Highlight

Alpine treeline ecotone patterns can indicate how montane forests may, or may not, move up into the alpine zone. This paper presents a low-cost method to create detailed maps of ecotone tree cover, leveraging recent developments in drone-based remote sensing and AI-based image analysis, which has the potential to support ecological studies not only at alpine treeline but in any open woodland or wood-grassland ecotone.

Dear Erik and colleagues,

Thank you for addressing my and the other reviewer's comments on your previous manuscript version. The new version has indeed improved, although some of my points were not solved by the changes made, as detailed below.

Your answer to my comment, that it would be interesting to see what the inaccuracy in tree detection means for the resulting spatial pattern metrics does not really address this point. What you would need to do to address it, is calculate the point patterns with and without the omitted trees and see how much they differ and whether the deviation is acceptable. How to decide whether it is acceptable? I guess that depends on what the differences mean for the ecological interpretation.

The other thing I am wondering about is whether it made sense to combine the point pattern analyses. If your goal is to understand pattern-process relationship, you would want to explore how the sites differ in their spatial patterns (the why would be a separate paper, I agree), not merge them.

Detailed comments:

I am referring to the version in which you marked your changes in green. As in the previous version, yellow markings in the pdf indicate sections that I think need to be adjusted.

L11-13 This sentence makes no sense: which "several" treeline studies, and what is with all other treeline studies? What kind of modelled spatial patterns are you talking about? And what is the studies" and "findings" you might be referring to, since no research question or goal has been presented. So, similarly, in L14, it is still not clear for what these points are limitations (as it was not before when the word was "gaps"), or what the "implications" in L16 refer to.

L53 Check for consistent use of "elevational" instead of "altitudinal"

L54 The "alternatively" does not fit, because the two sentences it connects both talk about neighbour interactions

L59 It still sounds weird to me to write that heterogeneity in patterns would be a problem for studying pattern-process relationships. It is what you NEED to study such relationships. You correctly write this now, but then what are you referring to when you write "constrains the extrapolation of case-specific observations, thereby limiting their broader ecological generalization."? Maybe you need to give an example to make clear what you are thinking of here.

L61-62 There are a lot of fancy adjectives in this sentence, but it is not clear what the combination of ground-based and rs data has to do with the fundamental question of how to tackle the "spatial heterogeneity issue".

L93-96 The "despite" does not fit here.

L99 These are not really hypotheses that can be formally tested. You could instead call them “assumptions” or “expectations”. (in iii the “that” should be removed to achieve a parallel list structure.) L 380: hypotheses are not confirmed (they may be supported etc) and this one was not even really a hypothesis, so you could write something like “confirming our expectation”.

L111-112 How can soils include xeric and mesic regions? I would expect to see soil types here, but as far as I am aware, a xeric region is a dry region and does not describe a soil type..

L115 MAT is the least ecologically-relevant temperature information possible. Maybe you can report annual ranges (e.g. of mean monthly temperatures) instead? Or information on snow cover or something else that may affect ecotone pattern.

L132 locations

L142-144 Sorry, but I do not understand this method of mitigating spatial resolution loss. Did you fly the entire plot at two altitudes? And then you used the data from the lower altitude for the lower part of the plots..? And what does the central position in the plot have to do with it? What was in a central position? The drone pilot?

L146 canopy detection

L155-156 I am probably missing something, but don’t you need the terrain model to be able to decide whether points are above or below 10 cm from the ground? This procedure seems a bit circular…

L160 With dwarf mountain pine you probably mean Pinus mugo, the krummholz-forming species. It would not hurt to mention these two terms here.

L184 I have a problem with calling these training polygons “ground truth”, because they obviously are not based on knowledge from the ground but on an alternative classification method. And you do have actual ground-truth data to work with too. Perhaps you can acknowledge this not quite correct use of the word “ground truth” by putting the term in quotation marks the first time, or by calling them training /validation polygons rather than ”ground truth”.

L185 annotation of the segments into tree and non-tree classes? Please explain the link between the use of segment-anything and the manual process more clearly.

L198 What do you mean by “from start”?

L250 & Figure 4. I think that here something got misinterpreted from the previous review comments. I think the point is not so much how >50-cm trees affected the position and height estimation accuracies, but also and especially how they, or the accuracy in general, affect (or not) the conclusions based on the point pattern analysis. I.e. taking the validation and evaluation of the model quality one step further.

L287 ““combine replicates” protocol” – I do not know this protocol, but this sounds like you are treating your sites as simple replicates rather than as the units providing the variation you are interested in…

L297 further demonstrating

L324 “Frequency and smoothed kernel density distribution”

Figure 4. I am not sure why this figure was added, but if it was because of one of my comments, that was a misunderstanding (see my comment above).

Figure 5. explain in the caption whether this is for one of the sites, or some sort of average (but see my comment above about the “combine replicates” protocol…

L336 & L346 Similarly, you here claim that the pattern is seen across study sites, but actually you do not, at this point, analyse the sites individually, you just take an average, which I find a strange choice if aiming at understanding pattern-process relationships.

L340 Appendix C is now figure 6?

L354 is this really called a correlation analysis? Also, instead of “of tall trees and small trees” maybe use “between small and large trees”?

L389 Check sentence. What exactly is in its infancy?

L390 Lowering flight height would also increase survey time in other habitats, wouldn’t it? Also, in this section there seems to be a confusion between data quality issues and AI abilities.

L419 With “gears”, do you mean equipment? Sensors?

L442 This is a very weak argument if you specify your grain and extent so precisely… In the preceding paragraph, make more clear what these studies (not works) did and how it relates to your study. E.g. also using remote sensing, also studying several sites, etc., but not…..

L481 Here, or somewhere else, you should explain clearly what sets your method apart from methods used in the many studies with which you compare you classification accuracy. What makes your method better / different?

L496 lots of adjectives. What do you mean with “sprawling”?