Responses to Reviewer #1: RC1

We sincerely appreciate your thorough evaluation and constructive feedback on our manuscript. Below, we provide detailed responses to all points raised. All comments have been carefully addressed and will be incorporated into the revised version of the manuscript.

On behalf of all co-authors,

Anna Trigubenko

General comments:

Reviewer#1: The analysis lacks statistical support. See for example reporting of tree ring and 13c results.

Response: We appreciate the reviewer's comment regarding the need for stronger statistical support. In the revised manuscript, we will include additional analyses to address this concern. Specifically, we will provide detailed geographical, structural and dendrochronological characteristics of the sampled sites, categorized by tree health status. We will also incorporate Basal Area Increment (BAI) calculations to better illustrate growth differences among healthy, damaged, and dead trees. Furthermore, we will present growth-climate and $\Delta^{13}C$-climate analyses, even in cases where correlations appear weak, in order to illustrate the potential influence of climate on tree physiology.

Reviewer#1: The tree ring methods could be more clearly described. In particular, I am uncertain whether all «dead» tree cores contained the same years as it is not clear that all trees died in the same year.

Response: We thank the reviewer for pointing out the need for clarification regarding the tree-ring methods. In the revised manuscript, we will carefully rework the sections describing the sampling and cross-dating procedures. While not all dead trees died in the same year, we note that, based on information provided by local forestry workers and national park staff, all trees classified as dead were already dead by 2016. For the stable carbon isotope analysis, we specifically selected trees whose cores included the final year of growth, ensuring comparability across individuals. We will revise the text to explain how we accounted for this variation, including the criteria used to determine the last year of growth for each dead tree and how these data were aligned for further analyses.

Reviewer#1: Crossdating also was only from a single core per tree and the comparison among the dated core and the isotope core is not well described.

Response: Thank you for your comment. The reviewer is correct that cross-dating was performed on a single core per tree, while the second core was kept intact for the stable isotope analysis. Please note that we sampled 20 trees per health category, which aligns with standard practice in dendrochronology. To minimize within-tree variability, both cores were extracted at the same height and orientation, whenever possible. Importantly: despite relying on a single dated core per tree, the resulting tree-ring chronologies were robust, with Expressed Population Signal (EPS) values exceeding 0.85 in all cases. We will clarify this methodological detail in the revised manuscript.

Reviewer#1: I do not find the assessment of climatic drivers compelling, given no statistical correlation or regression analyses are described or reported.

Response: Thank you for this insightful comment. We acknowledge the importance of statistically evaluating influence of climatic drivers on tree performance. In the revised manuscript, we will include the results of correlation analyses conducted between monthly climatic variables (mean air temperature and precipitation) and tree-ring width chronologies for each tree health category. These analyses will cover the period 1993-2022 for healthy and damaged trees and 1993-2016 for dead trees. Although the preliminary analyses show that the correlations are generally weak, we agree that reporting these findings adds transparency and supports our interpretation that climate is not a dominant driver of the observed tree mortality. We will revise the manuscript accordingly to reflect the outcome of the correlation analysis.

Reviewer#1: Some justification for the use of bulk ring 13c instead of cellulose 13c should be included.

Response: Thank you for your comment. We acknowledge the importance of selecting appropriate material for stable carbon isotope analysis. In our study, we chose to analyze $\delta^{13}C$ in bulk wood rather than extracting cellulose based on the review published by McCarroll and Loader (2004).

Line comments:

Ln 53. Please provide citation/evidence the beetle is non-aggressive. I have seen suggestions of exactly the opposite (aggressive). https://research.fs.usda.gov/treesearch/37559

Response: Thank you for pointing this out. We miswrote this point in the previous manuscript. Contrary to our earlier statement, the literature does describe the beetle (*Polygraphus proximus*) as an aggressive species capable of mass-attacking healthy trees, particularly during outbreaks. We will quote it with the appropriate references, including the one you kindly provided.

L61. This is kind of the definition of an aggressive bark beetle species, and D. ponderosae is an example of an aggressive species.

Response: You are absolutely right. We appreciate the comparison with *Dendroctonus ponderosae*, which helps contextualize the behavior of *P. proximus* within the broader framework of bark beetle ecology.

L96. Replace «thrives» with «is found»

Response: Done.

L98. Any examples of such critical roles?

Response: We agree and will clarify this point as follows: In mountainous regions with intense rainfall (1,000 to 3,000 mm in Yamagata Prefecture), the root systems of *Abies mariesii* help anchor the soil, reducing the risk of landslides.

L117. None of the three example species are coniferous

Response: Thank for the suggestion. We will include appropriate examples in the revised manuscript.

L137. Also looks like it's a ski area?

Response: Yes, the study area is indeed part of a popular ski area. Zao Mountains, located within the Zao Quasi-National Park in northeastern Japan, are not only ecologically important but also serve as a major winter and summer tourism destination. The area hosts a large ski resort and is internationally recognized for the unique natural phenomenon known as «Snow Monsters» (Juhyo in Japanese), where *Abies mariesii* trees become completely covered with snow and ice due to strong winds. However, our sampling sites are located far from the ski facilities and are therefore not influenced by tourism-related activities.

L145. So only a single core per tree was used for cross-dating? This is a bit unusual.

Response: Thank you for your comment. Yes, we used a single core per tree for cross-dating, which is a common and widely accepted practice in dendrochronology, particularly when sample sizes are sufficient and cores are well-preserved. This approach is supported by standard dendrochronological protocols and has been shown to provide reliable results when cross-dating quality is high. We will clarify this point in the revised manuscript.

L146. It looks like only four trees were eventually used per category? I understand limitations on 13c measurements, but this is a relatively small sample size for inference on ring widths.

Response: We thank the reviewer for this observation. All sampled trees (20 per health category) were included in the cross-dating and ring-width analyses. For the stable carbon isotope analysis, we selected the four best correlated trees per category following recommendation by McCarroll and Loader (2004) for dendro-isotopic studies. We agree that this methodological detail should be clarified, and we will revise the manuscript accordingly to ensure clarity regarding sample sizes used for each type of analysis.

L159, 162. What were the criteria used for validation? It would be good to at least report sensitivity and perhaps the relative frequency of missing rings in later years, particularly for dying trees.

Response: The cross-dating of the individual tree-ring series were validated using the COFECHA and ARSTAN programs. No missing rings were detected in any of the samples, including those from dead trees.

Chronology statistics for each health category were as follows:

Healthy trees: mean sensitivity = 0.207, Rbar = 0.195, EPS = 0.938

Damaged trees: mean sensitivity = 0.232, Rbar = 0.198, EPS = 0.936

Dead trees: mean sensitivity = 0.229, Rbar = 0.153, EPS = 0.918

All EPS values exceeded the commonly accepted threshold of 0.85. Mean sensitivity values were within the expected range for natural forests, reflecting moderate interannual variability in growth.

L165. Why would pre-whitening correct climate-driven growth anomalies? And, what is the benefit of doing so given the goal is (I think) to understand the effect of extreme climate on tree growth?

Response: Thank you for this important observation. We acknowledge that the original sentence was misleading and did not accurately reflect the purpose of pre-whitening. Given that one of the goals of this study is to identify interannual stress signals—such as those associated with pest outbreaks or climate extremes—pre-whitening is useful for removing low-frequency trends and enhancing the detection of high-frequency anomalies. This facilitates the identification of specific stress events that may not be apparent in the raw data. We will revise Section 2.3 to clearly explain the chronology development process and the rationale for applying pre-whitening in this context.

L169. Do the authors mean «four trees»? Were cores intended for isotopic analysis surfaced in any way prior to sectioning?

Response: Yes, by «four cores» we refer to four individual trees per health category. The cores selected for isotopic analysis were not surfaced, as they were kept intact to preserve the wood structure and prevent contamination prior to sectioning for stable carbon isotope measurements. We will revise the manuscript to clarify both points.

L177. Why not use individual rings for the same sets of years across health statuses?

Response: We appreciate the reviewer's suggestion, and agree that using individual rings for the same sets of years across health categories would be an ideal approach to improve comparability. Instead, during the isotope analysis, we followed the procedure outlined below:

- For dead trees, we established 2016 as the final growth year (the last ring formed before death), based on field observations and confirmation from local forestry authorities. From this reference, we traced rings backwards to 1993. Individual rings were preserved for isotope analysis for the years 2016, 2011, 2006, 2001, and 1996.

- For healthy and damaged trees, which were still alive at sampling in 2022, we applied a similar strategy: individual rings were preserved for the years 2022, 2017, 2012, 2007, 2002, and 1997.

While this method did not produce samples from exactly the same calendar years across tree health status, we consider this discrepancy minor and not critical for the objectives of the study. Nevertheless, we will clearly acknowledge this limitation in the revised manuscript and discuss its potential implications for interpreting our results.

L206. H6 in Fig 3 appears to also show progressive damage. This raises the question for me of how damage/health categories were assigned, as this is not described in L146.

Response: Thank you for your comment. We agree that tree H6 in Fig. 3 appears to show signs of progressive defoliation, particularly in the 2022 image. However, we classified H6 as a healthy tree based on field-based observations at the time of sampling. From the ground level, no visible signs of crown dieback or significant defoliation were observed.

We apologize for not clearly describing our classification criteria in the original manuscript. In this study, we followed the classification scheme of Leidemer (2025), which defines six tree health classes based on the level of defoliation observed from UAV images: healthy (0% defoliation), light damage (≤20%), moderate damage (21–50%), severe damage (>50%), dead (100% defoliation), and fallen (tree on the ground). Based on this scale and field level inspection, H6 fell within the «healthy» category. Furthermore, we recognize that crown appearance may vary across years in aerial images due to seasonal conditions (e.g., snow cover, lighting, canopy angle), which can complicate interpretation. We will revise the manuscript to clarify our classification methodology and acknowledge this potential source of uncertainty.

L219. No statistical support in this results section?

Response: We appreciate the reviewer's comment regarding the lack of sufficient statistical support in the Results section. As noted above, we will expand descriptive information of the sampling sites to include key parameters with associated statistics and relationships between health categories. Additionally, we will conduct Basal Area Increment (BAI) comparisons across health categories and perform correlation analyses between climatic variables and tree-ring and $\Delta^{13}C$ chronologies. We believe that these amendments will enhance the analytical clarity and scientific rigor to the manuscript.

L225-227. I would suggest to report a correlation

Response: Thank you for your suggestion. We apologize for not reporting the correlation in the original manuscript. In the revised version, we will include the correlation coefficient to support the relationship described and ensure the results are presented with appropriate statistical backing.

L230. How much higher? Please report? How is the climate different?

Response: Thank you for your question. The dead trees used in this study were located at higher elevations, ranging from 1600 to 1714 m a.s.l., near the treeline. In contrast, the healthy and damaged trees were sampled at lower elevations, between 1468 and 1535 m a.s.l. This altitudinal difference corresponds to markedly distinct environmental conditions. The upper plots experience lower mean annual and growing season temperatures, stronger and more persistent winds, greater snow accumulation and longer snow-melting periods. We will include this information in the revised manuscript to clarify these differences.

L232. So, some of the trees did not die in 2016? How can the authors be confident all the dead trees they sampled died in the same year, given they were sampled 6 years after mortality?

Response: Thank you for this important comment. While we cannot confirm with absolute certainty that all dead trees died in the same year, we took several steps to ensure consistency in our sampling. According to local forestry officials and the direct observations by ropeway personnel who monitor the mountain regularly, widespread tree mortality in the study area occurred around 2016. In the field, we selected dead trees that showed similar levels of decay and bark retention, indicating a comparable time since death. During tree-ring analysis, we also verified the final year of growth through visual cross-dating, and in all sampled dead trees the last visible ring corresponded to 2016. While there is always some uncertainty when sampling several years after mortality, we are confident that the sampled trees died within a narrow time window around 2016. We will clarify this point and explicitly acknowledge this limitation in the revised manuscript.

L240 no uncertainty is reported.

Response: Thank you for this observation. In dendrochronological studies, the reliability of a chronology is typically assessed using the Expressed Population Signal (EPS), with values above 0.85 indicating a strong common growth signal at the stand level. In our study, all chronologies exceeded this threshold, with EPS values of 0.94 for healthy trees, 0.94 for damaged trees and 0.92 for dead trees, demonstrating high internal coherency and robustness of the resultant chronologies. We will include the EPS values in the revised manuscript to clearly convey the statistical confidence associated with the developed chronologies.

L242. I would suggest increasing trends are present in a and b. How were trends quantified?

Response: Thank you for your suggestion. In the original version of the manuscript, the interpretation of $\Delta^{13}C$ data was based solely on visual assessment. We acknowledge that no formal trend analysis was conducted, and we apologize for this oversight. In the revised manuscript, we will re-examine the data and quantify trends using linear regression. If significant trends are identified, we will report them explicitly and revise the relevant figure captions and text accordingly.