

Referee comments on MS No. bg-2021-126: 'Separating autotrophic and heterotrophic soil CO₂ effluxes in afforested peatlands'

General comments

This study helps answer an important, highly policy-relevant question concerning use of peatlands in temperate regions for plantation forestry. Very limited research on the implications for climate change of this land use on this soil type has been published. This work provides empirical data to support modelling of the balance between CO₂ emission due to peat decomposition and atmospheric CO₂ removal into tree biomass. It clarifies the reliability of assumptions used about the relative rates of heterotrophic and autotrophic restoration to estimate the rate of peat decomposition from total soil CO₂ efflux and will inform similar assumptions in future. It highlights the important role of rhizosphere priming effects in decomposition of afforested peat. This study is excellent - well conceived, carefully undertaken and concisely reported. Its limitations are recognised and discussed.

Specific comments

1. Your finding that the soil of these 30-year-old forests is a net C sink is arguably as important as the findings about the relative magnitudes of the autotrophic and heterotrophic CO₂ effluxes. The title of the preprint indicates a focus on the latter. Consider expanding discussion of the net soil C balance and altering the title to reflect a dual focus.
2. The likelihood that killing roots by trenching will also have stopped rhizosphere priming of peat decomposition is acknowledged as a limitation of the study. The priming of litter decomposition in the same way is demonstrated to make a substantial difference to litter-derived CO₂ efflux by the litter decomposition measurements in the trenched and control plots but no evidence is provided on the likely size of this effect on peat decomposition. Any further evidence that can be obtained from the literature would help in assessing the degree of underestimation of peat decomposition by the trenching treatment.
3. Generally, you have been consistent about the boundaries of the system under study (line 74: 'the C budget of a drained and afforested peat soil'). Mentions of root growth in line 324 and belowground productivity in line 327 are slightly confusing because assimilation of C in tree biomass was not included in your study. If by 'root growth and turnover' and 'belowground productivity' you are referring to root litter and/or exudate deposition, make this clearer. It is important that readers do not confuse soil C stocks with below-ground C stocks.
4. The limitations of not measuring fluvial C fluxes or root litter and exudate deposition are briefly mentioned but could be discussed more fully in the context of their implications for afforested peatland soil C balance. These limitations and any conclusion about their likely implications for the main findings should be mentioned briefly in the abstract.

5. The final discussion point about the importance of knowing the net C balance over the lifespan of a plantation is important and welcome but, for balance, should be expanded. The fact that this lifespan normally ends with timber harvesting and deposition of large quantities of felling residues above ground and whole root systems below ground means that we need to go beyond a single forestry rotation to assess the soil C balance of the land use. The separate litter and dead root decomposition fluxes reported here may help inform assessment of post-felling CO₂ fluxes but need to recognise the different water table level and soil moisture conditions created by the soil rewetting associated with clear-felling.

Technical corrections

18. Consider adding a sentence saying that you measured and corrected for decomposition of the excised roots.
31. 'treed' perhaps better than forested as these can be quite sparse.
35. 'very little' better than 'a very little'.
51. Consider adding 'or outstrip' after 'could partly or wholly offset'.
52. 'original' could be omitted.
55. 'of poorer quality' could be replaced by 'less readily decomposed'.
58. Consider omitting 'chemical', the recalcitrance is also biological and due partly to the microbial environment of the peat.
61. Consider adding 'rhizodeposition' after 'litterfall'. Although you didn't measure it, it's important not to hide the fact that it occurs and needs to be considered as a C input to soil.
78. 'forestry plantations' is probably a better description of the land use/ecosystem than 'forest plantations'.
- 79-80. Something missing in Hypothesis 3. 'Interactions between C supply to the rhizosphere by trees' and what?
85. Insert a comma after 'drained'.
89. Is there a simpler way of saying 'with an average ratio per area of Sitka spruce : Lodgepole pine of 0.6'? Perhaps omit this and insert '3:5 (on average)' before 'mixture' in line 85.
92. 11.4 °C is the 30-year average maximum temperature. It would be better to give the average mean temperature or if not available, also give the average minimum, which is 3.3 °C for Kinbrace.
- 97-99. Excellent approach.
100. 'double ploughing' is ambiguous. Either say 'double-mouldboard ploughing', which is technically correct or 'twin-throw, spaced-furrow ploughing' which is perhaps more universally understood.
- 100-105. In section 2.2, could you reduce the text description to a single sentence by including the dimensions in Figure 1?
- 114-115. Consider replacing 'with closest trees located about 30 cm from trenches' by 'but did not represent ground within 30 cm of trees'. But if 30 cm was the distance from trees to the outer edge of the trench, the unrepresented ground would be that within 60 cm of trees.

133-134. Say how you distinguished the litter that had fallen since the previous measurement.

138-139. Say that the roots extracted from the soil cores and weighed included both live and dead roots.

142. Say if you assumed that root density in the 20-25 cm soil layer was the same as in the 0-20 cm layer.

144. Replace 'in' with 'into'.

213. remove 'at least' or 'over'.

227. Change 'higher soil temperatures' to 'soil temperature'.

229-230. If possible, state the soil temperature above which CO₂ efflux decreases with soil moisture.

241-243. Having already read the abstract, this was slightly confusing. It is clearly explained in the discussion (372-373) but can you add a few words here to emphasise that the model prediction of heterotrophic respiration includes that for decomposition of excised roots?

257-258. The increased litterfall into collars in the trenched treatment compared with the control is potentially interesting but is not supported by the litter trap catches. Say if the difference is significant but omit from the text if not.

263-264. Could be worth mentioning possible bias from not sampling ground close to trees.

267. Replace 'was' with 'were'.

283. Table 4. It is unclear what the figures in bold in the 'Decay constant' column are. If they are 2-year excised root-derived C emissions, consider moving them to a new column added on the right of the table or omit them altogether.

303. Replace 'weighed' with 'weighted'.

308. Table 6. Area-weighted fluxes and the breakdown into autotrophic and heterotrophic fluxes are quite sensitive to the area fractions of the different microforms. I checked these against some measurements I had for double-mouldboard ploughing at another northern Scotland site and found them to be quite different. Please double check that these are correct.

310. Omit comma after 'matter'.

313. Nice diagram. Would it be possible to add a net C balance figure for each microform and the area-weighted total?

316. Omit comma after '(grey)'.

324. As mentioned in Specific comment 3 above, consider replacing 'root growth and turnover' with 'root litter deposition' or 'rhizodeposition' (the latter would include root exudates).

327. As mentioned in Specific comment 3 above, consider replacing 'belowground productivity' with 'belowground litter and exudate deposition'.

341. Replace 'Southern Ireland' with 'the south of Ireland or just 'Ireland'.

361. Replace 'and' with 'the'.

370-371. The first half of the sentence is an important 'Methods' detail so I've suggested adding it around lines 138-139. If you do that, you might need to reword this sentence slightly.

376-377. This is an interesting finding that could inform the assessment of soil CO₂ fluxes after timber harvesting on afforested peatland. Consider adding it to the abstract.

384-386. A single citation of a tropical peatland study is not very helpful here. Consider either omitting this last sentence or citing a wider range of evidence, preferably as relevant as possible to temperate afforested peatlands.