

Congratulations to the authors for the extensive revision of their manuscript. It now reads more succinctly and coherently.

Thank you, Simon! We have rewritten LDT sections 1.3, 3.3., 4.2 and Conclusions; added sentences about taphonomy and re-checked the English.

The revised Introduction sets up the main arguments much more effectively. There are a few remaining issues that can be easily resolved:

1. The conclusion that, since fossil PARs and trap PARs show the same range of values, “indicates that there are no major biases hampering the application of the PMP Database data as a modern reference to interpret the fossil record” [p. 24, line 15]. This conclusion may be overly simplistic, given the limitations listed in section 4.4. I think a more useful conclusion would be for the authors to indicate what further research is required in order to make the link between fossil and trap PARs, or what considerations are needed in making such links. Otherwise we could find researchers erroneously linking their fossil PARs from large lakes to pollen traps that have completely different source areas and taphonomic processes. There is no doubt the trap PARs are very useful, but they must be used with care!

First paragraph of conclusions:

Comparison of the mean annual PAR from traps and fossil sites showed similar ranges for the common European trees at the continental scale. Fossil PAR values can be linked to modern analogues in Europe, opening up possibilities for using fossil PARs to inform on past changes in plant biomass and primary productivity. However, careful selection of fossil sites is necessary to avoid biases of absolute pollen deposition in the fossil record, which may be caused by lake internal processes such as focusing or the addition of pollen from the catchment or bank erosion.

2. There remains confusion about the reported thresholds for long-distance-transported pollen (LDT). The abstract reports 30 grains/cm<sup>2</sup>/yr, the conclusion reports < 80 grains/cm<sup>2</sup>/yr, but in the main text and figures there are different values for different taxa. Why not provide taxon-specific thresholds, which will be much more reliable? While 80 grains is probably okay for Fagus, it is clearly inappropriate for Tilia, which is insect-pollinated and a poor pollen disperser. Application of the 80-grains threshold could lead researchers to mistakenly infer absence of Tilia, when in fact it was present.

We provide species specific threshold in conclusions:

The following thresholds of PAR for were obtained for a distance of 200 km from a distribution limit: Quercus (50), Carpinus (39), Fraxinus (20), Corylus (15), Tilia (5) and Picea (0.3). The obtained threshold of 80 grains cm<sup>-2</sup> y<sup>-1</sup> for Fagus is likely too high.

, however, in abstract we included more general sentence:

The threshold of this long distance transport for individual species is generally below 60 grains cm<sup>-2</sup> y<sup>-1</sup>.

3. The same applies to the reporting “Regional forest cover >80% is indicated by >3200 tree pollen grains  $\text{cm}^{-2} \text{y}^{-1}$ ” – this value is obtained from the minimum trap values, not from the average, so it is unclear how it could be applied in the fossil context

OK, we describe the relationship followingly:

“In treeless vegetation PAR values of at least 140 grains  $\text{cm}^{-2} \text{year}^{-1}$  are found and with each 10% of forest cover tree PAR increases by 400 grains  $\text{cm}^{-2} \text{year}^{-1}$  at least.”

and in conclusions we add:

“Minimum PAR values rise with increasing forest cover within 10 km of the trap, while the maximum values are determined by local site conditions. Fossil PAR data may therefore be of limited use when aiming to reconstruct regional forest cover. At least 140 grains  $\text{cm}^{-2} \text{year}^{-1}$  of tree pollen may be found in treeless vegetation and with each 10% of forest cover tree PAR increases by at least by 400 grains  $\text{cm}^{-2} \text{year}^{-1}$ . “

4. Figures 6-13 (plus figures in the Supplement) show “Crossed squares indicate that pollen of the taxon was not found in any trap from the area”, yet many of these crossed traps actually seem to have pollen in them, as shown from coloured symbols in the 1-dimensional clustering. How is this possible?

corrected to: “Crossed squares indicate that pollen of the taxon was absent from at least in one trap from the area.”

Specific comments by page:line

[Title] Change semicolon (;) to a colon (:) or hyphen (-)

Changed to hyphen

[2:7-8] “grains grains” -> grains

done

[2:9] Mention which taxa this 30-grains threshold applies to, otherwise we could find this threshold being applied incorrectly. The Results section now includes taxon-specific thresholds (mostly 80 grains, section 3.3 p. 12), which are more useful than a blanket value.

Pollen traps situated beyond 200 km of the distribution of a given tree species still collect occasional pollen grains of that species. The threshold of this long distance transport for individual species is generally below 60 grains  $\text{cm}^{-2} \text{y}^{-1}$ .

[2:11] This sentence is hard to understand without a fuller explanation. Do you mean something like “For temperate taxa, modern analogues for fossil PARs are generally found downslope or southward of the fossil sites”?

changed

[2:13] “data is... aids” -> data are... aid

done

[2:19] “became the widely” -> has become the most widely

done

[3:23] “Europe” -> European

done

[3:28] the number 3) is missing here

done

[4:1] consider deleting “in addition to determining biomass” as this makes this question confusing

deleted

[4:9] “productivity than” -> productivity, then [note spelling]

done

[4:12] This section is very brief and would benefit from additional justification. Perhaps consult Froyd 2005 <https://doi.org/10.1890/04-0546> and literature therein for a discussion of rational limits and the limitations of traditional palynological methods in detecting tree migration.

expanded to:

Identification of the local presence of taxa in the past by comparison of different proxies, produces ambiguous results. Some studies show that the rise of PAR is able to mirror the first occurrence of a macrofossil [e.g. @giesecke2005holocene], others show an increase in PAR and percentage values thousands years after the first appearance of stomata [@froyd2005; @parshall documenting 1999]. So, the modern comparisons of PAR thresholds and recent vegetation are needed.

[4:19] consider “analogues” instead of “analogies”

done

[4:21] “environmental conditions assemblages” -> environmental conditions

done

[4:24] add a comma after “obtained”

added

[5:17] should “regional forest cover” be “regional biomass” to fit with section 1.2?

done

[6:16] Lagodekhi is misspelled here

done

[10:6] “in the Holocene perspective” -> from a Holocene perspective

done

[12:17] “a 3% wide bins of the forest” -> in 3% wide bins of forest

done

[the wording in this sentence is very unclear and it may help to rewrite it in simpler terms, perhaps 2 sentences; it's also unclear why 80% forest cover is important here – can you explain why this value is presented rather than 0% and 100%, which might be more useful?]

The traps with the lowest PAR per each 3%-wide bin of forest cover provide a regression model. The relationship predicts a PAR of at least 140 grains cm<sup>-2</sup> year<sup>-1</sup> in a treeless vegetation. With each 10% of forest cover within 10 km of the trap, tree PAR increases at least by 400 grains cm<sup>-2</sup> year<sup>-1</sup>.

[12:20] “distribution limit” -> distribution limits

done

[12:26] “that one trap” -> that only one trap

done

[12:31] “in average” -> on average

done

[14:5] “> 0.05” = non-significant; do you mean < 0.05 (i.e. significant)?

yes, I mean > 0.05 = non-significant and < 0.05 is significant. However, the null hypothesis of the t-test is that the mean of trap PAR and the mean of fossil PAR are equal, since the p-value is > 0.05, we can not reject the null hypothesis (means are equal or similar).

[14:17] “only analogous trap area with PAR for fossil sites” -> only trap area analogous to fossil sites

done

[16:Fig. 6 caption] “Mean modern PAR averaged” -> Mean modern PAR for selected tree taxa averaged;

done

“falling within the pollen taxa” -> falling within the pollen trapping area [?]

changed to “from the pollen taxa”

[16:5] replace comma with semicolon

done

[20:3-5] I suggest separating this into 2 sentences – one about using PARs to interpret fossil signals and another detailing the taphonomic differences.

done

The authors' implied claim that taphonomy is not important in this comparison needs additional justification.

Justification added: Processes involving differences in the efficiency of capture and deposition of pollen on a surface are important explaining local variability, while the added uncertainty is generally smaller than the overall signal. On the other hand lake internal processes like focusing, bank erosion

or riverine pollen input may alter the fossil signal substantially and here careful site selection and site specific interpretation are needed to allow comparisons [Giesecke2008].

[20:15] CO<sub>2</sub> is one factor, but temperature changes have also been shown to have an influence on pollen production (e.g. see this example from Switzerland: <https://doi.org/10.1007/s00484-008-0159-2>). Perhaps this could be incorporated?

An increase in primary productivity and pollen production has been shown in a carbon dioxide fertilization experiment [Wayne2002] and in an increase of the temperature due to global warming [Frei2008]. Both factors support the interpretation that average PAR of the same species may vary due to environmental parameters determining its productivity.

[20:16] remove “its”

done

[21:4] “arctic-apline” -> arctic-alpine

done

[21:5] “greater distances” – do you mean greater than in Seppä & Hicks 2006? It would help the reader to follow your reasoning if you provided the distances.

substituted by: “larger spatial scale and less precise vegetation data”

[21:12] “Corylus has a lighter pollen grain than Fagus, which can travel more easily over large distances” – this sentence means that Fagus pollen travels further than Corylus, but I don’t think that is the intended meaning. Perhaps “Corylus has a lighter pollen grain than Fagus that can travel more easily over large distances” or “Corylus pollen is lighter than Fagus pollen and able to travel greater distances”

changed to: “Corylus pollen is lighter than Fagus pollen and able to travel greater distances (Table S5).” Additionally we removed the comparison with the characteristic radius.

[21:13] “LDT for Picea results too low and Fagus too high” – unclear sentence. Is there a verb? This seems an important observation but lacks justification. Please elaborate.

rewritten

[21:17] “in average” -> on average [x 2]

done

[21:18] “by too leptokurtic” -> by the overly leptokurtic

done

[21:19] “that it underestimates dispersal of pollen with a large grain” -> that the model underestimates dispersal of large pollen grains

done

[21:21] “with the” -> with

done

[21:22] “the actual growth density” – do you mean “biomass”?

done

[21:22] “because of the worse climatic” -> because of unsuitable climatic

done

[23:4-5] “...individual sites. Unfortunately, the details cannot be discussed here. However...” – this structure is very jumpy. Why not simply say “...individual sites. For instance...”

done

[23:14] delete “Nevertheless” here

done

[23:17-19] avoid successive sentences starting with “Also... Nevertheless... Despite...” – this indicates poor structure.

removed

[23:25] delete “respectively” [not needed here];

done

the comment that the fossil PARs and trap PARs are have the same range of values seems lost here – what are the authors trying to say? Should we expect similar values when the taphonomic processes are different?

Taphonomic explanation added, see above.

[23:31ff] this paragraph repeats information from the Methods section and could be removed.

removed, information about the reduced PAR moved to Methods.

[24:7] “meters” -> metres [to conform with UK spelling used throughout the manuscript]

done

[24:14-16] “PAR from traps and fossil sites showed similar ranges for Abies, Alnus, Betula, Carpinus, Corylus, Fagus, Fraxinus, Picea, Pinus, Quercus and Tilia at the continental scale. This indicates that there are no major biases hampering the application of the PMP Database data as a modern reference to interpret the fossil record” – this assumes that pollen production has not changed through time, that the taphonomy of traps and lakes/wetlands is the same, that the vegetation mosaic is the same now as it was in the past, and that all the PAR measurements are accurate. Section 4.4 indicates that these assumptions are not met. What about a different conclusion, e.g. that fossil PAR values can be linked to modern analogues in Europe, opening up possibilities for using fossil PARs to reconstruct past plant biomass and primary productivity?

To sect 4.4 we added: lake internal processes often lead to PAR values exceeding modern ranges. Such biased fossil PAR estimates can in turn be used to elucidate the sedimentation history.

Conclusions substantially rewritten.

[24:18-19] “Minimum values suggest that an 80% forest cover within 10 km of the trap results in PAR above 3200 tree pollen grains cm<sup>-2</sup> year<sup>-1</sup>.” – as mentioned earlier [12:17] reporting these values seems strange, especially as a major conclusion of the paper – how can they be applied when they derive from the minimum PAR, which would not be known in the fossil context?

Conclusions:

„Fossil PAR data may therefore be of limited use when aiming to reconstruct regional forest cover. At least 140 grains cm<sup>-2</sup> year<sup>-1</sup> of tree pollen may be found in treeless vegetation and with each 10% of forest cover tree PAR increases by at least by 400 grains cm<sup>-2</sup> year<sup>-1</sup>.“

[24:20] the threshold here is different from the one in the Abstract

In treeless vegetation PAR values of at least 140 grains cm<sup>-2</sup> year<sup>-1</sup> are found and with each 10% of forest cover tree PAR increases by 400 grains cm<sup>-2</sup> year<sup>-1</sup> at least.

[Supplement] since page numbers are not a limitation in the supplement, why not arrange the text in the section “Taxa specific linkage of the highest average PAR at fossil sites [\*sites?] with individual trap values” so that each figure is accompanied by the relevant text? For example, the Carpinus plot could appear on the same page as the Carpinus text.

Thank you for the idea, that was original intention.