Biogeosciences Discussions

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# Reply on RC1

Roberto Pilli et al.

Author comment on "The European forest carbon budget under future climate conditions and current management practices" by Roberto Pilli et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-35-AC1, 2022

**Dear Reviewer,**

**Thank you for your positive review and for your constructive comments. We will certainly take into considerations your comments when we revise the manuscript. While waiting for other review comments, we take this opportunity to clarify some points.**

- The exclusive focus of the analysis on fluxes, relegating the changes in stocks to the Supplement, may allow misinterpretation and misappropriation of the findings to justify further intensive management policies.

**The objective of our study is "to investigate the medium to long-term evolution of the forest C sink, as affected by the complex interactions between climatic variables and forest ecosystems", focusing on the methodological aspects. In this sense, the continuation of forest management (BAU) was chosen just to test our method, but this is not a policy scenario. We will further clarify this aspect when we revise the manuscript. However, we take this opportunity to highlight that the CBM model used within our modelling framework does conserve mass, thus the sum of the fluxes is equal to the sum of the stock changes. Therefore, we think that there is no need to address both in the main text: the evolution of biomass C stocks is reported in the supplementary information (see Fig 13S).**

- This concern has two components – the change in stocks themselves under different scenarios, and the dynamics of heterotrophic respiration (Rh). I suggest moving figures 5S and 6S to the main body, and discussing the interaction of fluxes, pools and management all together.

**Figures 5S and 6S report the relative stock change applied to conifers and broadleaves respectively, as derived from the combination between climate simulations and LPJ-GUESS and used as input for CBM (for this reason this additional information was added as supplementary material), to calibrate the growth functions against climate change. Losses from fires are included in the DGVM simulations but not harvest. Both harvest and fires are included in the CBM simulations. The effect of management on C stocks is reported in figure 13S, under the reference scenario, therefore excluding climate change and it is discussed on the main text (i.e., L 544-546, 555 – 557, 647-650). We understand**

**the point highlighted by the reviewer, however, since we did not consider different management scenarios (because we did not assess policy scenarios linked to various management strategies), we mostly focused our discussion on the fluxes.**

- While the short-term flux dynamics certainly will reflect the developmental stage they are currently in, the harvest intensity must be balanced with the long-term NEP. Maximizing NEP does not maximize the climate mitigation potential of forests.

**We recall again the fact that, within the present study, we did not aim to provide any policy scenario analysis, therefore we never stated that we should "maximize NEP". However, we also notice that (i) a high NEP is an indication that the forest operates as a strong C sink (at least excluding the possible impact of natural disturbances), and (ii) to maximize the overall contribution of the forest sector to climate change mitigation, we need to maximize the "net sector productivity", including NEP and the net contribution of HWP emissions (which were not considered within our study). Both these factors are clearly linked to management practices. Other studies have previously used the CBM to conduct scenario analyses of changes in harvest rates in different regions and have demonstrated that harvest rates do affect future NEP (see for example, Pilli et al., 2013, Pilli et al., 2017, Jevšenak et al., 2020).**

- It would be appropriate to acknowledge that the depiction of Rh in LPJ-GUESS does not reflect the latest understanding that Rh can be partly decoupled from NPP (https://doi.org/10.1029/2020GL092366), and that management-related disturbances can stimulate Rh for years to decades (https://doi.org/10.1016/j.foreco.2015.05.019; https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2010JG001495; https://www.nature.com/articles/d41586-019-01026-8). These factors likely contribute to Rh being underestimated in the LPJ-GUESS simulations.

**In our study we used only net growth changes from LPJ-GUESS – as affected by climate change and fires – and we do not use Rh from that model in this analysis. In addition, we used "soc2005" LPG-GUESS simulations that uses fixed year-2005 land use and other human. Whether or not LPJ-GUESS represents Rh properly does not at all affect the outcomes of our study. In fact, the main point of the reviewer – i.e. that disturbances, including harvesting, can affect Rh for years to decades - is well represented in the CBM-CFS3. That is why NEP changes over time across the scenarios. Moreover, Rh in CBM-CFS3 is temperature dependent (and the temperature is varying within our simulation) – and thus is can and does vary independent of NPP and it is not assumed to be a fixed proportion of NPP.**

- I understand that a rigorous evaluation of these aspects is not feasible, but adding a paragraph to summarize remaining unknowns about soil C dynamics is appropriate, in my opinion. This section could also include references to the effect of nutrient availability (including deposition) on productivity, carbon allocation and the dynamics between plants and rhizosymbionts. There is growing evidence that these relationships are currently changing and may affect the growth and fitness of organisms involved, including changing the functional balance of soil microbial communities (leading to higher Rh).

**Thanks for your suggestion, we will add a paragraph to mention remaining uncertainties in these models. However, we recall that, in this case, soil C dynamic is represented in the CBM. Other studies have previously assessed the uncertainty of these parameters, within the CBM (see for example, Smyth *et al., 2009; Hararuk* et al., 2017; Blujdea et al., 2021)**

- While the use of wood in various products was not a factor in the current analysis, it may be appropriate to acknowledge that recent assessments of the substitution benefits of forest products conclude that these have likely been overestimated (http://dx.doi.org/10.1088/1748-9326/ab1e95, https://doi.org/10.1038/s41598-020-77527-8).

**We already highlighted within our conclusions, that "the additional mitigation potential provided from carbon storage in harvested wood products and material and energy substitution were not considered in our study" (L. 684-686). Taking into account the reviewer's suggestions, we can further emphasize this point in other sections, but discussing whether or not substitution benefits are over or underestimated in the literature is beyond the scope of this paper**

- Finally, while the paper is overall well written and easy to follow, there are a number of typographical errors (duplication of words and punctuation marks, and minor grammatical errors) that are easy to fix using the spell checker.

**Many thanks for highlighting this point, we will carefully review the text.**

**Additional References**

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