Dear Editor

Thank you for the opportunity to revise our manuscript title “Savanna ecosystem structure and productivity along a rainfall gradient: the role of competition and stress tolerance mediated by plant functional traits”. We appreciate the valuable feedback provided by you and the reviewers. We have carefully considered all comments and feedback and revised the manuscript accordingly. In the attached response document, we provide point-by-point responses to each reviewer's comment, including references to revised line numbers in the manuscript. We have thoroughly reviewed the manuscript for typographical errors and updated relevant sections, including figures, references, and the supplementary document.

Editor comments responses sheet
Editor comments are in **Normal type a**nd our responses with referring sections and line numbers are *Italics (Blue color).*

Editor Comment: You will find that in particular reviewer 1 raises critical points. It will be helpful in general to more clearly express the aim of the paper. You mention a central aim/hypothesis in the abstract (l. 22) and in the introduction (l. 83). It could be made more clear how this is translated into a quantitative analysis (how measured?).

- *Introduction section is edited where knowledge gap, study goal and hypothesis clearly mention (Line 49-121). A paragraph inserted in introduction section to explain knowledge gap and research question (Lines 79-91).*

Editor Comment: Then, you show results for a set of variables along a latitudinal gradient. It has been criticised that the presentation of results along a latitudinal gradient is not clearly linked to the framing and interpretation of central questions along an elevation gradient.

- *Figures 2 and 3 were plotted using latitude as the primary x-axis rather than elevation to preserve spatial continuity and avoid aggregation artefacts associated with the 30 arc-second resolutions of the elevation dataset. Direct binning or aggregation by elevation resulted in loss of fine-scale spatial variability along the transect. To maintain ecological interpretability, elevation has been included as a secondary axis, and all interpretations in the text are explicitly framed in relation to the elevational rather than latitude. We have clarified this in the figure captions and associated text to ensure consistency between presentation and interpretation.*

Editor Comment: Finally, the key conclusion "The model reliably reproduced key ecological patterns along the elevation gradient, with strong agreement between simulated outcomes and observations" (l. 484) and the statement" we successfully reproduced spatial and temporal patterns in vegetation composition, structure, and productivity along the elevation gradient." (l. 634) could be more clearly linked to the results presented. The model-data (mis-) match is difficult to interpret from the figures you show and results regarding a temporal pattern seem to be entirely missing.
We acknowledge that temporal pattern analysis is missing as we do not have data to validate temporal distribution of studied variable. Our analysis was focused on reproducing spatial patterns.

- *First paragraph (Lines 510-521) is edited.*
- *Conclusion section (Lines 702-707) is edited to incorporate suggestions.*

In general, I advise you to revise the visualisations thoroughly. A few points regarding visualisations that I noted:

Editor Comment: - Fig. 1: explain red points, a rectangle might work better for delineating the study region

- *Figure 1 updated with inclusion of elevation range (Earth Resources Observation and Science (EROS) Center, 2017) and ecoregion (Olson et al., 2001). The map showing spatial distribution of forest area (Land Resource Mapping Project, 1986) along the studies elevation range shifted to supplementary materials (Supplementary Figure 1).*

Editor Comment: - Fig. 2: legend is not instructive for understanding what curve represents LPJ-GUESS results vs. the GPP product from Bi & Zhou (2022). Boxplots may be a more appropriate choice for visualising distributions. Unclear how the x axis relates to the study region shown in Fig. 1.

Legend edited clearly distinguish between LPJ-GUESS simulated results and the GPP product from Bi & Zhou (2022).

Boxplots were considered to represent distributions; they resulted in overplotting and reduced clarity due to data overlap. Therefore, we retained the current visualization approach to preserve readability while ensuring that the distinction between datasets is clearly explained in the updated legend.

Figure 1 has been revised to explicitly show elevation ranges to improve consistency and spatial interpretation of Figure 2.

Editor Comment: - Fig. 3: I don't understand how simulations are shown. A trend line (may be non-linear) for observed and modelled biomass along elevation (not latitude) would be helpful.

Simulated biomass is produced at patch level (from 15 patches of 1000 m^2 each in each grids), while observed biomass is based on plot-level point measurements. Due to this mismatch in spatial scale and support, a direct one-to-one comparison or common trend line along elevation would not be statistically appropriate. Therefore, we compare the two datasets using latitude as a shared spatial reference across the transect, with simulated values representing patch values and observations representing corresponding field plots within the same spatial units. We have clarified the rationale of comparison in model validation section (Lines 294-308).

Editor Comment: - Fig. 2 and 3: It might be helpful to show this vs. elevation, not latitude since elevation the principal axis of variation in your study.

Figures 2 and 3 were plotted using latitude as the primary x-axis rather than elevation to preserve spatial continuity and avoid aggregation artefacts associated with the 30 arc-second resolutions of the elevation dataset.

Editor Comment: - Fig. 4: observations not shown. If no observations are available, this should be clarified and discussed in the text (also concerns other displayed variables with no corresponding observations).

Observed LAI form MODIS added by binning Both LAI data despite difference in spatial scale to show broad pattern in LAI from two sources.

Editor Comment: Finally, I noted an unclear point regarding the downscaling of the climate from half-degree to 3 km: how were elevational gradients in temperature, precipitation, and shortwave radiation resolved along topographic gradients? You describe only a bi-linear interpolation, which would not resolve the elevational variation which seems key for your study. Please explain.

The downscaling of CRU–JRA data to 3 km was performed using bicubic interpolation, which enhances spatial resolution but does not explicitly resolve elevational gradients through physical corrections such as lapse rates or orographic effects. We agree that this is a limitation, particularly given the importance of topographic gradients in our study system.

- *We have revised the Methods section to explicitly state the nature of the downscaling approach and its implications (Lines 205-207)*
- *We have also expanded the Discussion (Limitation section) to acknowledge that interpolated climate fields may not fully capture fine-scale variability in temperature, precipitation, and radiation across complex terrain (Lines 665-675)*

Despite this, the downscaled dataset was sufficient to reproduce broad elevational patterns in vegetation structure and composition, which are the primary focus of this study.

Reviewer #1 Comment Response Sheet

Reviewer comments are in normal types. Our responses are in normal type (red colour) and refereeing section, and line number are in *Italics (Blue Color).*

This manuscript aims to investigate roles of abiotic stress and competitive interactions in shaping plant community assembly by using dynamic vegetation model with plant functional types. The approach seems interesting however, I found several methodological uncertainties, potential flaws, styles and errors throughout the manuscript that should be addressed to make it convincing.

We thank the reviewer for this encouraging assessment. We agree that the manuscript would benefit from targeted clarification and refinement, and we have outlined below the specific revisions to implement in response to each point.

Reviewer Comment: Introduction: The foundation of the story is week for me. The knowledge gap or research questions and hypothesis are missing. Introduction is a bit general for me. Wise to make it more appealing by synthesizing key ecological aspects. Basically, it needs to present the significance of this study. For instance, what are the knowledge gaps based on previous studies in the Himalayan regions. How this study helps to advance our understanding on plant community assembly. There are several trait-based (morphological to elemental scale), field observation-based studies along the elevation gradients or focused on particular ecotones, which are overlooked in the manuscript. Those studies might be helpful to improve it.

Response: The goal of this paper is to evaluate how abiotic stress and competitive interactions jointly shape plant community assembly, structure, and productivity along the elevation gradient in the Central Himalayas, using a dynamic vegetation model parameterized with empirical trait and life-history data. Specifically, we aim to test the hypothesis of a vegetation composition and productivity transition from competition-driven (realised niche) dynamics at lower elevations to stress-driven (physiological niche) dynamics at higher elevations. We agree that the Introduction section does not currently communicate these objectives, research questions, and hypotheses with sufficient clarity or synthesis. We will revisit and restructure the Introduction to explicitly state the study's goals, identify key knowledge gaps in Himalayan plant community assembly, synthesize relevant trait-based and field observation studies, and clearly articulate how this modelling framework advances understanding beyond existing empirical and regional-scale studies.

- *Introduction section is edited where knowledge gap, study goal and hypothesis clearly mention (Lines 49-121).*

Reviewer Comment: The methodology needs several clarifications. There are several issues on data (parameters) used in the model simulation (see specific comments as well) which weakens the robustness of the model. For instance, Avolio et al. (2019) developed equation based on grassland plot data including species removal approach, it is not clear how authors link it with carbon masses. It is not clear, how this approach linked with observed traits data by Maharjan et al. 2023? Similarly, as Maharjan et al. (2021) collected the traits using common tree species, several deciduous species did not sample as they lost their leaves at the time of fieldwork (please see Maharjan et al. 2021). I am very curious, is these data really applicable to know the local species richness and evenness?

Response: We appreciate the reviewer's concern regarding the robustness of the parameterisation and the linkage between empirical trait data, competition metrics, and simulated carbon dynamics. In this study, we adopt a modified formulation based on Avolio et al. (2019) to quantify PFT performance under full competition and reduced-competition conditions (removing all tree PFTs except the targeted one from the system). While Avolio et al. (2019) derived this relationship from grassland species-removal experiments, we use the conceptual framework, modified rather than the original empirical coefficients. We will clarify this in the method section.

- *Competition index calculation and use of Avolio et al. (2019) framework expanded for clarity (Lines 311-326).*

The empirical trait data collected by Maharjan et al. (2021) represent 31 dominant tree species that account for the majority of above-ground carbon production and structural biomass along the Himalayan elevation gradient. These species were used to derive 13 functionally distinct PFTs through a hierarchical clustering approach, capturing major plant strategies and trait variability relevant to competition, stress tolerance, and growth form. Although some deciduous species were not sampled during leaf-off periods, we have 7 deciduous PFTs, and the parameterisation focuses on structural, allometric, and life-history traits that are expected to be representative of all deciduous species found along the gradient. We will elaborate on how these PFTs represent regional functional traits and plant strategies in the method and supplementary sections.

- *The use of 31 dominant species to derive 13 functional groups has been clarified in the Methods section (Line 233-248).*
- *Details description of clustering approaches is kept in Supplementary materials.*
- *Limitation of generalized PFTs on representation of local species richness and diversity is added in limitation section (Lines 665-675)*

We emphasize that the objective of the PFT framework is not to reproduce local species richness or plot-level evenness, but to represent dominant functional strategies that control ecosystem structure and carbon dynamics at landscape-to-regional scales. We acknowledge that we calculated PFTs level evenness and richness using fractional coverage, which does not reflect local species evenness and richness. We will clarify this conceptual distinction in the Methods and Discussion sections, explicitly stating the scope and limitations of trait-based PFT representation and its implications for interpreting simulated patterns of diversity and evenness.

- *Interpretation of evenness and richness calculated using FPC at PFTs level is added in section 3.5 (Lines 328-345).*

Reviewer Comment: It was not mentioned if the occurrence pixels. For example, sometimes the pixels be in the forest, doesn't fall to the forest but an open area, which is clearly an erroneous or inaccurate observation. The data point checking and cleaning could be done to ensure their correctness.

Response: The model simulations represent ecosystem structure and functioning across the full climatic gradient, independent of whether a given grid cell or simulated patch is currently forested or non-forested. In contrast, the observational above-ground biomass data used for evaluation (Khanal and Boer, 2023) are restricted to forested areas. Accordingly, no additional filtering of simulated pixels was applied to match land-use categories. The objective of this comparison is therefore to assess whether simulated and observed values exhibit consistent patterns across the elevation gradient, rather than to perform pixel-level validation. We will clarify this modelling rationale and explicitly acknowledge the resulting scale and conceptual mismatch between simulated potential vegetation and land-use–dependent observational data in the Methods and Discussion sections.

- *Inclusion of all simulated above-ground biomass across the ecosystem regardless of land use condition added in section 3.4 (Lines 294-298).*

Reviewer Comment: Result section is too comprehensive and very difficult to figure out the key findings. Better to present figures with key results in the main text and other can be transferred to the supporting information. I would suggest just to present the result. Don't mix it with some explanations.

Response: We will revisit the results section and, if possible, restructure it. We will move any explanatory interpretation to the discussion and focus solely on presenting results in the present section.

- *All figures have been updated using filtered elevation values. The Results section now strictly presents key findings, while interpretative and explanatory content has been moved to the Discussion.*

Reviewer Comment: The overall discussion is not well written for me. Mostly, authors just present their results and compare them with other similar studies and fail to provide scientific evidence or possible ecological mechanisms to support their results. Thus, it needs to synthesize the results rather than presenting results directly. Also, key results should be highlighted and justified with scientific evidences. Deeper discussion needed including the mechanisms why and how you obtained such results? What are the implications of these results under climatic changes? How PFTs drive ecological niche formation, how traits explain it, what are the ecological mechanisms and what are their ecological implications. It warrants deeper discussion and wide literature review.

Response: We will substantially revise the Discussion section focusing on underlying ecological mechanisms (e.g. abiotic filtering, competition asymmetry, trait-mediated niche differentiation), and discuss broader implications under different growth conditions. We will explicitly address how PFTs and traits drive niche formation and community assembly in our model along elevation gradients, supported by a more targeted literature review.

- *Whole discussion section is revised which clearly emphasizes on explaining ecological mechanism, trait-based niche formation, and implications under future climatic change.*

Reviewer Comment: L130: please cross-check the sentence. Generally, precipitation peaks above 1500-2500 m and it decreases from around 3000 m.

Response: We will cross-check the data and reference.

- *New citation added and text edited (Line 132).*

Reviewer Comment: L198: How do you define the wet days or dry days? What are the criteria?

Response: The Number of wet days is defined as a day with non-zero precipitation(>0mm) and annual counts are obtained for model simulation. We will edit the text accordingly in the Methods section.

- *Explained in methods section (Lines 210-212).*

Reviewer Comment: L215-220: how do you define these functional groups? What are the criteria? It should be well described and methods should be reproducible.

Response: We note that in the Methods section, PFTs are defined using a divisive hierarchical clustering approach. We agree that the current description could benefit from further elaboration. We will expand the Methods section to clearly describe the criteria and variables used in the clustering to ensure reproducibility. Detailed information on the clustering procedure, trait selection, and resulting PFT definitions and parameters will be provided in the Supplementary Material.

- *A detailed description of the clustering approach and criteria is provided in the Supplementary Material, while a concise summary is included in Section 3.3 (Lines 233–250).*

Reviewer Comment: Table 1: What are the sources of these data? source should be provided.

Response: We will add the source of data in the table footer.

- *Data sources added in the table caption (Line 268).*

Reviewer Comment: As I know authors used tree traits data ranging from about 100 m to 3800 m (see Figure 1 Maharjan et al. 2021), how model is simulated up to around 5800 m? Generally, trees are found up to around 4000 m, do this model is also applicable to simulate different ecosystems (such as alpine grasslands). This may create several issues about the robustness of the model. Since authors highlighted of the significance of study is comparing simulated and observed data (see L112-113), there is large gaps.

Response: The empirical tree trait data used for parameterisation span elevations from approximately 100 to 3800 m (Maharjan et al., 2021) and were used to define regional tree PFTs and to parameterise the model. Model simulations, however, extend to higher elevations (up to ~5800 m) to capture the full climatic gradient, including the transition from forested ecosystems to alpine and nival zones. Above the upper treeline (≈3800–4200 m in the Himalayas), tree PFTs are progressively excluded by temperature constraints and carbon balance limitations within the model. While occasional occurrences of tree PFTs may still appear at the grid level due to stochastic establishment processes, ecosystem structure at these elevations is overwhelmingly dominated by C_3 grass PFTs, with negligible woody biomass. Simulated vegetation above the treeline therefore, represents alpine grasslands or sparsely vegetated systems rather than forest ecosystems, consistent with ecological expectations.

- *Purpose of Maharjan et al. 2021 data explained in method section (lines 299-304) and retaining default parameters of C3 and C4 grass for simulating in hotter and colder end of gradient is added in methods section (Lines 188-191).*

We acknowledge that the field observations used for evaluation (Khanal and Boer, 2023) are restricted to forested areas. Accordingly, the purpose of this comparison is not point-by-point validation across the full elevation range, but to validate the broader patterns in above-ground biomass distribution. We will clarify this explicitly in the Methods and Discussion sections and clearly distinguish between evaluated forested elevations and higher-elevation model outputs, which are intended to illustrate emergent responses to climatic stress rather than to make direct comparisons with plot-level observations.

- *Method section (Lines 294-301) edited to describe data spatial resolution and their role in validating model performance.*

Reviewer Comment: Figure 3: above-ground carbon mass or above-ground biomass? some places authors mentioned carbon mass, some places biomass, it makes lots of confusions. The terminologies should be consistent. As I see in Khanal and Boer (2023), it might be above-ground biomass. As Forest lines normally up to around 4000 m and Nepal's forest inventory covers only forested areas, I am surprising to see the some observed data close to 6000 m. It indicates there are some errors using the plot-level data.

Response: We will standardize terminology throughout the manuscript (e.g. above-ground biomass vs above-ground carbon mass). Elevation values for each observed and simulated grid cell were extracted from the DEM. We will also re-examine the dataset used in Figure 3, clarify its spatial coverage, and explicitly discuss any apparent anomalies or uncertainties related to elevation limits of forest inventories.

- *Consistency in above-ground biomass maintained across the manuscript.*
- *We re-examined the elevation data extracted form DEM (Earth Resources Observation and Science (EROS) Center, 2017). Values presented in figures 3 and 4 were average across the simulated longitude along. After careful filtering and removing extreme outlier which could be associated with DEM bias new elevation values for each simulated latitude is calculated and used for plotting. All Figures updated with filtered elevation data (Lines 228-231).*

Reviewer Comment: L335: How did you simulated LAI? it is not mentioned in the methodology section.

Response: In the model, LAI is calculated dynamically from simulated leaf carbon pools using PFT-specific SLA, with LAI directly linked to carbon allocation, phenology, and canopy structure. Leaf carbon allocation is influenced by growth conditions and competition, and LAI emerges from the balance between leaf growth and turnover rather than being prescribed. We will incorporate this description into the Methods section to clearly explain how LAI is simulated and how it interacts with carbon allocation and canopy structure within the model framework.

- *Explained in model description section (Lines 173-176).*

Reviewer Comment: L342: How do you defined C4 and C3 grasses, as both types grasses found abundantly along the gradient.

Response: In this simulation, we used default C_3 and C_4 grass with default parameters as explained in Peng et al. (2024). In our model, C_3 and C_4 grasses are represented as distinct PFTs that differ in their photosynthetic pathways and associated physiological traits. C_4 grasses are characterized by higher temperature optima for photosynthesis, greater water-use efficiency, and reduced photorespiration, whereas C_3 grasses have lower temperature optima and are more competitive under cooler and less water-limited conditions. These differences are reflected in PFT-specific parameterization of photosynthesis, temperature response functions, and phenology. The relative abundance of C_3 and C_4 grasses along the elevation gradient therefore emerges from the interaction between climate (particularly temperature), competition, and disturbance within the model. We will elaborate on the Method section to briefly discuss C_3 and C_4 grasses' PFTs.

- *Added in vegetation model description and customization section (Lines 188-191).*

Reviewer Comment: Figure 4: For other parameters such as above-ground biomass and bole height, but just showing simulated LAI don't provide any insights whether it works well or not.

Response: We agree that only simulated LAI is currently shown. Independent PFT-level LAI observations are not available along the elevation gradient, which limits a direct validation of simulated LAI. As an alternative, we will compare simulated LAI with MODIS LAI products and carefully discuss uncertainties arising from differences in spatial scale and aggregation.

- *Monthly mean LAI from MODIS and simulated LAI boxplot diagram with binned elevation gradient by 200m interval added in top panel of Figure 4 to compare the spatial variability in LAI across the simulated elevation gradient despite difference in spatial scale (Lines 396-397).*

Reviewer Comment: Figure 5 caption: source of observed data should be acknowledged.

We will add the source in the figure caption.

- *Maharjan et al., 2021 added as reference for observed bole height added in figure caption (Line 414).*

Reviewer Comment: L451: Is there any pine species up to 4500 m? In my understanding, it is totally wrong.

We agree that *Pinus* species do not extend to ~4500 m in the Himalayas. In our model, three coniferous PFTs represent distinct elevational adaptations: (i) a sub-tropical coniferous PFT representing *Pinus roxburghii*, which dominates approximately between 400–2000 m; (ii) a temperate coniferous PFT representing *Pinus wallichiana*, which dominates approximately between 1800–3600 m; and (iii) an alpine coniferous PFT representing cold-tolerant conifer strategies characteristic of higher elevations. We will revise the manuscript to remove specific references to *Pinus* at higher elevations and instead describe the pattern in terms of evergreen conifer functional types. We will further clarify that conifer signals at higher elevations are more consistent with taxa such as *Abies* and *Juniperus*, and emphasize that the model results reflect functional responses to climatic constraints rather than species-level distributions.

- *The text has been edited to indicate that evergreen alpine coniferous PFTs (Abies and Juniperus) constitute one of the dominant groups in terms of relative contribution to FPC (Lines 553-556).*

Reviewer Comment: L467: As authors performed compare the patterns separately, thus, in my understanding, not well evaluated the complex interactions. To evaluate the overall interactions, it is wise to quantify the relative importance of different biotic and abiotic variables on PFTs.

We acknowledge that we did not explicitly quantify the relative importance of individual biotic and abiotic drivers using statistical attribution methods. Instead, in this study, complex interactions between biotic and abiotic variables are evaluated as emergent phenomena by analyzing PFTs' structure, composition, and productivity along the elevation gradient. Signals of interaction arise from the combined effects of plant competition, trait-based parameterization, and environmental constraints (particularly temperature) operating simultaneously along the elevation gradient, leading to emergent patterns in PFT composition, structure, productivity, and performance in abundance. By analysing PFTs' performance under competitive and stress-dominated conditions, we infer how biotic interactions and abiotic limitations jointly shape structure, composition, and productivity. Formal quantification of relative importance is unfortunately out of scope for this study. We will clarify this distinction in the manuscript and highlight such analyses as a potential avenue for future work in limitation section.

Reviewer Comment: L521-522: Actually, high elevations, particularly above 3000 m deciduous Betula utilis (Himalayan birch) is one of the most dominant species. Thus, this statement could be problematic.

Response: We will edit it and elaborate on the discussion section to acknowledge how generalized PFTs can have limitations in representing individual species in limitation sections.

- *The text has been revised accordingly to avoid this overgeneralization but focused on discussion mechanism that drives PFTs dominance in particular elevation (Lines 585-611).*
- *Limited section expanded to explain limitation of PFTs to represent local ecological variability (Lines 665-675).*

Reviewer Comment: L633: Not well discussed whether simulated results synchronized with observed data or not and reasons behind these.

Response: We will revise it.

- *Edited (Lines 702-707).*

Reviewer #2 Comment Response Sheet

Reviewer comments are in normal types. Our responses are in normal type (red colour) and refereeing section, and line number are in *Italics (Blue Color).*

Reviewer Comment: Overall, this manuscript makes a valuable contribution to understanding how competitive interactions shape plant community assembly across a large elevational gradient in the Central Himalayas, using a dynamic vegetation modelling framework that explicitly represents multiple plant functional types (PFTs). The integrative approach combining productivity, vegetation structure, and competition indices to examine vegetation–environment interactions is both timely and scientifically relevant. The study addresses an important gap in regional-scale ecosystem modelling for complex mountain systems. With some targeted revisions and clarifications, the manuscript could be further strengthened.

We thank the reviewer for this encouraging assessment. We agree that the manuscript would benefit from targeted clarification and refinement, and we have outlined below the specific revisions to implement in response to each point.

Reviewer Comment: One point that may benefit from refinement concerns the statement that PFT functional diversity declines monotonically with elevation while compositional evenness increases (L38–39). This pattern may hold under a strictly linear interpretation of the elevational gradient; however, empirical evidence from the Himalayas often suggests a mid-elevation peak in species and functional diversity, with lower diversity in both lowland plains and high alpine zones. This well-documented hump-shaped relationship could be acknowledged and discussed, particularly to clarify how the model results align with, or diverge from, observed diversity patterns.

We have acknowledged this important ecological nuance in the elevation gradient. In the manuscript (Lines 547–553), we note the widely reported hump-shaped (mid-dominance effect) relationship between PFT diversity and compositional evenness, and how our simulated result reflected this pattern. We will further expand this section (discussion) to explain how these simulated results, together with generalized PFT representations and large-scale climatic filtering, align with empirically observed mid-elevation diversity peaks.

- *Abstract sentence edited to included mid-elevation diversity (Lines 34-36).*
- *The influence of mid-domain effects and the emergence of a hump-shaped functional diversity pattern, along with the consistency of the simulated results with these patterns, are discussed in the Discussion section (Lines 599-611).*

Reviewer Comment: Regarding Figure 1, the source of the vegetation type data is unclear. The referenced web link does not appear to host the dataset used, and the map seems more consistent with vegetation layers produced under the Land Resource

Mapping Project of the 1980s. Clarifying the exact data source and citation would improve transparency and reproducibility.

We will clarify the data source used for Figure 1 by explicitly stating the origin of the vegetation map (e.g., Land Resource Mapping Project–derived datasets) in both the figure caption and the Methods section and add an appropriate citation.

- *Figure 1 updated with inclusion of elevation range (Earth Resources Observation and Science (EROS) Center, 2017) and ecoregion (Olson et al., 2001). The map showing spatial distribution of forest area ((Land Resource Mapping Project, 1986) along the studies elevation range shifted to supplementary materials.*

Reviewer Comment: In Lines 201–212, the allometry dataset is referred to as "BADD," whereas the correct name is the Biomass and Allometry Database (BAAD). This appears to be a minor typographical issue but should be corrected.

We acknowledge this typographical error and will correct the database name to Biomass and Allometry Database (BAAD).

- *Corrected (Line 227).*

Reviewer Comment: For Figure 2, I found the datasets and labels somewhat difficult to interpret. Lines 303–305 indicate that two estimates of GPP are being compared, but it is not entirely clear whether one of the point types represents GPP estimates from Bi and Zhou. If my reading of the figure is correct, the mean latitudinal trends appear similar at lower latitudes, with increasing divergence at higher latitudinal bands. It may be helpful to explicitly plot and compare the mean GPP trends for both datasets, or alternatively to clarify in the text whether the intention is simply to demonstrate broad similarity in overall trends.

GPP estimates from Bi and Zhou (2022), produced using a leaf light-use efficiency model for the period 2010–2020, are treated as an independent dataset for evaluating model performance. The purpose of this comparison is to assess the model's ability to capture broad spatial patterns in GPP. We will elaborate on this in the Methods section (Simulation protocol and model validation) and clarify that the intent of the figure is to demonstrate overall agreement in large-scale GPP patterns along the elevation gradient, with latitudinal variation used as a complementary spatial descriptor. We will also revise the figure caption, legend, and accompanying text to clearly specify the datasets being compared.

- *Figure caption and legend edited (Figure 2).*
- *Propose of comparing two datasets (GPP from Bi and Zhou (2022) and simulated using model) added in methos section (Lines 290-294).*

Reviewer Comment: In Lines 318–320, the manuscript attributes underestimated biomass regions primarily to dominance by the Rhododendron PFT. However, recent studies report that these regions are often dominated by Fir and Brown Oak in addition to Rhododendron. Including these species in the discussion would strengthen the interpretation, especially given that generalized PFT representations may not fully capture plot-level heterogeneity. These species achieve high biomass through contrasting strategies Brown Oak through high wood density, Fir through large stem volume despite lower wood density, and Rhododendron through high stem density which could help explain discrepancies between simulated and observed biomass.

We acknowledge that the PFTs we have designed do not represent individual species but rather dominant plant strategies and the ranges of functional traits that enable adaptations across diverse climatic conditions. We will expand the discussion section to include Fir and Brown Oak as important contributors to high biomass in these regions, alongside *Rhododendron*. We will also briefly discuss in the limitations section how contrasting biomass accumulation strategies occur across the elevation gradient, which may not be fully captured by generalized PFT representations, potentially contributing to observed–simulated discrepancies.

- *Discussion section expanded to explain incorporate reasons of plot-level heterogeneity associated with locally abundant species such as brown aak, Abies and Rhododendron (Lines 546-558).*
- *Limited section expanded to explain limitation of PFTs to represent local ecological variability (Lines 665-675).*

Reviewer Comment: For Figure 3 and the associated text, it is important to note that the observed carbon mass data represent forested areas only, whereas the model simulations cover the entire landscape, including non-forested vegetation. This mismatch may partly explain why the simulated carbon mass does not capture some extreme observed values. Several high-biomass observations at latitudes above ~28.5° occur at relatively low elevations (e.g., valley bottoms), where distinct topoclimatic conditions favor high biomass accumulation. Incorporating this perspective could help explain the observed relationship between biomass and simulated patch age (L324–327).

We have noted that in the discussion and limitation section. We will explicitly state in the methods section that these observations represent only the forest area. We will expand the discussion sections and add clarifying text to explain why high biomass is observed at higher elevations at the plot-level measurement. We will also elaborate limitation section on the role of topographic and topoclimatic variability in shaping biomass patterns and discuss potential avenues for future model development aimed at better capturing such fine-scale variability within a landscape-scale modelling framework.

- *Discussion section expanded to incorporate local level species abundance created by topography (Lines 571-581 and 599-611).*

- *Limitation section edited to further emphasis topography variability a higher elevation and associated difference in biomass accumulation (Lines 665-660).*

Reviewer Comment: I also note that bole height evaluation relies on observations reported by Maharjan et al. (2021), but it is not entirely clear how these observations correspond to the simulated bole height derived from the "dynamic bole height scheme for each cohort" described in Lines 166–167 using the Tallo database. Clarifying this linkage would be helpful. Additionally, in Figure 5, simulated bole heights appear systematically lower than observed values for most PFTs. A brief discussion of potential causes such as parameterization choices, structural constraints in the model, or uncertainties in observational data would strengthen the evaluation.

The Tallo data set was used to parameterize the model, which includes an adaptive allometry scheme (Paudel et al., 2026), in which allometric relationships are responsive to growth conditions. The bole height observed by Maharjan et al. (2021) is used for evaluating model performance. We disagree with the claim that simulated height is systematically lower than observed, as simulated PFTs have a broader bole-height range than observed bole height. We note that available observational bole-height data are limited in spatial coverage and largely restricted to dominant species and elevation ranges, which introduces uncertainty into direct comparisons with landscape-scale PFT simulations. We will explicitly acknowledge these limitations and clarify the interpretation of bole height comparisons in both the Results and Discussion sections.

- *Method section expanded to explain used of Maharjan et al., (2021) data for evaluating model performance (Lines 298-304).*

Reviewer Comment: For Figures 6, 9, and 10, the x-axis appears to represent elevation rather than latitude. If so, the axis labels should be corrected. In Figure 6, using contrasting line types and colors (rather than a color gradient alone) could improve readability and facilitate matching legend entries to plotted lines. In Figure 10, arranging panels in a single column with a shared x-axis may allow clearer comparison among classes.

We will correct the axis labelling to ensure consistency between the figures and the text. We will revise Figure 6 by using distinct line types for different PFTs to improve readability, and we will revise Figure 10 by arranging the panels in a single column.

- *Figure 6 and 8 edited for clarity with distinct line types and colour difference by temperature group.*
- *Figure 10 arranged in single column.*

Reviewer Comment: In Lines 388–389, the text refers to latitude, while the figure shows elevation on the x-axis. Although latitude and elevation are correlated in this region, consistency between text and figures is important. Additionally, the color scheme used to distinguish PFTs makes it difficult to visually separate groups. Using similar hues for tropical and subtropical PFTs, or alternatively a more strongly contrasting color palette, may improve interpretability and alignment with the results narrative.

We will edit the text and use contrasting colors across PFTs within the same climatic range to improve readability.

- *Both figures (Figure 6 and 8) caption and text have elevation as explanatory variable.*

Reviewer Comment: I also noticed some inconsistencies in terminology, such as the use of “above-ground carbon biomass,” “above-ground carbon mass,” and “above-ground biomass.” Standardizing terminology throughout the manuscript would improve clarity.

We will review the manuscript and remove any inconsistencies in terminology.

- *Consistency in above-ground biomass maintained across the manuscript.*

Reviewer Comment: Finally, the discussion could be strengthened by incorporating additional relevant literature. For example, statements in Lines 501–504 could be supported by recent studies demonstrating the role of topoclimatic variability in shaping forest carbon stocks in the Central Himalayas, including studies that use the same or comparable plot-level datasets as those employed here.

We will revise the discussion section by adding relevant literature, with particular emphasis on the role of temperature and associated topographic variability in shaping ecosystem productivity along the Himalayan elevation gradient.

- *Whole discussion section edited with addition of new citation.*
- *Lines 501-504 edited and supported by recent studies (Lines 548-558).*