

Response to Reviewer 2

We thank the reviewer for their positive review of the paper and for their specific comments and suggestions. Our response to these points are given below in blue and changes to the text are given in red.

General

Sweeney et al. present a new, simplified approach for deriving tree cover estimates from fossil pollen compositional data. The authors apply this approach to selected pollen records in Europe to reconstruct tree cover changes throughout the Holocene. They compare their results to similar previous studies that used different approaches, and discuss the new approach, recommending it for application in future studies in other regions or on a global scale. The manuscript is well written, and, especially important for a study focused on presenting such a new modeling approach, outlines the methods very clearly and understandably. With its interesting approach to understanding tree cover changes through time and a discussion-based nature, it fits within the scope of Biogeosciences. I would suggest the acceptance of this study after minor revisions, related mostly to the structure of the manuscript.

Specific comments

R1: “Forest cover” and “tree cover” from my point of view may not always refer to the same aspect. In the title, forest cover is mentioned, but throughout the manuscript the focus lies rather on tree cover. I suggest sticking to only one of these terms and including a brief definition in the introduction or methods section.

We agree that the two terms are not synonymous, and we will change the text to tree cover throughout (including in the title). We will explain that tree cover could reflect forest expansion but also growth of woodlands and more isolated trees in vegetation mosaics or in urban settings in the first paragraph, as follows:

<Line 35>. Tree cover in Europe has been expanding in recent decades (FAO, 2020; Turubanova et al., 2023), with potential implications for land-atmosphere energy exchanges, water and carbon cycles, and ultimately local and global climates (Bonan, 2008; Alkama and Cescatti, 2016). Changes in tree cover may reflect forest or woodland expansion, or the presence of trees in vegetation mosaics and urban settings. Tree cover both affects and is affected by the environment (Moyes et al., 2015; Abis and Brovkin, 2017) and this two-way relationship leads to complex interactions between both.

R2: While reading the results section, I was sometimes wondering if I had unknowingly entered the discussion (e.g., in L345 onwards) – I think in this case it may be acceptable to have some level of discussion within the results section in this style of manuscript, since it relies heavily on comparisons

to previous, similar studies. However, maybe the writing style could be adapted to better differentiate the two sections.

In the results section, we were trying to explain what the differences are and where these might come from. However, these are also issues that are covered in the Discussion and should, perhaps, be more appropriately dealt with there. We will remove the more discussion-oriented parts of the text from the Results section and simply focus on pointing out the differences. Specifically, we will remove the following speculation from the Discussion:

<Line 349>. This probably reflects differences in data coverage between Serge et al. (2023) and the other two reconstructions.

R3: The supplement to this manuscript provides very relevant information, especially if a reproduction of the approach is wished, and seems well-organized. However, I would suggest the inclusion of some of the spatially plotted model results also in the main manuscript. Some patterns across Europe are described in the results and discussion sections, and having some of the time-slice plots close by would be very helpful (e.g., one each from the early, mid, and late Holocene, referring to the full range of plots in the supplement, or what may fit best to your discussion).

We will add a figure showing the time slice plots for 11,000, 9,000, 6,000 and 2,000 yr BP in the main text and reference these in line 298, as follows:

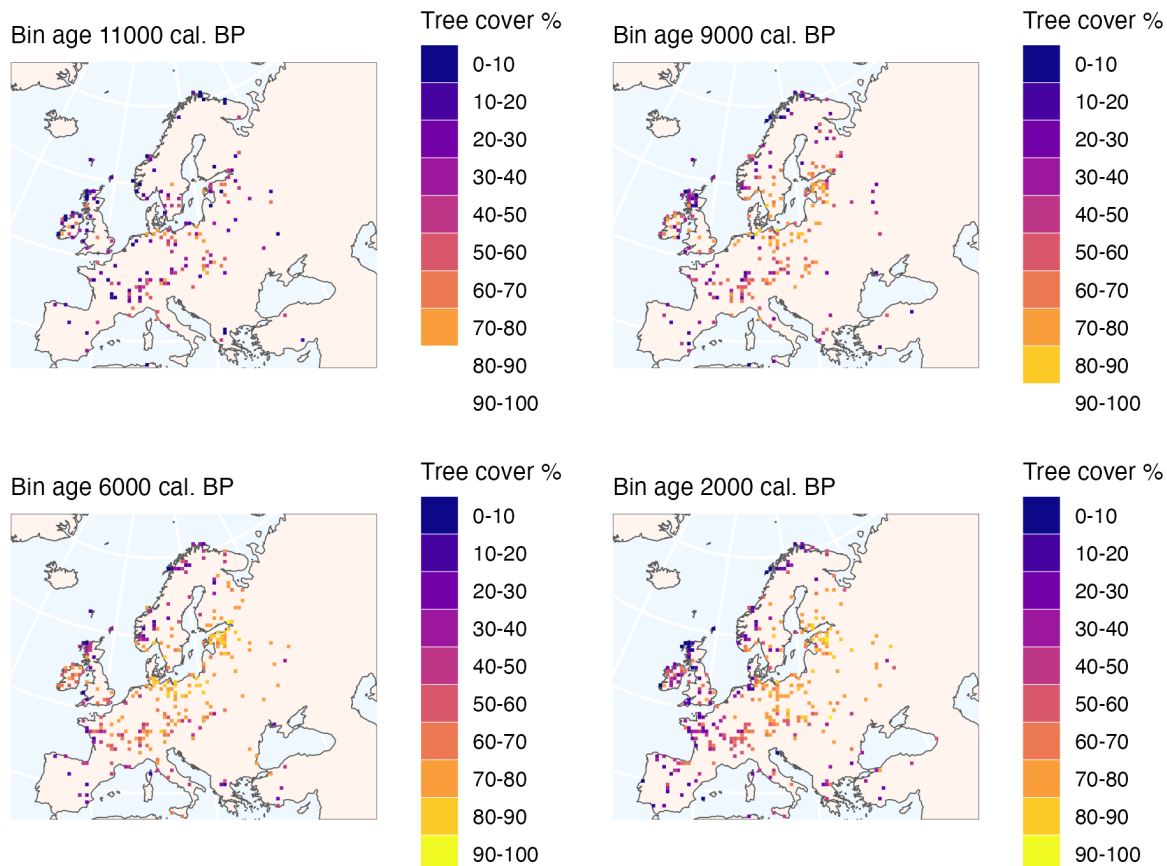


Figure 6: Gridded maps of average reconstructed tree cover for selected periods, for 50km² grid cells. Bin ages are 200-years in width, with ages referring to mid-point of each bin.

Technical comments

- L16: Not sure if “Earth System” needs to be written in capitals
No, this does not need to be capitalised here. We will correct this.

- L29: Re-phrase this section as it is a bit repetitive (“[...] our approach [...] provides a better approach [...]”)

We will rewrite this section as:

<Line 29>. The reconstructed patterns of change in tree cover are similar to those shown by previous reconstructions, but our approach is more robust and does not require RPPs and therefore provides a useful way to reconstruct tree cover in regions where data limitations preclude the use of alternative methods.

- L45: This may be purely subjective, but I’d suggest to use long-dashes when writing ranges
We will correct this throughout.

- L50: When saying that something is commonly done, I expected to find some references at the end of the statement

This is really a ubiquitous approach in non-statistical papers, and a similar unreferenced statement is made by Zanon et al. However, we can add some examples here. Specifically, we will cite:

Adam, M., Weitzel, N., and Rehfeld, K.: Identifying Global-Scale Patterns of Vegetation Change During the Last Deglaciation From Paleoclimate Networks, *Paleoceanogr Paleoclimatol*, 36, <https://doi.org/10.1029/2021PA004265>, 2021.

Hicks, S.: The use of annual arboreal pollen deposition values for delimiting tree-lines in the landscape and exploring models of pollen dispersal, *Rev Palaeobot Palynol*, 117, 1–29, [https://doi.org/10.1016/S0034-6667\(01\)00074-4](https://doi.org/10.1016/S0034-6667(01)00074-4), 2001.

Kaplan, J. O., Pfeiffer, M., Kolen, J. C. A., and Davis, B. A. S.: Large Scale Anthropogenic Reduction of Forest Cover in Last Glacial Maximum Europe, *PLoS One*, 11, e0166726, <https://doi.org/10.1371/journal.pone.0166726>, 2016.

- L70: Re-phrase to make clear that n=46 is the total amount of taxa and not the additional amount of taxa

We will rephrase this as:

<Line 70>.... is based on 1607 records and tested the impact of including 15 additional taxa (total n=46) on the vegetation reconstructions.

- L91: Suggest to standardize across the manuscript the way such lists are written using comma and only a single final “and” (e.g., “[...] data on tree cover, harmonized age models, and improved information [...]”; similar cases e.g. in L181, L223)

We will check and ensure that the lists are presented in a standardised way

- L126: Standardize the use of spaces before writing units across the manuscript (e.g., different way can be found in L219 – personally, I prefer the use of spaces)

We will check and ensure that the units are presented in a standardised way

- Figure 2A: Suggest to add either “%” next to the legend, or otherwise state in the caption that it depicts relative data

We will redraw the figure to make sure that it is clear that the legend refers to % cover, as follows:

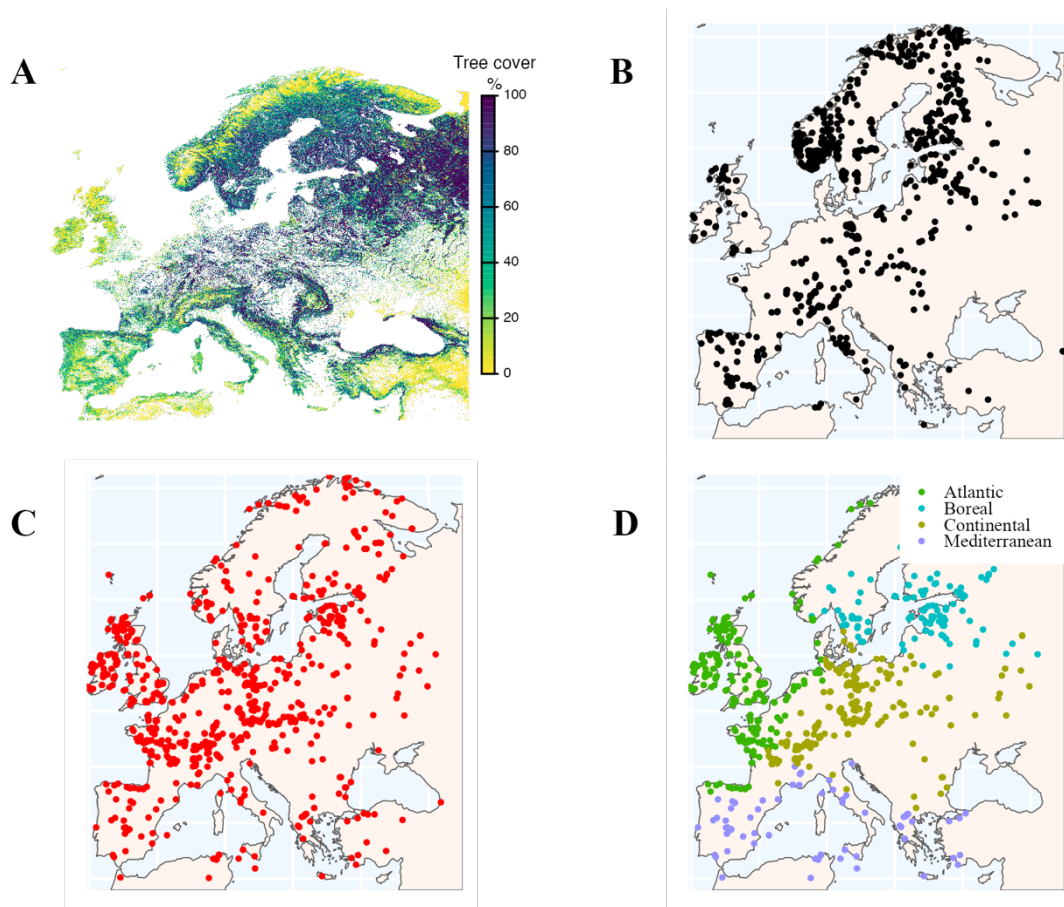


Figure 2: A - Observed tree cover based on compositing annual tree cover maps from the Copernicus land cover data sets (2015-2019) and screening out cells where the dominant land cover was not natural; B - Modern pollen records used for model fitting; C - Fossil pollen sites used for tree cover reconstructions; D - Classification of the fossil pollen sites into climatic sub-regions

- L198: I was not sure who “they indicate” was – is that information from the cited study, or personal communication with the authors?

This statement is in the Serge et al paper. We will clarify this as follows:

<Line 198>. We make comparisons to the Serge et al. (2023) reconstructions based on the 31 taxa originally used by Githumbi et al. (2022) since Serge et al. (2023) show that this produces better results than using the expanded data set of 46 taxa.

- L266: Dot missing in reference

We will correct this.

- L288: Comma or other separator missing in the R package citation

We will correct this.

- L324: Suggest to change “somewhat” to “slightly” and maybe separate this into two sentences

Thank you for this suggestion. We will rewrite as follows:

<Line 324>. Our reconstructed maximum cover is slightly lower (ca. 5-10%) than shown by the other reconstructions. However, the mid-Holocene timing of this maximum is broadly consistent across all of the reconstructions (although Zanon et al. (2018) show a double peak in tree cover, with an earlier peak at ca. 9,000 cal. BP) within the limitations of the age models and binning intervals used (see Supplementary Information: S10 and S11).

- L437: I think there's an “as” missing in “such how”

Yes, we will add this