

Dear Edzo Veldkamp,

I have corrected the typos and edited a few sentences according to the suggestions of the reviewers.

I wanted to let you know that the comment of one of the reviewer regarding the term « fire suppression » made me realize that it did not exactly carry the meaning we intended, so I have also edited the title of the article where I replaced « centuries of fire suppression » by « centuries of cultivation ».

Best regards,

Johanne Lebrun Thauront

Point by point response : answers in blue, changes to the text in italics.

## Reviewer 1

From the commented version of the manuscript sent by the reviewer. See that file for context.

### Abstract

- with full name (first time SOC is mentioned) → **done**
- maybe "soil types" would be clearer here → **done**
- higher in this type of soil compared to what type? → **replaced higher by highest**
- better to move to the last paragraph → **done**

### Introduction

- PyC is also formed by fossil fuel combustion and, now, we also know it is formed even in the ocean (e.g. Yamashita et al. 2022 *Science Advances*), maybe worth including this even if briefly → **added « and fossil fuels »**. This is clearly a land surfaces paper so I won't include the second part.
- only the most recalcitrant part of the PyC spectrum has really long residence time (SPAC in Bird's review). It would be good to include this information somewhere in the Intro → **« the stable structure of PyC allows most of it to persist for longer in soils relative to non-PyC »**
- and to dissolved forms → **included in leaching** mentionned later in that same sentence.
- and human processes such as plowing, correct? → yes but not mentioned in the cited articles so I will leave it as is
- two more recent studies worth including: - <https://doi.org/10.1029/2023RG000829> - <https://doi.org/10.1111/gcb.17354> → **included in this paragraph**
- better to say "fire conditions" or "fire properties", burn intensity is a very specific parameter (actually probably severity would be better here → **Thank you for spotting this mistake, severity is the word used in all cited articles so I have changed all occurrences of fire or burn intensity to severity**)
- rephrase, the authors did not find PyC accumulation but was really proved that is was only due to absence of flat toeslope? → **It is a bit unclear you are right, I modified the sentence as follows « but the absence of a flat toeslope (convex toposequence) may have prevented the accumulation of PyC near the stream 62 years after deforestation »**.
- please name those two methods → **done**

### Discussion

#### Section 4.1

- rephrase to, for example, "lack of fire", (fire suppression usually refers to extinguishing of fires by humans). → **I have seen the term used to encompass both extinguishing and reduction of fire (frequency, or burn area or other metric) by preventive measures and change of land-use to one that is less fire prone, e.g. in Jones et al. 2022 *Reviews of Geophysics* : « In the modern day, BA is comparable to the estimated annual BA for western US forests during the early twentieth century (Littell et al., 2009), highlighting the extent to which humans have suppressed fire in the region during the mid-to-late twentieth century through wildland firefighting and land conversion to agriculture (see Section 5). » (p.22). However you are right that this is not exactly what we meant here, as we cannot prove that fire frequency decreased with the conversion to continuous cropping, although fire is nonexistent in these croplands today. What we can assume is that persistent PyC inputs of the kind we measure by CTO and HyPy were reduced, even if practices such as stubble burning may have been practised, because of low fire temperatures (< 350°C) and limited amount of biomass burnt. I have made this explicit in the study site description : « Unintentional fires are virtually nonexistent in European croplands under temperate, oceanic climate**

(Forrest2024). Agricultural practices such as spreading of plant ashes (Antoine2000) or on-site stubble burning (banned from most of Western Europe in the 1980's) could have contributed relatively labile (low temperature) PyC to croplands (see also Appendix A2). » and in the discussion « The transition to continuous cropping may not have completely suppressed fire from the landscape, as stubble burning was practised in Western Europe, but we assumed that ensuing PyC inputs were either small (between 25 and 50% of cereal crop biomass is harvested and crop residues have many other uses besides burning, Smil1999), or/and of more labile nature due to low (<350°C) fire temperatures (Rasmussen1986). », and replaced all occurrences of « fire suppression » by « cultivation » or « cropping », including in the title of the article.

- it can also be due to the original physicochemical composition of the PyC produced in the different systems → *yes true, I have changed the sentence to « [...] different PyC mineralization rates (related to soil temperature and PyC quality) »*
- only correct if the other examples in Lines 373-375 did not have recent inputs of PyC either → *Not if we are talking of net losses, reduced inputs are one of the reason for soil organic carbon losses in croplands globally.*
- depths for those stocks? → *In the cited articles sampling was carried by horizon, not by depth, so the averaged stocks are given for the mineral soil down to the limit between the B and C horizon, which can be at a variable depth, I can't be more precise than this.*
- but these rates were calculated by contexts different to the current study one... how comparable really are to the expected here? maybe rephrase to make clear these rates are not necessarily those expected in this study → *this is already mentioned a few lines below : « Alternatively, the elevated rates measured in previous studies may apply only to soils with high porosity (Leifeld et al., 2007), coarse texture (Schiedung et al., 2020) and/or where annual rainfall is important (Alexis et al., 2012; Major et al., 2010; Nguyen et al., 2009), conditions that are not met in our study area »*
- and tilling? → *yes, as discussed in section 4.1, and tree windthrow too : « Soil mixing processes (bioturbation, peloturbation, cryoturbation and that induced by windthrow and agricultural practices) [...] ».*
- rephrase we "Thus, we argue that...." or similar (it is plausible but not a 100% sure statement) → *you are right, I have rephrased as suggested*
- HyPy is >7 (not sure why here it is stated 7-14) → *this comes from Wurster et al. 2013 <https://doi.org/10.1016/j.orggeochem.2013.06.009>, building on the work of Meredith et al. 2012, both cited in the method section when explaining HyPy.*
- rephrase, molecules with 7 rings or more are not soluble: <https://www.frontiersin.org/journals/earth-science/articles/10.3389/feart.2017.00075/full> → *several molecules with 7 and 8 rings are listed as « moderately soluble » in this article, and the authors further explain that some PyC may not be soluble per se but still found in the dissolved fraction, for reasons yet to elucidate. So I think solubilization is a possible explanation to our observations, although the molecules may not be intrinsically soluble, and I have changed the sentence accordingly.*

## Reviewer 2

The authors have done a thorough job of responding to my previous comments. I am fully satisfied that it is ready for publication, pending response to the following very minor comments (line numbers and sections refer to the revised manuscript without track changes).

Sentence starting line 139 – edit this sentence for grammar/clarity

« Heath and secondary growth woodland dominated the landscape until the end of the 19th century, when cropland became the predominant land-use. » changed to « The transition from a landscape

dominated by heath and secondary growth woodland to one where cropland are predominant occurred towards the end of the 19th century. »

Line 190 – is this sentence unfinished?

It wasn't per se but I've added one more information so it is more complete. « CEC was determined based on the exchange of cobaltihexamine ions at soil pH. 50 mL of cobaltihexamine solution at 50  $\text{mmol}^+ \text{L}^{-1}$  was mixed with 2.5 g of soil. The concentration of cobaltihexamine remaining in solution after exchange was measured by spectrophotometry at 475 nm and CEC was calculated by difference with the initial concentration. »

Section 2.3.4 – I suggest adding references to methods here: Tamm method and Mehra-Jackson.

Done. Tamm : « described in Courchesne and Turmel, 2008 », Mehra-Jackson : « Mehra and Jackson 1960 »

Line 223 – Change weighted to weighed.

Done

Figure 7 caption – PyC vertical transport could also be slower due to its lower solubility than many non-pyrolytic carbon.

Indeed, I agree with you, this is what we discuss in the text but the figure only illustrates our preferred hypothesis, that of greater biochemical stability of PyC. I have made that clear in the caption : « Figure 7. Conceptual, 1D model of PyC and non-PyC persistence in soils *based on differences in biological and chemical stability* .»