# Revision notes

- The comments to authors are in non-italicized text
- Response to comments and summary of revision by authors are in italics and blue color. All the page and line numbers shown in Revision notes are in agreement with the revised manuscript.
- The changes are highlighted in red color in the revised manuscript.

**Editor：**

*We sincerely thank you for the careful handling of our manuscript and the constructive summary of the reviewers' comments. We are sincerely grateful for the insightful issues that you raised on the basis of the two reviewers' comments. We have carefully considered each of these points, and our point-by-point responses are provided below.*

**Comment 1: Linkage of the deposited data to the manuscript**

***Response:*** *Thank you for your suggestion. In the new version, we have revised the Data Availability section to explicitly state which materials are deposited in the ScienceDB repository and where the other input data are documented in the manuscript, as follows: "The model simulation outputs (NPP, ET, APLK, DMRP, and CWHRI) generated in this study are openly available in the Science Data Bank (ScienceDB) at https://doi.org/10.57760/sciencedb.45502. The meteorological forcing data are described in Section 2.4.1, the soil hydraulic parameters in Section 2.4.2, and the eco-physiological parameters in Table S1."*

*This information can be found in the Lines 864-869 in the new version.*

**Comment 2: Interpretation of the XGBoost variable-importance analysis**

***Response:*** *Thank you for your comment. We fully agree that variable-importance metrics should not be interpreted as evidence of causal relationships. In the new version, we have revised statements regarding the XGBoost variable-importance results in the Abstract, Methods, Results, and Discussion, as follows:*

*(1)"The CWHRI is projected to decline by 23%–44%, and exhibit a southeast-to-northwest decreasing gradient, which is dominated by NPP, with a secondary contribution from water-related environmental factors.". This information can be found in the Lines 41-44 in the new version.*

*(2)"The relative importance of six meteorological variables (mean annual precipitation, MAP; mean annual temperature, MAT; mean annual maximum temperature, $MAT_{max}$; mean annual minimum temperature, $MAT_{min}$; mean annual vapor pressure deficit, VPD, mean annual soil water storage, SWS) for predicting CWHRI was assessed using*

*XGBoost." and "Variables with high relative importance identified by the XGBoost model were interpreted as factors statistically associated with the dynamic changes in CWHRI within the modelling framework, rather than as evidence of causal relationships.". Those information can be found in the Lines 425–429 and Lines 432–434 in the new version, respectively.*

*(3)"To deepen understanding of the factors associated with CWHRI variation and how the relative importance of these factors changes, Fig. 10b presents an XGBoost-based assessment of the relative importance of six environmental factors for regions with different risk levels during the baseline and future periods. In the baseline period, VPD and SWS showed the highest relative importance among the six environmental factors. Specifically, the relative importance of VPD was 86% in the low-risk zones, and of SWS was 42% and 61% in the medium- and high-risk zones, respectively. Under the SSP1–2.6 scenario, VPD continued to show the highest relative importance but its relative importance decreased by 49% and 59% in the low-risk zones during the NFP and MFP, respectively. MAP showed the highest relative importance value in the low-risk zones during the FFP, with a value of 56%. In the medium-risk zones, MAP showed the highest relative importance during the NFP and MFP, whereas SWS showed the highest relative importance during the FFP. In high-risk zones, MAP exhibited the highest relative importance in all three periods, ranging from 62% to 81%. Under the SSP2 – 4.5 scenario, $MAT_{max}$ showed the highest relative importance values in the NFP and FFP in low-risk zones, with values of 51% and 60%, respectively. MAP, VPD and $MAT_{max}$ collectively accounted for 91% of the relative importance in the MFP. In the medium-risk zones, MAP showed the highest relative importance in the NFP and MFP, while $MAT_{max}$ showed the highest relative importance in the FFP. In high-risk zones, MAP showed the highest relative importance in all three periods, ranging from 67% to 76%. Under the SSP5–8.5 scenario, VPD showed the highest relative importance in low-risk zones during all three future periods, with values exceeding 50%. In medium-risk zones, $MAT_{max}$ showed the highest relative importance during the NFP and MFP, with values exceeding 70%. VPD showed a relative importance of 99% during the FFP. In high-risk zones, MAP showed the highest relative importance in all three periods, ranging from 49% to 68%. Generally, the relative importance of MAP and $MAT_{max}$ increased from the baseline period into the future, suggesting that moisture- and temperature-related variables may become increasingly associated with CWHRI variation under future climate change.". This information can be found in the Lines 659–687 in the new version.*

*(4)"The environmental variables associated with CWHRI are related to the availability of water resources. During the baseline period, MAP, VPD, and SWS showed the highest relative importance. In all SSPs, the relative importance of MAP and $MAT_{max}$ will increase." and "Accordingly, these factors showed the highest relative importance for CWHRI variability. ". Those information can be found in the Lines 791–794 and Lines 797–798 in the new version, respectively.*

**Comment 3: Proofreading the revised manuscript to ensure clarity, consistency, and overall readability**

***Response:*** *We have carefully proofread the entire revised manuscript. In the new version, we have unified the abbreviations throughout the text, ensuring that each abbreviation is defined at its first appearance and used consistently thereafter, including CWHRI, DMRP, APLK, and PT among others. We have also unified the expressions of the SSP scenarios, including SSP1–2.6, SSP2–4.5, and SSP5–8.5.*

**Comment 4: Readability of Figures 3 and 4**

***Response:*** *Thank you for your comment. We apologize for the poor readability of the original figures. Figure 3 has been enlarged overall. In Figure 4, the histograms have been enlarged to improve readability. These revisions are shown in the revised Figures 3 and 4, as follow:*

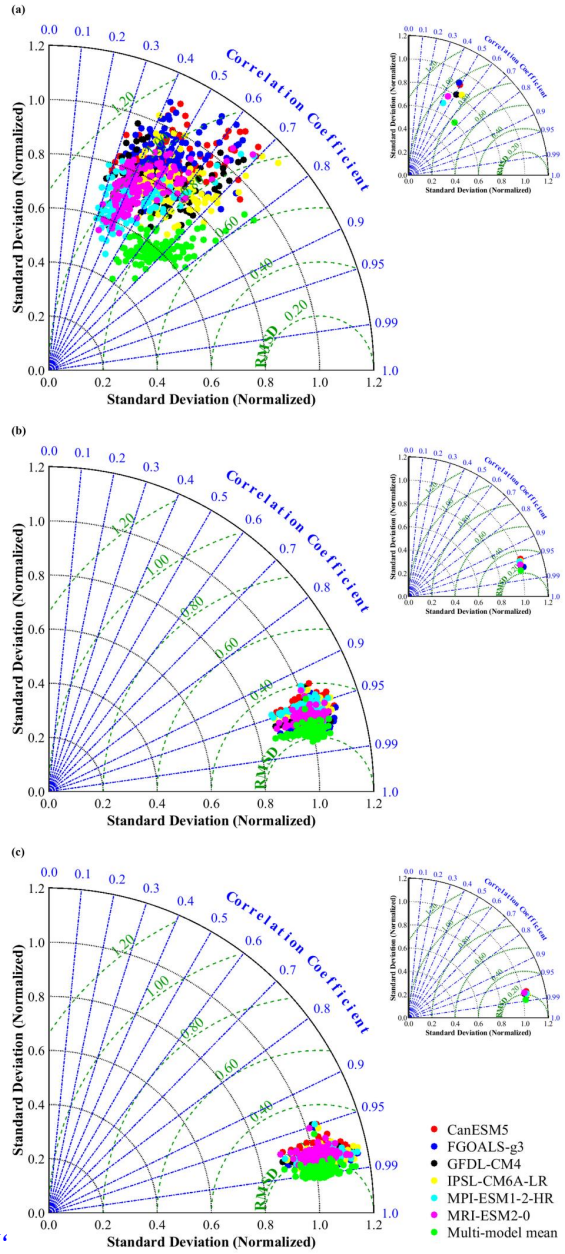



***Figure 3.*** *Taylor diagrams of monthly precipitation (a), monthly maximum temperature*

*(b), and monthly minimum temperature (c) at 130 meteorological stations in the study area from 1979 to 2014. The upper-right plot represents the mean values across all stations. Each color corresponds to a climate model or multi-model ensemble. The green dashed line represents the root mean square error (RMSE).".*
*This information can be found in the Lines 501–506 in the new version.*

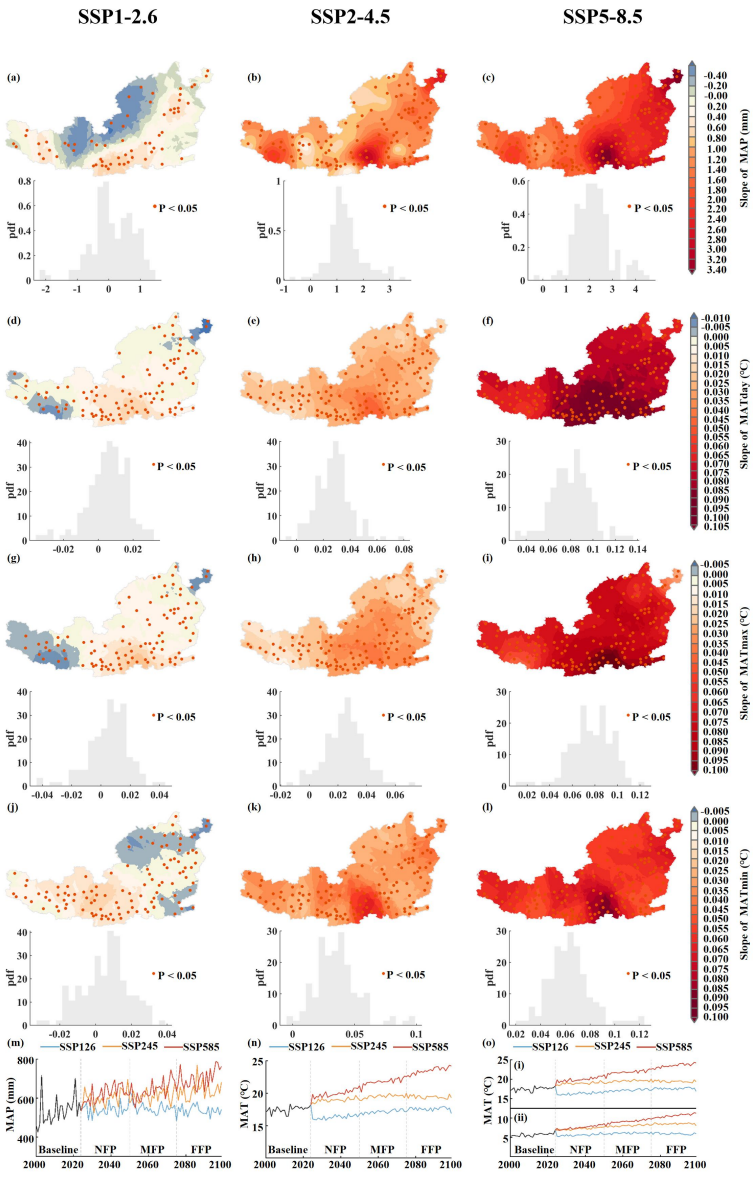



***Figure 4.*** *Spatiotemporal dynamics in mean annual precipitation (MAP), mean annual temperature (MAT), mean annual maximum temperature ($MAT_{max}$), and mean annual minimum temperature ($MAT_{min}$) within the study area from 2000 to 2099 under SSP1–2.6, SSP2–4.5, and SSP5–8.5 scenarios: (a)-(l), spatial distributions of linear trend slopes for each variable under the three scenarios, with probability density functions (PDFs) shown in the lower-left corner; (m)-(o), temporal variation of MAP, MAT, $MAT_{max}$ (i), and $MAT_{min}$ (ii) under all SSP scenarios.".*
*This information can be found in the Lines 541–548 in the new version.*

**Reviewer #1:**

**The study is timely and potentially valuable because it integrates carbon sequestration, water use and hydraulic risk across the Loess Plateau. However, several methodological definitions, validation procedures and interpretations need clarification. I would recommend moderate revision.**

**Moderate revision comments**

**1. Independence of model calibration and validation**
**Lines 335–340 state that several important hydraulic parameters were determined from transpiration observed at the Ansai site in 2024. However, lines 408–419 use the 2024 data again to evaluate model performance. This means that at least part of the reported evaluation is calibration rather than independent validation. The authors should clearly distinguish calibration and validation datasets. Ideally, calibrate against 2024 and validate independently against 2025. The corresponding statistics should also be reported separately.**

***Response**: Thank you for your advice. In the new version, we have revised the description of the calibration and validation datasets. The observations collected at the Ansai site in 2024 were used to calibrate the hydraulic parameters of the BBGC-Sperry model, whereas the observations collected in 2025 were used for model validation, as follows:*

*"2.3.1 Hydrological process calibration and validation*

*At the single-site scale, we established an experimental PT plantation site in Ansai District, Shaanxi Province on May 1, 2024. This area is a key zone for soil and water conservation projects. Field observations were conducted during the 2024 and 2025 growing seasons (1 May to 30 September), including daily transpiration ($T_{day}$), SWC, and midday leaf water potential ($\Psi_{md}$). The measured data during the 2024 growing season were used to calibrate the hydraulic parameters, whereas those measured during the 2025 growing season were used for model validation." This information can be found in the Lines 219–226 in the new version.*

*In addition, we also revised the relevant descriptions in Section 3.1 to ensure consistency with the updated calibration and validation framework, as follows:*
*"Measurements of $T_{day}$, SWC (0–500 cm), and $\Psi_{md}$ at the Ansai site during the 2024 growing season (May 1 to September 30) were used to calibrate the BBGC-Sperry model. As shown in Fig. 2a, c, and e, the $R^2$ between simulated and observed $T_{day}$ was 0.91, with NSE, MAE, RMSE, and rRMSE values of 0.90, 0.16 mm $d^{-1}$, 0.23 mm $d^{-1}$, and 13.61%, respectively. For SWC (0–500 cm), the $R^2$ value between simulated and observed values was 0.97, with NSE, MAE, RMSE, and rRMSE values of 0.97, 0.00 $cm^3$ $cm^{-3}$, 0.00 $cm^3$ $cm^{-3}$, and 1.75%, respectively. The $R^2$ value for $\Psi_{md}$ between simulated and observed values was 0.97, with NSE, MAE, RMSE, and rRMSE values of 0.98, 0.09 MPa, 0.09 MPa, and -7.42%, respectively.*

*Validation of the BBGC-Sperry model included hydrological and growth processes.*

*Hydrological validation was conducted based on $T_{day}$, SWC in the 0–500 cm profile, and $\Psi_{md}$ at the Ansai site during the 2025 growing season (May 1 to September 30), as well as multi-point transpiration data during the growing season. As shown in Fig. 2b, d, and f, the $R^2$ between the simulated and observed $T_{day}$ was 0.77, with NSE, MAE, RMSE, and rRMSE values of 0.67, 0.24 mm $d^{-1}$, 0.33 mm $d^{-1}$, and 27.98%, respectively. For SWC (0−500 cm), the $R^2$ value between the simulated and observed values was 0.94, with NSE, MAE, RMSE, and rRMSE values of 0.89, 0.00 $cm^3$ $cm^{-3}$, 0.00 $cm^3$ $cm^{-3}$, and 3.16%, respectively. The $R^2$ value for $\Psi_{md}$ between simulated and observed values was 0.99, with NSE, MAE, RMSE, and rRMSE values of 0.98, 0.11 MPa, 0.11 MPa, and -7.24%, respectively." This information has been added in the Lines 443–462 in the new version.*

*The revised captions of Fig. 2 are as follows:*

*"Figure 2. Comparison of simulated and observed values of daily transpiration ($T_{day}$), average soil water content (SWC) in the 0–500 cm soil profile, midday leaf water potential ($\Psi_{md}$), growing-season transpiration (T), and aboveground biomass (AGB) in Pinus tabuliformis Carrière plantations. (a), (c), and (e) show the calibration results (2024), while (b), (d), and (f) show the validation results (2025) for $T_{day}$, SWC, and $\Psi_{md}$, respectively. (g) shows the validation of growing-season transpiration (T) across multiple sites, with black and orange points representing observations obtained from the sap flow method and water balance estimates, respectively. (h) shows the validation of aboveground biomass (AGB)."This information can be found in the Lines 477–485 in the new version.*

**2. Definition and validation of the hydraulic mortality threshold**

**Lines 345–355 use an annual average loss of whole-plant hydraulic conductance of 60% as the mortality threshold. However, mortality thresholds are commonly defined using loss of xylem conductivity at the organ or tissue level, often based on maximum or sustained hydraulic damage rather than an annual mean. The authors need to demonstrate that the cited reference supports applying 60% specifically to annual mean whole-plant hydraulic conductance. It would also be valuable to test the sensitivity of DMRP to alternative thresholds, such as 50%, 60% and 70%.**

***Response**: Thank you for your comment. We acknowledge that the references cited in the original manuscript did not adequately demonstrate the applicability of the 60% threshold to annual-mean, whole-plant hydraulic conductance loss. In the new version, we revised expressions in the threshold based on Sperry and Love (2015) and Tai et al. (2018), which directly support applying the 60% threshold to growing-season-mean, whole-plant conductance loss. In Sperry and Love (2015), k denotes the hydraulic conductance of the entire soil–canopy continuum (i.e., whole-plant conductance), and the "chronic stress hypothesis" explicitly concerns sustained ("chronically high") PLC rather than peak instantaneous damage; notably, authors themselves applied the ~60–70% risk band to growing-season median daily PLC (their Fig. 8), a metric directly analogous to our APLK. Tai et al. (2018) explicitly reported "the average percentage*

*loss of whole-plant hydraulic conductance (PLK) during the growing season for every year" and used 60% as the mortality-risk threshold ("60% seasonal average PLK"), a metric identical to our APLK. We revised some expressions in the section of 2.5 Assessment of drought-induced mortality risk as follows:*

*"Annual average PLK (APLK, %) was then determined to represent the inter-annual variation in plant hydraulic safety. It was calculated as the arithmetic mean of daily PLK values during the modeled growing season of each year. The modeled growing season was defined as days with leaf carbon pool greater than zero (LeafC > 0). Previous studies have suggested that sustained losses of whole-plant hydraulic conductance exceeding 60% are associated with a high risk of drought-induced mortality (Sperry and Love, 2015; Yan et al., 2022; Zhang et al., 2024b). Tai et al. (2018) further applied a growing-season mean whole-plant PLK threshold of 60% for evaluating drought-induced mortality risk. We also adopted this threshold for assessing drought-induced mortality risk." This information can be found in the Lines 376–384 in the new version.*

***Reference:***


*Sperry, J. S. and Love, D. M.: What plant hydraulics can tell us about responses to climate-change droughts, New Phytol., 207, 14–27, https://doi.org/10.1111/nph.13354, 2015.*

*Tai, X., Mackay, D. S., Sperry, J. S., Brooks, P., Anderegg, W. R. L., Flanagan, L. B., Rood, S. B., and Hopkinson, C.: Distributed plant hydraulic and hydrological modeling to understand the susceptibility of riparian woodland trees to drought-induced mortality, Water Resour. Res., 54, 4901–4915, https://doi.org/10.1029/2018WR022801, 2018.*

*Yan, X. Y., Zhang, Z. D., Huang, M. B., Zhao, X. F., Yang, F., and Wu, X. F.: The impact of climate change on growth and drought-induced mortality risk of Robinia pseudoacacia plantations along a precipitation gradient on the Chinese Loess Plateau, Agric. For. Meteorol., 325, 109160, https://doi.org/10.1016/j.agrformet.2022.109160, 2022.*

*Zhang, Z. D., Liu, T. H., Huang, M. B., Yan, X. Y., Liu, M. H., Yan, J. H., Chen, F. Y., Yan, W., and Niu, J. Q.: Spatial pattern of drought-induced mortality risk and influencing factors for Robinia pseudoacacia L. plantations on the Chinese Loess Plateau, Forests, 15, 1477, https://doi.org/10.3390/f15081477, 2024b.*


*Furthermore, we have added a sensitivity analysis of DMRP using three hydraulic mortality thresholds (50%, 60%, and 70%). The results showed that DMRP values were highly correlated among the three thresholds, the rankings of high-risk sites were largely consistent, and the temporal patterns of DMRP under different climate scenarios were preserved across thresholds. These results demonstrate that the assessment of drought-induced mortality risk is relatively insensitive to the choice of hydraulic mortality threshold and support the use of the 60% threshold in this study.*

*The corresponding results are presented in the Supplementary Material (Fig. S3). We also have added a description in Section 2.5:" To evaluate the sensitivity of DMRP estimates to the hydraulic mortality threshold, we further calculated DMRP using three thresholds (50%, 60%, and 70%) and compared the resulting spatial patterns and temporal variations among thresholds (Fig. S3).", which can be found in Lines 385–388.*

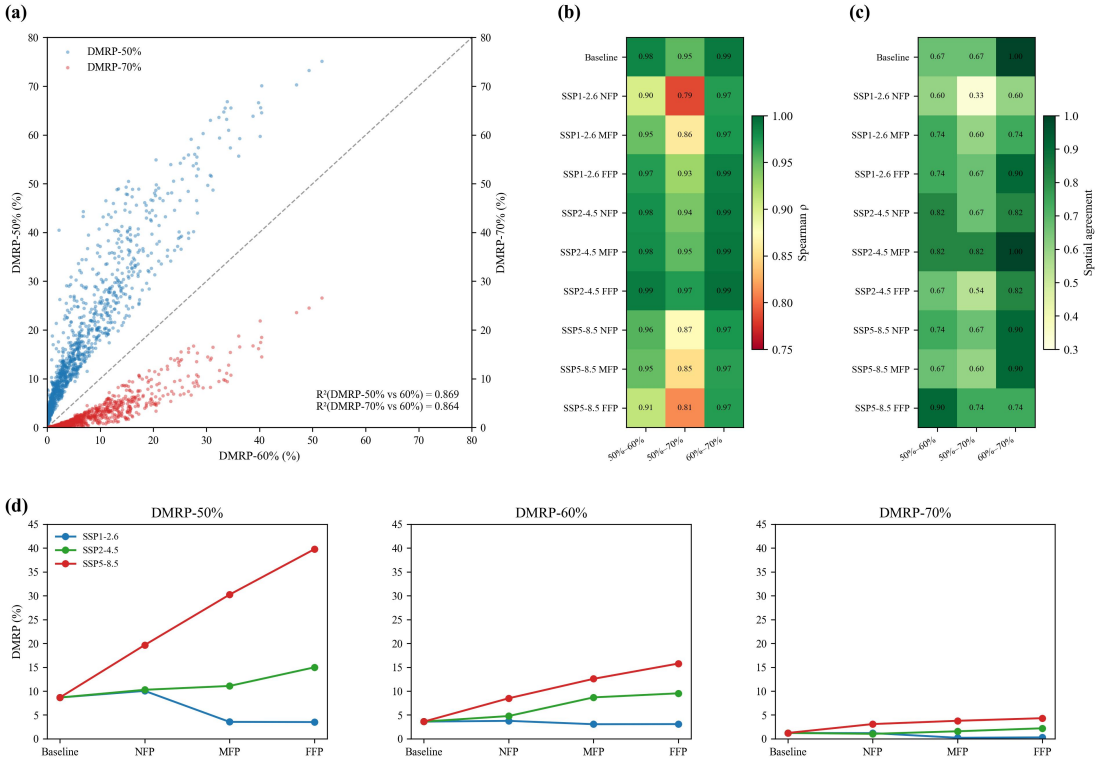



***Figure S3.*** *Sensitivity of drought-induced mortality risk (DMRP) to the choice of the hydraulic mortality threshold (50%, 60%, and 70%). (a) Comparison of DMRP values among hydraulic mortality thresholds (n = 1300 data points; blue points, left axis: DMRP-50% vs. DMRP-60%; red points, right axis: DMRP-70% vs. DMRP-60%; dashed line indicates the 1:1 reference). (b) Spearman rank correlation coefficients of site-level DMRP between thresholds for each period. (c) Spatial agreement of the top-20 highest-risk sites identified under different hydraulic mortality thresholds. (d) Temporal changes of DMRP-50%, -60%, and -70%. Baseline, NFP, MFP, and FFP are the same as defined in Fig. 5.*

### 3. Calculation of APLK needs clarification

**Lines 344–355 do not explain precisely how daily PLK values were converted into APLK. Was PLK averaged across the entire calendar year, the growing season, or only days with active transpiration? If embolism was assumed to be irreversible within a growing season, as stated in lines 349–351, clarify whether daily could subsequently recover as soil moisture increased. The calculation must be consistent with the assumed irreversibility of hydraulic damage.**

***Response**: We appreciate your comment. We revised expressions in the section of 2.5 Assessment of drought-induced mortality risk as follows:*

*"We assumed the xylem embolism of PT could not be refilled during the growing season, and that full hydraulic recovery occurs at the start of the next growing season due to the generation of root and/or stem pressure and the new growth of plant tissues in the spring (Choat et al., 2018). Under this assumption, daily PLK did not decrease following soil moisture recovery after drought events. Annual average PLK (APLK, %) was then determined to represent the inter-annual variation in plant hydraulic safety. It was calculated as the arithmetic mean of daily PLK values during the modeled growing season of each year. The modeled growing season was defined as days with leaf carbon pool greater than zero (LeafC > 0). " This information can be found in the Lines 371–379 in the new version.*

***Reference:***

*Choat, B., Brodribb, T. J., Brodersen, C. R., Duursma, R. A., Lopez, R., and Medlyn, B. E.: Triggers of tree mortality under drought, Nature, 558, 531–539, https://doi.org/10.1038/s41586-018-0240-x, 2018.*

**4. Water-balance calculation and transpiration validation**

**Lines 255–261 combine transpiration estimates derived from sap flow and a residual water-balance method. Residual estimates can contain accumulated errors from precipitation, runoff, evaporation and soil-water-storage measurements and are not equivalent in uncertainty to direct sap-flow observations. The sign convention for also needs clarification: if , transpiration should normally be calculated as . Please report results separately by measurement method or account for their differing uncertainties.**

***Response**: We appreciate your comment. We revised the description of the regional-scale validation dataset as follows:*

*"For regional-scale validation, we also collected observational data on the transpiration (T) during the growing season in the study area's PT plantations. A total of 48 T values were measured, covering nine meteorological stations, using two methods: (1) stem sap flow was measured using the heat probe method and converted to T (n=23); and (2) T was calculated using the water balance equation based on growing season precipitation (Pr, mm), runoff (R, mm), soil evaporation (E, mm), and the change in soil water storage ($\Delta S=SWS_{end}-SWS_{start}$, mm) during the growing season: $T = P_r-R-E-\Delta S$ (n=25). Considering the different uncertainty sources associated with the two observation approaches, model validation was conducted separately for sap flow measurements and water-balance-based transpiration estimates." This information can be found in the Lines 285–294 in the new version.*

*In addition, we also revised the relevant descriptions in Section 3.1 as follows:*

*"Fig. 2g shows that the $R^2$ between the simulated and observed T exceeded 0.7 for both sap flow measurements and water balance estimates. The NSE, MAE, RMSE, and rRMSE values for the sap flow measurements were 0.76, 23.69 mm, 34.26 mm, and 17.65%, respectively. For water balance estimates, these values were 0.93, 20.52 mm, 27.18 mm, and 10.40%, respectively." This information can be found in the Lines 462–466 in the new version.*

*Furthermore, Fig. 2g was modified accordingly to separately show the transpiration validation results derived from sap flow measurements and water-balance-based estimates, as follows:*

*"*

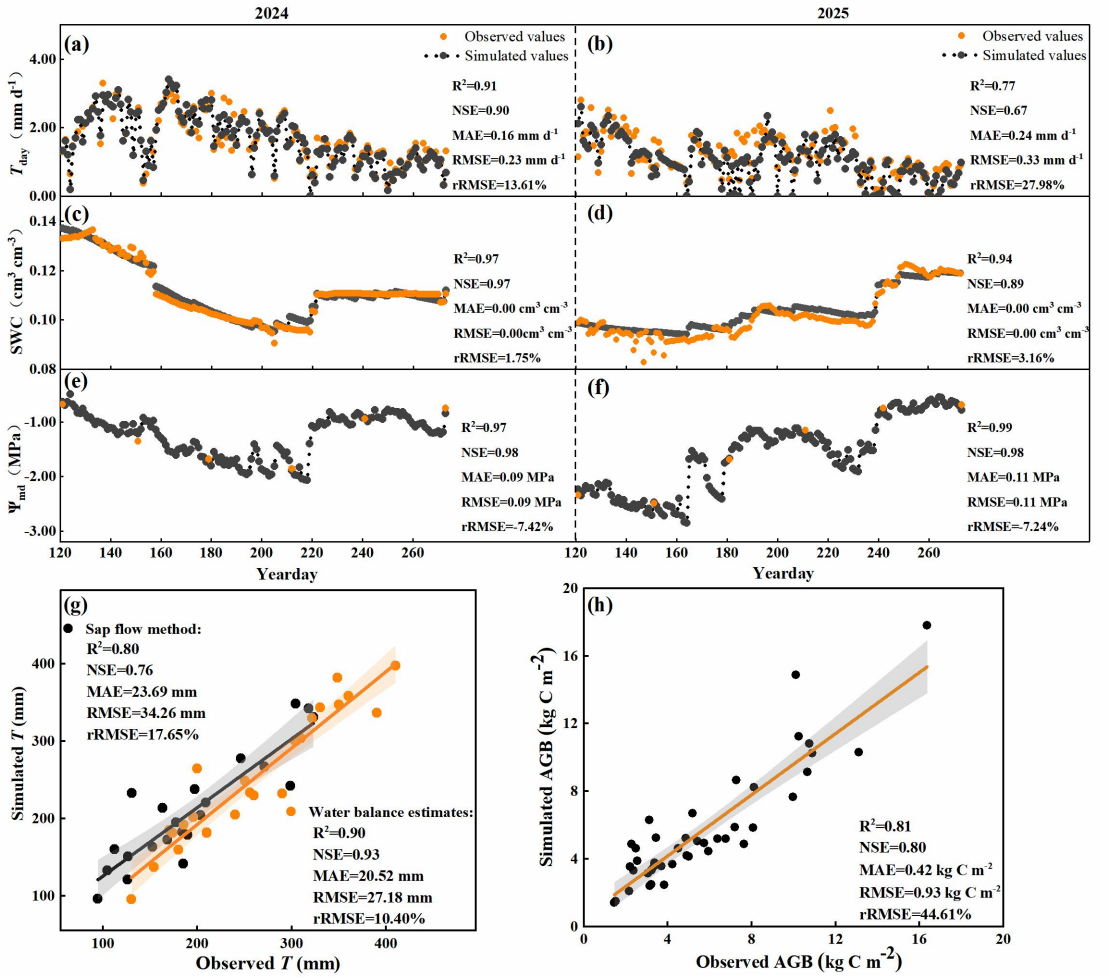



***Figure 2.*** *Comparison of simulated and observed values of daily transpiration (Tday), average soil water content (SWC) in the 0–500 cm soil profile, midday leaf water potential (Ψmd), growing-season transpiration (T), and aboveground biomass (AGB) in Pinus tabuliformis Carrière plantations. (a), (c), and (e) show the calibration results (2024), while (b), (d), and (f) show the validation results (2025) for Tday, SWC, and Ψmd, respectively. (g) shows the validation of growing-season transpiration (T) across multiple sites, with black and orange points representing observations obtained from the sap flow method and water balance estimates, respectively. (h) shows the validation of aboveground biomass (AGB)."*

*This information can be found in the Lines 475–485 in the new version.*

**5. Management recommendations go beyond the tested scenarios**

**Lines 779–785 recommend thinning, mixed planting, slope engineering and vegetation conversion, but none of these interventions were simulated. These are reasonable hypotheses, but the manuscript does not provide direct evidence of their effectiveness. Please frame them as potential strategies requiring further evaluation, rather than recommendations demonstrated by the present analysis.**

***Response**: We appreciate your comment. In the new version, we revised some expressions in the section of 4.4 Limitations and implications as follows:*

*"Future studies should accurately assess the optimal vegetation cover using soil moisture carrying capacity thresholds or early-warning models, and further evaluate the potential of adaptive strategies, including thinning management for existing PT plantations, mixed-species planting in low-risk southeastern regions, slope engineering practices in moderate-risk central and western regions (Yang et al., 2023), and gradual conversion of plantations toward drought-tolerant shrubs or sparse grasslands in high-risk northwestern regions."*

*This information can be found in the Lines 832–838 in the new version.*

***Reference:***

*Yang, K. Q., Ma, Z. H., Wang, K., Li, G. L., Zhang, X. Y., Zhen, Q., and Zheng, J. Y.: Combining infiltration hole and mulching techniques with fish-scale pits effectively improved soil water storage in semiarid areas with shallow buried bedrock (Pisha Sandstone) in China, Catena, 230, 107249, https://doi.org/10.1016/j.catena.2023.107249, 2023.*

**Minor revision comments**

**1. Lines 1–2 and throughout: Please make sure if the pine on the Loess Plateau is Pinus tabuliformis Carrière or Pinus tabuliformisL. Please ensure consistency throughout the title, text, tables and figure captions.**

***Response**: Thank you for your comment, the pine on the Loess Plateau is Pinus tabuliformis* Carrière*. We have revised it throughout the entire manuscript, including the title, text, tables, and figure captions, to ensure consistent use of the scientific name.*

*These information can be found in the Lines1–2, 20, 112, 271–272, 303, 480, 562, 578, 603, 627, 649, 722, 779 in the new version.*

**2. Lines 21–23: Revise the grammar. For example: "However, climate-change impacts on water resources pose a new challenge to the sustainability of restored ecosystems."**

***Response**: Thank you for your comment, we have revised the grammar of this sentence as follows:*

*"However, the impacts of climate-change on water resources pose a new challenge to the sustainability of restored ecosystems." This information can be found in the Lines 21–23 in the new version.*

**3. Lines 22–23: "plantations carbon sequestration" should be "plantation carbon sequestration"**

***Response**: We have revised this sentence as follows:*
*"To clarify the plantation carbon sequestration and water consumption,...". This information can be found in the Line 23 in the new version.*

**4. Lines 28–29: Define clearly whether ET and APLK are annual totals, growing-season values or annual averages. "Annual average percentage loss" is potentially ambiguous.**

***Response**: We revised the definition of ET and APLK in this part:*
*"The validated model simulated the dynamics of annual mean NPP, annual mean actual evapotranspiration (ET) and annual average percentage loss of whole-plant hydraulic conductivity (APLK) for PT plantations at 130 meteorological stations on the Loess Plateau.". This information can be found in the Lines 28–31 in the new version.*

**5. Lines 34–36: The percentage changes should identify their reference period and ranges across scenarios and periods. "Except in the FFP under SSP585" interrupts the interpretation and could be stated more clearly.**

***Response**: Thank you for your comment. We have revised some expressions in this part: "The results indicate that compared with the baseline period, the annual mean NPP is projected to decrease by 4%–27% under all scenario-management combinations, except for the FFP under SSP5–8.5, where it will increase by 8%. Annual mean ET and APLK are projected to increase from 0.05%–61% and 13%–84%, respectively, with the smallest increases under SSP1–2.6 with the NFP and the largest under SSP5–8.5 with the FFP. The CWHRI is projected to decline by 23%–44%, and exhibit a southeast-to-northwest decreasing gradient, which is dominated by NPP, with a secondary contribution from water-related environmental factors.". This information can be found in the Lines 36–44 in the new version.*

**6. Lines 45–47: Correct subject–verb agreement and punctuation: "Plantations … contribute"; insert a space after the full stop before "The."**

***Response**: Thank you for your comment. We have corrected the subject–verb agreement and punctuation in this part: "Plantations ... contribute to global biogeochemical cycles. The...". This information can be found in the Lines 52 in the new version.*

**7. Lines 68–70: Change "may lead to overestimate vegetation growth" to "may**

**lead to overestimation of vegetation growth."**

***Response**: We have revised the expression as follows:*
*"These methodological limitations may lead to an overestimation of vegetation growth,", which have been revised in the Lines 74–75 in the new version.*

**8. Lines 81–83: Remove the repeated "model": "developed the ecohydrological–hydraulic BBGC-Sperry model by coupling…"**

***Response**: Thank you for your comment. We have revised the expression as follows:*
*"Zhang et al. (2020) developed the ecohydrological-hydraulic BBGC-Sperry model by coupling a plant hydraulic process model (Sperry model) with a biogeochemical model (Biome-BGC model).". This information can be found in the Lines 87–89 in the new version.*

***Reference：***

**9. Lines 85–90: Correct grammar in "the Penman–Monteith equation, which used…" to "the Penman–Monteith equation used…"**

***Response**: We have revised the grammar of this sentence as follows:*
*"Wu et al. (2026) improved the Penman-Monteith equation used in the BBGC-Sperry model for evapotranspiration calculations". This information can be found in the Lines 94–96 in the new version.*

***Reference：***

**10. Lines 127–129: Revise "project future conditions the next 75 years" to "project conditions over the subsequent 75 years."**

***Response**: We have revised this sentence as follows:*
*"and to project conditions over the subsequent 75 years under three Shared Socioeconomic Pathways". This information can be found in the Lines 133–135 in the new version.*

**11. Lines 132–134: Remove the space before the full stop after "factors."**

***Response**: Thank you for your comment. We have removed the extra space before the full stop after "factors.". This information can be found in the Lines 140 in the new version.*

**12. Lines 150–151: Soil texture classes should follow standard terminology: "silty clay," "silty clay loam," "silt loam," "loam" and "sandy loam."**

***Response***: *Thank you for your comment. We have revised terminology of soil texture classes as follow: "The predominant soil types include silty clay, silty clay loam, silty loam, loam, and sandy loam". This information can be found in the Lines 155–157 in the new version.*

**13. Lines 169–171: "water, carbon, nitrogen, and nitrogen cycling" repeats nitrogen. Presumably this should be "water, carbon and nitrogen cycling."**

***Response***: *Thank you for your comment. We have revised the expression in this part by removing the repeated "nitrogen,": "water, carbon, and nitrogen cycling." This information can be found in Lines 176 in the new version.*

**14. Lines 179–180: "Canopy transpiration" is incorrectly defined as canopy evaporation plus evaporation from intercepted water. Transpiration and interception evaporation are distinct components and should be described separately.**

***Response***: *We agree with your comment. We accepted your suggestion and revised this part as follows:*

*"Water outflow includes soil evaporation, canopy transpiration, and canopy interception evaporation".*

*This information can be found in Lines 184–185 in the new version.*

**15. Lines 196–208: The carbon and nitrogen-cycle description requires checking. In particular, leaf litter transfers N from plants to soil rather than adding N to the plant pool, and heterotrophic respiration is unlikely to be a constant proportion of new tissue growth. Please verify these statements against the actual model formulation.**

***Response***: *Thank you for your comment. We agree with your comment and have rechecked the model documentation. We revised the descriptions of the carbon and nitrogen cycles according to the actual model formulation. Specifically, we clarified that nitrogen is transferred from plant pools to litter pools through tissue turnover and mortality rather than being added to plant pools. We also revised the description of heterotrophic respiration to indicate that it is calculated based on the decomposition of litter and soil organic matter pools and regulated by soil temperature and water availability. The revised text is as follows:*

*"The N cycle includes plant N pools, soil mineral N pools, and retranslocated N pools. Soil mineral N enters the system through mineralization from soil organic matter, atmospheric wet and dry deposition, and biological N fixation. Plants acquire mineral N through uptake, while N is transferred from plant pools to litter pools through tissue turnover and mortality, with partial N retranslocation occurring before leaf senescence. Mineral N is removed from the system through leaching and volatilization....Autotrophic maintenance respiration is simulated using a $Q_{10}$ function*

*of temperature and tissue nitrogen content. Heterotrophic respiration is calculated from the decomposition of litter and soil organic matter pools, with decomposition rates regulated by soil temperature and water availability".*

*This information can be found in Lines 204–217 in the new version.*

**16. Lines 224–250: Eight sap-flow trees were selected, but Eq. 4 sums from i=1 to 5, Please correct the equation or explain why only five trees were included.**

***Response**: Thank you for your comment. The upper limit of the summation in Eq. 4 was incorrectly set to 5 in the previous version. We have corrected the equation by changing the summation range from i = 1 to 5 to i = 1 to 8: "The average sap flow density ($J_s$; g $m^{-2}$ $s^{-1}$) in the tree's sapwood was calculated using the following equation:*

$$J_s = \frac{\sum_{i=1}^{8} F_{di} \times A_{si}}{\sum_{i=1}^{8} A_{si}} \quad (4)$$

*where i is the ith sample tree, and $F_{di}$ and $A_{si}$ represent the sapwood sap flow density and sapwood area of the ith sample tree, respectively.".This information can be found in Lines 256–260 in the new version.*

**17. Lines 262–269: The text lists nine sensor depths, whereas Table 1 contains ten depth intervals, including 100–140 and 140–160 cm. Clarify the exact number, position and depth represented by each sensor.**

***Response**: Thank you for your comment. We have revised the exact number and depth of each soil moisture sensor. The revised description is as follows:*
*"Soil moisture sensors (EC-5, Decagon, USA) connected to a CR1000 datalogger were used to monitor the SWC at 20, 40, 60, 80, 100, 140, 160, 200, 300, and 500 cm below the soil surface." This information can be found in Lines 265–267 in the new version.*

**18. Lines 319–330: Specify the SoilGrids depths used, how multilayer properties were assigned to the model soil profile and how the Arya–Paris-derived hydraulic functions were evaluated.**

***Response**: Thank you for your comment. We have revised this part to clarify the SoilGrids depths used (0.1, 0.3, 0.6, 1.0, and 2.0 m), the assignment of soil hydraulic parameters to the five soil layers in the BBGC-Sperry model, and the derivation of soil hydraulic functions using the Arya–Paris model followed by VG model fitting. The revised text is as follows:*
*"At the study area, clay, silt, sand, and bulk density data for the 130 simulated sites were obtained from the SoilGrids250m dataset (https://www.soilgrids.org/). These data were available at five standard depths of 0.1, 0.3, 0.6, 1.0, and 2.0 m. Soil moisture characteristic curves were estimated using the Arya–Paris model (Arya et al., 1999) based on soil texture and bulk density. This method has been shown to provide reliable estimates of soil hydraulic functions (da Silva et al., 2017). The simulated curves were*

*fitted with the van Genuchten (VG) model using RETC software to obtain $\theta_s$, $\theta_r$, $\alpha$, and n. Ks was obtained from the Northwest Arid Region Soil Hydraulic Parameters dataset, which provides values at the same five standard depths (Niu et al., 2024).The BBGC-Sperry model divided the soil profile into five layers: 0–0.13, 0.13–0.43, 0.43–0.96, 0.96–1.89, and 1.89–5.00 m. Soil hydraulic parameters were assigned to each model layer according to the corresponding depths. The first three layers used the values at 0.1 m, 0.3 m, and 0.6 m, respectively. For the fourth layer from 0.96 m to 1.89 m, soil hydraulic parameters were calculated as the average values at 1 m and 2 m depths. The deepest layer from 1.89 m to 5.00 m assigned the values at 2 m depth". This information can be found in Lines 338–353 in the new version.*

***Reference:***


*Arya, L. M., Leij, F. J., van Genuchten, M. T., and Shouse, P. J.: Scaling parameter to predict the soil water characteristic from particle-size distribution data, Soil Sci. Soc. Am. J., 63, 510–519, https://doi.org/10.2136/sssaj1999.03615995006300030013x, 1999.*

*da Silva, A. C., Armindo, R. A., dos Santos Brito, A., and Schaap, M. G.: SPLINTEX: A physically-based pedotransfer function for modeling soil hydraulic functions, Soil Till. Res., 174, 261 – 272, https://doi.org/10.1016/j.still.2017.07.011, 2017.*

*Niu, L., Jia, X., Li, X., Zhao, C., Ren, L., Hu, W., Zhu, P., Li, D., Zhang, B., and Shao, M.: Developing novel ensemble models for predicting soil hydraulic properties in China's arid region, J. Hydrol., 636, 131354, https://doi.org/10.1016/j.jhydrol.2024.131354, 2024.*


**19. Line 381: Delete the extra comma in "ET,, APLK."**

***Response**: Thank you for your comment. We have removed the extra comma. This information can be found in Line 417 in the new version.*

**20. Lines 439–447: Taylor diagrams normally show correlation, normalized standard deviation and centred RMSE. Please state exactly how the "best performance" of the ensemble mean was determined rather than relying only on correlation.**

***Response**: Thank you for your comment. We have added the description of this point in the revised manuscript as follows: "The multi-model average showed the highest correlation coefficients (R) and the lowest centered root-mean-square error (CRMSE) values among all simulations. Specifically, the corresponding R and CRMSE values were 0.66 and 0.76 for precipitation, 0.99 and 0.22 for maximum temperature, and 0.97 and 0.34 for minimum temperature, respectively. The normalized standard deviations of the multi-model average were generally comparable to those of individual models.", which can be found in the Lines 490–496 in the new version.*

**21. Lines 476–477: "An average increase of −0.105 mm $y^{-1}$" should be described as an average decrease of 0.105 mm $y^{-1}$. This also conflicts with the preceding statement that the future will be "warmer and wetter overall."**

***Response***: *Thank you for your comment. We have revised this part to correct the expression from "an average increase of −0.105 mm $y^{-1}$" to "an average decrease of 0.105 mm $y^{-1}$", which can be found in the Line 529 in the new version.*

*In addition, We also revised the description of future climate changes under all SSPs in the new manuscript as follows: "Fig. 4m-o shows future climate in the study area is expected to be warmer under all SSPs, while precipitation changes vary among different scenarios compared to the baseline period.", which can be found in the Lines 526–528 in the new version.*

**22. Lines 524–529: The caption of Fig. 6 states "spatial dynamics of NPP"; this should be "spatial dynamics of ET."**

***Response***: *Thank you for your comment. We have revised the caption of Fig. 6 by correcting "spatial dynamics of NPP" to "spatial dynamics of ET." This information can be found in Line 578 in the new version.*

**23. Lines 548–553: The caption of Fig. 7 also states "spatial dynamics of NPP"; this should be "spatial dynamics of APLK."**

***Response***: *Thank you for your comment. We have revised the caption of Fig. 7 by correcting "spatial dynamics of NPP" to "spatial dynamics of APLK." This information can be found in Line 606 in the new version.*

**24. Lines 607–632: Statements such as VPD having 99% relative importance should be interpreted cautiously, particularly under correlated predictors. Avoid treating model importance as direct causation.**

***Response***: *We agree with your comment. We have accepted your suggestion and revised this section by modifying the description of XGBoost-based relative importance to avoid overinterpreting the relationships between environmental variables and CWHRI variation. The revised text is as follows:*

*"To deepen understanding of the factors associated with CWHRI variation and how the relative importance of these factors changes, Fig. 10b presents an XGBoost-based assessment of the relative importance of six environmental factors for regions with different risk levels during the baseline and future periods. In the baseline period, VPD and SWS showed the highest relative importance among the six environmental factors. Specifically, the relative importance of VPD was 86% in the low-risk zones, and of SWS was 42% and 61% in the medium- and high-risk zones, respectively. Under the SSP1–2.6 scenario, VPD continued to show the highest relative importance but its relative importance decreased by 49% and 59% in the low-risk zones during the NFP*

*and MFP, respectively. MAP showed the highest relative importance value in the low-risk zones during the FFP, with a value of 56%. In the medium-risk zones, MAP showed the highest relative importance during the NFP and MFP, whereas SWS showed the highest relative importance during the FFP, similar to the baseline period. In high-risk zones, MAP exhibited the highest relative importance in all three periods, ranging from 62% to 81%. Under the SSP2–4.5 scenario, $MAT_{max}$ showed the highest relative importance values in the NFP and FFP in low-risk zones, with values of 51% and 60%, respectively. MAP,VPD and $MAT_{max}$ collectively accounted for 91% of the relative importance in the MFP. In the medium-risk zones, MAP showed the highest relative importance in the NFP and MFP, while $MAT_{max}$ showed the highest relative importance in the FFP. In high-risk zones, MAP showed the highest relative importance in all three periods, ranging from 67% to 76%. Under the SSP5–8.5 scenario, VPD showed the highest relative importance in low-risk zones during all three future periods, with values exceeding 50%. In medium-risk zones, $MAT_{max}$ showed the highest relative importance during the NFP and MFP, with values exceeding 70%. VPD showed a relative importance of 99% during the FFP. In high-risk zones, MAP showed the highest relative importance in all three periods, ranging from 49% to 68%. Generally, the relative importance of MAP and $MAT_{max}$ increased from the baseline period into the future, suggesting that moisture- and temperature-related variables may become increasingly associated with CWHRI variation under future climate change.".*

*This information can be found in Lines 659–687 in the new version.*

*In addition, we have revised statements regarding the XGBoost variable-importance results in the Abstract, Methods, and Discussion, as follows:*

*(1)"The CWHRI is projected to decline by 23%–44%, and exhibit a southeast-to-northwest decreasing gradient, which is dominated by NPP, with a secondary contribution from water-related environmental factors.". This information can be found in the Lines 41–44 in the new version.*

*(2)"The relative importance of six meteorological variables (mean annual precipitation, MAP; mean annual temperature, MAT; mean annual maximum temperature, MATmax; mean annual minimum temperature, MATmin; mean annual vapor pressure deficit, VPD, mean annual soil water storage, SWS) for predicting CWHRI was assessed using XGBoost." and "Variables with high relative importance identified by the XGBoost model were interpreted as factors statistically associated with the dynamic changes in CWHRI within the modelling framework, rather than as evidence of causal relationships.". Those information can be found in the Lines 425–429 and Lines 432–434 in the new version, respectively.*

*(3)"The environmental variables associated with CWHRI are related to the availability of water resources. During the baseline period, MAP, VPD, and SWS showed the highest relative importance. In all SSPs, the relative importance of MAP and $MAT_{max}$ will increase." and "Accordingly, these factors showed the highest relative importance for CWHRI variability. ". Those information can be found in the Lines 791–794 and Lines 797–798 in the new version, respectively.*

**25. Lines 681–693: The text first says NPP will generally decrease, then says it shows an upward trend across all periods and SSPs. Clarify the distinction between being below the baseline and increasing between successive future periods.**

***Response**: Thank you for your comment. We have revised this part as follows: "The results show that NPP in the study area remained below the baseline level under future climate scenarios. Precipitation, ... Although NPP under future climate scenarios remained below the baseline level, it increased progressively from the NFP to the FFP under all SSPs.". This information can be found in Lines 735–745 in the new version.*

**26. Lines 695–696: "Rising temperatures prolong ET" is unclear. Perhaps the authors mean that warming lengthens the growing season or increases atmospheric evaporative demand.**

***Response**: Thank you for your comment. We have revised this part as follows: "Rising temperatures may prolong the growing season and increase atmospheric evaporative demand, thereby directly increasing atmospheric water demand and promoting the transfer of more water from the soil and vegetation into the air.". This information can be found in Lines 751–754 in the new version.*

**27. Lines 713–717: The sentence beginning "This phenomenon may be attributed…" is grammatically incomplete. Revise to "…may be attributed to precipitation and $CO_2$ fertilization offsetting warming-induced suppression of productivity."**

***Response**: Thank you for your comment. We have revised this sentence as follows: "This phenomenon may be attributed to precipitation and $CO_2$ fertilization offsetting warming-induced suppression of productivity.". This information can be found in Lines 770–772 in the new version.*

**28. Lines 727–735: The conclusion that conventional water-use efficiency produces "optimistic estimates" follows partly from the way CWHRI is mathematically defined. This should be framed as an implication of the proposed index, not independent confirmation.**

***Response**: Thank you for your comment. We agree with your comment revised this part as follows: "This increasing contribution suggests that incorporating the increasing influence of hydraulic failure risk under future climate change may provide a more comprehensive assessment of long-term plantation sustainability.". This information can be found in Lines 786–789 in the new version.*

**29. Line 803: "CWHSI" should be "CWHRI."**

***Response***: *Thank you for your comment. We have corrected the abbreviation from "CWHSI" to "CWHRI" in this part. This information can be found in Line 855 in the new version.*

**30. Lines 812–813: "Data will be made available on request" limits reproducibility. The model inputs, station-level outputs, parameter files and analysis code should preferably be deposited in a public repository with a DOI.**

***Response***: *Thank you for your comment. The model simulation outputs (NPP, ET, APLK, DMRP, and CWHRI) used in this study are openly available in the Science Data Bank (ScienceDB) at https://doi.org/10.57760/sciencedb.45502. The meteorological forcing data, soil hydraulic parameters, and eco-physiological parameters are described in Sections 2.4.1, 2.4.2, and Table S1, respectively. This information can be found in Lines 865–869 in the new version.*

**31. Throughout: Standardize SSP formatting, for example SSP1-2.6, SSP2-4.5 and SSP5-8.5, or explain the abbreviated forms SSP126, SSP245 and SSP585.**

***Response***: *Thank you for your comment. We have revised the manuscript to standardize the SSP formatting and consistently used "SSP1–2.6", "SSP2–4.5", and "SSP5–8.5" throughout the text, tables, and figures. This information can be found throughout the new version. This information can be found in Lines 25, 36, 41, 134–135, 317, 323–324, 418–419, 513, 522–523, 528, 532, 536, 539, 544–545, 553–555, 562–563, 571–573, 578–579, 587, 589, 591, 597, 604, 614, 619, 622–623, 628, 635, 642, 649–650, 658, 666, 673, 679, 724, 756–757, 770, 786, 841–842, 848.*

**32. Throughout: The manuscript would benefit from careful English-language editing, particularly for subject–verb agreement, articles, spacing, pluralization, figure citations ("Figs." rather than "Fig.s") and consistency of tense.**

***Response***: *Thank you for your comment. We have carefully checked the entire manuscript. The main modifications are as follows:*
*(1) We have added a space before the parentheses in this part by correcting "Yan et al.(2022)" to "Yan et al. (2022)". This information can be found in Line 91 in the new version.*
*(2) We have added a space before the parentheses in this part by correcting "$MAT_{max}$(i)" to "$MAT_{max}$ (i)". This information can be found in Line 548 in the new version.*
*(3) We have added a space after the comma in this part by correcting "MAP,VPD" to "MAP, VPD". This information can be found in Line 674 in the new version.*
*(4) We have added a space before the degree symbol in this part by correcting "0.060℃" to "0.060 ℃". This information can be found in Line 537 in the new version.*
*(5) We have corrected the plural form in the heading of Section 2.2.2 by correcting "Carbon and nitrogen cycle" to "Carbon and nitrogen cycles". This information can be*

*found in Line 201 in the new version.*

*(6) We have corrected the plural form in the headings of Sections 4.2 and 4.3 by correcting "plantation" to "plantations". This information can be found in Lines 722 and 779 in the new version.*

*(7) We have corrected the capitalization in this part by correcting "BBGC-SPERRY" to "BBGC-Sperry". This information can be found in Line 102 in the new version.*

*(8) We have corrected the capitalization in the heading of Section 4.1 by correcting "BBGC-Sperry Model" to "BBGC-Sperry model". This information can be found in Line 701 in the new version.*

*(9) We have revised the tense of "However, the NPP in the FFP will be 577.9 g C $m^{-2}$ $yr^{-1}$ under the SSP5–8.5 scenario, which will be higher than in the baseline period.". These information can be found in Lines 554–555 in the new version.*

*(10) We have revised the tense of "The ET was 572.9 mm during the baseline period and will show no significant changes under the SSP1–2.6 scenario in the future periods. However, it will significantly increase under the SSP2–4.5 scenario and particularly under the SSP5–8.5 scenario". These information can be found in Lines 570–573 in the new version.*

*(11) We have revised the tense of "This pattern will be maintained in all SSPs.". This information can be found in Line 574 in the new version.*

*(12) We have revised the tense of "Under the SSP1–2.6 scenario, APLK values in the NFP, MFP, and FFP are projected to be 28.2, 28.7, and 29.5%, respectively, indicating an increasing trend with a relatively slow rate of change. Under the SSP2–4.5 scenario, APLK values for future periods are projected to be 29.1% (NFP), 33.3% (MFP), and 32.8% (FFP), indicating a larger increase compared to the baseline period. Under the SSP5–8.5 scenario, APLK values increased the most, with NFP, MFP, and FFP values of 31.7%, 41.1%, and 46.4%, respectively, indicating APLK values will significantly increase under a more severe climate change context.". This information can be found in Lines 587–594 in the new version.*

*(13) We have revised the tense of "Under the SSP5–8.5 scenario, only very central and southern regions will have APLK values below 35%, while most areas in the central and northern regions will have values above 50% in the FFP" This information can be found in Lines 596–599 in the new version.*

*(14) We have revised the tense of "DMRP will show an increasing trend under the SSP2–4.5 and SSP5–8.5 scenarios, but a slight decreasing trend under the SSP1–2.6 scenario.". This information can be found in Lines 621–623 in the new version.*

*(15) We have corrected "Fig.s" to "Figs.". This information can be found in Lines 734–735 in the new version.*

*(16) We have revised the tense of "Compared to the baseline period, the CWHRI will decrease significantly in the future, indicating PT plantation sustainability may face increasing constraints under future climate change.". This information can be found in Lines 781–783 in the new version.*

**Reviewer #2:**

**This study addresses an important topic by integrating carbon sequestration, water use, and hydraulic risks across the Loess Plateau. Using the BBGC-Sperry model, the authors provide valuable insights into the spatiotemporal variations of historical carbon–water–hydraulic risk dynamics and their future projections under climate change scenarios. The manuscript is generally well-written and should be of interest to Biogeosciences readers. I recommend moderate revision before acceptance.**

**1. Calculation of APLK needs clarification. Lines 344–355 do not clearly describe how daily PLK values were aggregated to calculate APLK. Please clarify whether APLK was calculated based on the entire calendar year, the growing season, or only days with active transpiration.**

**Response**: *We appreciate your comment. We revised expressions in the section of 2.5 Assessment of drought-induced mortality risk as follows:*

*"Annual average PLK (APLK, %) was then determined to represent the inter-annual variation in plant hydraulic safety. It was calculated as the arithmetic mean of daily PLK values during the modeled growing season of each year. The modeled growing season was defined as days with leaf carbon pool greater than zero (LeafC > 0).". This information can be found in the Lines 375–379 in the new version.*

**2. The rationale for selecting the APLK threshold requires further clarification. Lines 351–353 use a 60% loss of annual mean whole-plant hydraulic conductance (APLK) as the mortality threshold. However, the cited reference (McDowell et al., 2013) does not sufficiently support the application of this threshold to annual mean whole-plant hydraulic conductance. Please provide additional references to justify this threshold. The supporting literature should specifically address whole-plant hydraulic conductance loss and sustained hydraulic damage rather than instantaneous or organ-level xylem conductivity loss.**

**Response**: *Thank you for your comment. We acknowledge that the references cited in the original manuscript did not adequately demonstrate the applicability of the 60% threshold to annual-mean, whole-plant hydraulic conductance loss. In the new version, we revised expressions in the threshold based on Sperry and Love (2015) and Tai et al. (2018), which directly support applying the 60% threshold to growing-season-mean, whole-plant conductance loss. In Sperry and Love (2015), k denotes the hydraulic conductance of the entire soil–canopy continuum (i.e., whole-plant conductance), and the "chronic stress hypothesis" explicitly concerns sustained ("chronically high") PLC rather than peak instantaneous damage; notably, authors themselves applied the ~60–70% risk band to growing-season median daily PLC (their Fig. 8), a metric directly analogous to our APLK. Tai et al. (2018) explicitly reported "the average percentage loss of whole-plant hydraulic conductance (PLK) during the growing season for every*

*year" and used 60% as the mortality-risk threshold ("60% seasonal average PLK"), a metric identical to our APLK. We revised some expressions in the section of 2.5 Assessment of drought-induced mortality risk as follows:*

*"Previous studies have suggested that sustained losses of whole-plant hydraulic conductance exceeding 60% are associated with a high risk of drought-induced mortality (Sperry and Love, 2015; Yan et al., 2022; Zhang et al., 2024b). Tai et al. (2018) further applied a growing-season mean whole-plant PLK threshold of 60% for evaluating drought-induced mortality risk. So, we adopted this threshold for assessing drought-induced mortality risk in this study."*

*This information can be found in the Lines 380–384 in the new version.*

***Reference:***


*Sperry, J. S. and Love, D. M.: What plant hydraulics can tell us about responses to climate-change droughts, New Phytol., 207, 14–27, https://doi.org/10.1111/nph.13354, 2015.*

*Tai, X., Mackay, D. S., Sperry, J. S., Brooks, P., Anderegg, W. R. L., Flanagan, L. B., Rood, S. B., and Hopkinson, C.: Distributed plant hydraulic and hydrological modeling to understand the susceptibility of riparian woodland trees to drought-induced mortality, Water Resour. Res., 54, 4901–4915, https://doi.org/10.1029/2018WR022801, 2018.*

*Yan, X. Y., Zhang, Z. D., Huang, M. B., Zhao, X. F., Yang, F., and Wu, X. F.: The impact of climate change on growth and drought-induced mortality risk of Robinia pseudoacacia plantations along a precipitation gradient on the Chinese Loess Plateau, Agric. For. Meteorol., 325, 109160, https://doi.org/10.1016/j.agrformet.2022.109160, 2022.*

*Zhang, Z. D., Liu, T. H., Huang, M. B., Yan, X. Y., Liu, M. H., Yan, J. H., Chen, F. Y., Yan, W., and Niu, J. Q.: Spatial pattern of drought-induced mortality risk and influencing factors for Robinia pseudoacacia L. plantations on the Chinese Loess Plateau, Forests, 15, 1477, https://doi.org/10.3390/f15081477, 2024b.*


**3. Cautious interpretation of environmental factor importance analysis. Lines 604–632 reflect the statistical contributions of environmental factors within the model framework; therefore, these results should be interpreted cautiously and should not be regarded as direct causal relationships.**

***Response**: We agree with your comment. We have accepted your suggestion and revised this section by modifying the description of XGBoost-based relative importance to avoid overinterpreting the relationships between environmental variables and CWHRI variation. The revised text is as follows:*

*"To deepen understanding of the factors associated with CWHRI variation and how the relative importance of these factors changes, Fig. 10b presents an XGBoost-based assessment of the relative importance of six environmental factors for regions*

*with different risk levels during the baseline and future periods. In the baseline period, VPD and SWS showed the highest relative importance among the six environmental factors. Specifically, the relative importance of VPD was 86% in the low-risk zones, and of SWS was 42% and 61% in the medium- and high-risk zones, respectively. Under the SSP1-2.6 scenario, VPD continued to show the highest relative importance but its relative importance decreased by 49% and 59% in the low-risk zones during the NFP and MFP, respectively. MAP showed the highest relative importance value in the low-risk zones during the FFP, with a value of 56%. In the medium-risk zones, MAP showed the highest relative importance during the NFP and MFP, whereas SWS showed the highest relative importance during the FFP, similar to the baseline period. In high-risk zones, MAP exhibited the highest relative importance in all three periods, ranging from 62% to 81%. Under the SSP2-4.5 scenario, $MAT_{max}$ showed the highest relative importance values in the NFP and FFP in low-risk zones, with values of 51% and 60%, respectively. MAP,VPD and $MAT_{max}$ collectively accounted for 91% of the relative importance in the MFP. In the medium-risk zones, MAP showed the highest relative importance in the NFP and MFP, while $MAT_{max}$ showed the highest relative importance in the FFP. In high-risk zones, MAP showed the highest relative importance in all three periods, ranging from 67% to 76%. Under the SSP5-8.5 scenario, VPD showed the highest relative importance in low-risk zones during all three future periods, with values exceeding 50%. In medium-risk zones, $MAT_{max}$ showed the highest relative importance during the NFP and MFP, with values exceeding 70%. VPD showed a relative importance of 99% during the FFP. In high-risk zones, MAP showed the highest relative importance in all three periods, ranging from 49% to 68%. Generally, the relative importance of MAP and $MAT_{max}$ increased from the baseline period into the future, suggesting that moisture- and temperature-related variables may become increasingly associated with CWHRI variation under future climate change.".*

*This information can be found in Lines 659–687 in the new version.*

*In addition, we have revised statements regarding the XGBoost variable-importance results in the Abstract, Methods, and Discussion, as follows:*

*(1)"The CWHRI is projected to decline by 23%–44%, and exhibit a southeast-to-northwest decreasing gradient, which is dominated by NPP, with a secondary contribution from water-related environmental factors.". This information can be found in the Lines 41–44 in the new version.*

*(2)"The relative importance of six meteorological variables (mean annual precipitation, MAP; mean annual temperature, MAT; mean annual maximum temperature, $MAT_{max}$; mean annual minimum temperature, $MAT_{min}$; mean annual vapor pressure deficit, VPD, mean annual soil water storage, SWS) for predicting CWHRI was assessed using XGBoost." and "Variables with high relative importance identified by the XGBoost model were interpreted as factors statistically associated with the dynamic changes in CWHRI within the modelling framework, rather than as evidence of causal relationships.". Those information can be found in the Lines 425–429 and Lines 432–434 in the new version, respectively.*

*(3)"The environmental variables associated with CWHRI are related to the availability of water resources. During the baseline period, MAP, VPD, and SWS showed the*

*highest relative importance. In all SSPs, the relative importance of MAP and $MAT_{max}$ will increase." and "Accordingly, these factors showed the highest relative importance for CWHRI variability. ". Those information can be found in the Lines 791–794 and Lines 797–798 in the new version, respectively.*

**4. Lines 21–23: Revise the grammar of this sentence:"However, climate-change impacts on water resources pose a new challenge to the sustainability of restored ecosystems."**

***Response**: Thank you for your comment, we have revised the grammar of this sentence as follows:*

*"However, the impacts of climate-change on water resources pose a new challenge to the sustainability of restored ecosystems." This information can be found in the Lines 21–23 in the new version.*

**5. Lines 33–36: The percentage changes should identify their reference period.**

***Response**: Thank you for your comment. We have revised some expressions in this part: "The results indicate that compared with the baseline period, the annual mean NPP is projected to decrease by 4%–27% under all scenario-management combinations, except for the FFP under SSP5–8.5, where it will increase by 8%. Annual mean ET and APLK are projected to increase from 0.05%–61% and 13%–84%, respectively, with the smallest increases under SSP1–2.6 with the NFP and the largest under SSP5–8.5 with the FFP. The CWHRI is projected to decline by 23%–44%, and exhibit a southeast-to-northwest decreasing gradient, which is dominated by NPP, with a secondary contribution from water-related environmental factors.". This information can be found in the Lines 36–44 in the new version.*

**6. Lines 45–47: Insert a space after the full stop before "The."**

***Response**: Thank you for your comment. We have corrected the subject–verb agreement and punctuation in this part: "Plantations ... contribute to global biogeochemical cycles. The...". This information can be found in the Lines 52 in the new version.*

**7. Lines 68–70: Incorrect use of word forms. Change "may lead to overestimate vegetation growth" to "may lead to overestimation of vegetation growth."**

***Response**: We have revised the expression as follows:*

*"These methodological limitations may lead to an overestimation of vegetation growth,", which have been revised in the Lines 74–75 in the new version.*

**8. Line 85: Insert a space before the parenthesis in "Yan et al.(2022)".**

***Response**: Thank you for your comment. We have added a space before the parentheses*

*in this part by correcting "Yan et al.(2022)" to "Yan et al. (2022)". This information can be found in Line 91 in the new version.*

**9. Lines 95–96: Standardize the capitalization of "BBGC-Sperry" throughout the manuscript.**

***Response**: Thank you for your comment. We have revised the manuscript to standardize the capitalization of "BBGC-Sperry" in Lines 102.*

**10. Lines 169–171: Delete the redundant "nitrogen" in "water, carbon, nitrogen, and nitrogen cycling."**

***Response**: Thank you for your comment. We have revised the expression in this part by removing the repeated "nitrogen,": "water, carbon, and nitrogen cycling." This information can be found in Lines 176 in the new version.*

**11. Lines 224–250: Ensure that the summation range in Eq. 4 (i = 1 to 5) is consistent with the number of sap-flow trees selected (n = 8).**

***Response**: Thank you for your comment. The upper limit of the summation in Eq. 4 was incorrectly set to 5 in the previous version. We have corrected the equation by changing the summation range from i = 1 to 5 to i = 1 to 8: "The average sap flow density ($J_s$; g $m^{-2}$ $s^{-1}$) in the tree's sapwood was calculated using the following equation:*

$$J_s = \frac{\sum_{i=1}^{8} F_{di} \times A_{si}}{\sum_{i=1}^{8} A_{si}} \qquad (4)$$

*where i is the ith sample tree, and $F_{di}$ and $A_{si}$ represent the sapwood sap flow density and sapwood area of the ith sample tree, respectively.".This information can be found in Lines 256–260 in the new version.*

**12. Lines 262–269: Clarify the exact number. The text lists nine sensor depths, whereas Table 1 contains ten depth intervals.**

***Response**: Thank you for your comment. We have revised the exact number and depth of each soil moisture sensor. The revised description is as follows:*
*"Soil moisture sensors (EC-5, Decagon, USA) connected to a CR1000 datalogger were used to monitor the SWC at 20, 40, 60, 80, 100, 140, 160, 200, 300, and 500 cm below the soil surface." This information can be found in Lines 265–267 in the new version.*

**13. Line 381: Delete the extra comma in "ET,, APLK."**

***Response**: Thank you for your comment. We have removed the extra comma. This information can be found in Line 417 in the new version.*

**14. Line 387: "p<0.05" should be "p < 0.05."**

***Response***: *Thank you for your comment. We have added spaces before and after the less-than sign. This information can be found in Lines 424, 515,518,539,564,581,606 in the new version.*

**15. Lines 524–529: The caption of Fig. 6 should be corrected: "spatial dynamics of NPP"; this should be "spatial dynamics of ET."**

***Response***: *Thank you for your comment. We have revised the caption of Fig. 6 by correcting "spatial dynamics of NPP" to "spatial dynamics of ET." This information can be found in Line 578 in the new version.*

**16. Lines 548–553: The caption of Fig. 7 should be corrected: "spatial dynamics of NPP"; this should be "spatial dynamics of APLK."**

***Response***: *Thank you for your comment. We have revised the caption of Fig. 7 by correcting "spatial dynamics of NPP" to "spatial dynamics of APLK." This information can be found in Line 606 in the new version.*

**17. Lines 680–681: "Fig.s" should be "Figs." for figure citations.**

***Response***: *Thank you for your comment. We have corrected "Fig.s" to "Figs.". This information can be found in Lines 734–735 in the new version.*

**18. Lines 695–696: Clarify the meaning of "Rising temperatures prolong ET," as warming may affect ET through an extended growing season or increased atmospheric evaporative demand rather than directly prolonging ET.**

***Response***: *Thank you for your comment. We have revised this part as follows: "Rising temperatures may prolong the growing season and increase atmospheric evaporative demand, thereby directly increasing atmospheric water demand and promoting the transfer of more water from the soil and vegetation into the air.". This information can be found in Lines 751–754 in the new version.*

**19. Line 776: "is projected decline" should be "is projected to decline."**

***Response***: *Thank you for your comment. We have added "to" after "projected". This information can be found in Line 829 in the new version.*

**20. Line 803: "CWHSI" should be "CWHRI."**

***Response***: *Thank you for your comment. We have corrected the abbreviation from "CWHSI" to "CWHRI" in this part. This information can be found in Line 855 in the*

*new version.*

**21. Throughout: Standardize the SSP formatting, for example SSP1-2.6, SSP2-4.5 and SSP5-8.5.**

***Response**: Thank you for your comment. We have revised the manuscript to standardize the SSP formatting and consistently used "SSP1–2.6", "SSP2–4.5", and "SSP5–8.5" throughout the text, tables, and figures. This information can be found throughout the new version. This information can be found in Lines 25, 36, 41, 134–135, 317, 323–324, 418–419, 513, 522–523, 528, 532, 536, 539, 544–545, 553–555, 562–563, 571–573, 578–579, 587, 589, 591, 597, 604, 614, 619, 622–623, 628, 635, 642, 649–650, 658, 666, 673, 679, 724, 756–757, 770, 786, 841–842, 848.*

**22. Throughout: Check subject–verb agreement and tense consistency.**

***Response**: Thank you for your comment. We have carefully checked the entire manuscript. The main modifications are as follows:*
*(1) We have added a space before the parentheses in this part by correcting "$MAT_{max}$(i)" to "$MAT_{max}$ (i)". This information can be found in Line 548 in the new version.*
*(2) We have added a space after the comma in this part by correcting "MAP,VPD" to "MAP, VPD". This information can be found in Line 674 in the new version.*
*(3) We have added a space before the degree symbol in this part by correcting "0.060℃" to "0.060 ℃". This information can be found in Line 537 in the new version.*
*(4) We have corrected the plural form in the heading of Section 2.2.2 by correcting "Carbon and nitrogen cycle" to "Carbon and nitrogen cycles". This information can be found in Line 201 in the new version.*
*(5) We have corrected the plural form in the headings of Sections 4.2 and 4.3 by correcting "plantation" to "plantations". This information can be found in Lines 722 and 779 in the new version.*
(6) *We have revised the tense of "However, the NPP in the FFP will be 577.9 g C $m^{-2}$ $yr^{-1}$ under the SSP5–8.5 scenario, which will be higher than in the baseline period.". These information can be found in Lines 554–555 in the new version.*
(7) *We have revised the tense of "The ET was 572.9 mm during the baseline period and will show no significant changes under the SSP1–2.6 scenario in the future periods. However, it will significantly increase under the SSP2–4.5 scenario and particularly under the SSP5–8.5 scenario". These information can be found in Lines 570–573 in the new version.*
(8) *We have revised the tense of "This pattern will be maintained in all SSPs.". This information can be found in Line 574 in the new version.*
(9) *We have revised the tense of "Under the SSP1–2.6 scenario, APLK values in the NFP, MFP, and FFP are projected to be 28.2, 28.7, and 29.5%, respectively, indicating an increasing trend with a relatively slow rate of change. Under the SSP2–4.5 scenario, APLK values for future periods are projected to be 29.1% (NFP), 33.3% (MFP), and 32.8% (FFP), indicating a larger increase compared to the baseline period. Under the*

*SSP5–8.5 scenario, APLK values increased the most, with NFP, MFP, and FFP values of 31.7%, 41.1%, and 46.4%, respectively, indicating APLK values will significantly increase under a more severe climate change context.". This information can be found in Lines 587–594 in the new version.*

(10) *We have revised the tense of "Under the SSP5–8.5 scenario, only very central and southern regions will have APLK values below 35%, while most areas in the central and northern regions will have values above 50% in the FFP" This information can be found in Lines 596–599 in the new version.*

(11) *We have revised the tense of "DMRP will show an increasing trend under the SSP2–4.5 and SSP5–8.5 scenarios, but a slight decreasing trend under the SSP1–2.6 scenario.". This information can be found in Lines 621–623 in the new version.*

(12) *We have revised the tense of "Compared to the baseline period, the CWHRI will decrease significantly in the future, indicating PT plantation sustainability may face increasing constraints under future climate change.". This information can be found in Lines 781–783 in the new version.*