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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	No software was used for collecting data.
Data analysis	All data processing, statistical analyses and visualization were performed in R version 4.4.2. The analysis code is available at https://doi.org/10.5281/zenodo.21017602.

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

Seed production data were obtained from the MASTREE+ version 2 database (https://github.com/JJFoest/MASTREEplus/blob/main/Data/MASTREEplus_2024-06-26_V2.csv). Historical daily 2-m air temperature was obtained from the ERA5-Land Daily Statistics dataset (https://cds.climate.copernicus.eu/datasets/derived-era5-land-daily-statistics). Historical monthly climate variables were obtained from the ERA5-Land Monthly Averaged

Reanalysis dataset (https://cds.climate.copernicus.eu/datasets/reanalysis-era5-land-monthly-means). Future monthly climate projections under four Shared Socioeconomic Pathway scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5) were obtained from the Community Earth System Model version 2 (CESM2) within the Coupled Model Intercomparison Project Phase 6 (CMIP6) through the Copernicus Climate Data Store (https://cds.climate.copernicus.eu/datasets/projections-cmip6). Gross primary productivity data were obtained from the GLASS GPP V40 dataset (https://glass.hku.hk/).

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	N/A
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

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	Mast intervals reflect the time required for plants to accumulate and allocate sufficient resources between successive high-seeding events, but whether climate warming alters this process remains unclear. Here, we integrated 61,754 annual reproductive records from 700 perennial plant species across 1,987 sites in the Northern Hemisphere with ERA5-Land climate data and GLASS gross primary productivity data. We investigated whether mast intervals changed across successive reproductive cycles and whether these changes were associated with the rate and cumulative amount of thermal energy and carbon accumulation. Using linear mixed-effects models and a series of robustness analyses, we further examined how these relationships varied among climatic regions, historical periods and major plant clades. Finally, we trained an XGBoost classification model on historical reproductive and climate records and applied it to CESM2 climate projections for 2021–2100 to project future mast intervals under four SSP scenarios.
Research sample	Seed-production records were obtained from the MASTREE+ version 2 database (MASTREEplus_2024-06-26_V2), which compiles long-term plant reproductive time series from published studies, ecological monitoring networks and public datasets. The final dataset comprised 61,754 annual observations from 700 perennial plant species across 1,987 sites in the Northern Hemisphere during 1950–2021. It included 38,134 quantitative and 23,620 ordinal reproductive records. Quantitative records were used for the primary analyses, whereas ordinal records were used in robustness analyses.
Sampling strategy	No statistical method was used to predetermine sample size because this study was based on an existing global database. The sample size was determined by the availability of records that satisfied the study eligibility criteria. We retained records from perennial species that reported seed, fruit or cone production and contained at least five consecutive years of observations for each site-species time series. Records were restricted to the Northern Hemisphere and the period 1950–2021 to ensure adequate temporal coverage and reliable matching with historical climate data. When multiple reproductive metrics were available, seed-production records were preferentially retained to reduce methodological heterogeneity and inconsistencies among measurement units.
Data collection	Seed-production records were obtained from the MASTREE+ version 2 database (MASTREEplus_2024-06-26_V2), historical climate data from ERA5-Land, future climate projections from the CESM2 model through the Copernicus Climate Data Store, and gross primary productivity data from the GLASS GPP V40 dataset.
Timing and spatial scale	Historical reproductive and climate data covered 1950–2021 across 1,987 sites in the Northern Hemisphere. ERA5-Land climate data were obtained at a spatial resolution of 0.1°. GLASS GPP data consisted of 8-day estimates at a spatial resolution of 0.05° and covered 1981–2018. Future climate projections covered 2021–2100 and were analysed in four consecutive 20-year periods: 2021–2040, 2041–2060, 2061–2080 and 2081–2100.
Data exclusions	Records were excluded if they were not from perennial species, did not report seed, fruit or cone production, contained fewer than five consecutive years of observations within a site-species time series, occurred outside the Northern Hemisphere or fell outside the

period 1950–2021. When multiple reproductive metrics were available, seed-production records were preferentially retained. Tropical sites were excluded only from comparisons among climatic regions because of limited data coverage and greater uncertainty in the corresponding mast-interval estimates. These eligibility and exclusion criteria were applied before the corresponding statistical analyses.

Reproducibility

The robustness tests of the historical results included alternative thresholds for identifying high-seeding years (z-scores >0.5 and >1.5), ordinal reproductive records, subsets of site-species time series containing more than 7 or more than 11 mast cycles, and separate regressions fitted to individual site-species time series. Linear mixed-effects models were refitted to 1,000 bootstrap resamples to quantify uncertainty. All analysis code is publicly available at https://doi.org/10.5281/zenodo.21017602.

Randomization

For XGBoost modelling, the historical dataset was partitioned into training (70%) and independent testing (30%) subsets using stratified sampling.

Blinding

Blinding was 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

Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.

Novel plant genotypes

Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.

Authentication

Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosiacism, off-target gene editing) were examined.