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	No software was used for data collection.
Data analysis	All data analyses were conducted in R version 4.4.0 (www.R-project.org), including 'cati', 'FD', 'factoextra', 'piecewiseSEM' packages. R code is available online at Figshare (https://figshare.com/s/58d960e0f8ed868b0524).

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 data is available at Figshare (https://figshare.com/s/58d960e0f8ed868b0524).

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	This study combined a field survey of plant diversity with remote sensing estimates of primary productivity across a large environmental gradient in 235 grasslands across the Qinghai-Tibet Plateau and the Inner Mongolia Plateau. We investigated how functional traits along the fast-slow leaf economics spectrum mediate the effects of environmental change on ecosystem stability at contrasting spatial scales.
Research sample	For the field survey, aboveground biomass of each species and species richness of each community were collected. Functional traits of the dominant species (including specific leaf area (SLA), leaf nitrogen content and leaf phosphorus content) were collected. Soil fertility (including soil total carbon, total nitrogen and total phosphorus) was measured. Normalized difference vegetation index (NDVI) of each community from 2013 to 2022 was extracted from Landsat satellite mission used as a proxy for plant aboveground productivity.
Sampling strategy	We surveyed 235 grasslands across the Qinghai-Tibet Plateau and the Inner Mongolia Plateau. These sites ensured a large environmental gradient to test the effect of environmental factors on diversity and ecosystem stability. At each site, a 50 m × 50 m plot was established and 4 subplots of 0.5 × 0.5 m in size were selected at the four corners of the plot. 50-meter distance between subplots not only ensured heterogeneity among subplots, but also different NDVI values of each subplot extracted from Landsat according to their latitude and longitude.
Data collection	Latitude, longitude and elevation of each subplot were recorded. Species in each subplot was identified, cut above the soil surface, dried in the oven and weighted for the biomass. Functional traits of the dominant species of each site (including specific leaf area (SLA), leaf nitrogen content and leaf phosphorus content) were collected. Six soil cores were collected and soil total carbon, total nitrogen and total phosphorus were measured. See the Methods section in the text for more details.
Timing and spatial scale	For the data collected in the field, we surveyed 43 grassland sites in 2021 and 201 sites in 2022 across the Qinghai-Tibet Plateau (93 sites) and the Inner Mongolia Plateau (151 sites), China, during the peak growing season (July and August). Our sites spanned a latitudinal gradient from 26.98° N to 50.15° N and a longitudinal gradient from 79.03° E to 121.50° E. For the NDVI data extracted from Landsat, we collected the NDVI of each subplot of these sites from 2013 to 2022.
Data exclusions	We excluded 9 sites out of 244 sites we sampled in the field in data analyses, because at least two subplots are in the same pixel and have the same NDVI value due to insufficient spatial distance from each other (it happens when there is a slope between the two subplots).
Reproducibility	The sampling at each site follows the same procedure and is repeatable. The data and the R code is available at Figshare (https://figshare.com/s/58d960e0f8ed868b0524).
Randomization	At each site, we randomly selected a 50 m × 50 m plot to survey.
Blinding	NA

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions	The mean annual temperature and precipitation of the sites range from -4.6 to 10.3 ℃ and from 2.7 to 1338.5 mm in the period between 2013 and 2022.
Location	The sites are across the Qinghai-Tibet Plateau and the Inner Mongolia Plateau, and span a latitudinal gradient from 26.98° N to 50.15° N and a longitudinal gradient from 79.03° E to 121.50° E, with elevation ranging from 406.8 to 4957 m.
Access & import/export	Field surveys and sampling were carried out in accordance with applicable local and national regulations. The collection of plant and soil samples was non-destructive and did not involve protected or endangered species, and no samples were transported across national borders.
Disturbance	This study did not cause any environmental disturbance.

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	Plants were cut just above the soil surface, dried and weighed to estimate the aboveground biomass. Leaves were used to measure functional traits including SLA, leaf nitrogen and phosphorus content.
Novel plant genotypes	NA
Authentication	NA