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	Data were collected from the field as described in the Methods
Data analysis	Analyses were performed in R (version 4.4.1) using packages including lme4, nlme, randomForest, rfPermute, and ggplot2. Normality checks, model diagnostics, and exact P-values are reported in the manuscript. Partial correlations controlling for soil moisture were used as appropriate. All relevant effect sizes and confidence intervals are reported. The analysis scripts and software workflow are available at DOI 10.6084/m9.figshare.31210873.

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

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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	Sichuan Zoige Alpine Wetland Ecosystem National Observation and Research Station (32.83°N, 102.58°E), altitude 3500 m, flat alpine meadow; soil: Mat Cry-gelic Cambisol; dominant vegetation listed in Methods.
Research sample	Plot-level sampling units; 15 plots total; within-block randomization of treatments; repeated measurements across years.
Sampling strategy	Randomization within blocks; 3 m between plots; each block contains one plot per treatment.
Data collection	Reco measured with static chamber; Rsoil and Rmicro with two 10 cm PVC collars (surface 5 cm for Rsoil; deep 40 cm for Rmicro); aboveground biomass removed; LI-6400XT with canopy and soil chambers; temperature sensor at 10 cm depth; measurement cadence every 2–3 weeks in growing season.
Timing and spatial scale	Growing season; spatial scale defined by 15 plots across 5 blocks at the study site.
Data exclusions	Excluded flooding years
Reproducibility	Code and data available at Figshare (DOI: 10.6084/m9.figshare.31210873)
Randomization	Random assignment of treatments within each block
Blinding	N/A

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions	Field site is located at the Sichuan Zoige Alpine Wetland Ecosystem National Observation and Research Station, characterized as a flat alpine meadow with loamy sand soils. Climate is continental monsoon with mean annual temperature about 1.5°C and mean annual precipitation around 757 mm (1961–2022 data). In the growing season (May–September) >80% of rainfall occurs.
Location	Field site is located at the Sichuan Zoige Alpine Wetland Ecosystem National Observation and Research Station (32.83°N, 102.58°E), altitude 3500 m.
Access & import/export	Field access is by authorized personnel via established routes to the station; no additional permits beyond standard fieldwork permissions were required.
Disturbance	Disturbance to the field site is minimal. The study area is located far from human settlements and is fenced to prevent intrusion by humans and grazing animals. Field operations were limited to designated plots, with measures in place to minimize vegetation damage and wildlife 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	N/A
Novel plant genotypes	N/A
Authentication	N/A