

Interactive comment on “The decline of alpine lichen heaths generates atmospheric heating but subsurface cooling during the growing season” by Peter Aartsma et al.

Anonymous Referee #1

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This paper investigates the effect of lichen cover on alpine tundra microclimates, relative to increased shrub cover growth. The authors use two years worth of vegetation and microclimate data collected in Alpine Norway and find that a decline in lichens and increase in shrub cover lead to an overall atmospheric heating effect. I think this is a really well framed research gap highlighting an understudied and potentially very important research gap. While the data only come from one site, I think the topic is in the scope of Biogeosciences, as it has potential tundra-wide implications. I think the paper is overall clearly written, with a thorough methodology, and interesting discussion. However, I propose that this paper be reconsidered after major revisions because I feel like more work could be done to frame the research in the context of ecosystem-wide

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change, and I think more work could be done to frame hypotheses from the beginning of the paper.

The introduction and literature review is concise and persuasive, but I feel as though you could state clear hypotheses at the end of this section to better frame the rest of the paper. You have nice comprehensive microclimate measurements, and your methods section is replicable and thorough. I think your results section works well although I have provided some comments on the figures. Finally, I'd like to see more discussion of the implications of these findings for other alpine and Arctic tundra sites - do you expect to see similar trends across the biome? What significance do you think this has for the ecosystem as a whole? Do you expect to see similar trends in the Arctic tundra too, or just Alpine sites - and what is your justification for this? Finally, how much do you think shrub species matter in explaining the variation in your data? Are all tundra shrubs out-competing all lichens? I think this could be an interesting line of enquiry.

I'm looking forward to reading this paper again!

LINE COMMENTS: - generally, you should capitalise 'Arctic' -21: "we hypothesise" - reword. The placement of this phrase in the abstract makes it seem like a hypothesis you set at the beginning relating to this project as opposed to a theory you generated based on your results - 33: "this region" - I understand from context, but you could make it clearer which region you mean in this sentence (i.e. are you still talking about the Western Canadian Arctic, or Alpine Norway again?) - 36: not clear from this sentence if lichen is declining purely because of competition with shrubs, or if they aren't coping physiologically with a rapidly warming temperature - 61: I'd call it "macroclimate" instead of "large climate" - Figure 2:: could you add the letter labels to the photography too? Its currently quite hard to envision. - 161: be explicit here, what is the interaction and why did you include it? We get the interaction later on in the tables but I feel you could spell it out here. - Tab 2: maybe you should also add a column saying how much variation in % is explained by your random effects? Also you should add the slope/estimate and error in this table, as the F and P values are not very informative

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on their own. - Figure 4: a nice clear figure. Move the (d) label up a bit, it looks a bit cluttered at the moment. - Figure 5: looks great but I'd recommend changing the colours from red to blue to something less indicative of temperature. Currently it suggests lichens = hot, shrubs = cold. - Figure 8: useful site information, but maybe move to supplementary materials? You have a lot of figures and I feel like this one can be moved. - 298: "tundra plots" vs "shrub plots" = this is confusing because tundra can be very shrubby. Maybe rename these descriptors to make this more explicit?

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