This paper represents a methodological step towards quantitatively reconstructing past vegetation in the Iberian Peninsula based on pollen records. For the first time, relative pollen productivity (RPP) estimates are presented for 21 taxa. Modern pollen samples and vegetation data were used, drawing on several existing databases. Candidate RPPs were applied to compute REVEALS estimates of vegetation cover, which were then compared with observed vegetation. A loss function was used to identify the best-fitting RPPs by calculating the distance between modelled and observed vegetation. RPPs of eight arboreal taxa were validated in 26 present-day core tops across Iberia and compared with findings from other European studies.

The results show that Pinus and both evergreen and deciduous Quercus are high pollen producers, while temperate forest species (Betula, Corylus and Fagus) and herbaceous species produce medium to low amounts of pollen. Further research is needed, as previous reconstructions may have overestimated the presence of pine and oak, suggesting a more mosaic-like pattern of woodland and open landscapes.

General comments

I have read this manuscript as a non-specialist in quantitative reconstruction of past vegetation (e.g. REVEALS), but as a palaeoecologist with a broad interest in palaeoenvironment. I have tried to understand the main reasoning behind the methods applied to reconstruct past vegetation cover in Iberia and to quantify the relationships between fossil pollen assemblages and the vegetation that produced them.

The manuscript represents a substantial contribution to scientific progress within the scope of Biogeosciences. The approach and methods are valid (as far as I can judge) and the results are discussed in a proper and balanced way. I particularly appreciate the sub-chapter “Approach limitations” at the end of the Discussion section, as it critically evaluates both the methodology and the results.

The conclusions are substantial and clearly address the research objectives outlined in the introduction.

The manuscript is well structured and well written. It is rather long, but I believe all information is necessary. Figures/tables are appropriate and necessary.

Regarding the supplementary material, I have the impression that references in the main text to supplementary figures, tables and text are not made in a consistent or straightforward way. I think a considerable number of references are missing. The question is if all supplementary material is necessary.

Below, I provide some suggestions for the authors.

- *We are pleased that you found the article interesting. We are honoured by the recognition made on the substantial contribution that this manuscript represents. We would also like to thank you for your comments, we believe they have helped us to explain the content of the article more clearly, whilst also helping us to improve the phrasing and correct any spelling mistakes.*

  Ahead you will find our answers to your questions and concerns. We are referring to the lines of the manuscript with marked changes.

Key words

RPPs and PPEs. Are these both important/necessary? See also my comment for Lines 95-99.

- *Thank you for the question. We answered this together with your comment below for Lines 95-99.*

Vegetation cover instead of land cover?

- *The changes have now been implemented.*

Palaeoecology. Delete? This paper is not really about palaeoecology.

- *The changes have now been implemented.*

Maybe add palynology or pollen analysis to the key words.

- *The changes have now been implemented.*

Add Iberia?

- *The changes have now been implemented.*

Introduction

Line 56-57: Likewise, land cover reconstructions are crucial elements for answering various ecological questions and changes in land use. Rephrase: Land cover reconstructions are crucial for changes in land use? ...are crucial to reconstruct changes in land use? Something is wrong with this sentence.

- *The changes have now been implemented.*

Line 63 - ...traditional view of densely forested wilderness... add some references here?!

- *The changes have now been implemented*

Line 62-70: I am not sure if this discussion is relevant for the present study. Further in the text little is mentioned about this long-standing debate. Or it could be better linked to the study area. In conclusions the following is stated: Finally, these findings suggest that previous reconstructions of past vegetation dynamics in the Iberian Peninsula may have overestimated the presence of pines and oaks, and therefore fossil records from the Southwestern Mediterranean may require reinterpretation… could indicate a more mosaic-like pattern of broadleaf woodlands, conifers, temperate forests and open ecosystems, aligning with most recent findings. However, no information on previous pollen-vegetation reconstructions in Iberia is mentioned in the text.

- *Your concern about the initial discussion in the introduction section is legit, given that the current manuscript is not about palaeoecology, as you mentioned, and therefore we are not changing interpretations from previous reconstructions. Nevertheless, we believe that such initial statements address key perspectives for this manuscript audience of this paper, namely: 1) which new aspects are we indeed introducing, filling regional gaps, 2) why is it important and 3) what is the purpose of it? Furthermore, it announces what would be the next step (i.e. quantitative pollen-based reconstructions).*

  Regarding pollen-vegetation references in Iberia, these have been mentioned along with charcoal and macrofossil references in the Discussion section (Line 728 and on). Generally, pollen reconstruction studies in Iberia are mentioned throughout the manuscript

Line 82: change proxies into proxy records.

- *The changes have now been implemented.*

Lines 95-99: PPE and RPP are these the same? If not explain more clearly. I think it is better to use only RPPs as it is less confusing. In most of the text RPPs is used.

- *Yes, they refer to the same concept. Although PPEs have historically been the standard terminology, the use of RPPs is now preferred, as it more accurately reflects the relative nature of these measures. This is the reason why we included both acronyms in the keywords, so that the paper can address both queries.*

Line 102: RPP is already introduced in line 96. So move "(hereafter referred to as RPPs)" to line 96.

- *The changes have now been implemented.*

Lines 102 – 103. Both pollen productivity estimates (PPEs) as relative pollen productivity (RPPs) are mentioned here while in most of the text RPPs is used. It is confusing to me so leave PPEs out, if it is not necessary.

- *The changes have now been implemented.*

Caption Fig. 1: “green diamonds” instead of “green squares”?

- *The changes have now been implemented.*

Lines 148-157: in the description of the climate, the authors refer to several regions (landscapes) such as plateau regions, mountainous areas, coastal etc. For a reader not familiar with Spanish geography it might be useful to add a map where these regions are located, to make the connection with Fig. 2. Also show the delimitation of the Mediterranean bioclimatic region and Eurosiberian region.

- *We believe that adding such a map, although it is a great idea for readers not familiar with the Iberian Peninsula, could result in a complex visualisation. Instead, we simplify the description by adding “Southern Spain” in Line 159. Interior plateaus and mountainous regions can be inferred by the description of the temperatures and rainfall, as well as the coastal regions.*

  Figures 1 and 2 include now the delimitation between the Mediterranean and the Eurosiberian region.

Line 183: also, here a map would be useful! Add all geographical names used in the text on the map!

- *We have removed local toponyms in order to be easily understood (Line 192).*

Caption Fig. 2: change squares to diamonds?

- *The changes have now been implemented.*

Line 202: add bioclimatic in the sub-title as in a).

- *The changes have now been implemented.*

Line 247: (Theuerkauf and Couwenberg, 2022) change to Theuerkauf and Couwenberg (2022)?

- *The changes have now been implemented.*

Line 283: change “Our methodological approach” into Methodological approach…

- *The changes have now been implemented.*

Line 284: “relative to Poaceae”. Why Poaceae? Please explain.

- *Poaceae has been used historically as a reference since early studies. The main reason is that Poaceae is widespread and abundant, which means that this taxon is common across Europe, therefore implying a relatively direct comparison across studies, which has later been proved incorrect, e.g: this paper and several others). Then, Poaceae is not extremely over or underproductive, which means that ratios are numerically stable (if using* Pinus *as reference, most of the taxa would have really low RPPs; if using an entomophilous taxon, may taxa would have huge RPPs).*

Line 347: dispersion should be dispersal?

- *The changes have now been implemented.*

Lines 345-353: It is not entirely clear to me how pollen dispersal is integrated in the methodological framework. Please elaborate.

- *Thank you for your concern about the dispersal integration in the methodological framework. Pollen dispersal is taken into account from fundamental equations of pollen modelling, which describes that pollen loading is the result of pollen productivity multiplied by the vegetation abundance and by the dispersal factor. In our work, we can select different dispersal models according to the study area, and for which we selected the LSM. Regarding your concern, we have expanded the explanation in order to be easily understood (Lines 383-392).*

Line 355: “In short, we have developed a framework that could be applied in other regions, in which we use the inverted (Theuerkauf, 2025) or reverse REVEALS approach…”. Is the methodology used here is new or taken from Theuerkauf, 2025). Please make this obvious. Also use or “inverted” or “reverse” REVEALS, not both as this is confusing.

- *Thanks for stating that. We describe the developed framework as it integrates the steps of obtaining, validating, and comparing RPPs. However, the inverted REVEALS approach was previously used in Kuneš et al (2019) and named by Theuerkauf (2025) as inverted REVEALS. We have modified this paragraph accordingly.*

Line 379-380: How were the grids defined? Do they cover more than one vegetation type? And is that a challenge?

- *The grids were randomly set by dividing continental Spain in portions of 150km2. Each grid is composed of different vegetation types. Maybe by combining Figure 2 and Supplementary Figure 2, you can have a broader picture of the type of vegetation in each grid. We initially didn't combine both figures, as doing so would have resulted in an overly complex visualisation.*

  We acknowledge that patchy vegetation represents a significant challenge, as discussed in the manuscript. Such heterogeneity can lead to the overrepresentation of dominant or continuous vegetation communities, while more fragmented or scattered stands may be underrepresented. In practice, the assumptions of homogeneous forest structure, consistent vegetation composition, and the availability of fine-scale vegetation data are seldom met in complex landscapes such as those considered here.

Line 388: "pollen productivity estimates" is used here. Do you mean PPEs or RPPs. Please be consistent.

- *The changes have now been implemented.*

Line 390: This is the first time "pollen fall speed" is mentioned. Where is this fitting in the previous part of the methods, the methodological approach used? Is it important for pollen dispersal? Please clarify.

- *Thank you for letting us know. We have introduced pollen fall speed just after introducing dispersal models (Line 395). It is an important parameter for pollen dispersal regarding Gaussian Plume models (GPMs). In fact, GPMs rely heavily on the size of the pollen grain, giving more importance to heavier pollen grains (directly related to fall speed), therefore yielding higher (unreal) relative pollen productivity estimates, which is one of the reasons why we didn't use GPM.*

Line 428: LSM, please write in full. The abbreviation occurs only twice in the text.

- *The changes have now been implemented.*

Line 435-437: Why using abbreviations here. These are not occurring anymore later in the text.

- *We have removed the abbreviations according to the suggestions made.*

Line 449: what is meant by "numerical pipeline"?

- *It's a sequential workflow designed to process numerical data. We have changed "numerical pipeline" to "numerical workflow" in order to be easily understood.*

Lines 466-467: “Poaceae was used as the reference taxon and assigned a RPP value of 1”. Shouldn’t this be mentioned earlier? Poaceae is mentioned in lines 283 – 284 but very briefly.

- *The mention of Poaceae as a reference taxon in the comparison section is to emphasise the standardisation of a reference taxon in other studies.*

Fig. 5. In the table in the figure itself it says PPE instead of RPPs.

- *We have now changed it according to the terminology used in the text.*

Fig. 5: are Artemisia and Brassicaceae shrubs? I would classify them as herbs. Maybe it is useful to have some more information on the definition of the groups in figure 5.

- *Thank you for this comment. We double checked the present genera of Brassicaceae and woody taxa are rare, and therefore we have reclassified this family as herb taxa. Nonetheless,* Artemisia *presents different woody species in the Iberian Peninsula, such as* A. arborescens, A. herba-alba *or* A. assoana, *among others. Information about the taxa used is available at Tables 1 and 2 of the Supplementary*.

Fig. 7: add more information in the caption on what the figure shows. Why using two colours and what do they show?

- *The changes have now been implemented.*

Discussion

Line 588: here the authors refer to “heterogeneous environments”. I think it would be good to introduce this earlier. I also made a comment on the 125 x 125 km grids (Lines 379-380) where this heterogenous environments might play a role?

- *We mentioned this in the last paragraph of section “Brief overview of existing methods and why they are unsuitable for our study area”*

Line 589: “disaggregated by taxa” - this is also not specifically mentioned in the methods, I think.

- *The changes have been implemented.*

Line 599: please clarify better. “Nevertheless, our hypothesis is that some herb and shrub taxa would be overrepresented if we apply REVEALS, as in Li et al. (2023) or in Marquer et al. (2020), since in Iberia these are low pollen producers,

as it happens with other trees as Betula, Corylus and Fagus." These are what? The herb and shrub taxa?

- *We are unsure whether we understood correctly, but the message is that, if we apply the REVEALS model to herb and shrub taxa, they would appear rather overrepresented, as is the case with the aforementioned trees (Betula, Corylus and Fagus). We have reformulated this sentence to:*

  "Nevertheless, we hypothesise that some herbaceous and shrub taxa may be overrepresented when applying the REVEALS model (as in Li et al., 2023; Marquer et al., 2020). This is because, in the Iberian context, these taxa are relatively low pollen producers, similar to certain tree genera such as Betula, Corylus, and Fagus." - Line 657

...as it happens with other trees as as Betula, Corylus and Fagus. Do you mean rather "as is the case" instead of as it happens?

- *We have now refined the expression according to your comment.*

Lines 606-607: refer to a specific figure/chapter in supplementary material.

- *The changes have been implemented.*

Line 630: write SE in full (standard error).

- *The changes have been implemented.*

Line 642: how can these wood and macrofossil data overestimate the presence of pine? Please clarify?

- *It has traditionally been thought that the Iberian Peninsula was covered by a vast expanse of pine woodlands, which is partly true according to pollen, charcoal and macrofossil records. What we mean is that, based on the results obtained in this study, we would now be able to quantify the actual extent of the pine cover*.

Line 780: name the temperate taxa please.

- *The changes have been implemented*

<u>Technical corrections</u>

- *The changes have been implemented*

Line 173: delete point after Arnold?!

Line 189: sparse scrub and grasses, also line 222. What is meant by scrub? Scrub only occurs in the text in the chapter 2.1 Study area. Elsewhere in the text shrubs is used. Please clarify. Scrub is also not mentioned in Fig. 2, shrublands are.

Line 276: delete hyphen

Line 673: as well as

Line 720: two main factors