Response to the comment of Anonymous Referee #1

We appreciate the time and effort from Referee #1 to provide comments and great suggestions on our paper. We have divided the comments into points and address each point below, where the reviewer's comments are shown in italics. The line numbers refer to the revised document.

Comments

1) The writing needs to be improved for grammar, word usage and flow.

Thanks for this comment. We have now tried to make the text more readable with a focus on improving the flow. We have specifically focused mainly on revising the text in the abstract, last three paragraphs in the introduction, the results paragraphs starting from line 392 and 413 and the discussion paragraphs staring from line 645, 669, 711, 733, 747 and 760. We have also re-structured the methods sections to make it easier to follow (see point 2). We hope it is more clear now. We have also run the manuscript by a native english speaker to check for grammar and word usage throughout the manuscript.

2) I still find it difficult to follow the methods.

We regret that the methods description obviously still was not as clear as we had hoped. To make the methods clearer we have re-structured the site description to clearly describe the location and vegetation description of the sites HTM and NOR followed by a description of the plots on each site with a more thorough explanation of the number of trees selected for the study (from line 110). We have also improved Table 1 by adding a row clearly stating the number of trees measured at each plot as an addition to the number of samples taken of these trees. We have also added a final row indicating how many samples were taken in total from healthy (n = 144) and infested (n = 40) trees and the total samples (n = 184). Table 1 have also been indicated more clearly throughout the site description to avoid any confusion.

We have also improved the paragraph from line 140 where we describe where and when we installed a bark beetle trap to make it clearer why this was done and that it only resulted in two infested trees at this plot.

The text in section 2.2 was improved for clarity and flow to make it easier to follow the experimental design of the study.

In order to improve the transparency and clarity we have also added information about the outliers removed (paragraph starting at line 251) and that it resulted in 33 samples which could not be used reducing the samples in the analysis from 184 to 151 (113 samples from healthy trees and 38 from infested trees).

3) The reference list is not complete (e.g. Ortega & Helmig, 2008 is not included)

Thanks for spotting this! We are sorry for having missed the Ortega & Helmig (2008) reference, which is now added. We have also double-checked the reference list once again.

4) I think the sub-study with two trees should be removed from the manuscript as it is not possible to statistically compare two individuals.

We thank the reviewer for enlightening us about this mistake in the manuscript. The intention was never to statistically compare two individuals but rather their individual sample pool and progress over time. However, we realize that the end product was indeed a statistical comparison of only two

individuals to which we agree is not possible. We do however not agree with the reviewer that this section should be removed. What we indented was to have those two individual trees as a case-study as those trees were infested by the bark beetles during the experiment. This means that we have measurements of the trees at either a completely healthy stage or a lowered defense stage and also measurements of the same tree individuals when they were infested. This was something we had hoped for when we had placed out the pheromone trap. To our knowledge, this is the only reported study of this kind, other studies analyzing Norway spruce BVOC emission rates from bark beetle infested trees are only comparing healthy and infested trees and not investigating the progress from healthy to infested from the same individuals in-situ. That we only got measurements from two individuals is unfortunate but nothing we could control for as we could not decide where the bark beetles should go.

We believe these results to be important for the knowledge of bark beetle impacts and rather than removing this section we have made major alterations. We acknowledge to have used a misleading expression here when phrasing this section as a 'sub-study' and have thus changed it throughout the manuscript to be phrased as a case-study clearly stating the use of only two individuals firstly mentioned in the methods (line 144). As this is nothing we can statistically compare we have aimed at presenting it as preliminary results and have thus removed the hypothesis around this in the introduction. All statistics have been removed from this section (3.4) and the text is now altered to present the results for the two trees in relation to each other but not drawing any major conclusions.

The discussion section around this case-study (4.1.1) have also been majorly revised to clearly state that this is a case study presenting initial results from when a tree goes from healthy/decreased defense to infested by spruce bark beetle and the progress over time. We also highlight the importance of follow-up studies on this in the future, which there will be none if no results are published despite small sample size. We have also substantially reduced the amount of discussion dedicated to this section as an indication of the small but important contribution is has to the study as a whole.

We are not drawing any major significant statistical conclusions from this section, but we want to highlight the promising initial results we found that deserves to be shared.

5) The use of the word "campaign" is not correct. This needs to be changes in all instances.

We have removed to word 'campaign' throughout the manuscript and replaced it with other, more appropriate terms.

6) The paragraph beginning after line 55 needs more connection between the thoughts.

Thanks for these suggestions! We have rephrased the section after line 55 (line 64 in the revised MS) to better guide the reader and to improve the clarity of the text.

7) In the concluding paragraph of the introduction, I think it would be better to list all four aims in one sentence. It is confusing that aim (IV) is at the end of the paragraph.

Thanks for this comment! We agree that the research aims and research questions should not be spread out in the text. Following the removal of the 'sub-study' raised earlier, we have also revised the aims (i-iii) and hypothesis (H1-H3) of the study to now cover one compact section (L85-L95).

8) "Four Norway spruce trees were selected at each plot in HTM, and three trees at each plot in NOR. A total of 18 trees were measured, whereof 12 were measured repeatedly during the growing season in HTM.» I can't figure out how these statements fit with Tables 1 and 2.

We are sorry for this confusion and would also like to thank the reviewer for highlighting this as it led to the discovery of a mistake in the manuscript. A typo had led to one tree being missed in this statement, the correct amount of total trees measured is 19 and this have now been corrected throughout the MS. It is correct that in total 19 trees were used in the study, growing in two different forests in Sweden. All trees were measured repeatedly (typically 3 times per sample day), and trees at HTM were measured repeatedly throughout the season, while all trees at NOR were only measured once as the forests are ca 700km apart. We have added information on number of trees now to Table 1 explicitly (see answer to comment 2). Table 2 however is referring to the number of bark beetle holes per tree, and thus only contains infested trees.

9) How many total trees were included in the experiment?

A total of 19 trees were used in this study, growing in two different forests. We have added this information more clearly to Table 1.

10) From table 1 it seems that there were 31 infected trees, but table 2 indicates only 14.

No, this is a misunderstanding. 19 individual trees have been used, of which 9 were infested or got infested during the study. Table 1 now lists the number of trees, and the number of samples for those trees. Table 2 provides the number of bark beetle holes for each individual tree that was infested during each field visit. This is clear from the tree ID which appears multiple times for some trees which were measured several times as indicated by the date. The total number of infested trees still remains 9.

11) Were repeated measures performed only on some trees?

All trees were measured repeatedly (typically 3 times per sample day), and trees at HTM were also measured repeatedly throughout the season, while all trees at NOR were only measured once as the forests are ca 700km apart. We have added information on number of trees now to Table 1 explicitly, see also line 110-116. In total 184 samples were taken on the 19 trees of the study, 144 from healthy and 40 from infested trees (line 219 to 220).

12) Why were measurements at NOR only performed once and included only infected trees?

Unfortunately this information seems to have gotten lost during the revision. Normal forest practice is to remove all bark beetle infested trees as quickly as possible to prevent spreading of bark beetles in the stand. At NOR we had the opportunity to increase the number of samples on infested trees when an outbreak was occurring there. Because of limitations in time and resources only infested trees were measured, as the forest is located ca 700km away from HTM.

13) Are the tree genetics between these two sites the same?

14) How could genetics effect the BVOC results?

Reply to both 13) and 14):

No, both forests were commercial plantations, and they were different in age and probably genetics. We have done pre-studies on (needle) emissions from both stands (van Meeningen et al., https://doi.org/10.1016/j.atmosenv.2017.09.045) which resulted in similar emission patterns between trees from both stands. This can be compared with a study from Bäck et al. 2012 which analysed the chemodiversity between 40 conifers in a single stand in Finland, so there is always some kind of variation in a forest stand. However, these variations caused by genetics in healthy

trees are orders of magnitude lower than the effect of bark beetle induced emissions. We have revised the discussion to add a paragraph mentioning this (line 637 to 643).

15) Can you be sure that entry and exit holes were correctly designated without excavating the bark?

Excavating the bark was impossible as this would have been a destructive sampling that was not possible to do as the aim was to repeatedly measure on the same trees as we were interested in the temporal development of emissions. As the drilling of entry holes is related to the swarming of bark beetles, new holes in the early season are entry holes. A couple of weeks later, after successful placement of eggs in the galleries, new formed holes are exit holes. So there exists a clear temporal pattern that, besides shape and structure of the holes, help identifying hole type. However, for a given (chamber) area it will be impossible to find a spot were only exit holes exist, so we did characterize after the majority of holes for the analysis, which is stated for example in Table 2 as well.

16) Were any post-hoc test performed after the Kruskall-Wallis test?

We did not perform any post-hoc test after the Kruskall-Wallis test as we never needed to do so. To our knowledge post-hoc tests are used for comparing several groups, so when for example an ANOVA was made with significant results – a post-hoc is made to see what groups had a significant difference. For this you need at least three groups. We never compare more than two: healthy or infested. In one case we do actually compare three groups – the different sites for healthy trees. But as that resulted in a not significant result (which was expected) there is no use for a post-hoc.

17) Figure 6 I think early and late BVOCs in infected trees should be compared to early and late BVOCs in healthy trees rather than the full season.

Thanks for this idea, which we have implemented in this revision (Fig 6)! We previously used the full season emission rate for the healthy trees because the differences between early and late season for the healthy trees is much smaller than the difference between healthy and infested during any season and the difference for early and late emissions from healthy trees are not statistically significant. But we agree that a more consistent way of comparison is also providing seasonal differences for the healthy trees even if it does not in any way change what we intended to show with this figure.