

Supplemental file for

Long-Term Increase and Shifting Predictor Contributions of Net Ecosystem Production in Moso Bamboo Forests Across Anji County, China

FIGURES

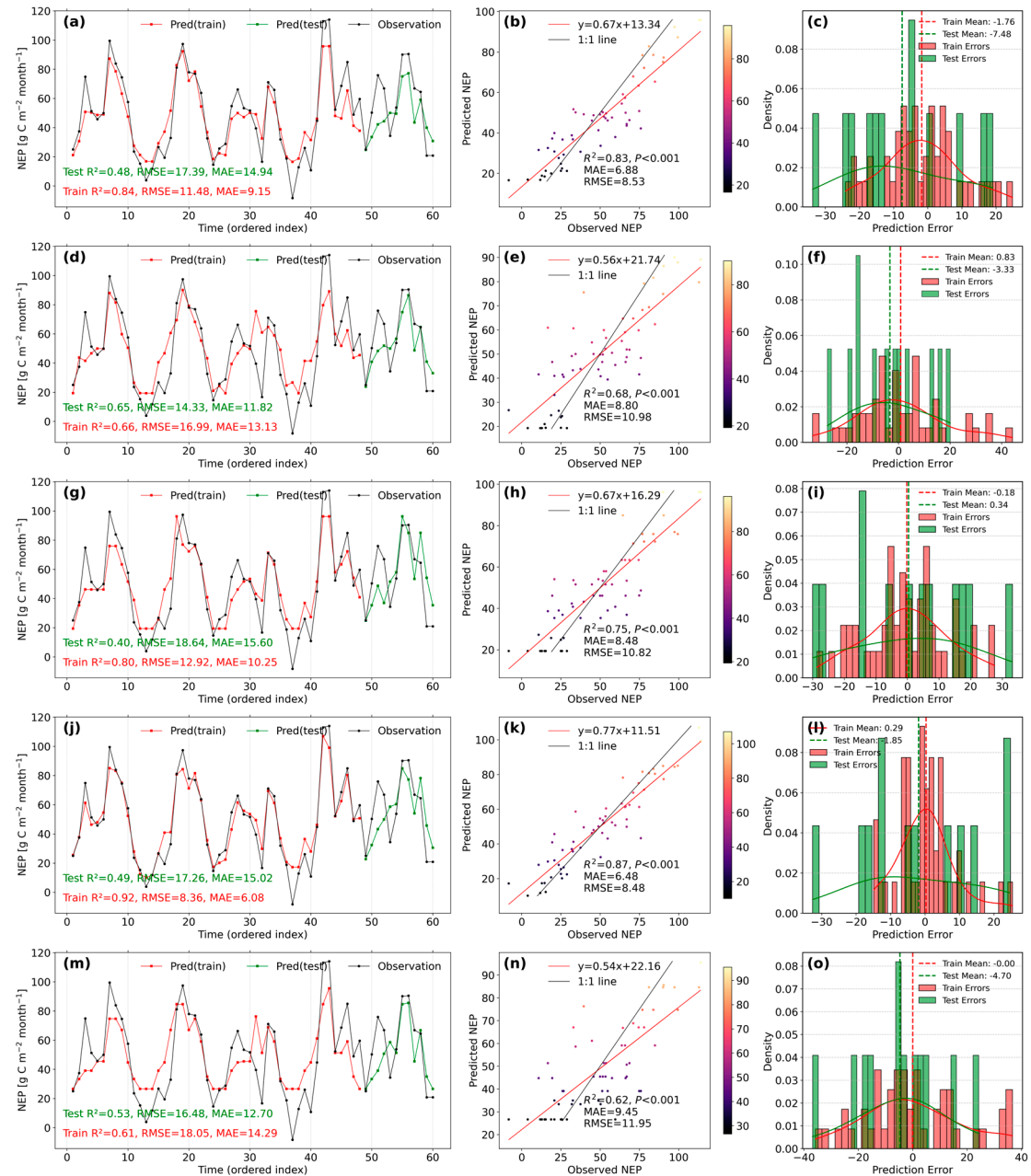


Figure S1. Performance of the five candidate models evaluated within the FLAML framework. The models were CatBoost (a–c), Random Forest (RF) (d–f), XGBoost (g–i), xgb_limitdepth (j–l), and Extra Trees (extra_tree) (m–o). RF had the highest R^2 on the chronological temporal holdout set.

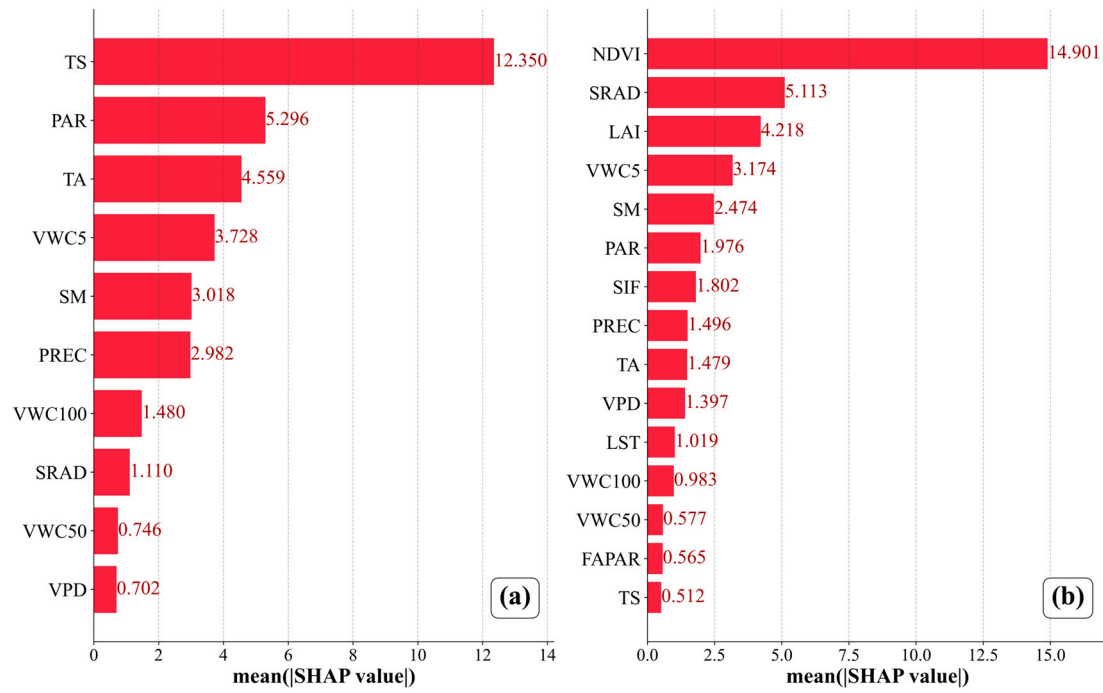
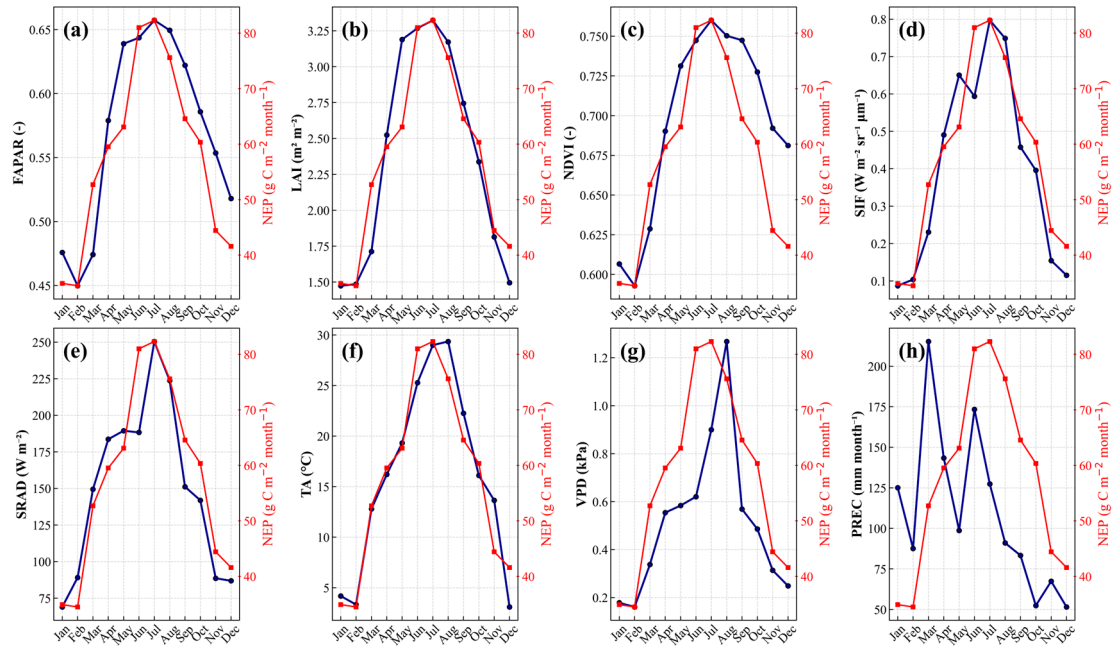
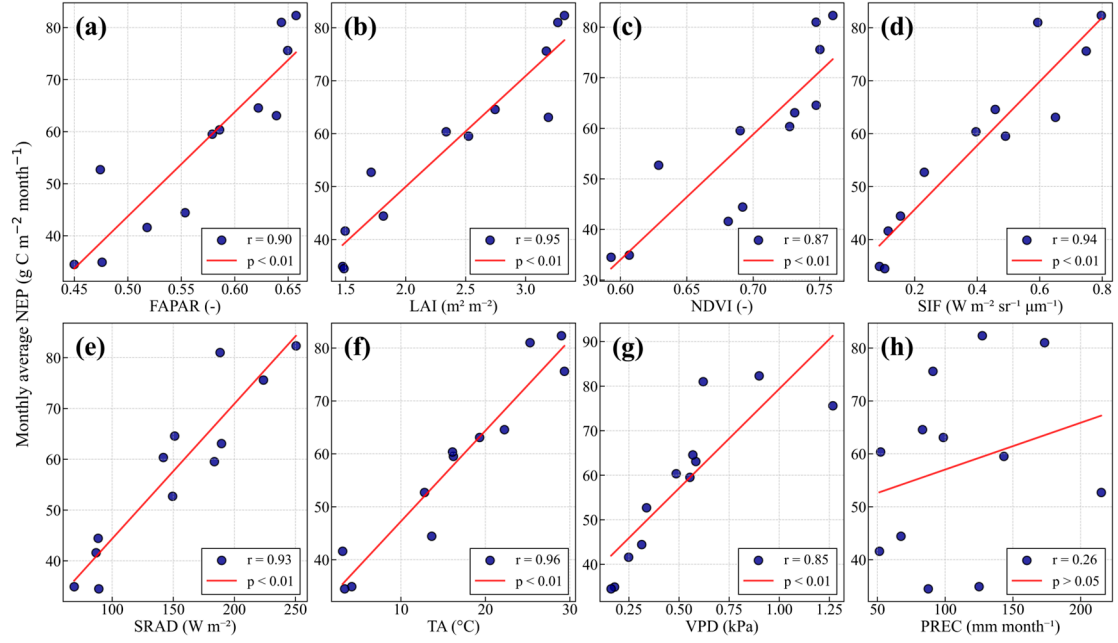


Figure S2. Exploratory SHAP variable-importance ranking from preliminary site-level predictors screening. (a) uses locally available meteorological and soil variables; (b) adds vegetation remote-sensing variables. This exploratory screening is distinct from the final eight-predictors regional RF model summarized in Table 1 and is not an external validation.



Figures S3. Intra-annual seasonal dynamics of monthly NEP and eight environmental factors in Anji bamboo forests. Red lines show NEP (right y-axis), and blue lines show each factor (left y-axis). NEP and the vegetation indices generally reached high values in June–July, whereas the timing and shape of the meteorological cycles differed among variables.



Figures S4. Intra-annual seasonal linear correlations between monthly NEP and eight environmental factors in Anji bamboo forests. Presents monthly pairwise linear regression scatter plots. TA had the strongest significant positive seasonal correlation with NEP ($r = 0.96$, $p < 0.01$), followed by LAI ($r = 0.95$, $p < 0.01$). SRAD, FAPAR, SIF, NDVI, and VPD also exhibited strong statistically significant positive correlations (all $p < 0.01$). Only monthly precipitation showed a weak non-significant correlation with seasonal NEP ($r = 0.26$, $p > 0.05$).

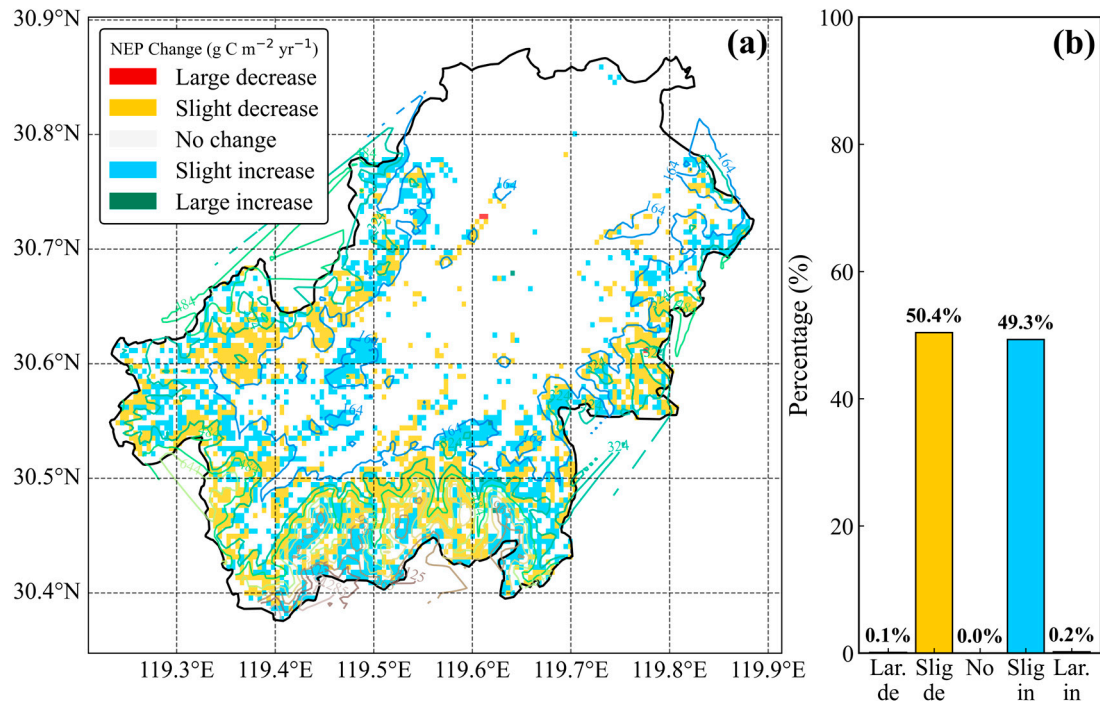


Figure S5. Spatial pattern and area proportion of annual modeled NEP anomalies for bamboo forests in Anji in 2006. Anomalies are deviations from the 2003–2022 multi-year mean and are classified with a fixed 50 g C m⁻² yr⁻¹ magnitude threshold for spatial comparison. Slightly decreased bamboo areas accounted for 50.4% of the mapped domain and slightly increased for 49.3%; large decreases and large increases accounted for 0.1% and 0.2%, respectively. No pixel had an exact zero anomaly. The terms large and slight describe fixed magnitude classes, not statistical significance.

2006

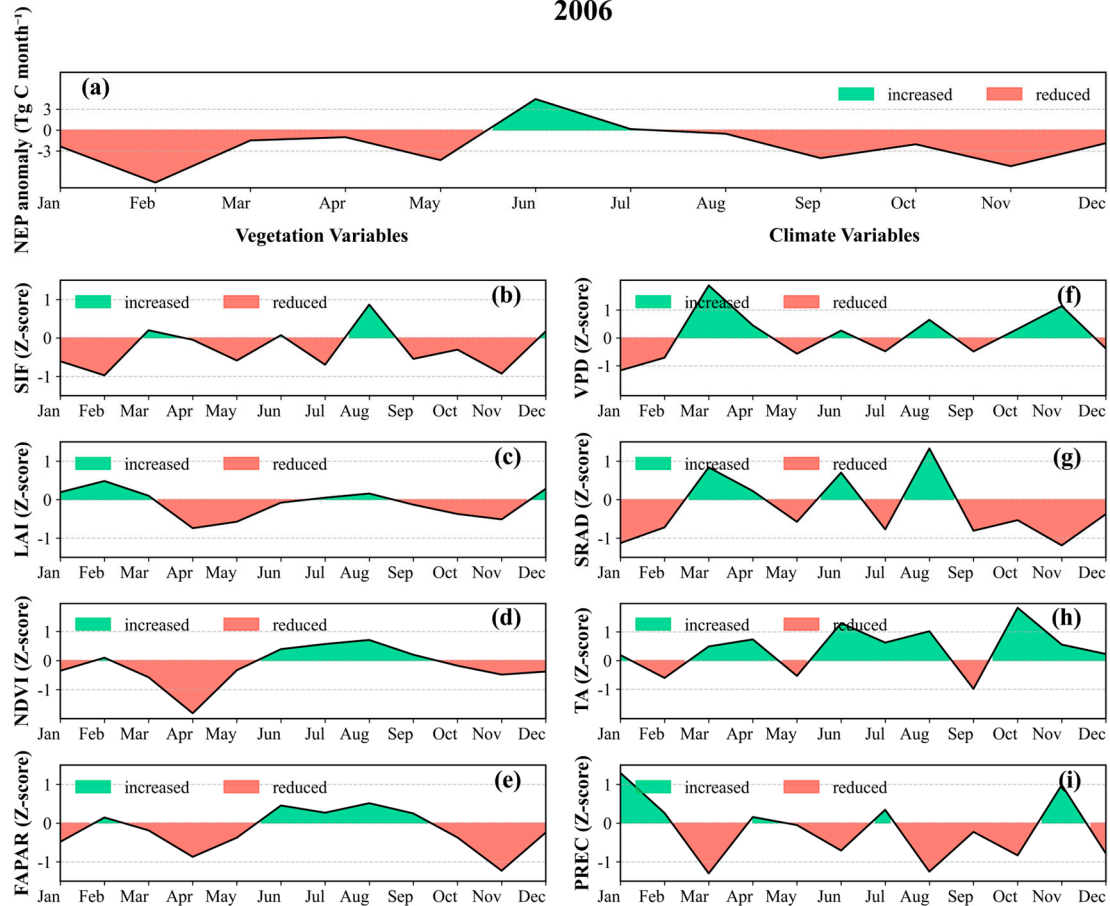


Figure S6. Monthly anomalies of modeled NEP, vegetation indicators, and climate factors in Anji County in 2006. (a) Monthly total modeled NEP anomalies (Tg C month⁻¹) were negative in most months, with a small positive anomaly in June. Vegetation indicators [(b) SIF, (c) LAI, (d) NDVI, and (e) FAPAR] were generally below their multi-year seasonal means during much of the growing season. Among the climate factors [(f) VPD, (g) SRAD, (h) TA, and (i) PREC], TA and SRAD showed temporary positive anomalies from late spring to summer, whereas PREC was below its seasonal mean during parts of spring and autumn. These parallel anomalies are consistent with, but do not independently demonstrate, a canopy- or drought-driven reduction in ecosystem carbon uptake.

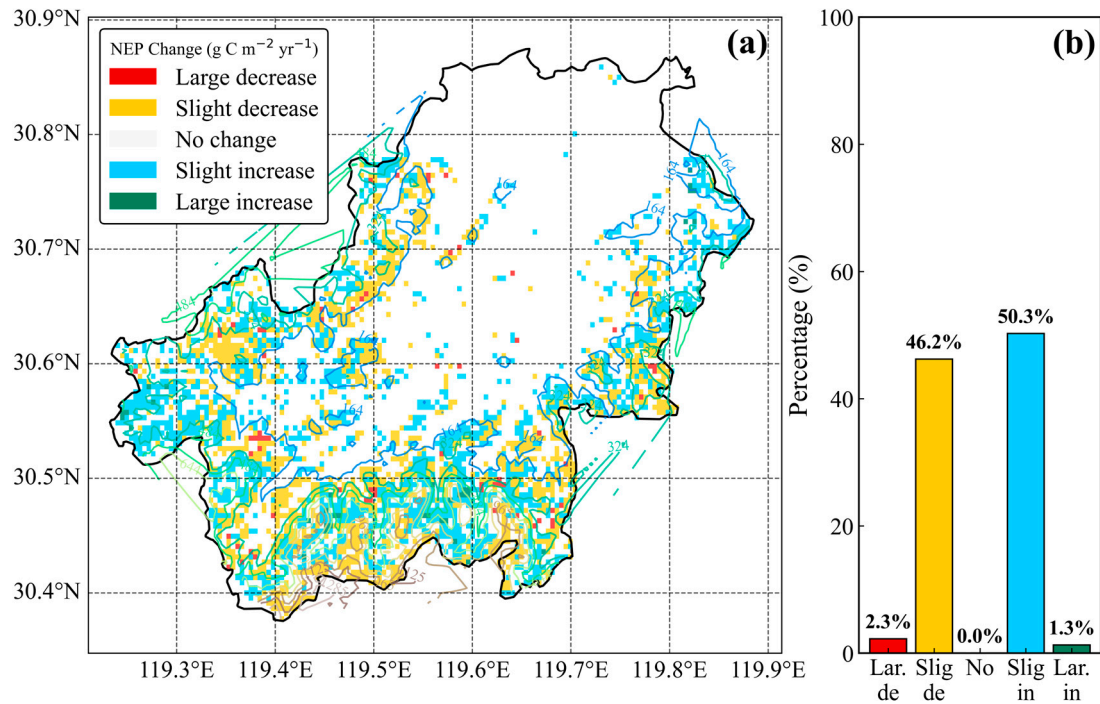


Figure S7. Spatial distribution and area proportion annual modeled NEP anomalies in Anji bamboo forests in 2022. Altitude contour are overlaid in subplot (a), and subplot (b) presents five fixed magnitude classes: slight increase (50.3%), slight decrease (46.2%), large decrease (2.3%), large increase (1.3%), and exact zero anomaly (0.0%). Compared with 2006, slight modeled NEP decreases were more common in the central and northern low hills, whereas increases were concentrated in southern high-altitude areas. The spatial pattern coincided with the documented 2022 Yangtze River Basin drought but does not independently establish its effect on NEP.

2022

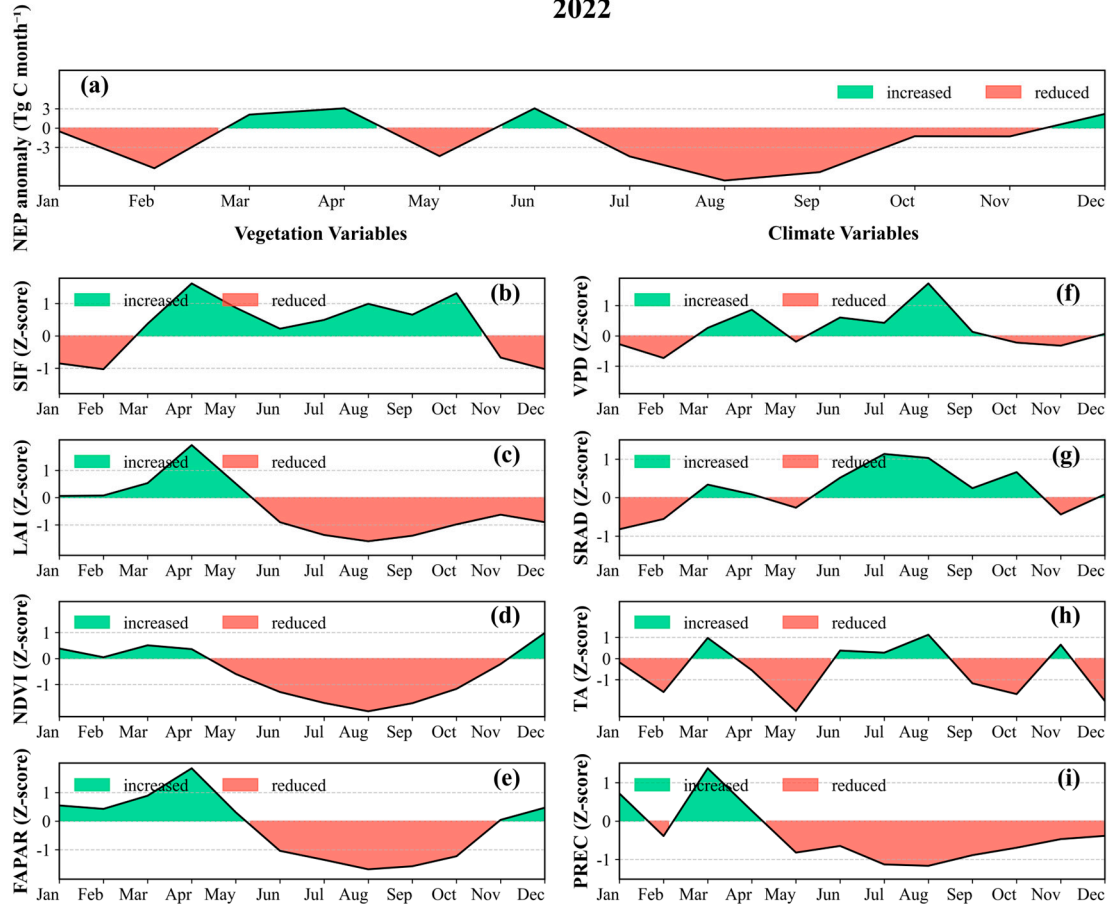


Figure S8. Monthly anomalies of modeled NEP, vegetation indicators, and climate factors in Anji County in 2022. (a) Modeled NEP anomalies (Tg C month^{-1}) were negative in January–February and July–November and positive in March–April and June. Vegetation indicators [(b) SIF, (c) LAI, (d) NDVI, and (e) FAPAR] were generally positive in spring and negative during much of summer and autumn. Among the climate factors [(f) VPD, (g) SRAD, (h) TA, and (i) PREC], PREC remained below its seasonal mean through much of spring–autumn, while SRAD, TA, and VPD had positive mid-summer anomalies. These concurrent model-input and output anomalies are consistent with the documented 2022 Yangtze River Basin drought but do not independently identify the cause or magnitude of the modeled NEP reduction.

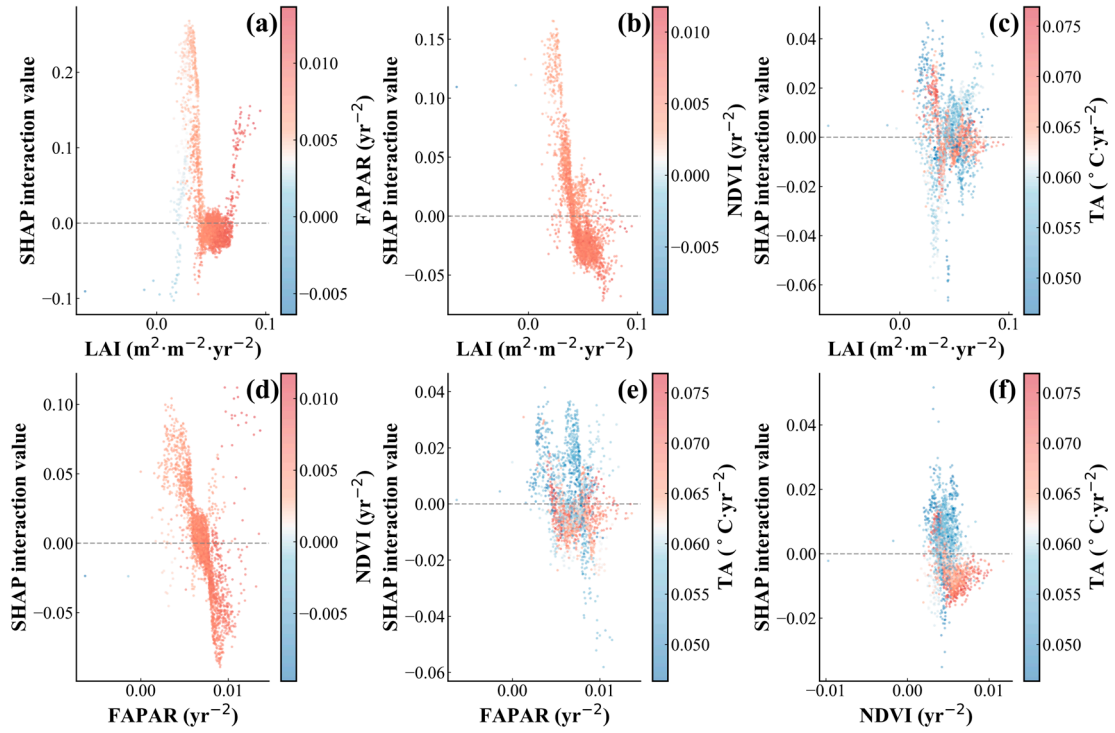


Figure S9. Pairwise SHAP interaction scatter plots for the top six canopy-indicator combinations. Subplots (a)–(f) display SHAP interaction allocations against the trend of the first predictor; point colour represents the trend magnitude of the second predictor. The dashed zero line separates positive and negative model interaction allocations, not ecological synergy or antagonism.

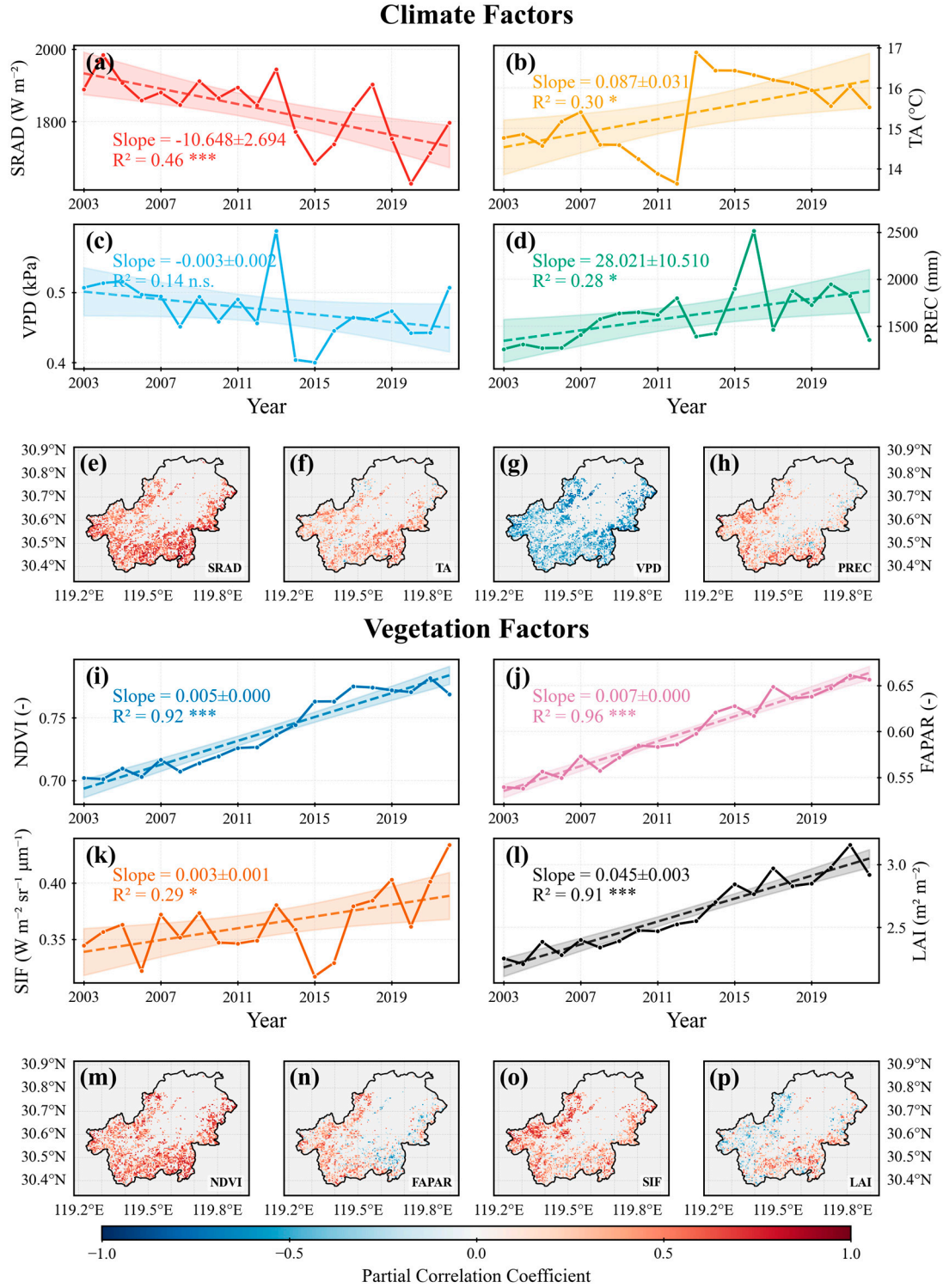


Figure S10. Interannual variations and spatial partial correlation patterns of climate and vegetation factors for modeled bamboo forest NEP in Anji from 2003 to 2022. Time series subplots (a–d, i–l) depict regional annual means and linear trend fits with 95% confidence bands, while spatial maps (e–h, m–p) show pixel-wise partial correlation coefficients with modeled NEP. NDVI, FAPAR, and LAI exhibited significant positive long-term increasing trends throughout the study period. The bottom color bar quantifies partial correlation values ranging from -1.0 to 1.0 .

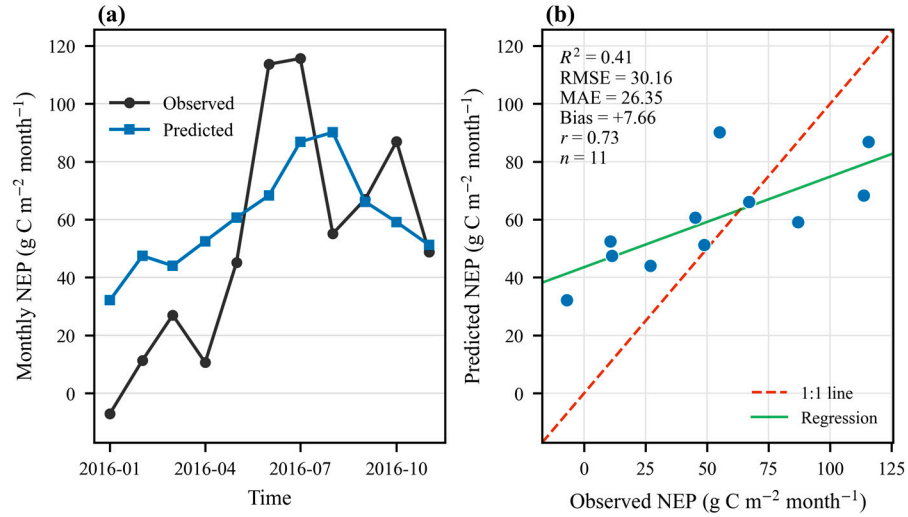


Figure S11. Same-site post-calibration independent temporal evaluation of the frozen RF model using 11 available monthly EC-based NEP observations from the same flux site in January–November 2016. (a) Observed and predicted monthly NEP; (b) predicted versus observed NEP. The dashed line indicates 1:1 agreement and the solid line is the ordinary least-squares regression. The 2016 observations were not used for model selection, hyperparameter tuning, or recalibration. December 2016 was unavailable and was not imputed. Prediction $R^2 = 0.41$, RMSE = $30.16 \text{ g C m}^{-2} \text{ month}^{-1}$, MAE = $26.35 \text{ g C m}^{-2} \text{ month}^{-1}$, mean bias = $+7.66 \text{ g C m}^{-2} \text{ month}^{-1}$, Pearson's $r = 0.73$ ($p = 0.01$), and $n = 11$. This same-site test evaluates temporal generalization but not spatial transferability.

TABLE**Table S1.** Candidate model performance on training and test sets.

Model	Train			Test		
	R ²	RMSE	MAE	R ²	RMSE	MAE
catboost	0.84	11.48	9.15	0.48	17.39	14.94
rf	0.66	16.99	13.13	0.65	14.33	11.82
xgboost	0.80	12.92	10.25	0.40	18.64	15.60
xgb_limitdepth	0.92	8.36	6.08	0.49	17.26	15.02
extra_tree	0.61	18.05	14.29	0.53	16.48	12.70