nature portfolio

Corresponding author(s): Xiaojuan Liu

Last updated by author(s): July 12, 2024

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 analyses were conducted with R v 4.0.5. R packages we used include piecewiseSEM and ggplot2.

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

Biodiversity and ecosystem function data that support the findings of this study are available in figshare: https://figshare.com/s/91cbc9f9aec78e2dced5.

Human research participants

Policy information about studies involving human research participants and Sex and Gender in Research.

Reporting on sex and gender	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	Here, we analyze how multidiversity is related to ecosystem multifunctionality in two large-scale biodiversity experiments in grasslands (Jena Experiment) and forests (BEF-China experiment). We considered species richness of 13 above- and below-ground trophic groups including soil bacteria, arbuscular mycorrhizae fungi, nematodes, soil mites, Cercozoa, Oomycetes, leaf-litter fungi, plants, arthropod herbivores, herbivore-associated bacteria, arthropod pollinators, arthropod predators, and arthropod parasitoids, as well as 13 ecosystem functions that are related to multiple ecosystem services. We calculated both average and threshold-based multifunctionality, as well as three types of average multifunctionality: provisioning (plant productivity and community stability), regulating (pathogen resistance, herbivory resistance, parasitism rate, and predation rate), and supporting multifunctionality (leaf litter production, leaf litter carbon, extracellular enzyme activities in litter [β-glucosidase BG and polyphenol oxidase PPO], soil organic carbon stock, soil microbial biomass carbon, and soil basal respiration).
Research sample	The study used data collected from two large-scale plant biodiversity experiments representing two different ecosystems: the Jena Experiment in grasslands in Germany and the Biodiversity–Ecosystem Functioning China (BEF-China) Experiment in forests of southeastern China.
Sampling strategy	The data for the grassland ecosystem were obtained from 80 grassland plots containing plant species ranging from 1 to 60 species (i.e. 1, 2, 4, 8, 16, 60), excluding free succession and bare ground plots. And the data for the forest ecosystem were collected from 47 plots (22 plots in site A and 25 plots in site B), encompassing a gradient from monocultures to plots with 24 species. Specifically, the number of plots sampled was 18, 13, 8, 4, 2, and 2 for the tree species richness levels of 1, 2, 4, 8, 16, and 24, respectively.
Data collection	In both ecosystems, we measured the species richness of various trophic groups. For the Jena Experiment, we collected aboveground arthropods, nematodes, and microorganisms. The data for these trophic groups were obtained using taxa-specific methods between 2017 and 2021. Furthermore, we focused on nine ecosystem functions, which were carried out over the period from 2014 to 2021 using established methods. In the BEF-China experiment, we examined eight trophic groups consisting of arthropods, soil nematodes, mites and microorganisms. These groups were categorized into different functional groups based on their feeding ecology and trophic rank. Data for these trophic groups were collected between 2015 and 2020 using taxa-specific methods as documented in various studies. Moreover, we conducted measurements of a comprehensive set of 10 ecosystem functions, which were carried out over the period from 2010 to 2022.
Timing and spatial scale	Data for higher trophic groups were collected between 2015 and 2021, and data for ecosystem functions were collected over the period from 2010 to 2022.
Data exclusions	N/A
Reproducibility	Detailed description of the methods are provided, all dataset are freely avaiable online and all analyses were performed in R. The results are fully reproducible using these data and packages.
Randomization	All species composition were randomized across plots.
Blinding	N/A

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions	The Jena Experiment is located in the Saale River floodplain near the city of Jena, Thuringia, Germany, with a mean annual temperature and precipitation of 9.8 °C and 571 mm, respectively. The BEF-China experiment is located in the subtropics of China with a mean annual temperature and precipitation of 16.7 °C and 1821 mm, respectively.
Location	The Jena Experiment is located in the Saale River floodplain near the city of Jena, Thuringia, Germany (50°55′N, 11°35′E). The BEF-China experiment is located in Xingangshan, Dexing, Jiangxi Province, China (29°05'00''–29°07'43'' N, 117°54'19''–117°55'53'' E).
Access & import/export	Both Jena and BEF-China experiments were established with permission of the local authorities in sites.
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

Methods

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

Animals and other research organisms

Policy information about studies involving animals; ARRIVE guidelines recommended for reporting animal research, and Sex and Gender in Research

Laboratory animals	N/A
Wild animals	The animals included in our study are nematodes, soil mites, arthropod herbivores, arthropod pollinators, arthropod predators, and arthropod parasitoids.
Reporting on sex	N/A
Field-collected samples	All samples were collected from the field i.e., the Jena Experiment (with a mean annual temperature and precipitation of 9.8 °C and 571 mm) and the BEF-China experiment (with a mean annual temperature and precipitation of 16.7 °C and 1821 mm).
Ethics oversight	This study was performed according to the international, national and institutional rules considering animal experiments, clinical studies and biodiversity rights.

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