Reply to Reviewer 1

Summary:

This study investigates the effect of simulated bioturbation by wild boar on forest soil carbon stocks and on soil C stability. Bioturbation was simulated by artificial soil disturbance down to the mineral soil. Total soil carbon stocks did not change after six years of regular soil disturbance. However, a major part of the litter layer carbon was incorporated into the mineral soil due to bioturbation. Accordingly, litter layer carbon stocks decreased and mineral soil carbon stocks increased following bioturbation. Moreover, mineral-associated carbon increased due to soil disturbance. The authors suggest that mineral soils were not carbon saturated and have an unused capacity to stabilize and store more carbon. In conclusion, the authors claim that wild boar bioturbation may enhance (speed up) carbon stabilization in the mineral soil.

General comments:

Overall, I think this is a very nice study. Wild boar populations are increasing across Europe and their effects on soil carbon dynamics are still not fully understood. The manuscript is well written, the study design and measurements are sound and the results are interpreted in a good way. However, I have a number of concerns regarding the sampling procedure, the statistical analysis, and some of the figures. Please, find my specific comments in the following. I think after a revision the manuscript will make a valuable contribution to the research field and should be considered for publication in Biogeosciences.

Reply: We thank the reviewer for the very helpful comments and the appreciation of our study.

Specific comments:

Title: In my opinion, it should be added to the title that wild boar bioturbation was actually simulated.

Reply: We agree and will change the title accordingly.

Abstract:

P 1, L 7: Please rephrase ‘can help’.

Reply: Rephrased in “can facilitate the incorporation of litter-derived carbon”

P 1, L 9: Add that wild boar bioturbation was simulated.

Reply: We added that bioturbation was simulated

P 1, L 17: Please rephrase ‘can help’.

Reply: Rephrased in: “Wild boar may speed up this process with their grubbing activity.”

Introduction:

P 1, L 30: I suggest either to replace ‘the main process’ by ‘a major process’ or to add an appropriate reference to that statement.

Reply: We changed this accordingly

P 3, L 2: Please add the references of the studies which have investigated wild boar effects on soil carbon stocks.

Reply: We will add the references to Wirthner, 2011 and Mohr and Topp, 2001 here.

P 3, L 11: Add that the effects of 'simulated' wild boar grubbing were investigated.

Reply: "Simulated" will be added.

Materials and Methods
P 3, L 16, 17: I think there should be an 'a' before mean annual temperature and moisture.
Reply: Will be added.

P 4, L 14-19: It took me a while to understand the idea behind mass equivalent sampling, and why you applied it in this study. However, I'm still not sure if I properly understand it and I'm therefore a bit concerned if this procedure might affect the results. By sampling the same amount of soil per horizon and pit, I have the feeling you could underestimate potential C losses from bioturbation. For example, in the theoretical case, 50% of the LF horizon organic matter stocks would have been mineralized due to bioturbation, this sampling procedure would artificially 'refill' the missing amount of organic matter with organic matter from the next horizon (i.e. O horizon). Now, the O horizon is (artificially) smaller, but will be 'refilled' with soil from the next layer, and so on. At some point, material from a deeper layer which has not been sampled at the reference plot would be sampled to 'refill' the missing amount of organic matter. Thus, the actual amount of lost C would be underestimated. I might be completely wrong, but then I suggest to elaborate more in detail on the sampling procedure.

Reply: We agree that the sampling procedure is not easy to understand. Therefore, we included the figure for illustration and we will revise this paragraph where necessary to make more clear. However, the general concept was developed by Ellert and Bettany 1995 and before also by Jenkinson (see also Wendt and Hauser 2013, EJSS). In most cases it is recommend applying a mass correction to the obtained soil data set. However, sampling directly in a mass corrected way is the preferable method to correct for differences in soil mass. The "refilling" of missing soil mass the reviewer are referring to, is done with subsoil material that is C poor. Thus, the sampling procedure can hardly bias results in a way outlined by the reviewer: If O horizon material (around 500 g/kg Corg) would be lost due to bioturbation, it would be replaced by subsoil material with 2.5 g/kg Corg in an equivalent soil mass sampling. Thus, a 10.00 % loss of O material would result in a 9.95% C-loss with the refilling from subsoil material. This is practically the same C-loss and the error is far below the precision that can be achieved with any soil sampling. We agree, that sampling the soil treatments is never completely without bias but, as explained above, the sampling procedure will not bias the results in a way that our interpretation is not valid anymore.

P 5, L 1-2: Was there only one composite sample per site, treatment and soil horizon? Please clarify.
Reply: We will add that it was one composite sample per site and treatment.

P 5, L 14: Which statistical test did you use? What was you level of significance? How, did you account for nesting within sites? Please clarify.
Reply: We will add the missing information (mixed linear model (lme function, nlme package) accounting for site and area as nested random factors (□=0.05)) with the following sentences: " The differences in SOC stocks were analysed using mixed linear models (package nlme, function lme) accounting for site and area as nested random factors (□=0.05). Tukey's honest significant difference post-hoc test was applied."

Results
P 5, L 17: Again, please indicate that bioturbation was simulated (here and elsewhere in the text).
Reply: We will add “simulated”

P 5, L 18: Fig. 2a not 2A.
Reply: Will be corrected

P 5, L 23: In my opinion it is not necessary to show the results of the individual plots. Thus I would suggest to move Fig. 3 to the supplements.
Reply: We agree and shift this figure to a supplement.

P 6, L 4: Instead of showing the individual plots (Fig. 3) I suggest to add a figure showing the bioturbation effect separate for the forest types.
Reply: As it is visible in Fig. 3, the variability between the sites is large and there are no differences between the forest types. The Fig. 3 is designed with four lines that comprise the different forest types in the two areas.

P 6, L 8-10: This should be part of the discussion.
Reply: We revised this to “This was related to greater thickness of the forest floor and a larger proportion of mineral soil SOC in deciduous and coniferous forest reference plots than in mixed forest plots.” and would argue that this is still a result and no interpretation.

P 6, L 14: It is stated earlier that fractions were determined on composite samples only. How did you do statistics on that? Please clarify.
Reply: Statistics was conducted not at site level but taking all sites and both areas into account (see above).

P6, L 15: Clarify that ‘treatment effects’ were similar among forest types. In the present form I first thought that e.g. POM fractions were similar among forest types.
Reply:

P 6, L 19: is ‘total stocks of MOM’ correct? Or should it be MOM fraction? This reads a bit confusing. I would also suggest to refer to Fig. 4a here.
Reply: Thank you for noticing. We will rephrase into “MOM fraction) and refer to Fig 4a and 4b.

P 6, L 23-24: Please add the forest floor POM/SOM proportion and stocks to Figure 4.
Reply: A fractionation of SOM into POM and MOM for the forest floor is technically not possible due to the very low fraction of minerals in the forest floor. We will add this in the figure legend. It can be approximated that almost all SOM in the forest floor is POM.

Although this results are included in Fig. 5, I think it would be more clear if you add it to Fig. 4.
Reply: See above.

P 7, L 4: Was there no mineral surface C in the forest floor of the reference plots? Did you measure it? Please clarify.
Reply: The forest floor had a carbon content of almost 50% with is equal to almost pure organic matter. With the applied fractionation procedure it was not possible to fractionate this material with almost no minerals.

Discussion:
P 8, L 30: I guess it should be Fig. 2b not 1b.
Reply: Thank you for noticing. It will be corrected.

P 9, L 10: Please cross-check figure reference.
Reply: Thank you for noticing. It will be corrected.

Conclusion
P 10, L 16: Please, add that wild boar activity was simulated.
Reply: Will be added.

To put your results into a bigger context, I suggest to add some information/thoughts about potential long-term consequences.
Reply: We added the following sentence: "On long-term this may even lead to enhanced SOC stocks due to an increased fraction of stabilised SOC. Soil disturbance with mixing and bioturbation were previously assumed to enhance SOC mineralisation and cause SOC losses. This could not be confirmed in our study and calls for a new perception. Soil mixing with bioturbation or anthropogenic with machinery lead to a more even distribution of SOC in the soil profile and may result in enhanced SOC stocks on long-term."

Figures:
Figure 2: In the case horizons showed significant differences between treatments please indicate that by adding significance stars to the figure.
Reply: We will include the information on the significance between the horizons in the figure captions since it is difficult to visualize between the bars: "Significant differences were found in 0-5 cm depth and in the combined forest floor (L+O layer)."

Figure 3: This figure should be moved to the supplements. Instead replace it with a barchart for each forest type. Add significance stars to the figure.
Reply: This figure illustrates the variability between the plots, but we agree that it can be shifted to the supplement. A figure with the forest types can be added, but it may not be useful since we found no significant differences between the forest types.

Figure 7: In the case horizons showed significant differences between treatments, please indicate that by adding significance stars to the figure. What happened to L+O of the reference plots?

Reply: This figure refers to the MOM-fraction. There was no mineral fraction in the L+O-horizon in the reference plots and therefore this fraction could not be analysed for the reference treatment.