Main summary

The manuscript is reconstructing the forest-line dynamics in the French Pyrenees and finds an upward shift of the tree-line which is related to both climate change and pastoral abandonment. The patterns of change are vastly different in the West and Eastern Pyrenees. The paper states two main goals: 1) the reconstruction of forest-line dynamics in the French Pyrenees from the minimum forest extent in 1850 to the present day, and 2) the exploitation of potential biophysical and anthropogenic drivers.

We note that this review document is jointly written by 1 senior researcher and 4 junior researchers. Each of us read and commented on the manuscript individually, then the paper was discussed as a group. We summarize here both the points we agree on as well as individual observations (marked as such).

We particularly enjoyed reading this manuscript and we think its main strengths lie in the fact that it reconstructs forest dynamics over very long time scales and a broad spatial area and that it relates these changes both to anthropogenic and climatic variation. The approach presented here is transferrable and while the reconstruction itself is not novel, there are many ingenious ways in which the authors deal with the limitations of the historical data (e.g. farming pressure, forest composition at tree line). We all felt that the research questions posed by the manuscript are answered, but we did have several major concerns that we feel need further clarification. Below, we describe these concerns and try to make suggestions on how to address them. We group our concerns in major concerns and other comments.

Major concerns:

The promise of climatic debt analyses and the tree line (not) tracking the isotherm shift is an overpromise of the paper that is not fully delivered on. These two concepts (climatic debt and isotherm shift) are mentioned only in abstract and discussion but not really analyzed per se in the text, albeit the fact that if they were, we feel like this paper would have a great(er) value. We believe that this conflict of the 'overpromising' manuscript could be solved by either 1) measuring actual climatic debt (eg. area that the forest could have moved to follow the isotherm, but did not) or by 2) not mentioning the climatic debt per se (because it is not really quantified here). The isotherm shift in our view would mean to find all points of a certain temperature (eg. 6 degrees at treeline) and spatially assess how much farther up those points are compared to historical baselines. We did not find this analysis described – but rather comparison to average change in temperature at a fixed point, which is interpreted as an upward isotherm shift.

The point above brings us to our second main concern: we did not fully grasp how the climatic (claimed isotherm shift at forest line) can be inferred from weather data that was sourced from a single weather station at Pic-Du-Midi which is located nearly 1000m higher than the forest line. The use of the climatic data was not clear to us from the text,but beyond this clarification: if indeed data from a single location was used for the entire study region, we find this problematic because a) it wipes out local variability. If spatially explicit climate data was indeed used, then the description of how this data was used and calculated needs to be clearer and offer similar weight and space in the manuscript as the pastoral pressure data.

We all agreed that while it is great that the study covers such an expanded timescale, there needs to be some more discussion and depending on possibilities also a sensitivity analyses that account for the way in which measuring annual change between only two points in time, may confound 'noise' with actual trends.

Other comments:

I would welcome a more thorough discussion of why the data was analyzed at municipality level rather than not used spatially explicitly. I believe this may be because of the anthropogenic variables, but then again the authors did a great job spatializing some of those too (eg. by accounting for livestock owners/ pasture).

L100: no overarching goal/ objective for the manuscript is stated – in addition to the specific questions.

Table 1: with variables could be accompanied by another column with expected effect direction

Figure 3b: the right axis scale seems to be transformed because values are not equidistant – can you detail the transformation applied?

L190: how was the data from Pic-du-Midi extrapolated to the whole study region? And if it was not, how can the link be made between isotherm shifts at more than 1000 m below this elevation?

We found that in parts the text provides excessive detail (eg. the map reconstruction, variables regarding grazing) and in others the text was particularly low in detail. For example, processing of the variables in cases where variables were not used should not be described in detail in the text but rather only in the supplement. Some examples include but are not limited to:

> L 220: why was the map from 1908 not used in the analyses of forest line change (it would have been great for mitigating the issue of variability within the two very distant observations from 1851 and 1993) but then mentioned in the text here?
>
> L280: why is the description of grazing intensity relevant here

Line 280: need to state how models were selected (forward, backward selection). Please list the final best selected model for each section.
L350: the forest line velocity shift model for 1993-2010 and for closed forest is explaining a very low amount of variation. I would deem this a bad model – is there an explanation why this is considered acceptable? What else may be missed in terms of variables?
L123: In the chapter 2.2 Selection of the studied municipalities you say that you exclude the municipalities that had already reached the maximum elevation of forest line in 1993 or 2010. Why do you exclude those from the study and would those municipalities not also be in line with the first objective of the study?
L160: Which forest extent is represented in the newer maps? the open forest line or closed forest line? In the sentence before the figures you mention that you create two vector maps for BDF1 and BDF2. Maybe you do not see a difference at that scale but it seems strange displaying three maps, when 5 are mentioned beforehand without specification which ones they are.
L262 - 283: You describe the variables for the three models. Maybe a graph with the same information would be more intuitive.
L396-402: Because you only mention in line 209 in the description of the graph that you use the temperature shift to estimate the upward shift in forest line and there is no further explanation in the methods, this part is confusing. You should explain that you use the + 0,62°C temperature shift in 1910 - 1993 and + 0,62°C for 1993 - 2010 in combination with the adiabatic gradient of - 0,55 °C / 100 m elevation to calculate the respective 112m theoretical upward shift in one place (considering the concerns about this broad approach earlier).
L331: In figure 6 the timespan mentions 1994 several times instead of 1993. The figure title also says 1993.
L166 and L172: metre instead of meter.
References: this piece of work from Eastern Europe on similar time scales and topics may be relevant: https://link.springer.com/chapter/10.1007/978-3-642-12725-0_16

Review Questions:

1. Does the paper address relevant scientific questions within the scope of BG

yes

2. Does the paper present novel concepts, ideas, tools, or data?

yes

3. Are substantial conclusions reached?

Yes, potential for it, but see major concerns above

4. Are the scientific methods and assumptions valid and clearly outlined?

The climatic data analyses needs clarification. More clarity on forest context metrics is needed.

5. Are the results sufficient to support the interpretations and conclusions?

Partly

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

At times too detailed, at times too little detail. See ‘other comments’. Further methodological details would help.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

We did not check all references in detail!

8. Does the title clearly reflect the contents of the paper?

Yes

9. Does the abstract provide a concise and complete summary?

The abstract feels a bit like an overstatement, it overpromises and the reader is bound to be disappointed in the actual paper. I think the abstract could be ‘toned down’ a bit.

10. Is the overall presentation well structured and clear?

Yes

11. Is the language fluent and precise?

Language could be checked and simplified. See also Q6.

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

NA

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

See major comments

14. Are the number and quality of references appropriate?

Yes

15. Is the amount and quality of supplementary material appropriate?

Yes