

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 (<i>n</i>) 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 <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ 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 <i>d</i> , Pearson's <i>r</i>), 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	The code was specifically designed for this analysis, and is available via Codeocean at https://codeocean.com/capsule/6790696/tree (doi: 10.24433/CO.6790696.v1)
Data analysis	All data analysis was performed using R (version 4.4.2 (2024-10-31) and RStudio (2024.12.0 Build 467, "Kousa Dogwood" Release for macOS)

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](#)

The tree-ring data from the International Tree-Ring Data Bank (ITRDB) is openly available in <https://www.nci.noaa.gov/products/paleoclimatology/tree-ring>. The additional tree-ring chronologies data that support the findings of this study have been deposited in Codeocean at <https://codeocean.com/capsule/6790696/tree> (doi: 10.24433/CO.6790696.v1). Climate data obtained from the CHELSA V2.1 database is available at <https://www.chelsa-climate.org/datasets>.

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. No human participants were involved in this study.
Reporting on race, ethnicity, or other socially relevant groupings	Not applicable. No human participants or socially relevant groupings were involved in this study.
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	This study investigates biome-scale variation in drought resistance, recovery and resilience of <i>Pinus sylvestris</i> across its Eurasian distribution. We compiled a large tree-ring dataset comprising tree chronologies (≈14,500 trees) from 534 sites spanning a broad climatic gradient in Europe and Asia. We quantified drought impacts using the Standardized Precipitation Evapotranspiration Index (SPEI) at multiple integration windows and assessed growth responses using established resilience metrics. Sites were grouped into climate clusters to examine spatial heterogeneity in drought–growth relationships.
Research sample	<i>Pinus sylvestris</i> L. (Scots pine) trees.
Sampling strategy	Tree-ring data were obtained from a combination of newly sampled stands and existing chronologies from public repositories and collaborators. Field sampling of living trees followed standard dendrochronological procedures: increment cores were extracted at breast height (1.3 m above ground level) using a Pressler borer, typically collecting two cores per tree to reduce measurement uncertainty and account for within-tree variability.
Data collection	The study is based on an aggregated dataset of available <i>Pinus sylvestris</i> chronologies meeting predefined quality criteria. Inclusion criteria required (i) accurate geographic coordinates, (ii) sufficient replication (minimum sample depth threshold), and (iii) coverage of at least one identified extreme drought event within the instrumental period. The dataset therefore represents a comprehensive compilation of available chronologies across the species' range rather than a statistically random sample of forest stands.
Timing and spatial scale	The analysis covers the instrumental climate period from 1950 to 2020. Drought responses were evaluated at annual resolution, with SPEI integration windows ranging from 3 to 24 months. The spatial extent spans Eurasia, encompassing boreal, temperate, and Mediterranean climate regimes. Analyses were conducted at both site level and aggregated cluster level to examine biome-scale heterogeneity.
Data exclusions	Chronologies were excluded if they lacked accurate geographic coordinates, had insufficient replication (below the predefined minimum sample depth threshold), or did not overlap sufficiently with the instrumental climate period required for drought identification. No additional exclusions were performed based on the magnitude or direction of growth responses. All inclusion criteria were defined prior to statistical analyses.
Reproducibility	All analyses were conducted using scripted workflows in R. Growth departures, resilience calculations, and statistical modelling were fully reproducible from the provided code. Processed datasets and analysis scripts are publicly available in CodeOcean enabling full reproducibility of figures and results. No manual adjustments were applied to model outputs.
Randomization	This study is observational and based on forest stands and historical tree-ring records. No experimental treatments were assigned and no randomization was performed.
Blinding	Blinding was not applicable, as the study is based on observational dendrochronological data and no experimental treatments or group assignments were performed.

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

Dual use research of concern

Policy information about [dual use research of concern](#)

Hazards

Could the accidental, deliberate or reckless misuse of agents or technologies generated in the work, or the application of information presented in the manuscript, pose a threat to:

No	Yes
☒	☐ Public health
☒	☐ National security
☒	☐ Crops and/or livestock
☒	☐ Ecosystems
☒	☐ Any other significant area

Experiments of concern

Does the work involve any of these experiments of concern:

No	Yes
☒	☐ Demonstrate how to render a vaccine ineffective
☒	☐ Confer resistance to therapeutically useful antibiotics or antiviral agents
☒	☐ Enhance the virulence of a pathogen or render a nonpathogen virulent
☒	☐ Increase transmissibility of a pathogen
☒	☐ Alter the host range of a pathogen
☒	☐ Enable evasion of diagnostic/detection modalities
☐	☐ Enable the weaponization of a biological agent or toxin
☒	☐ Any other potentially harmful combination of experiments and agents

Plants

Seed stocks

Only wooden cores from tree's stems were used.

Novel plant genotypes

Not applicable.

Authentication

Not applicable.