Response to the interactive comment on "Pollen-based quantitative land-cover reconstruction for northern Asia covering the last 40 ka"

Anonymous Referee #2

The aim of the study is to use pollen data for quantifying in very general terms the vegetation change in northern Asia over the last 40 ka. A key element in the study is the use the REVEALS method, which accounts for the differences in pollen productivity and dispersal, hence providing more robust abundance estimates than pollen percentage values. In general, I am in favor of suggesting that the paper can be accepted because it is based on a substantial dataset and presents results over a large area which has not been intensively investigated so far.

At the same time, I would urge the authors to amend the paper by making it clearer, more structured and more informative for readers. I found that large sections of the text, especially in Results and Discussion, were hard to follow. One reason is that there are too few references to figures and tables in the paper, making it hard to find out whether the interpretations presented in the text were sound and really supported by the results. For example, on page 10, the first long paragraph presents many types of results, but the only reference to a figure is at the end of the paragraph "(e.g. G"9,G39; Fig. 2)". Similarly, the next paragraph begins "The turnover in PFT composition is <0.7 SD units in almost all site-groups, except G8 (0.88 SD), G9 (0.73 SD), and G24 (0.76 SD) indicating only slight vegetation change during the Holocene" – are these results shown somewhere in the paper? I did not find them in the figures or tables.

Most of the results in the paper are shown in Fig. 2., which is a very big figure, divided into three parts. It is not an easy figure to follow together with the text. My suggestion would be to section the figure to smaller parts, either as three separate figures (Figs. 2, 3, 4) or sub-panels (Fig. 2a, 2b, 2c). Fig. 1 shows the study regions and the datapoints, but there are too much data squeezed into the figure, so it is a bit messy.

***Our response*: Agree. We have re-organized the manuscript, particularly Figures 1 and 2. In the new version, we present the reconstructed results for each cluster one by one, replacing the old Figure 2 (which presented reconstructing results by site-group). The new Figure 2**

includes 5 sub-figures (Figure 2A–2E) separated by modern vegetation: warm temperate forest margin zone, cool-temperate mixed forest, dark taiga forest, light taiga forest, and the tundra-taiga ecotone, which is consistent with the discussion part. We have added more references for Figure 2 in the main text. The new Figure 1 presents only the vegetation and permafrost background of site-groups. We put the map of pollen-data locations and IDs in the appendices as the new Appendix 1.

While I understand the motivation of using the REVEALS method in the paper, I also notice that the spreads in the estimated PPE values for different pollen types are remarkable. This can be best seen by looking at the Appendix 2. Consequently, there must be an enormous error associated with these estimates, and that uncertainty should be kept in mind throughout the discussion and conclusions. In addition, in the paper, the PPE value used for Larix is 3.642. But in the Appendix 2 it is indicated that there are two earlier PPE estimates for Larix, 0.00009 and 1.4. What is the value 3.642 based on? Note also that both "RPP" and "PPE" are used as abbreviations for the term "pollen productivity estimates", for example in Table 2 and Appendix 2.

Our response: **We have standardised the abbreviation for "relative pollen productivity estimates" as "PPE", and replaced "RPP" by "PPE" in the text. The old Appendix 2 (Appendix 4 in the new version) is quite a large table to present the PPE records for the 27 pollen taxa, so we separated it into two parts. There is another PPE value for *Larix* in the second part of the table of the new Appendix 4.**

In addition to the use of the REVEALS method, the pollen types are converted to plant functional types (pft) for defining the vegetation types for the study period. After this conversion, the selected 27 pollen types were reduced to only seven pft. This is sometimes useful because it allows a very generalized presentation of past vegetation types, but it also influences the results of

the vegetation turnover rate calculations, which the authors have carried out by applying DCCA with their pft data. This results is an extremely simplified measure, where the resulting turnover values includes errors that stem from the uncertainty in defining the PPE values and from the heavy generalization involved in converting the pollen types to pfts. I would not therefore place too much emphasis for the resulting turnover calculations presented in Fig 3.

Our response: **The first reviewer also mentioned this issue. Merging from pollen taxa to PFT does ignore some vegetation signal but also reduces the noise in the regional vegetation patterns. In our manuscript, we focus on the general and regional signal of vegetation change. Nevertheless, a spatial comparison of turnover in our study is still necessary to show the spatial variation in the density of vegetation changes. In addition, the conclusion of "minor with slight changes in PFTs" during the period between 12 and 1 cal ka BP, is not only based on the low turnover, but also on the insignificant primary change for many site-groups, which are also relative to some extent to summarize the taxa in the PFTs.**

Table 2 shows that *Corylus* is assigned to the plant functional type group "boreal deciduous trees". A "temperate deciduous tree" would probably be more correct. And how did the authors handle the pollen types which belong to two different plant functional type groups (for example, *Betula* is in boreal deciduous trees and boreal shrubs).

Our response**: The assignment of pollen taxa to PFT was completed follwing previous biome reconstruction literature (Tarasov et al., 1998, 2000; Bigelow et al., 2003; Ni et al., 2010). Pollen taxon "*Corylus*" was assigned to "cool-temperate cold-deciduous malacophyll broad-leaved tree or shrub" by Tarasov et al. (1998; 2000) and Ni et al. (2010), and to two PFTs - "boreal cold-deciduous malacophyll broad-leaved tree" and "temperate (spring-frost tolerant) cold-deciduous malacophyll broad-leaved tree" - by Bigelow et al. (2003; biome**

reconstruction for north of 55 °N). In this study, pollen taxon "*Corylus*" occurs only in 10 sites at more than 3% abundance and most of these sites are north of 50 °N. Hence, we assigned it to "boreal deciduous trees".

As well as *Betula*, the genus *Alnus* also has this problem of including both tree and shrub species within one genus. It is quite difficult to separate the pollen grains of genus *Betula* and *Alnus* into tree or shrub type by optical identification. In our dataset, many pollen records did not separate the tree and shrub type for the two genera, although some did. The undifferentiated *Betula* and *Alnus* grains were assigned to trees in our study, while pollen taxa with clear statements about their identity were separated based on these statements. We have modified Table 1.

Finally, the sites with pollen data were divided into 42 site groups. Each site groups includes many subregions, which are scattered around northern Asia. It remains unclear why such a subdivision was considered useful and how the site groups were defined. The description on page 8 says that "we divided the 203 into 42 site groups, based on criteria on geographic location, vegetation type, climate and permafrost. This is a confusing description because one site groups can contain subregions from different parts of Asia, so it is hard to understand how they could have been defined on the basis of geographic location or climate, for example.

***Our response:* We agree that the description in the manuscript was not very clear and we have modified it in the new version. Site-groups were defined by pollen data with the same vegetation-climate-permafrost conditions and similar pollen components and temporal patterns. In the new version, we re-organized Figure 1 following the results of cluster analysis to make the manuscript easier to read.**

Lines 165-170

"Here, due to the sparse distribution of available sites, we divided the 203 sites into 42 site-groups, based on criteria of geographic location, vegetation type (vegetation zone map modified from Tseplyayev, 1961; Dulamsuren et al., 2005; Hou, 2001), climate (based on modern precipitation and temperature contours), and permafrost (Brown, 1997) following the strategy of Li (2016), and the pollen data within one site-group should be of similar components and temporal patterns."