Responses to review No. 1

Reviewer general comment: The authors have sufficiently answered all my questions and made the suggested changes. Thanks to the authors for their efforts. I have a few minor suggestions below. All of these line numbers correspond to the version with track changes.

Author's response: We sincerely thank the reviewer for taking the time to reread the manuscript, for the valuable comments, and for recognizing the value of our work. Below, we provide detailed, point-by-point responses to all remarks and suggestions included in the review.

Line 291: sentence suggestion: "However, REML was used to reanalyse the data in place of ML as a smoothing parameter, although it did not make an appreciable difference to the results."

Author's response: The correction proposed by the reviewer indeed improves the sentence structure, making it stylistically better and more coherent.

Actions: We have adjusted the sentence as suggested by the reviewer.

Before: However, REML was used to reanalyse the data in place of ML as a smoothing parameter, and it didn't make an appreciable difference to the results.

After: However, REML was used to reanalyse the data in place of ML as a smoothing parameter, although it did not make an appreciable difference to the results.

Line 528: Pinus sylvestris type should be italicized.

Author's response: We appreciate the reviewer's attention to this detail in the manuscript.

Actions: We have adjusted the sentence as suggested by the reviewer.

Before: […] the PrC scores and the relative contributions of deciduous trees, arboreal pollen, Pinus sylvestris type and NPPs.

After: […] the PrC scores and the relative contributions of deciduous trees, arboreal pollen, *Pinus sylvestris* type and NPPs.

Lines 535-539: Sorry to change the sentence again. Suggest saying: "Previous multi-proxy palaeoecological studies exist from the Noteć Forest; however, they were unable to…". Also, can you clarify what you mean by "provide such information?" What information were they unable to provide, specifically? I assume the admixture of other species.

Author's response: The correction proposed by the reviewer indeed improves the sentence structure, making it stylistically better and more coherent. We acknowledge that greater precision was needed in specifying the scope of the information presented.

Actions: We have adjusted the sentence as suggested by the reviewer. We have expanded the sentence to make it clearer and to eliminate any potential ambiguity.

Before*:* Previous multi-proxy palaeoecological studies exist from the Noteć Forest; however, those previous ones were unable to provide such information because the cores collected from the Rzecin peatland […]

After: Previous multi-proxy palaeoecological studies from the Noteć Forest exist; however, they were unable to provide information on the proportion of admixture tree species in the forest composition prior to the onset of planned forest management. The cores collected from the Rzecin peatland […].

Line 588: sentence suggestion: "The instability of the ecosystem witnessed after the 20th century is a consequence of…."

Author's response: We appreciate the suggestion, which improves the sentence's style and clarity.

Actions: We have adjusted the sentence as suggested by the reviewer.

Before*:* The instability of the ecosystem is a consequence of the introduction of planned forest management […]

After: The instability of the ecosystem witnessed after the 20th century is a consequence of the introduction of planned forest management […]

Lines 685-686. I believe there are some typos or maybe missing words in this sentence. Should it read, "However, we emphasize that we did not use advanced extraction methods that could potentially preserve the delicate structures of the butterfly wing remains…."?

Author's response: We appreciate the suggestion, which improves the sentence's style and clarity.

Actions: We have adjusted the sentence as suggested by the reviewer.

Before*:* However, we emphasize that we did not use advanced extraction methods the delicate structures of the butterfly wing remains […]

After: However, we emphasize that we did not use advanced extraction methods that could potentially preserve the delicate structures of the butterfly wing remains […]

Line 718: "We noted a gradual transition from a moderately rich fen to a poor fen in phase 4…"

Author's response: We thank the reviewer for their attention to the grammatical accuracy of the manuscript.

Actions: We have corrected the sentence as suggested by the reviewer.

Before: We noted a gradual transition from the moderately rich fen to the poor fen in phase 4 (ca. 1660-1960 cal. CE**)**.

After: We noted a gradual transition from a moderately rich fen to a poor fen in phase 4 (ca. 1660-1960 cal. CE).

Lines 721-722: "Bąk et al. (2024) pointed out that such changes are a result of…"

Author's response: We thank the reviewer for their attention to the stylistic accuracy of the manuscript.

Actions: We have corrected the sentence as suggested by the reviewer.

Before: Bąk et al. (2024) pointed out that such changes are characteristic as a result of forest management activities and can be caused by drainage and transformation in forest species composition.

After: Bąk et al. (2024) pointed out that such changes are a result of forest management activities and can be caused by drainage and transformation in forest species composition.

Line 727: "…documented by the complete disappearance of Cyanobacteria and algae…"

Author's response: We thank the reviewer for their attention to the stylistic accuracy of the manuscript.

Actions: We have adjusted the sentence as suggested by the reviewer.

Before: The change in trophic conditions at this time, and the concomitant change in hydrological conditions, are also documented by the completely disappearing Cyanobacteria and algae […]

After: The change in trophic conditions at this time, and the concomitant change in hydrological conditions, are also documented by the complete disappearance of Cyanobacteria and algae […]

Line 730: "…suggesting a lowering of the water table and substantial water table fluctuations…"

Author's response: We thank the reviewer for their attention to the grammatical accuracy of the manuscript.

Action: We have corrected the sentence as suggested by the reviewer.

Before: […] species that tolerate unstable hydrological conditions became dominant, suggesting the lowering of the water table and substantial water table fluctuations […]

After: […] species that tolerate unstable hydrological conditions became dominant, suggesting a lowering of the water table and substantial water table fluctuations […]

Line 743: "… in a peatland…" Which peatland are you referring to?

Author's response: We agree with the reviewer that the sentence requires greater precision.

Action: We have adjusted the sentence as suggested by the reviewer.

Before: In the period of the transition of trophic and hydrological conditions in a peatland (ca. 1925-1960 CE) […]

After: In the period of the transition of trophic and hydrological conditions in a Miały peatland (ca. 1925-1960 CE) […]

Line 761. Sphagnum should be italicized.

Author's response: We appreciate the reviewer's attention to this detail in the manuscript.

Action: We have corrected the sentence as suggested by the reviewer.

Before: […] decided to separate the developmental phase of the object they studied, which they referred to as Sphagnum bog […]

After: […] decided to separate the developmental phase of the object they studied, which they referred to as *Sphagnum* bog […]

Responses to the Editor's Comments

Reviewer general comment: Thank you for the submitted revision. Apart of minor changes suggested by one reviewer, I additionally found minor issues that should be addressed

Author's response: We thank the editor for the comments on the manuscript provided below. We agree that these issues required clarification, revision, or elaboration. We have made every effort to revise the text following the editor's expectations.

Fig. 4 - 'Charcoals' change to 'charcoal'
What are the white bands around 20cm?

Author's response: Thank you for the comment. We agree that the figure needs to be improved in this regard and that the presence of the white bands should be properly explained.

Action: We have corrected the error by changing "charcoals" to "charcoal." The white bands visible in the figure have been explained in the methodology section related to the palynological analysis — two samples (from depths 19–18 cm and 17–16 cm) were excluded from the analysis due to extremely low pollen concentration. We have updated the figure caption to include this information.

Before:

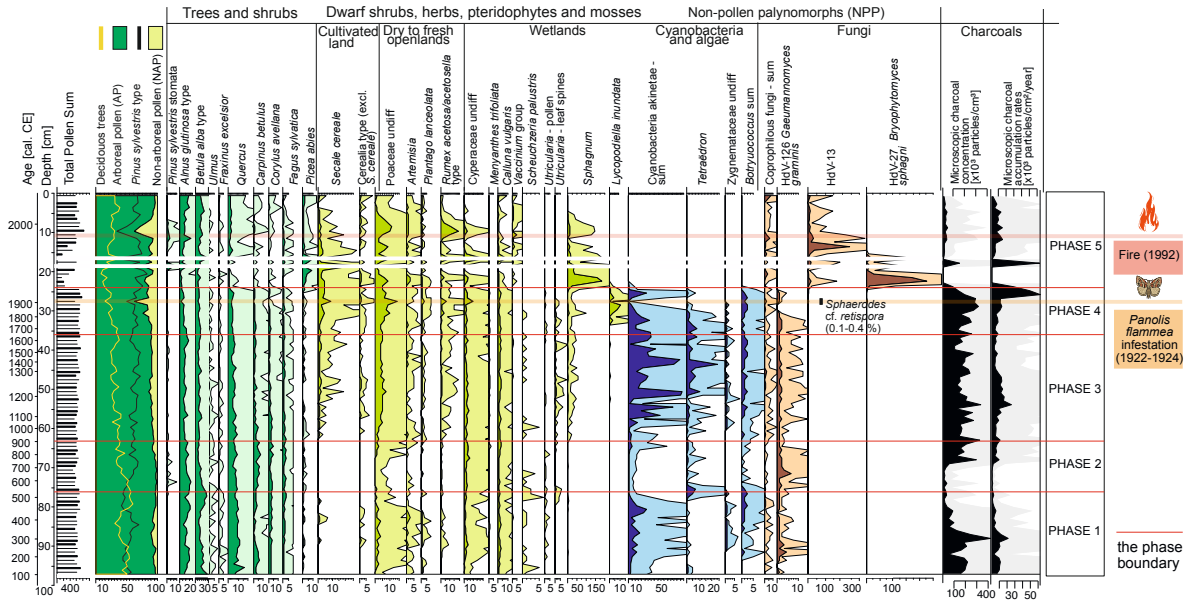

Figure 4. Pollen diagram with selected taxa presented (full list of taxa is provided in the associated open dataset). Pollen percentages are shown in black, and 10 times exaggeration is marked. Microscopic charcoal concentrations and influx as an extra-local fire proxy are also presented.

After:

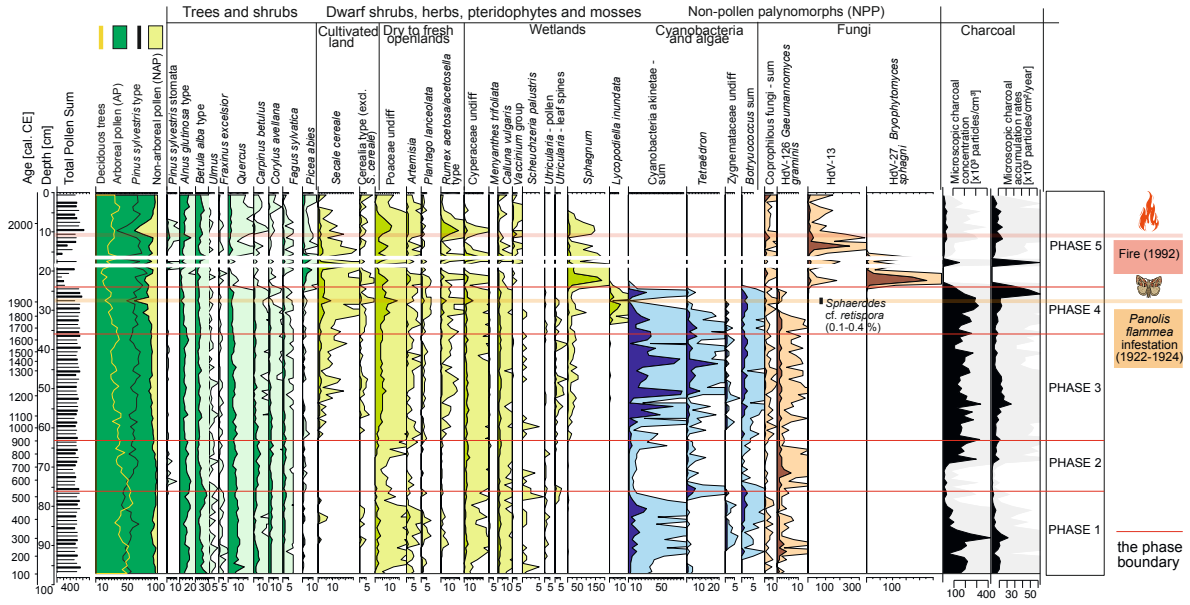

Figure 4. Pollen diagram with selected taxa presented (full list of taxa is provided in the associated open dataset). Pollen percentages are shown in black, and 10 times exaggeration is marked. Microscopic charcoal concentrations and influx as an extra-local fire proxy are also presented. Two samples (depths: 19–18 and 17–16 cm) were excluded from the diagram due to extremely low pollen concentration (no data shown for these depths).

L. 283—First, you say that palynological data were used to calculate PrC. Here, you write that NPPs also contributed to the inferred change (which I think is a wrong approach). Could you clarify?

Author's response: The term *palynological* does not exclusively refer to pollen; it encompasses all palynomorphs, including NPPs. Therefore, there is no contradiction in our use of the term here.

The reviewer does not explain why they consider our approach inappropriate, but we interpret their concern as relating to the use of proxies that reflect environmental changes at different spatial scales. While most RoC (Rate-of-Change) studies rely on a single proxy, the combination of multiple proxies, including pollen and algae, has been applied in previous research (e.g., Abrook et al., 2019). Theoretically, there is no methodological issue with combining proxies in RoC analyses, provided that the approach is clearly justified.

By integrating pollen and NPPs, we aimed to provide a more nuanced understanding of compositional change resulting from hydrological and trophic shifts by using the full palynological dataset. Our rationale was that we intended to detect vegetation shifts across both local and broader landscape scales. In practice, however, the pollen diagram alone shows limited variation until relatively recently, the dominant signal originates from the NPPs, highlighting the primarily local character of these environmental changes. We chose to present the composite signal, as it offered the clearest and most comprehensive picture of change through time, although using the NPPs alone would have led to the same interpretation.

Action: We revised the methodological description of the statistical analysis to clarify that we examined not only the pollen record (reflecting changes in vegetation composition at both regional and local scales) but also the NPP record (reflecting local trophic and hydrological changes on the peatland). We also added that combining multiple proxy indicators in Rate-of-Change analyses has already been successfully applied in previous scientific studies.

We also revised a section of the discussion to clarify that the PrC analysis reveals not only rapid changes in forest composition but, even more importantly, changes in vegetation, hydrological, and trophic conditions on the peatland. These changes resulted from forest management practices and subsequent catastrophic events to which such management likely contributed.

We also removed the section of the discussion related to the fire that referred to the PrC analysis, as it did not provide any additional insights beyond what had already been discussed earlier.

Before: To quantify periods of rapid botanical change and recovery, we apply the principal response curves (PrC) to the data, as outlined by Burge et al. (2023) in their R package 'baselines'.

After: To quantify periods of rapid vegetation change in the forest (regional scale) and on the peatland (local scale), as well as hydrological, and trophic shifts on the peatland, we apply the principal response curves (PrC) to the data, as outlined by Burge et al. (2023) in their R package 'baselines'.

Lines 267-270 in the new file with tracking changes.

Before: Thus, PrC results trace changes in the relative abundance of pollen and NPP over time. This method is useful for detecting changes in data with a strong underlying gradient in palaeoecological studies (Van Den Brink and Ter Braak, 1999; De'ath, 1999).

After: Thus, PrC results trace changes in the relative abundance of pollen and NPP over time. While most RoC (Rate-of-Change) studies rely on a single proxy, the combination of multiple proxies, including pollen and algae, has been applied in previous research (e.g., Abrook et al., 2020).
This method is useful for detecting changes in data with a strong underlying gradient in palaeoecological studies (Van Den Brink and Ter Braak, 1999; De'ath, 1999).

Lines 273-276 in the new file with tracking changes.

Before: Around this time, the PrC analysis began to reveal periods of significant and rapid change in the palynological record. Consequently, the forest has continued to undergo substantially rapid changes ever since, unlike the preceding changes.

After: Around this time, the PrC analysis began to reveal periods of significant and rapid change in the palynological record. Since then, both the forest and, even more so, the Miały peatland within it have continued to undergo substantially rapid changes ever since, unlike the preceding changes.

Lines 515-518 in the file with tracking changes.

Before: Only an enclave of several hectares of deciduous old-growth forest resisted the fire. This event roughly coincides with the period of substantial rapid change identified by the PrC curve (Fig. 5), suggesting that this change may have contributed to the rapid alteration of the forest ecosystem reflected in pollen record.

After: Only an enclave of several hectares of deciduous old-growth forest resisted the fire.

Lines 753-757 in the new file with tracking changes.

L. 298 - What kind of constrained ordination?
Where is the significance test of PrC, which you mention in the discussion?

Author's response: We used Principal Response Curves (PrC), a constrained ordination technique used to assess time series data in ecological studies, which is explained in the text above.

The methodological foundations of the statistical analysis are described in detail in the "Statistical analyses" section.

Lines 267-294 in the new file with tracking changes.

In response to the question regarding the significance test of PrC: This is not strictly a test of the PrC but a test of significantly rapid rates of change based on the GAMM fitted to the PrC data, as explained in the section 'statistical methods'- lines 288 to 289 (in the tracking change file): "*Periods of significant change were identified in the GAMM models by calculating the time intervals, where the confidence intervals surrounding the first derivative did not include zero.*

Action: We made sure that wherever references to statistically significant rates of change appear in the text, the correct terminology is used (i.e., rate-of-change analysis, significant rate of change, etc.). Where necessary, we made the appropriate changes.

Before: The results of the PrC analysis proved to be statistically significant, confirming the occurrence of critical transitions in the peatland on a scale that was not observed in the older part of the core.

After: The results of the PrC analysis indicated a significant rate of change, confirming the occurrence of critical transitions in the peatland on a scale that was not observed in the older part of the core.

Lines 519-521 in the new file with tracking changes.

Before: Nevertheless, all three above-mentioned disturbance factors (introduction of planned forest management, 1922-1924 outbreak, and 1992 fire) affected the condition of the peatland and were recorded as statistically significant critical transitions in the GAMM model (Fig. 5).

After: Nevertheless, all three above-mentioned disturbance factors (introduction of planned forest management, 1922-1924 outbreak, and 1992 fire) affected the condition of the peatland and were recorded as significant rates of change in the GAMM model, which can be interpreted as critical transitions (Fig. 5).

Lines 565-568 in the new file with tracking changes.