In the previous review round, the manuscript was carefully reworked based on minor suggestions from two reviewers. In this rebuttal letter, we provide a detailed response to a 3rd reviewer who proposed additional revisions that we addressed in this 2nd review round.

Author comments (ACs)

We appreciate that reviewer 3 carefully revised our work, and found the manuscript interesting. The main issues that reviewer#3 commented on were : (i) improvement of structure and content of the abstract, (ii) need to write down research objectives and hypotheses in the introduction, (iii) need to clarify some terms like 'critical zone', 'paramo ecosystem', etc.

Below, we respond to each and every comment of reviewer#3. For easy reading, the comments are shown in black font, and our reply in *italic blue font*.

Report #3

The data presented are of interest, however, overall, the manuscript is purely descriptive, without clear objectives or hypotheses to test. I would like to encourage the authors to carefully revise their manuscript to turn it into solid scientific paper.

We appreciate that reviewer#3 finds our data of interest, but we do not agree with the reviewer's statement that the manuscript is 'purely descriptive without clear objectives or hypotheses'. In fact, in the original manuscript, the three research questions that were driving our research were explicitly spelled out in the last paragraph of the introduction (L99-102). These questions are addressed one-by-one in the discussion.

As the research questions were not clearly conceived by the reviewer, we have rewritten the last paragraph of the introduction, and explicitly mentioned the objective (L93-94) by rephrasing the first sentence from an implicit to explicit overall objective. We also included a sentence where we stated the hypotheses- i.e. that soil drainage, moisture conditions and rock-derived nutrient availability vary with vegetation type (L102-103). We added in each section of the discussion a sentence that makes the link between the research questions and the discussion of the results.

Title : I am not sure if vegetation 'controls' nutrient availability. I suggest that the authors revise the title.

We rephrased the title into:

'Vegetation patterns associated with nutrient availability and supply in high-elevation tropical Andean ecosystems'

Abstract

Main comment

I find the current abstract little informative. Given that most readers will decide after the abstract if to read further, it is highly recommended that the authors construct a logical abstract that informs the reader about the relevance and scientific question(s) of the work reported and how the work has contributed to advancing the field: background/contextualisation, objectives, methods, results, conclusion.

We have rewritten the abstract following the reviewer's suggestions. We now mention the relevance of studying soil-water-vegetation interactions in High Andean ecosystems, and improved the structure and writing of the abstract (L22-40).

Minor comments

Line 5 - Presumably interesting because the generally low rates of decomposition vary with topography, soils and hydrology - all interconnected with vegetation.

This is correct, we have added this element in the justification of the study case (L27-28).

Line 6 - The paramo, by definition is a vegetation type above the treeline, thus, the presence of forest indicates land cover change from forest. At the treeline ecotone, in marginal conditions for tree growth one may encounter tree groves in sheltered locations.

In this study we have used the definition of 'paramo' from the research team of the Missouri Botanical Garden (James L. Luteyn). This research group has vast expertise on paramo ecosystem, and they are considered to be a world-leading reference in this field[1] having written the book 'Páramos: A Checklist of Plant Diversity, Geographical Distribution, and Botanical Literature' in the volume 'Memoirs of the New York Botanical Garden' (Luteyn, 1999).

Studies typically divide the páramo into three broad zones (superpáramo, grass páramo and subpáramo) based on overall altitude and vegetation structure. In the northern Andes (where our case study is located) the grass páramo can be found above the treeline ecotone, and is situated above the upper limit (~ 3200 m) of montane cloud forest. In the grass paramo, tussock grasses are the dominant vegetation type, but other vegetation types co-occur such as cushion plants and polylepis forest.

Our study area is located at elevations between 3600 m and 4000 m above sea level, and clearly above the treeline ecotone of montane cloud forest. The vegetation is dominated by tussock grasses (81%), followed by cushion-forming plants (17.5%), and polylepis forest (1.5%). The patches of polylepis forest are found in the upper part of the catchment at remote places.

[1] https://www.mobot.org/mobot/research/paramo_ecosystem/introduction.shtml

Introduction

Lines 35 – 82 - Based on this 'Introduction' the reader does not get to know the relevance, the research question(s), the state of knowledge, the knowledge gaps and how the authors' work is expected to fill the identified research gaps.

The research gap is now explicitly mentioned on L74-75.

Lines 84-95 - What were the objectives and hypotheses and how were the hypotheses tested?

We have carefully reworked the introduction. We now explicitly mention the overall objectives, research questions and hypotheses. – see also reply above

Materials and methods

To be able to judge this section adequately (i.e., if the materials and methods used are adequate to test the hypotheses) the reader would need to know the objectives of the study and the hypotheses tested.

See comments above where this is addressed

Nonetheless, I have made several comments and suggestions of text editing on the pdf of the manuscript.

Thank you

Line 151 - The weathering front is the interface between intact or unweathered bedrock and the weathered rock, saprolite, regolith, or soil above it; 15-cm below the weathering front is solid rock - revise text.

We refer here to the 'soil weathering front', the limit between soil material (mobile regolith) and the saprolite (L160).

Line 193 - How was it determined that two months were sufficient?

This is based on earlier work by Schwendenmann and Veldkamp (2005). We have now added the reference for clarification (L202-205).

Line 194 - How were sampling times decided?

In principle, soil water was collected biweekly over one hydrological year. Because of the remoteness of the sites, access to the field sites was not possible at a few occasions (e.g., due to safety issues, accessibility of the sites after landslides along the access road, or logistical problems at the University). Therefore, the interval is biweekly to monthly. We have added this information (L203-204).

Results: No major comment, for minor comments see annotated pdf.

We addressed all minor comments, and marked the changes in the manuscript.

Discussion: As there are no clear objectives and hypotheses defined it is difficult to judge this section.

See comments above where this is addressed

The discussion was structured along the lines of the three research questions that were spelled out in the last paragraph of the introduction. Question 1 on 'How does vegetation regulate soil moisture, drainage and soil development?', is addressed in 5.1. Question 2 and 3 '(2) How are soil moisture conditions related to the availability of rock-derived nutrients (Ca, K, Mg, Na, P and Si) in the soil solution? and (3) How does vegetation influence the relative availability of nutrients?' are addressed in 5.2. We have made this more explicit now to avoid confusion (L385-386; L412-417).

There are some parts that are repetitions of the results (e.g., lines 410-16).

We have verified the discussions to avoid repetition.

Conclusions : Lines 457-8 - This is rather unexpected a depression are places of accumulation of eroded material from convex surfaces. Could the authors offer an explanation for the depressions having the shallowest soil in their study?

We have added a sentence to clarify this (L476-477).

In areas where lateral redistribution of soil along slope is important, one would indeed expect to have the deepest soil profiles in the concavities as a result of lateral soil particle transport (by e.g. water or gravity) and deposition of eroded material in the concavities.

This is not what we observe here. The thinnest soils are found under cushion-forming plants that are prevalent in topographic depressions with convergence of flow paths. We attributed this to the fact that lateral redistribution of soil particles along slope is slow in preserved paramo ecosystems, and, hence, not overprinting the signal that is related to in situ weathering processes. The latter is further supported by the observation that the dissolved load of high Andean rivers exceeds the suspended solid load during normal hydrological years (Tenorio et al., 2018).

References cited herein

Luteyn, James L.: Páramos: A Checklist of Plant Diversity, Geographical Distribution, and Botanical Literature. Memoirs of the New York Botanical Garden, Volume 84, 1999.

Schwendenmann, L. and Veldkamp, E.: The role of dissolved organic carbon, dissolved organic nitrogen and dissolved inorganic nitrogen in a tropical wet forest ecosystem, Ecosystems, 8, 339-351, https://doi.org/10.1007/s10021-003-0088-1, 2005.

Tenorio, G. E., Vanacker, V., Campforts, B., Álvarez, L., Zhiminaicela, S., Vercruysse, K., Molina, A., and Govers, G.: Tracking spatial variation in river load from Andean highlands to inter-Andean valleys, Geomorphology, 308, 175–189, https://doi.org/10.1016/j.geomorph.2018.02.009, 2018.