**In response to:** *L156-160: For control soils, the 3-pool model assigns 10% of POC to a fast-cycling Litter C pool, in line with the author's argument that the POC pool is heterogeneous. However, for the litter-addition treatment, the Litter C pool appears to contain only the added litter, with the native fast-cycling fraction folded back into POC. If POC heterogeneity is a general property of these soils, the litter-addition model's Litter C pool should include both added and native fast-cycling material. I recommend the authors should clarify this choice and discuss whether it affects the fitted parameters or model performance.*

We sincerely thank the reviewer for this and the following comment. The reviewer points out a straightforward issue regarding the modelling assumptions that we had overlooked. We addressed these comments, which led to more robust and precise results.

Originally, the decision to define the Litter C pool to contain only the added litter was based on the fact that assigning a proportion of the POC pool to a fast-cycling C pool requires an additional assumption. Because the litter-added C represented a clearly defined C pool, we considered it more parsimonious to model the added litter as the fast-cycling C pool. However, as the reviewer correctly points out, we overlooked that, as in the control samples, the litter-addition samples should also include native fast-cycling C.

Therefore, after both “L156-160” and “L160” comments, we explored models assigning a proportion of POC as Litter C. We evaluated the models performance across a wide range (0, 5, 10, 15, 20, 25, 30 and 40%) of proportions of POC as Litter C and we report the results below.

We should clarify that, in this new optimization process, we implemented an algorithm that allowed us to identify parameter sets with lower AIC and MSE values than those reported in the original manuscript. Hence, the fitted parameters and model performance changed. However, as shown in the manuscript, these changes do not affect the patterns observed or the conclusions discussed in the study.

Assuming different proportions of POC as a fast-cycling C pool for litter-addition samples affected both model performance and the fitted parameters (Fig. 1, Table 1 and Table 2). Interestingly, as observed for the control samples, assigning a fraction of POC to a fast-cycling C pool improved the model performance. Specifically, assuming 30% of POC as a Litter C pool yielded the lowest AIC and MSE values. However, these results had relatively small differences compared to other model assumptions: For example, assumptions of 25%, 20%, and 15% resulted in AIC values that were 1.6%, 1.7%, and 4.3% higher, respectively, than the value obtained for the 30% assumption, whereas for MSE, these values were 4.6%, 4.8% and 13% higher, respectively (Table 1).

Given these similar performances, we then examined the fitted parameter values. We found that the 30%, 25%, and 20% assumptions, despite yielding low AIC and MSE values, produced some unrealistic parameter estimates, with annual decomposition rates on the order of 10^-4 to 10^-6 (Table 2). Therefore, we selected an assumption of 15% of POC as Litter C, as it provided biologically realistic parameter values while maintaining relatively low AIC and MSE values. Furthermore, as shown below, this decision is consistent with the results obtained for the control samples, where exploring different proportions of POC assigned to the Litter C pool also led us to select the 15% assumption. We replaced the original results in the manuscript with those obtained under this assumption. We also added the sensitivity analysis method to the manuscript and provide the Tables and Figures in the Supplementary material.

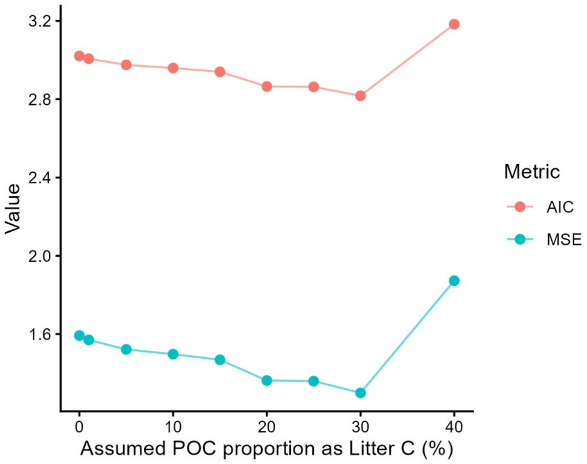


Fig. 1. AIC and MSE values for litter-addition-samples models assuming different proportions of POC assigned to the Litter C pool.

Table 1. AIC and MSE values and their relative values compared with the model showing the lowest AIC and MSE values, for litter-addition samples models assuming different proportions of POC assigned to the Litter C pool.

| POC as Litter C assumption (%) | AIC | Relative AIC to best model (%) | MSE | Relative MSE to best model (%) |
|---|---|---|---|---|
| 0 | 3.021 | 107.2 | 1.592 | 122.5 |
| 5 | 2.975 | 105.6 | 1.522 | 117.1 |
| 10 | 2.959 | 105.0 | 1.497 | 115.2 |
| 15 | 2.940 | 104.3 | 1.469 | 113.0 |
| 20 | 2.865 | 101.7 | 1.363 | 104.8 |
| 25 | 2.863 | 101.6 | 1.360 | 104.6 |
| 30 | 2.817 | 100 | 1.299 | 100.0 |
| 40 | 3.183 | 113.0 | 1.873 | 144.1 |

Table 2. Parameter values for litter-addition-samples models assuming different proportions of POC assigned to the Litter C pool.

| POC as Litter C assumption (%) | $k_1$ | $k_2$ | $k_3$ | $a_{21}$ | $a_{32}$ | $a_{31}$ |
|---|---|---|---|---|---|---|
| 0 | 6.25 | 4.5 E-15 | 3.4 E-11 | 0.027 | 1.7 E-16 | 0.049 |
| 5 | 6.16 | 0.002 | 1.2 E-7 | 0.284 | 0.002 | 0.275 |
| 10 | 6.32 | 0.064 | 0.028 | 1.28 | 0.064 | 0.080 |
| 15 | 6.81 | 0.018 | 0.046 | 1.850 | 0.017 | 0.404 |
| 20 | 6.46 | 5.7 E-5 | 0.027 | 2.010 | 5.6 E-5 | 0.158 |
| 25 | 6.10 | 0.015 | 4.1 E-4 | 1.745 | 0.014 | 0.271 |
| 30 | 6.04 | 6.69 E-4 | 1.1 E-6 | 2.160 | 6.6 E-4 | 0.065 |
| 40 | 6.04 | 0.003 | 0.003 | 0.035 | 0.003 | 2.614 |

**In response to**: *L160: Additionally, for control soils, the 3-pool model requires assigning a fraction of initial POC to the Litter C pool. In the manuscript, the authors choose an arbitrary value of 10% (L160) but do not report how sensitive the results are to this choice. Since the litter-addition result is acknowledged as "almost self-evident" (L321), the control soil comparison is the stronger, non-trivial test of the 3-pool model's advantage, however, it depends in large part on this assumption. I recommend that the authors either (a) report the sensitivity of the 3-pool model's advantage/parameterization to changes in the Litter C fractions (e.g., 5-20%), or (b) attempt to fit the initial Litter C fraction as an additional parameter in the inverse optimization (if identifiability permits).*

Following up on the previous comment, the reviewer points out an important issue regarding the modelling assumptions that we had overlooked. Again, we sincerely thank the reviewer for this comment, which led to more precise results. We evaluated the model performance across a wide range (5, 10, 15, 20, 25, 30 and 40%) of assumptions regarding the proportions of POC as Litter C, and we report the results below. Once again, we found that different assumptions resulted in different model performance and fitted parameter values (Fig. 2, Table 3 and Table 4). Our original assumption of assigning 10% of POC to the Litter C pool did not yield the best model performance. Rather, the 20% assumption produced the lowest AIC and MSE values. However, these values differed only slightly from those obtained with the 15% assumption, which resulted in AIC and MSE values that were 8.4% and 10.7% higher, respectively (Table 3). Given these similar performances, we then examined the fitted parameter values, and the 20% assumption produced an unrealistic yearly POC decomposition rate (8.06*10^-4). Therefore, and consistent with the litter-addition samples, we selected an assumption of 15% of POC as Litter C due to its biologically realistic parameter values and relatively low AIC and MSE values. We replaced the original results in the manuscript with those obtained under this assumption. We also added the sensitivity analysis method to the manuscript and provide the Tables and Figures in the Supplementary material.

Fig. 2. AIC and MSE values for control-samples models assuming different proportions of POC assigned to the Litter C pool.

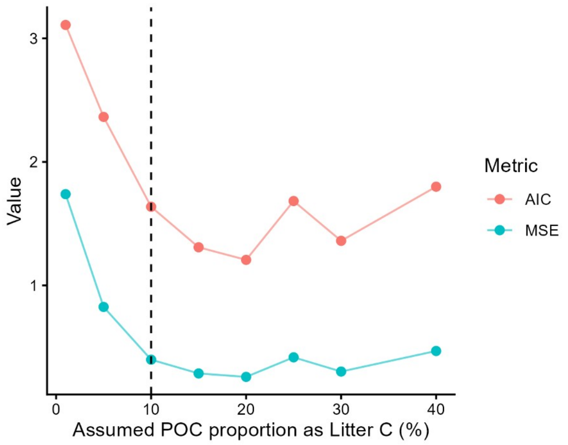


Table 3. AIC and MSE values and their relative values compared with the model showing the lowest AIC and MSE values, for control-samples models assuming different proportions of POC assigned to the Litter C pool.

| **POC as fast-cycling C assumption (%)** | AIC | **Relative AIC to best model (%)** | MSE | **Relative MSE to best model (%)** |
|---|---|---|---|---|
| 5 | 2.364 | 195.9 | 0.826 | 318.1 |
| 10 | 1.637 | 135.6 | 0.399 | 153.7 |
| 15 | 1.309 | 108.4 | 0.287 | 110.7 |
| 20 | 1.207 | 100.0 | 0.260 | 100.0 |
| 25 | 1.683 | 139.5 | 0.418 | 161.0 |
| 30 | 1.361 | 112.8 | 0.303 | 116.7 |
| 40 | 1.799 | 149.1 | 0.469 | 180.8 |

Table 4. Parameter values for control-samples models assuming different proportions of POC assigned to the Litter C pool.

| **Litter addition assumption (%)** | $\mathbf{k_1}$ | $\mathbf{k_2}$ | $\mathbf{k_3}$ | $\mathbf{a_{21}}$ | $\mathbf{a_{32}}$ | $\mathbf{a_{31}}$ |
|---|---|---|---|---|---|---|
| **5** | 13.622 | 0.05 | 0.131 | 0.101 | 0.045 | 0.105 |
| **10** | 8.152 | 0.15 | 0.086 | 0.411 | 0.134 | 0.123 |
| **15** | 5.896 | 0.070 | 0.060 | 0.257 | 0.069 | 0.195 |
| **20** | 4.701 | 8.06E-07 | 0.027 | 0.087 | 7.93E-07 | 0.078 |
| **25** | 4.165 | 2.78E-04 | 0.004 | 0.067 | 2.72E-04 | 0.209 |
| **30** | 5.170 | 0.19 | 0.023 | 1.678 | 0.137 | 0.533 |
| **40** | 5.989 | 0.06 | 0.056 | 0.194 | 0.047 | 3.728 |

**In response to:** *Section 4.1: Since the 2- and 3-pool models are fitted independently to each treatment, I'm curious whether the 3-pool parameters fitted to the litter-addition treatment would also predict the control soil dynamics (or vice versa), with only the Litter C initial condition changing. If so, that would be strong evidence that the 3-pool structure captures a real property of these soils rather than reflecting additional fitting flexibility. This may be beyond the scope of the current revision, but it could act as a useful cross validation and I encourage the authors to consider it.*

We agree that litter-addition parameters fitted to control samples data and vice versa may represent a useful cross-validation for the 3-pool model structure, providing additional evidence that the models capture intrisic propierties of these soil C dynamics. However, we believe that this is beyond the scope of the current study. These analyses would considerably increase the amount of results to present, making the presentation of our main results less tractable. Nevertheless, after the reviewer comment, we explored this possibility, and we did not find a good fitting when interchanging parameters between control and litter-addition soils, which is shown below (Fig. 3). We observed the differences mainly for the respiration fluxes. We believe that this is because a litter amendment to the soil may trigger processes that result in different C dynamics compared to soils that did not receive litter. Hence, one set of parameters do not necesarilly fit the other dataset adequately. For example, litter-addition soils yielded faster litter C decomposition rates ($k_1$, Table 2), but also a higher transference from Litter to POC and MAOC ($a_{21}$, $a_{31}$, Table 2), which resulted in poor predictions for respiration fluxes.

Fig. 3. Left panels: Control soils fitted with litter-addition parameters. Right panels: Litter-addition soils fitted with control parameters (note that the y-axis have different scales).