nature portfolio

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Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒	A description of all covariates tested
☒	☐	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	All data is publicly available and cited within the research.
Data analysis	We utilized MATLAB R2024a, R 4.2.0, ArcGIS Pro 3.0.2, IBM SPSS Statistics 27, and Google Earth Engine for data analysis. Upon acceptance of the manuscript, the code used for analysis, along with the processed data, will be made publicly available on the Zenodo platform. Notably, the MATLAB and R software packages employed in this study are open source.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:
- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

Forest type data is available from https://lpdaac.usgs.gov/products/mcd12q1v061/; NDVI data is available from https://lpdaac.usgs.gov/products/mcd43a4v006/; LAI data is available from https://. lpdaac.usgs.gov/products/mcd15a3hv061/; PTC data available from https://lpdaac.usgs.gov/products/mod44bv061/; CI data available from https://code.earthengine. google.com/?scriptPath=users%2Flrvings%2FGMap%3AClumpingIndex%2FCAS-CI; Climate variable data were obtained

using CRU TS v. 4.07, available from https://crudata.uea.ac.uk/cru/data/ hrg/. You can access continents and country boundaries maps from the GADM database at https://gadm.org/.

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender (identity/presentation), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender	Not applicable.
Reporting on race, ethnicity, or other socially relevant groupings	Not applicable.
Population characteristics	Not applicable.
Recruitment	Not applicable.
Ethics oversight	Not applicable.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences   ☐ Behavioural & social sciences   ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see [nature.com/documents/nr-reporting-summary-flat.pdf](#)

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	In this study, we conducted a global assessment to investigate trends in forest canopy structure across different forest types and their responses to climate change. We developed a Forest Canopy Structure Index (FCSI) , utilizing data with a spatial resolution of 1 km while accounting for the classification of distinct forest types. In addition, we considered the cumulative and delayed effects of climate impacts on forests and determined the optimal temporal benefits. The response of the forest canopy structure index to climate was then analyzed using a partial least squares regression model. Our approach accounts for correlations not only between dependent and independent variables but also among independent variables, addressing multicollinearity effectively. This method enables a fine-grained analysis of canopy structure trends across diverse forest types on a global scale, providing accurate quantification of their responses to varying climatic conditions.
Research sample	In our study, we identified the global forest population as the study focus, encompassing deciduous broadleaf forests, deciduous needleleaf forests, evergreen broadleaf forests, evergreen needleleaf forests, mixed forests, and woody savannas. The climate classification applied was global in scope, ensuring that our analysis spanned all regions worldwide. To perform this categorization, we utilized 10 distinct climate variables representing current climatic conditions. This comprehensive approach enabled us to accurately determine the distribution and prevalence of forest canopy structures across various climatic classifications on a global scale.
Sampling strategy	Given the global scope of our study, our methodology was designed to comprehensively capture the effects of diverse climatic conditions on forest canopy structure. We incorporated data on forest types, vegetation indices, and climate classifications, mapping them onto a 1 km × 1 km grid of image elements.
Data collection	All data used in this study were sourced from publicly available datasets and independently collected online by the authors.
Timing and spatial scale	In this study, we analyzed global-scale trends in forest canopy structure changes and their responses to climate during the growing seasons (June–August) from 2005 to 2021. Our findings provide insights into long-term trends in forest canopy structure and their climatic responses over an extensive temporal and spatial scale.
Data exclusions	No data was excluded from this study.
Reproducibility	This research does not fall into the category of experimental studies; rather, it is an observational study. Consequently, traditional experimental reproducibility is not applicable.
Randomization	This research does not fall into the category of experimental studies; rather, it is an observational study. Consequently, traditional experimental randomization is not applicable.
Blinding	This research does not fall into the category of experimental studies; rather, it is an observational study. Consequently, blinding is not applicable.

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒ ☐	Antibodies
☒ ☐	Eukaryotic cell lines
☒ ☐	Palaeontology and archaeology
☒ ☐	Animals and other organisms
☒ ☐	Clinical data
☒ ☐	Dual use research of concern
☒ ☐	Plants

Methods

n/a	Involved in the study
☒ ☐	ChIP-seq
☒ ☐	Flow cytometry
☒ ☐	MRI-based neuroimaging

Plants

Seed stocks	Not applicable.
Novel plant genotypes	Not applicable.
Authentication	Not applicable.