for this study and assume here that species composition changes with decreasing light availability. It would be excellent to underline this finding by data. Can you provide data that show this shift of species? The statement could significantly gain importance if the change in species could be correlated to the decreasing light. As it stands now, it reads like an assumption.

- We will add further data and better explain the already presented data. We agree that adding more data about single species from e.g. 2011 and 2015 would be very useful and beneficial. Unfortunately, we do not have any further detailed species lists as it was not possible to sample biocrusts but in 2013. Classifications in other years were done by visual judgement in the field.

10.) 279-280: Irrelevant for the study. Can be deleted.

- Agreed. Will be deleted.

11.) Additional minor comments: Some of the writing does not seem to be appropriate. Please reconsider 34: "Our" experimental forest ecosystem 36: Biocrust "covers" were still increasing 42: quickly colonise gaps in" higher vegetation layers" – what do you mean with layers? Which gaps are closed? 207: "traces of lichens" 210: organisms were found in minor numbers – is this fewer species, individuals or coverage? 243: early stage of the ecosystem 283: fasten themselves on the soil surface 329: They developed quickly to later-stages

- Thank you for pointing out mistakes and incomprehensibilities in writing. We will change the writing according to your comments and the whole manuscript will be counterchecked by an English native speaker after revision.